LIS Links Newsletter, Vol. 11, No. 1, 2025
ISSN (Online): 2454-3462
Website: http://newsletter.lislinks.com

Author Productivity and Application of Lotka's Law on Deforestation Research Publications

K. Kanipriyan
Assistant Librarian, Adhiyamaan College of Engineering, Tamil Nadu, India
Email: kanipriyan112003@gmail.com.

E. Deepa
Assistant Librarian, AVS College of Arts and Science (Autonomous), Tamil Nadu, India
Email: deepasunelangoo1104@gmail.com.

G. Kannan
Assistant Librarian, Adhiyamaan College of Engineering, Tamil Nadu, India
Email: peterganan2@gmail.com.

Received: *11 November, 2025.* ***Revised:*** *1 December, 2025.* ***Accepted:*** *19 December, 2025*

Abstract

Purpose: *The purpose of this study is to analyze the global research trends in deforestation research through a scientometric approach. The study aims to identify publication growth, authorship patterns, collaboration trends, language distribution, country-wise contributions, and growth indicators in deforestation literature published between 2020 and 2024.*

Design/Methodology/Approach: *The study adopts a quantitative scientometric research design. Data were retrieved from the Web of Science (WoS) core collection database for the period 2020–2024. A total of 8,928 records were extracted and analyzed using Bibexcel for bibliographic data processing and VoSviewer for visualization of collaboration and research patterns. Indicators such as year-wise publication output, author productivity, co-authorship pattern, degree of collaboration, relative growth rate (RGR), doubling time (DT), document type, language, and country-wise distribution were used for analysis. Lotka's Law of Scientific Productivity and Zipf's Law of word occurrence were applied to test author and word productivity.*

Findings: *The findings reveal a steady growth in deforestation research during the study period, with the highest number of publications recorded in 2021 (21.94%). The Relative Growth Rate (RGR) increased from 0.67 in 2021 to 1.76 in 2024, indicating accelerating research output. The United States emerged as the leading contributor with 2,398 publications. Most of the retrieved documents were journal articles (8,928), and English was the dominant language with 8,837 publications. Authorship analysis showed that Aragão, L. E. O. C. was the most prolific author with 45 publications, and a high degree of collaborative research was observed globally.*

Research Limitations: *The study is limited to publications indexed only in the Web of Science database, excluding other major databases such as Scopus, Dimensions, or Google Scholar. The analysis is confined to a five-year period (2020–2024) and does not include citation impact indicators such as h-index or normalized citation scores.*

How to Cite this Article
Kanipriyan, K., Deepa, E. & Kannan, G. (2025). Author Productivity and Application of Lotka's Law on Deforestation Research Publications. *LIS Links Newsletter*, 11(1), 36-54. http://newsletter.lislinks.com

Practical Implications: *The results provide valuable insights for researchers, environmental scientists, policymakers, and librarians by identifying key contributors, dominant countries, and publication trends in deforestation research. The findings can assist in collection development, research planning, collaboration strategies, and policy formulation related to environmental sustainability and forest conservation.*
Originality/Value: *This study contributes original value by offering a comprehensive scientometric mapping of deforestation research for the recent five-year period using established bibliometric indicators and visualization tools. The application of Lotka's Law and Zipf's Law strengthens the empirical assessment of author and keyword productivity, enriches the existing literature by highlighting growth dynamics, collaborative patterns, and geographical distribution of deforestation research.*
Keywords: *Scientometric Analysis, Deforestation, Web of Science, Bibexcel, VOSviewer, Lotka's Law, Zipf's Law, Relative Growth Rate, Degree of Collaboration, and Environmental Research.*

1. Introduction

Deforestation, a critical environmental issue, refers to the clearing, removal, or thinning of forests, often resulting in the conversion of forested land to non-forested uses such as agriculture, urban development, or industrial purposes. According to a study by Lucht et al. (2006), the number of peer-reviewed publications on deforestation grew exponentially from the 1980s onward, largely driven by advancements in satellite technology, remote sensing, and geographic information systems (GIS). A scientometric analysis by Rodrigues et al. (2019) highlights that countries like Brazil, Indonesia, and the Democratic Republic of Congo account for a substantial proportion of deforestation studies, reflecting the severity of forest loss in these areas. The term "deforestation" has been defined and interpreted in diverse ways, reflecting the complexity and multidimensionality of the issue. A widely cited definition is provided by the Food and Agriculture Organization (FAO), which describes deforestation as the "conversion of forest to other land uses, whether human-induced or natural, with no prospects of re-establishment in the short or medium term." Kaimowitz and Angelsen (1998) provide a socio-economic perspective, defining deforestation as "the clearing of forests to make way for agricultural expansion, infrastructure development, and urbanization. Similarly, Geist and Lambin (2002) analyze deforestation through a lens of proximate and underlying causes, arguing that deforestation results from complex interactions between direct factors (e.g., logging and agriculture) and indirect drivers (e.g., economic policies and population growth). According to a landmark study by Hansen et al. (2013), tropical deforestation accounts for approximately 10% of global carbon emissions, making it a significant contributor to global warming. Scientometric analysis reveals several emerging trends in deforestation research. Studies increasingly focus on the role of technology, such as satellite imagery and machine learning, in monitoring forest loss. Research by Bebbington et al. (2018) highlights the importance of integrating local knowledge and participatory approaches to mitigate deforestation and promote reforestation. The United Nations' Sustainable Development Goals (SDGs), particularly Goal 15 (Life on Land), have galvanized international efforts to combat deforestation.

2. Review of Literature

Aleixandre-Benavent, et. al analysed that a bibliometric and social network analysis of publications from the Web of Science database, the primary goal of this study was to analyze research themes, scientific productivity, international collaboration, and the most cited papers on deforestation. Ecology, Environmental Studies, and Environmental Sciences were the most productive topic areas. A total of 458 journals published the publications. There were 2051 research articles in all. "Land use change," "conservation," "climate change," "rain forests," and "reducing emissions from deforestation and degradation" are the primary issues linked to deforestation. Economic and social issues receive little attention. The triangle comprising the United States, Brazil, and the European Union, among others, has been characterized as an essential level of international collaboration.

Tunga (2021) to ascertain the applicability of Lotka's law and author productivity in the economic literature, the current study will examine the citation pattern of Economica, New Series as a source journal. Research in all areas of economics is the focus of this worldwide publication. The article comprises 8347 citations that are appended to 302 publications that were published between 2007 and 2016 in volumes 74, number 393, and 83, number 432. The results show that there were 8347 citations in 302 articles in 10 volumes (40 issues) of Economica, New Series, with an average of 208.675 citations per issue. Journal articles account for 5328 (63.831%) citations, with books coming in second with 2211 (26.489%). Of the 5328 journal citations, 1013 (19.013%) citations are from single-authored journals, and 4315 (80.987%) citations are from multi-authored journals. Lotka's law is not appropriate for the economic literature of author productivity distribution.

Pal and Bhattacharjee (2022) carried out a study on research shows that the literature has grown steadily over this time, with an average annual growth rate of 30.53% and an average of 1232 citations per document. Additionally, 10649 numbers in all are discovered. The authors employ a variety of keywords. There is a total of 13579 writers in this study, of whom 111 are solo authors, 5.55 are coauthors per document, and 38.1% are international coauthors. According to the study's findings, the journal "Sustainability (Switzerland)" is the leading contributor in the field of environmental research, and the most popular subjects were plastic, microplastic, COVID-19, and environmental contamination.

Pratiwi, Ibrahim, and Alkarimah (2024) aims to identify the pattern of author production in the subject of library science in the Library Science Journal Q1, which is indexed by Scopus, using Lotka's law. A bibliometric technique was used in conjunction with the quantitative descriptive method to investigate several facets of scientific literature. According to the study's findings, there were 61 library science journals that Scopus Q1 has indexed. The number of n was 1,717 and the value of C was 0,518 according to the examination of Lotka's law computations. The productivity equation for SCOPUS-indexed writers in Library Science journals from 2018 to 2022 was 0.518, meaning that 51.84% of authors contributed to the publication of one article. Furthermore, the analysis's findings indicate that Dmax was 0.280 with a critical value of 0.009.

Wahyudi and Junaedi (2025) tries to identify the writer production trend in the Edulib journal using Lotka's law. Articles published in the Edulib journal between 2011 and 2021 are the subject of this study. There were 166 articles total, written by 206 different authors. The number of writers determined is 127 because there are 79 second authors. The parameter values n and C are 2.6895 and 0.7985, respectively, according to the computation results. This indicates that 79.85% of all writers contributed one article between 2011 and 2021.

Radhakrishnan and Baskaran (2019) collected 13215 records from 2014 to 2018 from SCOPUS online database. This study focuses mostly on writing productivity, Pareto's 80/20 rule, Price square root law, and the applicability of Lotka's law. In the examination of Lotka's law, the Chi square value is 225.65, which is greater than the table value. According to Price square Root Law, the square root of all authors, who have contributed 7.94% of the total, is 255.52. According to Pareto's 80/20 guidelines, just 46.60% of the overall contribution was made by 20% of the authors.

Thamaraiselvi Lakshmi and Manthiramoorthi (2023) examine the the application of scientometric indicators on author productivity in the Scientometrics journal. From 2012 to 2021, information was gathered from the dimension database. Scientometric indicators include Lotka's law, Price's square root law, Pareto's 80/20 laws, most impact authors, most cited authors, and most referenced sources. Over the course of the study, 2500 papers were published in the Scientometrics journal. According to the study, the average year of the document is 4.99, the average number of citations per document is 14.48, the average number of citations per year per document is 2.22, and the average number of references referenced in the documents is 41153, with 299 single-authored documents and 3673 multi-authored documents. The scientometric journal featured 7119 (3972) writers in total. Additionally, 0.629 documents per author, 1.59 authors per document, 2.85 co-authors per document, and 1.82 collaboration index were found. The most impact author is Abramo G contributed 17 papers with h index (12), g index (17), m index (1.091) and total citations (332). With 307 citations overall, Bornmann L. is the most referenced author in the Scientometrics journal. The Scientometrics Journal (18084) has the most referenced articles and is ranked top. Additionally, the analysis found that while Price's square root rule and Pareto's principle do not suit the data set, Lotka's law does fit the sample.

The application of quantitative metrics to evaluate journal and author performance has gained traction in Indian LIS research. Halder and Mondal (2022), writing in the LIS Links Newsletter, conducted a comparative bibliometric analysis of the Journal of the Indian Library Association and the IASLIC Bulletin. Their work emphasizes the importance of mapping authorship patterns and research trends to understand the evolution of academic disciplines, a methodology that this study extends to the field of Deforestation.

3. Objectives

i) To analyze the year-wise distribution of publications on deforestation research.

ii) To identify the document-wise distribution of publications on deforestation research.

iii) To examine the country-wise distribution of the publications in deforestation research.
iv) To analyze the authorship pattern of the publications.
v) To test Lotka's Law of Scientific Productivity in deforestation research.
vi) To apply Zipf's Law of word occurrence and Karl Pearson's correlation coefficient to the collected data.

4. Methodology

The present study adopts a quantitative scientometric research design to analyze research publications on deforestation. The required data were collected from the Web of Science Core Collection database published by Clarivate Analytics for the period 2020-2024. A total of 8,928 publications were retrieved using a basic keyword search strategy with the term "Deforestation." The collected data were analyzed using Bibexcel for bibliographic data processing and VoSviewer for visualization of collaboration and research patterns. Various Scientometric indicators such as year-wise publication output, author-wise distribution, document type, language-wise distribution, and country-wise distribution were examined. Author productivity was analyzed by applying Lotka's Law of Scientific Productivity, and its validity was tested using the Kolmogorov-Smirnov (K-S) goodness-of-fit test. In addition, Zipf's Law of word occurrence was applied to analyze keyword frequency, and Karl Pearson's correlation coefficient was used to examine the relationship between the number of authors and publications. For testing Lotka's Law, individual author names were extracted from the Web of Science records, and the frequency of publications per author was computed using Bibexcel before applying the Lotka's Law distribution.

5. Analysis and Discussion

Table 1 presents the year-wise distribution of research publications on deforestation. The year 2021 recorded the highest number of publications, totaling 1,959, followed closely by 1,864 papers in 2020, 1,845 papers in 2022, and 1,717 papers in 2023. The lowest output was observed in 2024, with only 1,543 publications.

Table 1: Year Wise Distribution of Deforestation Research Publications

S.No	PY	Records	%	Cumulative Records	Cumulative %
1.	2020	1864	20.88	1864	20.88
2.	2021	1959	21.94	3823	42.82
3.	2022	1845	20.66	5668	63.48
4.	2023	1717	19.23	7385	82.71
5.	2024	1543	17.28	8928	100
Total		**8928**	**100**		

Table 2 presents the trend values of deforestation research output using a straight-line time series analysis. The calculated trend coefficient (b = - 88.4) indicates a declining trend in research output during the study period. Based on the corrected trend equation $Y_C = a + bX$, the estimated number of publications for the year 2029 is 1166.8, and for the year 2035 is 636.4.

Table 2: Trend Value of Deforestation Research Output

S.No.	PY	Records	X	X^2	XY
1.	2020	1864	-2	4	-3728
2.	2021	1959	-1	1	-1959
3.	2022	1845	0	0	0
4.	2023	1717	1	1	1717
5.	2024	1543	2	4	3086
Total		**8928**	**0**	**10**	**-884**

Straight line equation Yc = a+bX since ∑x = 0 for SAP

$$a = \frac{\sum Y}{N},$$

Where, ∑y = Total Number of Paper, N = Number of Years

$$b = \frac{\sum XY}{\sum}$$

Where, ∑XY = Total Number of XY Tables, ∑ = Total of X^2 Tables

$$a = \frac{\sum Y}{N} = \frac{8,928}{5} = 1785.6,$$

$$b = \frac{\sum XY}{\sum} = \frac{-884}{10} = -88.4.$$

Estimated Literature in 2029 is when X = 2029 - 2022 = 7

$$Yc = 1785.6 + (- 88.4 \times 7)$$
$$Yc = 1785.6 – 618.8$$
$$Yc = 1166.8$$

Estimated Literature in 2035 is when X = 2035 - 2022 = 13

$$Yc = 1785.6 + (- 88.4 \times 13)$$
$$Yc = 1785.6 – 1149.2$$
$$Yc = 636.4$$

Table 3: Doubling Time of Deforestation Research Publications (2020-2024)

S. No	Year	Number of Record	Cumulative Total	$Log_e W_1$	$Log_e W_2$	RGR = W_2-W_1	Mean Relative Growth	DT = 0.693 /R	Mean
1.	2020	1864	-	7.53	-	-		-	
2.	2021	1959	3823	7.58	8.25	0.67		1.03	
3.	2022	1845	5668	7.52	8.64	1.12		0.62	
4.	2023	1717	7385	7.45	8.91	1.46	1.002	0.47	0.502
5.	2024	1543	8928	7.34	9.10	1.76		0.39	

Where,
W1 = Natural Logarithm of cumulative publications at time t_1
W2 = Natural Logarithm of cumulative publications at time t_2
RGR = Relative Growth Rate per unit time
DT = Doubling Time, calculated as In(2)/RGR

Table 3 represent that the Relative Growth Rate (RGR) of deforestation research increased steadily from 0.67 in 2021 to 1.76 in 2024, indicating an acceleration in cumulative research output over time. Correspondingly, the Doubling Time (DT) declined from 1.03 years in 2021 to 0.39 years in 2024, confirming the expected inverse relationship between RGR and DT.

Table 4 Exponential Growth Rate of Deforestation Research Publications (2020-2024)

S.No.	PY	Records	EGR
1.	2020	1864	-
2.	2021	1959	1.05
3.	2022	1845	0.94
4.	2023	1717	0.93
5.	2024	1543	0.90
	Total	**8928**	

Table 4 reveals the Exponential Growth Rate of Deforestation over the study period (2020 to 2024). Over the course of five years, an exponential growth rate in the number of publications on deforestation was noted. The highest Growth Rate of 1.05 was observed during the year 2021 with 1,959 publications. The average Exponential Growth Rate during the period of study is 0.764 and this is found in the above table.

Table 5 Document-wise Distribution of Deforestation Research Publications

S.No.	DT	Records	%
1.	Articles	8147	91.25
2.	Review Articles	572	6.41
3.	Early Access	212	2.38
4.	Editorial Material	127	1.42
5.	Letter	30	0.34
6	Correction	19	0.21
7.	Data Paper	19	0.21
8.	Proceeding Paper	18	0.20
9.	News Item	17	0.19
10.	Book Chapters	11	0.12
11.	Meeting Abstract	9	0.10
12.	Book Review	5	0.06
13.	Retracted Publication	5	0.06
14.	Reprint	1	0.01
15.	Retraction	1	0.01

Table 5 shows the document wise distribution of the publications on deforestation for the period 2020-2024. The article takes up 91.25% (8,147 records) of the Overall Publications on Deforestation followed by Review Article with 6.41% (572 records), the Early Access with 2.38% (212 records), Editorial Material with 1.42% (127 records), Letter with 0.34% (30 records) and the document types like Correction, Data Paper, Proceeding Paper, News Item, Book Chapter, Meeting Abstract, Book Review, Retracted Publication, Reprint and Retraction has only one record of Publication for each type of Document.

The table 6 discloses the year-wise authorship pattern of article publications in the research area of the entire 5 years wherein above four authors scored in first position have contributed 1,357. The scores for three authors and five authors in each of the 1,320 and 1,220 counts were in

second and third place. The second and sixth authors achieved fourth and fifth place in each 991 and 945 Counts.

Table 6 Author-wise Distribution of Deforestation Research Publications

AP	2020	2021	2022	2023	2024	Total	Rank
One Author	126	132	101	120	87	566	VIII
Two Authors	220	211	182	203	175	991	IV
Three Authors	293	298	254	266	209	1320	II
Four Authors	297	283	280	281	216	1357	I
Five Authors	248	292	253	190	237	1220	III
Six Authors	196	213	202	193	141	945	V
Seven Authors	135	133	164	120	133	685	VII
Eight Authors	87	115	96	88	89	475	IX
Nine Authors	65	76	80	56	67	344	X
Ten Authors	53	47	65	48	36	249	XI
Above Ten Authors	144	159	168	152	153	776	VI
Total	**1864**	**1959**	**1845**	**1717**	**1543**	**8928**	

Table 7 Year-Wise Distribution of Degree of Collaboration in Deforestation Research Publications

PY	Single Author (NS)	Multiple Author (NM)	Total (NS+NM)	Degree of Collaboration (DC)
2020	126	1738	1864	0.93
2021	132	1827	1959	0.93
2022	101	1744	1845	0.94
2023	120	1597	1717	0.93
2024	87	1456	1543	0.94

To determine the Degree of Collaboration between single-authored and multi-authored publications, the formula suggested by Subramanyam (1983) was applied:

$$DC = \frac{NM}{NM+NS}$$

Where, NM denotes the number of multi-authored publications and NS denotes the number of single-authored publications.
For example, in the year 2020:

$$DC = \frac{1738}{1864}$$

$$DC = 0.93$$

Table 7 shows that the Degree of Collaboration (DC) ranges from 0.93 to 0.94 during the study period (2020 – 2024), with an average DC value of 0.93. A DC value closer to 1 clearly indicates the dominance of multi-authored (collaborative) research, while a value closer to 0 represents predominance of single-authored works. It supports the fact that high collaboration is now the standard in modern scientific research (Halder & Mondal, 2022).

The distribution of publications on the productivity of deforestation research by language is displayed in Table 8. It has been observed that eleven languages contributed to the overall productivity of deforestation research. English has the highest number of publication with 8,837 records (98.98%), followed by Spanish with 47 records (0.53%), French with 18

records (0.20%), Portuguese with 14 records (0.16%), German with 5 records (0.06%), Chinese with 2 records (0.02%), and Afrikaans, Croatian, Czech, Russian and Swedish with 1 records (0.01%) research publication respectively.

Table 8 Language-wise Distributions of Deforestation Research Publications

S.No.	Language	Records	% of 5245
1.	English	8837	98.98
2.	Spanish	47	0.53
3.	French	18	0.20
4.	Portuguese	14	0.16
5.	German	5	0.06
6.	Chinese	2	0.02
7.	Afrikaans	1	0.01
8.	Croatian	1	0.01
9.	Czech	1	0.01
10.	Russian	1	0.01
11.	Swedish	1	0.01

Table 9 Country-wise Distribution of Deforestation Research Publications

S.No.	Countries	Records	%
1.	USA	2398	20.25
2.	Brazil	1781	15.04
3.	Peoples R China	1524	9.49
4.	England	1063	8.98
5.	Germany	955	8.07
6.	Australia	581	4.91
7.	France	553	4.50
8.	Netherlands	463	3.91
9.	India	410	3.46
10.	Spain	393	3.32
11.	Canada	392	3.31
12.	Mexico	387	3.27
13.	Switzerland	374	3.16
14.	Indonesia	366	2.84
15.	Italy	329	2.78
16.	Colombia	321	2.71

Table 9 indicates the country-wise distribution of deforestation research output covered for the study period 2020-2024. USA tops with 2,398 (20.25%) Publications followed by Brazil with 1,781 (15.04%), the Peoples R China with 1,524 (9.49%), England with 1,063 (8.98%), Germany with 955 (8.07%), Australia with 581 (4.91%), France with 553 (4.50%), Netherlands with 463 (3.91%), India with 410 (3.46%) and Spain with 398 (3.32%), etc., Research Publication respectively.

Fig. 1: Visualization Map of Country Wise Distribution of Deforestation Research Publications

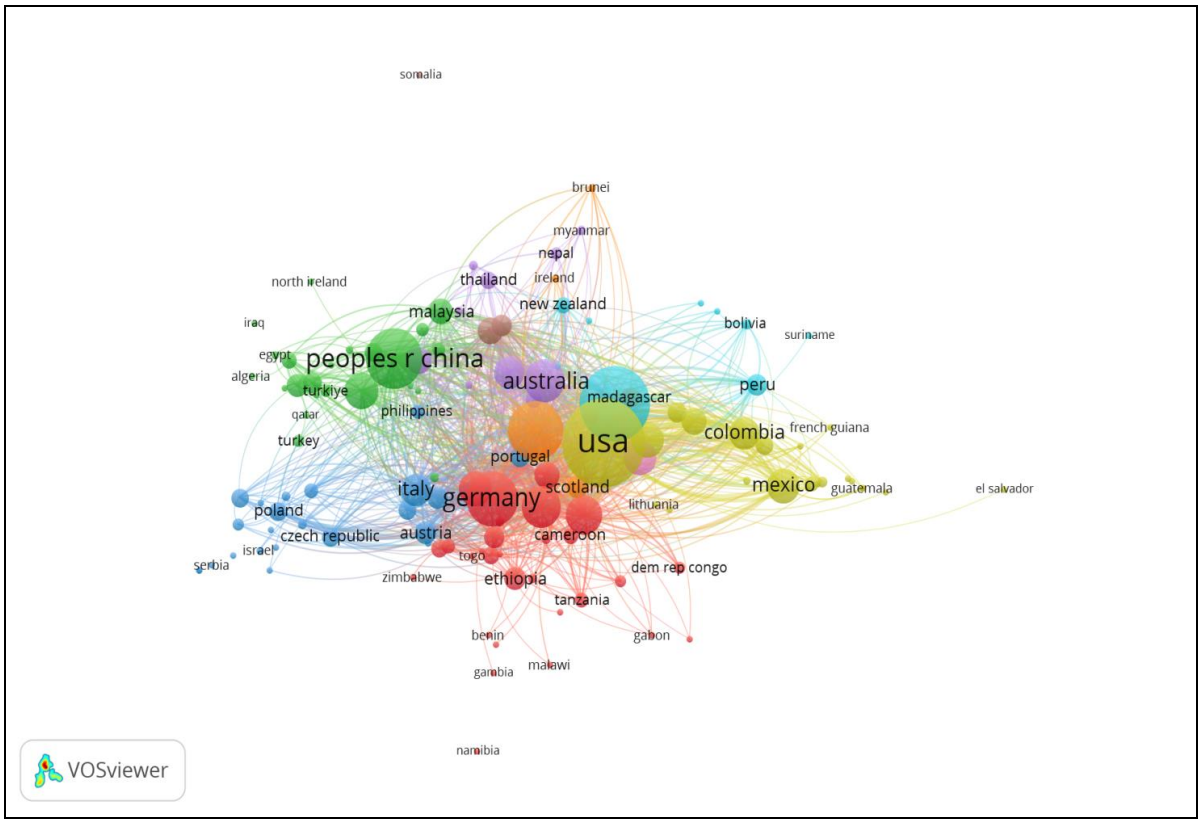


Table 10 Most Prolific Authors in Deforestation Research Publications (Top 10)

S.No	Author	Records	%
1.	Aragao L E O C	45	12.86
2.	Fearnside P M	43	12.29
3.	Ciais P	42	12.00
4.	Meyfroidt P	39	11.14
5.	Herold M	33	9.43
6.	Peres C A	32	9.14
7.	Kuemmerle T	30	8.57
8.	Li Y	29	8.29
9.	Pongratz J	29	8.29
10.	Anderson L O	28	8.00
Total		**350**	**100**

Table 10 denotes the most prolific author based on publishing. With 45 publications, author Aragao L E O C holds the top spot. Followed by Feamside P M with 43 Publications, Ciais P with 42 Publications, and Meyfroidt P with 39 Publications. Less than 39 publications have been contributed by the remaining authors.

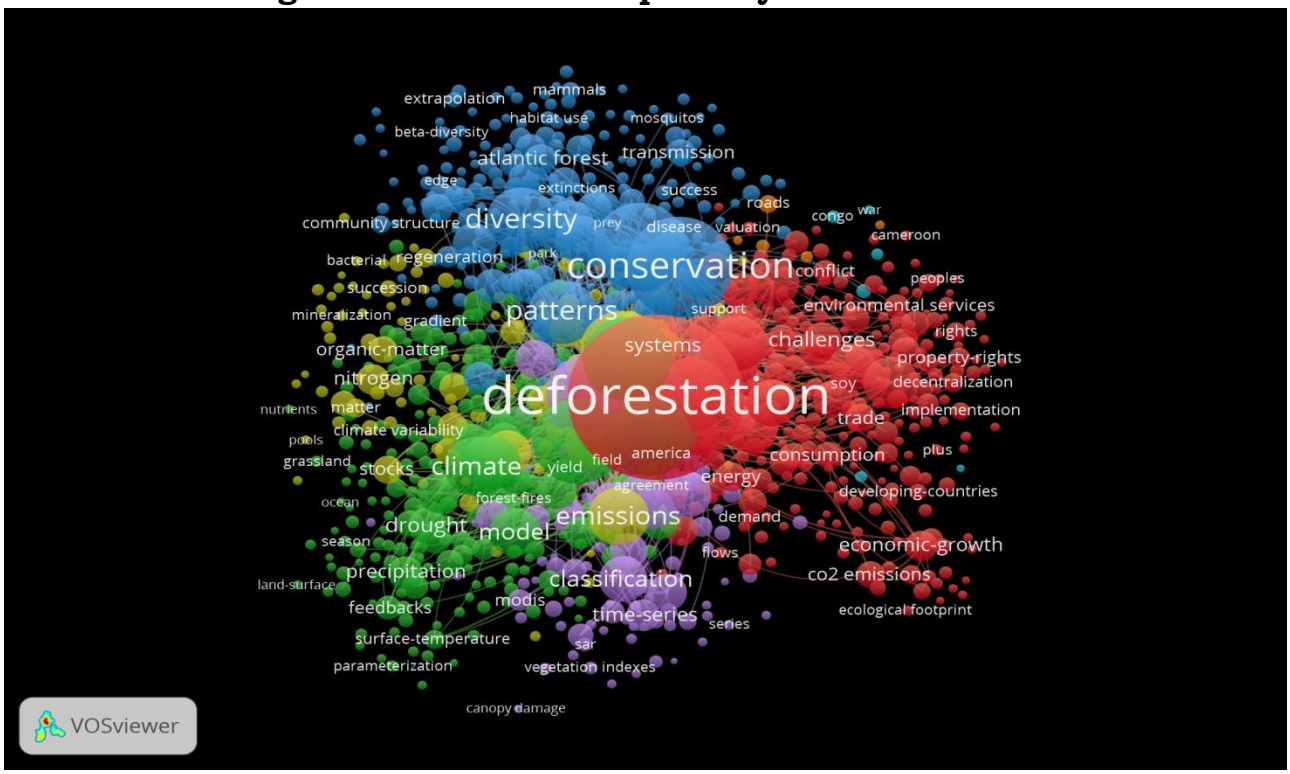
Table 11 shows that a total of 8,928 words were identified from the publications selected for the study on Deforestation. Among these, the term “Deforestation” appears most frequently, occurring in 3,020 records, and hence ranks first. This is followed by the word “Impact”, which occurs in 1,254 records and holds the second position. The term “Conservation” is

found in 1,116 records, securing the third rank, while "Biodiversity" appears in 856 records, placing it in the fourth position in terms of frequency.

Table 11 Words-wise Distribution of Deforestation Research Publications

S.No	Words	Records	%
1.	DEFORESTATION	3020	30.93
2.	IMPACT	1254	12.84
3.	CONSERVATION	1116	11.43
4.	BIODIVERSITY	856	8.77
5.	CLIMATE CHANGE	801	8.20
6.	LAND-USE	782	8.01
7.	FOREST	685	7.01
8.	DYNAMICS	654	6.70
9.	MANAGEMENT	596	6.10

Fig. 2: Visualization Map of Keyword Occurrence



5.1 Zipf's Law of Word Occurrence

In 1935, George Kingsley Zipf formulated a law to predict the frequency of words in a text. According to Zipf's law, if the words in a sufficiently long text are ranked from most to least frequent, the product of a word's rank and its frequency remain constant:

$$r \times f = C \text{ (where C is Constant)}$$

Taking the logarithm of both sides gives:

$$\log f \times \log r = \log C$$

To utilize this law, the words from article titles were collected and sorted in descending order based on how often they occurred.

Table 12: Ranking of Word Occurrence

S.No.	Words	Frequency	Rank	Log F	Log R	Log C
1.	DEFORESTATION	3020	1	3.48	0	0
2.	IMPACT	1254	2	3.10	0.30	0.93
3.	CONSERVATION	1116	3	3.05	0.48	1.46
4.	BIODIVERSITY	856	4	2.93	0.60	1.76
5.	CLIMATE CHANGE	801	5	2.90	0.70	2.03
6.	LAND-USE	782	6	2.89	0.78	2.25
7.	FOREST	685	7	2.83	0.84	2.38
8.	DYNAMICS	654	8	2.81	0.90	2.53
9.	MANAGEMENT	596	9	2.77	0.95	2.63

Table 4.12 presents the ranking of frequently occurring words after keyword standardization and normalization. The word "Deforestation" occupies the first rank with a frequency of 3,020, followed by "Impact" (1,254) and "Conservation" (1,116). The Standardization keyword "Biodiversity", with 856 occurrences, ranks fourth.

1. Word: DEFORESTATION
   Frequency: 3,020
   Rank: 1
   log of Frequency × log of Rank
   log 3,020 × log 1
   = 3.48 × 0
   = 0
2. Word: CLIMATE CHANGE
   Frequency: 801
   Rank: 4
   log of Frequency × log of Rank
   log 801 × log 4
   = 2.90 × 0.70
   = 2.03

The closeness of these values demonstrates that Zipf's Law is valid for deforestation research literature during the study period.

5.2 Lotka's Law of Scientific Productivity

Generally, author productivity is determined based on the number of individual authors by number of articles contributed to a specific field. It is quite pertinent to study the impact of apply the Lotka's law in examining the author productivity in Deforestation Research Output.

The data used for testing Lotka's Law (Table 13) were derived directly from the same Web of Science dataset used for authorship pattern analysis. Individual author publication frequencies were extracted from the bibliographic records and reorganized to calculate the number of authors contributing one, two, three or more papers. Thus, the author counts in Table 4.13 strictly correspond to the raw author data obtained from Web of Science Core Collection and are fully consistent with the overall dataset of 8,298 publications.

Table 13: Lotka's Law of Scientific Productivity in Deforestation Research Output

S. No.	No of Authors	No of Article	X (LogX)	Y (Log Y)	X.Y	X^2	X^n	$1/X^n$	yx/∑yx	∑(yx/∑yx)	Excepted Value F (x) =c($1/x^n$)	D
1.	1	566	0.000	6.338	0.000	0.000	1.0000	1.000	0.063	0.063	6.604	0
2.	2	991	0.6931	6.899	4.782	0.480	0.2209	4.527	0.111	0.174	29.896	0.069
3.	3	1320	1.099	7.185	7.896	1.208	0.0914	10.941	0.148	0.322	72.254	0.174
4.	4	1357	1.386	7.213	9.997	1.921	0.0488	20.492	0.152	0.474	135.329	0.322
5.	5	1220	1.609	7.107	11.435	2.589	0.0300	33.333	0.137	0.611	220.131	0.474
6.	6	945	1.791	6.851	12.270	3.208	0.0202	49.505	0.106	0.717	326.931	0.611
7.	7	685	1.946	6.529	12.705	3.787	0.0144	69.444	0.077	0.794	458.608	0.717
8.	8	475	2.079	6.163	12.813	4.322	0.0108	92.592	0.053	0.847	611.477	0.794
9.	9	344	2.197	5.841	12.833	4.827	0.0083	120.482	0.038	0.885	795.663	0.847
10.	10	249	2.302	5.517	12.700	5.299	0.0066	151.515	0.028	0.913	1000.605	0.885
11.	11	196	2.398	5.278	12.657	5.750	0.0054	185.185	0.022	0.935	1222.961	0.913
12.	12	129	2.485	4.859	12.075	6.175	0.0045	222.222	0.014	0.949	1467.554	0.935
13.	13	64	2.565	4.159	10.668	6.579	0.0047	212.766	0.007	0.956	1405.107	0.949
14.	14	80	2.639	4.382	11.564	6.964	0.0032	312.500	0.009	0.965	2063.750	0.956
15.	15	54	2.708	3.989	10.802	7.333	0.0027	370.370	0.006	0.971	2445.923	0.965
16.	16	38	2.773	3.638	10.088	7.689	0.0024	416.667	0.004	0.975	2751.669	0.971
17.	17	35	2.833	3.555	10.071	8.026	0.0021	476.191	0.004	0.979	3144.765	0.975
18.	18	24	2.890	3.178	9.184	8.352	0.0018	555.556	0.003	0.982	3668.892	0.979
19.	19	18	2.944	2.890	8.508	8.667	0.0016	625.000	0.002	0.984	4127.500	0.982
20.	20	10	2.996	2.302	6.897	8.976	0.0014	714.286	0.001	0.985	4717.145	0.984
21.	21	16	3.044	2.772	8.438	9.266	0.0013	769.231	0.001	0.986	5080.002	0.985
22.	22	10	3.091	2.302	7.115	9.554	0.0011	909.091	0.001	0.987	6003.637	0.986
23.	23	10	3.135	2.302	7.217	9.828	0.0011	909.091	0.001	0.988	6003.637	0.987
24.	24	10	3.178	2.302	7.316	10.099	0.0009	1111.111	0.001	0.989	7337.778	0.988
25.	25	7	3.219	1.946	6.264	10.362	0.0009	1111.111	0.000	0.989	7337.778	0.989
26.	26	6	3.258	1.792	5.839	10.614	0.0008	1250.000	0.000	0.989	8255.000	0.989
27.	27	7	3.296	1.946	6.414	10.864	0.0007	1428.571	0.000	0.989	9434.283	0.989
28.	28	6	3.332	1.792	5.971	11.102	0.0007	1428.571	0.000	0.989	9434.283	0.989
29.	29	1	3.367	0.000	0.000	11.337	0.0006	1666.667	0.000	0.989	11006.669	0.989
30.	30	9	3.401	2.197	7.472	11.567	0.0006	1666.667	0.001	0.990	11006.669	0.989
31.	31	3	3.434	1.099	3.774	11.792	0.0005	2000.000	0.000	0.990	13208.000	0.990
32.	32	2	3.466	0.693	2.402	12.013	0.0005	2000.000	0.000	0.990	13208.000	0.990
33.	33	4	3.497	1.386	4.847	12.229	0.0004	2500.000	0.000	0.990	16510.000	0.990
34.	35	2	3.555	0.693	2.464	12.638	0.0004	2500.000	0.000	0.990	16510.000	0.990
35.	36	1	3.584	0.000	0.000	12.845	0.0004	2500.000	0.000	0.990	16510.000	0.990
36.	37	1	3.611	0.000	0.000	13.039	0.0004	2500.000	0.000	0.990	16510.000	0.990
37.	38	4	3.638	1.386	5.042	13.235	0.0003	3333.333	0.000	0.990	22013.331	0.990
38.	39	2	3.664	0.693	2.539	13.425	0.0003	3333.333	0.000	0.990	22013.331	0.990
39.	41	1	3.714	0.000	0.000	13.794	0.0003	3333.333	0.000	0.990	22013.331	0.990
40.	42	1	3.738	0.000	0.000	13.973	0.0002	5000.000	0.000	0.990	33020.000	0.990
41.	47	1	3.851	0.000	0.000	14.830	0.0002	5000.000	0.000	0.990	33020.000	0.990
42.	48	2	3.871	0.693	2.683	14.985	0.0002	5000.000	0.000	0.990	33020.000	0.990
43.	49	2	3.892	0.693	2.697	15.148	0.0002	5000.000	0.000	0.990	33020.000	0.990
44.	50	1	3.912	0.000	0.000	15.304	0.0001	10000.000	0.000	0.990	66040.000	0.990
45.	51	1	3.932	0.000	0.000	15.461	0.0001	10000.000	0.000	0.990	66040.000	0.990
46.	52	2	3.951	0.693	2.738	15.610	0.001	10000.000	0.000	0.990	66040.000	0.990
47.	56	1	4.025	0.000	0.000	16.201	0.0001	10000.000	0.000	0.990	66040.000	0.990
48.	58	1	4.060	0.000	0.000	16.484	0.0001	10000.000	0.000	0.990	66040.000	0.990
49.	59	1	4.078	0.000	0.000	16.630	0.0001	10000.000	0.000	0.990	66040.000	0.990
50.	61	1	4.111	0.000	0.000	16.900	0.0001	10000.000	0.000	0.990	66040.000	0.990
51.	62	1	4.127	0.000	0.000	17.032	0.0001	10000.000	0.000	0.990	66040.000	0.990
52.	66	1	4.189	0.000	0.000	17.548	0.0001	10000.000	0.000	0.990	66040.000	0.990
53.	75	1	4.317	0.000	0.000	18.636	8.2435	0.121	0.000	0.990	0.799	0.990
54.	84	1	4.308	0.000	0.000	18.559	6.4405	0.155	0.000	0.990	1.024	0.990
55.	86	1	4.454	0.000	0.000	19.838	6.1187	0.163	0.000	0.990	1.076	0.990
56.	90	1	4.499	0.000	0.000	20.241	5.5419	0.180	0.000	0.990	1.1899	0.990
57.	94	2	5.532	0.693	3.141	20.539	5.0411	0.198	0.000	0.990	1.307	0.990
58.	106	1	4.663	0.000	0.000	21.744	3.8804	0.258	0.000	0.990	1.704	0.990
59.	110	1	4.700	0.000	0.000	22.090	3.5797	0.279	0.000	0.990	1.842	0.990
60.	123	1	4.812	0.000	0.000	23.155	2.8066	0.356	0.000	0.990	2.351	0.990
61.	172	1	5.147	0.000	0.000	26.491	1.3521	0.739	0.000	0.990	4.880	0.990
Total		**8,928**	**199.9861**	**131.946**	**294.273**	**719.154**		**151411.618**				

Lotka law of scientific productivity,

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

$$n = \frac{61 \times 294.273 - 199.9861 \times 131.946}{61 \times 719.154 - (199.9861)^2}$$

$$n = \frac{17{,}950.653 - 26{,}387.366}{43{,}868.394 - 39{,}944.440}$$

$$n = \frac{-8{,}436.713}{3{,}873.954}$$

$$n = -2.178$$

Calculated Value

$$C = \frac{1}{\sum \frac{1}{x^n}}$$

$$C = \frac{1}{1/151{,}411.618}$$

$$C = 6.604$$

Critical Value

$$C.V = \frac{n}{\sqrt{\sum Y}}$$

$$C.V = \frac{2.178}{\sqrt{8928}}$$

$$C.V = \frac{2.178}{94.4881}$$

Critical Value (C.V) = 0.0230

To test the goodness of fit of Lotka's Law, the Kolmogorov-Smirnov (K-S) test was applied by comparing the cumulative observed distribution of author productivity with the cumulative expected distribution derived from Lotka's inverse square law. The expected number of authors was calculating using the formula.

$$f(x) = C\ (1/X^n)$$

where C = 6.604 and n = 2.178. The cumulative proportions of observed and expected values were computed, and the maximum absolute difference (D) between the two distributions was identified.

The calculated K-S Statistic (D = 0.990) was found to be greater than the critical value (0.0230) at the chosen significance level. Therefore, the null hypothesis that deforestation research productivity follows Lotka's Law is rejected. This result indicates that the observed author productivity distribution does not conform to Lotka's inverse square law. The deviation may be attributed to the high level of collaborative research, multi-authored publications, and interdisciplinary nature of deforestation studies, which often diverge from classical individual productivity models.

5.3 Karl Pearson's Correlation Coefficient

Karl Pearson's, a British biometrician developed the coefficient of correlation to express the degree of relationship between the two variables. We apply the Karl Pearson's Correlation Coefficient

$$r(X, Y) = \frac{Covariance\ between\ X\ and\ Y}{(Standard\ deviation\ of\ X) \times (Standard\ deviation\ of\ Y)}$$

Table 14: Karl Pearson's Correlation Coefficient in Deforestation

Number of Authors (X)	Number of Publications (Y)	X^2	Y^2	XY
1	566	1	320356	566
2	991	4	982081	1982
3	1320	9	1742400	3960
4	1357	16	1841449	5428
5	1220	25	1488400	6100
6	945	36	893025	5670
7	685	49	469225	4795
8	475	64	225625	3800
9	344	81	18336	3096
10	249	100	62001	2490
11	196	121	38416	2156
12	129	144	16641	1548
13	64	169	4096	832
14	80	196	6400	1120
15	54	225	2916	810
16	38	256	1444	608
17	35	289	1225	595
18	24	324	576	435
19	18	361	324	342
20	10	400	100	200
21	16	441	256	336
22	10	484	100	220
23	10	529	100	230
24	10	576	100	240
25	7	625	49	175
26	6	676	36	156
27	7	729	49	189
28	6	784	36	168
29	1	841	1	29
30	9	900	81	270
31	3	961	9	93
32	2	1024	4	64
33	4	1089	16	132
35	2	1225	4	70
36	1	1296	1	36
37	1	1369	1	37
38	4	1444	16	152
39	2	1521	4	78
41	1	1681	1	41
42	1	1764	1	42
47	1	2209	1	47
48	2	2304	4	96
49	2	2401	4	98
50	1	2500	1	50
51	1	2601	1	51
52	2	2704	4	104
56	1	3136	1	56
58	1	3364	1	58
59	1	3481	1	59
61	1	3721	1	61
62	1	3844	1	62
66	1	4356	1	66
75	1	5625	1	75
84	1	7056	1	84
86	1	7396	1	86
90	1	8100	1	90
94	2	8836	4	188
106	1	11236	1	106
110	1	12100	1	110
123	1	15129	1	123
172	1	29584	1	172
2,427	**8,928**	**1,64,512**	**82,15,934**	**51132**

$$r(X,Y) = \frac{N\sum XY - \sum X \sum Y}{\sqrt{N\sum x^2 - (\sum X^2)} \cdot \sqrt{N\sum y^2 - (\sum y^2)}}$$

$$= \frac{61\ (51132) - (2427)\ (8928)}{\sqrt{61\ (164512) - (2427)^2}\ .\ \sqrt{61\ (8215934) - (8928)^2}}$$

$$= \frac{3119052 - 21668256}{\sqrt{10035232 - 5890329} \times \sqrt{501171974 - 79709184}}$$

$$= \frac{-18549204}{\sqrt{4144903} \times \sqrt{421462790}}$$

$$= \frac{-18549204}{2035.903 \times 20529.559}$$

$$= \frac{-18549204}{41796190.757}$$

r (X , Y) = -0.444

It is measured the analysis of Karl Pearson Correlation Coefficient, based the data of deforestation during the period of study and identified as 1 and showed a negative correlation between the number of authors and number of publications. Hence, “There is a negative correlation relationship between the number of authors and number of publications has not been proved and it has been rejected.

6. Findings

During the study period (2020-2024), a total of 8,928 research articles on deforestation were published globally and indexed in the Web of Science database.

Year-wise analysis reveals that the highest number of publications (1,959 records) was recorded in 2021, followed by 1,864 publications in 2020, 1,845 in 2022, 1,717 in 2023, and 1,543 publications in 2024, indicating a gradual decline in annual output after 2021.

Contrary to the increasing global environmental crisis, trend analysis using a straight-line equation shows a negative slope value (b = - 88.4), indicating a slight downward trend in WoS- indexed publications using the specific keyword “Deforestation”.

The Relative Growth Rate (RGR) and Doubling Time (DT) analysis shows an inverse relationship, with an average Doubling Time of 0.502 years, reflecting cumulative growth of deforestation-related literature despite annual fluctuations.

Authorship analysis reveals that multi-authored publications dominate deforestation research, with a Degree of Collaboration of 0.93, highlighting the collaborative and interdisciplinary nature of environmental research.

Aragao L E O C. emerged as the most prolific author with 45 publications, followed by Fearnside, P.M. (43), Ciais, P. (42), Meyfroidt, P. (39), Herold, M. (33), Peres, C.A. (32), and Kuemmerle, T. (30) during the study period.

Document-type analysis shows that journal articles constitute the majority (91.25%; 8,147 records), followed by review articles (6.41%; 572 records), early access articles (2.38%; 212 records), and editorial materials (1.42%; 127 records), while other document types contribute marginally.

Country-wise distribution indicates that the United States leads deforestation research with 2,398 publications (20.25%), followed by Brazil (1,781; 15.04%), China (1,524; 9.49%), England (1,063; 8.98%), Germany (955; 8.07%), Australia (681; 4.91%), and Spain (398; 3.32%).

Language-wise analysis shows a strong dominance of English-language publications (98.98%; 8,837 records), followed by Spanish (0.53%), French (0.20%), Portuguese (0.16%), and other languages contributing marginally.

7. Conclusion

This scientometric study comprehensively analyzed global research output on deforestation during the period 2020-2024 using publications indexed in the Web of Science database. The analysis examined year-wise publication trends, growth indicators, authorship and collaboration patterns, document types, keyword occurrence, language distribution, and country-wise research contributions. The finding reveals that the United States and Brazil dominate deforestation research output, contributing the highest number of publications during the study period. This dominance can be largely attributed to the global significance of the Amazon rainforest, where large-scale deforestation, biodiversity loss, and climate change impacts have intensified international scientific attention. Brazil's prominent contribution reflects its geographical and ecological proximity to the Amazon region, while the United States' leadership highlights its strong research infrastructure, funding capacity, and global environmental research collaborations. Keyword analysis indicates that research on deforestation is increasingly interconnected with broader themes such as conservation, biodiversity, climate change, and land-use dynamics, suggesting an interdisciplinary shift in research focus. Although trend analysis shows a slight decline in publications using the explicit keyword "deforestation," this does not indicate reduced research interest rather, it reflects a terminological transition toward integrated environmental and sustainability frameworks.

References

Aleixandre-Benavent, R., Aleixandre-Tudó, J. L., Castelló-Cogollos, L., & Aleixandre, J. L. (2018). *Trends in global research in deforestation: A bibliometric analysis*. Land Use Policy, 72, 293–302. https://doi.org/10.1016/j.landusepol.2017.12.060.

Da Silva, H. A., Santos, L. A. C., Pacheco, A. R., Calil, F. N., & de Melo e Silva Neto, C. (2021). *Crop-livestock-forest integration systems: A scientometric analysis*. Revista Ecologia e Nutrição Florestal - ENFLO, 9, e03. https://doi.org/10.5902/2316980X68190.

Da Silva, S., Perlin, M., Matsushita, R., Santos, A. A. P., Imasato, T., & Borenstein, D. (2019). *Lotka's law for the Brazilian scientific output published in journals. Journal of Information Science, 45*(5), 705–709. https://doi.org/10.1177/0165551518801813.

Farooqi, T. J. A., Irfan, M., Zhou, X., Pan, S., Atta, A., & Li, J. (2024). *Advancing knowledge in forest water use efficiency under global climate change through scientometric analysis*. Forests, 15(11), 1893. https://doi.org/10.3390/f15111893.

Farooqi, T. J. A., Portela, R., Xu, Z., Pan, S., Irfan, M., & Ali, A. (2024). *Advancing forest hydrological research: Exploring global research trends and future directions through scientometric analysis*. Journal of Forestry Research, 35(1), 128. https://doi.org/10.1007/s11676-024-01771-1.

Gupta, H., & Singh, N. K. (2023). *Climate change and biodiversity synergies: A scientometric analysis in the context of UNFCCC and CBD*.

Anthropocene Science, 2(1), 5–18. https://doi.org/10.1007/s44177-023-00046-4.

Halder, Sukanta & Mondal, Abhishek (2022). Journal of the Indian Library Association and IASLIC Bulletin: A Comparative Bibliometric Study. LIS Links Newsletter, 8(1), 8-15. http://newsletter.lislinks.com

Huang, Y., Li, F., & Xie, H. (2020). *A scientometrics review on farmland abandonment research*. Land, 9(8), 263. https://doi.org/10.3390/land9080263.

Iancu, T., Tudor, V. C., Dumitru, E. A., Sterie, C. M., Micu, M. M., Smedescu, D., Marcuta, L., Tonea, E., Stoicea, P., Vintu, C., Jitareanu, A. F., & Costuleanu, L. C. (2022). *A scientometric analysis of climate change adaptation studies*. Sustainability, 14(19), 12945. https://doi.org/10.3390/su141912945.

Kanipriyan, K. (2024). *Mapping the nephrology research output during 2020–2024: A scientometrics study*. International Journal of Research in Library Science (IJRLS), 10(4), 142–158. https://doi.org/10.26761/IJRLS.10.4.2024.1807.

Li, T., Cui, L., Xu, Z., Hu, R., Joshi, P. K., Song, X., Tang, L., Xia, A., Wang, Y., & Guo, D. (2021). *Quantitative analysis of the research trends and areas in grassland remote sensing: A scientometrics analysis of Web of Science from 1980 to 2020*. Remote Sensing, 13(7), 1279. https://doi.org/10.3390/rs13071279.

Maz-Machado, A., Madrid, M. J., Jiménez-Fanjul, N., & León-Mantero, C. (2017). *Empirical examination of Lotka's law for information science and library science. Pakistan Journal of Information Management & Libraries, 19*, 37–51. https://doi.org/10.47657/2017191106.

Naheem, K. T., Sivaraman, P., & Saravanan, G. (2019). *Application of Lotka's law in Bell's palsy (facial paralysis) research output during 2004–2018. Library Philosophy and Practice (e-journal).* https://digitalcommons.unl.edu/libphilprac/2892/.

Naqvi, S. H., & Fatima, N. (2017). Authorship patterns in international business literature: Applicability of Lotka's law. *Annals of Library and Information Studies, 64*(4), 253–259. https://doi.org/10.56042/alis.v64i4.16390.

Pal, S. K., & Bhattacharjee, S. (2022, December 10). *A scientometric analysis and assessment on environmental science research*. Journal of Academia and Zoology (JAZ), 43(S1). https://doi.org/10.53555/jaz.v43iS1.

Pillai Sudhier, K. G. (2013). *Lotka's law and pattern of author productivity in the area of physics research.* DESIDOC Journal of Library & Information Technology, 33(6), 457–464. https://doi.org/10.14429/djlit.33.6.5477.

Pratiwi, N. M., Ibrahim, C., Alkarimah, N. U., (2024). Author productivity analysis in Q1 of authors in journal *Library and Information Science* Q1 journals using Lotka's law. *Berkala Ilmu Perpustakaan dan Informasi, 20*(1), 163–176. https://doi.org/10.22146/bip.v20i1.8272.

Radhakrishnan, S., & Baskaran, C. (2019). Authorship productivity and applicability of Lotka's law in phytochemistry literature. *Library Philosophy and Practice (e-journal).* https://digitalcommons.unl.edu/libphilprac/3618/.

Sahu, A., & Jena, P. (2022). *Lotka's law and author productivity pattern of research in law discipline. Collection and Curation, 41*(2), 62–73. https://doi.org/10.1108/CC04-2021-0012.

Thamaraiselvi, M., Lakshmi, S., & Manthiramoorthi, M. (2023). *Application of scientometric indicators on author productivity with reference to Scientometrics Journal.* College Libraries, 37(I), 45–55. https://collegelibraries.in/index.php/CL/article/view/65.

Tunga, S. K. (2021). Lotka's Law and Author Productivity in the Economic Literature: A Citation Study. *Indian Journal of Information Sources and Services*, *11*(2), 1–8. https://doi.org/10.51983/ijiss-2021.11.2.2998.

Wahyudi, A., & Junaedi, J. (2025). Bibliometric study: Writer's productivity according to Lotka's law in The Edulib Journal. *Edulib*. https://ejournal.upi.edu/index.php/edulib/article/view/56710.