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Research Article

Emerging Research Trends in Energy Footprint: A Bibliometric Analysis Using VOSviewer

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ABSTRACT

Although the empirical research in energy footprint have been ballooned in size, bibliometric research of energy of footprint remains limited. Using VOSviewer, we wish to contribute a bibliometric assessment of emerging research trends on energy footprint from 2001 to 2023. Publication characteristics, author keywords, authors collaboration, institutions, and countries were all examined. This analysis also recorded a total of 817 papers from the Web of Science Core Collection database. Study on energy footprint gives significant evidence on the possible linkages between energy and other threatening processes; and assists policy makers to prioritize the feasible departing idea for reducing energy footprint based on the research themes and evolutionary dynamics, hence produces some useful inferences that may be important policy implications. The finding of the bibliometric analysis, containing both the network analysis and the descriptive analysis, as well as focusing on the author keyword, reveal that science, followed by computer science dominate the number of studies in terms of author keyword, keyword cluster and author keyword co-occurrence network. Based on the findings, energy footprint research is expected to increase intensely in the near future. The USA accumulated the most documents and citations over the observed period. *Journal of Cleaner Production* was the most productive journal while *Nature* was the most cited journal in energy footprint literature. Owen A had the most publications in this subject area. Machine learning, China, water-energy-food nexus, water footprint, artificial intelligence, internet of things and edge computing have been the topic of previous research. Lastly, the outcomes of this study suggest that future studies of energy footprint could find themselves more innovative by venturing into some aspects of social science such as economic growth and institutional quality, so that the literature on energy footprint could be more diverse and comprehensive.

Keywords: Emerging Research Trends, Energy Footprint, Bibliometric Analysis, VOSviewer, Web of Science.

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INTRODUCTION

Energy footprint refers to the sum of all lands used to give non-food and non-feed energy like cultivated lands for energy and fuel crops, land for forest wood fuel as well as land used for hydropower generation.[1] In essence, it is a measure of lands needed to absorb carbon dioxide (CO_2) emissions, mainly resulting from human activities such as fossil fuel combustion. These emissions, had in turn, led to a dramatic rise in Greenhouse Gas (GHG) concentration since the pre-industrial era.[2,3] With average temperatures rising by about 1.2°C, as a result, the Earth has been warming at an alarming rate over the past few centuries.[2] This has increased the risk of climate change for both natural and human systems, including sea level rise, species extinction, extreme weather, food and water shortages, etc. In the same vein, projections of rising global energy consumption, which is primarily met by fossil fuels, conflict with the Paris Agreement's (2015) goal of reducing Greenhouse Gas (GHG) emissions.[4] This necessitates changing environmental policies, particularly those relating to energy. Reducing energy use and GHG emissions without compromising economic growth is possible by increasing energy efficiency. Numerous nations like China, France, U.S., among others, focus on energy efficiency in their Nationally Determined Contributions (NDCs) to the Paris Agreement, and the Sustainable Development Goals of the UN place a strong emphasis on it.[4]

However, the goal of energy efficiency and hence reduction in GHG emissions, faces enormous challenges and treats. First of all, energy embedded in final production and consumption is not addressed by energy policies, which largely concentrate on the energy usage of production activities inside the territory (see, for example, Nieto *et al.*, Iyer *et al.*,).[5,6] The energy used for a

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country's territorial production may differ significantly from the energy needed for final production and consumption especially in a globalised world where international trade is characterised by vertical specialisation and global supply chains (e.g., Koopman *et al.*, Johnson and Noguera).[7,8] Energy strategies that focus on local manufacturing fall short of reducing a country's overall energy footprint because they neglect to take into account the energy included in imported intermediates and finished commodities. Furthermore, in view of the goal to reach net zero by 2050, the world's energy intensity has decreased at a rate that is significantly slower than previously predicted.[9] Moreover, fossil fuels continue to dominate the energy structure, which will be responsible for 80% of all global GHG emissions by 2050.[10] The issue is exacerbated by the fact that the pursuance of renewable energy like hydropower and solar power, in response to reduce over-reliance on fossil fuels, has been facing challenges in the form of limited access to modern electricity (13% of the world's population).[10]

After all, the issues relating to energy footprint lead to bibliometric research questions of (1) What is the annual publication trend of energy footprint?; (2) Which country contributed the most to energy footprint; (3) Which is the most influential journal in the research area of energy footprint?. While there had been case studies on carbon footprint;[11,12] while on water footprint[13] as well as bibliometric analysis on carbon footprint[14-16] water footprint;[13,17,18] greenhouse gas emission[19-21] focused on the environmental aspects, bibliometric research on energy footprint in particular is still limited, as far as this study is concern. The latter group of research has just been (started to be) conducted recently by Zeng *et al.*,[22] on household as well as by Li *et al.*,[14] on higher education. For example, Li *et al.*,[14] found that the USA and the University of California System were the most productive country and institution respectively, during the period of Year 2010-2019; and keywords identified through cluster analysis include life-cycle assessment, environmental performance and carbon management, greenhouse gas emissions, design, system, and sustainability. On the other hand, Zeng *et al.*,[22] revealed that carbon emission should become the focus of future research. Taken together, the recent trend of bibliometric research on energy footprint implies the increasing importance of bibliometric analysis particularly on the area of energy footprint.

Accordingly, this paper aims to bibliometrically assess the global research trends on energy footprint by investigating the existing as well as future publication characteristics, most productive source titles and publishers, most cited papers, keyword clusters etc., from 2001 to 2022. It is unique, as compared to the literature for three reasons. Firstly, prior studies have already unearthed the link between environmental footprint, biodiversity loss, ecosystem service, human well-being and ecological footprint (see: Tan *et al.*, Wang *et al.*, Xie *et al.*, Yang and Meng).[23-26] This paper, however, focuses on bibliometric analysis of energy footprint. The latter is at utmost importance to tackle, for a reduced ecological footprint, compared to the former group of studies. Given the energy efficiency, it raises resource rents of countries as a sustainable energy demand drives the restore of resources, particularly the mineral resources, and mitigate negative externalities from the resource market.[27] On the other hand, tackling energy poverty and inequalities is inevitable for household well-being, reducing energy demand and therefore, reducing ecological footprint.[28] In the absence of policies aiming for sufficient energy usage, we will not be able to mitigate the effects of our lifestyles. Taken together, studying energy footprint is particularly vital to the environmental quality[29] as energy used largely leads to environmental degradation.[30] Thirdly, this research evaluates the publishing trends of energy footprint by (1) using the latest dataset (till 2022); (2) based on an extensive 817 papers record documented from 2001 to 2022; and (3) based on a renowned source of data – Web of Science Core Collection database.

In a nutshell, this study provides important insights by focusing on energy footprint, as the main term to scrutinize publishing patterns in the discipline. The study utilizes the network analysis and the descriptive analysis to identify hotspots in the field and explores the existing co-authorship networks. This comprehensive bibliometric study is beneficial for scholars in identifying research hotspots as well as its research gap and influential journals. The study will assist young researchers and postgraduate students to develop their co-authorship networks to improve their quality of research in the field of energy footprint. Additionally, the study could also help policy makers prioritize the feasible departing idea for reducing energy footprint based on the research themes and evolutionary dynamics, hence produces some useful inferences that may be important policy implications. According to Mihajlovski *et al.*,[31] energy footprint is an indicator of sustainability, the universal and ultimate goal of the United Nations (U.N).

METHODOLOGY

Materials

In line with Li *et al.*,[14] the data in this study was collected from a comprehensive bibliographic database namely Web of Science core collection (WoSCC) that provides access of high impact published articles. Based on the Web of Science core collection (WoSCC), this research manages to obtain the earliest publication with the keyword "energy footprint" in 2001. Thus, this research will collect all the publications from the Web of Science core collection (WoSCC). The data was collected on 20 December 2022. The literature search was based on topic (TS) that includes title, abstract, author keywords and Keywords Plus. The search string was TS=("energy footprint*" OR "emergy footprint*"). Emergy refers to the total energy available to produce a goods or service like biomass, money and information flow in which all values are expressed in term of the similar unit of solar energy joules.[32] No limiters were used to refine the literature searching such as document type, publication years, languages and others. Lastly, there were 817 papers record documented from 2001 and 2022.

Methods

The free software programme VOSviewer (version 1.6.18) was created by Van Eck and Waltman,[33] and it is widely used for bibliometric analysis to create networks for scientific journals, research centres, nations, and keywords.

The two components of the bibliometric analysis are the network analysis and the descriptive analysis. The study's core facts, including publications and citations for research fields, authors, journals, nations, and institutions, are outlined in the descriptive analysis. Examples of network analysis include co-citation, co-authorship, and keyword co-occurrence.

Van Eck and Waltman[33] define a citation connection as the relationship between two items in which one item cites the other. A co-citation link indicates the similarity of two sources that are both quoted in the same text. A co-authorship relationship is the similarity of things based on the quantity of documents co-authored. The thing of interest could be a term or possibly an author, a nation, a document, an organisation, or a source.

In particular, author co-citation refers to a situation in which two writers are frequently mentioned together by other academics because they share the same theoretical perspective.[34] When two researchers are connected together, it means a third author has referenced both of them together.[35] Extensive use of co-authorship analysis is made to comprehend and evaluate patterns of scientific collaboration.[36] A co-authorship network must be established in order to properly acknowledge the contributions of two or more writers or organisations, according to Newman.[37] Authors, nations, or institutions that have co-authored a paper together might be the nodes in a co-authorship network.[37]

Keywords from sources like Author Keywords and words in abstracts, offer a thorough summary of research trends in a certain field.[38] One of the categories of keywords available in the Web of Science Core Collection is Author Keywords-the keywords provided by the original authors.[39] An article's content and specifics are suitably consulted by the author's keyword analysis.[40]

RESULTS AND DISCUSSION

Publication characteristics

Figure 1 shown that there are 817 papers in total were published around the world with the trends in publication from 2001 to 2023. The first publication was in 2001 with earned only 1 citation and there is consistently to have additional one articles for next five year. It is clear shown that over the 2000s, the number of articles and citations grew steadily. However, started from year 2016 the both citation rate and publication speeded up. Based on the data collected as of 20 December 2022, there were 104 publications and 3146 citations, which is the year when both numbers reached their pinnacle in 2021. Overall, during the study period, there was a steady growth in both publications and citations. This indicates a rise in interest in disciplines concerned with the energy footprint. The future seems to hold significant promise for publications and citations, according to current patterns. Despite an increase in publication on energy footprint, however there is lack of awareness on the vital role-play by energy footprint as developed nations are growing more and more dependent on emerging nations for the supply of commodities and services. The topic of whether energy is more traded as energy incorporated in internationally traded items is raised by the fact that not only are energy markets but also supply chains in general are becoming more globalised.[41,42] Energy security has evolved into a more complicated policy concern for nations in particular due to the relationship between energy needs and global trade. This is due to the fact that energy security is stated not only in

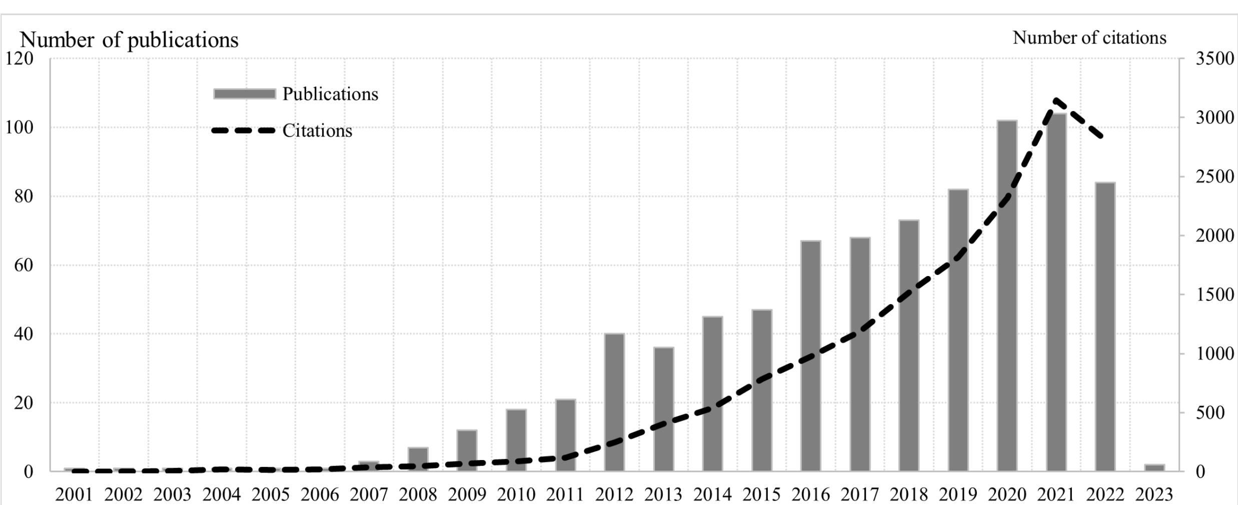

Figure 1: Number of publications and citations, 2001-2023.

Table 1: The 10 most cited papers.

Rank	Title	Authors	Source Title	Publication Year	Total Citations	Average per Year
1	Porous materials with optimal adsorption thermodynamics and kinetics for CO_2 separation	Nugent, Patrick; Belmabkhout, Youssef; Burd, Stephen D.; Cairns, Amy J.; Luebke, Ryan; Forrest, Katherine; Pham, Tony; Ma, Shengqian; Space, Brian; Wojtas, Lukasz; Eddaoudi, Mohamed; Zaworotko, Michael J.	Nature	2013	1682	168.2
2	STIRPAT, IPAT and ImPACT: Analytic tools for unpacking the driving forces of environmental impacts	York, R; Rosa, EA; Dietz, T	Ecological Economics	2003	1144	57.2
3	Global water crisis and future food security in an era of climate change	Hanjra, Munir A.; Qureshi, M. Ejaz	Food Policy	2010	651	50.08
4	Separation technologies for the recovery and dehydration of alcohols from fermentation broths	Vane, Leland M.	Biofuels Bioproducts & Biorefining-Biofpr	2008	417	27.8
5	Sustainable machining: selection of optimum turning conditions based on minimum energy considerations	Rajemi, M. F.; Mativenga, P. T.; Aramcharoen, A.	Journal Of Cleaner Production	2010	287	22.08
6	Conventional, hybrid, plug-in hybrid or electric vehicles? State-based comparative carbon and energy footprint analysis in the United States	Onat, Nuri Cihat; Kucukvar, Murat; Tatari, Omer	Applied Energy	2015	206	25.75
7	Footprints of water and energy inputs in food production - Global perspectives	Khan, Shahbaz; Hanjra, Munir A.	Food Policy	2009	194	13.86
8	Scalpel: Customizing DNN Pruning to the Underlying Hardware Parallelism	Yu, Jiecao; Lukefahr, Andrew; Palframan, David; Dasika, Ganesh; Das, Reetuparna; Mahlke, Scott	44th Annual International Symposium on Computer Architecture (ISCA 2017)	2017	189	31.5

Rank	Title	Authors	Source Title	Publication Year	Total Citations	Average per Year
9	Energy and water autarky of wastewater treatment and power generation systems	Gude, Veera Gnaneswar	Renewable & Sustainable Energy Reviews	2015	186	23.25
10	A structural decomposition analysis of global energy footprints	Lan, Jun; Malik, Arunima; Lenzen, Manfred; McBain, Darian; Kanemoto, Keiichiro	Applied Energy	2016	183	26.14

terms of the direct trade of coal, oil, and gas, but also in terms of how dependent global supply chains are on the availability of home energy.[42]

Figure 2 summarise the 10 most productive journals. The leading journal was Journal of Cleaner production (34 articles), followed by Applied Energy (16 articles) and Journal of Industrial Ecology (14 articles). Besides, from the total of 817 papers, majority of the articles were published under Elsevier (253 documents), followed by IEEE (182 documents) and Springer Nature (63 articles).

Meanwhile, according to Table 1 The Top 10 Most Cited Paper. The highest cited paper is refereeing to *"Porous materials with optimal adsorption thermodynamics and kinetics for CO_2 separation"* with the total citation of 1682, average per year hit 168.2 from published in *Nature*. The studies focused on the energy expenditures involved in separating and purifying industrial products including gases, fine chemicals, and fresh water,[43] porous metal-organic frameworks for gas storage and separation. The second highest cited paper is referring to *"STIRPAT, IPAT and ImPACT: analytic tools for unpacking the driving forces of environmental impacts"* (1144 citation) which published under *Ecological Economic* in the year of 2003. The study examines the driving forces of environmental impact by using three different tools namely IPAT identity, ImPACT identity and STIRPAT model[44] "Global water crisis and future food security in an era of climate change" (651 citation) is the third most cited paper. The paper focus on analysis of the overall role of climate change, water scarcity, energy crisis, as well as credit crisis and population growth in redefining global food security.[45] Among these journals, *Applied Energy* had the highest impact score at 11.20, in the Year 2022. *Journal of Cleaner Production* and *Ecological Economics* with the impact score of 10.96 and 5.99 respectively. In summary, the top 10 most cited articles on the topic of energy footprint with 1682 citations, from 2001 to 2023, are as shown in Figure 1.

Co-word analysis

Keyword clusters

In the bibliometric analysis, author-generated keywords play a significant role in providing the insights into the recent research hotspot. Nevertheless, research always employ keyword strategically, which may lead to a deviance from the study's objective to capture the public attention. This occurrence can illustrate by Naidoo *et al.*,[46] whose research focus on "food nexus" keyword but dip into the study on job and wealth creation, improved livelihoods and well-being, and regional integration. The objective of the bibliometric study is to identify the most popular keywords in the energy footprint domain during the study period. In order to enhance the understanding of this research, the minimum number of occurrences of a keyword was set at six in all sample articles. Figure 3 shows the network visualization maps of the keywords co-occurrence. It portrays the Author Keywords co-occurrence network visualization map, which consists of a minimum of 6 occurrences, for a total of 40 keywords. The node size displays the number of times a keyword appears in the energy footprint documents. The bigger the node in size indicates the more frequently a keyword is found in the energy footprint records. The distance between two nodes represents the strength between the two keywords and their topic similarity, while the same coloured nodes display a comparable topic.[47]

The Author Keywords can be classified into seven clusters; each cluster displays a subfield of energy footprint from 2001 to 2022. Cluster 1 denotes the red cluster, which is the biggest of the seven clusters and contains of 10 items including energy efficiency, energy consumption, renewable energy, internet of things, power consumption, machine learning, edge computing, cloud computing, IOT, and machining. All these clearly response to the domain of energy efficacy. The green cluster (cluster 2) and ultramarine cluster (cluster 3) have seven items and five items, respectively. Keywords for the green cluster are energy footprint, carbon footprint, life cycle assessment, wastewater treatment, anaerobic digestion, activated sludge, and LCA, which are related to energy footprints. On the other hands, the keywords for the ultramarine cluster include energy, China, footprint, energy management, and efficiency are primarily connected to energy footprint. The gold cluster (cluster 4, 5 items) includes the keywords of sustainable development, ecological footprint, input-output analysis, embodied energy, and energy intensity while the purple

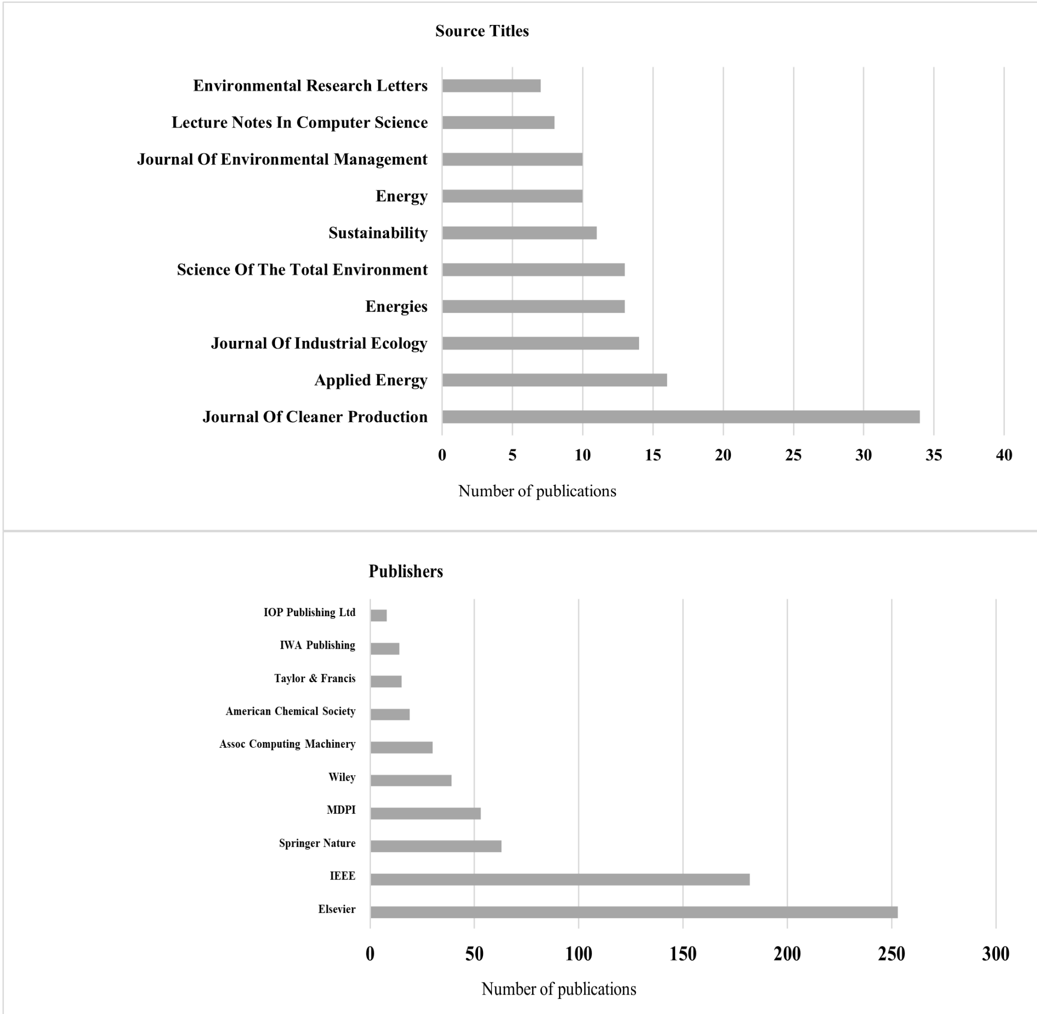

Figure 2: The 10 most productive source titles and publishers.

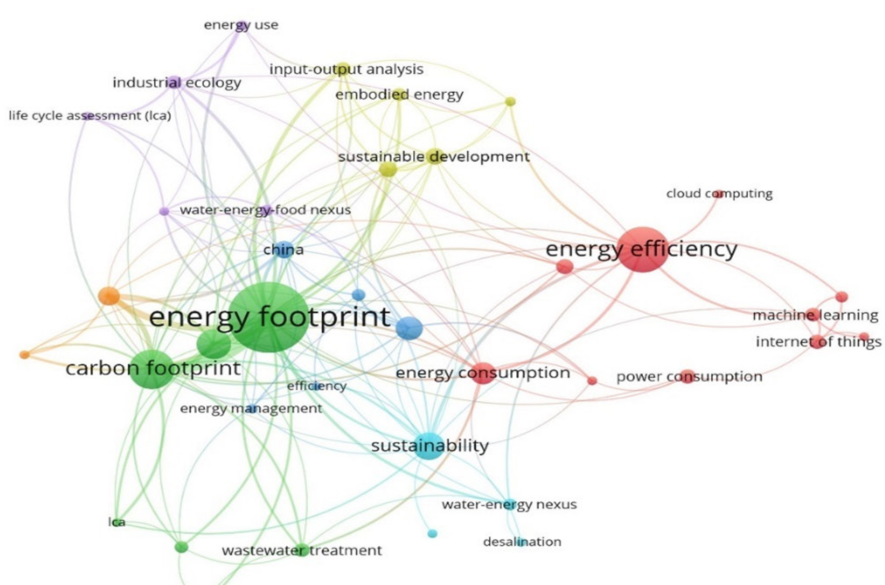

Figure 3: Author keyword co-occurrence network. Notes: Minimum number of occurrences of a keyword is 6 and 40 author keywords and 7 clusters meet the threshold. The largest set of connected keywords consists of 38 authors keywords. Node= author keyword; size of node= occurrence.

cluster (cluster 5, 5 items) refers to industrial ecology with the keywords of industrial ecology, water-energy- food nexus, energy use, agriculture, and Life Cycle Assessment (LCA). Next, the sky-blue cluster with four keywords (sustainability, water-energy nexus, artificial intelligence, and desalination) is mainly associated with the sustainability mechanism. Lastly, the last cluster with orange colour shows the water footprint that comes with the keywords of water footprint and climate change.

The evolution of keywords

Figure 4 shown the network mapping of author generated keyword, by providing an insight between the interaction on the main domain-energy footprint within the field. The overlay links the keywords to the publication year which can help to trace the evolution of a specific topic over the studied period.[35] The note size given in the figure shown the volume of research in the specific area, the largest the note represent a higher number of publications. Based on Figure 4, the largest note is referring to the 'energy footprint' occurs 114 times across all sampled articles. Additionally, the visualisation demonstrates four colours to composite the four primary clusters, there are referring to green, blue, light green and purple. Table 2 shown the details of these composition of the four primary clusters. Although all keywords are highly associated with energy footprint, ach cluster represent a unique avenue of researcher's interest. The green cluster primarily delves into the sustainability aspect of carbon footprint through energy footprint. Energy footprint had integrated in various carbon footprint context, which includes carbon feedstock CO_2,[48] health care carbon footprint,[49] sustainability of food processing system[50] and economic performance.[51] The blue cluster shown the integration between the energy efficiency and energy footprint via technology adoption such as cloud computing[52] enable to provide service quality guarantee with lower energy consumption and carbon footprint. Besides, the research also includes the influence of energy footprint on input output analysis.[53,54] While the light green cluster focus more on the research area of waste water treatment,[55] water energy nexus,[56] and the integration of water energy food nexus and carbon footprint[57,58] in developing the on-farm water, energy, food and carbon footprint (WEFE) nexus index for farm performance. The purple cluster emphasises the relationship between industrial ecology and power consumption[59,60] on the dynamic effect of industrialisation and urbanisation on energy footprint.

Collaboration analysis

Authors collaboration

Figure 5 illustrates the co-authorship network visualization maps. The minimum number documents of an author is 2 while the minimum number of citations of an author is 2. There are 6 clusters meet the threshold. The largest set of connected documents consists of 29 documents. Owen A had the largest node size which indicates that the author had the most documents in the subject area. Besides, the author also had the most connecting linkages from other authors. In other words, the author collaborated the most with other authors, namely

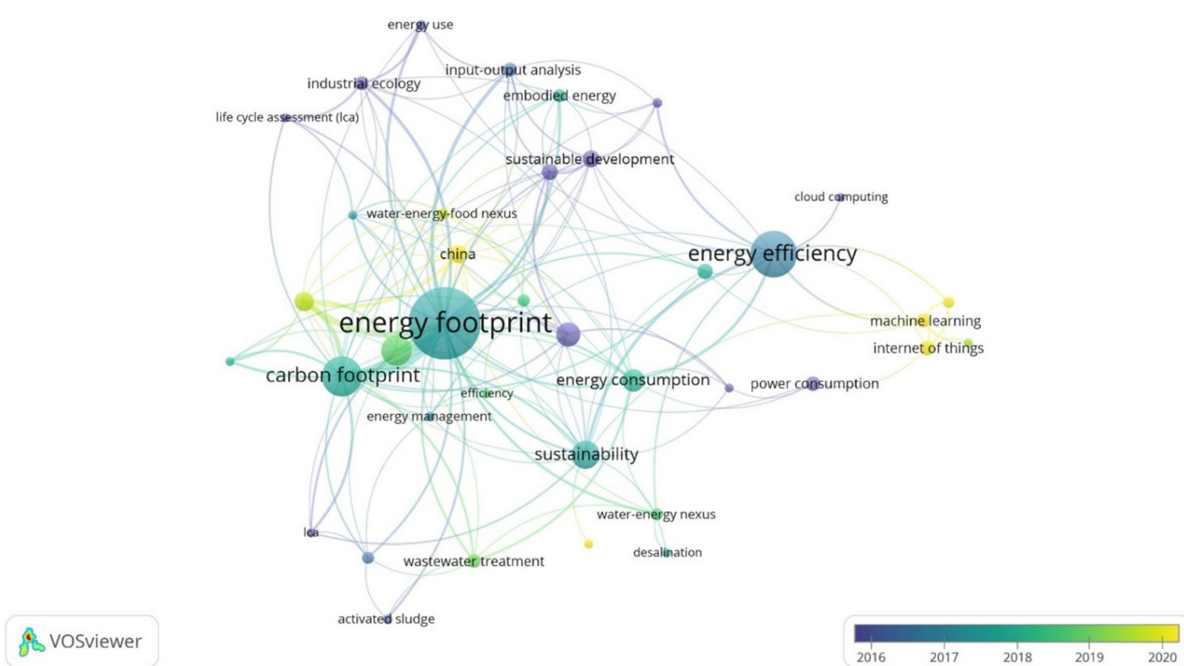

Figure 4: Author keywords co-occurrence time line. Notes: Mi**nimum number of occurrences of a keyword is 6** and 40 author keywords and 7 clusters meet the threshold. The largest set of connected keywords consists of 38 authors keywords. **Node= author keyword**; **size of node= occurrence.**

Baltruszewicz, M, Brand- Correa L I, and Oswald Y. Bueno G and Lenzen M came in second and third of the authors who has the most documents in the subject area.

Organizations collaboration

Figure 6 shows the organizations co-authorship network maps. The minimum number documents of an organization is 4 while the minimum number of citations of an organization is 2 documents. There are 9 clusters meet the threshold and they accumulated to 42 documents. The size of the node shows the number of documents in the subject area. The Columbia University had the most documents in the study of energy footprint then it was followed by the University of Leeds.

Countries collaboration

Figure 7 shows the co-authorship network visualization of countries with at least 4 papers and 2 citations. The largest set of connected countries consists of 11 clusters which amounted to 44 countries. The largest cluster (red cluster) had 9 countries, namely Australia, Bangladesh, Indonesia, Malaysia, Pakistan, Peoples Republic of China, South Korea, Thailand, and Turkey. This is followed by the light green cluster (5 countries) which includes Austria, Norway, Romania, Sweden, and Switzerland. The third cluster (dark blue cluster, five countries) includes Belgium, Canada, Ireland, New Zealand, and South Africa. Nevertheless, the USA accumulated the most documents and citations over the observed period.

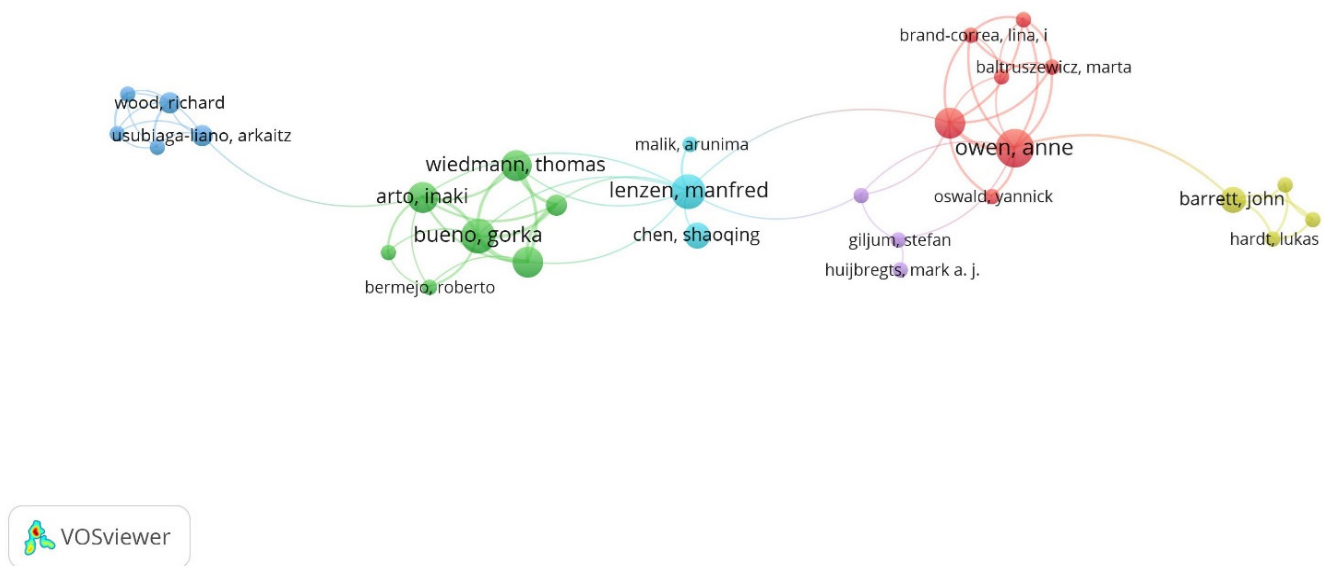

Figure 5: Authors co-authorship network. Notes: Minimum number documents of an author is 2 and minimum number of citations of an author is 2. 294 documents and 6 clusters meet the threshold. The largest set of connected documents consists of 29 documents. Node=author, size of the node=document.

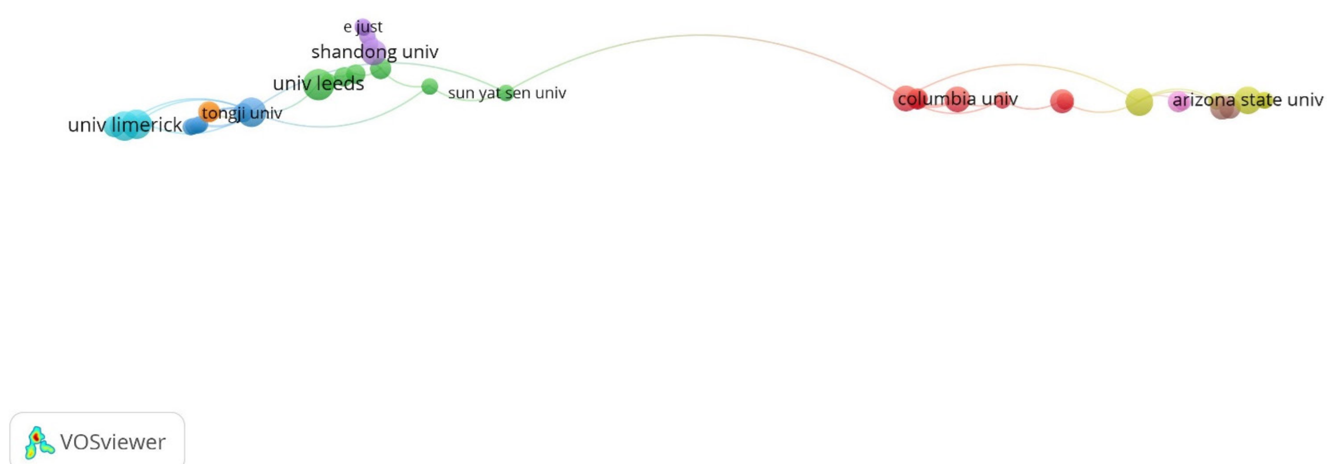

Figure 6: Organizations co-authorship network. Notes: Minimum number documents of an organization is 4 and minimum number of citations of an organization is 2. 76 documents and 9 clusters meet the threshold. The largest set of connected documents consists of 42 documents. Node=organization, size of the node=document.

Table 2: The Top Four Main Clusters of Keywords Co-occurrence.

Cluster	Represented Color	Item
1	Green	Carbon footprint, sustainability, energy consumption, embodied energy.
2	Blue	Energy efficiency, activated sludge, input-output analysis, energy management, desalination, cloud computing.
3	Light Green	Wastewater treatment, water energy nexus, water energy food nexus.
4	Purple	Sustainable development, energy use, industrial ecology, life cycle assessment, power consumption.

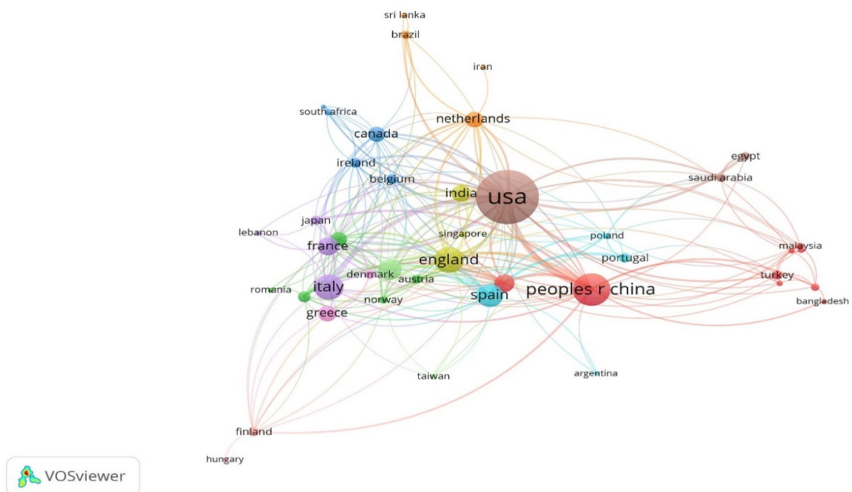

Figure 7: Countries co-authorship network. Notes: **Minimum number documents of a country is 4 and minimum number of citations of a country is 2**. 45 documents **and 6 clusters** meet the threshold. The largest set of connected documents consists of 44 documents**.** Node=country, **size of the node=document.**

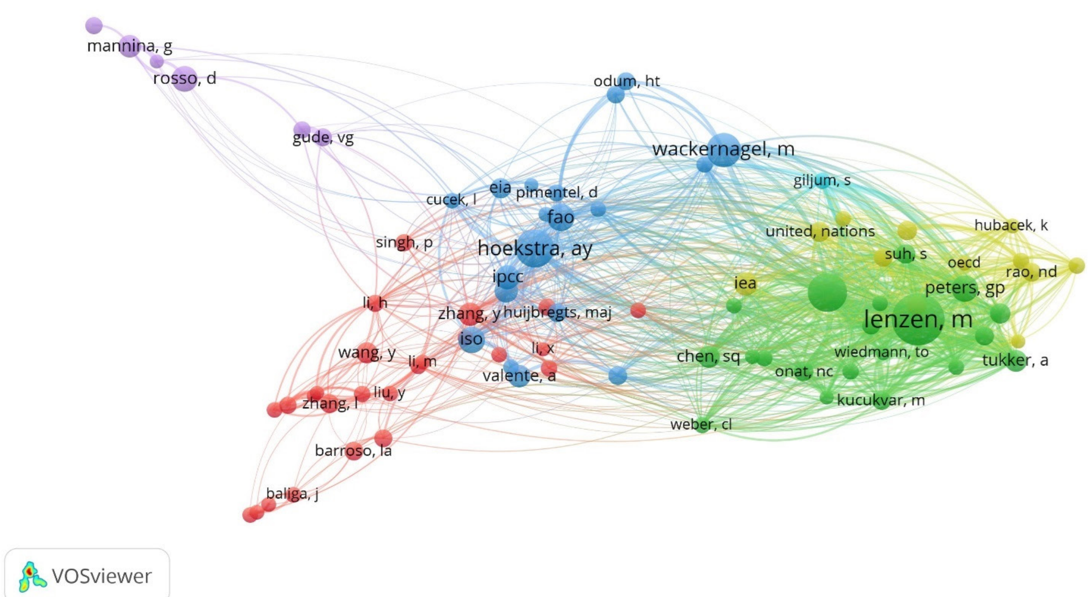

Figure 8: Authors co-citation network. **Notes: Minimum number of citations of an author is 16. 84 authors and 6 clusters meet the threshold.** The largest set of connected authors consists of 83 authors**.** Node=cited author**, size of node=citation.**

Co-citation analysis

Authors co-citation

Figure 8 illustrates the authors co-citation network map. The size of node signifies the co-citation frequency as stated in the references. The larger the node, the greater the co-citation frequency. The node colour denotes the clustering by authors. Each author had at least 16 citations. There are 84 authors and 6 clusters met the threshold. Lenzen M, Hoekstra AY, and Wackernagel M obtained the most co-citations. In other words, they have been the most regularly co-cited by other authors.

CONCLUSION

Energy footprint led to a dramatic rise in Greenhouse Gas (GHG) concentration since the pre-industrial era. It has been recognized as one of the major environmental issues. This bibliometric assessment offers a valuable picture on energy footprint from numerous aspects. Most of the environmental related bibliometric analysis focus on carbon footprint,[14-16] water footprint,[13,17,18] greenhouse gas emission.[19-21] However, the bibliometric analysis on energy footprint is still limited.

Through the bibliometric analysis involving VOS Viewer Software and data collected from Web of Science database on energy footprint, this study delved into the most productive sources titles, publishers, papers, author-co-author, co-citation, keywords, countries. Notably, energy footprint served as most frequently occurred keyword and the highest Total Link Strength (TLS), recorded 114 occurrence and 124 TLS, in Year 2017. This subject area (energy footprint) is Anne Owen's actively researched field. The author not only served as the most productive researcher (with 6487 citations) in the energy footprint area of research but she is also the most connectable/connected (for as high as 29 documents connected with other authors namely Baltruszewicz, M., Brand-Correa L. I., and Oswald, Y.) authors in the subject area, followed by Bueno, G. (second place) and Lenzen M. (third place). The consistency between the top research area-energy footprint and the most influential author reinforces the significance of these scholarly contributions in framing the discourse around energy footprint in the environmental sustainability. It is found that science, followed by computer science dominate the number of studies in terms of author keyword, keyword cluster and author keyword co-occurrence network. This implies that in general, scientific researchers are still confining their scientific research to science and computer science, given the fact that social science is also crucial to scientific research. However, higher institutional quality or governance might play a role in monitoring and restricting these footprints as the industrial players need to comply with the strongly enforced and upheld environmental standard and regulation.

As such future studies of energy footprint could find themselves more innovative by venturing into these aspects of social science, so that the literature on energy footprint could be more diverse and comprehensive. A number of other potential limitations have been found. They generally include time constraints, database and key words. The sole dependence on Web of Science as the scientific database provides rooms for improvement. It is recommended to incorporate other databases like Scopus and CNKI in order to reach a more comprehensive overview of how energy footprint serves as a hot topic of research in various aspects including co-word analysis, co-author analysis, co-citation analysis and others alike. With the support of multiple databases, researchers could ensure higher number of related literatures, thereby increasing the reliability and validity of the bibliometric analysis. Last but not least, the dataset collected as of 20 December 2022 may not capture papers published eventually because of the continuous update of database. It is advisable for future researchers to aware of the dynamic nature of databases and periodically search databases for most recent publications, which in turn allowing the study's relevance to the latest development in the subject matter.

Taken together, the study's findings highlighted the importance of the energy footprint in providing implications to policy makers and hence contributing towards achievement of SDG7 (Affordable & Clean Energy) and SDG 13 (Climate Change), despite a number of recommendations for future research.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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