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Applicability of Lotka's Law on the Authors of Annals of Library and Information Studies

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Abstract: In the contemporary landscape of academia, bibliometric studies have emerged as indispensable tools for evaluating the impact of scholarly publications and tracing the evolution of knowledge. The present study focused on a detailed bibliometric study on the authors of Annals of Library and Information Studies. Emphasis was given to the most fertile author of Annals, the top ten authors of Annals, and the collaboration pattern of research. It was also attempted to find out which institution and which country produce the largest number of articles in this reputed journal and last but not the least whether Lotka's law is applicable to the authors of Annals. This bibliometric study analyzes authorship trends in the *Annals of Library and Information Studies* from 2012 to 2021, based on 316 articles. Key findings include B.K. Sen as the most prolific author and CSIR-NISTADS as the top contributing institution. The study highlights a preference for collaborative research, with most publications coming from India and limited contributions from other countries. Lotka's Law was found to be inapplicable to the authors of the journal. Data analysis was conducted using the Kolmogorov-Smirnov test.

Keywords: Bibliometrics, citation study, k-s test, lotka's law

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1. Introduction

Bibliometric is the statistical analysis and content analysis of scholarly journals, books, and research papers. The quantitative impact of a given publication is appraised by measuring the number of times that particular work is cited by other resources. By the implication of bibliometric, we can understand the influence or impact of work on the rest of the related literature. From this study, we measure an author's productivity, institutional productivity and so on. Author productivity describes the frequency of publication by authors in any given field. It states that the number of authors making contributions in a given period is a fraction of the number making a single contribution. On the other hand, institutional productivity refers to the counting of publications in a given period of time. It is the cumulative number of publications written by different authors, affiliating with the same institution.

2. Objectives

- 2.1 To identify the most prolific author and most productive institution of *Annals* in the last ten years.
- 2.2 To study the collaboration/ authorship pattern and to test Lotka's law on the authors of *Annals*.
- 2.3 To find out country-wise research productivity in the last ten year

3. Review of Related Literature

Garg and Tripathi (2018) conducted a bibliometric study of 902 papers published by Indian scholars from 1995 to 2014. The study indicated that the share of theoretical studies using mathematical and statistical techniques, which was missing in the earlier period (1970–1994), had increased from 1995–2014. Among all subject fields, medicine received the highest attention. Jahina, Batcha, and Ahmad (2020) explored author productivity in the field of brain concussion research and found that the collaborative index from 2008 to 2017 was 0.18. The article established that, in the field of brain concussion research, the applicability of Lotka's Law was fairly good. Sen (2010) conducted a conceptual study on Lotka's Law, providing a framework for determining the values of c and n .

Nath and Jana (2020) focused on a bibliometric analysis from 2008 to 2018, calculating measures of authorship such as the Degree of Collaboration (DC), Collaborative Index (CI), and Collaborative Coefficient (CC). Tunga (2020) conducted a citation study to test the applicability of Lotka's Law to the publications of horticulture scientists at Bidhan Chandra Krishi Viswavidyalaya (BCKV) and Uttar Banga Krishi Viswavidyalaya (UBKV).

A Kolmogorov-Smirnov (K-S) test was used to determine the extent to which author productivity conforms to Lotka's Law. The study found that Lotka's Law did not fit the literature on horticulture.

Ahmad and Batcha (2019) tested Lotka's Law on authorship productivity in artificial intelligence (AI) to confirm its applicability to a dataset from 2008–2017. The study indicated a high multi-authorship pattern, with an average of 3.31 authors per paper.

Chaturbhuj and Batcha (2020) conducted research in the field of thermodynamics from 2015–2019 to test the applicability of Lotka's Law. They applied the Kolmogorov-Smirnov (K-S) test to thermodynamics research data and found that Wang, J., with 159 articles, was the most productive author, while the *Journal of Molecular Liquids* was the most productive journal, publishing 547 articles. The study concluded that international collaboration was highest with various countries.

Sudhier (2013) performed a conceptual study to examine authorship distribution in physics literature and evaluated the applicability of Lotka's Law to scientific publication productivity. Using the K-S statistical test and Chi-Square test, the study revealed that Lotka's Law did not fit the authors of the physics literature

Sevukan and Sharma (2008) conducted a detailed analysis to examine the research performance of biotechnology faculties at Central Universities in India from 1997 to 2006. The collected data were analyzed using bibliometric techniques. The study revealed a steady growth in biotechnology literature, increasing from 15 articles in 1997 to 43 articles in 2006. Using the test square method, the applicability of Lotka's Law was clarified with the values $n=2.12$, $C=0.669$, and $D=0.027$.

Ahmed and Rahman (2009) investigated the applicability of Lotka's Law to authorship distribution in the field of nutrition research in Bangladesh. Articles on nutrition research published from 1972 to 2009 in Bangladesh were collected for analysis. Generalized, modified, and K-S tests were used to examine the applicability of Lotka's Law. They found that Lotka's generalized inverse square law did not fit nutrition research; however, using least squares excluding highly productive authors and maximum likelihood methods, Lotka's Law was applicable to nutrition research in Bangladesh

Senthilkumar and Kumar (2019) investigated the scientific productivity patterns of authors in the field of astronomy and astrophysics research in India, as well as the applicability of Lotka's Law in this domain. For their study, data from 6,363 papers authored by 2,719 individuals during 2013–2017 were analyzed..

The study revealed that productivity distribution did not conform to Lotka's Law in either its generalized or original form.

Naqvi and Fatima (2017) evaluated the applicability of Lotka's Law to international business literature using data from 11,202 references included in research articles published in the *Journal of World Business* during 2012–2014. Their findings showed that Lotka's Law was applicable to international business literature, as confirmed through Chi-Square and K-S statistical tests.

Naheem, Sivaraman, and Saravanan (2019) investigated the conformity of Lotka's Law to authorship distribution in the field of parasitology, using data collected from Scopus between 2007 and 2016. A total of 5,792 articles published by 3,473 unique first authors were analyzed. Lotka's Law was examined in both its generalized and modified forms using the formula $x^ny = c$ and $y = cx^n$, and the values of the exponent n and constant c were calculated. K-S and Chi-square tests were applied, and the study found that Lotka's Law is applicable to the authorship productivity distribution pattern in parasitology literature.

Naheem and Saravanan (2019) also investigated the applicability of Lotka's Law to scientific publication productivity on Bell's palsy disease from 2004 to 2018. Data were collected from the Web of Science database, encompassing 4,039 articles and 3,384 authors using the straight count method and 14,517 authors with the complete count method. The K-S goodness-of-fit statistical test was applied, and the results revealed that Lotka's Law is applicable to the data using the straight count method, but not to the complete count authorship. Therefore, the study concluded that Lotka's Law is partially applicable to Bell's palsy literature.

Jalal (2019) investigated research collaboration between India and Bangladesh based on 1,156 papers published by both countries from 1991 to 2017. Data were gathered from the Web of Science, and a collaboration network based on co-authorship and co-occurrences was established using the Bibliometrix R package. VOS viewer was used to create network maps highlighting collaborative zones with respect to authors, subjects, and keywords. The study found that the major collaborations occurred in medical science, followed by agriculture and biological sciences. Verification of Lotka's Law was performed using the *lotka()* function in the Bibliometrix R package, and the study concluded that Lotka's Law remains applicable to international co-authorship data.

Jeyshankar, Rao, and Vellaichamy (2014) conducted a quantitative study of the productivity, characteristics, and aspects of food and nutrition research in India. Data were collected from the SCOPUS database, focusing on the academic productivity of food and nutrition scientists in India from 1960 to 2011. A total

of 1,291 Indian contributions were considered. The study highlighted regular publications from scientists in New Delhi, Andhra Pradesh, Karnataka, and Tamil Nadu. It was found that food and nutrition output was influenced by two-authored papers. Additionally, the study examined relative growth rates, doubling time, authorship patterns, co-authorship patterns, highly prolific authors, productive institutions, and preferred journals among Indian scientists.

Sharma (2021) investigated the digitization status and variations in services provided to users in twenty-two heritage and modern libraries in the Jammu province of Jammu & Kashmir. Data were retrieved from various institute and library websites. The study found that the majority of libraries housed unique collections of manuscripts and historical documents that are necessary to preserve for future generations. However, only a few libraries had initiated digitization efforts in this regard.

4. Methodology

The Publication data has been collected from archives of *Annals of Library and Information Studies*. At first archives of this journal have been searched within the time frame of 2012 to 2021. All publication data from 2012 -21 were collected and extracted into an Excel sheet. Collaborative authors were extracted one by one and all authors were given the same weightage. Citations of both authors and institutions were analyzed according to their frequency of occurrence. The degree of collaboration is calculated by Subramanyam's Law. The law is as follows

DEGREE OF COLLABORATION

The degree of collaboration of authors can be calculated according to the law suggested by Subramanyam (1983)

$$C = N_m / (N_m + N_s) \dots \dots \dots (1)$$

Where

C = degree of collaboration

N_m = number of multi-authored research articles/ books, N_s = number of single-authored research articles/books

LOTKA'S LAW

Applicability of Lotka's Law on the authors of *Annals*, is calculated by the law of Lotka. The law is as follows

$$X^n Y = C \dots \dots \dots (2)$$

Where X = Number of publications; Y = number of authors

N=2 (according to Lotka)

C=constant (to be calculated)

Calculation of n

The formula of exponent n is given below

$$n = (N \sum XY - \sum X \sum Y) / \{ N \sum X^2 - (\sum X)^2 \}$$

Where N = number of data.

X = log of x i.e. number of publication Y = log of y i.e. number of authors

Calculation of C

The value of C is calculated by the formula as

$$C = \frac{1}{\sum_{p=1}^{p-1} \frac{1}{n^2} + \frac{1}{(n-1)(p-1)} + \frac{1}{2p^n} + \frac{n}{24(p-1)^{n+1}}}$$

KOLMOGOROV-SMIRNOV

The k-S test is a statistical test of goodness of fit to determine the difference between the observed and theoretical distribution of authors' productivity (Cole 366). The maximum difference between observed and cumulative frequency is calculated by the following formula

$$D_{\max} = F_0(x) - S_n(x)$$

$F_0(x)$ = theoretical cumulative

frequency $S_n(x)$ = observed

cumulative frequency

The test has been done at the 0.05 or at 0.01 level of significance. But when the size of sample is greater than 35, the value of critical significance is calculated by the

$$\frac{1.36}{\sqrt{y}} \text{ [At 0.05 level of significance]}$$

$$\frac{1.63}{\sqrt{y}} \text{ [At 0.01 level of significance], where } y \text{ is the number of population}$$

4.1 Scope of the Study

In order to carry on the research the data has been taken from Annals archive for the period often years starting from 2012 to 2021. The total number of articles selected for the study was 316.

5. Data Analysis

After the collection of data, an analysis has been done according to the objectives of the project. Firstly, the authors' contribution has been analyzed and next to that Lotka's law has been tested on the authors of Annals. After testing Lotka's law, the institution's contribution has been assessed. And lastly country-wise distribution has been examined. Total data analysis has been presented by tables and figures which are as follows:

5.1 Prolific Authors Contributing Five and More than Five Articles

In this part, most contributing authors of Annals have been focused. Here all the authors who have five or more articles have been taken into account.

Sl. No.	Name of the Author	Number of Articles	% of articles
1	B K Sen	14	4.43
2	K.C.Garg	12	3.80
3	ParthaPratim Ray	8	2.53
4	B.M. Gupta	6	1.90
5	BharviDutt	6	1.90
6	Bidyarthi Dutta	6	1.90
7	H.K.Tripathi	6	1.90
8	Siladitya Jana	6	1.90
9	Suresh Kumar	6	1.90
10	K G Pillai Sudhier	5	1.58
11	Manoj Kumar Verma	5	1.58

Table 1: Most Prolific Authors of Annals Journal

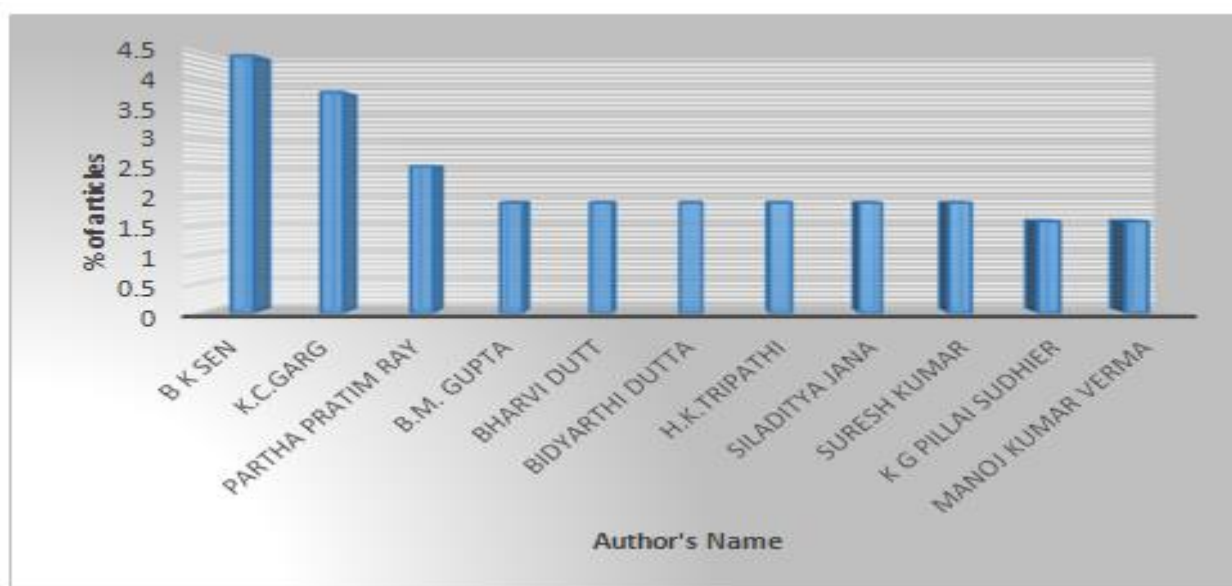


Figure 1: Authors contributing five and more than five articles

Table 1 and Figure 1 show that B.K. Sen is the highest contributing author of *Annals*. He contributed 14 articles in the last 10 years which is 4.43 % of the total number of articles. The next highest contributing author is K. G. Garg who contributed 12 articles and which is 3.8% of the total contribution. The third contributing author is Partha Pratim Roy who contributed 8 articles which is 2.53% of the total contribution. B. M Gupta, Bharvi Dutta, Bidyarthi Dutta, H. K. Tripathi, Siladitya Jana and Suresh Kumar each contributed 6 articles which is 1.90% of the total contribution. K. G. Sudhier and Manoj Kumar Verma each contributed five articles and which is 1.58 % of total contribution.

5.2 Application of Lotka's Law on the Authors of *Annals*

Lotka's Law

Lotka's law describes the author productivity. In 1926 Alfred J Lotka a statistician of Metropolitan Life Insurance Company, USA wanted to study the people's contribution in the progress of science. In this context he consulted the index of Chemical Abstract during 1907 to 1916. After the study he found that the author's productivity can be written in a simple equation. According to him "the number (of authors) making n contribution, which make single contribution is about 60%". It means among all the authors in a subject 60% author publish only one article, 15% publish two article and 7% publish 3 articles and so on. About 6% authors in a subject publish more than ten articles. The law is also called as 'inverse square law' that means there is an inverse relation between number of authors and number of publication.

The equation of Lotka's Law is

$$x^n y = c$$

Where x= number of article

y= number of authors and c= constant and n= 2

according to Lotka in most of the cases.

Calculation of Lotka's Law:

According to Lotka the formula is

$$X^n Y = C$$

Where X= Number of publications Y=

number of authors

N= 2 (according to lotka)

C= constant (to be calculated)

Calculation of n

The formula of exponent n is given below

$$n = (N \sum XY - \sum X \sum Y) / \{ N \sum X^2 - (\sum X)^2 \}$$

Where N= number of data.

X= log of x i.e. number of publication Y=log of y i.e. number of authors

Calculation of c:

$$c = \frac{1}{\sum_{i=1}^{p-1} \frac{1}{x^2} + \frac{1}{(x-1)(p^{x-1})} + \frac{1}{2 \cdot p^x} + \frac{x}{24(p-1)^{x+1}}}$$

$$c = \frac{1}{\frac{1}{-1.23^2} + \frac{1}{(-1.23-1)(20^{-1.23-1})} + \frac{1}{2 \cdot 20^{-1.23}} + \frac{1}{24(20-1)^{-1.23+1}}}$$

$$c = \frac{1}{1.51 + 2.23 \cdot 797.7 + 0.0251 + 4.088}$$

$$c = \frac{1}{1.51 + 1778.87 + 0.0251 + 4.088}$$

$$C = 1/1784.63 = .0005$$

Kolmogorv-Smirnov (k-s) Test

To verify that the observed distribution of author productivity fits the estimated distribution, he suggested applying the non-parametric Kolmogorov-Smirnov (K-S) goodness-of-fit test. To this end, the maximum difference between the real and estimated accumulated frequencies was

calculated, and this value was then compared with the critical value (c.v.) obtained from the following equation:

$$c.v. = 1.63 / \{ \sum Y_x + (\sum Y_x / 10) \}^{1/2} \dots \dots \dots (4)$$

D = Dmax = Differences between the columns of the observed and expected cumulative frequencies

$$= \sum f(x) - \sum (y_x / \sum y_x)$$

Calculation of exponent n:

The formula to calculate the slope of α the exponent is given as follows

Calculation of n:

Number of Articles (X)	No. of Author (Y)	X=logx	Y=logy	XY	X ²
1	185	0	2.26	0	0
2	85	0.301	1.92	0.57792	0.090601
3	15	0.477	1.17	0.55809	0.227529
4	14	0.602	1.14	0.68628	0.362404
5	2	0.698	0.301	0.210098	0.487204
6	6	0.778	0.77	0.59906	0.605284
8	1	0.9	0	0	0.81
12	1	1.07	0	0	1.1449
14	1	1.46	0	0	2.1316
		6.286	7.561	2.631448	5.859522
		$\sum X$	$\sum Y$	$\sum XY$	$\sum X^2$

$$n = \frac{9 \cdot 2.63 - 50.11}{9 \cdot 5.8 - 6.28^2}$$

$$n = \frac{23.63 - 50.11}{4811.13 - 4789.74}$$

$$n = \frac{-26.48}{21.39}$$

$$n = -1.23$$

K-S test for the Authors of Annals

No. of Author s(y)	$y_x/\Sigma y_x$	$\Sigma(y_x/\Sigma y_x)$ (Observed)	$1/x^n$	$F_x=C(1/x^n)$,c=0.0005	ΣF_x (Expected)	D=
185	0.596774	0.596774	1.00	0.0005	0.0003	0.596274
85	0.274194	0.870968	0.42	0.00021	0.00051	0.870758
15	0.048387	0.919355	0.25	0.000125	0.000635	0.91923
14	0.045161	0.964516	0.18	0.00009	0.000725	0.964426
2	0.006452	0.970968	0.13	0.000065	0.00079	0.970903
6	0.019355	0.990322	0.11	0.000055	0.000845	0.990267
1	0.003226	0.993548	0.077	0.0000385	0.000884	0.99351
1	0.003226	0.996774	0.04	0.00002	0.000904	0.996754
1	0.003226	1	0.03	0.000015	0.000919	0.999985

After calculating the exponent n and c we conclude that the value of n is 1.23 and the value of c is 0.0005. After putting the value of n and c , k-s test has been done to test the applicability of Lotka's law.

From the table $D_{\max}=0.999$

According to K-S test the critical value $c.v=1.63/\{\Sigma Y_x + (\Sigma Y_x/10)\}^{1/2}$
 $=0.56$

Here $D_{\max}$ is greater than the K.S Critical Value then we can say that the Lotka's Law is not applicable on the author productivity of the authors of Annals.

5.3. Institution-wise Distribution of Articles

Institution-wise distribution of articles within a regime of the research field is an important issue to map the productivity of the institutions as a whole in that particular area of research. Herein, we focus on the institution-wise articles in the journal Annals which reveal a clear idea about the

institutional contribution.

Sl. No	Name of the Institution	% of Articles	No. of Articles
1	CSIR-National Institute of Science Technology and Development Studies	6.33	20
2	University of Delhi	5.70	18
3	Banaras Hindu University	4.75	15
4	Indira Gandhi National Open University	3.80	12
5	University of Calcutta	3.80	12
6	Vidyasagar University	3.48	11
7	Jawaharlal Nehru University	2.85	9
8	Visva-Bharati, Sriniketan	2.85	9
9	Indian Institute of Science Education and Research, Kolkata	2.53	8
10	Mizoram University	2.53	8
11	University of Colombo, Sri Lanka	2.53	8
12	University of Kashmir	2.53	8
13	Indian Statistical Institute, Kolkata	2.22	7
14	University of Mysore	2.22	7
15	Jadavpur University	1.90	6
16	Kuvempu University, Shivamogga	1.90	6
17	SavitribaiPhule Pune University	1.90	6
18	Tshwane University of Technology, Pretoria, Republic of South Africa	1.90	6
19	University of Port Harcourt, Nigeria	1.90	6
20	CSIR-National Institute of Science	1.58	5
21	CSIR-National Institute of Science Communication and Policy Research	1.58	5

22	Raman Research Institute, Bangalore	1.58	5
23	University of Kerala	1.58	5
24	other institutions publish 4 or less than 4 article	36.08	114

Table2: Institution-Wise Distribution of Articles

Table 2 reflects that CSIR-National Institute of Science Technology and Development Studies is the highest contributing institution which contributed 20 articles during 2011-2021 and this is 6.33% of total articles. Next, highest contributing institution is the University of Delhi which contributed 18 articles and 5.70% of the total articles. Banaras Hindu University and Indira Gandhi National Open University hold the third and fourth positions respectively publishing 15 and 12 articles during the period. The rest of the institution published less than 12 articles.

5.4. Authorship Pattern

In this section authorship pattern has been analyzed. Here author's contribution by solo or group has been studied. It indicates the preferences of single or multiple authors' articles.

Table3: Authorship Pattern

Number of Authors	Number of Articles	% of Articles
Double Author	162	51.27
Single Author	107	33.86
Multiple Author	47	14.87
Total	316	100.00

Table3: Authorship Pattern

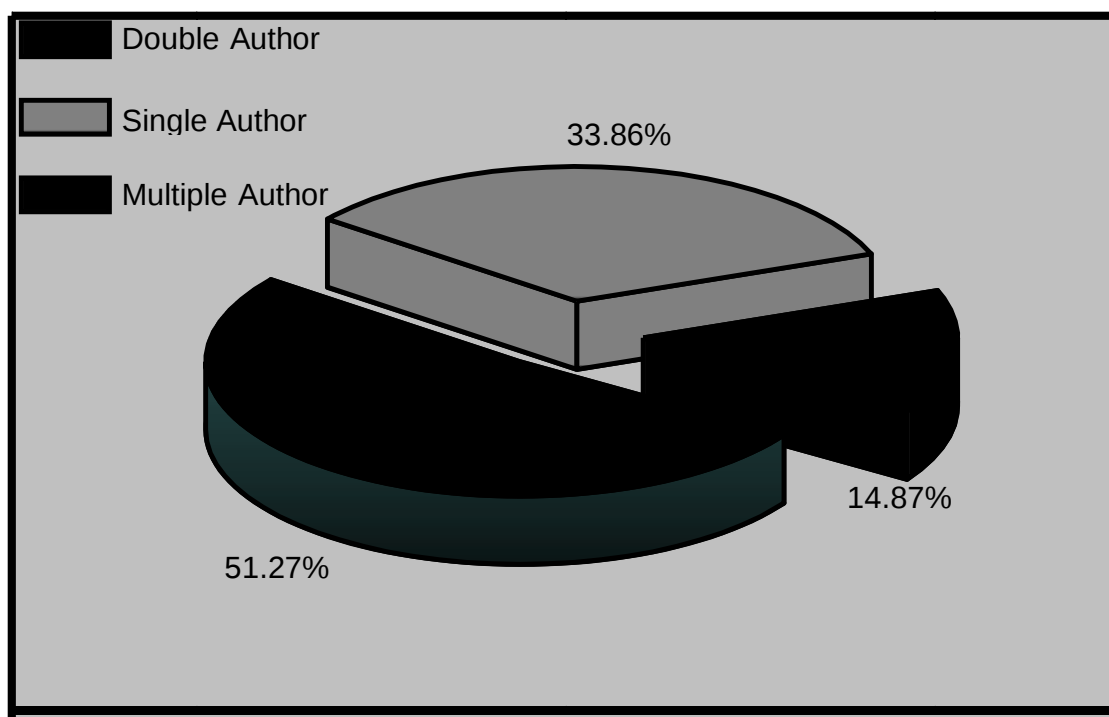


Fig3: Authorship Pattern

Table 3 and Figure 3 show that the number of articles written by two authors, in the journal of *Annals*, is the highest in number and it is 162 articles which is 51.27% of total articles. Next, 107 articles are single authored articles which is 33.86% of total articles. Multiple- author- article that means articles having more than 2 authors is 47 in number which is 14.87% of total articles.

5.5. Degree of Collaboration

Degree of collaboration of authors can be calculated according to the law as suggested by Subramanyam (1983)

$$C = N_m / (N_m + N_s)$$

Where,

C = degree of collaboration,

N_m = number of multi-authored research articles/ books N_s =

number of single-authored Research article/books

Here from the study, it is found that $C = 209 / 316 = 0.66$

From the above equation, it is cleared that degree of collaboration of articles in *Annals* tends to be 1 which means collaborative research is preferable to solo research.

5.6. Country-Wise Distribution of Articles

The country-wise contribution of publication in the journal *Annals* is important and interesting

parameter to study. It reflects the international impact, acceptability, and success of the journal itself.

Sl.No	Country	No. of Articles	% of Article
1	India	251	79.43
2	Nigeria	19	6.01
3	Sri Lanka	13	4.11
4	Iran	10	3.16
5	South Africa	6	1.90
6	Bangladesh	4	1.27
7	Brazil	2	0.63
8	Sudan	2	0.63
9	United States of America	2	0.63
10	Kazakhstan	1	0.32
11	Poland	1	0.32
12	Portugal	1	0.32
13	Solan	1	0.32
14	Spain	1	0.32
15	Tanzania	1	0.32
16	Turkey	1	0.32

Table4: Country-wise Distribution of Articles

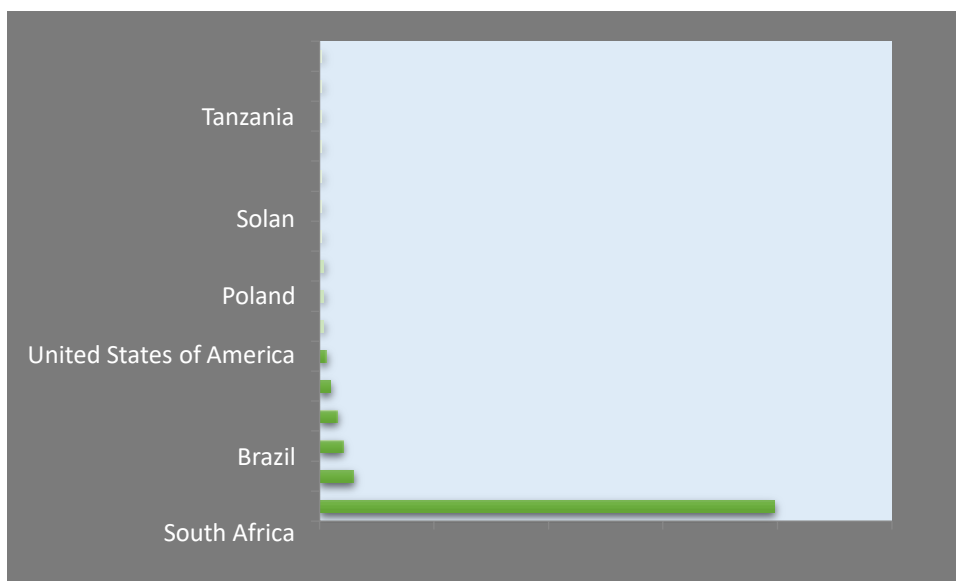


Fig4: Country-wise Distribution of Articles

Table 4 and Figure 4 show that India published a maximum number of articles (251) in the Journal of Annals during 2012-21, which is 79.43% of total publishing articles. Nigeria and Sri Lanka are the second and third-highest countries contributing 19 and 13 articles respectively. The rest of the country published less than 13 articles which is less significant. The data table reveals that the journal Annals is mostly contributed by Indian authors and the foreign contribution is altogether around 20 % which is very less.

6. Findings and Conclusion

The present study reflects that B. K. Sen, is a highly productive author, followed by K.C. Garg (12 articles, 3.8%) and Partha Pratim Roy (8 articles, 2.53%). B. M. Gupta, Bharvi Dutta, Bidyarthi Dutta, H. K. Tripathi, Siladitya Jana, and Suresh Kumar each contributed 6 articles which is 1.90% of the total contribution. K. G. Sudhier and Manoj Kumar Verma each contributed five articles which is 1.58 % of the total contribution.

After studying the authors' contributions, Lotka's law has been tested on the authors of Annals and it is found that Lotka's law is not applicable due to insufficient data.

Next, institution-wise distribution of articles has been assessed and it reflects that CSIR-NISTADS leads institution-wise contributions (20 articles, 6.33%), with the University of Delhi (18 articles) and Banaras Hindu University (15 articles) following. Indira Gandhi National Open University hold the fourth position publishing 12 articles during the period. The publications of other institutes are very meager. Next, the study reveals that Double-authored articles were most common, indicating high collaboration. India contributed 79.43% of articles (251), with limited foreign contributions (~20).

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