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Mapping Global Performance on Open Access GIS Research: A Scientometrics Study

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Abstract

GIS has emerged in last few decades as an essential tool for mapping of geo-reference data and it can be used by researchers having different disciplines for various aspects. It represents an integration of different subject domains. The purpose of this paper is to examine the research trend in open access GIS research. This paper aims to analyze global output on open access GIS research as index in WoS database during the period 2009 to 2018, in respect of growth rate, year-wise publications and citations, major productive countries in addition to international collaborations, most productive authors and their citation impact, preferred journals, top institutions, author's keywords, mode of scholarly communications etc. A total 8,917 papers contributed by 32,071 authors from 167 different countries in 12 modes of communications and received 116,571 citations, average 13.07 citations per paper during the study period. USA registered the most productive country with 21.51% world publications share and 11.42% international collaborations. The average growth rate was 13.95% and highest growth rate (31.86%) of publications was registered in 2016. The researcher from Chinese Academy of Science published maximum number (311) of articles and the author B. Pradhan have made published (70) highest publications. This study indicates the growth of open access GIS research across the world irrespective of citation count, collaboration rate etc.

Keywords: GIS; Geographical Information System; Mapping research; co-citation network; co-authors network; VOSviewer.

Introduction

The term Geographic Information Systems or GIS began in the 1960s, as a computer based application of geospatial data, developed by Canada Geographic Information System (CGIS) in collaboration with IBM team, within the multiple projects that headed by Roger Tomlinson (Goodchild, 2018). GIS is a special class of information system which provides a set of powerful tools for collecting, organizing, storing, transforming and displaying geospatial data within a specific geographical reference framework from the real world. The definition was given by Dueker (1979) as “a special class of information system where the database consists of observations on spatially distributed features, activities, or events, which are definable in space as points, lines, or areas”. At the stage of its origin, the system was mainly used by public sector. After versatile research and development in 1970s and 1980s, GIS has rapidly grown as a discipline across the world. Nowadays, GIS has a most important and versatile tool for researchers having different subject domains (Anselin, 1995).

Literature Review

A significant number of researches have been published in different timespan to analyzed global output across disciplines.

Kumar and Khormi (2012) examined hotspots and research productivity on remote sensing & GIS research in Australia. They used 10 peer-reviewed journal publications from 1991 to 2010 and identified different clusters of research hotspot, institutional collaborations, authorship pattern in GIS research. The clustering of those research hotspot activities was significantly changed over time. In the early 1990s, few clusters which were found very productive and others were rapidly increased over time. Pandey and Thaker (2016) carried out a study on GIS research publication that contributed by Indian researchers during 25 (1991-2014) years study period and noticed that 9750 % growth of GIS research in the past two decades. Tian et al. (2008) conducted a bibliometric analysis of global research production on GIS research published during 1997 to 2006 and indexed by Science Citation Index. This study found that the trend of GIS research has increased rapidly over the past decades across the globe and the most productive countries were USA, UK, Canada and China respectively. Sweileh (2018) conducted a study on diabetes depression and suicide with 1664 journal documents and despite that 26.9 citations received per articles. Global publications start from 1949 but the notable increasing trend was shown after 2001. Most productive countries were USA, UK, Germany and the Netherlands respectively during the study period. The author has used VOSviewer software package for visualizing most productive authors and co-authors network and also identified positively moderately correlation between Gross Domestic Product (GDP) and research outputs. The other study has been carried out by Alhaider et al. (2014) on date palm that indexed in SCOPUS database published from 2000 to 2011. This study included 1,376 papers during the timespan and analyzed in respect of top productive countries and their research impact, most preferred journals, productive authors, journals, institutions and collaboration rates.

In another study, Verma and Shukla (2019) analyzed 9,496 papers on Information Literacy during 10 years (2008-2017) study period. The authors also identified characteristics of highly contributing authors, countries, growth rate. The highest number of papers and citations was recorded in the year 2016 and 2010 respectively and overall citations per article were 10.33. Batcha (2018) examine 2,606 papers published by Indian scientists on oral cancer during 2010 to 2017 and found that, in terms of research output on oral cancer, India ranked 4th position all over the globe. He also noticed that 50% of Indian publications were the result of collaborative research with 114 countries. Gupta et al. (2018) reviewed 4,402 papers on robotics research in India during 2007-2016 and revealed that, the growth rate of publications was registered 24.84%, international collaborations was 9.63%, and average CPP was 4.13 during the period.

Objectives

The primary objectives of this study are to identify open access global research performance on GIS research with regards to publication pattern, citation pattern, growth rate, top authors, top journal etc. In order to achieve the primary objectives, the specific objectives are listed below...

- To examine global research performance on GIS research,
- To enumerate the growth rate of publications,
- To determine year-wise output and citation on GIS research,
- To identify top global researchers in this research field,
- To explore the ranking of top journals in which most of the researchers preferred to publish their works.

Methodology

To obtain the set of specific objectives, the data for this work has been collected from the WoS database for the publications on GIS research during the timespan 2009 to 2018. The main search string has been used to retrieve data on GIS research was as below:

TS=("GIS" or "Geographical Information System" or "Geographical Information Science" or "GIScience" or "Geospatial Science" or "Geospatial information" or "Geospatial data" or "Geospatial analysis" or "Spatial data" or "location data" or "digital cartography").

The study has been covered only open access publications for ten years study period (2009-2018). Impact factor of journals obtained from Journal Citation Report (2018) for measuring scholarly impact of publishing journals. Data analysis has been carried out using Bibexcel statistical software. For keyword, co-authorship map and co-citation network mapping, VOSviewer visualization software was applied.

Data analysis and Discussion

This research work has been carried out in two manners i) analysis of global research output, ii) mapping global research on GIS.

Year-wise distribution of outputs

Global research output on GIS research was recorded and retrieved as a cumulative total of 8,917 during ten years study period 2009 to 2018. From table-1, total publication on GIS research varies from 431 in the year 2009 to 1510 in the year 2018. Total 116571 citations received by the researchers during the period under study and citation expanded from 2548 in the year 2018 to 15727 in the year 2010.

Year	TP	TC	CPP
2009	431	14821	34.39
2010	512	15727	30.72
2011	510	12731	24.96
2012	652	14909	22.87
2013	757	14111	18.64
2014	958	14659	15.30
2015	951	10555	11.10
2016	1254	9297	7.41
2017	1382	7213	5.22
2018	1510	2548	1.69
2009-2018	8917	116571	13.07

The overall citation per paper (CPP) was recorded 13.07 and it varies from 1.69 in the 2018 to 34.39 in the year 2009.

Growth Rate

Growth rate indicates the changes of unit over specific period of time in the base value where it is measured. Here, Annual growth rate of publications calculated by using formula,

$$AGR = \frac{\text{End Value} - \text{First Value}}{\text{End Value}} \times 100$$

Table- 2 indicates annual growth rate of publications over period. The AGR value increased from -0.73 in 2015 to 31.86 in 2016. The AGR of whole study period was recorded 13.95%.

Most Productive Countries

This study identified 8,917 publications during ten years study period, which contributed by 135 countries. Table- 3 reveals the top twenty most productive countries in open access GIS research. During the period under study, USA ranked first among top 20 most productive countries with 1,918 publications and 11.42% international collaboration share, this is followed by Peoples R China with 946 publications (10.89% global publications share), UK with 604 publications (14.90% global publications share), Italy with 396 publications (12.37% global publications share) and then Brazil with 353 publications (12.46% global share) and so forth. Mexico registered the highest research impact 21.05 CPP, followed by India (18.36), Japan (17.10), Brazil (16.61), Sweden (16.12) and et al.

Year	Total Publication	Avg. GR
2009	431	0
2010	512	18.79
2011	510	-0.39
2012	652	27.84
2013	757	16.1
2014	958	26.55
2015	951	-0.73
2016	1254	31.86
2017	1382	10.21
2018	1510	9.26

Top Authors

A total number of 32,071 unique authors contributed 8,917 publications to global GIS research, in which 31,766 authors were published 1-5 article each, 251 authors were published 6-10 articles each, 43 authors were published 11-20 articles each, 8 authors were published 21-32 articles each, and only 1 author contributed 70 papers. Top 15 most productive authors (table-4) contributed 17-70 publications, cumulated 384 papers and 10838 citations. The author Pradhan B registered highest rank with 70 publications and 2636 citations, followed by Wang Y with 32 publications and 252 citations, Zhang Y with 29 publications and 320 citations and so forth. The author Blaschke T registered maximum research impact 132 CPP, followed by Sallis JF (61.37), Tatem AJ (43.64), Bui DT (40.82), Pradhan B (37.66) and so on. The author Pradhan B contributed highest number of publications in GIS research. Thus, it can be said that he was a senior researcher in this research filed.

Countries	Total Publications	Total Citations	CPP	ICP	%ICP
USA	1918	30515	15.91	219	11.42
Peoples R China	946	10144	10.72	103	10.89
UK	604	7907	13.09	83	13.74
Italy	396	4101	10.36	49	12.37

Brazil	353	5863	16.61	44	12.46
Spain	345	3432	9.95	36	10.43
Canada	327	4869	14.89	19	5.81
Germany	275	3604	13.11	38	13.82
Australia	240	3417	14.24	21	8.75
India	211	3875	18.36	23	10.90
South Korea	173	1430	8.27	13	7.51
Japan	172	2942	17.10	18	10.47
France	163	2489	15.27	20	12.27
Iran	163	1359	8.34	15	9.20
Netherlands	160	1609	10.06	11	6.88
Turkey	151	1181	7.82	16	10.60
Poland	120	1064	8.87	15	12.50
Sweden	112	1805	16.12	10	8.93
Mexico	107	2252	21.05	9	8.41
Switzerland	101	1163	11.51	12	11.88

Table- 4: Most productive authors in GIS research, 2008-18

Authors	Affiliations	TP	TC	CPP	Rank
Pradhan B	Dresden Univ of Tech	70	2636	37.66	1
Wang Y	Chinese Academy of Sci	32	252	7.88	2
Zhang Y	Canada Centre for Remote Sensing	29	320	11.03	3
Lee S	Korea Institute of Geoscience and Mineral Resources	27	231	8.56	4
Liu Y	Wuhan Univ	27	862	31.93	5
Li X	Beijing Normal Univ	23	183	7.96	6
Chen W	Chinese Academy of Sci	22	245	11.14	7
Tatem AJ	Univ of Florida	22	960	43.64	8
Blaschke T	Univ of Salzburg	21	2772	132.00	9
Li Y	George Mason Univ	20	177	8.85	10
Sallis JF	San Diego State Univ	19	1166	61.37	11
Wang J	Chinese Academy of Sci	19	39	2.05	12
Li L	Wuhan Univ	18	87	4.83	13
Wang L	Chinese Academy of Sci	18	214	11.89	14
Bui DT	Norwegian Univ of Life Sci	17	694	40.82	15

Most Preferred Journals

The Global OA research output on GIS was published in 1,682 international and national journals. The top 20 journals with the highest number of research output published on GIS are projected in Table 5. The top 20 most preferred journals published 45 to 458 papers, it cumulated to 3,008 (33.73% publication share of global output) papers were published during the period. In this study period, many authors preferred journal was *ISPRS International Journal of Geo-information* (458 publications and IF2018=1.84) for publishing their research report. Other journals include *PLOS ONE* with 397 publications (IF2018=2.78), *Sustainability* with 338 publications (IF2018=2.60), *Remote Sensing* with 215 outputs (IF2018=4.12) and others. As per JCR 2018, the most impactful journal was *Hydrology and Earth System Sciences* (IF2018=4.94), where the global authors published 57 papers, followed by *Scientific Reports* (52

publications) with the IF=4.52, *Remote Sensing* (215 publications) with the IF=4.12, *Sensors* (109 publications) with the IF=3.03 and others. As far as citation per paper (CPP) is concerned, the topmost impactful journal was *International Journal of Health Geographics* with 20.25 CPP, other includes *Natural Hazards and Earth System Sciences* with 19.27 CPP, *Hydrology and Earth System Sciences* with 18.25 CPP, *Remote Sensing* with 16.73 CPP.

Table- 5: Top journals preferred by GIS researchers

Journal Title	Country	TP	TC	CPP	IF2018
ISPRS International Journal of Geo-information	Switzerland	458	2179	4.76	1.84
PLOS ONE	California, US	397	5858	14.8	2.78
Sustainability	Switzerland	338	1356	4.01	2.6
Remote Sensing	Switzerland	215	3596	16.7	4.12
International Journal of Environmental Research and Public Health	Switzerland	204	1873	9.18	2.47
Natural Hazards and Earth System Sciences	Germany	184	3545	19.3	2.88
International Journal of Health Geographics	United Kingdom	153	3099	20.3	2.87
Geospatial Health	Italy	139	1166	8.39	1.42
Water	Switzerland	125	677	5.42	2.52
Journal of Maps	United Kingdom	121	630	5.21	1.6
Sensors	Switzerland	109	1211	11.1	3.03
Geomatics Natural Hazards & Risk	United Kingdom	103	786	7.63	2.33
BMC Public Health	United Kingdom	76	1209	15.9	2.58
Current Science	India	75	275	3.67	0.77
Energies	Switzerland	59	364	6.17	2.71
Hydrology and Earth System Sciences	Germany	57	1040	18.3	4.94
Scientific Reports	United Kingdom	52	529	10.2	4.52
Malaria Journal	United Kingdom	50	799	16	2.8
Applied Ecology and Environmental Research	Hungary	48	84	1.75	0.72
Forests	Switzerland	45	329	7.31	2.17

TP= Total Papers; TC= Total Citations; CPP= Citation per paper; IF= Impact Factor

Top institutions in GIS research

A total frequency of 8,120 institutions participated in GIS research during 2009 to 2018 study period and it was found that only two institutions published more than a hundred publications on GIS. Table- 6 highlighted top 20 most productive institutions and their research impact. Out of 8,120 institutions, 7709 institutions were published 1-10 publications each, 252 institutions were published 11-20 publications each, 80 institutions were published 21-30 publications each, 58 institutions were published 31-50 publications each, 20 institutions were published 51-140 publications each and only 1 institution was published 311 publications. Top publishing institutions have made 53-311 publications and their cumulated contributions were 1650 (18.50% of global share) and cumulated 36,306 citations received during the ten year study period.

Chin. Academy of Sci. was the topmost publishing (311 publications; 18.85%) institute during 2009-2018, followed by *Wuhan Univ.* with 140 (8.48%) publications, *Univ. of Chin. Academy of Sci.* with 89 (5.39%) publications, *Harv. Univ.* with 85 (5.15%) publications, *Univ. of Califo.* with 82 (4.97%) publications and others.

Institutions	TP	% of TP	TC	CPP
Chinese Academy of Sciences	311	18.85	3515	11.30
Wuhan University	140	8.48	680	4.86
University of Chinese Academy of Sciences	89	5.39	561	6.30
Harvard University	85	5.15	3662	43.08
University of California, Berkeley	82	4.97	1767	21.55
U.S. Geological Survey	79	4.79	1257	15.91
University Putra Malaysia	75	4.55	2890	38.53
University of North Carolina	74	4.48	2193	29.64
University of Washington	72	4.36	2322	32.25
University Florida	71	4.30	1338	18.85
Pennsylvania State University	65	3.94	782	12.03
University College London (UCL)	61	3.70	2082	34.13
University of British Columbia	60	3.64	2119	35.32
University of Cambridge	60	3.64	1069	17.82

Author's Keywords

Table- 7 and Figure-1 reveal most preferred keyword that used by researchers in their research papers. Among the top 15 keywords, GIS occurred in 1,729 (48.31%) records, remote sensing occurred in 410 (11.46%) records, spatial analysis occurred in 188 (5.25%) records, geographic information system occurred in 180 (5.03%) records. Here the authors have shown visualization of research hotspots with frequently occurring keywords during the period under study using VOSviewer software.

Document types

Table- 8 depicts the document wise distribution of papers on GIS research during the timespan (2009-18) and it is found that most of the papers were article (8405; 94.26%), followed by review (245; 2.75%), proceedings paper (115; 1.29%) and others. As far as CPP is concerned, highest CPP registered by review article (44.25 CPP), followed by book review (30.00 CPP), proceedings paper (14.66 CPP) and so on.

Co-authorship network

GIS research is highly interdisciplinary research in nature. Therefore, researchers from different disciplines like geography, environmental science, regional planning, waste management, information technology, computer science, physics, infrastructure and transportation planning, land utilization, weather forecasting etc. where cooperation between researchers makes advantage for conducting research and archiving research goals. Co-authorship analysis provide a window for measuring collaboration pattern between researchers within the research community (Galyani-Moghaddam, 2019). Collaboration may occurs at department level, national level, institutional or organizational level. Therefore, analyzing co-authorship network of researchers can provide valuable information for organization to develop cooperation groups,

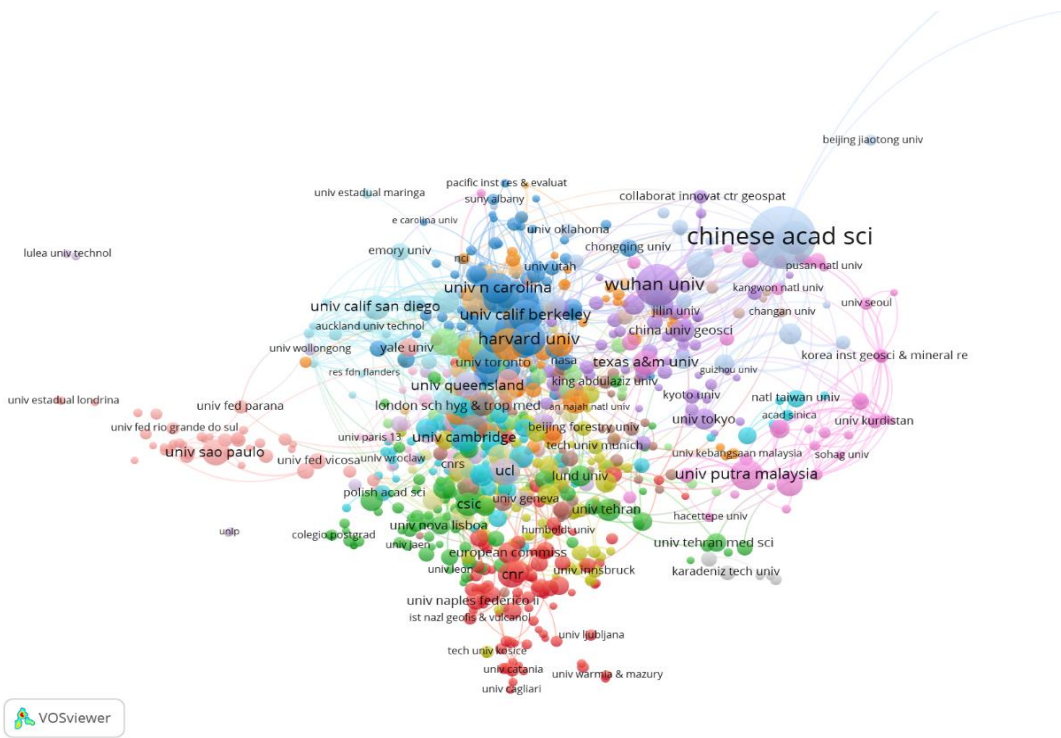


Figure- 3: Co-authorship network among major institutions

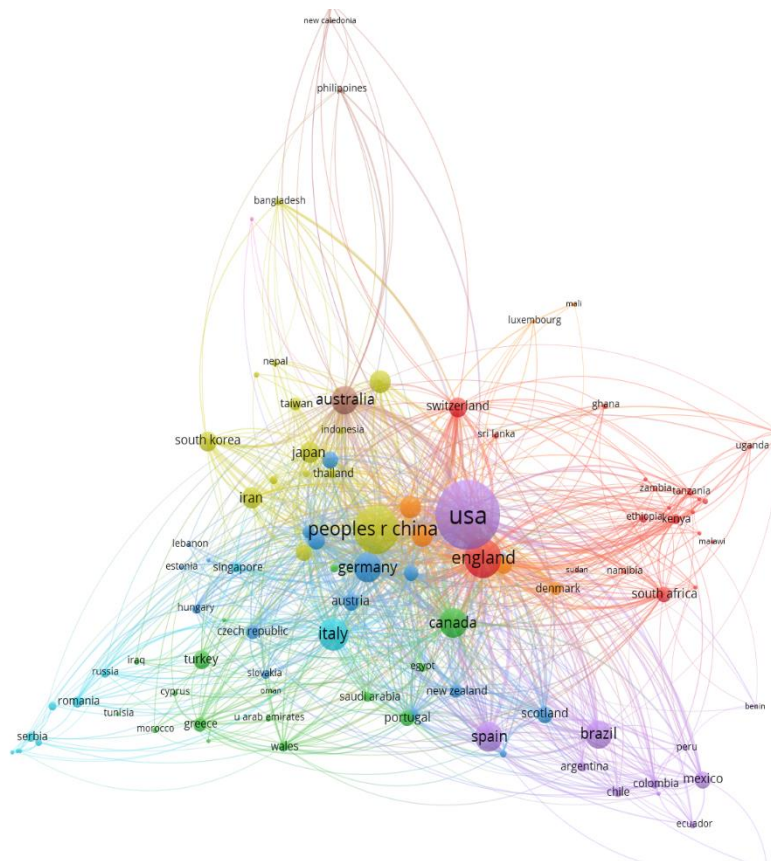


Figure- 4: Co-authorship network among productive countries

Table- 7: Author's keywords in GIS research		
Keywords	Frequency	%
GIS	1729	48.31
Remote sensing	410	11.46
Spatial analysis	188	5.25
Geographic information systems	180	5.03
Geographical information system	154	4.30
Geographic information system	127	3.55
Climate change	124	3.46
Geographic Information System (GIS)	116	3.24
Geographic Information Systems (GIS)	102	2.85
Land use	84	2.35
Epidemiology	81	2.26
Mapping	78	2.18
Spatial data	70	1.96
Physical activity	69	1.93
Built environment	67	1.87

Co-citation network

Co-citation study is an attempt to navigate primary focus area of academic research in a citation network by clustering co-cited documents (Braam et al., 1991). The structure of co-citation cluster has been constructed from the list of references given by the authors in their research publications (Zou et al., 2018). Figure-7 reveals top co-citation network during the period under study.

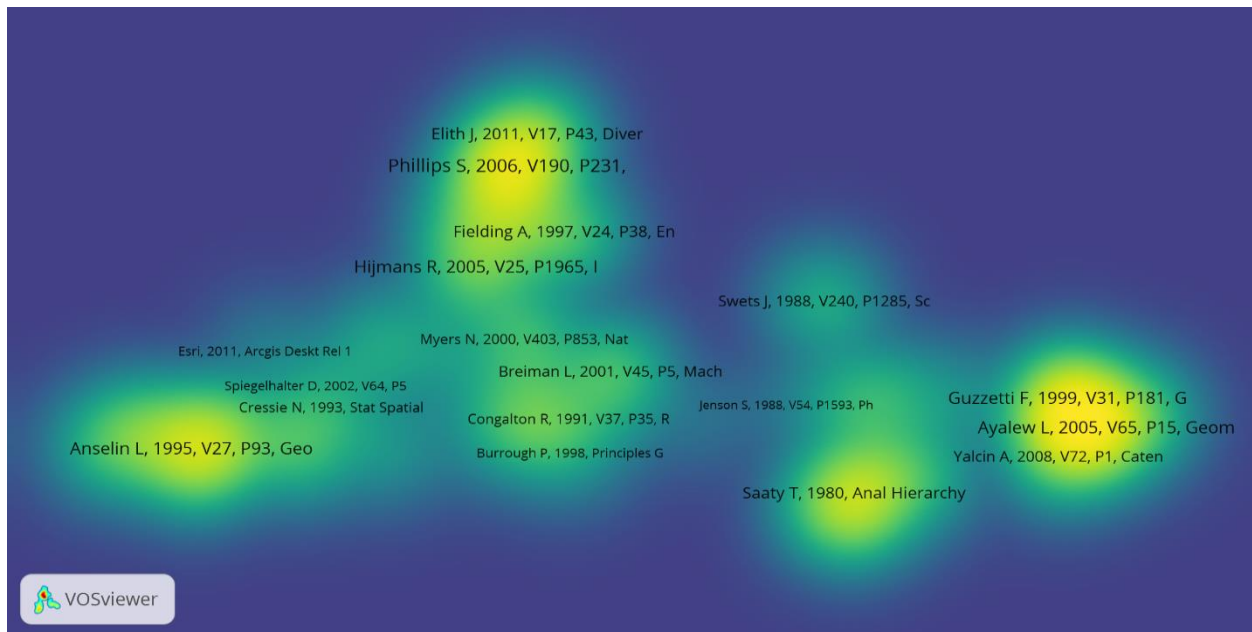


Figure- 5: Density visualization of co-citation map based on cited references

Table- 8: Type of documents in GIS research			
Document type	TP	TC	CPP
Article	8405	103097	12.27
Review	245	10841	44.25
Proceedings Paper	115	1686	14.66
Editorial Material	71	576	8.11
Data Paper Article	24	269	11.21
Correction	18	9	0.50
Meeting Abstract	15	3	0.20
Letter	8	14	1.75
Book Review	7	1	0.14
News Item	3	5	1.67
Book Chapter	2	6	3.00
Book Chapter Review	2	60	30.00
Retracted Publication Article	2	4	2.00

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Conclusion

GIS have emerged in last few decades as an essential tool for mapping of geo-reference data and it can be used by researchers having different disciplines for various aspects. GIS represents the integration approach of different subject domains. The function of GIS includes data storing, displaying, data analysis, management and retrieval. The present study demonstrate increasing trend towards open access GIS research among researchers. The average annual growth rate was 13.95% and highest growth rate has been registered in the year 2016. The highest paper published from USA, then Peoples R China, UK, Italy, Brazil and others during the marked study period. The maximum citations varies from 2548 in the year 2018 to 15,727 in the year 2010 and highest citations received by 'Book Chapter Review' Most productive author was Pradhan, B from Dresden Univ of Tech with 70 publications and Chines Academy of Sci has made highest contributions.

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