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A Comprehensive Bibliometric Mapping of Carbon-Footprint Calculators: Methods, Applications, and Methodological Fragmentation (2007–2025)

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Abstract

The accurate interpretation of carbon-footprint measure is a key to the effective climate policy formulation, design of the sustainable production system, and the design of informed environmental decision-making. The current paper is an exploration of the methodological, technical, and applied aspects of the carbon-footprint calculators as a world-wide scholarly area based on the structural determinants of the system boundary, the variability of the emission factor, and the industrial or sector-specific modelling models and the socio-practical factors, which include the household behaviour, agricultural activities, and the use of the digital tools. Scopus was searched in which 124 publications, published between 2007 and 2025, were extracted and analyzed visually and by applying bibliometric methods through VOSviewer. Early review of research dynamics shows that the first phase of research (2007-2012) was followed by a velocity of growth and expansion of calculator tools (2013-2020) and then by a recent period of study (2021-2025) marked by methodological skepticism, digitalisation and integration of AI-enabled systems. The analysis of the author, country and keyword revealed that Europe and East Asia have the most contributions to the research, and the theme groups include household consumption modelling, AI-assisted agri-food infrastructures, and site-specific agricultural evaluation. Results indicate that despite the advancement of carbon-footprint calculators into highly complex decision support tools there exist considerable inconsistencies due to inconsistent methodological selection, data quality concerns, and differing assumptions on emission-factors. The new issues raise the need to have increased transparency, harmonisation, and interoperability to make policy more relevant and increase cross-study comparability. The research presents practical, methodological, and research implications to the stakeholders who want to enhance the efficacy and quality of carbon-accounting tools.

Keywords: *Carbon Footprint, Carbon Calculator, Sustainability, Environmental Assessment, Bibliometric Analysis, VOSviewer*

Introduction

Climate change mitigation has increased the interest of the world in the quantification of the greenhouse gas (GHG) emissions of anthropogenic activities, products, and systems. Calculators of carbon footprint are now widely used tools of converting the complex environmental impacts into quantifiable estimates of carbon dioxide equivalent (CO 2e) within fixed system constraints. Carbon footprinting, though initially intended to facilitate the creation of social awareness, has since refocused itself as the core element of climate policy design, corporate sustainability reporting and behavioural change agendas, as it attaches actions of ordinary people to calculable climate effects. The overall basis of these calculators is the principles of life-cycle assessment (LCA), emission factors, and activity-based models, although the design, complexity, and target user base of such tools are different in sectors (Colomb et al., 2013; Green et al., 2017). Two large traditions of methodology have influenced the making of carbon footprint calculators within the wider discipline. The original, which is driven by engineering and LCA, has an emphasis on accuracy, transparency of boundaries of systems, process data specific to the sector, and sound modelling systems are commonly seen in agriculture, infrastructure design, and industrial systems. The second is a behavioural and simplified calculator tradition that puts greater emphasis on usability, open accessibility, and quick approximation and is used widely in domestic awareness systems, consumer behaviour websites and lifestyle-oriented applications. Such customary practices represent a clash between methodological rigour and simplicity - a rift that still pervades the discussion of the validity and applicability of carbon footprint outcomes. This duality can be traced in the development of carbon footprinting.

The preliminary research (2007-2012) was devoted to the formulation of conceptual definitions of carbon footprints and making LCA methodology more accessible to the general audience. In the period between 2013 and 2020, studies have increased in the field of domain-specific calculators, such as agriculture, transport, buildings and food systems (Brazil and Caulfield, 2013; Adewale et al., 2019). More modern literature (2021-2025) has gravitated towards methodologies, digitalisation, AI-assistance types of modelling and industry-specific extensions like high-resolution agricultural calculators and standardised corporate reporting platforms. This trend has increased calculator use but has brought its own inconsistencies, demonstrating fragmentation of tools, industries and methods of calculation. The current literature indicates that time and again carbon footprint calculators can give different results of similar activities, which casts doubts on comparability and methodological soundness (Colomb et al., 2013). Such differences occur due to the differences in the system boundaries, databases of emission factors and sources of data, rules of allocation, temporal assumptions, and indirect emissions. An example is that agricultural calculators are very place-specific with consideration of soil properties, crop management and inputs of nitrogen, and biofuel models vary drastically depending on assumptions regarding land-use change (Adewale et al., 2019; Taheripour et al., 2024).

In addition, the conflict between simplified awareness calculators and technically sound modelling software remains a matter that influences discussions regarding transparency, usability as well as standardisation (Chen et al., 2022). Although calculators of carbon footprint are seen as valuable tools in climate studies and policy, the area is still disjointed with little integration among the sectors, methodologies, and areas of application. The existing studies that have been conducted mostly assess single calculators or case studies that are small in magnitude and will give insights that are locally applicable though not enough in developing a consistent picture as to how the field has changed over time. Up to this point, no whole-body literature on calculation tools of carbon footprint has undergone a comprehensive bibliometric mapping in terms of publication trends, collaboration patterns, themes of research, and methodological trends.

In this respect, the current study aims at answering the following research question: What are the key areas of application, methodological methods, and shortcomings of carbon footprint calculators, as indicated in the scientific literature?

To provide the answer to this question, a bibliometric analysis of 124 publications (20072025) of the Scopus database was carried out in VOSviewer. The paper focuses on the trends of publications, networks of authors and institutions cooperation, thematic clusters, and citation patterns in providing a refined picture of the evolution, diversification, and development of the field.

Importance of the Study

The value of the research is that it offers the first cross-sectoral systematic mapping of intellectual and methodological space of carbon footprint calculators. Calculators are being applied extensively in climate policy, corporate disclosure, agricultural modelling and consumer behaviour interventions, but there is no common framework that can be used to compare assumptions, logic behind their computation and their uses. This disintegration has practical implications: no uniform results will give way to the confidence of stakeholders, no easy way to implement a policy, and obstacles to standardisation. This synthesis of patterns of publications, themes of methodological differences, and structures of collaboration will help understand how various scientific communities deal with the quantification of carbon, the origin of methodological differences, and in what sectors innovation is promoted. It also shows the areas of convergence emerging including with ISO 14067 and life-cycle concepts, major gaps including transparency in the choice of emission-factors, indirect impacts and harmonisation among behavioural and engineering calculator traditions. With carbon accounting being integrated into climate laws, corporate ESG reporting, agricultural advisor systems, and online consumer platforms, it is vital to gain a better insight into the strengths and weaknesses of the methodologies. The bibliometric mapping can offer researchers, policymakers, and practitioners with an evidence-based basis to enhance transparency, enhance comparability, and reinforce efforts to standardise as well as the future development of methods. Finally, the research paper leads to the creation of more credible, harmonised and decision-relevant carbon footprint calculators.

Methodology

Data Collection and Search Strategy.

The proposed study assumes a bibliometric research design that will allow the researcher to map the scientific literature related to calculators of carbon footprints in a systematic manner. The Scopus database has been chosen as the main source of data due to its enormous coverage of peer-reviewed journals in the field of engineering, environmental sciences, economics, mathematics, and computational disciplines and the organization of the metadata as well as its integration with bibliometric software.

The search was conducted through the following query applied on titles of articles, abstracts and keywords:

TITLE-ABS-KEY (carbon calculator) OR (carbon footprint calculator).

AND (LIMIT-TO (SUBJAREA, ENGI) or LIMIT-TO (subjareas, ENGI) or LIMIT-TO (subjareas, ENGI) or LIMIT-TO (subjareas, ENGI) or LIMIT-TO (subjareas, ENGI) or LIMIT-TO (subjareas, ENGI) or LIMIT-TO (subjareas, ENGI) or LIMIT-TO (subjareas, ENGI) or LIMIT-TO (subjareas, ENGI) or LIMIT-TO (subjareas,

AND (LIMIT-TO (DOCTYPE, “ar”))

AND (EXCLUDE (LANGUAGE, Russian)

The limit of search was limited to peer-reviewed journal articles to maintain consistency in the methodology and academic rigor. To identify both technical and applied aspects of carbon footprint calculators such as the development of methodology, digitalisation, agricultural modelling, and environmental assessment, subject-area filters were utilized. The search was conducted in the year 2007 up to 2025 which is the period when the research on carbon footprint calculator has emerged, expanded and undergone diversification in its methodology. The first search provided 124 publications, which were filtered on duplicates and totality.

Preparation and Data screening.

The entire bibliographic record had been extracted out of Scopus as a CSV file, which included metadata elements of the names of the authors, its affiliations, and the year of publication, keywords, abstracts, the number of references and also the reference list. Screening of records was done to avoid incomplete metadata and also to provide consistency in entries. No redundants were detected and therefore all 124 records were included into analysis. Bibliometric mapping and quantitative/qualitative interpretation were based on the cleansed dataset.

Bibliometric Analysis and Visualization.

Bibliometric analysis of the literature was performed on VOSviewer (version X.X), which is an environment that specially focuses on creating, analysing and visualising bibliometric networks. Several methods of analysis were used to treat the organisational structure and intellectualisation of the field:

Co-authorship (authors, institutions, countries) analysis has been done to find collaborative networks. Co-occurrence of keywords was used to determine the dominant theme areas and the developing clusters of research topics. Citation analysis was done to find out the most influential authors, documents, and journals. Bibliographic coupling had been conducted to identify common intellectual bases of publications. Co-citation analysis was done in order to visualize the concept topography and theoretic bedrock of the area. Inclusion criteria (e.g., minimum citations, number of documents, number of mentions of a keyword) were introduced in a series of iterations that depended upon the network density and readability and were presented with the resultant findings.

Cluster Identification and Qualitative Interpretation.

The study generated clusters of inter-related authors, key-words, and institutions in terms of their strengths of bibliometric connections with the help of the clustering algorithm contained in VOSviewer. The qualitative analysis of each cluster served to explain the prevailing themes, characteristics of methods and patterns of the sector that were manifested in each cluster. This mixed approach helped to combine the quantitative bibliometric trends with qualitative thematic findings, which allowed us to understand the application, creation, and critique of carbon footprint calculators in different fields better.

Methodological Limitations

Although bibliometric analysis gives effective information on structures of collaboration, thematic development, and intellectual connection, it does not test the empirical correctness of calculators of carbon footprints themselves. Besides, the use of Scopus alone could help to leave out other useful publications that are stored in other databases, like Web of Science or Google Scholar. These are the limitations, which are taken into account and used in the interpretation of the results of this research.

Analysis

Co-Authorship and Author

Co-author analysis with the authors as the unit of analysis used the following inclusion criteria, a minimum of two documents per author, a minimum of three citations, or a maximum of 20 authors per publication. Out of the 400 respondents sampled, 33 met the criteria, and it is clear that the study of carbon-footprint calculators is a relatively gourmet field, with power concentrated within a small, globally dispersed group of researchers. The VOSviewer map showed eight separate clusters of authors, each of which represented the variability in application areas and methodological paradigms in the sphere of the research on carbon-footprint calculators. Cluster 1 constitutes preliminary research on the subject of household and lifestyle carbon-footprint calculators, with the purpose of estimating individual emissions and behavioural advice. These researches focus on usability, the process of awareness-raising, and individual decision-making (Alexopoulos et al., n.d.). This cluster is likely to rise to the fore because the carbon-footprint tools were initially aimed at the public rather than technical optimisation. Cluster 2 is concerned with low-carbon consumption practices in the Nordic countries, including low car ownership and non-animal diets. Although these interventions have a strong impact on emission reduction by households, the results of the research indicate the chronic low level of engagement, indicating the existence of behavioural inertia among the environmentally conscious populations (Olson et al., 2024). This cluster is an indication of the increased fusion of calculators in behavioural and socio-economic studies. Cluster 3 includes engineering-based instruments, such as a bridge-design carbon calculator that assesses embodied emissions in steel-only concrete composite buildings (Smith et al., 2014). Such researches turn calculators into technical optimisation, but not into the raising of awareness, since now engineers are able to contrast their design alternatives and input the project-specific information. Cluster 4 is concerned with agri-food supply chains, especially with carbon -accounting instruments in the dairy industry. These calculators help with the process of decision-making that aims to decrease the emission of greenhouse-gases and enhance productivity, primarily in Europe and North America (Green et al., 2017). The level of their methodological orientation is more detailed as it reflects on system-specific emission factors and farm-level data. Cluster 5 proposes new AI-enabled carbon-data infrastructures to produce soft-fruits and brew. These works indicate the prospects of automation and real-time surveillance and remind of three common conditions of trustworthy calculators: quality information, clear algorithms, and involvement of users (Marković et al., 2024). Cluster 6 looks at calculators based on transport that are found within smartphone journey-planning apps. Information on real-time emissions has been revealed to cause users to switch to lower-carbon modes of transportation and this proves the behavioural feasibility of integrated digital tools (Brazil & Cauldfield, 2013). This group is a connection between environmental psychology and digital-mobility studies. Cluster 7 focuses on the variability of agricultural carbon-footprints, as an example of which is a comparative analysis of two organic farms. Findings indicate that the size of the farm, soil properties, and climatic condition have a significant impact on the measure of the emission, which supports the fact that site-specific emission factors are necessary (Adewale et al., 2019). Cluster 8 deals with bioenergy and land- use change, and introduces huge discrepancies between calculators in the estimation of indirect land-use change (ILUC) emissions of sustainable aviation fuels. The methodological assumptions produce highly dissimilar results even when the underlying patterns of land-use change are similar (Taheripour et al., 2024), which reveals a major weakness in cross-model comparability. Combined, these clusters create a picture of a very fragmented field, and methodological approaches differ significantly across sectors. Whereas there are those writers who are interested in behavioural engagement, others are interested in engineering precision or supply-chain modelling. This heterogeneity highlights the flexibility of carbon-footprint calculators and the enduring difficulty in harmonising the research methodologies across disciplines.

Table 1

Co-Authorship and Author

Author	Documents	Citations	Total Link Strength
Alexopoulos, Charalampos	2	4	8
Andersson, David	4	89	2
Axelsson, Katarina	2	64	1
Barendregt, Wolmet	2	39	2
Biørn-Hansen, Aksel	2	18	3
Bowler, Alexander Lewis	2	10	2
Brazil, William	2	80	2
Carpenter-Boggs, Lynne A.	2	79	2
Caulfield, Brian Michael	2	80	2
Charalabidis, Yannis K.	2	4	8
Czepkiewicz, Michał	2	11	6
Dolling, Chris	2	10	6
Gram-Hanssen, Kirsten	2	25	1
Green, Andrew	2	14	6
Heinonen, Jukka Taneli	4	16	9
Hendy, Chris R.	2	10	6
Higgins, Stewart Smock	2	79	2

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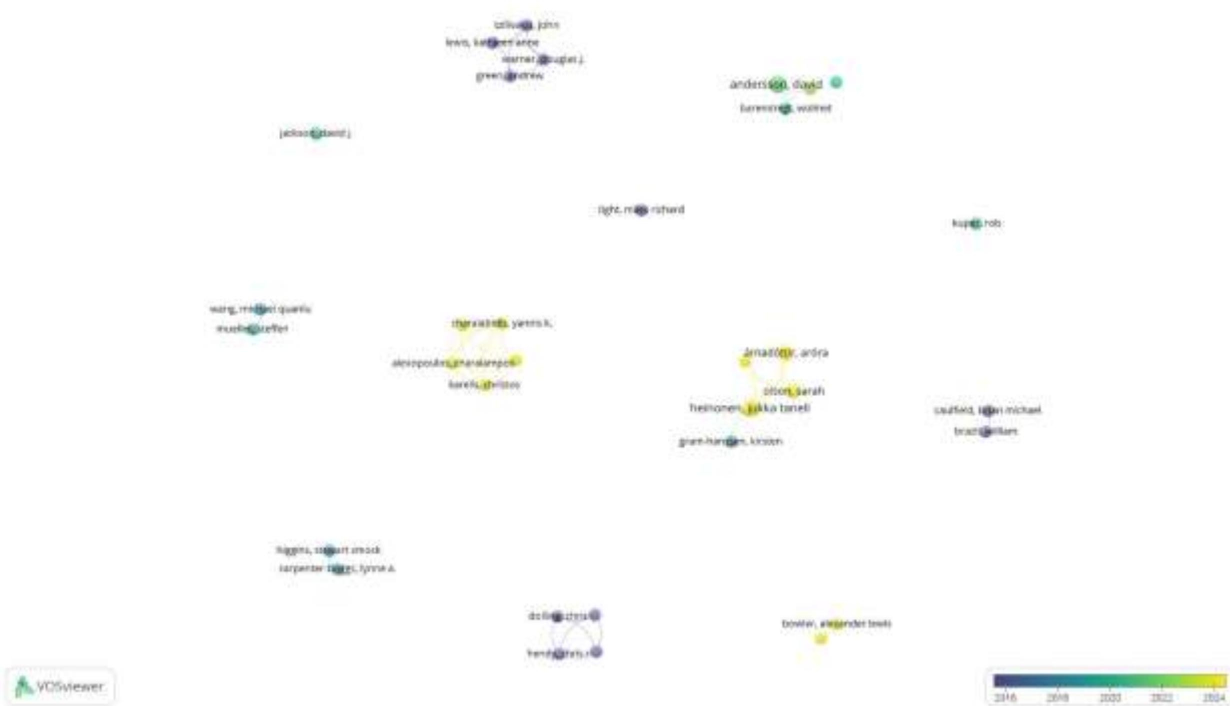
Figure 1

Co-Authorship and Author



Source: Made by the Author

Co-Authorship and Organization.

The organizational co-authorship analysis, which used organizations as the unit of analysis, used thresholds of 1 document in an organization, a minimum of 20 citations and a maximum of 25 organizations per publication. Among 203 organizations, 64 fit these criteria, which is a sign that carbon-footprint calculator study is fairly fragmented though supported by the group of highly influential institutions. The resulting network identifies seven key organization clusters that are associated with unique methodological perspectives and areas of application to carbon-accounting studies. Cluster 1 contains mainly research groups that study industrial value chains and a remarkable work is on carbon footprints in the craft-brewing industry. The study records an average of 205 to 1,483 3 -footprint of one litre of beer, and of the total effect, Scope3 emissions cover the difference between 57 and 95 percent (Bowler et al., 2023). The cluster highlights that calculation equipment facing industries should include vast upstream and downstream supply-chain emissions. Cluster 2 consists of institutions that examine variability of biofuel feedstock and land-use change (LUC). Their relative evaluation of corn, corn stover, switchgrass, and miscanthus ethanol show big differences, with corn ethanol being more heavily emitting up to 7.6 gCO 2 e MJ -1, and miscanthus ethanol showing negative net emissions (-10 gCO 2 e MJ -1). The cluster underscores that carbon calculator results rely heavily on the LUC modeling assumptions, which supports the necessity of uniform methodological standards when conducting bioenergy analyses. Cluster 3 dwells on urban ecosystem carbon accounting, which can be demonstrated by the example of multi-method assessment of carbon sequestration in urban forests of Bolzano, Italy. The estimates were between 5.73 and 8.27 -1 MgCO2/year which showed that varying methodological decisions could reduce the reported urban green space carbon-storage capacity significantly (Russo et al., 2014). This group highlights the need to use region-specific models to account for the carbon in the land. Cluster 4 unites those organizations that examine the impact of purpose of use, awareness, reporting, product comparison, or policy evaluation, on the design and choice of carbon calculators. According to such studies, to provide accurate greenhouse-gas (GHG) assessments, calculator tools have to identify both consumer-facing and decision support tools and caution that the inconsistent treatment of land-use change may compromise such analysis (Colomb et al, 2013). This cluster is the conceptual center of standardization argument in carbon accounting. Cluster 5 documents work initiated by Centrale Nantes and French national agencies, where an open-source institutional carbon-footprint estimator is developed on the basis of the national Nos Gestes Climat simulator. The research points to the significance of user-centred design whereby the participants rated transparency, diversification of activities and usability as important. This data indicates that further carbon-neutrality shifts can be triggered by the universities (Auger et al., 2021). Cluster 6 focuses on the regional studies, namely a high-resolution examination of the household carbon footprint in the 16 sub-national regions of Germany. The study conducted with the help of a multi-regional input-output (MRIO) hybrid LCA approach demonstrates that household size and income, as well as regional features, are significant predictors of carbon emissions (Miehe et al., 2016). The cluster puts into focus the role of spatial diversity when it comes to the development of generalized carbon calculators. Cluster 7 contains behavioral studies that look at short-term mobility of reducing Carbon. This article confirms that the low-emission consumption recommendations can slow down household footprints by approximately 10 -percent in the short-term yet the impact decreases in the following weeks (Enlund et al., 2023). These results indicate the limitations of behavior of awareness-based calculators in the form of behavioral constraints and support the necessity of long-term engagement mechanisms. Collectively, the organizational collaboration networks demonstrate that the research of carbon-footprint is methodologically varied and institutionally wide with its branches in engineering, bioenergy, behavioral science, environmental policy, and design of digital platforms. The high-impact institutions like the Argonne National Laboratory, the Centrale Nantes and Aalborg University are the centers that combine the technical modeling with the applied decision support development. Fragmentation of clusters also indicates the major dilemma of the discipline, namely lack of a single methodological framework, notwithstanding the increasing institutional involvement in the areas.

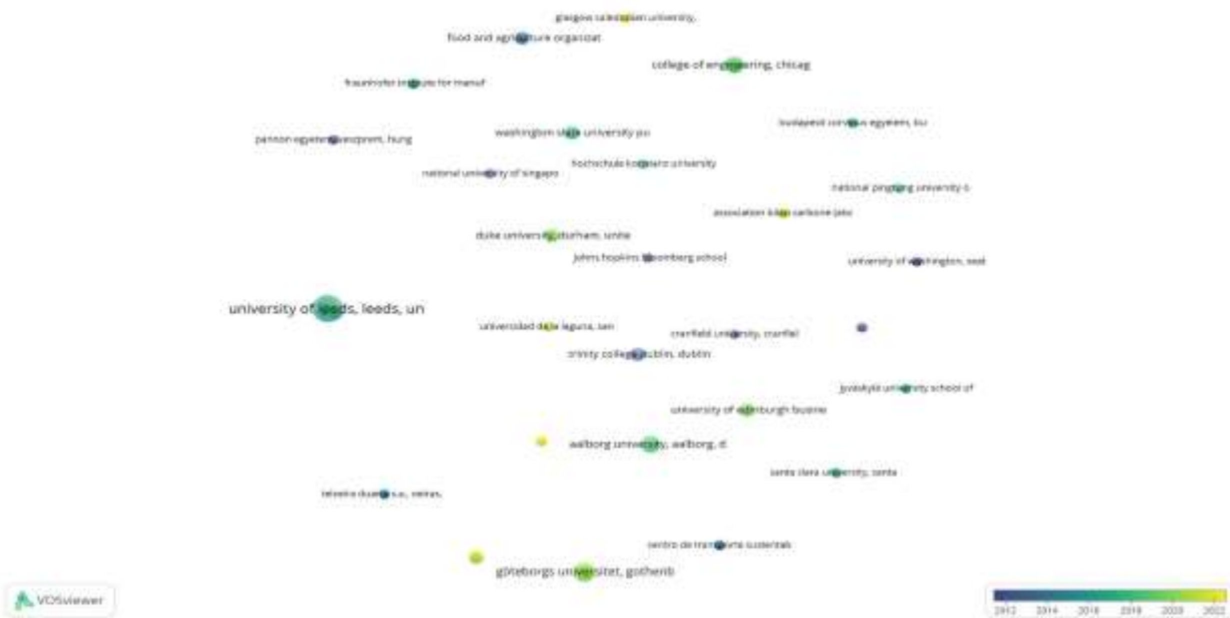
Table 2

Co-Authorship and Organization

organization	documents	citations	total link strength
"aalborg university, aalborg, denmark"	3	53	0
"ademe, angers, france"	1	56	2
"argonne national laboratory, lemont, united states"	2	148	3
"association bilan carbone (abc), paris, france”	1	22	2
"budapesti corvinus egyetem, budapest, hungary"	1	61	1
"centro de transporte sustentable de mexico, mexico city, mexico"	1	87	3
"chalmers university of technology, gothenburg, sweden"	2	32	1
"college of engineering, chicago, united states"	3	251	4
"cranfield university, cranfield, united kingdom"	1	64	0
"datagir, cedex 01, angers, france"	1	22	2

Figure 2

Co-Authorship and Organization



Source: Made by the author

Co-Occurence and All Keywords

The overall co-occurrence study of all the keywords was carried out to define the main conceptual frameworks defining the research on carbon footprint calculators. Using a minimum occurrence of five, 41 out of 1,100 extracted keywords met the requirement. The most common lexemes of the sample, carbon footprint (67 instances), carbon (19), and carbon emissions (17), suggest that the academic field is systematically grounded in the quantification of greenhouse gases, the development of methods, and the use of specific applications in the sector. Cluster 1 focuses on the use of carbon-accounting tools in the dairy industry. The research included in this cluster explores the use of calculators on the quantification of farm-level greenhouse-gas emissions and the mitigation practices, especially those in developed countries like Europe and North America (Green et al., 2017). Such a tendency implies the swelling focus on incorporating calculators into the agricultural decision-support systems. Cluster 2 causes a shift of effort to lifestyle and mobility-related emissions. It has been shown through a study of carbon footprint among marathon runners that the annual carbon emissions per person in terms of training, running and travelling could be 4.3 t CO 2e. The environmental price of long-range mobility is a single trans-Atlantic flight to the New York Marathon has the environmental impact of contributing about 3.5t CO 2e into the atmosphere, or 83 per cent of the average footprint of an average French resident each year. These results explain why calculators can be useful in the calculation of behaviour-related emissions and highlight the importance of raising awareness among sportspeople and event managers (Castaignède et al., 2021). Comprehensively, the keyword clusters demonstrate that the study of carbon-footprint calculators has evolved out of the methods controversy and has now entered various spheres of everyday life, manufacturing, and mobility. The wide thematic scatter highlights the growing importance of calculators in the work of the masses, industry-specific decarbonization policies, and climate-reduction planning.

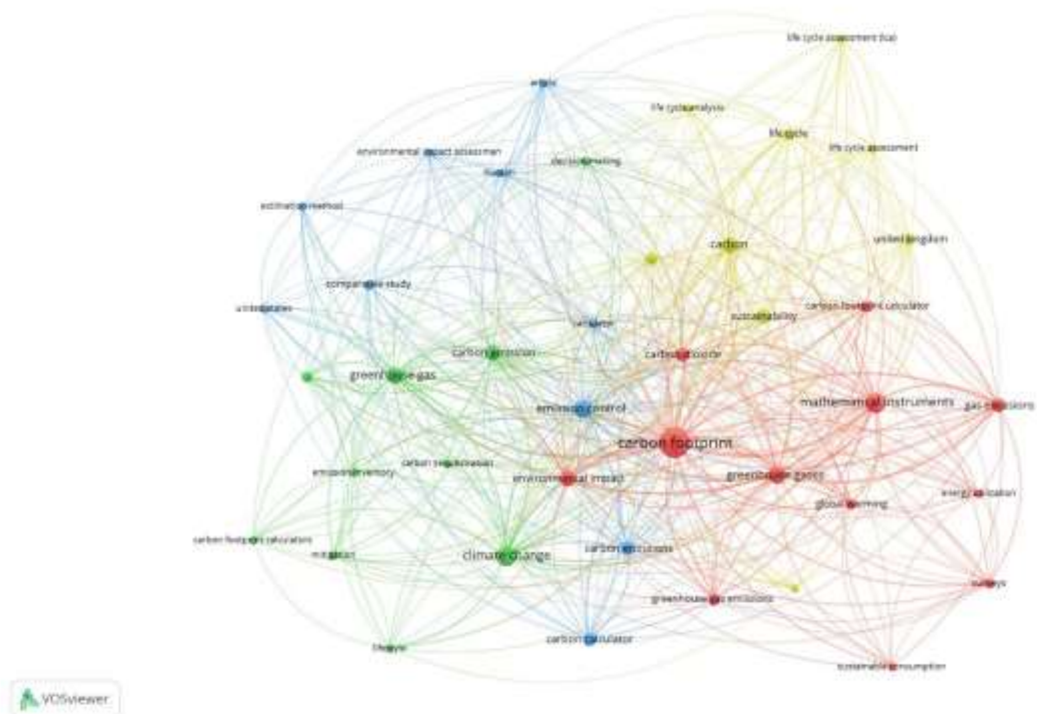
Table 3

Co-Occurence and All Keywords

keyword	occurrences	total link strength
a-carbon	5	28
article	5	39
calculator	6	34
carbon	19	94
carbon calculator	13	53
carbon calculators	8	33
carbon dioxide	13	65
carbon emission	17	80
carbon emissions	15	67
carbon footprint	67	288

Figure 3

Co-Occurence and All Keywords



Source: Made by the author

Citation and Organization

The citation analysis using organizations as the unit of analysis had three thresholds, which are: a maximum of twenty-five organizations per document, minimum of one organization per document, and minimum of twenty citations per document. Out of the 203 organisations surveyed, 64 of those met these requirements, meaning a comparatively minor group of institutions does a disproportionate share of work that has been cited by researchers on carbon-footprint calculators. Cluster 1 underlines the behavioural aspect of the carbon-footprint calculator use. Research papers in this category show that the people tend to review their consumption habits after interacting with computations and thus indicate a sense of agency in making climate action. However, more socioeconomic classes are more likely to be sceptic about the recommendations on emission reduction, and those with lower carbon footprints perceive their ability to drive change more (Jack et al., 2023). Such a trend implies that carbon calculators have the ability to influence climate attitudes, although they have different effects on different social groups. Cluster 2 concentrates on methodological and contextual determinants during the selection of calculators of carbon-footprints. It is important to note that researchers indicate that calculators should be selected based on the desired goal which can be raising awareness, reporting, evaluation or assessing products and geographic location and user expertise. The differences in the boundaries of systems, especially in relation to land-use change (LUC), can cause a substantial difference in the estimates of greenhouse-gasses, hence the need to have standardisation to create comparability (Colomb et al, 2013). Cluster 3 focuses on the carbon accounting of biofuels. In this case, life-cycle analysis of feedstocks corn, corn stover, switch grass and miscanthus indicate that there is a high degree of heterogeneity in greenhouse gas emissions. Corn ethanol has the highest, at 7.6 gCO 2 e MJ -1, and miscanthus ethanol the lowest, at -10 gCO 2 e MJ -1, effectively showing the wide range of environmental impact of various biofuels (Dunn et al., 2013). Cluster 4 pertains to innovation in the estimation of carbon-footprint with tools. Studies in this category talk of the creation of open-source systems, such as the calculator designed at Centrale Nantes and made using the Nos Gestes Climat simulator. The successful implementation of this kind of tools relies on the transparency, user-centred design and feedback systems. Such platforms are used in addition to other institutional efforts to reach carbon neutrality (Auger et al., 2021). Taken together, the clusters reveal that the most highly cited studies on carbon-footprint calculators cut across behavioural science, methodology, and the evaluation of biofuels, as well as the innovation of digital tools making the field an interdisciplinary one.

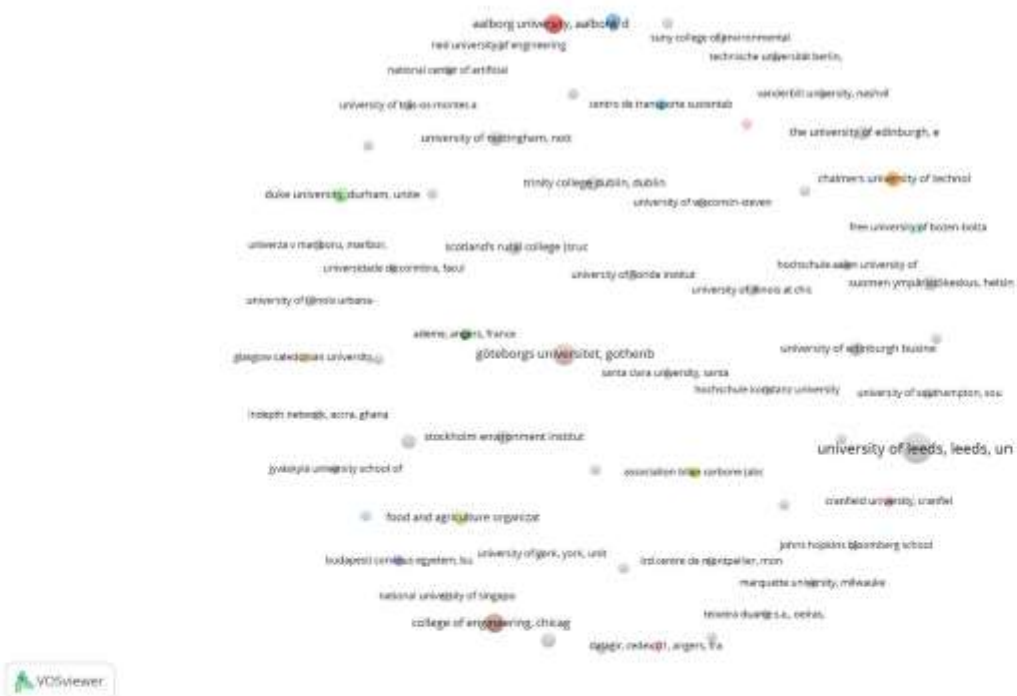
Table 4

Citation and Organization

organization	documents	citations	total link strength
"aalborg university, aalborg, denmark"	3	53	0
"ademe, angers, france"	1	56	0
"argonne national laboratory, lemont, united states"	2	148	0
"association bilan carbone (abc), paris, france"	1	22	0
"budapesti corvinus egyetem, budapest, hungary”	1	61	0
"centro de transporte sustentable de mexico, mexico city, mexico"	1	87	0
"chalmers university of technology, gothenburg, sweden"	2	32	0
"college of engineering, chicago, united states"	3	251	0
"cranfield university, cranfield, united kingdom"	1	64	0
"datagir, cedex 01, angers, france"	1	22	0

Figure 4

Citation and Organization



Source: Made by the Author

Citation and Authors

Citation analysis, which was conducted using the authors as the unit of analysis, had three thresholds; 25 authors per document, 1 publication per author, and 40 citations. Out of the 400 authors analysed 71 met all the three criteria, meaning that a fairly small group of well-cited researchers has developed the intellectual framework behind the study of carbon-footprint calculators. Cluster 1 focuses on agricultural carbon modelling and site modelling. Empirical research in this category highlights the fact that the carbon footprint of agricultural systems is closely allied to local soil characteristics, climatic variation and farm-scale management choices. As an example, Adewale et al. (2019) compared two organic farms and found that the differences in hotspots contribution and crop-level footprints were brisk. Their results show that the proper estimation of agricultural carbon emissions requires the deployment of localised calibrated emission factors instead of the application of global averaged emissions.

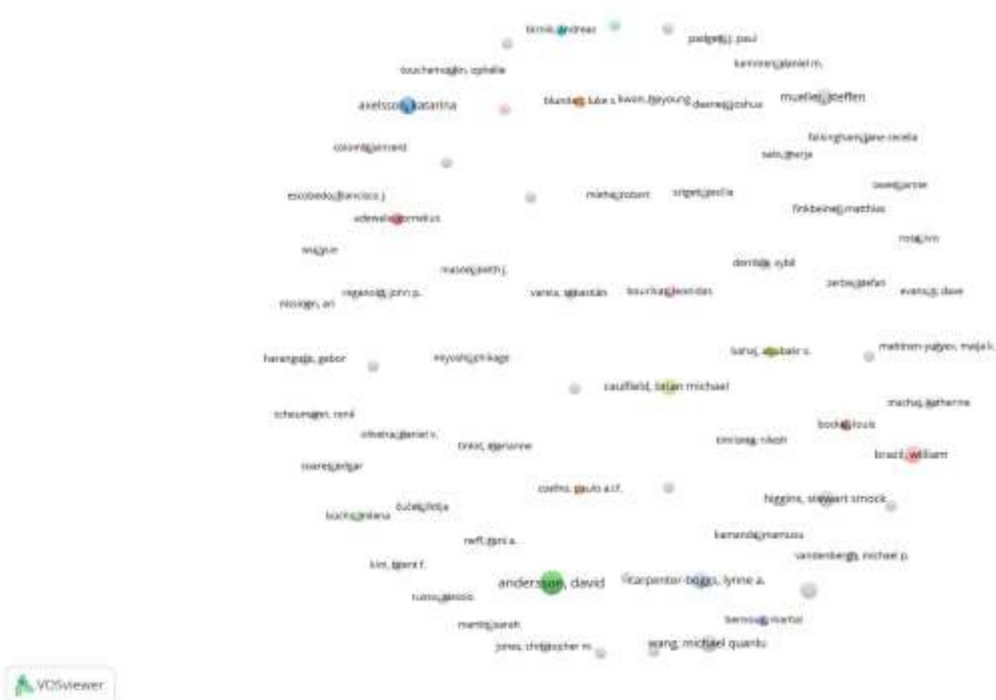
Table 5

Citation and Authors

author	documents	citations	total link strength
"adewale, cornelius"	1	68	0
"andersson, david"	4	89	0
"axelsson, katarina"	2	64	0
"bahaj, abubakr s."	1	69	0
"bernoux, martial"	1	56	0
"birnik, andreas"	1	56	0
"blunden, luke s."	1	69	0
"bockel, louis"	1	56	0
"bourikas, leonidas"	1	69	0
"brazil, william"	2	80	0

Figure 5

Citation and Authors



Source: Made by the Author

Bibliographic coupling and Organizations

The bibliographic analysis of coupling, where organizations are used as the unit of observation, used three thresholds of 25 organizations per document, one document per organization and 20 citation.

These thresholds were met by 64 out of 203 organizations meaning that there is a limited number of institutions at the core of creating the methodological, behavioral and technological basics behind carbon footprint calculators. Cluster 1 is characterized by research institutes that are engaged in regional and household level carbon accounting. One of the major contributions in this cluster is the article by Miehe et al. (2016), who study the changes in domestic carbon footprints in sixteen subnational entities in Germany. The analysis based on a multi-regional input-output hybrid life-cycle assessment model shows that social-economic status and household size are very important determinants of regional emissions. In this cluster, organizations like Aalborg University, Chalmers University of Technology often recur, as they contribute well in the socio-economic modelling, accounting of emissions consumption based, and analysis of carbon footprint in regions.The clusters of bibliographic coupling together demonstrate four significant institutional ways along which carbon footprint calculators are evolving:

(1) carbon counting on a regional and household level,

(2) modeling of the transport and mobility emissions,

(3) methodology standardization and carbon accounting systems, and

(4) modeling systems on advanced energy and LCA.

These organizational networks bring to light the manner in which carbon calculators have been developed in interdisciplinary partnerships within environmental science, energy modeling, behavioral studies and national carbon governance.

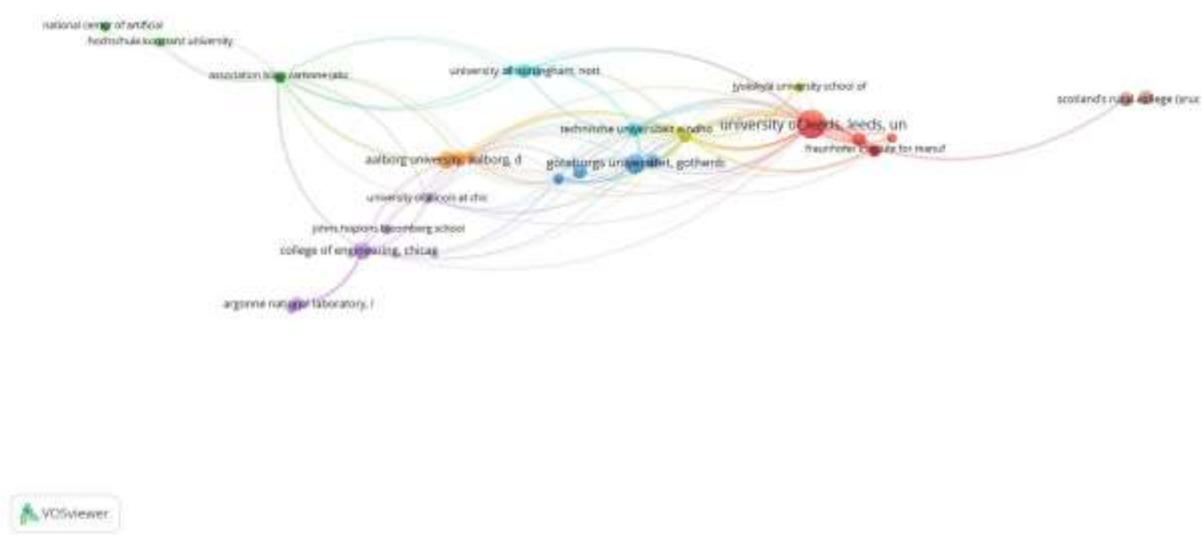
Table 6

Bibliographic coupling and Organizations

organization	documents	citations	total link strength
"aalborg university, aalborg, denmark"	3	53	1
"ademe, angers, france"	1	56	16
"argonne national laboratory, lemont, united states"	2	148	29
"association bilan carbone (abc), paris, france"	1	22	25
"budapesti corvinus egyetem, budapest, Hungary"	1	61	20
"centro de transporte sustentable de mexico, mexico city, mexico"	1	87	30
"chalmers university of technology, gothenburg, sweden"	2	32	18
"college of engineering, chicago, united states"	3	251	56
"cranfield university, cranfield, united kingdom"	1	64	0
"datagir, cedex 01, angers, france"	1	22	25

Figure 6

Bibliographic coupling and Organizations



Source: Made by the Author

Bibliographic coupling and Authors

The bibliographic coupling analysis that used the authors as the unit of analysis used three thresholds; a maximum of 25 authors in one document, a minimum of one document in one author, and a minimum of 40 citations. Among the 400 names in the database, 71 authors met these criteria, thus identifying a whittled-down group of researchers whose efforts form the main intellectual bedrock of carbon footprint calculation, climate-behaviour analysis and methodology. Cluster 1 includes researchers whose studies assess behavioural or cognitive reactions to climate information and the role of personalised intervention when making carbon-related behaviour. Indicatively, Buchs et al. (2018) illustrate that customised climate-related news are capable of increasing awareness, but individualised feedback does not cause a lasting behaviour change. This is highlighted in their results on the long-standing socio-technological and psychological obstacles including habit formation, structural limitations, and information overloads that limit the effectiveness of voluntary carbon-reduction policies. Such a cluster highlights the importance of policy and system-level interventions, which are squarely aligned with research on carbon-footprint calculators, which is dependent on both individual action and institutional assistance. This association of these writers implies that they are anchored on a similar methodological basis in systems modelling and hybrid evaluation procedures, which enhances analytical performance of the more general carbon accounting instruments. All-in-all, it can be noted that the bibliographic coupling construction has shown that carbon-footprint calculator studies are based on four overlapping academic fields: (1) climate-behaviour and communication, (2) agricultural and environmental LCA, (3) household energy and building emissions, and (4) systems-based carbon modelling. These groups demonstrate the interdisciplinarity of carbon-footprint calculators and can be used to understand the variety of methodology, choice of emission-factors, behavioural assumptions and system-scope used by different calculators.

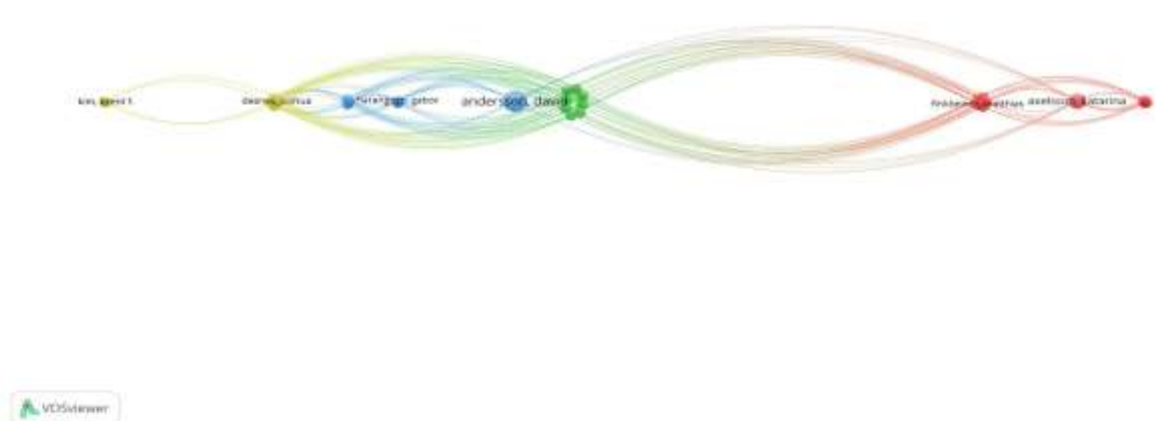
Table 7

Bibliographies coupling and Authors

author	documents	citations	total link strength
"adewale, cornelius"	1	68	42
"andersson, david"	4	89	57
"axelsson, katarina"	2	64	44
"bahaj, abubakr s."	1	69	75
"bernoux, martial"	1	56	48
"birnik, andreas"	1	56	0
"blunden, luke s."	1	69	75
"bockel, louis"	1	56	48
"bourikas, leonidas"	1	69	75
"brazil, william"	2	80	14

Figure 7

Bibliographies coupling and Authors



Source: Made by the Author

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Co-Citation and Cited Authors

Co- citation analysis where the authors are the unit of analysis used a minimum number or two citations per author. Among the 334 authors discussed, 64 passed this test indicating that a small group of scholars is the common intellectual constituent of the research of carbon-footprint calculators. Co-citation patterns reveal conceptual associations between authors, the way they are commonly co-cited, thus providing an opportunity to see the underlying theories, methodological strategies and knowledge streams that define the field. Cluster 1 consists of the work of those authors whose work appraised the structure, transparency, and the methodological diversity of carbon-footprint calculators. Mulrow, Machaj, Deenes and Derrible (2019) note that there is a wide diversity in the currently existing online calculator tools, in terms of system boundaries, emissions coverage, spatial granularity and inclusion (or lack) of product- or region-specific customization. Their analysis reveals that few calculators: the Carbon Footprint Ltd., Carbon Independent, and the CoolClimate Network calculators are able to offer complex interactivity, detailed breakdowns, and transparency in methodology. This group reflects the basic study which directly guides the assessment and comparison of calculators used in the behavioral, academic, and policy settings. On the whole, the co-citation pattern shows that carbon-footprint calculator studies are supported by three significant intellectual fields, including (1) the assessment of tools and their methodological transparency, (2) the role of behavior and psychology in carbon-related decision-making and (3) the technical and modeling basis of estimations of carbon. All these areas have an overall influence on the development, accuracy, and effects of carbon-footprint calculators both academically and practically.

Table 8
Co-Citation and Cited Authors

author	citations	total link strength
7444 lncs	5	26
abatzoglou	2	4
aichholzer	5	26
alrwashdeh	4	20
anderson	2	2
andor	2	2
andrea j.	5	13
ashworth	2	4
baker	2	10
barr	4	6

Figure 8
Co-Citation and Cited Authors

Source: Made by the Author

Co-Authorship and Countries

The co- authorship analysis using countries as the unit of analysis used the following limits: did not exceed 25 countries in one document, two documents in one country and five citations. There were 21 countries out of the 45 sampled in the dataset that passed these inclusion criteria and this shows a moderately global but skewed distribution of research collaboration in the literature on carbon-footprint calculators. Cluster 1 is a look ahead research on the creation of EU-wide farm-level carbon calculator to help quantify agricultural greenhouse-gas (GHG) emissions using the principles of the life-cycle assessment (LCA) and internationally standardised methodologies. The calculator evaluates both whole-farm level and five large farm-product categories of emissions and gives farm-specific mitigation advice and carbon-sequestration sites, based on operational practices. The instrument was tested on 54 farms in eight EU Member States, to ensure that the sample was diverse in terms of farming systems, production scale and geographical area. Findings showed that there was a significant variation in carbon-footprint performance among farms, which suggested that emissions by the agricultural sector were very site-sensitive, depending on various site-specific factors, including the management, land-use, and environmental factors. The mitigation part of the calculator was effective to find out actions that can significantly decrease farm level GHG emissions. Leip et al. (2014) emphasize that it would be desirable to expand the calculator to include more categories of environmental impact, which include water use, nutrient runoff, and biodiversity, to avoid burden-shifting and allow making more holistic environmental decisions. This cluster, therefore, is an essential part of global cooperation resulting in an increment of methodological complexity and policy applicability in agricultural carbon-footprint accounting instruments.

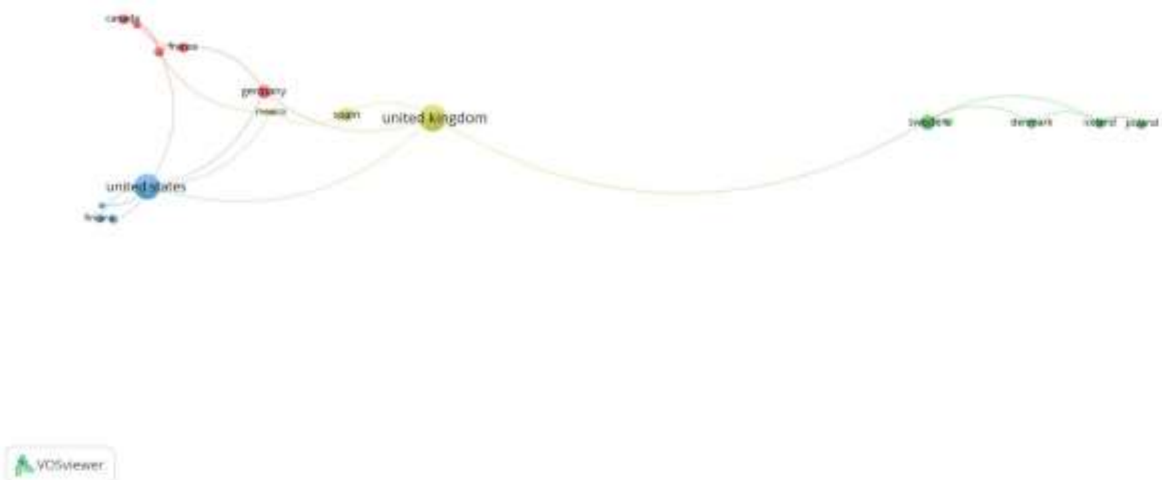
Table 9

Co-Authorship and Countries

country	documents	citations	total link strength
australia	3	25	0
belgium	3	29	3
canada	4	36	2
china	2	32	2
denmark	4	53	2
finland	3	96	1
france	4	99	3
germany	7	178	3
hungary	2	828	0
iceland	4	16	5

Figure 9

Co-Authorship and Countries



Source: Made by the Author

Research Dynamics of Carbon Footprint Calculator Studies

The historical timeline of the development of carbon-footprint calculators indicates the rising popularity of carbon accounting in sustainability science and climate politics. Corpus analyses indicate that the publications are dated between 2007 and 2025 indicating that there exists a clear line of progression between nascent conceptualisation and application-oriented and methodologically advanced studies.

Early Development Phase (2007–2012)

Early studies in the dataset were conducted between the years 2007 and 2012, and they were mainly related to the definition of carbon footprints and the methodological background of carbon accounting. The production of scholarly work was minimal during this period with an average of less than five publications in a year. Classic literature defined the conceptual meaning of carbon footprints and investigated the possibility of measuring products and activity emissions based on the principles of life-cycle assessment. It was also in this phase that the challenges with system boundaries, data availability, and choice of emission-factor were raised and this gave the basis of future discussions on consistency and comparability. The small publication book highlights the underdeveloped nature of the carbon-footprint calculator and its lack of application beyond the academic and policy-focused settings.

Expansion and Application Phase (2013-2017)

Increased research began to take off in 2013, and this was in line with the wider use of carbon-footprint calculators in sector-specific uses. Publication rates increased consistently annually, and the significant contribution was made in the areas of agriculture, transport, bioenergy, and infrastructure assessment. The main papers during this period included the appropriateness of calculators in decision-making in agriculture and forestry (Colomb et al., 2013), infrastructure design (Smith et al., 2014), and household and regional consumption patterns (Miehe et al., 2016). Studies in this era became more and more empirical in nature, less speculative, and showed high variability of findings among calculators, and situations. These results underscored how the carbon footprint can be affected by methodological assumptions, especially in land-use change and emission-factor choice (Dunn et al., 2013).

Consolidation and Behavioural Focus (2018-2020).

The literature period between 2018 and 2020 was characterised by a consolidation of the themes along with the increasing focus on behavioural change and user engagement. Carbon-footprint calculators were gradually being placed not as the means of quantification but as a means of a change in consumption trends and environmental sensitization. Articles like Adewale et al. (2019) showed that site-specific emission factors were important in estimating the carbon-footprint in agriculture, whereas transport and lifestyle calculators studies showed the magnitude of the impact of emissions on decision-making (Brazil and Caulfield, 2013; Enlund et al., 2023). This stage was also associated with increased focus on transparency, usability and results reporting, which is in line with the growing role of calculators in publicly oriented sustainability campaigns.

Acceleration and Methodological Scrutiny Phase (2021-2025).

The strongest increase in publications was seen beginning in 2021 and reaching its peak in 2024 and continuing with a high level of activity till 2025. It is a time of methodological questioning, of digitalisation, and of open-source development of calculators of carbon-footprints. New research aims at developing calculators better, incorporating high-resolution data, and dealing with discrepancies between tools. As an example, Augger et al. (2021) chronicle the creation of an open-source carbon-footprint estimator used in university applications with the focus on transparency and user feedback. Equally, Bowler et al. (2023) introduce an open-source calculator of craft-brewing sector, which highlights the importance of Scope 3 emissions. Meanwhile, methodological issues remain one of the key issues. Chen et al. (2022) elucidate in a systematic way the variability in results due to the disparities in data sources, greenhouse-gas coverage, and structural assumptions, which supports the idea of standardisation. More recent bioenergy analyses also demonstrate the sensitivity of carbon-footprint results to the assumption of land-use change, especially in sustainable aviation-fuel scenarios (Taheripour et al., 2024).

Overall Trends

Overall, the research dynamics reveal a very evident change of conceptualisation to application and methodological elaboration. Initial research made first-time definitions and methodology with subsequent research progressing to the broader spheres of application and further questioning the credibility and consistency of carbon-footprint calculators. The increase in the number of publications in recent years can be attributed to the increasing policy interest in carbon accounting, as well as awareness of the need to refine the calculator design to make informed decisions and take effective, mitigative measures to reduce climate changes.

Discussion

Through this bibliometric review, it can be seen that the current state of research on the importance of carbon footprint calculators has moved into a heterogeneous, practice-oriented research area, with a large range of areas of application, extensive methodological heterogeneity, and a range of unresolved issues on accuracy, transparency, and comparability. The synthesis of collaboration networks, keyword clusters, citation structures, explores the design, application, and constraints of carbon footprint calculators, thus explaining why these instruments have continued to be limited in what they can do.

Carbon Footprint Calculators Applications.

The results show that the carbon footprint calculators are spread in a broad industry, consisting of household consumption, agriculture, transport, infrastructure, bioenergy, food systems, and industrial production. The initial and mainly current applications are household- and lifestyle-related tools, which are typically aimed at increasing awareness and encouraging behavioural change (Colomb et al., 2013; Enlund et al., 2023). Even though these types of calculators can have a short-term effect on decision making, their effect on the reduction of emissions in the long run is not well understood (Enlund et al., 2023; Jack et al., 2023). Another great field is agriculture and food systems, which is also seen through the consistency of co-authorship and key words clusters. Here, the emission hotspots and mitigation opportunities at the farm-level can be determined with the help of calculators (Green et al., 2017; Adewale et al., 2019). Nonetheless, due to the strong localisation of agricultural emissions, which relies on soil conditions, climatic conditions, and management practices, the subsequent estimations provide a high percentage of context-specificity, thus restricting their applicability to other regions. In the transport industry, calculators are becoming part of the digital technology, including mobility applications. There is also some evidence that the provision of emissions information could affect travel decisions and prompt changes in favor of lower-carbon modes (Brazil & Caulfield, 2013). However, the responses of behaviour differ significantly across groups of users, which contributes to the importance of socioeconomic and contextual factors. Applications that are more technically advanced are found in infrastructure, bio-energy and industrial value chain, where calculators provide comparative analysis of the system, systems optimisation, and supply-chain modelling instead of mere awareness-raising (Smith et al., 2014; Bowler et al., 2023). The most extreme example of the methodological sensitivity is bioenergy applications, in which assumptions regarding indirect land-use change (ILUC) can result in radically different estimates of emissions using similar underlying data (Dunn et al., 2013; Taheripour et al., 2024). Together, these applications manifest the practicality of carbon footprint calculators as well as the enormous issues with domain-specific assumptions.

Approaches to Methodology and Sources of Variability.

Although there are different uses of the carbon footprint calculator, the majority of them are based on the idea of life-cycle assessment (LCA), in which the activity data is combined with emission factors to determine greenhouse gas emissions (Pandey et al., 2011; Colomb et al., 2013). In the literature, however, there is undoubtedly and strongly heterogeneous methodology. Such differences in the system boundaries, coverage of the greenhouse gases, the choice of the emission-factor, the allocation procedures, and treatment of uncertainty tend to give uneven results when calculators are used to evaluate similar activities (Colomb et al., 2013; Chen et al., 2022). Sector specific differences also increase inconsistency. The outcome of agriculture differs based on the generic or localised factors of emission (Adewale et al., 2019). Infrastructure assessment, the assumption of prefabrication of materials, design of structures, and the quality of data adds even more variability (Chen et al., 2022). The model of bioenergy is highly sensitive to land-use change assumptions, which means that data obtainability is secondary to methodological decisions in the process of developing outcomes (Dunn et al., 2013; Taheripour et al., 2024). All these findings support the key finding that methodological transparency, especially related to boundaries, data sources, and assumptions is necessary in order to secure the credibility and comparability of carbon footprint calculators.

Continuous Restrictions and Problems.

In industries and techniques, there are still a number of structural constraints defining the performance and image of carbon footprint calculators. First, there is methodological inconsistency that decreases comparability and diminishes trust, particularly at the time when calculators guide benchmarking, regulation, or policy formulation (Colomb et al., 2013; Chen et al., 2022). Second, simplicity and accuracy continue to be at cross. Awareness-focused instruments are usability-oriented, and usually based on simplified assumptions, whereas assessment-focused calculators are required to have detailed data and more complex models (Colomb et al., 2013). These conflicting design philosophies make interpretation difficult and the chances of misinterpretation by the users increase. Third, there is chronic data available and quality that is constrained. Even the sophisticated calculators rely on emission-factor databases, which can be either old, limited to a specific geographic area, or inconsistent among sectors (Chen et al., 2022). In spite of such bright options of open-source tools and approaches related to participation, the current data gaps are not completely addressed yet (Auger et al., 2021; Bowler et al., 2023).

Future Research and Practice Implications.

The review highlights a general agreement that, in future, more attention should be paid to the methodological alignment, transparency, and purposeful design. The literature encourages the creation of specialised tools, which are based on harmonised frameworks, standardised databases, and well-defined boundaries because, instead of a single universal calculator, these are expected to be developed (Colomb et al., 2013; Chen et al., 2022). Bibliometric trends too indicate a move in a field towards the refinement and assessment rather than the extension of tools. The growing popularity of open-source platforms, high-resolution data, and user-friendly interfaces are the indicators of an attempt to strike a balance between scientific accuracy and interface accessibility (Auger et al., 2021; Bowler et al., 2023). Increasing the interdisciplinary teamwork, including environmental science, engineering, economics and computer science, will prove important in enhancing the soundness, credibility and policy applicability of carbon footprint calculators especially when they are incorporated into the climate mitigation efforts.

Conclusion

This bibliometric review demonstrates how research on carbon footprint calculators has evolved in both methodological sophistication and thematic direction. The analysis of publication trends and collaboration networks shows that while early studies concentrated on defining the carbon footprint concept and establishing life-cycle–based calculation principles, later research has shifted toward more sector-specific applications and digital decision-support tools. Co-occurrence and co-authorship patterns further reveal that household consumption, agriculture, transport, infrastructure, and bioenergy have emerged as dominant areas of application, reflecting the expanding role of calculators beyond awareness-building into operational sustainability planning. The co-citation analysis highlights that despite substantial innovation, methodological inconsistencies remain a persistent challenge across the literature. Differences in system boundaries, greenhouse gas coverage, emission factor selection, data resolution, and modelling assumptions often lead to substantial variation in results even when calculators assess similar activities. These discrepancies reduce comparability, weaken credibility, and limit the policy relevance of carbon footprint calculators, particularly in cross-sector benchmarking and regulatory evaluation. At the same time, recent publications indicate a growing emphasis on transparency, digital integration, and participatory design. The rise of open-source platforms, high-resolution datasets, and user-interactive interfaces suggests a shift toward tools that balance scientific rigour with practical usability. Nevertheless, the durability of data gaps and the heterogeneity of methodological choices indicate that standardisation is still needed. Future research should prioritise the development of harmonised system boundary guidelines, unified emission-factor databases, and empirically validated modelling frameworks. Building cross-sector, high-resolution datasets and strengthening interdisciplinary collaboration among environmental scientists, engineers, economists, and software developers would significantly improve the robustness and policy relevance of carbon footprint calculators. Additionally, more comparative work across countries and technologies would help identify how contextual factors shape calculator performance and behavioural outcome. Overall, this review contributes to the literature by mapping the intellectual structure, methodological evolution, and persistent challenges in carbon footprint calculator research. By synthesising thematic clusters and identifying foundational limitations, the study underscores that improving transparency, standardisation, and empirical validation will be essential for developing calculators capable of supporting credible climate mitigation strategies and accelerating sustainability transitions.

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