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Scientific Research output on Satellite Communications during the period 2011-2020: A Scientometric Analysis

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ABSTRACT

The growth of research publications published in the field of satellite Communication literature during the study period 2011-2020. Altogether 12168 publications were published. A maximum of 1156 (12.79%) was published in the year 2018. Followed by 1461(12.01%) were published in the year 2016. While less number of research publications 856(7.03%) were published in the year 2013. There is a study growth found in research output from one year to proceed next year. Further, is found that the ratio of growth in an increase in the number of publications per year is 0.86%, and the compound annual growth ratio is 0.64. A maximum RGR of 0.59 has been recorded in the year 2012 and the minimum RGR of 0.10 has been counted in the year 2020, while the maximum doubling time of 7.00 has been counted in the year 2020 and the minimum doubling time of 1.17 has been counted in the year 2012. In the study, a maximum of 100(17.61%) research publications are contributed by Panagopoulos, A.D. in China. A maximum of 6840(56.28%) research publications are contributed by Conference papers. The highest percentage of 2797(22.99% is recorded by three authors, the mean of the degree of collaboration during the study period shows 0.86. The mean CI is 3.76, and the mean CC is 0.642. The mean MCC is 3.76. A maximum of 3373(32.90%) research publications are contributed by China. And a maximum of 250(15.99%) research publications are contributed by proceedings of the international astronautically congress iac. A maximum of 227(12.80%) research publications are contributed by the Chinese Academy of Sciences. Time-series analysis research publications in the year 2025 are around are equal to 1717 and in the year 2030 is around are equal to 1967. So that time serious analysis confirmed is increasing trend. The highly cited paper with 3123 Calheiros, R.N. et al(2011) CloudSim: A toolkit for modeling and simulation of cloud computing environments and evaluation of resource provisioning algorithms, Software - Practice and Experience,41(1), 23-50.

KEYWORDS: Scientometrics, Collaborative Index, Degree of Collaboration, Co-authorship Index, Collaborative Coefficient, Modified Collaborative Coefficient.

INTRODUCTION

The origin of satellite communication: The idea of satellite communications was conceived by Arthur C. Clarke a famous British science fiction writer in 1945. He had already pointed out that a satellite in a circular equatorial orbit with a radius of about 42,242 km wound has an angular velocity that matched the earth. So it would always remain above the same spot on the ground and it could receive the relay signals from most of the hemisphere. Three satellites spaced 120 degrees apart could cover the whole world with someone over provided, the message could be relayed between the satellites and thus reliable communications between any two points in the world was possible. He had also stated that the electrical power for the satellite would be obtained by the conversion of the son's radiation by means of solar cells; Even the rocket technology was available to put a satellite into a low orbit; synchronous orbit was not achieved until 1963.

History of satellite communication: In 1945 an RAF electronics offer and member of the British Interplanetary Society, Arthur C, Clarke, wrote a short article on the wireless world that described the use of satellites in 24 hours orbits high above the world's landmasses to distribute television programs. His article apparently had little lasting effects in spite of Clarkes repeating the story in his 1951 exploration of space. Perhaps the first person to carefully evaluate the financial prospects was John R. Pierce of AT & Ts bell telephone laboratories Who in a 1954 speech and 1955 article, elaborated on the utility of a communications "mirror" in space, a medium orbit "repeated". In comparing the communications capacity of a satellite, which he estimated at 1,000 simultaneous telephone calls, and the communications capacity of the first trans-Atlantic telephone cable (TAT-1), which could carry, 36 simultaneous telephone calls at a cost of 30-50 million dollars, Price wondered if a satellite would be worth a billion dollars. After the 1957 launch of Sputnik 1, many considered the benefits, profiles, and prestige, associated with satellite communications. Because of congressional fear of "duplication". NASA confined itself to experiments with "mirror" or "passive" communications satellites (ECHO), while the department of defense was responsible for "repeater" or "active" satellites amplifying the received signals at the satellite-providing much higher quality communications.

By1964, two TELESTARS, two RELAYS, and two synonyms had operated successfully in space. This timing was fortunate because the communications satellite corporation (COMSAT) formed as a result of the communications satellite Act of 1962, was in process of contracting its first satellite. For a variety of reasons, including costs, COMSAT ultimately chose to reject the joints AT&T/RCA offer of a medium–orbit satellite incorporating the best of TELESTAR and RELAY. They chose the 24-hour orbit (geosynchronous) satellite offered by Hughes Aircraft Company for their first two systems and a TRW geosynchronous satellite for their third system. On April 6, 1965, COMSAT's first satellite, EARLY BIRD, was launched from Cape Canaveral Global satellite communication had begun.[1]

BIBLIOMETRIC STUDY

The application of mathematical and statistical methods to books and other media processes of written communication and the nature and course of a discipline is known as bibliometric. In continental Europe, the team popular is Scientometric it considers publication cannot and citation count as two bibliometric parameters which are used in scientometric research. Today bibliometrics has emerged as a subject in its own right with various facts. The other developed area of bibliometrics is informetric, Info metrics is that branch of knowledge that employs

mathematical and statistical techniques to quantity documents or their components and concepts: measure their growth, propagation, use, and obsolescence, establish knowledge governing these factors.[2]

Scientometrics is concerned with measuring the degree to which knowledge progresses. It was first defined by **Nalimov and Mulcjenko (1971)**[3] as "the quantitative method of research on the development of science as an informational process". According to **Tague-Sutcliffe (1992)**[4] scientometrics is "the study of the quantitative aspects of science as a discipline or economic activity. It is part of the sociology of science and has application to science policy-making. It involves quantitative studies of scientific activities, including, among others, publication, and so overlaps bibliometric to some extent". **Hess (1997)**[5] defined scientometrics as the "quantitative study of science, communication in science and science policy". Some of the main themes of scientometrics are the measurement of impact, citation analysis, mapping science, and, the use of scientific indicators for policy and management context

REVIEW OF LITERATURE

Ravichandran and Vivekanandhan (2021)[6] examine the Scientometric analysis of wastewater management research publications from 2010 to 2019 from the Scopus database. The study identified that a maximum of 2842(14.31%) research publications with 19857 citations are contributed in the year 2019. Ngo, H.H contributed a maximum of 101(0.51%) research publications, maximum of 19355 articles were contributed by joint authors and the average degree of collaboration was 0.97. A maximum of 2102(10.58%) research publications are contributed in Bioresource technology, ministry of education, china with 863(22.32%) research publications and China has contributed the maximum of 5919(29.80%) research publications

Kavitha R et.al (2018)[7] analyzed the research output on Solar cell research publications from the Scopus database from 1978 to 2017 with 150201 publications. Out of that, 4430 (2.95%) publications were open-source publications, and 145771 (97.5%) publications were from other sources. The study identified that 55% of articles appeared last six years during the study period. A maximum of 15113 (10.06%) publications are published in the year 2017. 14 countries contributed more than 2750 publications and 96377(64.17%) papers were published by Journal.

Kumar (2014)[8] analyzes scientometric study on digital literacy research publications from library information science and technology abstracts (LISTA) during 1997-2011 with 137 articles. Out of that 53.28% of articles focus significantly on digital literacy. Academic journals and periodicals are published 69.34% of articles in the field of digital literacy. The triple authorship pattern was 35.04% publications and 35-40 age group authors are published a high number of 39.42% articles. U.K. (27.01%) and U.S.A. (24.82%) were published more numbers of articles. International journal of information and library review published a maximum of 8.03% of articles.

Ravichandran and Vivekanandhan (2021)[9] analyzed the wireless sensor network research output in India from 2010 to 2019 from the Scopus database with 11775. This study identified that a maximum number of 2058(17.48%) publications are contributed in the year 2019 and the compound annual growth rate was 5.44. This study identified that the relative growth rate was decreasing trend and doubling time was increasing trend. The average degree of collaboration was 0.96 and CAI was decreasing trend for more than three authors from 1st block year (106.71) to 2nd block year (97.39).

Vivekanandhan et.al (2016)[10] analyzed the pollution control research output from the Scopus database during the period 1985 to 2014. They analyzed his study growth of literature the number of citations, and bibliographic distribution. Further, they analyzed scientometric tools such as authorship pattern, Citation Index, Collaborative Coefficient, modified collaborative coefficient, and block year-wise publications. Maximum numbers of 13692 (25.43%) publications are contributed in the 6thblock of 2010 – 2014 and block year wise average degree of collaboration was 0.72.

Sudhakar and Thanuskodi (2018)[11] analyzed the scientometric analysis of Marine Pollution Bulletin Journal research publications from 2008 to 2017 with 5416 publications. Maximum numbers of 905(16.71%) publications are contributed in the year 2017. This study identified that RGR has been decreased from 0.63 to 0.18 and at the same time doubling time has been increased from 1.10 to 3.85. The degree of collaboration was 0.94, which clearly indicates the dominance of multiple authors' contributions. Liu J. was the top-ranked author with 49 articles. Maximum numbers of 910 (12.06%) publications are contributed by the United States.

Dhanya and Raja (2017)[12] analyzed the Indian research output of industrial pollution indexed in the Web of Science database with 805 publications during 2007-2016 which received 9699citations. Kumar A and Kumar R are the most productive authors with 13 (1.6%) publications. The most productive journal is Environmental Monitoring and Assessment with 103 (12.8%) publications and the maximum of articles are published in the year 2016 with 113(14%) publications. The relative Growth Rate is 0.16 in the year 2016 and the Doubling Time is 4.58 in the year 2016.

OBJECTIVES

- To analyze the year–wise growth of the ratio in the research output from publications literature
- To study the Relative Growth Rate (RGR) of publications and doubling time
- To study the top ten authors, document type
- To analyze the authorship pattern, and degree of collaboration
- To analyze the research trend with Collaborative index CC, CI MCC in the global literature
- To Analysis of Co-author index, the top ten countries of Publication at the Global Level
- To study the top ten journals, and top ten institutions
- To Analysis the time series analysis and Highly cited paper

METHODOLOGY

The study was data downloaded from the Scopus database for ten years of study periods, 2011 to 2020. The data was collected on 12-04-2021. The searches were performed on the name of Satellite Communication using the basic search at the Scopus database Collection with all probabilities. Your query: (TITLE-ABS-KEY ("Satellite Communications") AND PUBYEAR > 2010 AND PUBYEAR < 2021) the data downloading to a Microsoft Excel sheet.

Analysis and Interpretation of the Results

The ratio of Growth (ROG)

The ratio of growth is identified by the increase in the number of publications ratio is compare with the current year to the previous year. The ROG is calculated by the following statistical formula,

$$ROG = \frac{\text{No of Publications in the Current Year}}{\text{No of Publications in the Previous Year}}$$

Compound Annual Growth Rate [CAGR]

The Compound Annual Growth Rate [CAGR] is one of the useful measures to identify the growth, over multiple time periods. It can be measured from the initial number of publications to the ending number of publications. The mathematical formula of CAGR is used by **Ashok Kumar and Gopala Krishnan (2013)**[13]

The compound annual growth rate was calculated by the following formula,

$$CAGR = \left[\frac{\text{Ending Value}}{\text{Begining Value}}\right]^{\left[\frac{1}{\#\text{ of Years}}\right]} - 1$$

During the ten-year study period compound annual growth rate is calculated by the satellite communication research outputs from the beginning year and ending year. It is identified in table 1 the that compound annual growth rate is 5.44.

Year Wise Distribution and Ratio of Growth of Publications in Satellite Communication

Table-1 Year Wise Distribution and Ratio of Growth of Publications in Satellite Communication

S.No	Year	Publications	%	Cum	%	ROG
1	2011	1076	8.84	1076	1.72	
2	2012	869	7.14	1945	3.11	0.81
3	2013	856	7.03	2801	4.48	0.99
4	2014	1083	8.90	3884	6.21	1.27
5	2015	1334	10.96	5218	8.34	1.23
6	2016	1461	12.01	6679	10.68	1.10
7	2017	1429	11.74	8108	12.96	0.98
8	2018	1556	12.79	9664	15.45	1.09
9	2019	1357	11.15	11021	17.62	0.87
10	2020	1147	9.43	12168	19.45	0.85
	Total	12168	100.00	62564	100.00	
		CAGR	**0.64**			

Table 1 depicts the growth of research publications published in the field of satellite Communication literature during the study period 2011-2020. Altogether 12168 publications were published. A maximum of 1156 (12.79%) was published in the year 2018. Followed by 1461(12.01%) were published in the year 2016. While less number of research publications 856(7.03%) were published in the year 2013. There is a study growth found in research output from one year to proceed next year. Further, is found that the ratio of growth in an increase in the number of publications per year is 0.86%, and the compound annual growth ratio is 0.64.

Relative Growth Rate (RGR)

The most important feature of science and technology in recent years has been calculated by the rate of growth. Scientific growth has been involved not only in an increase in manpower and financial investment. The relative

growth rate is identified by the increase in the number of publications per unit of time. The mean relative growth rate over the particular period of the interval can be calculated in the following formula developed by **Mahapatra (1985)**[14]

$$R(a) = \frac{(W_2 - W_1)}{(T_2 - T_1)}$$

Where,

R (a) = RGR = the mean relative growth rate over the specific period of interval

W_1 = the logarithm of the beginning number of publications/pages

W_2= the logarithm of the ending number of publications/pages after a specific period of interval

$T_2 - T_1$ = the unit difference between the beginning time and the ending time.

The doubling time is the time taken for the doubling of the number of records actually published within a stipulated period. The doubling time is calculated from the relative growth rate and the natural logarithm number is used, the difference has a value of 0.693. The corresponding doubling time can be calculated by the following formula,

Relative Growth Rate and Doubling Time in Satellite Communication

Table 2: Relative Growth Rate and Doubling Time in Satellite Communication

Year	Publications	Cum	W_1	W_2	RT(p)	Mean RP(p)	Dt(p)	Mean Dt(p)
2011	1076	1076		6.98				
2012	869	1945	6.98	7.57	0.59		1.17	
2013	856	2801	7.57	7.94	0.36		1.90	
2014	1083	3884	7.94	8.26	0.33	0.31	2.12	1.50
2015	1334	5218	8.26	8.56	0.30		2.35	
2016	1461	6679	8.56	8.81	0.25		2.81	
2017	1429	8108	8.81	9.00	0.19		3.57	
2018	1556	9664	9.00	9.18	0.18	0.17	3.95	4.52
2019	1357	11021	9.18	9.31	0.13		5.27	
2020	1147	12168	9.31	9.41	0.10		7.00	
Total	12168		75.6073	85.01	2.43		30.14	

Table 2 explains the relative growth rate and doubling time of Solar cell publications from 2011- to 2020. On the observation of the current table, it found that the maximum RGR of 0.59 has been recorded in the year 2012 and the minimum RGR of 0.10 has been counted in the year 2020, while the maximum doubling time of 7.00 has been counted in the year 2020 and the minimum doubling time 1.17 has been counted in the year 2012. It can be seen in table 2 that the value of the average relative growth rate of publications [R (a)] increased and decreased gradually from 0.31 to 0.17 from 2014 to 2020. The corresponding mean doubling time [Dt (a)] for the period increased from 0.1.50 to 4.52.

Author wise Contributions in Satellite Communication

Table 3 top ten Author wise Contributions to Satellite Communication

S.No	Authors	**Country**	Publications	%
1	Panagopoulos, A.D.	China	100	17.61
2	Chatzinotas, S.	United States	79	13.91
3	Ottersten, B.	India	76	13.38
4	Toyoshima, M.	Germany	58	10.21
5	Kourogiorgas, C.I.	Italy	47	8.27
6	Wu, J.	Japan	45	7.92
7	Vanelli-Coralli, A.	United Kingdom	44	7.75
8	Pham, K.	France	43	7.57
9	Chen, G.	South Korea	40	7.04
10	Knopp, A.	Spain	36	6.34
	Total		568	100.00

Table 4 identified the top ten author contributions for the research publications of satellite communication research publications from the Scopus database. From the study, it is identified that a maximum of 100(17.61%) research publications are contributed by Panagopoulos, A.D. China, followed by Chatzinotas, S. The United States with 79(13.91%) research publications, Ottersten, B. India with 76(13.38%) research publications. The lowest authors were Spain with 36(6.34%) Knopp, A.

Document Type wise Contributions in Satellite Communication

Table 4 Document Type wise Contributions in Satellite Communication

S.No	**Document type**	**Publications**	**%**	**Cum**	**%**
1	Conference Paper	6840	56.28	6840	5.96
2	Article	4730	38.92	11570	10.08
3	Book Chapter	195	1.60	11765	10.25
4	Review	145	1.19	11910	10.38
5	Conference Review	135	1.11	12045	10.49
6	Book	51	0.42	12096	10.54
7	Note	27	0.22	12123	10.56
8	Editorial	19	0.16	12142	10.58
9	Erratum	6	0.05	12148	10.58
10	Letter	6	0.05	12154	10.59
	Total	12154	100.00	114793	100.00

Table 4 identified the Document type contributions for the research publications of satellite communication research publications from the Scopus database. From the study, it is identified that a maximum of 6840(56.28%) research publications are contributed by Conference papers. followed by an Article with 4730(38.92%) research publications, book chapter with 195(1.60%) research publications, and Review with 145(1.19%), Conference review with

135(1.11%), book with 51(0.42%), Note with 27(0.22%), Editorial with 19(0.16%), Erratum with 6(0.05%), Letter with 6(0.05%). Conference paper and articles both with 95.20%, and others with 4.80% during the study period of the document type.

Authorship Pattern in Satellite Communication

Table 5: Analysis of Authorship Pattern in Satellite Communication

Authorship pattern												
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**>9**	**Total**	**%**
2011	115	206	250	234	109	81	27	18	15	21	1076	8.84
2012	86	161	207	213	90	56	25	7	11	13	869	7.14
2013	119	140	192	186	112	58	18	12	6	13	856	7.03
2014	80	212	280	253	133	61	34	10	5	15	1083	8.90
2015	97	261	317	282	166	108	35	26	14	28	1334	10.96
2016	130	320	343	295	163	79	62	26	13	30	1461	12.01
2017	112	278	345	281	196	97	51	28	9	32	1429	11.74
2018	90	295	350	335	211	134	56	25	14	46	1556	12.79
2019	108	220	268	262	219	139	43	40	18	40	1357	11.15
2020	76	198	245	213	176	109	53	32	15	30	1147	9.43
Total	1013	2291	2797	2554	1575	922	404	224	120	268	12168	100.00
%	8.33	18.83	22.99	20.99	12.94	7.58	3.32	1.84	0.99	2.20	100.00	

Table 3 illustrates the year-wise distribution of authorship patterns of global satellite communication literature. Out of 12168 papers, the authorship pattern of up to 9 authors results in a total of 11900 research output remaining 268 papers have been published by more than nine authors. Single author contributions accounted for 1013(8.33%) during the study period. The highest percentage of 2797(22.99% is recorded by three authors, followed by four and two authors showing 2554(20.99%) and 2291(18.83%) respectively. And followed by five, six, more than nine, seven, and eight authors showing 1575(12.94%), 922(87.58%), 268(2.20%), 224(1.84%), and 120(0.99%) respectively. The number of authors engaging in collaborative research is found increasing year by year from 2015 to 2018 ranging from 1334 to 1556 It can be noticed that alternatives increased and decreased of the highest percentage of the year, an author's/scientists collectively contribute one paper in the field of satellite communication literature.

Collaborative Coefficient (CC)

The pattern of co-authorship collaboration among the authors can be measured with the following formula suggested by **Ajiferuke, et al. (1988)**[15]

$$CC = 1 - \left[\sum_{j=0}^{k}\left(\frac{1}{j}\right) \times Fj/N\right]$$

Whereas,

Fj = Number of publications with j author papers

N = Total number of research publications and

k = the greatest number of authors/papers in the given field.

Collaboration Index (CI)

The simple indicator is presently employed in the publications to the collaboration index, which is to be understood nearly as the mean number of authors per paper are suggested by **Ajiferuke, et al (1988)**[15]

$$CI = \frac{\sum_{j=1}^{k} jfj}{N}$$

Here

J - The number of co-authored papers appearing in a discipline

N - The total number of publications in the field over the same time period of interval and

k - The highest number of authors per paper in the same time field.

Degree of Collaboration

The degree of collaboration is the relationship between the single author and multi-author contributions. The degree of collaboration is calculated by the **Subramanian formula (1983)**[16]**, used by Vivekanandhan (2016),**[17] **Ravichandran (2021)**[18]

$$DC = \frac{Nm}{(Nm + Ns)}$$

Where DC = Degree of Collaboration

N_m = Number of multi-authored publications

N_s = Number of single-authored publications

The study number of multi-authors = 11347, number of single author = 428

Average the degree of collaboration is =11347/ (428+11347) = 0.96

Co-authorship Index (CAI)

To study how the pattern of co-authorship and the use of the co-authorship index suggested by **Garg and Padhi (2001)**[19] has been explained in the undermentioned formula. To evaluate the co-authorship index (CAI) the whole set of data is divided into 2 block years.

$$CAI = \left[\frac{(Nij/Nio)}{(Noj/Noo)}\right] \times 100$$

Whereas,

Nij - Number of publications having j authors in I block

Nio - Total publications of I block

Noj - Number of publications having j authors for all blocks

Noo-: Total number of publications for all authors and all blocks

Here CAI=100 implies that a country's co-authorship effort for particular authorship corresponds to the world average

CAI > 100 reflects a higher than average co-authorship effort

CAI < 100 reflects lower than average co-authorship effort by the given type of authorship pattern.

For calculating the co-authorship index for authors, years have been replaced with block years. For this study, the authors have been classified into two blocks (ie.2010-2014 and 2015-2019) Vs**.** Single, Two, Three authors, and More than 3 authors.

Modified Collaboration Coefficient

The modified collaboration coefficient (MCC) counted by the formula which is suggested by **Savanur and Srikanth, (2010)**[20]

Which is given below:

Where,

$$MCC = \frac{N}{N-1}\left[1 - \frac{\sum_{j=1}^{k} jfj}{N}\right]$$

j = the number authors in an article i.e. 1, 2, 3.....

Fj = the number of j authored articles

N = the total number of articles published in a year, and

A = the total number of authors per article

Table 4 attempts to analyze different collaboration factors for the period of 10 years (2011- 2020). The analysis of the table includes CI, DC, CAI, CC, and MCC. The Table shows the collaborative index at the lowest level in the year 2013. The collaborative index is highest in the year 2018, and 2020 and the mean collaborative index during the time of study is 3.76. Subramanyam propounded the degree of collaboration, a measure to calculate the proportion of single and multi-author papers and to interpret it as a degree of collaboration varies from 0 when all the papers have a single author to 1 when all the papers have more than one author. It can be easily calculated and can also be easily interpreted.

Analysis of Collaboration factors in Satellite Communications Publication

Table 6: Analysis of Collaboration factors in Satellite Communications Publication

Authorship pattern	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
1	115	86	119	80	97	130	112	90	108	76	1013
2	206	161	140	212	261	320	278	295	220	198	2291
3	250	207	192	280	317	343	345	350	268	245	2797
4	234	213	186	253	282	295	281	335	262	213	2554
5	109	90	112	133	166	163	196	211	219	176	1575
6	81	56	58	61	108	79	97	134	139	109	922
7	27	25	18	34	35	62	51	56	43	53	404
8	18	7	12	10	26	26	28	25	40	32	224
9	15	11	6	5	14	13	9	14	18	15	120
10	21	13	13	15	28	30	32	46	40	30	268
Total	1076	869	856	1083	1334	1461	1429	1556	1357	1147	12168
CI	3.64	3.6	3.54	3.6	3.77	3.65	3.76	3.92	4.06	4.06	37.6

DC	0.89	0.90	0.86	0.93	0.93	0.91	0.92	0.94	0.92	0.93	9.13
CAI	128.38	118.87	166.99	88.73	87.34	106.88	94.14	69.48	95.60	79.59	1036.01
CC	0.62	0.63	0.61	0.64	0.65	0.63	0.65	0.67	0.66	0.67	6.43
MCC	3.65	3.6	3.55	3.6	3.78	3.65	3.76	3.93	4.06	4.06	37.64
MCC-CC	3.02	2.97	2.94	2.96	3.13	3.02	3.12	3.26	3.4	3.39	31.21

CI - Collaborative Index, DC - Degree of Collaboration, CAI! – Co-authorship Index, CC - Collaborative Co-efficient, MCC - Modified Collaborative Co-efficient

It is found in this study that degree of collaboration was lowest at 0.86 in 2013 and highest at 0.94 in 2018. In the year multi-authored papers are steadily increasing, but in 2017 it is at its lowest and hence the mean degree of collaboration during the study period shows 0.86. The collaborative index value in this study was the lowest in 2013 when it was 3.54. It was at the highest value of 4.06 in 2020, 2020. The mean collaborative index during the period of the study was 3.76.

The value of CAI in the first year starts at 128.38 and it progressively increases in respect of other proceeding years as multi and mega-authored papers increase. This implied that during the first year of study single-authored papers are high in the scenario. From the year 2011 onwards the value of CAI steadily increases from 128.38 to 166.99 in 2013 and from 2016 to goes down further and in the year 2018, it goes lowest i.e. 69.48, suggesting the trend in the later years is marked by fewer research papers with small team size.

This result is supported by the outcome of CC. In this study, CC is also the lowest in 2013 showing 0.61. It is at the highest rate of 0.67 in 2018, 2020. The mean CC is 0.642. The study found that MCC was lowest in 2013 when it was 3.55. It was at the highest value of 4.06 in 2019, 2020. The mean MCC during the period of study was 3.76.

It is also observed from the table that the mean difference between CC and MCC is 3.02. The least difference between CC and MCC, i.e. 2.94 is observed during the year 2013. The highest difference between CC and MCC, which is 3.39, is observed in the year 2020. It can be concluded that no significant difference can be observed between CC values and MCC values, and also this variation narrows down when the number of authorships increases.

Out of 12168 articles published, the single-author share is 1013 and the multiple paper author shares are 11155. This indicates that a single paper contribution is less than multiple author papers. It can be summarized from the above discussion that very high collaborative research activities are observed in global satellite communication literature.

Top ten Country-wise Contributions to Satellite Communication

Table 7 top ten Country-wise Contributions to Satellite Communication

S.No	Country	Publications	%
1	China	3373	32.90
2	United States	1711	16.69
3	India	1340	13.07
4	Germany	720	7.02
5	Italy	636	6.20

6	Japan	591	5.76
7	United Kingdom	565	5.51
8	France	512	4.99
9	South Korea	405	3.95
10	Spain	399	3.89
	Total	10252	100.00

Table 7 identified the top ten Country contributions to the research publications of satellite communication research publications from the Scopus database. From the study, it is identified that a maximum of 3373(32.90%) research publications are contributed by China. followed by the United States with 1711(16.69%) research publications, India with 1340(13.07%) research publications. The lowest publications are Spain 399(3.89%)

Top ten Journals-wise Contributions to Satellite Communication

Table 8 top ten Journals-wise Contributions to Satellite Communication

S. No	Journals	Publications	%
1	Proceedings Of The International Astronautical Congress Iac	250	15.99
2	Proceedings Of SPIE The International Society For Optical Engineering	230	14.72
3	IEEE Access	176	11.26
4	IEEE Transactions On Antennas And Propagation	160	10.24
5	International Journal Of Satellite Communications And Networking	152	9.72
6	IEEE Communications Letters	149	9.53
7	Lecture Notes In Electrical Engineering	122	7.81
8	Proceedings IEEE Military Communications Conference MILCOM	121	7.74
9	IEEE Aerospace Conference Proceedings	102	6.53
10	IEEE Transactions On Communications	101	6.46
	Total	1563	100.00

Table 8 identified the top ten Journals' contributions to the research publications of satellite communication research publications from the Scopus database. From the study, it is identified that a maximum of 250(15.99%) research publications are contributed by proceedings of the international astronautically congress iac. followed by the proceedings of SPIE the International Society For optical engineering with 230(14.72%) research publications, IEEE Access with 176(11.26%) research publications. The lowest publications in IEEE Transactions on Communications 101(6.46%).

Top ten Institutions-wise Contributions to Satellite Communication

Table 9 top ten Institutions-wise Contributions to Satellite Communication

S.No	Institutions	Publications	%
1	Chinese Academy of Sciences	227	12.80
2	ESTEC - European Space Research and Technology Centre	215	12.13
3	Deutsches Zentrum fur Luft- Und Raumfahrt	195	11.00

4	Beijing University of Posts and Telecommunications	191	10.77
5	Xidian University	189	10.66
6	Tsinghua University	184	10.38
7	Southeast University, Nanjing	147	8.29
8	National University of Defense Technology	147	8.29
9	Harbin Institute of Technology	141	7.95
10	University of Electronic Science and Technology of China	137	7.73
	Total	1773	100.00

Table 9 identified the top ten Institutions' contributions to the research publications of satellite communication research publications from the Scopus database. From the study, it is identified that a Maximum of 227(12.80%) research publications are contributed by the Chinese Academy of Sciences. followed by the ESTEC - European Space Research and Technology Centre with 215(12.13%) research publications, Deutsches Zentrum fur Luft- und Raumfahrt with 195(11.00%) research publications. The lowest number of publications in the University of Electronic Science and Technology of China was 137(7.73%).

Time Series Analysis in Satellite Communication

Table 10 Time Series Analysis in Satellite Communication

S.No	Year	Count(y)	X	Y2	XY
1	2011	1076	-5	25	-5380
2	2012	869	-4	16	-3476
3	2013	856	-3	9	-2568
4	2014	1083	-2	4	-2166
5	2015	1334	-1	1	-1334
6	2016	1461	1	1	1461
7	2017	1429	2	4	2858
8	2018	1556	3	9	4668
9	2019	1357	4	16	5428
10	2020	1147	5	25	5735
	Total	12168		110	5226

Time series analysis reveals that the estimated growth values are identified based on previous data. A straight–line equation is adapted to measure the future values based on previous data. Time series analysis used by **Ravichandran (2022)**[21]

Table 10 shows that the time series analysis formula has been predicted for satellite communication research publications for the years 2020 and 2025

Straight Line Equation is

$Y = a + bx$

Here,

$\sum Y = 12168$, $\sum X^2 = 110$, $\sum XY = 5226$

$a = \sum Y/N = 12168/10 = 1216.8 = 1217$

$b = \sum XY/ \sum X^2 = 5226/110 = 50.236 = 50$

Estimated publications in the year 2025 are when X=2025-2015=10

$Y = a + bx$

$= 1217 + (50*10) = 1217+500 = 1717$

Estimated literature in 2030 is when X=2030-2015=15

$Y = a + bx$

$= 1217 + (50*15) = 1217 + 750 = 1967$

The time-series analysis of the estimated growth based on a statistical application will be expected in the satellite communication research publications in the year 2025 is around are equal to 1717 and in the year 2030 is around are equal to 1967. So that time serious analysis conformed that the publications on satellite communication research are increasing trend.

Top 10 Highly Cited Papers in Satellite Communication

Table 11 top 10 Highly Cited Papers in Satellite Communication

S.No	Titles	Citations	Document
1	Calheiros, R.N. et. al(2011) CloudSim: A toolkit for modeling and simulation of cloud computing environments and evaluation of resource provisioning algorithms, Software - Practice and Experience,41(1), 23-50.	3123	Article
2	Raiciu, C. et.al (2011) Improving datacenter performance and robustness with multipath TCP, Proceedings of the ACM SIGCOMM 2011 Conference, SIGCOMM'11, 266-277.	494	Conference Paper
3	Gill, P. et.al (2011) Understanding network failures in data centers: Measurement, analysis, and implications, Proceedings of the ACM SIGCOMM 2011 Conference, SIGCOMM'11, 350-361.	480	Conference Paper
4	Van Donkelaar, A., et. al (2016) Global Estimates of Fine Particulate Matter using a Combined Geophysical-Statistical Method with Information from Satellites, Models, and Monitors, Environmental Science and Technology, 50(7), 3762-3772.	473	Article
5	Christodoulou, C.G., et.al (2012) Reconfigurable antennas for wireless and space applications, Proceedings of the IEEE, 100(4), Art. No.6178263, 2250-2261.	437	Conference Paper
6	Rahmatallah, Y., et.al (2013) Peak-to-average power ratio reduction in OFDM systems: A survey and taxonomy, IEEE Communications Surveys and Tutorials, 15(4) Art. No.6476061, 1567-1592.	423	Review
7	Bocherer, G. et.al (2015) Bandwidth Efficient, and Rate-Matched Low-Density Parity-Check Coded Modulation, IEEE Transactions on Communications, 63(12), Art. No.7307154, 4651-4665.	407	Article

8	Kaushal, H., et.al (2016) Underwater Optical Wireless Communication, IEEE Access, 4, Art.No. 7450595, 1518-1547.	402	Article
9	Ma, Z., (2014) Estimating ground-level PM2.5 in china using satellite remote sensing, Environmental Science and Technology, 48(13), 7436-7444.	348	Article
10	Gao, S.S., (2013) Circularly polarized antennas, Circularly Polarized Antennas, 1-307.	298	Book

The highly cited paper with 3123 Calheiros, R.N. et .al (2011) CloudSim: A toolkit for modeling and simulation of cloud computing environments and evaluation of resource provisioning algorithms, Software - Practice and Experience,41(1), 23-50. Second highly cited paper with 494 Raiciu, C. et.al (2011) Improving datacenter performance and robustness with multipath TCP, Proceedings of the ACM SIGCOMM 2011 Conference, SIGCOMM'11, 66 -277. Third highly cited paper with 480 Gill, P. et.al (2011) Understanding network failures in data centers: Measurement, analysis, and implications, Proceedings of the ACM SIGCOMM 2011 Conference, SIGCOMM'11, 350-361, The total article 05, conference paper 03, review 01 and book 01.

MAJOR FINDING

- The growth of research publications in the field of satellite Communication literature during the study period 2011-2020. Altogether 12168 publications were published. A maximum of 1156 (12.79%) was published in the year 2018. Followed by 1461(12.01%) were published in the year 2016. While less number of research publications 856(7.03%) were published in the year 2013. There is a study growth found in research output from one year to proceed next year. Further, is found that the ratio of growth in an increase in the number of publications per year is 0.86%, and the compound annual growth ratio is 0.64.
- In the study, a maximum RGR of 0.59 has been recorded in the year 2012 and the minimum RGR of 0.10 has been counted in the year 2020, while the maximum doubling time of 7.00 has been counted in the year 2020 and the minimum doubling time of 1.17 has been counted in the year 2012. It can be seen in table 2 that the value of the average relative growth rate of publications [R (a)] increased and decreased gradually from 0.31 to 0.17 from 2014 to 2020. The corresponding mean doubling time (Dt) (a)] for the period increased from 0.1.50 to 4.52.
- The study a maximum of 100(17.61%) research publications are contributed by Panagopoulos, A.D. China, followed by Chatzinotas, S. The United States with 79(13.91%) research publications, Ottersten, B. India with 76(13.38%) research publications.
- During the study, a maximum of 6840(56.28%) research publications are contributed by Conference papers. followed by an Article with 4730(38.92%) research publications, a book chapter with 195(1.60%) research publications document type.
- The highest percentage of 2797(22.99% is recorded by three authors, followed by four and two authors showing 2554(20.99%) and 2291(18.83%) respectively.
- The study that the degree of collaboration was lowest at 0.86 in 2013 and highest at 0.94 in 2018. The mean of the degree of collaboration during the study period shows 0.86. The CI value in this study was the lowest in 2013 when it was 3.54. It was at the highest value of 4.06 in 2020, 2020. The mean CI during the period of the study was 3.76.

- The value of CAI in the first year starts at 128.38 and it progressively increases in respect of other proceeding years as multi and mega-authored papers increase. From the year 2011 onwards the value of CAI steadily increases from 128.38 to 166.99 in 2013 and from 2016 to goes down further in the year 2018.
- In this study, CC is also the lowest in 2013 showing 0.61. It is at the highest rate of 0.67 in 2018, 2020. The mean CC is 0.642. The study found that MCC was lowest in 2013 when it was 3.55. It was at the highest value of 4.06 in 2019, 2020. The mean MCC during the period of study was 3.76.
- The mean difference between CC and MCC is 3.02. The least difference between CC and MCC, i.e. 2.94 is observed during the year 2013. The highest difference between CC and MCC, which is 3.39, is observed in the year 2020.
- A maximum of 3373(32.90%) research publications are contributed by China. followed by the United States with 1711(16.69%) research publications, India with 1340(13.07%) research publications.
- In the study, a maximum of 250(15.99%) research publications are contributed by proceedings of the international astronautically congress iac. followed by the proceedings of SPIE the International Society For optical engineering with 230(14.72%) research publications.
- During that, a maximum of 227(12.80%) research publications are contributed by the Chinese Academy of Sciences. followed by the ESTEC - European Space Research and Technology Centre with 215(12.13%) research publications,
- The estimated growth based on a time series analysis statistical application will be expected in the satellite communication research publications in the year 2025 is around are equal to 1717 and in the year 2030 is around are equal to 1967. So that time serious analysis conformed that the publications on satellite communication research are increasing trend.
- The highly cited paper with 3123 Calheiros, R.N. et. al(2011) CloudSim: A toolkit for modeling and simulation of cloud computing environments and evaluation of resource provisioning algorithms, Software - Practice and Experience,41(1), 23-50.

REFERENCES

[1] Sapna Katiyar, Satellite communication, S.K. Kataria & sons, Ansari road, Daryaganj, New Delhi, 2007-2008, 1-2.

[2] Master of library and information science bibliometric paper, Annamalai University, Directorate of Distance Education 056 E 180: MLIS 2015-2016, 97-100.

[3] Nalimov, V., & Mulcjenko, B. (1971).Measurement of science: Study of the development of science as an information process. Washington DC: Foreign Technology Division.

[4] Tague-Sutcliffe, J. M. (1992). An introduction to informetrics.Information Processing & Management, 28, 1–3.

[5] Hess, D. J. (1997).Science studies: An advanced introduction. New York: New York University Press.

[6] Ravichandran S and Vivekandhan S (2021). Scientometric analysis of wastewater management research publications from the SCOPUS database from 2010 to 2019. *Library Philosophy and Practice (e-journal),* 5139, 1-18.

[7] Kavitha R et.al (2018) solar cell research output: a bibliometric study. "*Knowledge Librarian" An International Peer Reviewed Bilingual E-Journal of Library and Information Science*, 5(2):244-259.

[8] Kumar K. (2014). A Scientometric Study of Digital Literacy in Online Library Information Science and Technology Abstracts (LISTA). *Library Philosophy and Practice (e-journal),* 1044, 1-14.

[9] Ravichandran S and Vivekandhan S (2021). Wireless sensor network research output in India research publications from SCOPUS database during 2010-2019. *Library Philosophy and Practice (e-journal),* 5509, 1-12.

[10] Vivekanandhan S, et.al (2016). Growth of Literature in Pollution Control Research Output during 1985–2014: A Scientometric Study. *Journal of Advances in Library and Information Science*, 5 (2), 170-178.

[11] Sudhakar K, and Thanuskodi S (2018). Marine Pollution Bulletin: A Scientometric Analysis (2008 to 2017). *Library Philosophy and Practice e-journal* -2043. 10.

[12] Dhanya P, and Raja S (2017). A Scientometric Study on Industrial Pollution in Indian Perspective (2007 to 2016). *International Journal of Information Movement,* 2(4) 118-130 11.

[13] Ashokkumar, L. and Gopala Krishnan, S. (2013). Indian literature output on Textile Research: A Scientometric Study. *Journal of Advances in Library and Information Science*, 2(4), 251-258.

[14] Mahapatra, M. (1985). On the validity of the theory of exponential growth of scientific literature. *In 15th IASLIC conference proceedings*, Bangalore, 61-70.

[15] Ajiferuke, I., Burrel, Q. and Tauge, J. (1988). Collaborative Co-efficient: A single measure of the degree of collaboration in research. *Scientometrics,* 14, 421-433.

[16] Subramanyam K (1983). Bibliometric studies of research collaboration: A review. *Journal of Information Science*. 6(1), 33-38.

[17] Vivekanandhan. S et.al (2016). Growth of literature in pollution control Research output: A Scientometric Study. *Journal of Advances in Library and information science,* 5 (2):170-178.

[18] Ravichandran and Vivekananda (2021) Wireless Network Research Output in India from Scopus Database during 2010 -2019: A Scientometric Analysis, *Library Philosophy, and Practice (e-journal*). 5833, 1-11.

[19] Garg, K.C., and Padhi, P. (2001). A study of collaboration in laser science and technology. *Scientometrics,* 51(2), 415-427.

[20] Kiran Savanur and Srikanth. (2010) Modified Collaborative Coefficient: a new measure for quantifying the degree of research collaboration. *Scientometrics*, 1-11.

[21] Ravichandran and Vivekanandhan (2022) Scientometric Analysis of Diabetics Research Output From Scopus Database during 1971-2020 in India, International Journal of Development Research, 12(04): 55074-55080.
