Análisis cienciométrico de métodos cuantitativos para evaluar la capacidad de absorción de CO_2 en bosques tropicales

Scientometric Analysis of Quantitative Methods for Assessing CO_2 Absorption Capacity in Tropical Forests

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Abstract

Climate change has heightened the need to accurately quantify the CO_2 absorption capacity of tropical forests, which serve as key carbon sinks in the global carbon balance. To address this issue, a scientometric analysis was conducted to synthesize the available scientific literature using databases such as Scopus and Web of Science (WoS). This analysis aimed to identify prevailing research trends and the most commonly used methodological approaches in the field. The results reveal the emergence of innovative methods for quantifying carbon storage; however, significant challenges remain, including the standardization of techniques, the lack of studies in Neotropical regions, and the weak linkage between scientific research and public policy aimed at climate change mitigation. Within this framework, this review article aims to reduce existing knowledge gaps by identifying methodological trends and research voids related to the estimation of CO_2 absorption capacity in tropical forests.

Keywords: Climate change mitigation, carbon sinks, tropical forests, allometric equations, CO_2, scientometrics.

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Resumen

El cambio climático ha incrementado la necesidad de cuantificar con precisión la capacidad de absorción de CO_2 de los bosques tropicales, que funcionan como sumideros clave de carbono en el equilibrio global del carbono. Para abordar esta cuestión, se llevó a cabo un análisis cienciométrico con el fin de sintetizar la literatura científica disponible, utilizando bases de datos como Scopus y Web of Science (WoS). Este análisis tuvo como objetivo identificar las tendencias de investigación predominantes y los enfoques metodológicos más utilizados en el campo. Los resultados revelan la aparición de métodos innovadores para la cuantificación del almacenamiento de carbono; sin embargo, persisten desafíos importantes, como la estandarización de técnicas, la escasez de estudios en regiones neotropicales y la débil vinculación entre la investigación científica y las políticas públicas orientadas a la mitigación del cambio climático. En este contexto, el presente artículo de revisión busca reducir las brechas de conocimiento existentes mediante la identificación de tendencias metodológicas y vacíos de investigación relacionados con la estimación de la capacidad de absorción de CO_2 en los bosques tropicales.

Palabras claves: Mitigación del cambio climático, almacenes de carbono, bosques tropicales, ecuaciones alométricas, CO_2, cienciometría.

1. Introduction

This research focuses on the scientometric analysis of quantitative methods used to estimate CO_2 absorption capacity in tropical forests. This approach makes it possible to outline the current state of the field and identify which countries, institutions, or authors are leading the research, which journals are most influential, and which methodologies are most frequently employed. Scientometrics plays a key role in understanding the evolution and dissemination of scientific knowledge [1]. This effort gains importance amid growing global concern over the greenhouse effect and its consequences, such as global warming—an issue of planetary scale that demands a coordinated response. Within this framework, a scientific priority has emerged: the need to quantify the CO_2 absorption capacity of tropical forest ecosystems [2].

In this context, forests, particularly tropical forests, play a fundamental role as carbon sinks. The structural layers of these ecosystems (herbaceous stratum, understory, and canopy) absorb atmospheric CO_2 through the biochemical process of photosynthesis. At the end of this process, a portion of the carbon remains stored in the plant biomass, which includes leaves, stems, roots, fruits, and volatile organic compounds [3]. Tropical forests are responsible for absorbing approximately 30% of global CO_2 emissions, which positions them as strategic components in global efforts to mitigate climate change—an environmental challenge that has intensified since the beginning of the Industrial Revolution [4]. Due to their critical role in climate regulation, tropical forests have gained increasing relevance in recent years within the field of quantitative methodologies for estimating aboveground forest biomass and stored carbon, particularly those based on allometric equations. These approaches have become central to international strategies such as REDD+ (Reducing Emissions from Deforestation and Forest Degradation) [5].

Numerous empirical studies have proposed innovative approaches aimed at improving the accuracy and efficiency of biomass and carbon stock estimations [6] [7]. One such example is a study conducted in Mexico, which aimed to develop an allometric equation using data obtained through light detection and ranging (LiDAR) technology, allowing for a more accurate estimation of the aboveground biomass of *Pinus hartwegii* trees [8]. In the same country, another investigation highlighted the limited development of allometric equations for Dipterocarp forests, leading to the formulation of a model designed to meet the required methodological standards [9].

An empirical study conducted in the Republic of Ghana, located in West Africa, sought to develop a mixed allometric model in response to the absence of a suitable local methodological basis for accurate estimations [10]. The study utilized seven models based on 745 destructively sampled trees, and the best-performing model was validated through statistical tests against the pan-tropical model developed by Chave et al. [7]. Additionally, another study conducted in Mexico provided evidence that the combination of pastoral systems and remnant forests significantly improves carbon absorption [11].

Similarly, a study conducted in the state of Guanajuato, Mexico, aimed to estimate both plant and soil biomass in the Protected Natural Area of the "La Purísima" Dam. The results revealed that 71.21% of the carbon was stored in the soil, followed by the arboreal stratum with 24.6%, the shrub layer with 1.86%, grasses with 0.75%, and finally, the herbaceous stratum—plants located below the understory—with 1.57% [12]. Complementarily, a study conducted in grazed riparian ecosystems in California demonstrated that restoration efforts significantly increased soil carbon stocks and woody biomass, highlighting the potential of restoration practices to enhance CO_2 capture in degraded ecosystems [13] .

Moreover, a study in the Western Himalayan forests of India assessed carbon sequestration potential through forest inventories and statistical modeling, identifying altitude and tree density as key determinants [14]. Various studies have demonstrated the potential of different ecosystems to act as carbon sinks, using quantitative methods for their evaluation. In species-rich grasslands, simulated drought conditions were found to enhance carbon sequestration capacity compared to moist environments, based on measurements of biomass and soil carbon [15].

In Chinese salt marshes, the role of tidal creeks in carbon distribution was analyzed through quantitative techniques that characterized the different forms of carbon present in sediments [16]. Likewise, a study conducted in the seagrass meadows of Gazi Bay, Kenya, quantified carbon storage in both sediments and biomass, highlighting the importance of these coastal ecosystems in climate change mitigation [17]. These investigations showcase diverse yet complementary methodological approaches that enhance the understanding of the ecological function these natural systems perform in CO_2 capture.

Despite the progress achieved on this subject, notable knowledge gaps remain concerning the quantification of CO_2 absorption capacity in tropical forests [18]. In this context, the current scientometric study aims to contribute to addressing these gaps by analyzing the main trends, methodological approaches, and research voids related to the estimation of CO_2 absorption capacity in tropical ecosystems.[19].

2. Methodology

As part of this research, a scientometric review was conducted on existing methods for quantifying CO_2 absorption in tropical forests [18]. The analysis relied on two content-rich scientific databases, Scopus and Web of Science, which were used to search, process, and evaluate the relevant scholarly literature. These platforms encompass an extensive collection of peer-reviewed scientific journals and serve as essential tools for accessing publication metadata [20] [21]. Based on these sources, the study conducted a comprehensive analysis and synthesis of publication metrics covering the period from 2003 to the present. The focus was specifically on the scientometric assessment of quantitative methods used to estimate CO_2 absorption capacity in tropical forests. Additionally, high-quality and relevant information was gathered through the electronic resources of the Universidad Nacional de Colombia (UNAL), known as Bases UNAL. These resources enabled the identification of key articles for analysis and supported the synthesis of literature related to the research topic.

Table I. Search parameters used in Scopus and WoS databases

Parameter	WoS	Scopus
Range	2003-2024	
Date	April 10	
Document type	Articles	
Words	TITLE-ABS-KEY (carbon AND sequestration AND bank) AND PUB YEAR > 2003 AND PUB YEAR < 2026 AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (DOCTYPE , "ar"))	
Results	386	194
Total (WoS + Scopus)	402	

Regarding the processing of our bibliometric data collected from the Scopus and Web of Science (WoS) databases, and based on the search criteria detailed in Table 1, the search covered a time period from 2003 to the present—amounting to a 21-year range. This search was conducted on April 10 of the current year, and the results were limited to articles published in English, as English is the most widely accepted language within the scientific community. In WoS, keywords were applied to the Title, Abstract, or Keywords fields. In Scopus, the following query was used: TITLE-ABS-KEY (carbon AND sequestration AND bank) AND PUBYEAR > 2003 AND PUBYEAR < 2025 AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (DOCTYPE, "ar")). This yielded 386 articles in WoS and 194 in Scopus, totaling 580 records.

Initially, 124 duplicate articles were identified and removed from the combined database, resulting in 402 unique and non-redundant records. These records were organized into 22 Excel spreadsheets, collectively referred to as the database, which included data such as references, countries of origin, year of publication, citation count, journal quartile, and co-authorship networks. Finally, interconnections between publications were established, highlighting collaboration and citation networks within the global scientific production related to carbon capture and storage. This process enabled an assessment of the impact and trends in this field of research (Figure 1).

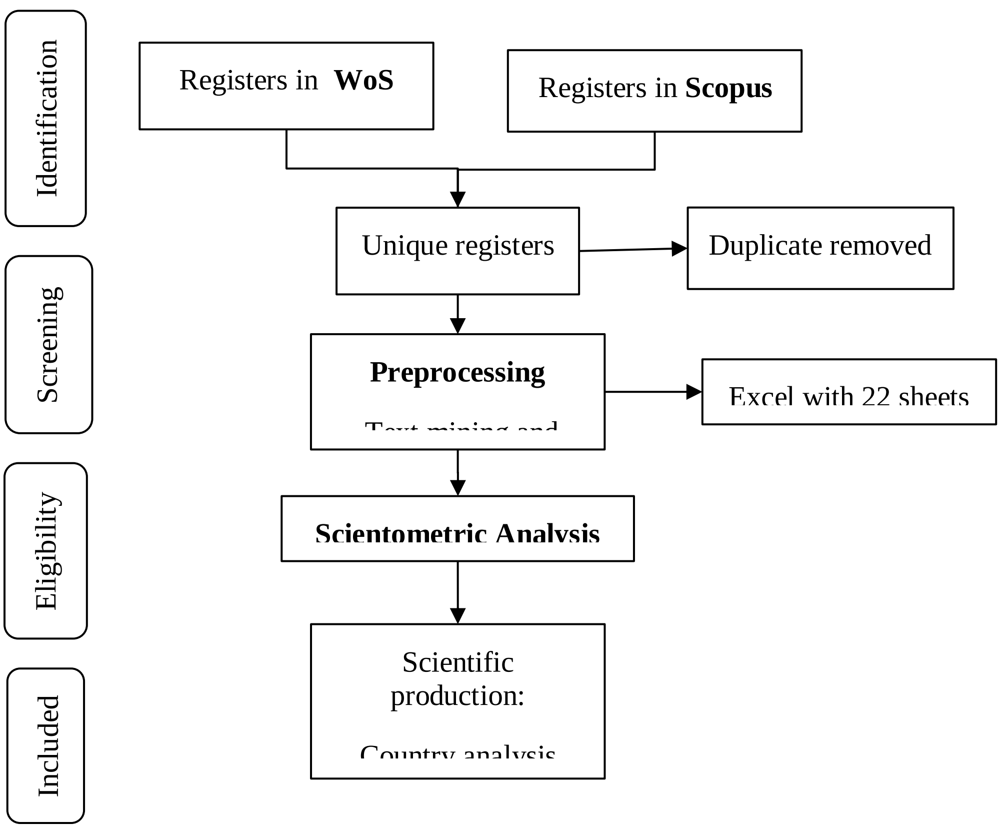

Figure 1. Detailed illustration of collected information

Once the search results from each database were obtained, the Google extension known as Google Colab was used—a tool commonly employed in academic studies that accommodates beginners through a user-friendly interface while also meeting the needs of advanced users [22]. This platform enabled the interactive execution of Python scripts. Through the developed script, the database containing relevant information from Scopus and WoS was read, processed, and visualized. Finally, Gephi 10.1 software was used to generate networks, facilitating an accessible visualization of each collected study. This software is open-source and freely available.

3. Results

Scientific Annual Production

Figure 2 presents a comparative analysis between annual scientific output and the total number of citations received over time, within the context of quantitative methods used to assess CO_2 absorption capacity in tropical forests. Based on data from Scopus and WoS, this figure illustrates temporal trends in article production from 2003 to the present, along with cumulative impact as measured by citations. This analysis allowed for the identification of periods of heightened research activity and their correlation with scientific impact, highlighting the years with the highest output and the most influential publications in the field.

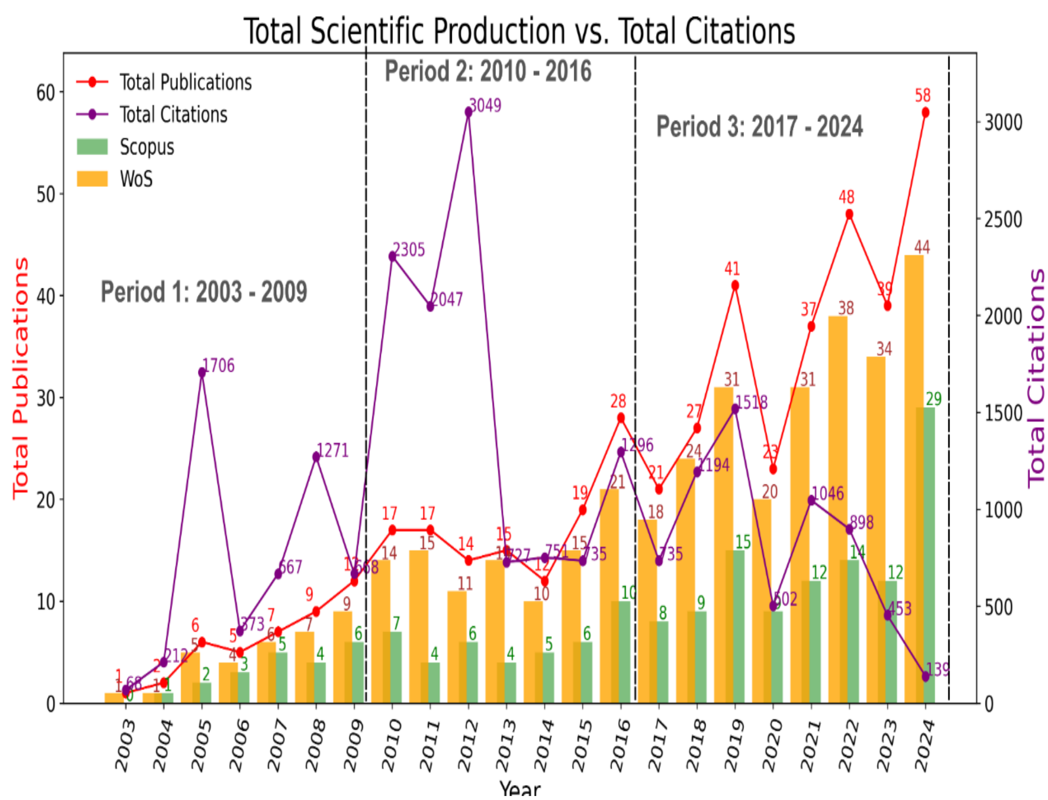

Figure 2. Scientific Production vs. Total Citations over the time

Additionally, the figure provides a detailed overview of academic production, where each graphical element is defined as follows: WoS (bars represented in yellow), Scopus (bars represented in green), and the total number of combined publications from both sources (line represented in red). Likewise, it shows the total number of citations obtained from WoS and Scopus (line represented in purple).

Finally, the dashed line represents the boundaries between the defined periods, which are as follows: Period 1, referred to as the Initiation Phase, spans from 2003 to 2009; Period 2, known as the Exponential Growth Phase, extends from 2010 to 2016; and Period 3, labeled the Consolidation Phase, runs from 2017 to the present.

Period 1: Initiation Phase (2003–2009)

During this period, a slow growth in scientific production is observed. The red line, which represents the total number of publications, starts with just one article in 2003 and increases gradually to nine publications by 2009, marking the end of this phase. The purple line, which reflects total citations, shows an abrupt pattern with noticeable peaks in 2005 (1,706 citations) and 2008 (1,271 citations). These peaks suggest the publication of highly influential articles in years with otherwise low output. The bars representing Scopus and WoS publications are small in the early years; however, from 2005 onward, a slight increase in visibility through these databases becomes evident, although still limited during this phase.

Period 2: Exponential Growth Phase (2010–2016)

In this period, the red line indicates a marked increase in the number of publications, particularly from 2010 to 2011. Although the growth became irregular between 2011 and 2014, it begins to rise more significantly in 2015, reaching a total of 28 publications. The purple line, indicating citations, reaches its highest values during this phase: 2,305 citations in 2010, 2,047 in 2011, and a peak of 3,049 in 2012. Similarly, the Scopus and WoS bars show a fluctuating pattern but also reflect an overall increase during 2010 and 2011.

Period 3: Consolidation Phase (2017–2024)

In this phase, the red line continues to show a significant upward trend, despite two intervals of decline in the total number of publications. In contrast, the purple line reveals an abrupt pattern. Initially, citation counts grow steadily alongside publication output up to 2019, but a decline occurs in 2020. Although a modest recovery is noted from 2021 onward, citation peaks do not appear to match the growth in publications. This discrepancy may be attributed to a lack of visibility of recent articles, possibly due to limited dissemination efforts such as promotion via social media, academic conferences, or open access availability. Lastly, the Scopus and WoS bars exhibit a trend consistent with the red and purple lines, with a noticeable preference for WoS across all three periods.

Country Analysis

Table II presents an analysis of scientific production and impact by country in the field of quantitative methods for assessing CO_2 absorption capacity in tropical forests. Although the corresponding figure is still under development [23], the table compiles key data from the publications, likely including metrics such as the number of articles per country, total citations received, and other impact indicators. The data were extracted from Scopus and Web of Science databases and structured to identify the countries with the highest scientific output in this domain. This analysis highlights international collaboration networks and the geographic regions with the most research activity, offering a global perspective on trends in scientific production related to carbon capture in tropical forest ecosystems.

Table I. Scientific Production and Impact by Country

Country	Production		Citation		Quality			
	Count	%	Count	%	Q1	Q2	Q3	Q4
Usa	141	16.87	8542	25.59	91	13	3	4
China	84	10.05	1684	5.04	62	9	3	0
United Kingdom	62	7.42	3026	9.06	47	6	1	0
India	47	5.62	1664	4.98	17	14	3	1
Canada	37	4.43	1183	3.54	28	3	0	0
Australia	30	3.59	1133	3.39	21	5	0	0
Netherlands	27	3.23	599	1.79	18	4	0	1
Germany	25	2.99	844	2.53	19	2	0	0
France	21	2.51	1729	5.18	17	2	0	1
South Africa	19	2.27	870	2.61	10	4	1	3

During the execution of a study in 2025, Soil Organic Carbon (SOC) stocks were mapped using large databases (n = 144,197) and pedotransfer functions, mediated by models such as Model B—based on district-level data. This model showed significantly better performance compared to others, with an average RMSE of 0.28%, and was therefore selected to generate SOC maps. These maps revealed an average SOC stock of 1.46 ± 0.54 kg m^{-2}, identifying Ultisols and grasslands as the largest carbon reservoirs (4,209 and 4,654 Mg km^{-2}, respectively) [24](10.3390/f10020103). This research represents a significant advancement in the scientometric analysis of quantitative methods for evaluating CO_2 absorption capacity in tropical dry forests, as it provides a robust approach for the spatial mapping and quantification of SOC. Moreover, it offers methodological frameworks that can be adapted to improve carbon stock estimates in tropical ecosystems, in alignment with climate change mitigation goals [25].

Subsequently, studies conducted in the mangrove forests of northern India assessed the extent of aboveground biomass carbon storage using forest inventories and allometric equations.

These studies highlighted significant variability across different environmental settings and emphasized the importance of these ecosystems in carbon capture [26], [27].

An additional study related to this research explored the role of African forests in mitigating climate change, emphasizing their functionality as carbon sinks through the capture of atmospheric CO_2. It was revealed that forests cover approximately 22% of the African continent. Data collected over 100 years were analyzed, including variables such as CO_2 emissions, forest loss and recovery, and land-use change [28]. The use of geospatial tools such as ArcGIS, the InVEST model, and the K and S indices demonstrated that 77.36% of African countries experienced greater forest losses than gains. It is critically important to highlight deforestation as a key factor in this loss, primarily driven by anthropogenic activities; thus, if this continues, the problem will worsen significantly.

In line with previous studies, this type of research contributes to the expansion of the field of quantitative methods for assessing CO_2 absorption in tropical forests by providing a detailed spatiotemporal analysis of carbon sequestration. It emphasizes the importance of proper forest conservation and introduces valuable methodologies such as InVEST, which will have a significant effect on improving biomass and carbon stock estimates in tropical ecosystems [2].

Figure 3 It illustrates and allows the analysis of scientific collaboration networks among countries that have worked on this topic.The network displays four communities, which are: Community 1 represented by dark blue, Community 2 by red, Community 3 by pink, and finally Community 4 by sky blue. As observed, the figure shows a dominance of Communities 1 and 2, with Community 1 encompassing 42 countries and Community 2 including 36 countries.

It is important to note that all communities show active connections among the countries within them, indicating a diverse and interconnected scientific collaboration network centered on this topic. Although Colombia does not stand out in the figure, it has also contributed to this study. For example, one study focused on estimating carbon capture in forest cover, followed by calculating the monetary value of the ecosystem services of CO_2 storage in a tropical dry forest in Carmen de Bolívar, Colombia, using a quantitative approach. The results confirmed that despite anthropogenic activities such as logging, burning, etc., it remains a good carbon sink, and that trees with greater biomass and structure have higher CO_2 fixation [29].

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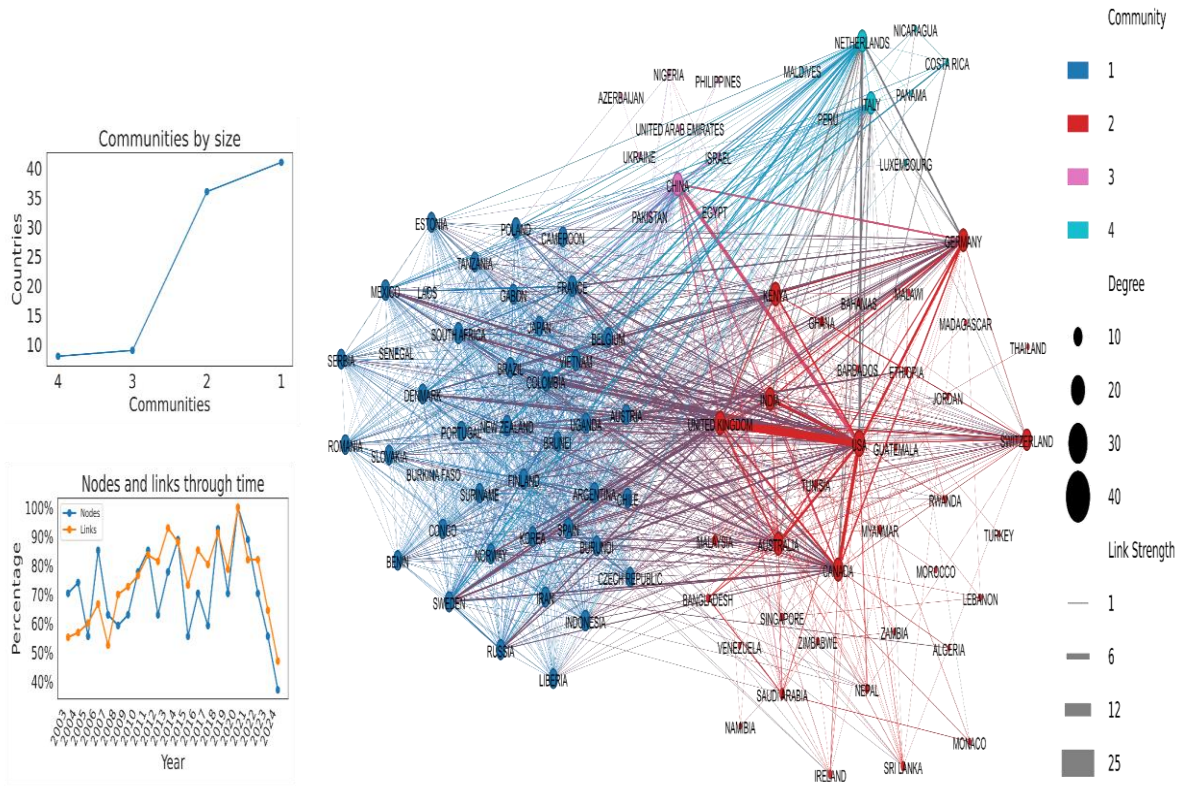

Figure 3. Global Collaboration Network

Journal Analysis

Table III shows that all the evaluated publications fall within the Q1 category of Scimago, demonstrating their high reputation. However, notable discrepancies exist in their key indicators: *Global Change Biology* stands out for having the highest impact (SJR = 4.6), while *PLOS ONE* has the highest H-index (467), indicating significant long-term influence. Regarding productivity, *Science of the Total Environment* and *Geoderma* lead with 12 publications each. Nonetheless, variations were detected in the "Total" articles column (for example, *PLOS ONE* shows 0 articles despite having 11 combined between WoS and Scopus). Similarly, imbalances in indexing were found, such as *Sustainability* with 0 in WoS and 9 in Scopus, or *CATENA* with 6 in WoS.

Table III. Productivity and Impact of Leading Journals

Journal	SN	Wos	Scopus	Total	SJR	H-index	Quartile
Science of the Total Environment	489697	6	8	12	2,137	399	Q1
Geoderma	167061	10	4	12	2,067	215	Q1
Global Change Biology	13541013	11	0	11	4,600	332	Q1
Journal of Environmental Management	3014797	5	5	8	1,994	268	Q1
Forest Ecology and Management	3781127	5	5	8	1,319	217	Q1
Plos One	19326203	8	0	8	0,803	467	Q1
Environmental Research Letters	17489326	7	2	7	2,144	201	Q1
Agroforestry Systems	1674366	6	3	7	0,575	98	Q1
Sustainability	20711050	9	0	7	0,688	207	Q1
CATENA	3418162	6	0	7	1,684	175	Q1

Additionally, the same table presents the ten journals with the highest scientific output on quantitative models for estimating CO_2 absorption, along with their impact factor, H-index, and Scimago quartile. The journal with the most publications on this topic is *Science of the Total Environment*, which belongs to Q1, indicating it is one of the most important in this area. The most cited article is a review conducted by a group of researchers on the impact and presence of microplastics in aquatic ecosystems.

In a study published in 2024, researchers conducted a meta-analysis with 873 observations from three continents to evaluate the contribution of fungal necromass carbon (FNC) to soil organic carbon (SOC) in global croplands, highlighting the role of recalcitrant fungal melanin. Soils in North America showed the highest FNC content (8.39 g kg^{-1}) compared to those in Asia and Europe, with microbial biomass carbon (MBC), soil pH, and clay content identified as the main drivers, while the C/N ratio and climatic factors had less influence [30]. Practices such as zero or reduced tillage (45% efficiency), cover cropping (32%), and straw amendment (26%) significantly increased FNC, which accounts for more than a quarter of SOC [31].

This work complements your research on quantitative methods for evaluating CO_2 absorption in tropical forests by highlighting how conservation practices in agricultural soils optimize carbon sequestration, offering approaches that could inspire management strategies in forest ecosystems to mitigate climate change, aligning with your goals of linking science and environmental policy [32]. A clear example of this is an article focusing on a forest management approach for climate change mitigation and adaptation in Germany and Japan, presenting sustainable forest management (SFM) aimed at simultaneously enhancing forest resilience and carbon sink potential [33].

A study conducted in Brazil investigated carbon and nitrogen sequestration in soils under Marandu grass pastures, with and without nitrogen fertilization or in combination with forage legumes [34]. The research was conducted across two regions with contrasting soil types: Lavras (clayey Ferralsol) and Itabela (sandy Acrisol). As a complementary analysis, the carbon sequestration potential of Umedalen, India, was assessed, providing a comparative perspective across different ecosystems regarding CO_2 absorption capacity [35](. The findings showed that, after 15 to 20 years, pasture systems enriched with legumes or nitrogen fertilization in Lavras restored carbon stocks to levels comparable to those of native vegetation. Conversely, Itabela exhibited lower carbon stocks, attributable to its predominantly sandy soil composition, highlighting the influence of soil type and land-use history.

This research supports and complements the study of quantitative methods applied to the assessment of CO_2 absorption in tropical forests by highlighting the importance of sustainable soil management as a key strategy to optimize carbon sequestration. It also provides valuable insights into mitigation strategies for climate change in forest ecosystems [36].

Additionally, a study published in the *Journal of Environmental Management* synthesized the carbon sequestration potential of agroforestry systems in India using quantitative methods based on biomass and soil carbon data, highlighting their importance in climate change mitigation [37]. Furthermore, another study explored the relationship between plant establishment and carbon accumulation processes [38], while an additional study assessed how silvopastoral systems directly influence carbon sequestration in tropical cropping systems [39].

Figure 4 illustrates a citation network among journals, thematically grouping them according to their research focus. In it, we see three communities. The first community is led by Science, Geoderma, etc., whose focus is on biotechnology, soil-plant-atmosphere interactions, soil studies, aspects of soil science, and its associated pedagogy. These journals, as seen, value interdisciplinary work [40]. For example, one of the mentioned scientific journals produced a study about forest biomass estimation using the Global Ecosystem Dynamics Investigation (GEDI) instrument and Earth observation data obtained through remote sensing, resulting in significantly greater accuracy in biomass estimation.

Therefore, this study emphasizes the use of these technologies for biomass estimation based on satellite data [41]. On the other hand, in the second community, journals such as Nature Communications, Forests, Biological Conservation, among others, can be seen, whose focuses are sustainable forest management, climate change, and soil carbon. As an example, a study published by these journals deals with the meticulous selection of allometric equations to estimate forest biomass based on predictive performance at the plot level rather than the individual level, resulting in the conclusion that model selection has a critical influence on forest biomass estimation [42].

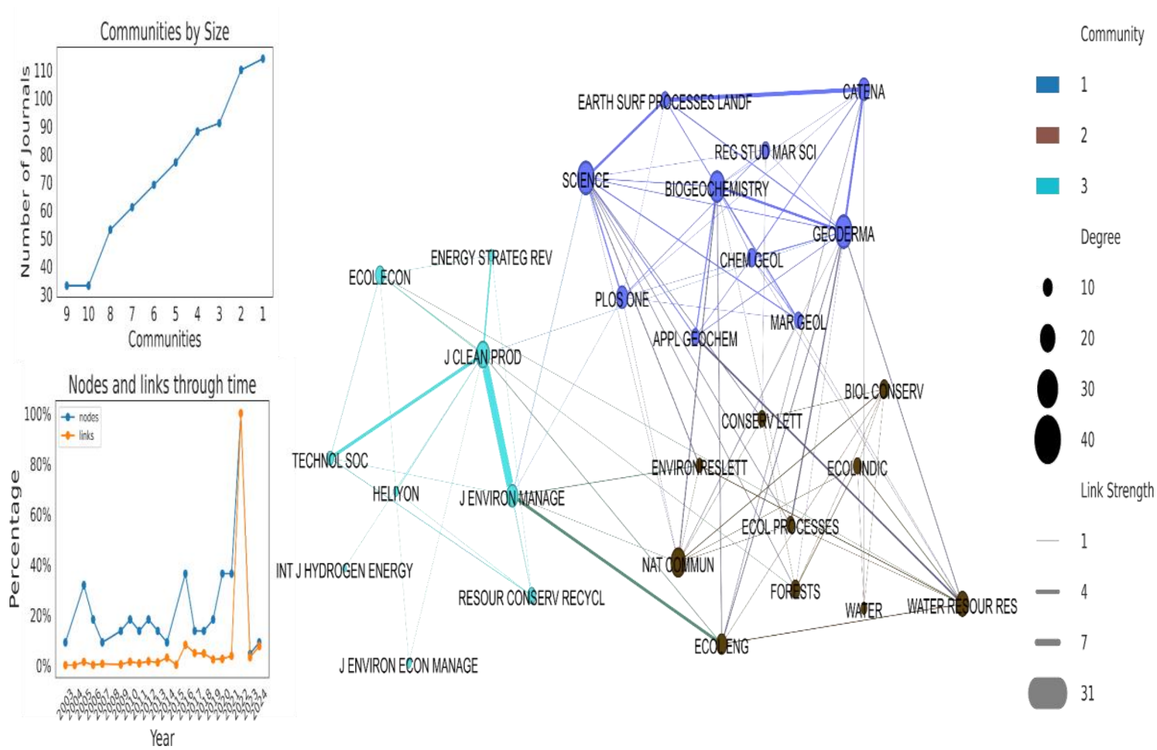

Figure 4. Citation Network of Leading Journals

Finally, the last community includes several journals—though not all—focused on theoretical and empirical studies related to environmental and natural resource topics. A notable example is an article published in *Heliyon*, which implemented an integrated water management system in coconut palm cultivation, effectively reducing CO_2 emissions and land subsidence. The results suggest that this sustainable approach holds great promise for the future [43].

Author Analysis

Table IV displays the most productive authors in the field of publications on quantitative methods for assessing CO_2 absorption capacity in tropical dry forests. It shows that, in terms of total number of publications (Total Papers), Liz Z leads with 8 studies, followed by Chaplot V, Rahman M, and Shang Z with 6 studies each. Other authors such as Bluffton E. R., Braimoh A., Cao J., Ibrahim M., Li S., and Liu X have 5 publications, indicating they have contributed fewer articles on the topic. However, looking at the next column—total number of citations received by these publications—Chaplot V leads with 537 citations, followed by Ibrahim M with 369, and so on, down to Li S, who has received the fewest citations.

Table IV. Principales autores más productivos en el ámbito de las publicaciones de los métodos cuantitativos para evaluar la capacidad de absorción de CO_2 en bosques tropicales.

Author	Papers Total	Total Citations	H-Index	Effective_Size	Constraint	CDI
Li Z	8	156	5	242.31	0.02	0.04
Chaplot V	6	537	6	60.65	0.05	0.05
Rahman M	6	65	3	149.56	0.02	0.07
Shang Z	6	192	6	27.65	0.09	0.07
Bluffstone R	5	86	4	25.06	0.1	0.14
Braimoh A	5	22	2	1.0	1.0	1.0
CAO J	5	161	5	57.88	0.05	0.04
Ibrahim M	5	369	5	73.35	0.04	0.12
Li S	5	8	2	259.08	0.01	0.04
Liu X	5	124	4	379.43	0.01	0.04

The H-Index, an indicator that combines productivity and citations, is led by Chaplot V and Shang Z, each with an H-Index of 6. They are followed by Liz Z and Ibrahim M, both with an H-Index of 5, and so on, down to the researchers with the lowest H-Index scores, namely Li S and Braimoh A.

Another indicator is the effective size, where Liu X stands out for having the largest collaboration network among all authors in this table, with a value of 379.43, while Braimoh A has a small collaboration network. Regarding the Constraint metric, Braimoh A has a value of 1.0, indicating a high dependence on a small group of collaborators, meaning he has few links with other authors, which limits his dissemination—as reflected in the table. In contrast, Li S has a Constraint value of 0.01), indicating a much broader collaboration network. Finally, the Scientific Collaboration Degree Index (CDI) is notable, with Braimoh A showing a value of (1.0) despite having few connections with other authors.

Figure 5 The collaboration of the most productive authors is presented through a scientific collaboration network, where the nodes represent the main authors and researchers, and the connections between them indicate collaborative relationships. Three distinct communities are observed, delineated by the following colors: Community 1 (light blue), Community 2 (brown), and Community 3 (dark blue). Among them, Community 1 appears to have the most dominant component, as suggested by the clustering of nodes and the variation in their size and color, which likely reflects the degree of collaboration or influence of each author. The legend indicates degrees (1, 3, 10, 20, 40) and link strengths (1, 3, 5, 7), representing different levels of collaboration intensity, with higher-degree nodes indicating more central or influential contributors

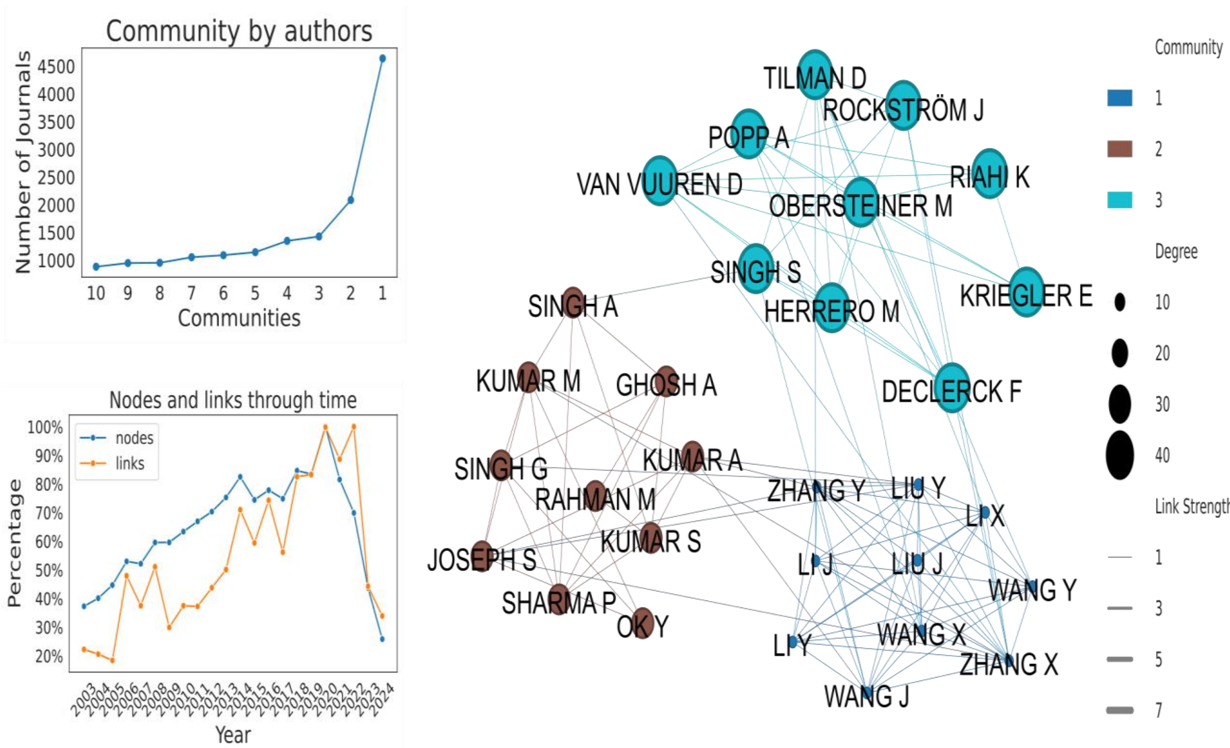

Figure 5. Network Collaboration of the Most Productive Authors

Conclusions

This study conducted a scientometric review of existing methods for quantifying CO_2 absorption in tropical forests, using searches in both Scopus and Web of Science. The results show that the topic is highly relevant, highlighting significant methodological advances such as the use of LiDAR technology and regional allometric models, among others. These developments have enabled a better understanding of the dynamics and specific roles within tropical forests. However, important challenges persist, including the standardization of techniques, the need for increased research in Neotropical regions, and the strengthening of the link between science and public policy. The scientometric analysis revealed key contributions from prominent authors such as Liz Z, Sh, Chaplot V, and Ibrahim M., as well as influential journals like *Global Change Biology* and *Science of the Total Environment*, which have played a fundamental role in the dissemination of these topics. Among the countries with the highest research output are the United States and China, while the United Kingdom, despite having fewer publications, demonstrates a significant citation rate, reflecting its impact in terms of contributions.

This scientometric analysis reveals a series of clear trends in research on quantitative methods for assessing CO_2 absorption capacity in tropical forests. An initial observation indicates sustained growth in scientific output since 2015, driven by a rising global interest in climate change mitigation. Countries such as the United States, China, and the United Kingdom lead in both productivity and impact, while scientific collaboration networks show increasing international interconnectedness. Prestigious journals, all ranked in Q1, reflect the consolidation of this topic as a priority on the environmental science agenda. Furthermore, there is a notable methodological advancement toward more precise and comprehensive approaches, such as the use of LiDAR technology and the inclusion of soil carbon, suggesting a trend toward more robust estimations applicable to a wider range of ecological contexts..

The research reflects common limitations in scientometric analysis, primarily due to the exclusive reliance on databases such as Scopus and Web of Science. This approach tends to exclude relevant literature published in languages other than English or in local journals that are not indexed—particularly in tropical regions, where most field studies are conducted. As a result, it limits the ability to conduct in-depth assessments of methodological quality and the practical applicability of the studies. Therefore, the findings should be interpreted as a complementary panoramic overview rather than a substitute for qualitative systematic reviews

Future research should broaden the scope of bibliographic sources by including grey literature and publications in other languages, as well as by deepening qualitative analyses that evaluate the efficiency and applicability of the identified quantitative methods. Additionally, it is essential to conduct studies in underrepresented tropical regions.

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