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Wireless Network Research Output in India from Scopus Database during 2010 -2019: A Scientometric Analysis

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Abstract:

This study aims to analyze the scientometric study of wireless network research publications in India from SCOPUS database during 2010 - 2019. From this study, it is identified that India has occupied third placed and the contribution is 8559 publications and average publications per year is 856 publications. Out of that, maximum of 1561(18.24%) publications in the year 2019, CAGR is 35.98. and total numbers of citation is 25558. During the study period, 74 countries are collaborated by India with 914 publications. The relative growth rate is 0.91 in the year 2011 and 0.20 in the year 2019. At the same time, doubling time is found that 0.76 in the year 2011 and 3.44 in the year 2019. During the study period, maximum of 5194(60.68%) papers are contributed in conference paper. Maximum of 3903(45.60%) publications are contributed by two authorship modes. This study identified that, average degree of collaboration is 0.96. From the study, it is identified that CAI for single, two and three authorship contributions are decreasing trend from 1st block year to 2nd block year. At the same time, CAI is increasing trend for more than three authors from 1st block year to 2nd block years. Maximum of 43(11.53%) papers are published by Tamma, B.R with 216(8.71%) citations, h-index is 8 and RCI is 0.55. Anna University published 293 publications and it is received by 905 citations, citation per paper is 3.09, h-index is 13 and RCI is 0.63. International Journal of Applied Engineering Research published a maximum of 256(16.91%) publications and it is received by 232 citations, citation per paper is 0.91, h-index is 6. Time series analysis study will be expected in the wireless network research publications in India in the year 2025 is around are equal to 1986 and the year 2030 is around are equal to 2551.

Keywords: Scientometric, wireless network, degree of collaboration, co-authorship index, relative growth rate and the doubling time, publication efficiency index, relative citation index and time series analysis.

Introduction

Wireless networking has emerged as its discipline over the past decade. From cellular voice telephony to wireless access to the internet and wireless home network. Wireless networks have profoundly impacted our lifestyle. After a decade of exponential growth, today's wireless industry is one of the largest industries in the world. At the time of this writing, close to one billion people subscribe to cellular service. Close to 200 billion GSM short messages are exchanged yearly, and the penetration of the cellular telephone in Finland exceeded 75%, the highest in the world. Several universities and other educational institutions have started wireless research and teaching programming and several engineers and scientists are re-educating themselves in this field.¹

Wireless communication is described as transmitting/receiving voice and data using electromagnetic waves in open space. Mobile, portable and fixed is the types of wireless communication. Cellular systems, wireless LANs, satellite systems, and wireless PANSs are the current wireless systems. The most advantage of wireless communication systems is that a mobile user can make a call anywhere and anytime. Wireless networking refers to the "utilization of cross-vendor industry standards, such as IEEE 802.11, where nodes communicate without needing to be wired"(Mamoukaris & Economides 2003, p.1).² The present study investigates the present trends on research publications in the field of wireless network and it is investigating the Scientometrics analysis of wireless network literature contributed by Indian scientists during the year 2010 -2019.

Scientometric Study

Scientometric is a Science of measuring and analyzing the science which studies the quantitative aspects of science. Nlimov and Mulchenko (1989)³ defined Scientometrics as 'the quantitative method which deals with the analysis of science viewed as information process'. Beck (1978)⁴ defined Scientometrics as 'a study of the quantitative evaluation and intercomparison of scientific activity, productivity, and progress'. Koenig and Bookstein (1995)⁵ defined Scientometrics as "the science of measuring science". A.F.J. Van Raan (1997)⁶ described as scientometric research is devoted to quantitative studies of science and technology Vinker P (2010)⁷ defined scientometrics as a scientific field dealing with all aspects of people, or group of people, matters and phenomena in science and their relationship which do not restrict scientometrics to information aspects only. Wireless communication is the fastest-growing segment in the field communications industry for the last decads.

Review of Related Literature

Mesdaginia et al., (2015)⁸ has analyzed solid waste research papers published by Iran from 1982 to 2013 with 340 articles. The study identified that most of the articles were occupied in the English language with 300 article records (88.24%). Out of 340 articles, Iran was involved, 280 (82.35%) independent papers and remaining 60(17.65%) papers were internationally collaborative publications. The study identified that 857 authors are published 340 articles and 0.39 articles per author during the study. **Hanyu Ma, Yuh-Shan Ho and Hui-Zhen Fu (2011)**⁹ had been conducted a study on solid waste interrelated research publications from the web of science database during 1991-2010 with 7819 publications. Among the study 6424(83%) articles were single country publications and remaining 1291 (17%) publications were international collaborative articles. Majority of the total articles are published by G7 countries, especially USA had the most publications of 1392.

Ravichandran and Vivekanandhan (2021)¹⁰ examine the Scientometric analysis of waste water management research publications during 2010-2019 from Scopus database. The study identified that 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 average degree of collaboration was 0.97. Maximum of 2102(10.58%) research publications are contributed in Bio resource technology, ministry of education, china with 863(22.32%) research publication and China has contributed maximum of 5919(29.80%) research publications. **Adesina and Opesade (2018)**¹¹ have analyzed sickle cell anemia research publications on Nigeria from the pubmed database during 2006-2016 with 326 publications. Most prolific publications are contributed by the Nigerian Journal of Clinical Practice with 15(5.8%) articles. University of Nigeria teaching Hospital had contributed the highest number of (132) 10% publications. Average degree of collaboration was 0.93 and the majority of authors had contributed from Nigeria.

Alagu and Thanuskodi (2019)¹² examined the digital literacy publications are indexed in web of science database between 1992 and 2011 with 512 publications. The highest number of 126 research publications has been published in the years 2011. Most productive country is USA with 169 articles, most of 429 publications are article and average degree of collaboration was 0.602. **Ravichandran and Vivekanandhan (2021)**¹³ analyzed the wireless sensor network research output in India during 2010-2019 from SCOPUS database with 11775. This study identified that,

maximum number of 2058(17.48%) publications are contributed in the year 2019 and compound annual growth rate was 5.44. This study identified that, relative growth rate was decreasing trend and doubling time was increasing trend. 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).

Kavitha R et.al (2018)¹⁴ analyzed the research output on Solar cell research publications from Scopus database during 1978 – 2017 with 150201 publications. Out of that, 4430 (2.95%) publications were open sources 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. Maximum of 15113 (10.06%) publications are published in the year 2017. 14 countries are contributed more than 2750 publications and 96377(64.17%) papers were published by Journal. **Kumar (2014)**¹⁵ 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 journal and periodicals are published 69.34% articles in the field of digital literacy. Triple authorship pattern was 35.04% publications and 35-40 age group authors are published 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 maximum of 8.03% of articles.

Objectives

- To identify the country-wise research publications at the Global level
- To find out the year-wise growth of publications in Global and India.
- To identify the year wise international collaborative publications
- To find out the international collaborating countries in India
- To find out the relative growth rate and the doubling time
- To find out the type of documents involved in the research
- To find the authorship pattern and degree of collaboration
- To find the co-authorship index
- To identify the top 10 authors, institutions, and journals contributions
- To analyze the publication efficiency index
- To test the time series analysis.

Methodology

This study analyzes the wireless network research publications from SCOPUS international and multidisciplinary online databases during the period of 2010 - 2019. The following search strings are used to retrieve the data. The search key is ((TITLE-ABS-KEY ("Wireless Network") OR ("Digital wireless") OR ("e-wireless") OR ("Wi-Fi") OR ("Global wireless"))) AND PUBYEAR > 2009 AND PUBYEAR < 2020. The data has been collected on 12.11.2020 and it has been analyzed using Microsoft Excel.

Analysis and Interpretation

Country wise wireless network research publications in global level

Table 1 Top 10 country wise wireless network research publications in Global Level

S.No	Country	No of Publications			Share of Publications			Publications Rank		
		2010-2014	2015-2019	2010-2019	2010-2014	2015-2019	2010-2019	2010-2014	2015-2019	2010-2019
1	China	9542	9234	18776	9.30	9.00	18.31	1	1	1
2	United States	7508	6835	14342	7.32	6.66	13.98	2	2	2
3	India	2517	6042	8559	2.45	5.89	8.34	3	3	3
4	South Korea	2124	2182	4184	2.07	2.13	4.08	4	4	4
5	Canada	1799	2060	3541	1.75	2.01	3.45	5	5	6
6	United Kingdom	1670	1743	3852	1.63	1.70	3.76	6	6	5
7	France	1605	1653	3258	1.56	1.61	3.18	7	7	7
8	Germany	1480	1418	2898	1.44	1.38	2.83	8	8	8
9	Taiwan	1451	1360	2533	1.41	1.33	2.47	9	9	9
10	Italy	1347	1241	2588	1.31	1.21	2.52	10	10	10
11	Undefined	983	834	1816	0.96	0.81	1.77			
12	Others	16960	18982	36220	16.54	18.51	35.31			
	Total	48986	53584	102567	47.76	52.24	100.00			

Table 1 shows that, country-wise wireless network research publications at the global level. Among the top 10 most productive countries, China has contributed the maximum number of 18776(18.31%) research publications with top rank. Followed by the United States with 14342(13.98%) publications, India has 8559(8.34%) publications and it is occupied the third rank globally. This study period is divided in two block years. From the block years study, it is identified that maximum number of 53584(52.24%) publications are contributed in the second block year of 2015-2019 and 48986(47.76%) publications are contributed in the first block year of 2010-2014.

Year wise Global and India Publications

Table 2 Year wise Global and India Publications

S.No	Year	Global		India		
		No of Publications	%	No of Publications	%	Share %
1	2010	9973	12.56	396	4.63	3.97
2	2011	8939	11.26	586	6.85	6.56
3	2012	6204	7.82	457	5.34	7.37
4	2013	6218	7.83	476	5.56	7.66

5	2014	6781	8.54	602	7.03	8.88
6	2015	7309	9.21	903	10.55	12.35
7	2016	8170	10.29	1129	13.19	13.82
8	2017	8241	10.38	1049	12.26	12.73
9	2018	8624	10.86	1400	16.36	16.23
10	2019	8926	11.24	1561	18.24	17.49
	Total	79385	100.00	8559	100.00	10.78
	Average	7938.5		855.9		

Table 2 shows that the year-wise growth of wireless network research publications in global and India. From the table 2, highest number of 9973(12.56%) publications in the year 2010, lowest in the year 2012 with 6204(7.82%) publications, and average publications per year is 7939. Out of 79385 research publications, India is contributed 8559(10.78%) publications. Out of 8559 publications in India, the highest number of 1561(18.24%) publications are contributed in the year 2019 with a share of 17.49%, the lowest number of 396 (4.63%) research publications in the year 2010 with a share of 3.97% research publications. The average publication per year in India is 856.

Year wise Indian publications, citations and international collaborated paper

Table 3 Year wise Indian publications, citations and international collaborated paper

Year	No of Publications	No of Citations	ACPP	ICP	ICP %
2010	396	792	2.00	54	5.91
2011	586	4595	7.84	68	7.44
2012	457	1371	3.00	67	7.33
2013	476	2769	5.82	45	4.92
2014	602	1204	2.00	51	5.58
2015	903	5161	5.72	83	9.08
2016	1129	2258	2.00	96	10.50
2017	1049	1049	1.00	136	14.88
2018	1400	4200	3.00	132	14.44
2019	1561	2159	1.38	182	19.91
2010-2019	8559	25558	2.99	914.00	100.00
2010-2014	2517	10731	4.26	285	31.18
2015-2019	6042	14827	2.45	629	68.82
	CAGR	35.98			

ACPP- Average Citation Per Paper, ICP - International Collaborative paper

During the study period Table 3 identified that, India has published 8559 papers with 25558 citations and average citation per paper is 2.99 citations in wireless network research. This study identified that, maximum number of 1561 papers with 2159 citations in the year 2019 and ACPP is 1.38. The cumulative growth of wireless network research publications in India is 2517 papers with 10731 citations in the first block year of 2010-2014 and 6042 papers with 14827 citations during the second block year of 2015-2019. 914 papers are identified year-wise international collaborative publications, which is increased from 285(31.18%) collaborated papers are published in the first block year of 2010 to 2014 and 629(68.82%) papers are published in the second block year of 2015 to 2019. During the study period maximum of 182(19.91%) papers are collaborated in the year 2010 and the minimum number of 45(4.92%) collaborated publications in the year 2013.

Compound Annual Growth Rate [CAGR]

The Compound Annual Growth Rate [CAGR] is one of the useful measures to identify the growth, over the multiple time periods. It can be measure from the initial number of publications to ending number of publications. The mathematical formula of CAGR is used Ashok Kumar and Gopala Krishnan (2013)¹⁶ was calculated by the following formula,

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

During the ten year study period compound annual growth rate is calculated by the wireless network research outputs in India is identified from the table 3, the compound annual growth rate is 35.98.

International Collaborated Countries Publications in India

Table 4 International Collaborated Countries Publications in India

Collaborating Country	International Collaborated Publications in India (ICP)			ICP Share %		
	2010 - 2014	2015 - 2019	2010 - 2019	2010 - 2014	2015 - 2019	2010 - 2019
United States	100	152	252	10.94	16.63	27.57
United Kingdom	23	39	62	2.52	4.27	6.78
Canada	24	31	55	2.63	3.39	6.02
France	19	27	46	2.08	2.95	5.03
China	4	39	43	0.44	4.27	4.70
Australia	13	23	36	1.42	2.52	3.94
South Korea	7	25	32	0.77	2.74	3.50
Singapore	10	17	27	1.09	1.86	2.95
Saudi Arabia	5	21	26	0.55	2.30	2.84
Germany	9	13	22	0.98	1.42	2.41

Others 64 countries	71	242	313	7.77	26.48	34.25
Total	285	629	914	31.18	68.82	100.00

Table 4 reflects that, top 10 collaborating countries in India authors in the field of the wireless network research publications. During the study period, Indian researchers are collaborate with 914 research publications in 74 countries. During the study period, from the top 10 collaborating countries, maximum of 252(27.57%) papers are collaborated by the United States, followed by the United Kingdom is 62(6.78%) papers, Canada has 55(6.02%) papers, and etc., During the study period, collaborating countries are dived in two block years. Out of that, maximum number 629 (68.82%) publications are collaborated by 2nd block year period of 2015 to 2019 and 285(31.18%) papers in 1st block year period of 2010-2014

Relative Growth Rate and Doubling Time in Wireless Network Research

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 increase in manpower and financial investment. The relative growth rate is identified by the increase in number of publications per unit of time. The mean relative growth rate over the particular period of interval can be calculated in the following formula developed by Mahapatra (1985)¹⁷

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

Where,

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

W₁ = the logarithm of beginning number of publications/pages

W₂= the logarithm of ending number of publications/pages after a specific period of interval

T₂ – T₁ = the unit difference between the beginning time and the ending time.

Doubling Time (Dt)

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,

$$Dt = \frac{0.693}{R(a)}$$

Table 5 Relative Growth Rate and Doubling Time

S.No	Year	No of Publications	Cum.	W ₁	W ₂	RGR=(W ₂ -W ₁)	Dt=(0.693/RGR)
1	2010	396	396	-	5.98	-	-
2	2011	586	982	5.98	6.89	0.91	0.76
3	2012	457	1439	6.89	7.27	0.38	1.81
4	2013	476	1915	7.27	7.56	0.29	2.43
5	2014	602	2517	7.56	7.83	0.27	2.54
6	2015	903	3420	7.83	8.14	0.31	2.26
7	2016	1129	4549	8.14	8.42	0.29	2.43
8	2017	1049	5598	8.42	8.63	0.21	3.34
9	2018	1400	6998	8.63	8.85	0.22	3.10
10	2019	1561	8559	8.85	9.05	0.20	3.44
	Total	8559					

The relative growth rate and the doubling time (Dt) in wireless network research output in India are calculated and the results are presented in Table 5. From the study, it is identified that the relative growth rate is 0.91 in the year 2011 and 0.20 in the year 2019. This study confirmed that the relative growth rate is decreasing trend from 2010 to 2019. At the same time, doubling time is found that 0.76 in the year 2011 and 3.44 in the year 2019. It is confirmed that doubling time is an increasing trend during the study period.

Types of Documents

Table 6 Types of Documents

S.No	Document Type	2010-2014	2015-2019	2010-2019	%
1	Conference Paper	1723	3471	5194	60.68
2	Article	724	2343	3067	35.83
3	Book Chapter	46	142	188	2.20
4	Review	18	61	79	0.92
5	Book	2	12	14	0.16
6	Editorial	3	5	8	0.09
7	Erratum	0	2	2	0.02
8	Letter	0	2	2	0.02
9	Note	0	2	2	0.02
10	Short Survey	1	0	1	0.01
11	Retracted	0	1	1	0.01
12	Undefined	0	1	1	0.01
	Total	2517	6042	8559	100.00

Table 6 very clearly states that, the block year-wise different types of research publications in Indian authors in the field of wireless network research for the selected ten year study period. From the study it is identified that, maximum number of 5194(60.68%) papers are contributed by

conference paper. Followed by article with 3067(35.83%) publications and book chapter with 188(2.20%) publications in third place and remaining form of publications are very less publications.

Authorship Pattern in Wireless Network Research Outputs in India

Table 7 Authorship Pattern in Wireless Network Research Outputs in India

Year	Authorship Pattern						Total Publications
	1	2	3	4	5	>5	
2010	18	137	139	72	22	8	396
2011	13	287	176	70	27	13	586
2012	24	213	139	64	13	4	457
2013	26	214	152	61	10	13	476
2014	33	319	154	66	19	11	602
2015	31	476	216	112	42	26	903
2016	56	563	300	137	52	21	1129
2017	41	453	284	155	75	41	1049
2018	40	581	411	218	88	62	1400
2019	63	660	430	238	95	75	1561
Total	345	3903	2401	1193	443	274	8559
%	4.03	45.60	28.05	13.94	5.18	3.20	100

Table 7 indicates the authorship pattern in the field of wireless network research output in India for the selected ten-year study period. From the study it is identified from the table-7, majority of the authors in the field are preferred to publish their research works in two authorship modes with 3903(45.60%) publications. Followed by three authorship modes with 2401 (28.05%) publications, four authorship modes with 1193 (13.94%) publications. During the study period, more than five authors are contributed only 274(3.20%) publications. Single authors are contributed only 345 (4.03%) publications during the study period. This study confirmed that more than 95% of publications are contributed by multiple authors.

Degree of Collaboration

Degree of collaboration is relationship between the single author and multi author's contributions. The degree of collaboration is calculated by the Subramanian formula (1983)¹⁸, used by Vivekanandhan (2016),¹⁹ Sivasamy (2020).²⁰ Rajendran (2021)²¹

$$DC = \frac{N_m}{(N_m + N_s)}$$

Where DC = Degree of Collaboration

N_m = Number of multi authored publications

N_s = Number of single authored publications

In the present study, $N_m = 8214$, $N_s = 345$

So that, the degree of collaboration is $= 8214 / (345 + 8214) = 0.96$

Table 8 shows that, degree of collaboration in wireless network research publications in India for the selected ten-year studies period. From this study, it is identified that the degree of collaboration is between 0.95 in the year 2010 and 0.96 in the year 2019. The average degree of collaboration is 0.96. From this study, it is identified that the majority of wireless network research publications are contributed by collaborative authors.

Table 8 Degree of Collaboration

Year	Single Author Publications	Multi Authors Publications	Total Publications	Degree of Collaboration DC= N_m/N_m+N_s
2010	18	378	396	0.95
2011	13	573	586	0.98
2012	24	433	457	0.95
2013	26	450	476	0.95
2014	33	569	602	0.95
2015	31	872	903	0.97
2016	56	1073	1129	0.95
2017	41	1008	1049	0.96
2018	40	1360	1400	0.97
2019	63	1498	1561	0.96
Total	345	8214	8559	0.96

Co-authorship Index (CAI)

To study how the pattern of co-authorship and the use of co-authorship index suggested by Garg and Padhi (2001)²² has been explained the under mentioned formula. To evaluate the co-authorship index (CAI) is the whole set of data is divided into 2 block years.

$$CAI = \left[\frac{(N_{ij}/N_{io})}{(N_{oj}/N_{oo})} \right] \times 100$$

Whereas,

N_{ij} - Number of publications having j authors in i block

N_{io} - Total publications of i block

N_{oj} - Number of publications having j authors for all blocks

N_{oo} - Total number of publications for all authors and the all blocks

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

CAI > 100 reflects 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 in block years. From this study, the authors have been classified in two blocks (ie.2010-2014 and 2015-2019) Vs. Single, Two, Three authors and more than three authors.

Co- Authorship Index (CAI) in wireless sensor network in India

Table 9 Co- Authorship Index

Five year Block	Single Author	CAI	Two Authors	CAI	Three Authors	CAI	More than Three Authors	CAI	Total Publications
2010-2014	114	112.36	1170	101.94	760	107.64	473	84.21	2517
2015-2019	231	94.85	2733	99.19	1641	96.82	1437	106.58	6042
Total	345		3903		2401		1910		8559

Table 9 shows that Co-Authorship Index values for wireless network research publications in India for the selected ten-year study period. From the study, it is identified that CAI for single, two and three authorship contributions are decreasing trend from 1st block year to 2nd block year. At the same time, CAI is increasing trend for more than three authors from 1st block year (84.21) to 2nd block years (106.58).

Relative Citation Index (RCI)

Relative citation index (RCI) was developed by the Institute of Scientific Information and it is examine the impact of different countries and institutions. The scientific impact of leading countries are examined by using two relative indicators, namely citations per paper (CPP) and relative citations index (RCI). Citations per paper (CPP) are a relative indicator computed as the average number of citation per paper. It has been broadly used into the bibliometric studies as it normalizes a large difference in the volumes of publications among most productive countries, institutions and authors. To measure the both influence and visibility of a country research in global wise, the following formula has been used by Bharvi Dutt and Khaiser Nikam (2016)²³

$$RCI = \frac{\text{A Country share of the World Citations}}{\text{A Country share of the World Publications}}$$

RCI = 1 indicate that a country's citation rate is equal to the world citation rate

RCI > 1 indicate that a country's citation rate is greater than the world citation rate

RCI < 1 indicate that a country's citation rate is lower than the world citation rate

Top 10 author's contribution and its Citations, h-index in Wireless Network

Table 10 Top 10 author's publications, citations and RCI

S.No	Author	Publications	%	Citations	%	h-index	RCI
1	Tamma, B.R.	43	15.81	216	8.71	8	0.55
2	Misra, S.	37	13.60	735	29.64	17	2.18
3	Ramesh, M.V.	28	10.29	377	15.20	10	1.48
4	Madhav, B.T.P.	26	9.56	158	6.37	7	0.67
5	De, S.	24	8.82	231	9.31	7	1.06
6	Lobiyal, D.K.	23	8.46	71	2.86	5	0.34
7	Murthy, C.S.R.	23	8.46	218	8.79	7	1.04
8	Nandi, S.	23	8.46	214	8.63	10	1.02
9	Trivedi, A.	23	8.46	72	2.90	5	0.34
10	Karandikar, A.	22	8.09	188	7.58	7	0.94
	Total	272	100.00	2480	100.00		

Table 10 shows that, top 10 Indian authors are contribution in the field of wireless network research publications in India. From this study it is identified that, total number of 272 publications are contributed by top 10 authors. Out of that maximum number of 43(15.81%) Publications are published by Tamma, B.R. and has 216(8.71%) citations, h-index is 8 and RCI is 0.55. Followed by Misra, S. 37(13.60%) Publications, 735(29.64%) citations, h-index is 17 and RCI is 2.18. Ramesh, M.V, has 28(10.29%) Publications, 377(15.20%) citations, h-index is 10 and RCI is 1.48, Madhav, B.T.P. has 26(9.56%) Publications, 158 (6.37%) citations, h-index is 7 and RCI is 0.67. Out of the top 10 authors, 5 authors RCI value is more than the world average and remaining 5 authors RCI value is below the world average.

Top 10 Indian Institution contributions, citation and RCI

Table 11 Top 10 Indian Institution Contributions, Citation and RCI

S.No	Name of Indian Institution	No of Publications	%	No of Citations	%	CPP	h-index	RCI
1	Anna University	293	18.66	905	9.73	3.09	13	0.52
2	Vellore Institute of Technology, Vellore	243	15.48	1512	16.25	6.22	20	1.05
3	K L Deemed to be University	167	10.64	470	5.05	2.81	10	0.47
4	Indian Institute of Technology Kharagpur	160	10.19	1473	15.83	9.21	20	1.55
5	Indian Institute of Science, Bengaluru	142	9.04	1054	11.33	7.42	14	1.25
6	Sathyabama Institute of Science and Technology	138	8.79	464	4.99	3.36	8	0.57
7	Indian Institute of Technology, Bombay	119	7.58	1406	15.11	11.82	13	1.99
8	Jadavpur University	115	7.32	480	5.16	4.17	11	0.70

9	Indian Institute of Technology Madras	113	7.20	929	9.99	8.22	16	1.39
10	Indian Institute of Technology Delhi	80	5.10	610	6.56	7.63	12	1.29
Total		1570 (15.7%)	100.00	9303	100.00			

Table 11 shows that, top 10 Indian institution contributions, citation, citation per paper, h-index, and RCI. During the study period, a total number of 1570(15.7%) publications are contributed by the top 10 institutions. Out of that, maximum of 293(18.66%) publications are contributed by Anna University with 905(9.73%) citations, citation per paper is 3.09, h-index is 13, and relative citation index value is 0.52. Followed by Vellore Institute of Technology, Vellore with 243(15.48%) publications, 1512(16.25%) citations, citation per paper is 6.22, h-index is 20 and RCI is 1.05. KL Deemed to be University contributed by the third place with 167(10.64%) publications, 470(5.05%) citations, CPP is 2.81 citation, h-index is 10 and RCI is 0.47. From the top 10 institutions, 6 institutions RCI value is more than the world average, and the remaining 4 institutions RCI value is below the world average in the field of wireless network research publications in India.

Top 10 Indian Journals Contributions, Citation and RCI

Table 12 Top 10 Indian Journals Contributions, Citation and RCI

S.No	Name of Indian Journals	No of Publications	%	No of Citations	%	CPP	h-index	RCI
1	International Journal of Applied Engineering Research	256	16.91	232	6.60	0.91	6	0.39
2	Advances in Intelligent Systems and Computing	211	13.94	330	9.39	1.56	7	0.67
3	Communications in Computer and Information Science	203	13.41	413	11.76	2.03	10	0.88
4	Wireless Personal Communications	170	11.23	1954	55.62	11.49	18	4.95
5	International Journal of Innovative Technology and Exploring Engineering	155	10.24	124	3.53	0.80	4	0.34
6	International Journal of Recent Technology and Engineering	119	7.86	80	2.28	0.67	3	0.29
7	Proceedings of the 2019 Teqip III Sponsored International Conference on Microwave Integrated Circuits Photonics and Wireless Networks Imicpw 2019	112	7.40	26	0.74	0.23	2	0.10
8	Journal of Advanced Research in Dynamical and Control Systems	102	6.74	65	1.85	0.64	4	0.27
9	ACM International Conference Proceeding Series	98	6.47	196	5.58	2.00	6	0.86
10	Lecture Notes in Electrical Engineering	88	5.81	93	2.65	1.06	5	0.46
Total Publications		1514	100.00	3513	100.00			

Table 12 shows that, top 10 Indian Journals contributions and its citations, citation per paper, h-index, and RCI. During the study period, total number of 1514 publications are contributed by the top 10 Journals. Out of that, maximum of 256(16.91%) publications are published by the International Journal of Applied Engineering Research with 232(6.6%) citations, citation per paper is 0.91, h-index is 6 and relative citation index is 0.39. Followed by Advanced in Intelligence Systems and Information Science with 211(13.94%) publications, 330(9.39%) citations, citation per paper is 1.56, h-index is 7 and relative citation index is 0.67. The third-ranking journal is Communications in computer and Information Science published by 203(13.41%) publications, 413(11.76%) citations, CPP is 2.03, h-index is 10 and relative citation index is 0.88. From the top 10 journals, the RCI value is more than the world average for Wireless Personal Communications journal, and the remaining 9 journals RCI value is below the world average.

Publication Efficiency Index (PEI)

The relative research effort is being measured by the Publication Efficiency Index (PEI), based on the references appended to the research articles by the authors. PEI is calculated by the formula used by Guan, J., & Ma, M. (2007)²⁴

$$PEI = \frac{TNC_i/TNC_t}{TNP_i/TNP_t}$$

Where,

TNC_i = total number of references in a year,

TNC_t = total number of references for all the years

TNP_i = total number of papers in a year,

TNP_t = total number of papers for all the years

Table 13 Publication Efficiency Index

Year	No of Publications	No of References	ARPP	PEI
2010	396	5176	13.07	0.82
2011	586	7688	13.12	0.83
2012	457	6648	14.55	0.92
2013	476	7324	15.39	0.97
2014	602	9502	15.78	0.99
2015	903	13779	15.26	0.96
2016	1129	17914	15.87	1.00
2017	1049	18089	17.24	1.09
2018	1400	22431	16.02	1.01
2019	1561	27409	17.56	1.11
2010-2019	8559	135960	15.89	1.00
2010-2014	2517	36338	14.44	0.91
2015-2019	6042	99622	16.49	1.04

(ARPP-average reference per paper)

If the value of PEI is greater than 1, it is indicate that the impact of publications is more than the world average and PEI is less than 1, it is indicate that impact of publications is less than the world average. PEI is calculated by number of reference are used for the selected study period. Table 13 describes the year-wise PEI in the field of wireless network research publications in India. Publication Efficiency Index (PEI) has been calculated during the study period and it is shown in table 13. From the study, it is identified that total number of 8559 publications are used 135960 references. Out of that, a maximum of 1561 publications are used 27409 references and ARPP is 17.56 references, PEI is 1.11 in the year 2019. Followed by 1400 publications are used 22431 references and ARPP is 16.02 references, PEI is 1.01. Further this study identified that 2nd block year of 2015-2019 contributed a maximum of 6042 publications with 99622 references and ARPP is 16.49 references, PEI is 1.04.

Time Series Analysis

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 (2021)²⁵

Table 14 Time Series Analysis of Wireless Network

S.No	Year	Count (Y)	X	X ²	XY
1	2010	396	-5	25	-1980
2	2011	586	-4	16	-2344
3	2012	457	-3	9	-1371
4	2013	476	-2	4	-952
5	2014	602	-1	1	-602
6	2015	903	1	1	903
7	2016	1129	2	4	2258
8	2017	1049	3	9	3147
9	2018	1400	4	16	5600
10	2019	1561	5	25	7805
	Total	8559		110	12464

Table 14 shows that, time series analysis formula has been predicted on wireless network research publications for the year 2025 and 2030

Straight Line Equation is

$$Y = a + bx$$

Here,

$$\sum Y = 8559, \sum X^2 = 110, \sum XY = 12464 \text{ and } N = 10$$

$$a = \sum Y/N = 8559/10 = 855.9 = 856$$

$$b = \sum XY / \sum X^2 = 12464/110 = 113.30 = 113$$

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

$$Y = a + bx$$

$$= 856 + (113*10) = 856 + 1130 = 1986$$

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

$$Y = a + bx$$

$$= 856 + (113*15) = 856 + 1695 = 2551$$

From this study it is identified that, estimated growth value based on a time series analysis statistical application will be expected in wireless network research publications in India for the year 2025 is around are equal to 1986 publications and the year 2030 is around are equal to 2551 research publications. So that time series analysis study confirmed that, the publication growth on wireless network research publications in India is increasing trend.

Major Finding

- ❖ During the study period it is identified that China has contributed maximum number of 18776(18.31%) research publications with top rank. India has placed in third rank with 8559 publications. Out of that, highest number of 1561(18.24%) publications are contributed in the year 2019 with a share of 17.49%.
- ❖ During the study period Indian researchers have collaborated with 914 publications into 74 countries. Out of that most of 252(27.57%) publications are collaborated by the United States.
- ❖ India has published 8559 papers with 25558 citations, CPP is 2.99 in the field of wireless network research publications. Out of that, the highest number of 1561(18.24%) publications are contributed in the year 2019 with a share of 17.49, and the average number of publications per year in India is 856. and compound annual growth rate is 35.98
- ❖ The relative growth rate is 0.91 in the year 2011 and 0.20 in the year 2019. At the same time doubling time is found that 0.76 in the year 2011 and 3.44 in the year 2019. So that this study confirmed that, relative growth rate is decreasing trend and doubling time is increasing trend.

- ❖ During the study period, the maximum number of 5194(60.68%) papers are contributed to the conference paper. Majority of the authors in the field are preferred to publish their research works in two authorship modes with 3903(45.60%) publications and average degree of collaboration is 0.96.
- ❖ From the study, it is identified that CAI for single, two and three authorship contributions are decreasing trend from 1st block year to 2nd block year. At the same time, CAI is increasing trend for more than three authors from 1st block year to 2nd block years.
- ❖ Top 10 Indian authors have been contributed 272 publications. Out of that, the highest number of 43(15.81%) papers are published by Tamma, B.R with 216 citations, h-index is 8 and RCI is 0.55. During the study period, total number of 1570 publications are contributed by top 10 institutions. Out of that, maximum of 293(18.66%) publications are contributed by Anna University with 905 citations, citation per paper is 3.09, h-index is 13.
- ❖ From the top 10 journals, maximum of 256(16.91%) publications are published by the International Journal of Applied Engineering Research with 232(6.6%) citations, citation per paper is 0.91, h-index is 6 and relative citation index is 0.39. From the top 10 journals, the RCI value is more than the world average for Wireless Personal Communications journal, and the remaining 9 journals RCI value is below the world average.
- ❖ From the study it is identified that total number of 8559 publications are used 135960 references. Out of that, a maximum of 1561 publications are used 27409 references and average reference per paper is 17.56 references, PEI is 1.11 in the year 2019.
- ❖ Time series analysis study will be expected in wireless network research publications in India for the year 2025 is around are equal to 1986 publications and the year 2030 is around are equal to 2551 publications.

Conclusion

The recent year's wireless network research is increased day by day using various aspects and innovations. Wireless internet technologies deserve the particular attention, not only because of their importance to the development process, but also because of its ability to reduce the costs of providing ICT access and ICT - enabled services to underserved areas. During the study period it is conclude that, developed countries are doing many more research activities in the field of a wireless networks research. Further, this study concludes that developing countries are also will do the many more research and provide the better service in the field of wireless networks research activities.

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