



Bibliometric Analysis of Clean Development Mechanism (CDM) Research: Trends, Impact, and Key Contributions

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ABSTRACT: This study is a bibliometric analysis of Clean Development Mechanism (CDM) research from 2001 to 2024. The bibliometric data was collected from Scopus database. Biblioshiny in R studio was used to analyse this data. The study primarily aims to identify the most cited sources, journals, authors, countries and references in the field of CDM research and examine the current research trends in CDM research. The study found that CDM research has grown significantly, with noticeable high in 2012 and 2017, suggesting that scholarly interest has remained constant. Leading publications including Journal of Cleaner Production, Scientific Reports, and PLOS ONE are highlighted in the report, along with well-known writers like Michaelowa A. and De La Torre J. The majority of CDM research contributions come from developed nations, including the USA, China, and the UK. The report also tracks changing research themes, from early 2000s policy-driven debates to late 2010 market-focused viewpoints and, more recently, to technology-driven methods like machine learning. The relevance of CDM in sustainability, carbon reduction, and policy frameworks is reinforced by the strong academic interconnection shown by co-citation and collaboration networks. All things considered, CDM research is still a vibrant, multidisciplinary field that tackles the financial, technological, and environmental aspects of climate change.

I. INTRODUCTION

United Nation Framework Convention on Climate Change (UNFCCC) conference held in Kyoto in 1997 introduced three mechanisms to combat with climate change problems they are Clean Development Mechanism (CDM), Joint Implementation (JI) and Emission Trading. Clean Development Mechanism (CDM) allows developed countries to invest in emission reduction projects in developing countries. These projects generate Certified Emission Reduction (CER) this helps developed countries to meet their emission reduction targets. Both developed and developing countries are actively participate in this Clean Development Mechanism (CDM) projects. It is important to understand the nature of research conducted in this area. This will help scholars and other academicians to know the in most cited sources, journals, authors, countries and references in the field of CDM research and to understand research trend in CDM research. Bibliometric analysis crucial tool for comprehending research trends, patterns of collaboration, and the influence of scientific publications [1]. This study aims to analyse the bibliometric information of CDM research and find the most cited sources, journals, authors, countries, references, and trends in the field of CDM research and tries to find the research direction in CDM research.

II. REVIEW OF LITERATURE

A variety of economic, environmental, and policy-driven effects are found in research on Clean Development Mechanism (CDM) projects. Businesses generally invest in CDM to boost income and reputation, but consistent adoption is hampered by financial and regulatory uncertainty [2], [3]. Although CDM has helped reduce emissions, especially in the areas of renewable energy and green transportation [4], technology transfer is still scarce and frequently limited to operational knowledge rather than equipment [5]. Economic prosperity, trading experience, and government incentives are some of the elements that affect how CDM projects are distributed [6]. As a result of increasing energy demand after investment, several studies show that CDM projects paradoxically increase firm-level emissions [7]. According to [8], businesses lament the absence of standard accounting techniques but value CERs for their cost advantages. Enhancing regulatory structures and improving financial systems may increase CDM's sustainability and long-term efficacy.



Bibliometric analysis crucial tool for comprehending research trends, patterns of collaboration, and the influence of scientific publications. By classifying it into teacher-student, colleague, and international collaborations, [1] emphasized the growing trend of research collaboration and showed that it was positively correlated with research funding and productivity. To facilitate science mapping, [9] presented Bibliometrix, an open-source R tool that offers a thorough workflow for bibliometric analysis by combining data collecting, analysis, and visualization. Bibliometrix was further developed by [10], who emphasized its adaptability and capacity to facilitate systematic literature evaluations by permitting organized examination of research domains. [11] addressed the difficulties brought on by the exponential expansion of scholarly information and offered a thorough methodological guide on doing bibliometric analysis, emphasizing its function in systematic literature reviews. Together, these findings highlight how important bibliometric methods are for improving research productivity, charting scientific landscapes, and assisting academics in making evidence-based decisions.

This study aims to analyse the bibliometric information of CDM research and find the most cited sources, journals, authors, countries, references, and trends in the field of CDM research and tries to find the research direction in CDM research.

III. OBJECTIVES

- To explore bibliometric information in CDM research.
- To analyse most cited sources, journals, authors, countries and references in the field of CDM research.
- To identify the research trend in CDM research

IV. METHODOLOGY

Bibliometric analysis on CDM research was conducted using the secondary data collected from Scopus database. This bibliometric data was analysed using Biblioshiny in R studio. The data were collected for period from 2001 to 2024 as CSV file.

V. SEARCH PROCEDURE AND FILTERS APPLIED.

Bibliometric data was collected from Scopus database. The search keywords used was “clean development mechanism” or “CDM”. Clean development mechanism is one of the market-based mechanism introduced in Kyoto protocol in 1997 and came into force 2001 therefore data was collected for a period from 2001 to 2024. 41444 documents were retrieved from Scopus, then this result was filtered. Only English documents were included for this study and article type documents were included. Subject area included in filtration were social science, economics econometrics and finance, business management and accounting, multidisciplinary. Finally, 1197 documents were selected for this study and these documents are from 523 sources. Table 1 shows the main information about this data.

Table 4.1 Main Information About Data

Description	Results
Timespan	2001:2024
Sources (Journals, Books, etc)	523
Documents	1197
Annual Growth Rate %	4.4
Document Average Age	10.4
Average citations per doc	24.31
References	49002
DOCUMENT CONTENTS	
Keywords Plus (ID)	4561
Author's Keywords (DE)	2943
AUTHORS	
Authors	3220
Authors of single-authored docs	238
AUTHORS COLLABORATION	
Single-authored docs	262
Co-Authors per Doc	3.18
International co-authorships %	23.98
DOCUMENT TYPES	
article	1197

VI. RESULT AND DISCUSSION**A. Annual scientific production**

Figure 1 shows papers were published annually between 2001 and 2024. The quantity of articles first varied, reaching a low of seven in 2003 before steadily rising in subsequent years. There is a noticeable increase starting in 2009 (71 articles), with maxima in 2012 (74 articles) and 2017 (72 articles), suggesting that there was increased interest in the topic throughout these years. Between 2013 and 2019, the numbers stayed largely consistent, ranging from 54 to 72 articles every year. However, there was a discernible decline in 2020 (43 articles), which might have been brought on by outside disturbances like the COVID-19 epidemic. Publication counts recovered after 2020, with 2022 (71 articles) and 2024 (70 articles) indicating a resurgence of interest. According to the data, there has been an increase in research activities recently.

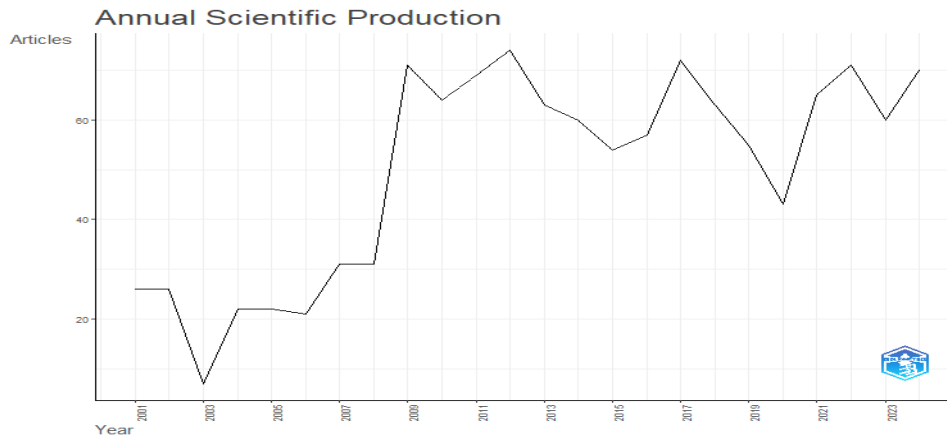


Figure 5.1: Annual scientific production Source: Bibliometrix

B. Average citation per year

Figure 2 shows average citation per year of clean development mechanism project study. The trend of average citations per year from 2001 to 2023 shows significant fluctuations over time, with a sharp decline observed after 2021 and a significant drop in 2023. A notable rise is seen around 2008, when citations reached their highest point, followed by a sharp decline and sporadic smaller peaks in 2010, 2013, and 2019. This pattern suggests that certain high-impact publications may have driven the peaks, while the recent decline may indicate a shift in research focus or the time lag in accumulating citations for newer publications.

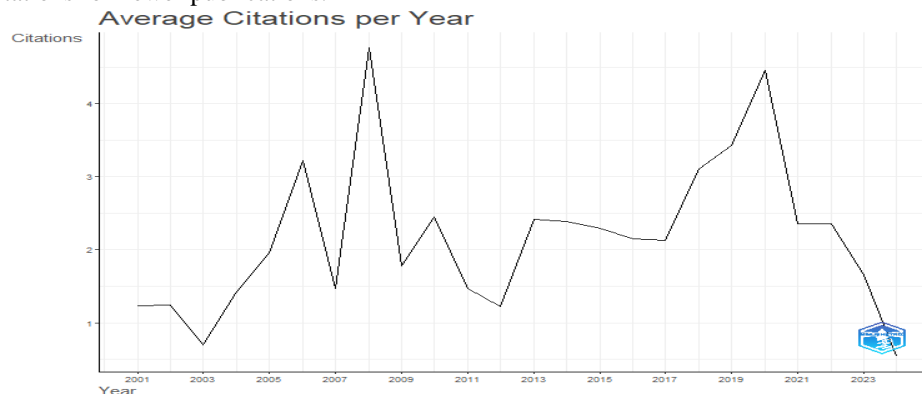


Figure 5.2: Average citation per year Source: Bibliometrix

C. Three field plot

Three field plot shows the relationship between cited references (CR), authors (AU), and keywords/descriptors (DE) in Clean Development Mechanism (CDM). Key cited references are highlighted in the left side; some works are mentioned more than once, emphasizing their fundamental effect. These sources are linked to important writers like de la Torre J., Olsen K.H., and Ellis J. in the middle section, demonstrating their noteworthy contributions to CDM research. Research themes are categorized in the right section using terms such as "clean development mechanism (CDM)," "sustainable development," "climate change," "carbon markets," and "renewable energy." Figure 3 highlight how extremely interdisciplinary CDM research is, with a focus on sustainability, emission reduction tactics, and policy frameworks. Strong ties between writers, sources, and major ideas point to a substantial corpus of work addressing the financial, ecological and technological aspects of CDM.

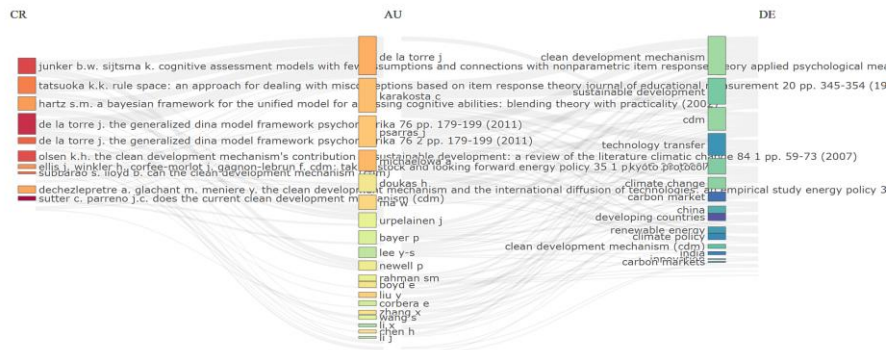


Figure 5.3: Three field plot Source: *Bibliometrix*

D. Most relevant sources

Figure 4 shows the most relevant source on Clean Development Mechanism (CDM) studies. The most relevant source on this topic is Plos One journal with 42 documents followed by Scientific reports with 34 studies. International environmental agreements: politics law and economics (31), Ecological economics (25), Journal of cleaner production (25) and Sustainability (Switzerland)(22) are also other relevant journals in this area.

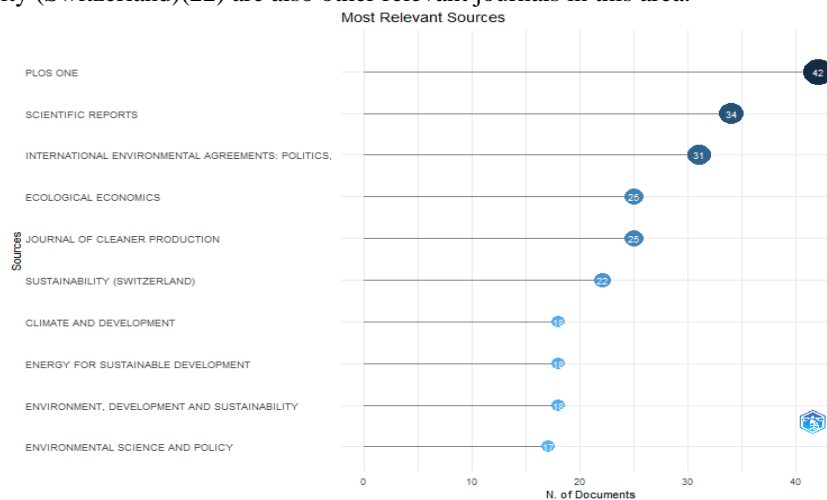


Figure 5.4: Most relevant sources Source: *Bibliometrix*

E.Source local impact by H index

Figure 5 highlight the source local impact by H index on Clean Development Mechanism (CDM) studies. Journal of cleaner production have the highest H index (22) on this topic followed by Plos one with 21 H index. Ecological economics (17), International environmental agreements: politics law and economics (17), Energy for sustainable development (13) and Environmental science and policy also have high local impact.

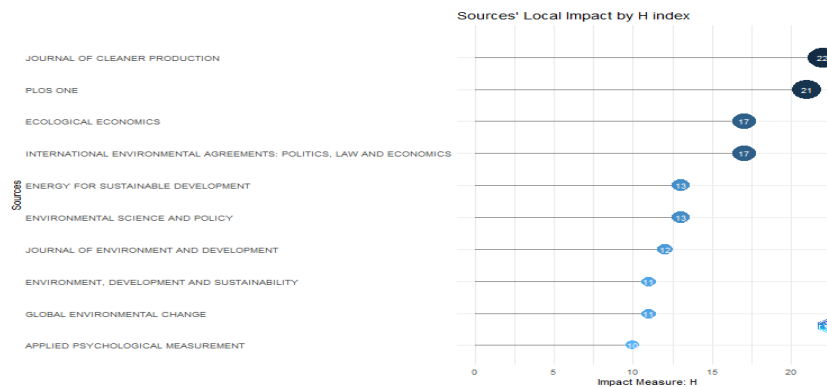


Figure 5.5: Source local impact by H index Source: *Bibliometrix*

F.Sources' production over time

Figure 6 shows the change in research on CMD published in various journals from 2001 to 2024. Initially there was very small studies on CDM, Cleaner Production and Ecological Economics journal had few articles. From 2008 the number of studies gradually increased. With number of articles increased sharply from 2010 onward to 42 in 2024, PLOS ONE become a preeminent publication. Similarly, after 2020, the number of publications in Scientific Reports increased significantly. The coherence among the Journal of Cleaner Production, Ecological Economics, and International Environmental Agreements suggests that CDM research continues to be multidisciplinary, tackling economic, policy, and sustainability issues. The general pattern points to an increase in intellectual participation.

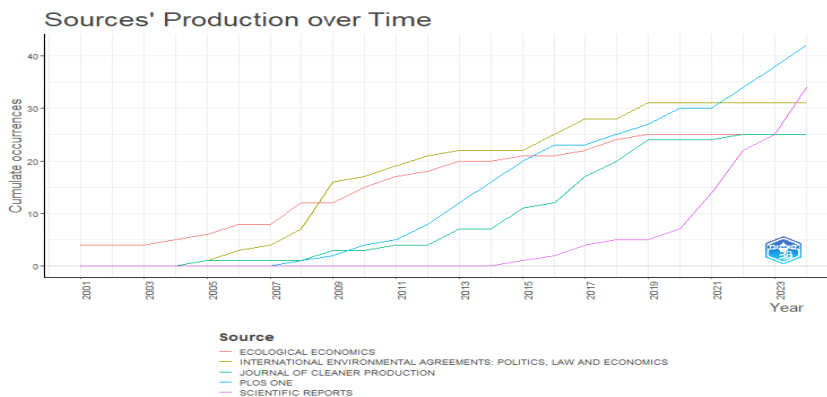


Figure 5.6: Sources' production over time Source: *Bibliometrix*

G.Most relevant authors

Figure7 indicates the most relevant authors on Clean Development Mechanism (CDM) studies. De La Torre J has the highest number of articles (16) on this topic. Michaelowa A has 14 articles on Clean Development Mechanism (CDM).

These two authors are the most prominent authors in this field. Karakosta C (10), Psarras J (9), Liu Y (8), Ma W (8), Chen H (7) and Zhang X (7) are other relevant authors in this area.

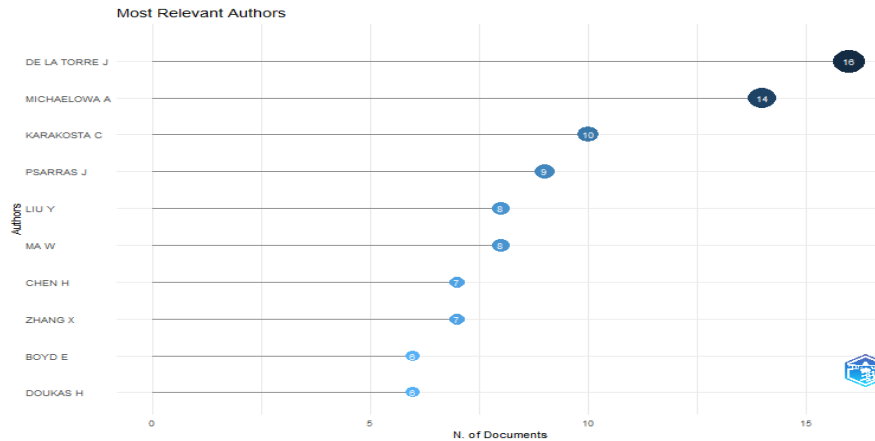


Figure 5.7: Most relevant authors Source: *Bibliometrix*

H. Authors local impact by H index

Figure 8 shows the influential authors in Clean Development Mechanism (CDM) studies through h- index. Leading the pack with an h-index of 12, Michaelowa A has made a substantial contribution to CDM research. De La Torre J comes in second with an h-index of 11. With an h-index of 7, other noteworthy contributors like Karakosta C, Liu Y, and Psarras J demonstrate their significant influence in the subject. Boyd E, Chen H, and Doukas H are among the few scholars with an h-index between 4 and 6, indicating a broad and expanding academic community interested in CDM-related subjects.

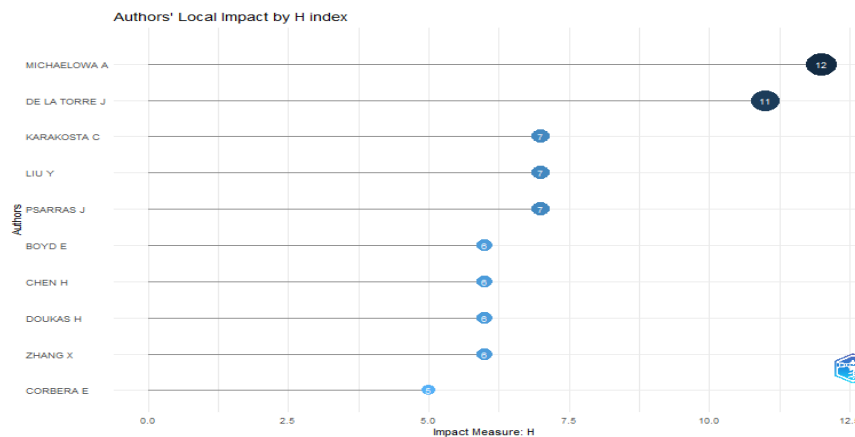


Figure 5.8: Authors local impact by H index Source: *Bibliometrix*

I. Countries scientific production

Figure 9 indicates the research contributions of each country on Clean Development Mechanism (CDM). The USA is on the top in CDM research with 656 papers, followed by China with 376 papers and UK with 248 papers. Countries like Germany (232), India (176), Japan (161), South Korea (154), Australia (123) and Brazil (120) also made high contributions in CDM research. The information highlights a large-scale, globally dispersed study on CDM.

Country Scientific Production

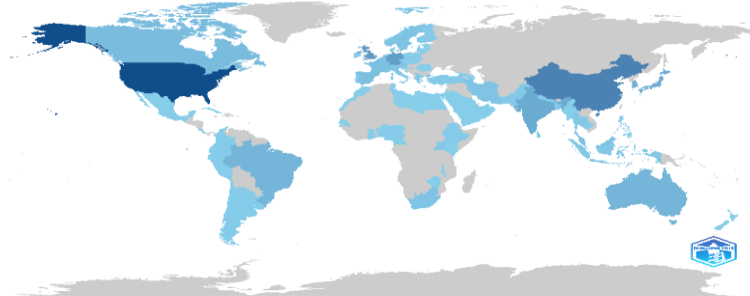


Figure 5.9: Countries scientific production *Source: Bibliometrix*

J. Most cited countries

Figure 10 shows the most cited countries on CDM research. It indicates dominance of USA with 5439 citations China (2054 citations) and the United Kingdom (2825 citations) come in second and third, respectively, suggesting that they have a big influence on the conversation on CDM. Notable contributions from Norway (131) and Germany (168) also demonstrate their scholarly and political interests in carbon markets and sustainability. The citation counts of other nations, such as Canada, India, Australia, the Netherlands, and Italy, range from 18 to 88, indicating relatively lower but nevertheless significant participation in CDM research. The distribution highlights how wealthy countries dominate the academic conversation on CDM and have an impact on global climate plans, especially those with robust research institutions and climate regulations.

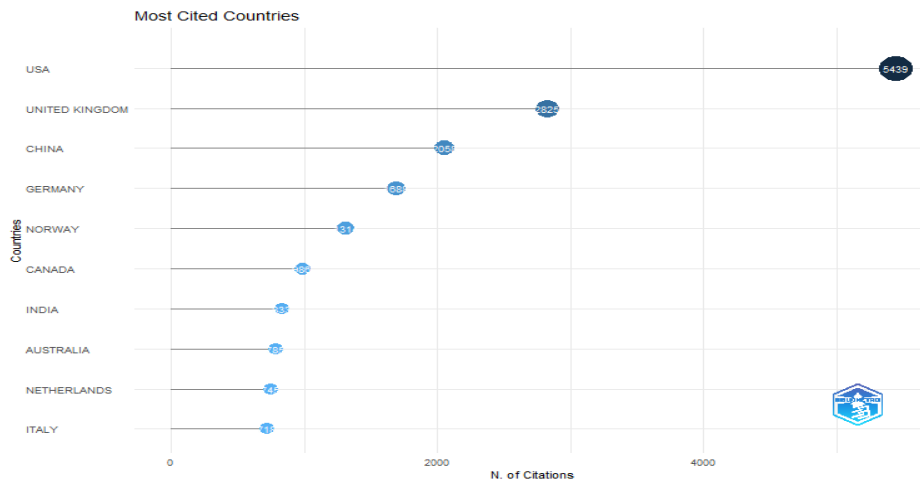


Figure 5.10: Most cited countries *Source: Bibliometrix*

K. Most global cited documents

Figure 11 shows the most cited documents on CDM studies. The result highlights that the study of Peters GP (2008, Ecological Economics) is the most cited paper with 913 citations. The paper of Governato F (2010, Nature) has 8610 citations indicating significant interdisciplinary interest. Other highly referenced studies that highlight the economic policies and geographical aspects of CDM are Griffith R. (2006, Oxford Review of Economic Policy) and Bumpus AG. (2008, Economic Geography), which have 516 and 510 citations, respectively. The studies of Denton F. (2002, Gender & Development), Yao S. (2006, PNAS) and Yuan B. (2018, Journal of Cleaner Production) also have high citation with 452, 437 and 396 respectively.

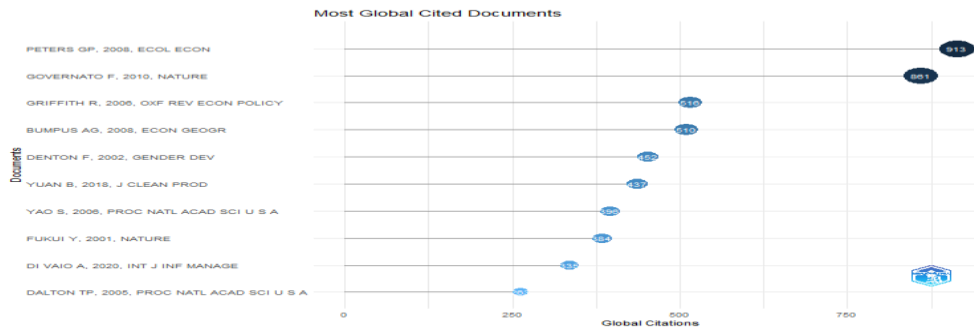


Figure 5.11: Most global cited documents Source: Bibliometrix

L. Most relevant words

Figure 12 shows the key terms in CDM research. Clean Development Mechanism (CDM) is the most common term occurs 391 times. The terms “emission control” and “climate change” occurs 253 times and 191 times respectively, these terms are also common in CDM studies. Words like "project method" (131) and "sustainable development" (133) draw attention to the importance of CDM in promoting sustainability and methodical implementation strategies. Other commonly used terms are "markets" (126), "human" (120), and "trade" (93), "biomass" (91) and "greenhouse gas" (92).

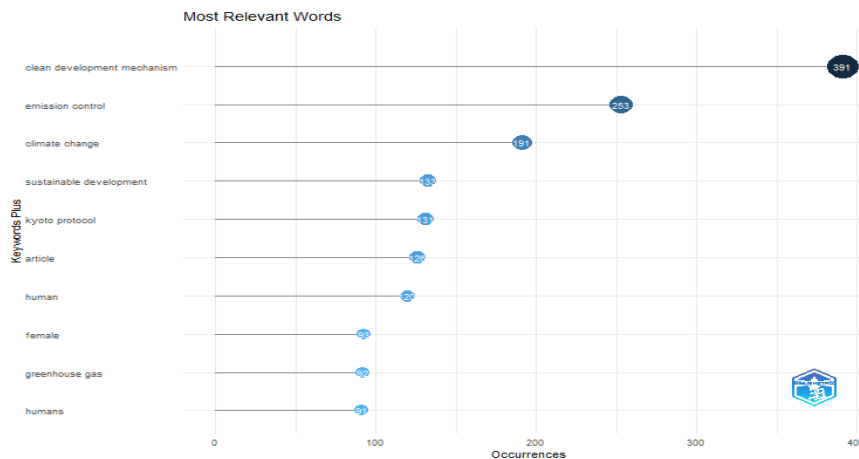


Figure 5.12: Most relevant words Source: Bibliometrix

M. Trend topics

Figure 13 highlight the trendy topics in CDM research. The result shows that during 2002 to 2010 "Kyoto Protocol," "sustainable development," "carbon dioxide," "climate change," and "emission control," was the trendy topics. From 2010 there was a shift towards market driven economic topics like "environmental economics," "carbon emissions," "energy policy," and "investment,". Recent trend shows that the focus was shifted to technological areas with terms "machine learning," "algorithm," and "simulation,".

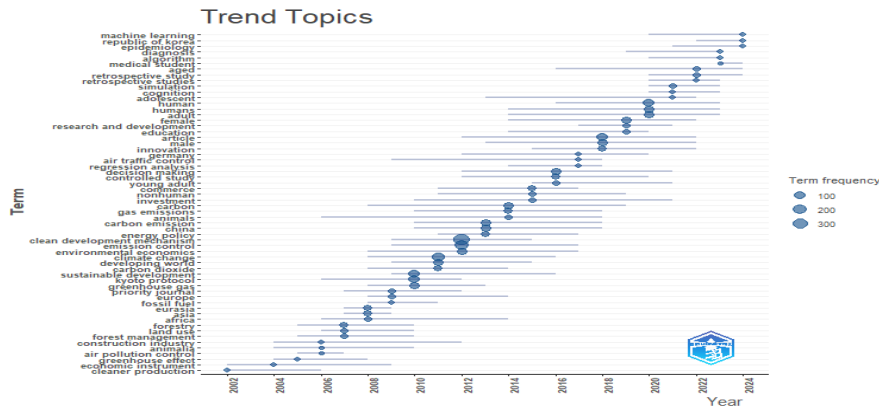


Figure 5.13: Trend topics Source: Bibliometrix

N.Co citation network

Clusters of highly referenced works are highlighted by the co-citation network in CDM (Clean Development Mechanism) studies, indicating significant scholarly influences in the subject. Sutter C is a key author in the largest and most interconnected cluster (red and blue nodes), which centres on basic research on CDM, the Kyoto Protocol, and climate policy. This suggests a solid body of research relating sustainable development, policy frameworks, and the efficacy of CDM. Other noteworthy clusters include an autonomous grouping (brown nodes) headed by Griffith R. (2006), which probably focuses on market-based or economic viewpoints regarding carbon markets and emissions trading. Furthermore, de la Torre J. (2011) is at the core of another unique network (purple and orange nodes),

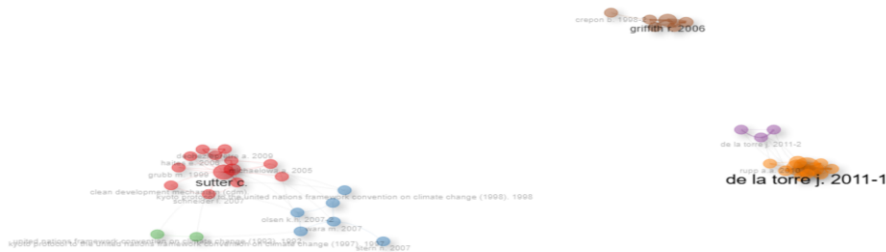


Figure 5.14: Co citation network Source: Bibliometrix

O.Collaboration network

Figure 14 shows the academic collaboration on CDM research. This collaboration is indicated as clusters. The most important cluster is centered around de la Torre J. Zhang X., Zhang Y., and Liu Y are another prominent cluster they focused on emission trading or climate policy. Michaelowa A shows another remote cluster they have fewer direct collaborations. Cluster led by Karakosta C is smaller and autonomus.

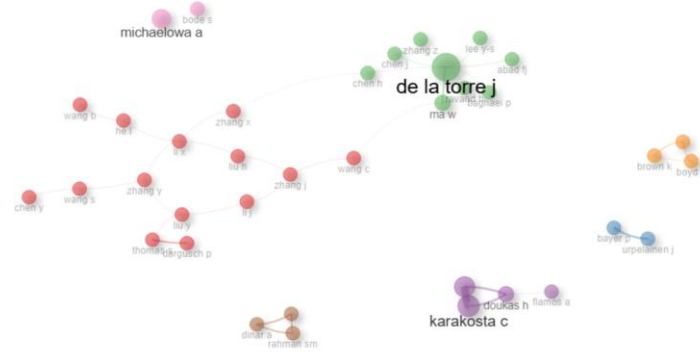


Figure 5. 15: Collaboration network Source: Bibliometrix

VII. CONCLUSION

Bibliometric analysis on Clean Development Mechanism (CDM) research from 2001 to 2024 indicates Significant expansion, interdisciplinary involvement, and changing research patterns. The research has been rising consistently and peaks in 2012 and 2017, indicates a ongoing scholarly interest. Even if citation patterns fluctuate, the discourse is nonetheless shaped by early, significant works. Key authors and research topics are shown in the three-field plot, which also shows CDM's contribution to sustainability, carbon reduction, and policy frameworks. Prominent journals including Journal of Cleaner Production, Scientific Reports, and PLOS ONE all provide substantial contributions; the latter has the highest H-index. Important writers are Michaelowa A. and De La Torre J. Developed countries dominates in CDM research, USA is the leading contributor., followed by China and the UK. Prominent authors' highly referenced papers highlight CDM's sustainability, policy, and economic aspects. From policy-focused subjects in the early 2000s to market-driven debates after 2010, and more recently, to technology-based methods like machine learning, research trends have changed. Strong academic interconnectedness can be shown in co-citation and collaboration networks, with clusters centered around well-known researchers. All things considered, CDM research remains a vibrant, interdisciplinary subject that tackles the environmental, technological, and financial difficulties associated with mitigating climate change.

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