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Mapping wetland research in India in comparison with the rest of the world (1998-2021) - A meta-analysis

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Abstract

Wetlands are crucial for maintaining the earth's ecosystems, which control water supplies, modify local climates and provide humans with food. Nevertheless, wetlands confront substantial challenges attributed to human activities and natural alterations, encompassing issues like area contraction, functional deterioration, declining biodiversity and numerous other concerns. The current study used the Web of Science (WoS) database to analyse the wetland research output during the last three decades spanning from 1988 to 2021. This analysis evaluated the scientific production of wetland research in India and the rest of the world using a total of 63671 articles. Analysis was also done on the global publication share, ranking, and progress in terms of research and bibliometric indices such as total citations, h-index, and average citations per paper. The USA accounted for 32.629% of the total publications, placing it topmost among the most productive nations in terms of overall publications. The network visualisation map showed that USA was the primary cooperating nation, but that there was very little cross-national cooperation. Since the WoS database contains only journals that are indexed by the WoS, the real number of publications is expected to be much larger than in the current study. This study also revealed the specific areas on wetland research where future directions for investigation can be decided by experts in the field. However, wetlands face significant problems because of human activity and other natural changes, such as area contraction, functional deterioration, decline in biodiversity and much more.

Introduction

"Areas of marsh, fen, peatland, or water, whether natural or manmade, permanent, or temporary, with water that is static or flowing, fresh, brackish, or salt, including areas of marine water, the depth of which at low tides does not exceed six metres" is the definition of a wetland as per Ramsar Convention, Article 1.1 (Gardner and Davidson, 2011). Among the planet's many ecosystems that are covered by water either seasonally or permanently, this particular environment stands out as one of the most unique and productive. About six percentage of Earth's land area is made up by wetlands and these areas play an essential role in many environmental processes, including the hydrological cycle, environmental cleanliness, food production, drought prevention, soil erosion control and climatic regulation (Ramsar Convention on Wetlands, 2018). A wide variety of wetland habitats are found across the Indian subcontinent because of the region's varied topography and climate (Prasad *et al*., 2002). They cover an area of 12.1 million km^2 and are responsible for 40.6% of the total value of ecosystem services (ES) worldwide (Costanza *et al.,* 2014; Ramsar Convention on Wetlands, 2018). The global expanse of wetlands has decreased by 35% since 1970 due to their unsustainable use or overexploitation (Mitsch and Gossilink, 2000; Rebelo *et al*., 2017; Ramsar Convention on Wetlands, 2018). The Ramsar Convention has been signed by 169 countries, although wetland degradation and loss still occur (Ramsar Convention on Wetlands, 2018). From the Himalayas to the Deccan Plateau, India's wetland region is believed to make up between 1 to 5% of the country's total landmass and it is crucial to the country's rich biodiversity (Bassi *et al*., 2014). In addition, it also provides many important services such as water

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sanctification, groundwater recharge, climate purification, nutrient cycling, flood mitigation and biodiversity preservation (Russi *et al.,* 2013), thereby providing a means of income generation, livelihood and wellbeing of the rural communities. However, from the mid-twentieth century, due to lack of effective management measures and proper appreciation of the true worth of wetlands, wetlands are facing several challenges. Intensive economic development, rapid recovery of farmland, overuse of organic resources, overexploitation for tourism development and pollution are the major reasons due to which many wetland ecosystems in India have witnessed a rapid detraction, reduction in area, deterioration in water quality and loss of biodiversity. Because of the significance of the wetland habitat, there are numerous important pieces of legislation to protect wetlands around the world (Xu *et al*., 2020).

Due to the recent globalisation of information, wetlands have become a focal point for the accumulation of extensive knowledge and information on a global scale. However, there are occasions when access to some of the literature is limited because of financial constraints, submissions published in journals with low impact and linguistic restrictions, among other factors. The primary objective of the present study was to systematically map the scientific literature on wetlands in space and time. The study was conducted by examinining publication outputs catalogued in Web of Science (WoS) during the period 1988-2021. Furthermore, a comparative assessment with a specific focus on India was also done to provide additional insights into the regional contributions towards global wetland research.

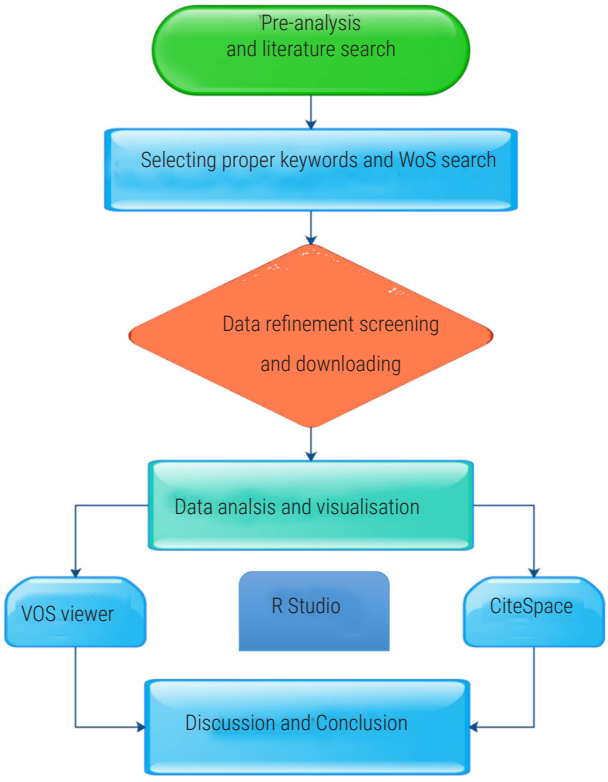

Fig. 1. A schematic representation of the research design

Materials and methods

For the investigation, a number of bibliometric research analysis tools were used (Gupta and Bala, 2013; Zyoud *et al.,* 2015; Bhoomaiah *et al.,* 2020; Rathinam *et al.,* 2021; Anatharaja *et al.,* 2023). The Web of Science (WoS) database maintained by Clarivate Analytics served as the source for all credentials used in this analysis (Clarivate-Analytics, 2017; Li *et al.,* 2018). The search was conducted in WoS from October to December 2021 using the keywords Wetlands; or Wetland in the TOPIC arena, which comprises the title, abstract, and keywords (both authors; keywords and keywords plus) of each publication. It focused on articles published between 1988 and 2021. Fig. 1 depicts a schematic representation of the research design. For additional investigation, the metadata was retrieved in plain text and BibTex formats. For major trend topic analysis, factorial analysis and three field plots, the retrieved metadata was analysed in R version 4.0.1 coupled with Rstudio version 1.3.959 using the bibliometrix R-package (Aria and Cuccurullo, 2017). To evaluate the trends in scientific research productivity, citation impact and collaboration status, country-specific scientific articles on WETLANDS throughout the study period (1988–2021) were obtained from the WoS database. The productivity of institutions and authors was evaluated using scientometric indices of publications, such as total citation counts, average citation per paper (ACPP) and h-Index. Based on the most frequently referenced research publications and the total number of citations, the h-Index is a statistic used to assess the quality of research output (Hirsch, 2005). The most productive organisations, writers and highly cited publications in this field were found using information from the WoS database. Following that, the data was examined and visualised using the free freeware VOS viewer (Leiden University, Leiden, Netherlands). Examples include using associations between countries, authors, and keywords to separate the data into various clusters, each of which was colour-coded (van Eck *et al.*, 2010; Waltman *et al.*, 2010). Utilising the network visualisation technique, the relationship between each of them was shown, with the distance between two circles signifying how similar they are to one another (Khalil and Crawford, 2015; Zhao *et al.,* 2018). In the Vos viewer, network visualisation was created using a minimum of two papers per author and nation, while the same visualisation was done using keyword occurrence in more than two documents.

Results

Overview of wetland research across the world *vis-a-vis* India

A total of 63,671 research publications were on wetland research spanning the period 1988-2021 and were retrieved. Among them 87.09% of the research publications comprised research article, 11% were proceedings papers, 3.53% review articles and 0.47% meeting abstracts. About 1,16,316 authors contributed to the wetland research, documents per author was 1.84 and the collaboration index was 1.92 (Fig. 2). An increasing trend in the year-wise publications on wetland research during 1988-2021 was noticed. It ranged from 2 publications per year in 1998

Wetland - Main information (1988-2021)

Description	Result
Main information about data	
Timespan	1988:2022
Sources (Journal, book, etc)	5416
Documents	63231
Average years from publication	8.1
Average citations per documents	21.43
Average citations per year per doc inf	
Reference	1339845
Documents types	
Article	51798
Article; book chapter	10
Article data paper	59
Article; early access	439
Articles proceedings paper	2270
Article; retracted publication	4
Biographical item	2
Book review	41

Ducuments contents	
Keywords plus (ID)	48424
Author's keywords (DE)	86908
Authors	
Authors	116316
Author appearances	276799
Authors of single-authored documents	3188
Authors of multi-authored documents	113128
Authors collaboration	
Single-authored documents	4228
Documents per author	0.544
Authors per docment	1.84
Co-authors per documents	4.38

Collaboration index - 1.92

Fig. 2. Summary of literature (metadata) on wetland research during 1991-2021

to 4996 publications per year in the year 2021 (Table 1). Country-wise, contribution by USA was the highest (32.629%) followed by China (19.09%), Canada (6.994%), Australia (6.039%) and England (4.74%), (Fig. 3 and 4) whereas India secured 10th position with the share of 3.25% publications (Table 2). Furthermore, the network visualisation (in terms of total publications) of top countries and their association with other countries using VoS viewer exhibited very few collaborations between countries (Fig. 5) except the USA and China which have comparatively more collaboration with other countries.

A total of 2, 066 documents from India for the period 1988-2021 were retrieved from WoS database . It comprised of 1,682 research articles; 139 review publications and 14 editorial materials. Total of 4, 671 authors were found with 0.442 documents per author and the collaboration index was 2.35 (Fig. 6). Year-wise publications on wetland research from India exhibited a linear graph with few downfalls in some years from 1998-2021 (Fig. 7). In 2018, a peak was observed followed by a fall in 2019 and from 2019 a gradual increase was observed till 2021. International collaboration of India with several countries is depicted in Fig. 8. The trend topics on

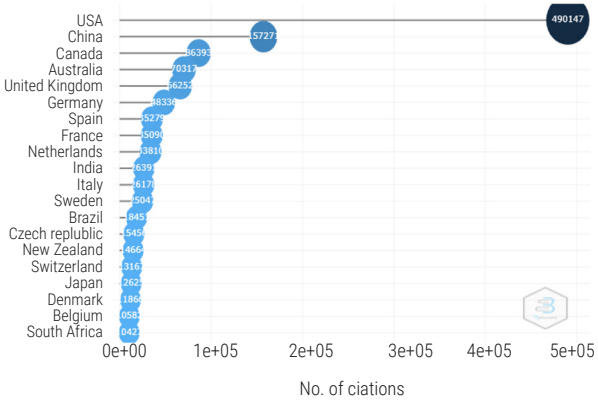

Fig. 4. Most cited countries on wetland research during 1991-2021

wetland research in India analysed using R studio revealed that wetlands, phosphorus, nitrogen, climate change, biodiversity, ecosystem services, artificial wetlands, vegetation, aquatic plants and greenhouse-gas emissions were the major focus in wetland research during 1988-2021 (Fig. 9).

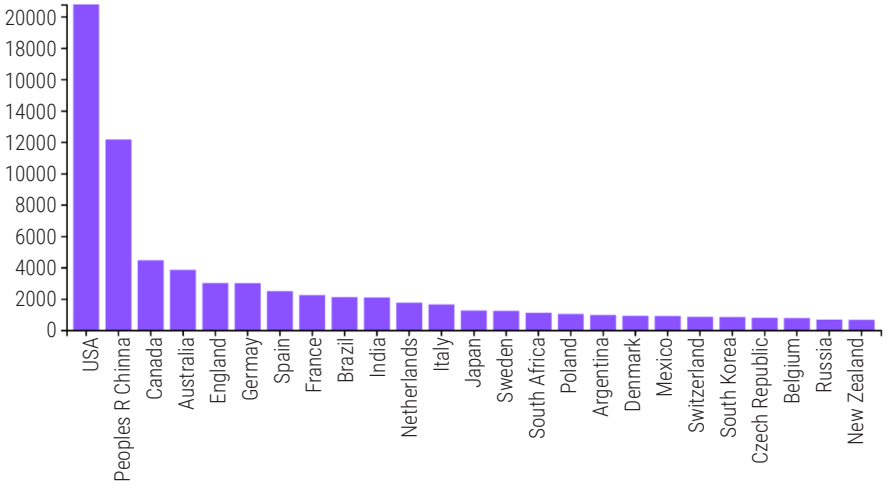

Fig. 3. Country-wise publication on wetland research from 1988-2021

Table 1. Global trend of year-wise research productivity on wetland research during 1991-2021

Publication years	No. of publications	Total citations	Without self-citation	h-index	ACPP
1991	19	78	78	6	4.11
1992	2	0	0	0	0
1993	6	2	2	1	0.33
1994	8	194	194	3	24.25
1995	15	380	380	5	25.33
1996	3	68	68	2	22.67
1997	15	504	504	4	33.6
1998	939	41667	41592	98	44.37
1999	1016	46468	46384	98	45.74
2000	1069	48481	48338	106	45.35
2001	1134	47628	47528	101	42
2002	1144	54018	53889	102	47.22
2003	1336	60811	6066	114	45.52
2004	1354	61210	61116	106	45.21
2005	1636	63703	63488	113	38.94
2006	1754	73567	73366	113	41.94
2007	1866	64965	64746	105	34.82
2008	1962	69885	69702	108	35.62
2009	2457	79409	79043	113	32.32
2010	2601	75183	74803	111	28.91
2011	2893	74306	73850	103	25.68
2012	2909	69078	68646	100	23.75
2013	3332	73613	73031	98	22.09
2014	3365	70269	69715	97	20.88
2015	3717	66002	65449	89	17.76
2016	3942	63085	62291	82	16
2017	3993	55911.	55131	74	14
2018	4291	48718	47758	66	11.35
2019	4688	39088	37888	52	8.34
2020	5203	23176	21531	39	4.45
2021	4996	4906	3388	16	4.45

Table 2. Publication output of top 10 countries in the research on Wetlands during 1991-2021

S. No	Country	Total no of publication	% Share	Total Citations	Without self-citations	ACPP	h-index
1	USA	20774	32.629	346371	334711	16.67	331
2	China	12158	19.096	102281	95212	8.41	158
3	Canada	4453	6.994	89314	86220	31.15	141
4	Australia	3845	6.039	71729	69091	28.77	124
5	England	3001	4.714	73931	72281	32.96	132
6	Germany	2994	4.703	70782	69071	33.04	130
7	Spain	2489	3.909	39318	37764	22.27	97
8	France	2239	3.517	48382	47104	28.44	103
9	Brazil	2106	3.308	23623	22307	15.67	69
10	India	2074	3.258	25932	24799	16.04	71

Research indicators

Citation, ACPP and h-index are the quintessential indicators of research efficiency and it also helps to measure the research productivity on any specific research area. In the current study, the average citation per paper (ACCP) varied from 8.41 to 33.04 for the top 10 countries (Table 2). The highest citation was observed in the USA with 3, 46, 371 citations followed by China with 1, 02, 281 citations. In case of ACPP, although the number of publications (4.7%) were less in Germany, the average citations per paper was found to be highest (33.04) followed by England (32.96). The h-index was found to be the highest in the USA (331), followed by China (158) and Canada (141) among the top publishing countries on wetlands.

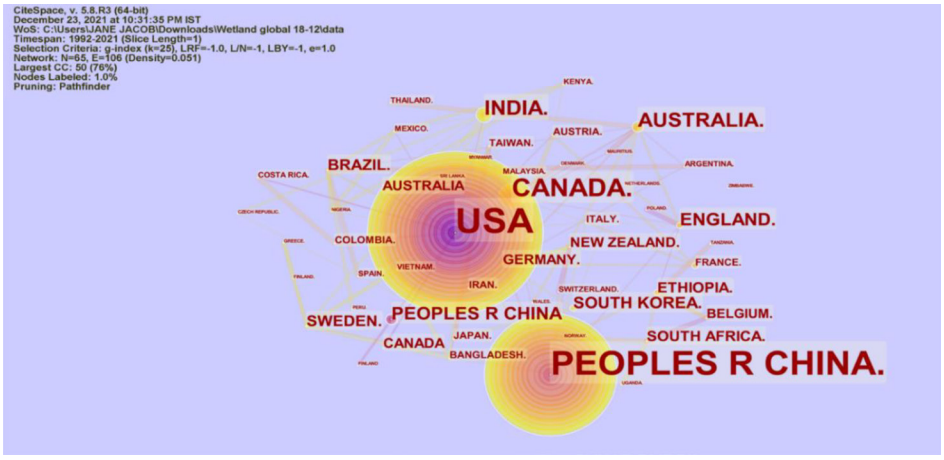

Fig. 5. Collaboration network of major countries on wetland research during 1991-2021 (The dots after the country are due to auto generation in cite space software).

Main information about data	
Timespan	1991:2021
Sources (Journal, book, etc)	663
Documents	2066
Average years from publication	6.04
Average citations per documents	16
Average citations per year per doc	2.49
Reference	82661
Documents types	
Article	1682
Article; data paper	1
Article; early access	53
Articles proceedings paper	48
Article; retracted publication	4
Correction	7
Editorial material	14
Letter	12
Meeting adstract	4
News item	1
Proceedings paper: book chapter	91
Proceedings paper	1
Review	139

Ducuments contents	
Keywords plus (ID)	4450
Author's keywords (DE)	5665
Authors	
Authors	4671
Author appearances	8331
Authors of single-authored documents	74
Authors of multi-authored documents	4597
Authors collaboration	
Single-authored documents	108
Documents per author	0.442
Authors per docment	2.26
Co-authors per documents	4.03
Collaboration index	2.35

Collaboration index - 2.35

Fig. 6. Summary of literature (metadata) on wetland research from India

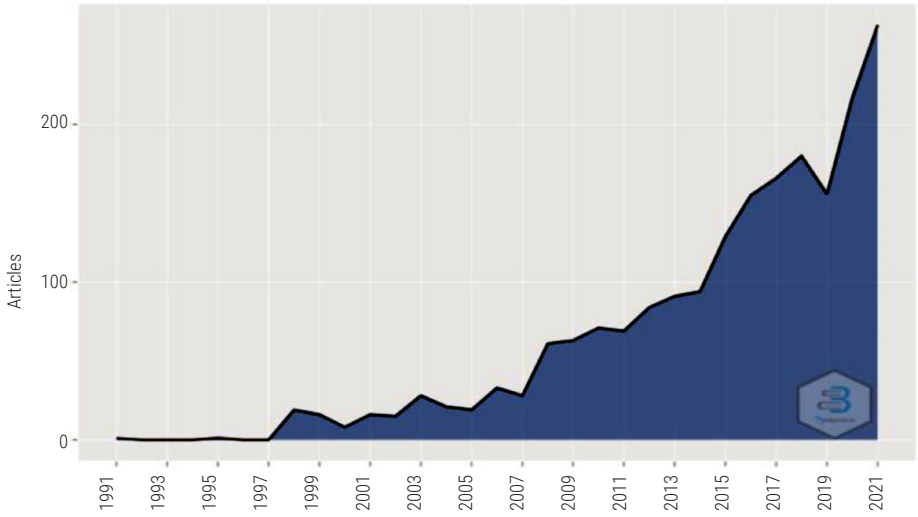

Fig. 7. Annual scientific production in wetland research from India

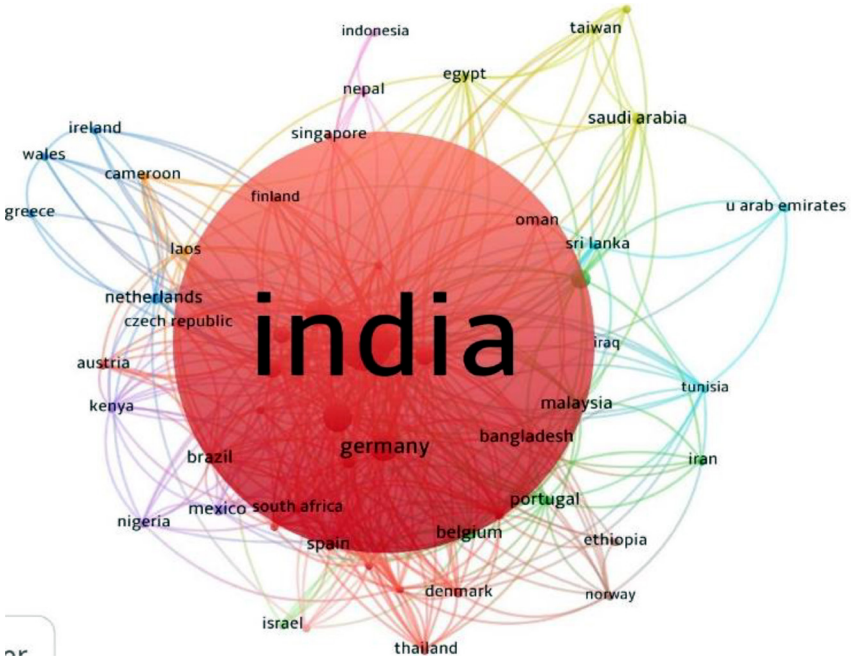

Fig. 8. Collaboration network of India with major countries on wetland research

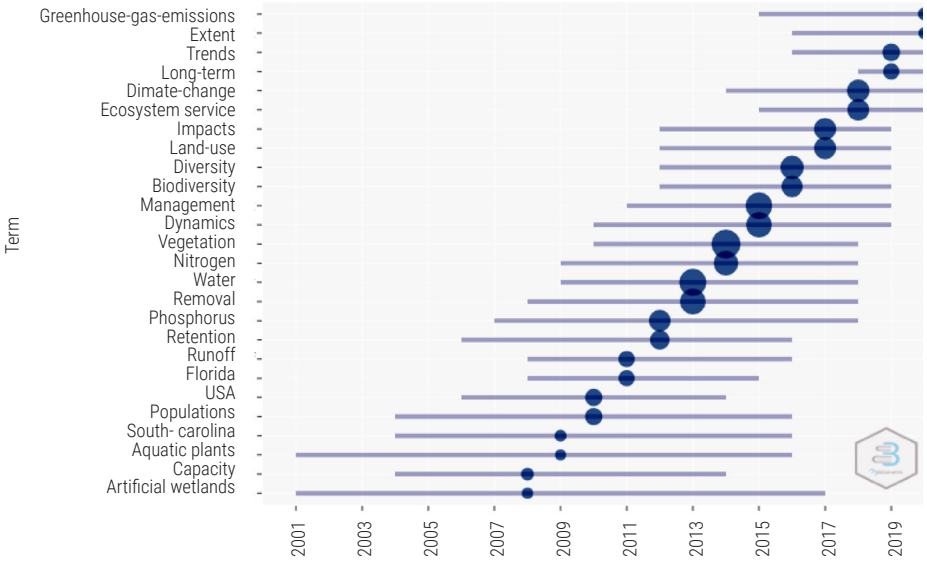

Fig. 9. Trend in topics of wetland research in India

Most productive institutions

Regarding research publications, the topmost productive institutions on wetland research during 1988-2021 were analysed. Institutions in the USA, *i.e.,* United States Department of the Interior (2, 924 publications), United States Geological Survey (2, 472 publications), State University System of Florida (1, 967 publications), University of California (1,448), United States Department of Agriculture (1, 313), Louisiana State University (1, 005) and University of Florida (983) were listed in the top 10 institutes. Apart from the institutes of the USA, two institutes from China namely, Chinese Academy of Sciences (5.827%) and University of Chinese Academy of Sciences (2.043%) were also listed among the top most 10 productive institutions across the world (Table 3).

In India, University of Calcutta (122) followed by Indian Institute of Technology (89) and Jadavpur University (62) were identified as the most productive institutions that were working on wetland research from 1988-2021. ICAR-Central Inland Fisheries Research Institute and Banaras Hindu University with 56 publications reached fourth position among the top 10 institutions (Fig. 10).

Table 3. Research productivity of top 10 institutions in research on wetlands during 1991–2021

Institution	Country	No. of records	% Share
Chinese Academy of Sciences	China	3710	5.827
United States Department of the Interior	USA	2924	4.593
United States Geological Survey	USA	2472	3.883
State University System of Florida	USA	1967	3.086
University of California System	USA	1448	2.274
United States Department of Agriculture	USA	1313	2.062
University of Chinese Academy of Sciences	China	1301	2.043
Centre National de la Recherche Scientifique	France	1274	2.001
Louisiana State University System	USA	1005	1.579
University of Florida	USA	983	1.544
Others			

Most productive authors and their collaboration networks

The scientific productivity of the most productive authors on wetland research during 1988-2021, arrived based on the publication data derived from the Web of Science database is presented in Table 4. The highest contribution was from the Chinese authors (Dr. Zhang, Y., with 271 publications followed by Dr. Zhang, J. with 223 publications). It was found that both international and national collaboration among institutes are high. The authors from China were the top contributors and have close collaboration compared to many other countries. It was found that the top author with high citations in wetland related research varied with the authors with maximum number of publications and h-index of top authors (Fig. 11). Authors production over time was linear in nature in particular, from the year 2017 to 2020, wherein a visible increase in the density of publications was observed. The practice of multiple corresponding authors for papers was observed in China followed by USA in wetland research (Fig. 12). The network of authors and the chief research groups in this regime of research was depicted using VoS viewer in Fig. 13. Lotka's law is utilised to evaluate author's productivity. It was evident from the graph that very few authors have published more than 10 papers and <10% of authors only contributed to >1 and <10 papers during the selected time period. It implies that Lotka's Law does not apply to global wetland research which means the frequency of researchers publishing manuscripts is very low (Fig. 14).

Indian authors *i.e.*, Pal, S. and Sarkar, S. K. were the most productive authors identified on wetland research. They both were invariably placed at first and second position in all the author productivity analysis carried out in the study (Fig. 15). Many of the author's production over time were increased and a few authors were observed to maintain the same number of publications over time. Network visualisation of Indian authors and the major research groups working on wetland research both in terms of number of publications and citation were depicted using VoS viewer in Fig. 16. Lotka's law analysis for Indian authors on wetland research implied that less than 10% of the authors have contributed to 5 publications. Based on the results of analysis, it appears that Lotka's law does not apply for wetland research of Indian authors (Fig. 14).

Top 10 journals on wetland research

The topmost ten journals those published research literature on wetland are tabulated in Table 5. It was observed that the journal "Ecological Engineering" published the highest number of research articles (2036 publications) on wetland with total citations of 30,229, followed by the journal Wetlands (1,959 papers), however, the citation was higher in the journal "Science of the Total Environment" which holds third position. The impact factor of the journals fluctuated from 1.63 to 7.96 as per the Journal Citation Report, 2021 by Clarivate-Analytics (2021). Similarly, the local impact of the journals based on its h-index was analysed using R studio. Ecological Engineering and Science of the Total Environment had high impact with the h-index of 106 and 82, followed by Water Research and Wetlands with h-index of 81. Furthermore, among the most relevant journals, Ecological Engineering, Wetlands and Science of the Total Environment were the top three journals (Fig. 17).

Environmental Monitoring and Assessment (82 publications), Current Science (66 publications), Ecological Engineering and Environmental Science and Pollution Research (40 publications)

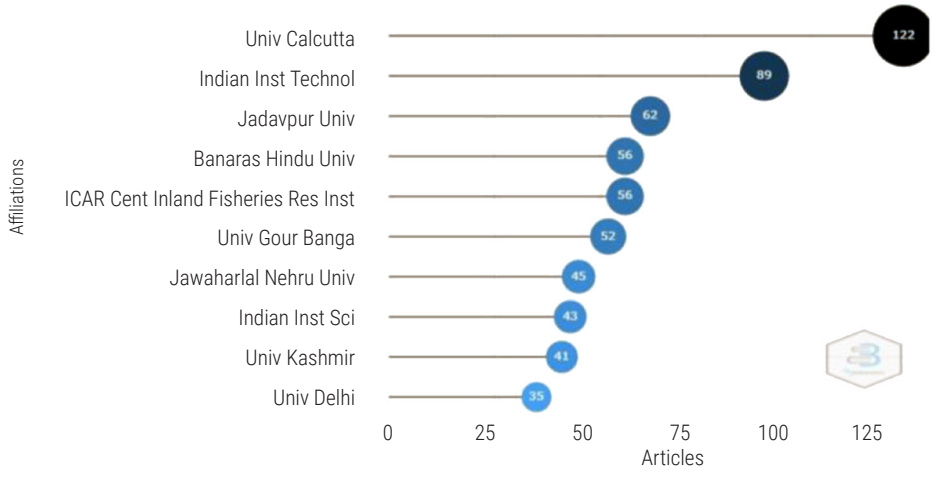

Fig. 10. Most productive Indian institutions on wetland research

Table 4. Productivity of top 10 authors based on the publication output on wetlands worldwide (1991-2021)

S. No	Name of the author	Affiliation	Country	No. of publications	TC	% Share	h-index
1.	Zhang, Y.	Cent China Normal Univ, Wuhan,	China	271	4066	0.426	35
2.	Zhang, J.	Central South University of Forestry and Technology Sch Forestry, Changsha	China	223	3118	0.350%	36
3.	Liu, Y.	Jilin University Minist Educ, Changchun	China	214	2537	0.336%	28
4.	Wang, Y.	Chinese Academy of Sciences Synth Res Ctr Chinese Ecosyst Res Network, Beijing	China	204	4034	0.320%	32
5.	Wang, H.	H7.ohai University Coll Hydrol and Water Resources Nanjing	China	199	2712	0.313%	29
6.	Li, Y.	Shenyang University Coll Business Adm Shenyang, Liaoning	China	198	2333	0.311%	27
7.	Wang, L.	Hainan Normal University Coll Geog and Environm Sci, Haikou, Hainan	China	182	2157	0.286%	25
8.	Zhang, L.	Florida Gulf Coast University, Naples, FL	USA	180	3051	0.283%	27
9.	Bai, JH.	Binzhou University	China	165	2869	0.259%	37
10.	Li, J.	Shenyang University Coll Business Adm, Shenyang, Liaoning	China	155	1778	0.243%	21

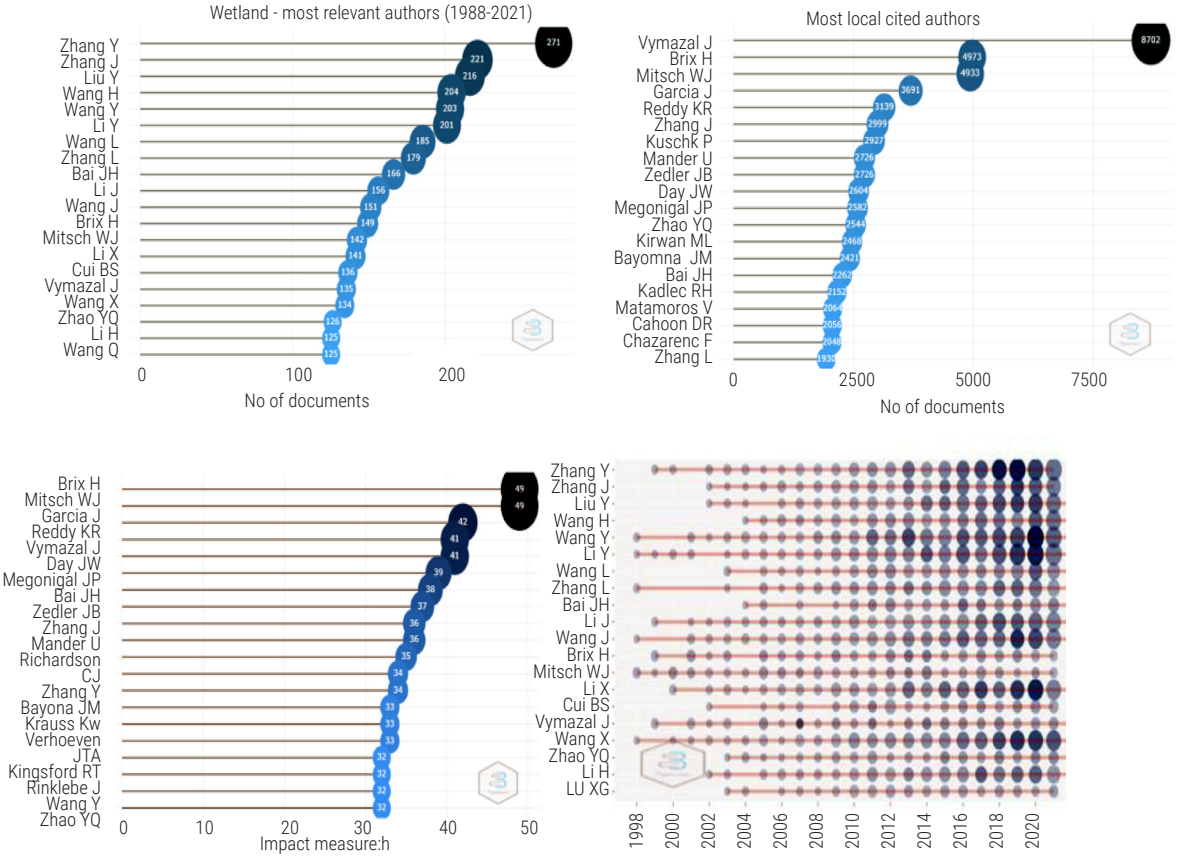

Fig. 11. Most relevant, local cited global authors, authors impact in terms of h-index and authors productivity over time on wetland research (1991-2021)

were the journals identified as the most preferable journals on wetland research in India. In terms of h-index, journals like Ecological Engineering (28 h-index) followed by Environmental Monitoring and Assessment (18 h-index) and Journal of Environmental Management (16 h-index) were found top ranked journals in Indian wetland research (Fig. 18).

Funding sources on wetland research

The major funding agencies that contributed to wetland research during 1988-2021are given in Table 6. A total of 38,285 funding agencies were found based on the WoS database. However, around 26,414 publications which formed around 41% of the total publications did not discuss the details of their funding. Chinese

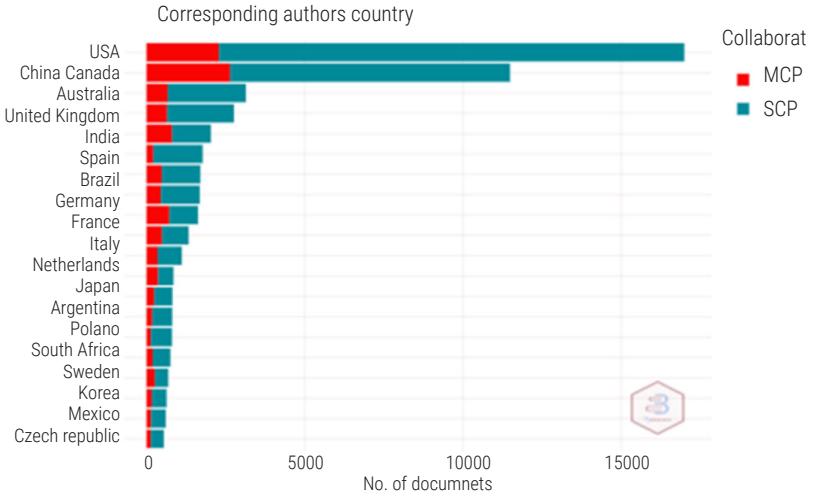

Fig. 12. Top most productive corresponding author's country on global wetland research (1991-2021)

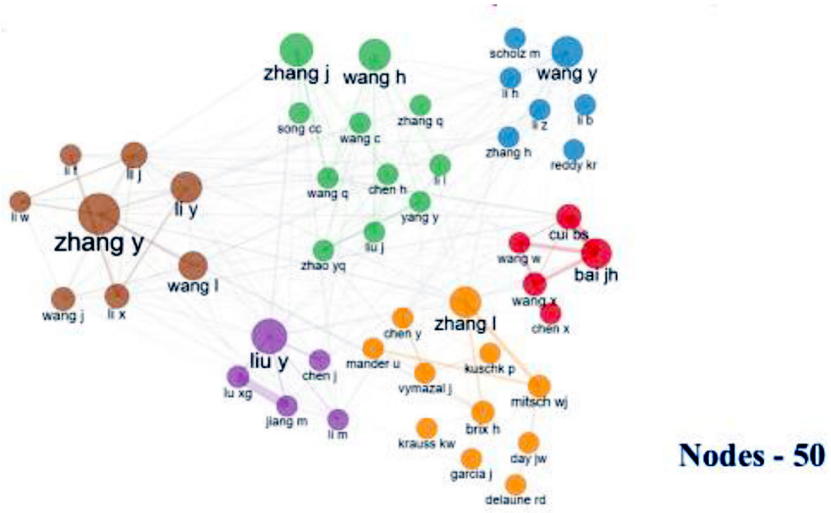

Fig. 13. Network visualisation of authors across the world on wetland research (1991-2021)

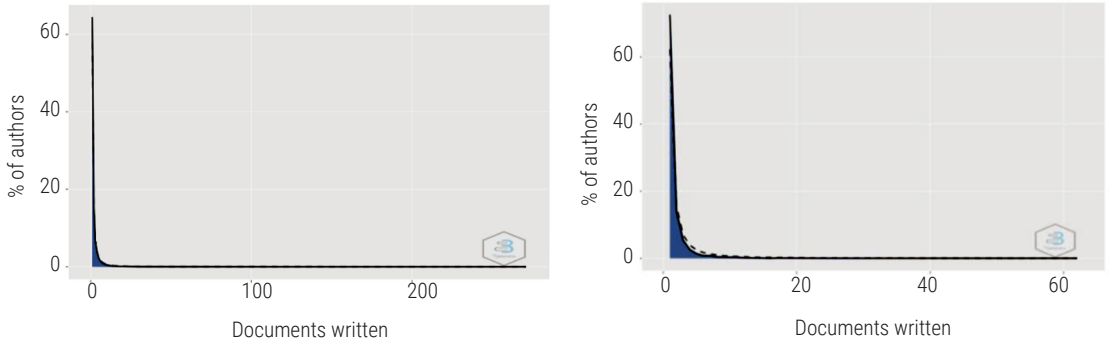

Fig. 14. Lotka's law analysis of global and Indian authors productivity on wetland research

Table 5. Top 10 journals those published research articles on wetlands during 1991-2021

S. No.	Name of the journal	Publications	% Share	Total citation	ACPP	Impact factor (2021)
1.	Ecological Engineering	2036	3.198	30229	31.81	4.0
2.	Wetlands	1959	3.077	23707	20.37	2.204
3.	Science of the total environment	1,562	2.453	31115	25.94	7.96
4.	Water science and technology	850	1.335	9054	17.63	1.63
5.	Environmental science and pollution research	694	1.090	7891	13.52	4.223
6.	Hydrobiologia	674	1.059	13121	23.84	2.69
7.	Water	603	0.947	3721	7.16	3.166
8.	Journal of Environmental Management	598	0.939	11297	22.1	6.7
9.	Plos One	539	0.847	10521	20.83	3.24
10.	Ecological Indicators	529	0.831	7276	16.57	4.95

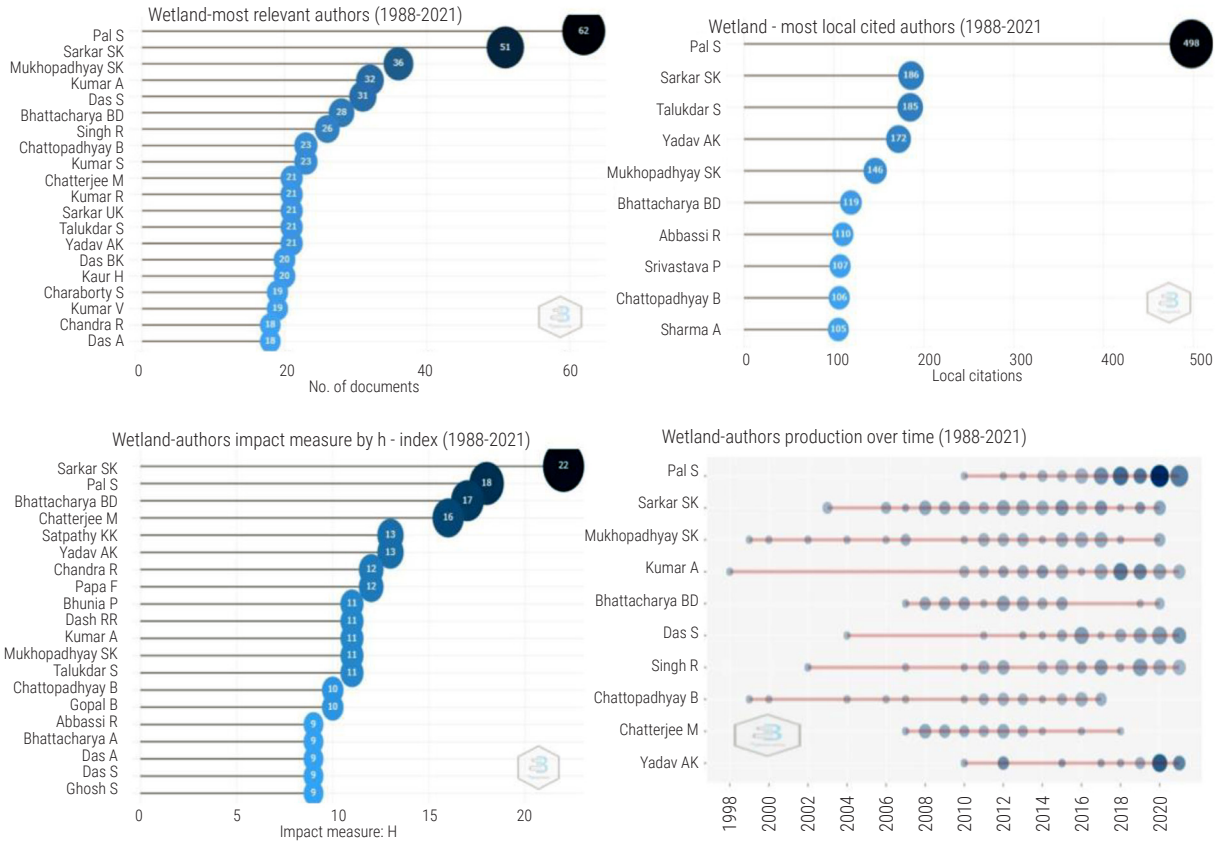

Fig. 15. Most relevant, local cited Indian authors, authors impact in terms of h-index and authors productivity over time on wetland research

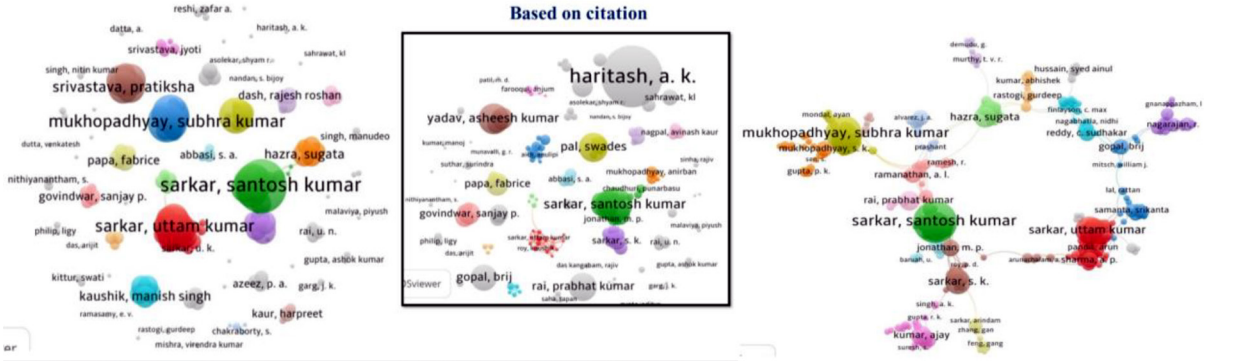

Fig. 16. Network visualisation of Indian authors and their collaboration on wetland research

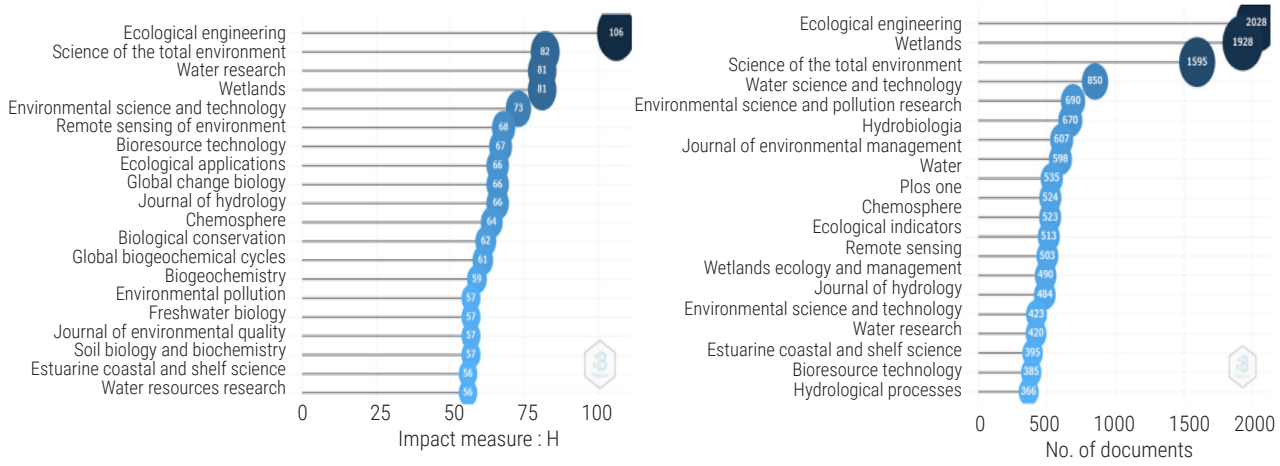

Fig. 17. Most productive journals based on publications and h-index on global wetland research (1991-2021)

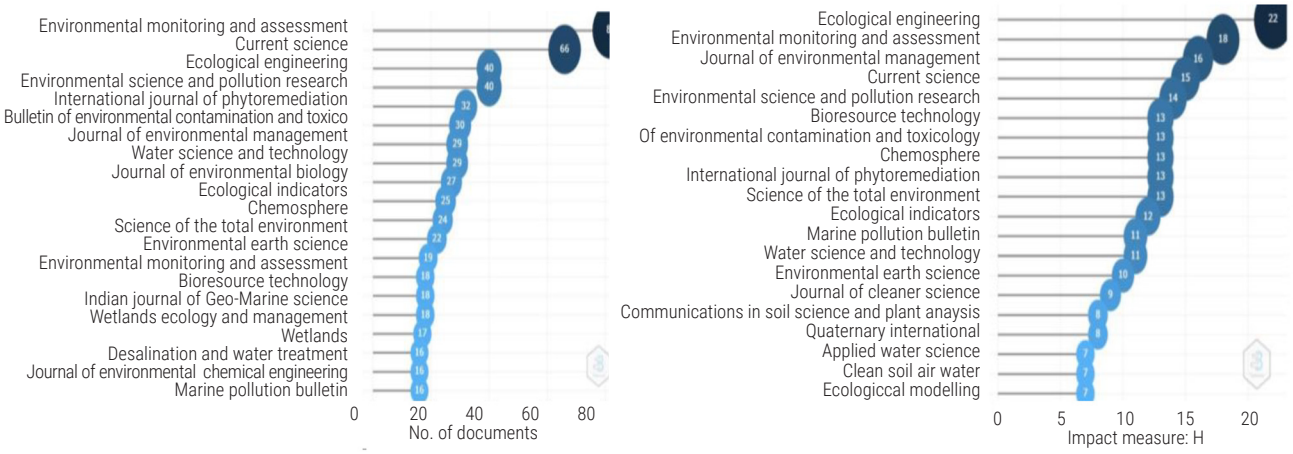

Fig. 18. Most productive journals based on publications and h-index on wetland research in India

Table 6. Top 10 funding agencies, which yielded maximum research publications during 1991-2021 on the research on wetlands

S. No.	Name of the funding agency	No of records	% Share
1	National Natural Science Foundation of China (NSFC)	6,576	10.329
2	National Science Foundation (NSF), USA	2,534	3.980
3	European Commission	1,657	2.603
4	Natural Sciences and Engineering Research Council of Canada (NSERC)	1,225	1.924
5	Chinese Academy of Sciences	895	1.406
6	Conselho Nacional De Desenvolvimento Cientifico E Tecnologico	889	1.396
7	National Basic Research Program of China	832	1.307
8	Uk Research Innovation (UKRI)	742	1.165
9	United States Department of Agriculture (USDA)	685	1.076
10	Fundamental Research Funds for the Central Universities	638	1.002

institutions *i.e.*, National Natural Science Foundation of China (NSFC); Chinese Academy of Sciences and National Basic Research Program of China alone contributed funding for 8, 303 publications (13%). National Science foundation (NSF), USA and European Commission holds second and third positions among the top 10 funding agencies with 3.9 and 2.6% contribution, respectively.

Major research areas and keywords

Environmental sciences is the major research domain on the wetland research with 27,012 papers, followed by Ecology with 13,525 publications and Water resources with 9,285 publications (Fig. 6). Fisheries was found to have 892 research publications on wetland. Based on the keyword analysis using R studio,

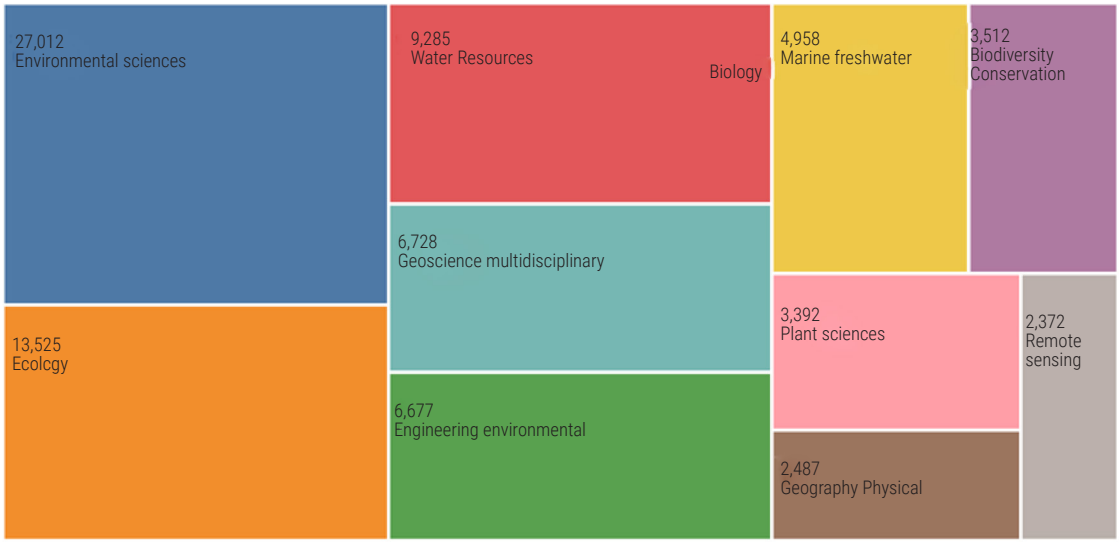

Fig. 19. Top major areas on wetland research worldwide during 1991-2021

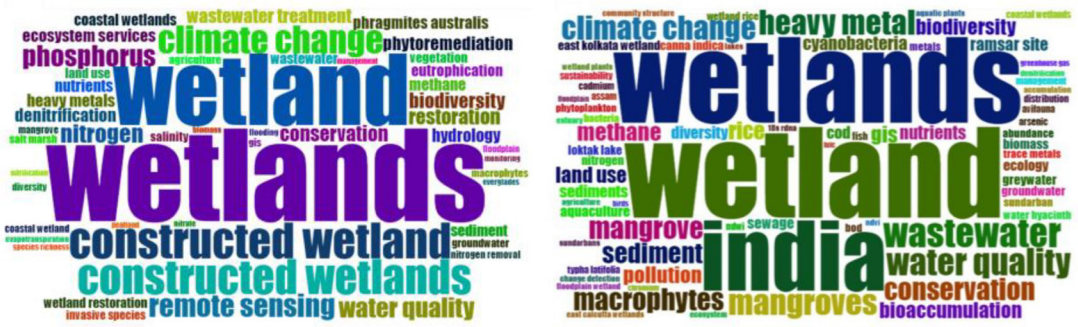

Fig. 20. Major keywords used in the publications on wetland research worldwide *vis-a-vis* India

majorly used keywords on wetland research were analysed (Fig. 19). Keywords such as Wetland, Wetlands, Constructed Wetland, Climate change and Remote sensing are used frequently on global wetland research. In case of India, Wetland, Wetlands, India, Macrophytes, Climate change, Heavy metal, Water quality, Waste water and Mangroves were found to be the most common keywords (Fig. 20).

Keyword interaction analysis was carried out for Indian wetland research to clearly understand the clusters of major topics focused during the selected time period. Four major clusters indicating various aspects of wetland research was observed (Fig. 21). Red cluster emphasises research studies on wetland associated biodiversity and their dynamics along with their threat and vulnerability during climate change. Yellow colour highlights the nutrient removal and constructed wetland concept and their management. Green colour indicates the significant research investigations carried out on biogeochemical cycles in wetlands; emission and sequestration. Blue colour depicts studies on pollution, contamination in wetlands with minor works on phylogeny and molecular identification. Violet colour displays the topics such as accumulation, toxicity and phytoremediation.

Discussion

This study was the first of its type to attempt a global examination of wetland research, with an emphasis on India. The significance of a study, author, or research organisation can be gauged by looking at how far their particular field of study has progressed. In this investigation, we analysed the published scientific literature on Wetland studies between 1988 and 2021 using the WoS database. Ontology studies, Sandalwood, Parkinson's disease, WSSV, *Aeromonas,* Fisheries and Journals are few of the areas that have seen comparable scientometric analyses by several authors. (Arkhipov *et al.*, 1999; Dastidar *et al.*, 2013; Kumaresan, *et al.*, 2014a, b; Singh *et al.*, 2019; Zhong *et al.*, 2019; George *et al.*, 2020; Liu *et al.*, 2020; Bhoomaiah *et al.*, 2020; Rathinam *et al*., 2021).

The current study's finding that the USA and China produced more publications than any other nations is consistent with the rankings of both countries as the world leaders in natural science research (Nature Index, 2020). Total citations, h-index and average citations per paper were utilised to evaluate the value of individual articles within a certain scientific field. Publications' quality, usefulness, and significance are measured by their citation counts (Hirch, 2007).

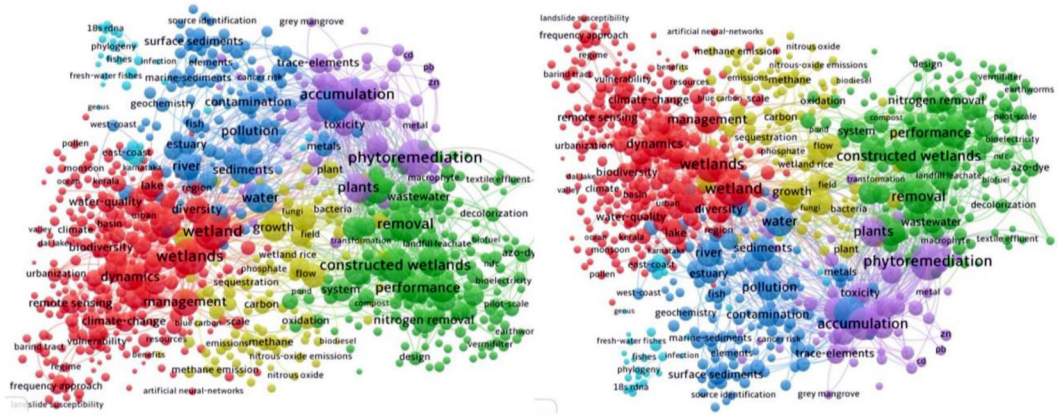

Fig. 21. Network visualisation of keyword interaction on wetland research in India using VoS viewer

However, when compared to the top-performing nations in this area of study, Germany ranked only sixth in terms of the impact per document of its published works on wetlands. The research also shows that India has made important contribution to the study of wetlands. Most research was related to wetland fisheries rather than investigating the biology alone, despite the country's ranking as the tenth-best in the world for wetland research. Additionally, the network of collaborators showed that over 30 countries work closely with India on wetland studies, but major powers like the USA, China and Canada were not found to be working with India. This may account for its prominence in studies of wetlands all over the world.

The availability of financial support is a major factor on the size, diversity and output of a given scientific community, making it an essential consideration in scientific research (Jacob and Lefgren, 2011). According to Aksnes *et al.* (2019), funded research publications were better in terms of citation and journal ranking than unsponsored research investigations. The current analysis found that China's research output on wetland research was the highest in the world since it received the most funding from the National Natural Science Foundation of China. A significant barrier to understanding the full financing status is that many articles gave proper acknowledgment to the externally supporting institution but omit the identification of internal research sponsors (Bhoomaiah *et al.,* 2020). Nearly half of the 66,000 papers in the present study did not disclose their funding sources and a similar pattern was seen in the previous analyses. (Rathinam *et al.,* 2021; Anantharaja *et al.,* 2023; Nayak and Iburahim, 2023).

As a method for tracking the progression of knowledge, the analysis of metadata including keywords, titles and abstracts from published research paprers proves highly advantageous (Li *et al.,* 2018). According to the results, the most effective way to increase the visibility of a publication about wetlands is to have it published in one of the top 10 journals in the field, all of which have impact factors ranging from 1.63 to 7.96. (JCR, 2021). It is worth noting that the actual number of wetlands-related articles is likely higher than what was calculated in this study. This is because many regional, national, and worldwide journals are not indexed in the most comprehensive online resources such as Elsevier Scopus. However, this is merely a general limitation, as no single scientific database can possibly be all-inclusive; rather, each database has its own distinct advantages and disadvantages (Falagas *et al*., 2008).

There has been a worldwide increase in the value placed on wetlands since the Ramsar Treaty was first introduced in 1971. India entered into the Ramsar Treaty on 01 February 1982. There are currently 75 sites in India that have been designated as Wetlands of International Importance, covering an area of 1,250,361 ha (Ramsar Sites). Over the past three decades, there has been an increase in protected wetland areas, which in turn has attracted more funds and studies. This study used scientometric techniques to examine the Wetland research published between 1988 and 2021. To obtain a feel for the breadth and depth of this field's research activity, the authors combed through data from 6,3671 scholarly articles. Separating and analysing the research literature published between 1988 and 2021 has revealed shifts in authorship and affiliation patterns. It mapped out the primary fields of study, nationalities of researchers, and names of writers who are leading the way in the field of Wetland studies. This research demonstrated that inter- and intra-national collaboration is weaker than previously thought. Quantitatively, the USA was judged to be the primary contributor; qualitatively, however, other countries, particularly Germany and England, were deemed to be more important. Research funding was found to be a significant factor affecting research output in this area. There is also a clustering of research topics that can be seen through a keyword analysis performed with the VoS viewer. As a result, new avenues for investigation into the wetland realm are illuminated.

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