



## Citation Practices and Priorities of Environmental Science Researchers in Western Himalayan Region of India

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This study aimed to explore citation practices and priorities of environmental science researchers in the Western Himalayan Region of India through a bibliometric analysis of 23,292 sources cited in publications from 2012 to 2021. Employing Bibliometrix and Biblioshiny tools within R Studio, the research scrutinized citation behaviours, journal preferences, authorship patterns, and thematic orientations in the region. Findings indicate a predominant reliance on journal articles (59.84%), emphasizing a preference for up-to-date, peer-reviewed research. The data reflects a strong international influence, with most citations from high-impact global journals. Additionally, the study reveals strong collaboration patterns, predominantly multi-authored works that support interdisciplinary research. Key themes identified include 'climate change', 'biodiversity', and 'water resource management', emphasizing their importance to the regional research agenda. Although limited to secondary citation data, this study provides critical insights for academics, policymakers, and practitioners, emphasizing the need for sustained interdisciplinary research and international collaboration to enhance sustainable environmental management in the Western Himalayan Region.

**Keywords:** Citation analysis; Environmental science; Western Himalayan Region; Biblioshiny; Bibliometrix, Scopus

### Introduction

Bibliometric studies are essential for providing quantitative insights into the dynamics of scientific communication and the evolution of academic disciplines<sup>1-2</sup>. By examining citation patterns, these studies help identify key researchers and seminal works, clarify the structure of scholarly networks, and understand how knowledge is disseminated and evolved. Such insights are pivotal for informing research funding, policy-making, and curriculum development, which emphasizes the role of bibliometrics in shaping both academic and practical approaches to addressing environmental challenges<sup>3-5</sup>. The scope of the present study is limited to Environmental Science (EVS) scholars from central universities in India's Western Himalayan Region (WHR), a uniquely critical area for environmental research due to its diverse ecological and geological characteristics. Encompassing Jammu, Kashmir, Himachal Pradesh, and Uttarakhand<sup>6</sup>, the WHR is distinguished by its rugged landscapes, harsh climatic conditions, and rich biodiversity. It includes deep forests, high deserts, and alluvial plains, home to various animal species<sup>7-9</sup>.

The study employs citation analysis to evaluate the significance and influence of research, drawing on previous bibliometric analyses<sup>10</sup> to understand scholarly communication in this important region. This research is crucial for stakeholders, including academic institutions, policymakers, and scholars, who rely on such analyses to formulate strategies for future research directions, enhance educational practices, and boost the overall impact of scientific research.

### Literature Review

The analysis of citations offers insightful perspectives into the scholarly dynamics within a field, providing more than just numerical data it illustrate the influence and evolution of scientific discourse<sup>3-5</sup>. A fundamental element of citation analysis is to reveal the motivations behind why researchers cite specific works. As Cronin<sup>11</sup> discussed, these motivations range from acknowledging previous work and supporting or contrasting one's research findings to critiquing existing methods.

In recent years, bibliometric analysis has proven invaluable for evaluating research trends and impacts across various scientific disciplines<sup>12</sup>. Employing

methodologies such as keyword extraction from research works, these studies identify emerging themes within a discipline. Keywords play a significant role as they encapsulate the core ideas of scholarly investigations, thus providing a bird's-eye view of thematic shifts within a field<sup>15</sup>. Through the analysis of keyword prevalence, co-occurrence, and shifts within cited sources, researchers gain a comprehensive understanding of the current state of the field and potential future directions. This form of analysis bridges the explicit content of scholarly publications with the broader intellectual currents, propelling scientific inquiry and thereby becoming indispensable for adapting to shifting trends and making informed decisions in research, education, and policy<sup>14</sup>.

The existing literature, including comprehensive reviews by authors like Haunschild<sup>15</sup> *et al.*, Sweileh<sup>16</sup>, Urhan<sup>17</sup> *et al.*, Wan<sup>18</sup> *et al.* and others, has used bibliometric analyses to cover various aspects of research on topics such as climate change. These studies provide insights into publication patterns, citation analysis, collaboration networks, and research themes, offering a comprehensive overview of current research in these fields and highlights key findings and gaps. A recent study conducted by Muruli and Harinarayana investigated physics<sup>10</sup> and chemistry<sup>20</sup> researchers of WHR and discussed the patterns in the citation behaviour of researchers; however, there is a need to evaluate other researchers of this region. And, most existing analyses offer a global or at least a continental perspective, often overlooking specific regional citation practices. This study aims to fill these gaps by providing a detailed bibliometric analysis of environmental science in the WHR.

### Objectives

This study aims to analyze the citation behaviour of environmental science researchers in the WHR of India with the following specific objectives:

- To analyze the types of sources cited by environmental science researchers.
- To identify the most frequently cited journals and affiliations.
- To assess patterns of authorship and collaboration among cited works.
- To evaluate the primary themes and research focuses through keyword analysis.
- To conduct a co-word analysis to reveal the interconnected nature of research topics

### Methodology

This study investigates the citation practices and priorities of environmental science researchers in the WHR of India using a comprehensive bibliometric analysis framework. By incorporating techniques such as citation analysis, keyword analysis and employing various visualization tools like word clouds and tree-map visualizations.

### Scope and Limitations

This study aims to explore the environmental science research from four Central Universities in the WHR: the Central University of Himachal Pradesh (CUHP), the Central University of Jammu (CUJ), the Central University of Kashmir (CUK), and Hemwati Nandan Bahuguna Garhwal University (HNBGU). The analysis focuses on the period between 2012 and 2021 to shed light on the recent evolutions and prevailing trends within the domain of environmental science research across these institutions.

### Data Source and Sample Selection

The primary source of data for this study is the Scopus database. Scopus was chosen for its extensive coverage of peer-reviewed literature across a wide range of disciplines, including environmental science. This database is known for its high-quality records and is frequently used in bibliometric studies for its comprehensive indexing of articles, conference papers, and reviews<sup>19</sup>.

The study focuses on publications from four Central Universities in the WHR. These institutions were selected based on their significant contributions to research in the region. The inclusion criteria for the publications were:

- **Document Type:** Only 'articles' and 'reviews' were included to focus on substantial scholarly contributions.
- **Time Frame:** Publications from the period 2012 to 2021 were analyzed to capture the recent decade of research outputs.
- **Field of Study:** The focus was narrowed to environmental science to maintain relevance to the study's aim

### Data Collection

Data collection involved conducting a structured search on Scopus using affiliation identifier (CUHP-60107368; CUJ-60104778; CUK-60107398; HNBGU-60069550) for universities in the WHR.

Scopus uses unique identifiers for each affiliation, allowing it to categorize documents linked to specific institutions distinctly. The search was refined by the specified document types and publication years. A total of 23,292 citations data were downloaded in CSV, BibTeX and other file formats for further processing.

### Data Analysis

The Data analysis was performed using R Studio equipped with the Bibliometrix and Biblioshiny packages, chosen for their specialized capabilities in bibliometric analysis<sup>1</sup>. Initial steps in the data analysis included:

- **Descriptive Analysis:** Basic bibliometric indicators such as publication count, citation counts, and annual publication trends were assessed.
- **Content Analysis:** Frequently used keywords were analyzed to identify dominant research themes and trends.
- **Citation Analysis:** Most frequently cited sources, documents, and authors were identified to determine the influence within the field.
- **Network Analysis:** Collaboration patterns among authors, institutions, and countries were also examined through co-authorship and citation networks

### Results

#### Types of Document Cited by researchers

Table 1 outlines document types cited in environmental science research within the WHR,

showing a strong preference for journal articles (59.84%) due to their timeliness and peer-reviewed nature. Review articles are also frequently cited for their role in synthesizing existing research. In contrast, books and book chapters are less cited, likely because they are not updated as frequently. Citations also include conference papers, editorials, and letters, indicating a vibrant scholarly communication. However, 28.37% of citations are "undefined," suggesting a need for better metadata accuracy to improve bibliographic clarity. These trends reflect the fast-paced, interdisciplinary nature of environmental science and are consistent with global academic practices, highlighting the importance of up-to-date research and areas for improvement in scholarly communication.

#### Most Frequently Cited Journals

Table 2 lists the top ten journals frequently cited by EVS researchers in the WHR of India, offering insights into citation practices and scholarly priorities within this specific geographic and academic context. These journals, ranging from "Bioresource Technology" to "Environmental Science & Technology," represent a global span originating from countries like the UK, US, and the Netherlands and also highlight the significant impact and credibility each holds through their h-index, SJR, and CiteScore metrics. This diversity in the top journals demonstrates the researchers' engagement with leading international sources and emphasizes their commitment to contributing to high-quality, impactful environmental science research. The presence of these reputable

Table 1 — Types of Documents Cited by EVS Researchers of the WHR

S. N	Document Types	CUHP	%	CUJ	%	CUK	%	HNBGU	%	Total	%
1	Article	3006	68.87	3573	66.38	252	55.02	7106	54.30	13937	59.84
2	Book	5	0.11	18	0.33	3	0.66	37	0.28	63	0.27
3	Book Chapter	29	0.66	59	1.10	1	0.22	61	0.47	150	0.64
4	Conference Paper	73	1.67	116	2.15	17	3.71	199	1.52	405	1.74
5	Data Paper	0	0.00	0	0.00	0	0.00	3	0.02	3	0.01
6	Editorial	7	0.16	10	0.19	2	0.44	17	0.13	36	0.15
7	Erratum	0	0.00	0	0.00	0	0.00	1	0.01	1	0
8	Letter	6	0.14	9	0.17	0	0.00	48	0.37	63	0.27
9	Note	10	0.23	17	0.32	1	0.22	30	0.23	58	0.25
10	Retracted	0	0.00	1	0.02	0	0.00	1	0.01	2	0.01
11	Review	425	9.74	731	13.58	24	5.24	694	5.30	1874	8.05
12	Short Survey	19	0.44	22	0.41	0	0.00	52	0.40	93	0.4
13	Undefined	785	17.98	827	15.36	158	34.50	4837	36.96	6607	28.37
	Total	4365	100	5383	100	458	100	13086	100	23292	100

Table 2 — Top Ten Journals cited by the EVS researchers of the WHR

Rank	Source	Freq	Country	Publisher	h-index (2023)	SJR (2023)	Quartile (2023)	CiteScore (2022)	SNIP (2022)
1	<i>Bioresource Technology</i>	349	United Kingdom	Elsevier	364	2.58	Q1	19.0	2.016
2	<i>Atmospheric Environment</i>	250	United Kingdom	Elsevier	279	1.17	Q1	10.3	1.296
3	<i>Science of the Total Environment</i>	217	Netherlands	Elsevier	353	2	Q1	16.8	2.026
4	<i>Environmental Science &amp; Technology</i>	213	United States	American Chemical Society	480	3.52	Q1	16.7	2.052
5	<i>Chemosphere</i>	207	United Kingdom	Elsevier Ltd.	311	1.81	Q1	13.3	1.624
6	<i>Journal of Hazardous Materials</i>	192	Netherlands	Elsevier	352	2.95	Q1	20.2	2.136
7	<i>Current Science</i>	149	India	Indian Academy of Sciences	137	0.24	Q2	1.7	0.559
8	<i>Science</i>	144	United States	American Association for the Advancement of Science	1336	11.9	Q1	59.0	7.729
9	<i>Applied and Environmental Microbiology</i>	126	United States	American Society for Microbiology	367	1.02	Q1	7.3	1.103
10	<i>Environmental Science and Pollution Research</i>	118	Germany	Springer Science + Business Media	179	1.01	Q1	7.9	1.214

Note: *h-index, SJR, and Quartile Ranking data were retrieved from SCImago Journal Rank, and CiteScore and SNIP data were obtained from Scopus on 1st May 2024.*

Table 3 — Authorship patterns in the sources cited by the EVS researchers

No of Authors	Article	%	BBC	%	CP	%	Review	%	Other	%	Total	%
1	1025	7.35	68	31.92	70	17.28	279	14.89	3161	46.06	4603	19.76
2	2530	18.15	69	32.39	73	18.02	460	24.55	1647	24.00	4779	20.52
3	2758	19.79	35	16.43	83	20.49	356	19.00	950	13.84	4182	17.95
4	2322	16.66	19	8.92	72	17.78	280	14.94	511	7.45	3204	13.76
5	1765	12.66	7	3.29	48	11.85	171	9.12	255	3.72	2246	9.64
6	1263	9.06	4	1.88	25	6.17	115	6.14	142	2.07	1549	6.65
7	719	5.16	2	0.94	15	3.70	72	3.84	65	0.95	873	3.75
8	545	3.91	1	0.47	9	2.22	38	2.03	52	0.76	645	2.77
9	314	2.25	2	0.94	3	0.74	24	1.28	15	0.22	358	1.54
10	182	1.31	1	0.47	2	0.49	19	1.01	28	0.41	232	1.00
More than 10	514	3.69	5	2.35	5	1.23	60	3.20	37	0.54	621	2.67
Total	13937	100	213	100	405	100	1874	100	6863	100	23292	100

Note: *BBC - Books & Book Chapters; CP- Conference Papers; Other sources includes – Data Paper, Editorial, Erratum, Letter, Note, Retracted, Short Survey, and Undefined.*

journals in citation lists points towards prioritising strong, peer-reviewed research outputs that shape the WHR's environmental policies, research directions, and sustainability initiatives.

**Authorship & Collaboration Patterns**

Table 3 presents the authorship patterns among different types of documents cited by researchers in EVS within the WHR. It highlights a strong culture of collaboration in this academic area. Most cited publications feature two authors, representing 20.52%

of the total, with three-author papers following at 17.95%. This emphasizes the importance of teamwork and cross-disciplinary collaboration in EVS. There is a noticeable decrease in the frequency of publications as the number of author increases. Publications authored by more than ten individuals constitute only 2.67% of the citations, indicating that larger collaborative projects are less common and pivotal in substantial research. In essence, the data from Table 3 highlights the critical role of collaborative research in environmental science.

**Top 10 Affiliations Cited by Researchers**

The University of California is the most cited affiliation, showcasing its pivotal role and substantial contributions to environmental science research. It is followed by Mae Fah Luang University and Chiang Mai University, highlighting the significant Asian academic influence. Banaras Hindu University and the Indian Institute of Technology are also prominently featured, emphasizing their critical contributions. Prestigious institutes like the Kunming Institute of Botany, Jawaharlal Nehru University, Oregon State University, King Saud University, and the Wadia Institute of Himalayan Geology are also on the top 10 list, reflecting their respective impacts within the environmental science community. These leading institutions function as hubs of research and innovation, drawing skilled researchers and fostering environments conducive to ground-breaking work.

**Top 10 Countries Cited by Researchers**

Table 5 lists the top 10 countries cited by researchers in EVS in WHR. India leads with the highest number of cited articles (3067), with a considerable number of both single-country publications (SCP) and multi-country publications (MCP), demonstrating both domestic and collaborative research strengths. The USA follows

closely with 2803 citations, showing a substantial collaborative index, indicated by its higher MCP ratio (0.25). China ranks third with 1719 citations, emphasizing its growing influence and a high degree of international collaboration, as shown by its MCP ratio (0.32). The United Kingdom (UK) and Germany also feature prominently, indicating robust research outputs and high levels of international collaboration, with MCP ratios of 0.36 and 0.38, respectively. Japan, Canada, Spain, Italy, and France round out the list, each showcasing noteworthy citation counts and collaboration efforts, particularly in France, with the highest MCP ratio of 0.45 among them

**Analysis of Frequently Used Keywords**

The keyword analysis (Figures 1 and 2) of EVS research in the WHR demonstrates a wide-ranging and focused study area, emphasizing themes like "taxonomy," "adsorption," "heavy metals," "climate change," and "phylogeny." It covers environmental processes, climatic impacts, and the classification of life forms, with a regional focus on areas like "India," "Himalaya," and "Garhwal." The research notably concentrates on water issues, biodiversity conservation, and forest ecology, highlighting the significance of water resources, species diversity, and the carbon cycle. The analysis also points out advanced technologies such as "Remote Sensing" and "Microbial Fuel Cell," showing a commitment to utilizing innovative methods to address environmental challenges

**Co-Word Network Analysis**

The Co-Word Network shown in Figure 3 is based on the author keywords found in the sources cited by EVS researchers in the WHR. It illustrates different clusters of keywords and their relationships, which provide insights into common research themes and associations between concepts. The nodes in the

Table 4 — Top 10 affiliations

S. N	Affiliation	No. of Cited Articles
1	University of California	472
2	Mae Fah Luang University	226
3	Chiang Mai University	162
4	Banaras Hindu University	160
5	Indian Institute of Technology	157
6	Kunming Institute of Botany	147
7	Jawaharlal Nehru University	140
8	Oregon State University	132
9	King Saud University	127
10	Wadia Institute of Himalayan Geology	119

Table 5 — Top 10 Countries

S.N	Country	No. of Cited Articles	SCP	MCP	Freq	MCP_Ratio
1	India	3067	2643	424	0.13	0.14
2	USA	2803	2093	710	0.12	0.25
3	China	1719	1162	557	0.07	0.32
4	UK	683	435	248	0.03	0.36
5	Germany	511	315	196	0.02	0.38
6	Japan	441	320	121	0.02	0.27
7	Canada	411	303	108	0.02	0.26
8	Spain	371	265	106	0.02	0.29
9	Italy	321	213	108	0.01	0.34
10	France	310	169	141	0.01	0.45



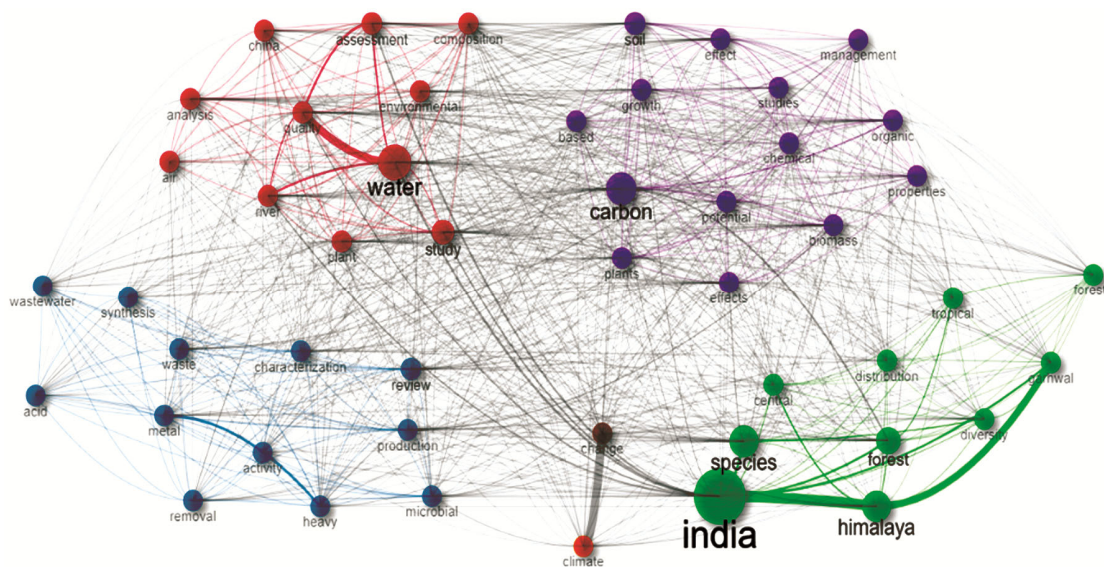


Fig. 4 — Co-occurrence Network - Based on Title Keywords

"conservation," "soil," "diversity," "radon," "temperature," "pollution," "species richness," "gis," and "remote sensing."

- *Cluster 3 - Pollution and Remediation:* Keywords in this cluster primarily relate to pollution and remediation strategies such as "adsorption," "heavy metals," "biosorption," "kinetics," "cadmium," "arsenic," "wastewater," "bioremediation," "phytoremediation," "fluoride," "toxicity," "photocatalysis," "carbon nanotubes," "copper," "biodegradation."
- *Cluster 4 - Taxonomy and Biological Classification:* This cluster revolves around taxonomy and biological classification, including keywords like "taxonomy," "phylogeny," "systematics," "fungi," "ascomycota."
- *Cluster 5 - Air Quality and Pollutants:* Keywords such as "pm2.5," "pahs," "particulate matter," "source apportionment," "pm10" are centred on air quality, particulate matter, and pollutant sources.

The Co-occurrence Network analysis (Figure 4) reveals the interconnectedness of specific keywords in the titles cited by the EVS researchers from the WHR. The network is structured into different clusters, each represents thematic group of related keywords.

- *Cluster 1 - Environmental Assessment and Quality:* Keywords such as "water," "study," "analysis," and "assessment" form a closely connected cluster, indicating a strong association in research articles.

This cluster suggests a focus on environmental assessment, water quality studies, and analytical methodologies.

- *Cluster 2 - Production and Synthesis:* Terms like "review," "production," "removal," and "synthesis" are interconnected, highlighting a thematic cluster related to reviews, production processes, and synthetic methodologies in environmental research.
- *Cluster 3 - Biodiversity and Regional Focus:* "india," "species," "himalaya," and "forest" form a tightly connected cluster, suggesting a thematic focus on biodiversity, regional ecosystems, and the unique environmental aspects of the WHR.
- *Cluster 4 - Soil and Organic Studies:* "carbon," "soil," "effects," and "organic" are closely linked, indicating a cluster focused on soil studies, the effects of environmental factors, and research related to organic materials.
- *Cluster 5 - Climate Change:* "climate" forms a separate cluster, emphasizing a distinct focus on climate-related studies. This could include research on climate change impacts, adaptation, and mitigation strategies in the WHR.

Overall, the co-word network analysis (Figures 3 and 4) highlights the multidisciplinary and interconnected nature of the field. Key thematic clusters identified include environmental techniques and pollution remediation, biodiversity and ecosystem studies, climate change, and air quality, emphasizing the breadth of

research focus areas. These findings strongly emphasize innovative environmental management practices, unique biodiversity conservation, and the significance of addressing climate change and air pollution. The analysis highlights the importance of interdisciplinary approaches in tackling the complex environmental challenges in the WHR, pointing towards a holistic research ecosystem that integrates diverse methodologies and insights to promote sustainability and environmental protection in the region.

### Findings and Conclusions

The findings of this study provide valuable insights into the various aspects of citation practices and priorities of EVS researchers in India's WHR. The predominance of citations from high-impact journals such as "*Bioresource Technology*" and "*Environmental Science & Technology*" emphasizes the global orientation of researchers in the WHR. These journals are noted for their rigorous peer-review processes and international reach, suggesting that the region's researchers are engaged in cutting-edge environmental science that aligns with global research standards and innovations. This also reflects a commitment to contributing to international sustainability and environmental management discourses.

The authorship patterns highlight a strong inclination towards collaboration, with most studies involving two to three authors. This suggests a culture of teamwork, which is essential for tackling the multifaceted nature of environmental issues that require diverse expertise. Significant collaborations, both within the country and internationally, further support the integration of local research with global knowledge networks.

Keyword analysis revealed concentrated efforts on issues such as *climate change*, *water quality*, and *biodiversity*, which are critical to the WHR. The focus on these areas indicates the regional priorities and challenges the local ecosystems and communities face. Additionally, using advanced technologies like "*Remote Sensing*" and "*Microbial Fuel Cells*" points to an innovative environmental monitoring and remediation approach. The co-word analysis illustrated the interconnected nature of research topics, with clusters focusing on pollution remediation, biodiversity, and climate change. This indicates a holistic approach to environmental research where different disciplines converge to provide comprehensive solutions. The thematic diversity within these clusters highlights the WHR's

unique environmental challenges and the region's response through targeted research endeavours.

This study illustrated environmental science researchers' citation practices and priorities in the WHR. The findings indicate that environmental research in the WHR aligns with global scientific standards and actively contributes to the broader discourse on environmental sustainability and conservation. These findings can inform policy-makers and academic institutions in the WHR by highlighting critical research and international collaboration areas. Enhancing support for areas such as water resource management, climate change adaptation, and biodiversity conservation can be prioritized to address the region's specific needs. Also, fostering environments that encourage further interdisciplinary research and international collaborations can enhance the region's capacity to manage its environmental resources effectively.

Although this study is limited to secondary citation data, future research should consider incorporating primary data sources for a more comprehensive analysis. Further studies could also examine the influence of these research outputs on local and national environmental policies. An in-depth analysis of how research translates into practice would provide valuable insights into the effectiveness of the current research ecosystem. Additionally, expanding this bibliometric study to include a broader range of data sources and more institutions could offer a more detailed understanding of the environmental science scope in India.

In conclusion, environmental science research in the WHR is characterized by solid engagement with global research networks, a focus on regional environmental challenges, and a multidisciplinary approach that emphasizes the complexity of environmental management. These findings emphasize the critical role of academic research in informing sustainable and effective environmental policies in the region.

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