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Discovering Global Trends of Design in Sustainable Transportation: A Bibliometric Analysis and Visualization

Andi Nursyuhada Abdul Kadir[a], Raja AhmadAzmeer Raja Ahmad Effendi[a], Shahrizal Dolah[a], Saiful Hasley Ramli[a], Jusang Bolong[b], and Norzaliza Md Nor[c]

[a]Industrial Design Department, Faculty of Design and Architecture, Universiti Putra Malaysia, 43400 Serdang Selangor, Malaysia, [b]Communication Department, Faculty of Modern Language and Communication, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia, [c]Computer Science Department, Kulliyyah of Information and Communication Technology, International Islamic Universiri Malaysia, 50728 Kuala Lumpur, Malaysia

Email: azmeer@upm.edu.my, shahrizal@upm.edu.my, shr@upm.edu.my, jusang@upm.edu.my, norzaliza@iium.edu.my

Corresponding Author Email: andinursyuhada@gmail.com

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Abstract

Several studies on sustainable transportation have been explored in multidisciplinary background fields. However, the social approach still lacks a connection between sustainable transportation studies and the design field. Hence, the bibliometric analysis was conducted to scope the design, sustainability, and transportation research trends. Bibliometric details extracted 254 documents from the Scopus database from 1969 until September 2023 with the research strings of "sustainable transportation design" OR "sustainable transportation" AND "transportation design" OR "design*." Adopted PRISMA was used as methodology, and the analysis of 254 documents was divided into five sections: Document Type and Language Used, Research Trend and Citation Pattern, Productive Author Analysis, Top Countries Contributed to The Publication and Topical Cluster by Keyword and Title-Abstract Analysis. The results showed the trend of research increasing over the years while the citation fluctuated due to the different times of citation impact. The Productive author was Awasthi (TC=308; NCP=3; *h*=3), and the top countries are the United States, China, and Canada. The top keyword data extracted from the Scopus database showed that "Sustainable Transportation" was the highest keyword in publications (TP=124; P=48.82%), the keywords "Transportation" came at the second-highest (TP=66; P=25.98%), and the third-highest keywords in the publication was "Sustainable Development" (TP=55; P=21.65%). The exciting part to acknowledge is that the

keywords "design" with (TP=14; P=5.51%) also appeared in the Top 20 of the highest keywords in publication. The keywords, title and abstract analysis led to the topical cluster that showed the connection between sustainability, transportation and design through network map visualization. The study concluded with discussions on the contribution by feeding the gaps, limitations, suggestions on design perspectives, database comparison and in-depth content analysis.
Keywords: Global Trends, Design, Sustainable Transportation, Bibliometric Analysis, Visualization

Introduction

Over the years, the research on sustainability has mainly been explored by researchers in various multidisciplinary background studies. The most popular research on sustainability was obviously on the significance of Sustainable Development Goal (SDG) (Brundltland Commission, 1987). The World Commission on Environment and Development (1987) also highlighted the definition of sustainability as a development that meets the needs of the present without compromising the ability of future generations to meet their market. This concept was defined through Brundltland in a reported document entitled Our Common Future.

Sustainable development studies have been discussed globally for over 30 years, and even now, due to the increase in population that has potentially climate change and urbanization (Division, 2018). Hence, the SDG focuses not only on developing countries but requires the action of all countries, as targeted in Agenda 2030, which adopted 17 Sustainable Development Goals (SDGs) by the United Nations in 2015 (Meschede, 2020), as presented in Table 1.

Table 1
Sustainable Development Goals and Description

No	Sustainable Development Goals	Description
1	Zero Poverty	End poverty in all its forms everywhere
2	No Hunger	End hunger to achieve food security improve nutrition, and promote sustainable agriculture
3	Good Health and Well Being	Ensure healthy lives and promote well-being for all ages
4	Quality Education	Ensure inclusive and equitable education and promote lifelong learning opportunities for all
5	Gender Equality	Achieve gender equality and empower all women and girls
6	Clean Water and Sanitation	Ensure availability and sustainable management of water and sanitation for all
7	Affordable and clean energy	Ensure access to affordable, reliable, sustainable and modern energy for all
8	Decent work and economic growth	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

9	Industry, Innovation and Infrastructure	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
10	Reduced inequalities	Reduce inequality within and among countries
11	Sustainable cities and communities	Make cities and human settlements inclusive, safe, resilient and sustainable
12	Responsible consumption and production	Ensure sustainable consumption and production patterns
13	Climate action	Take urgent action to combat climate change and its impacts
14	Life below water	Conserve and sustainably use the oceans, seas and marine resources for sustainable development
15	Life on land	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation and halt biodiversity loss
16	Peace, justice and strong institutions	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all level
17	Partnerships for the goals	Strengthen the means of implementation and revitalize the global partnership for sustainable development

One of the meta-goals in SDGs draws particular attention to the global partnership as proficient as the importance of international and national research in sustainable development (Leal Filho et al., 2018). Other than international cooperations, the target of SDGs is impossible to achieve without multidisciplinary research due to its intricacy. Hence, the research contribution needs to identify the niche in 17 SDGs. Besides urban sustainability studies, transportation has also become a hot topic in sustainable development for the past two decades. Indirectly, it dramatically affected the global environmental pollution and energy consumption concerns over the last few decades (Badassa et al., 2020).

Inevitably, this has become the main challenge in sustainable transportation, which is to have a properly designed transportation system that should accommodate mobility and people's requirements by providing safer and eco-friendly transport (Senkowsky et al., 1990). Even sustainable transportation research presents vast related research, such as the connection of transportation system holistically in the level of growth related to the economic, social and environmental aspects (Ogryzek et al., 2018). Miller et al (2016) studies concluded the study on sustainability and public transport which still needs further research and development to support how transportation impacts urban sustainability.

The concept from sustainable to relatable transportation is extracted from a significant perspective by analogically seeing the sustainable study with an eagle eye. In this case, there will be a connection found in every detail of research studies. Moreover, this leads to the purpose of bibliometric studies of Donthu et al (2021), where the dotted connection could be seen between sustainable studies with multidisciplinary, specifically with transportation design. Hence, this study proposes the bibliometric analysis to scope Sustainable Transportation Design by evaluating the trends, impact, research area, including publishing

countries, author keywords, gaps and future direction. The following section presents the problem statement, research questions, purpose of the study, research methods, bibliometric and visual data findings, besides the conclusion.

Transportation is one of the essential factors for humans to move from one station to another (Downing et al., 1991; Klimach & Ogryzek, 2020). The design is value-added to have better transportation for the aesthetic part and ergonomically and usability consideration as practice in industrial design studies (Candi & Gemser, 2010; Desmet & Hekkert, 2007). Design studies are a subfield in the sustainable transportation approach that has its role to embark on economic, social, and environmental issues which aims to reduce the negative impacts of transport~~s~~ and designs on human health and wellbeing (Division, 2018).

An example of environmental issues for e.g. air pollution is a severe problem in most cities of the world, sustainable transportation design studies play a crucial role in minimizing the emission of possible pollutants since vehicles are one of its primary sources (Karjalainen, 2007). The situation is also the same in social issues such as road accident cases. Most sources that contribute to it are the transport itself, therefore, the study of sustainable transportation design is needed to identify the ways from the design approach to reduce it (Beshah & Hill, 2010).

In comparison, the importance of design studies in sustainable transportation-related to economic returns shows how the transportation design could penetrate the market (Heskett, 2009). Research on new vehicle designs, alternative fuels like electric cars and new highway systems is a type of design study. Despite the significance of design studies in sustainable transportation design, few efforts have been made to obtain data concerning the global scientific output of sustainable transportation design (Tomaszewska & Florea, 2018).

Due to the complexity of sustainability and transportation, bibliometric analysis has become a current interest in seeing the studies within a larger context and the connection between the research areas. There are various bibliometric studies on sustainability and transportation. For example, Meschede (2020) studied the sustainable development goals on a bibliometric overview, while Chàfer et al (2021) analyzed the trends and gaps in global research of greenery systems by using bibliometric, while Det Udomsap and Hallinger (2020) studied the bibliometric on sustainable construction.

Subsequently, Tomaszewska and Florea (2018) used bibliometric analysis to study smart urban mobility in scientific literature, Braga et al (2019) considered bibliometric studies on urban mobility performance, while Tian et al (2018) used bibliometric analysis on trends and characters of carbon emissions from the transport sector. In addition Badassa et al (2020) focused on the bibliometric to show the connection between sustainable transportation infrastructure and economic returns. However, no attempt was made to establish the specific relationship that highlights design connection in sustainable transportation, which indirectly realizes the gaps identified based on several bibliometric studies regarding sustainable transportation.

Based on all related literature on the bibliometric study of sustainable transportation, the highlights, which include SDGs, greenery system, sustainable construction, smart urban mobility, urban mobility performance, the character of carbon emission from the transport sector and economic returns has triggered the curiosity on the contribution of design studies to be seen from the global overview in connection to the sustainable transportation study. Therefore, this study aims to discover the research trend and current citation patterns of publications on sustainable transportation-design relationships. Other than that, the study also concentrates on the authorship progression of sustainable transportation design.

Identifying the research areas by figuring out the theme related to the design in sustainable transportation is the third objective of this study.

These purposes highlight the trend and development in sustainability and transportation as a significant perspective for researchers to understand the connection of design in sustainable transport. Hence, the analysis is needed to figure out the documents, publications, author's contribution, countries distribution and topical keywords in sustainable transport studies. The investigation analogy could be the same as the heuristic device that would extract the relatable sustainable transportation design literature in feeding the design practitioners with the latest research development. Through this study, there will be another niche-area to explore for future research on the design approach.

Methodology

Research methods for this study involves a holistic procedure on how the data retrieved and filtered from the beginning until the end of the process is firm and ready to be analyzed. The process involved the database identification for the accessible data sources, the usage of review adopted PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analyses) and the software used for the data analysis and data visualization.

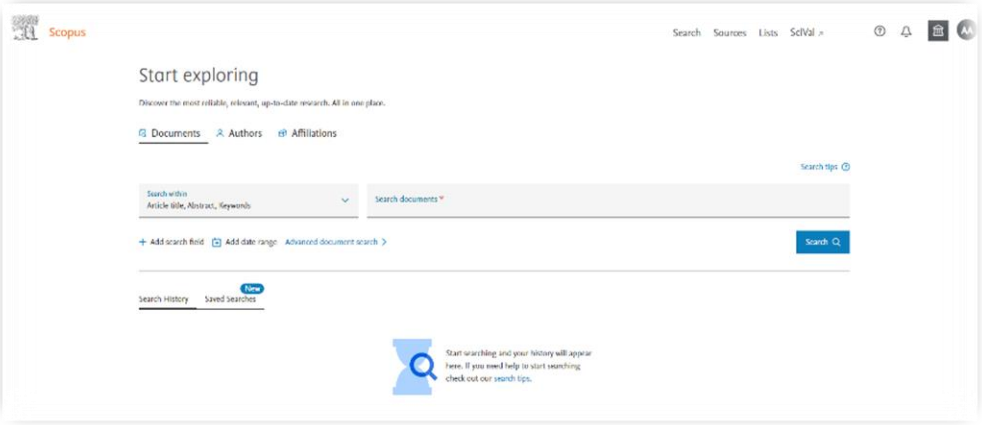
Database Identification

The Scopus index was selected as the repository to extract research data of sustainable transportation design, whereby the Scopus Database Interface is shown in Figure 1. The selection was based on its comprehensiveness in the coverage of sources (Hallinger & Kovačević, 2019). Burnham, (2006) reviewed the Scopus database and highlighted it as the largest single abstract and indexing while Ahmi et al., (2019); Falagas et al., (2008) studied it as the most extensive searchable citation and abstract literature search list. The process of extracting the data from the Scopus database will be explained in the next section of the usage adopted by PRISMA.

Figure 1. Scopus Database Interface

Adopted PRISMA

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) Moher et al (2009); Zakaria et al (2021) was adopted as a guideline for the research protocol of this study, as shown in Figure 2. The queries to extract the data from the Scopus database were



performed on 01 September 2023 using the search string (TITLE("sustainable transportation design" OR "sustainable transportation" OR "transportation design") and obtained 490

documents. The searching was restricted to the article title, and combination keywords were used to catch related documents.

The search then was narrowed by adding ("design" *) to the string to scope design, specifically between 490 documents and successfully received a total related number of 254 documents after the series of data cleaning was done to ensure there is no redundancy or duplication of the documents. Scopus data was then extracted as Comma Separated Values (.csv) and Research Information System (.ris) files. The details from the database include the type of documents, year, abstract, language, source title, keywords, citations, affiliation, country and authorship of the documents.

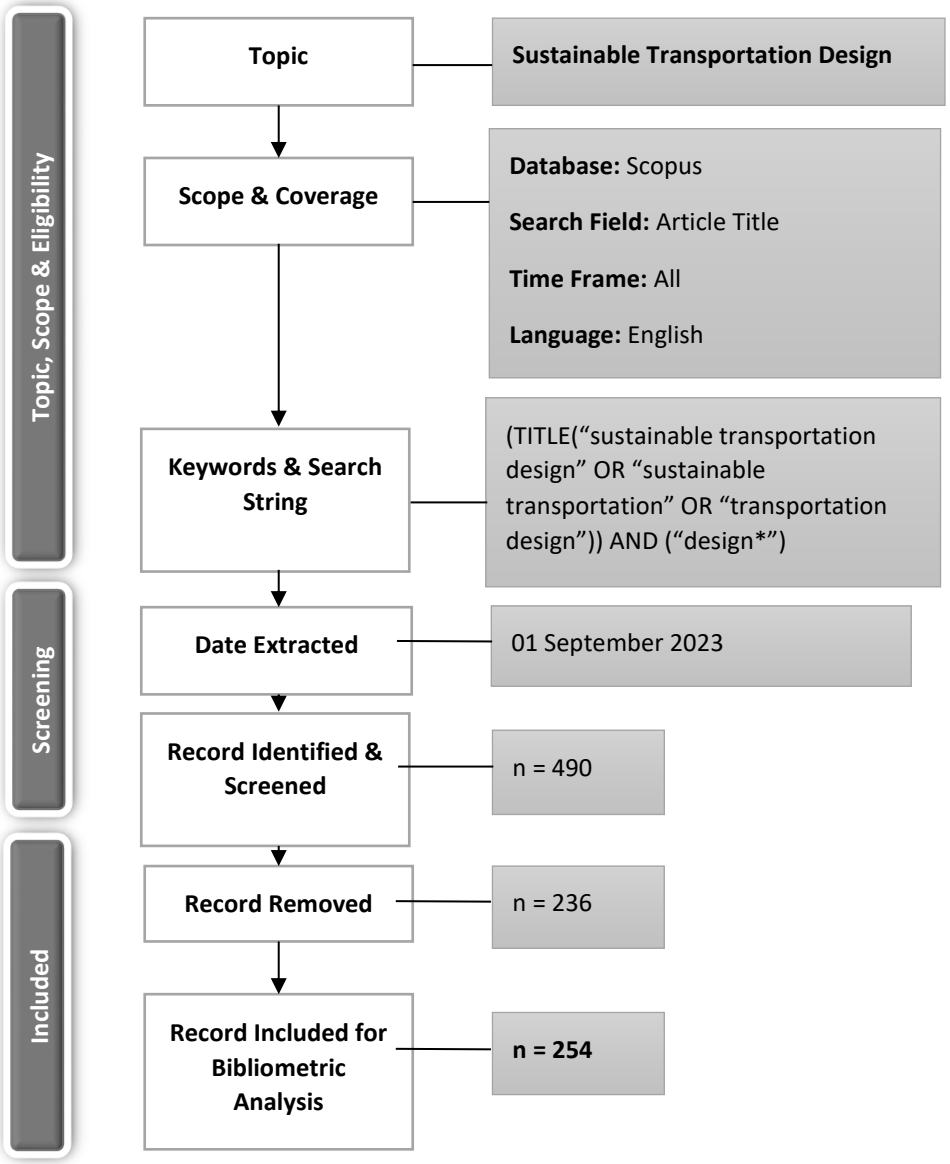


Figure 2. Flow diagram of the search strategy adopted by (Moher et al., 2009; Zakaria et al., 2021)

Tools (Software Used)

The software used in this study are Microsoft Excel, Harzing's Publish or Perish and Visualization of Similairitis (VOSviewer). Here, Microsoft Excel and Harzing's Publish or Perish were used for data analysis, while VOSviewer was used for data visualization. The VOSviewer

is a powerful approach to network mapping that will transform patterns into a social network map that visualizes similarities among focus subjects (Bastian et al., 2009; Eck & Waltman, 2020).

Results and Discussion

In this part, the findings are presented through five sections to achieve the aims of this research that were developed earlier. The first section is considered a documents profile covering the document type and language used for publications. Next, the research trend and current citation patterns of publication answered in Section Two that surrounded the publication and citation by year, citation metrics, top publisher, top 10 highly cited articles and subject area. The section then continues with Section Three which presents the authorship progression. The analysis conducted had presented the most productive authors and co-authorship map. Section Four highlighted the top countries that contributed to the publication through the world map distribution and network visualization. The following section showed the keyword analysis and co-occurrence of the title and abstract analysis and scoping the design in sustainable transportation as the main highlight contribution of this study. The said contribution will be discussed in the last section with limitations and potential suggestions for future research.

Generally, most of the findings were presented in the format frequency and percentage, while a number of analysts have been expanded by identifying the number of cited publications (NCP), total citations (TC), average citations per publication (C/P), average citation per cited publication (C/CP), h-index, and g-index. Another format included the publisher, the current Cite Score, SCImago Journal Rank (SJR) 2020 and Source Normalized Impact per Paper (SNIP) 2020 based on the Scopus database presented in the most active source title. Based on this, the weighted citations received by the source title were measured by SJR, and the actual citations received relative to the source title's subject field were measured by SNIP. Other than that, the finding was also presented through visualization by using a world map and VOSviewer that builds graphical maps of bibliographic coupling co-citation and co-occurrence of keywords.

Document Type and Language of Publication

The type of documents in this study is classified into a few categories: article, conference paper, review, conference review, book chapter, book, editorial, and noted as summaries in Figure 3. The data showed more than half of its dominance by article (57%) followed by a conference paper (27%), and the others are just below 7% of the overall documents.

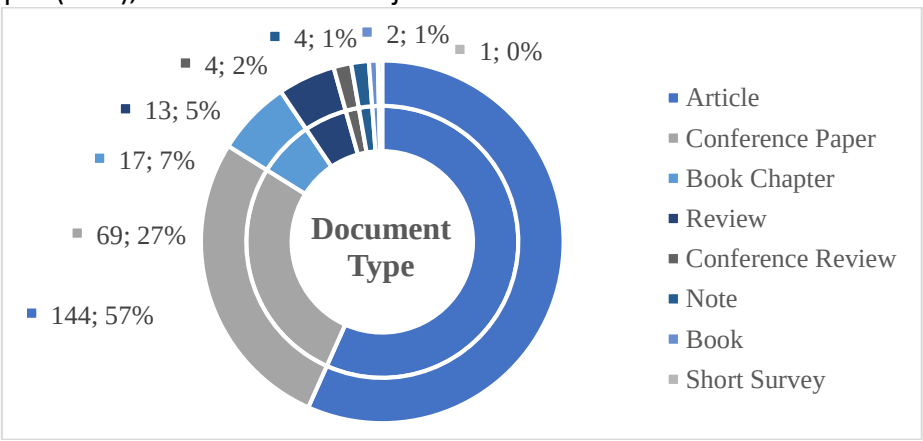


Figure 3. Document type

The language used for publication involved three languages, and obviously, English (99.22%) is the higher language usage in publication documents followed by Chinese (0.39%) and German (0.39%), respectively as shown in Table 2.

Table 2
*Language Used *1 documents have been prepared in dual language.*

Language	Total Publication (TP)	Percentage (%)
English	253	99.22
Chinese	1	0.39
German	1	0.39
Total	**255**	**100.00**

Research Trends on Pattern Publication and Citation by Year

The first aims of this study are to distinguish the research trend and citation pattern related to design in sustainable transportation. The finding from the extracted data of Scopus shows the publication by year, as shown in Table 3, summarizes the total of publication since its first publication in 1969 until 01 September 2023 on sustainable transportation and design research trend with 254 publications. The growth of publications was slow in the beginning, with less than 5% even after 30 years since 1969, but gradually increased ten years ago.

Table 3
Publication and citation by year

Year	TP	NCP	TC	C/P	C/CP	h	g
1969	1	0	0	0.00	N/A	0	0
1982	1	1	4	4.00	4.00	1	1
1984	1	0	0	0.00	N/A	0	0
1986	1	1	1	1.00	1.00	1	1
1989	1	0	0	0.00	N/A	0	0
1995	1	0	0	0.00	N/A	0	0
1996	2	2	128	64.00	64.00	2	2
2000	2	1	6	3.00	6.00	1	2
2001	1	1	8	8.00	8.00	1	1
2002	2	1	9	4.50	9.00	1	2
2003	4	4	326	81.50	81.50	3	4
2004	2	2	45	22.50	22.50	1	2
2005	5	3	20	4.00	6.67	2	4
2006	3	1	268	89.33	268.00	1	3
2007	6	2	13	2.17	6.50	1	3
2008	6	4	96	16.00	24.00	3	6
2009	7	5	31	4.43	6.20	3	5
2010	5	2	12	2.40	6.00	1	3
2011	10	8	233	23.30	29.13	5	10
2012	10	6	83	8.30	13.83	4	9
2013	13	8	177	13.62	22.13	6	13
2014	11	9	71	6.45	7.89	5	8
2015	26	19	357	13.73	18.79	10	18

2016	10	9	143	14.30	15.89	7	10
2017	16	14	148	9.25	10.57	7	12
2018	10	10	107	10.07	10.07	3	4
2019	12	9	93	7.75	10.33	3	5
2020	13	11	81	6.23	7.36	4	9
2021	16	10	147	9.18	14.7	6	13
2022	28	18	193	6.89	10.72	6	13
2023	28	11	38	1.36	3.45	3	5
Total	**254**						

Notes: TP=total number of publications; NCP=number of cited publications; TC=total citations; C/P=average citations per publication; C/CP=average citations per cited publication; h=h-index; and g=g-index.

However, the publication trends began to increase in 2011 with 10 publications a year. Then, it reached the highest number of publications in 2022 with 28 publications and maintained until 2023. Between 2011 and 2023, the peak of 357 total citations as shown in 2015 as the highest h-index (h=10). The total citation (TC=128) in 1996 was the first peak of citation as cited (Black, 1996), appeared to be the US perspective on sustainable transportation.

Figure 4 shows the publication trend that increased over the years while the citation pattern displayed fluctuation as the citation of previous literature could be based on the best interest and relatedness of the study. The research trend and citation pattern show the sustainable transportation-related design which started to attract more research studies to explore design in sustainable transportation.

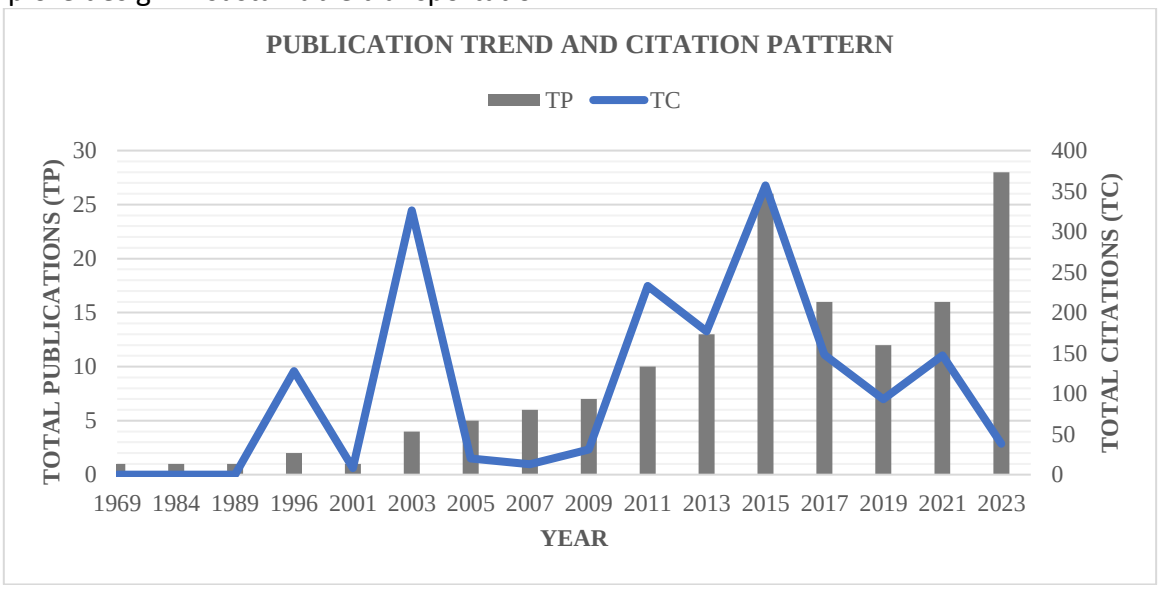


Figure 4. Publication Trend and Citation Pattern

Citation Metrics

The citation pattern analysis could be seen through the overview of the citation metric of sustainable transportation-design studies, as shown in Table 4. The documents retrieved as of 01 September 2023 presented 254 articles with 52.55 average citations per year and 2838, as per total number of citations reported. Other than that, the exciting finding is to identify the top-cited article based on the number of times it was cited, as presented in Table 5.

Table 4
Citation Metrics

Metrics	Data
Papers	254
Number of Citations	2838
Years	54
Citations per Year	52.55
Citations per Paper	11.17
Cites_Author	1411.66
Papers_Author	108.5
Authors_Paper	3.09

Here, the "Issues in Sustainable Transportation" by Litman (2006) showed the highest total of citations (TC=268;C/Y=75), followed by Balsas (2003) with "sustainable transportation planning on college campuses" achieved (TC=191;C/Y=55) and the third top cited article on "Application of fuzzy TOPSI in evaluating sustainable transportation systems" by Awasthi et al (2011) showed (TC=171;C/Y=27.33).

Table 5
Top Cited Article

Authors	Title	Total Citation (TC)	Citation/ Year (C/Y)
Litman (2006)	Issues in sustainable transportation	268	75
Balsas (2003)	Sustainable transportation planning on college campuses	191	55
Awasthi et al. (2011)	Application of fuzzy TOPSIS in evaluating sustainable transportation systems	171	27.33
Shiftan et al. (2003)	Scenario building as a tool for planning a sustainable transportation system	130	22.33
Black (1996)	Sustainable transportation: A US perspective	125	17.87

Most Active Source Title

Eck & Waltman (2020) mentioned that the number of citations by documents published by a source, author, organization or country Top 10 source title was selected as the most active sources as shown in Table 6. These source titles consist of five sources: journal, conference paper, book series, book and trade journal. Table 6 shows the most active source title led by Sustainability Switzerland with twelve publications, followed by the International Journal of Sustainable Transportation with eight publications while Iop Conference Series Earth and Environmental Science also had eight publications.

Meanwhile, the highest citation goes to Transport Policy with 319 citations, followed by the Journal of Cleaner Production with 184 total citations and International Journal of Sustainable Transportation with 96 citations. A previous study on sustainable transportation infrastructure also found Transport Policy scored the highest total citation (Badassa et al.,

2020). The Cite Score 2020, SJR 2020 and SNIP 2020 are also presented in Table 6 for significant references as sustainable transportation-design related studies are starting growth attention for future research.

Table 6
Top 10 Source Title

Source Title	TP	TC	Publisher	Cite Score 2020	SJR 2020	SNIP 2020
Sustainability Switzerland	12	57	MDPI	3.9	0.612	1.242
International Journal of Sustainable Transportation	8	96	Taylor and Francis	6.1	1.254	1.633
Iop Conference Series Earth and Environmental Science	8	1	IOP Publishing	0.5	0.179	0.436
Transportation Research Record	8	17	SAGE	2.4	0.624	0.869
Journal Of Cleaner Production	7	184	Elsevier	13.1	1.937	2.476
Energies	5	22	MDPI	4.7	0.598	1.161
ITE Journal Institute Of Transportation Engineers	4	15	Institute of Transportation Engineers	0.9	0.175	0.254
Sustainable Transportation And Smart Logistics Decision Making Models And Solutions	4	27	Elsevier	N/A	N/A	N/A
Transport Policy	4	319	Elsevier	6.9	1.687	2.126
Journal Of Physics Conference Series	3	4	Institute of Physics Publishing	0.7	0.21	0.464

Subject Area

The subject area highlighted the interdisciplinary characteristic of sustainable transportation-design research, as shown in Figure 5. Engineering corresponds to the highest percentage with 130 total publications (51.18%) as half of the all subject areas, followed by Social Sciences with 96 publications (37.80%) and Environmental Science with 81 publications (31.89 %).

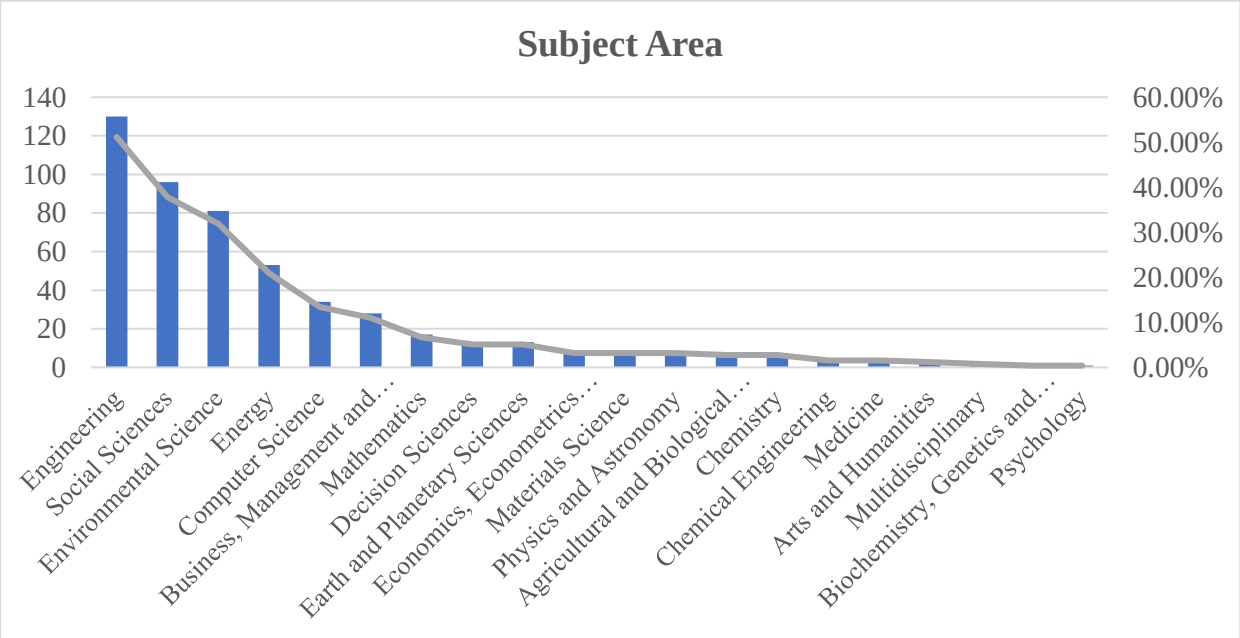


Figure 5. Subject Area

Productive Authors Analysis

The second objective of this study is to analyse the productive. The top ten authors as the most effective authors in the field are listed in Table 7. There were three authors from Canada,

another three from the United States, two from Spain, and one from Australia and Malaysia, respectively. The data showed that most of the authors produced received a similar Total Publication (TP), that is, three publications and only the author from Malaysia achieved two publications.

However, Awasthi, A., affiliated with Concordia University Montreal, Canada, deserved to be the most productive author as Awasthi was the highest h-index (h=3), Total Citation (TC=308) and Number of Cited Publication (NCP=3). Kachroo, P., Khaddar, R., and Maheswari, P., from the University of Nevada, United States, was the second-highest total citation (TC=40). Using the default given by VOSviewer, the three minimum numbers of documents and zero minimum number of citations have met 15 thresholds and showed the connection between authors through visualization, as seen in Figure 6.

Table 7
Most Productive Authors

Author Name	Affiliation	Country	TP	NCP	TC	C/P	C/CP	h	g
Awasthi, A.	Concordia University Montreal	Canada	3	3	308	102.67	102.67	3	3
Kachroo, P.	University of Nevada	United States	3	2	40	13.33	20.00	2	3
Khaddar, R.	University of Nevada	United States	3	2	40	13.33	20.00	2	3
Maheshwari, P.	University of Nevada	United States	3	2	40	13.33	20.00	2	3
Paz, A.	Queensland University of Technology	Australia	3	2	40	13.33	20.00	2	3
Adnan, N.	Universiti Teknologi ~~Y~~ PETRONAS	Malaysia	2	2	22	11.00	11.00	2	2
Kar, N.C.	University of Windsor Canada	Canada	3	3	16	3.33	5.33	2	2
Khan, M.	University of Windsor Canada	Canada	3	3	16	5.33	5.33	2	3
Faulin, J.	Universidad Publica de Navarra	Spain	3	2	15	5.00	7.50	2	3
Juan, A.A.	Universitat Oberta de Catalunya	Spain	3	2	15	5.00	7.50	2	3

Notes: TP=total number of publications; NCP=number of cited publications; TC=total citations; C/P=average citations per publication; C/CP=average citations per cited publication; h=h-index; and g=g-index.

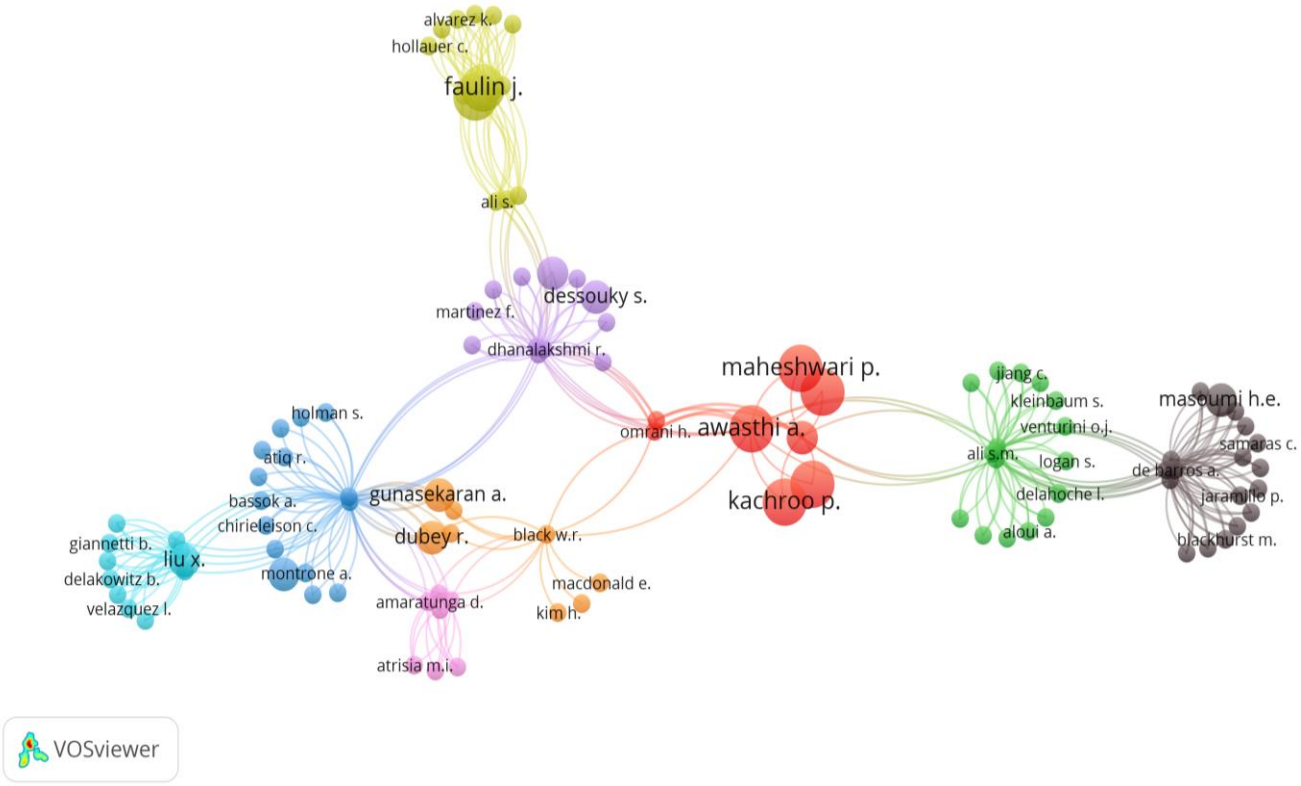


Figure 6. Authorship Analysis in VOSviewer

Top Countries contributed to the Publications

The top 20 countries from 41 countries recorded as the most productive countries contributed to the publications, as shown in Figure 7. The world map was used to indicate the distribution of publications by countries from 1 to 83 publications. The darkest blue represents the most publications contributed by the representative countries. Top on the list is the United States, with a total of 83 (32.68%) documents, followed by China 29 (11.42) and Canada 28 (11.02%). Additionally, 4 four Asian countries are ranked in the top 20, including Malaysia, with 4 (1.97%).

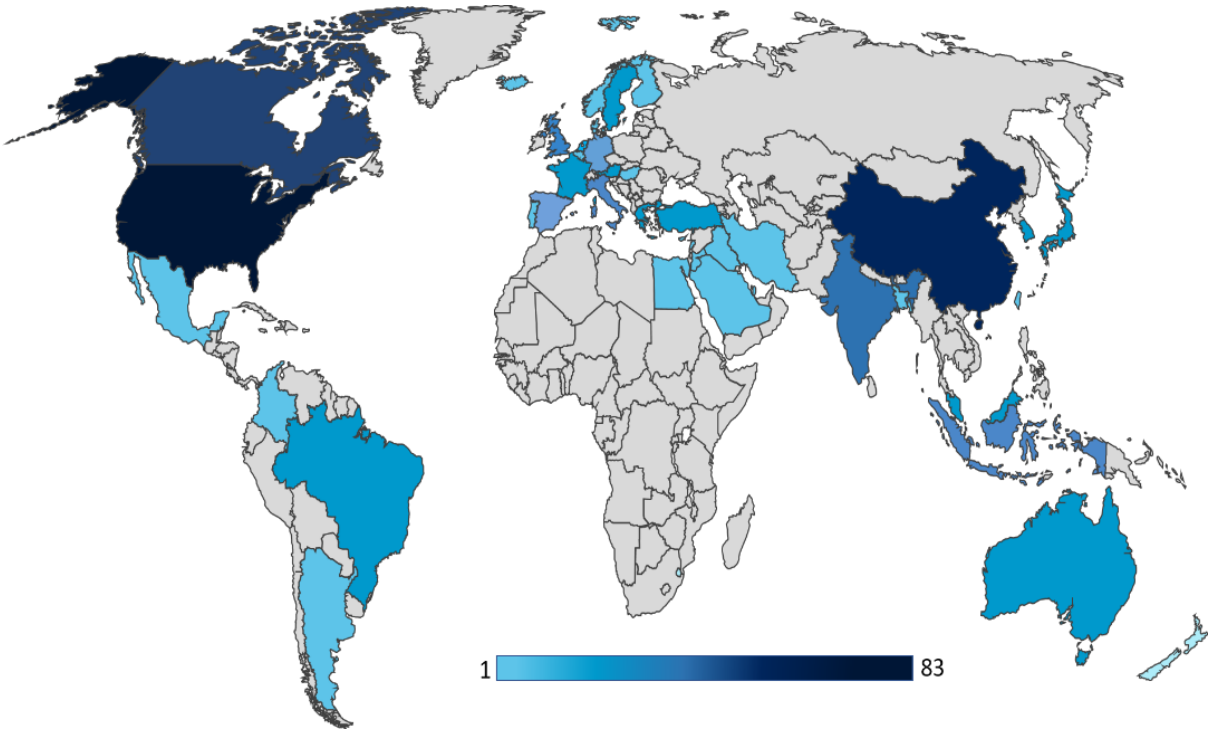


Figure 7. Distribution of Publication by countries through World Map

An interesting study on the visualization by using the VosViewer is to see the connection among countries as Figure 8 contributes to the tremendous understanding of the distribution of publications graphically. One minimum number of documents and one minimum number of citations of an author has led to a total of 52 countries that have met this threshold; however, only 41 are connected. The visual parallel with the world map, since the United States, Canada and United Kingdom, presents a high number of citations in sustainable transportation-design studies. Malaysia, with a total link strength of 3.00, connected with the United Kingdom with an 11.00 total link strength.

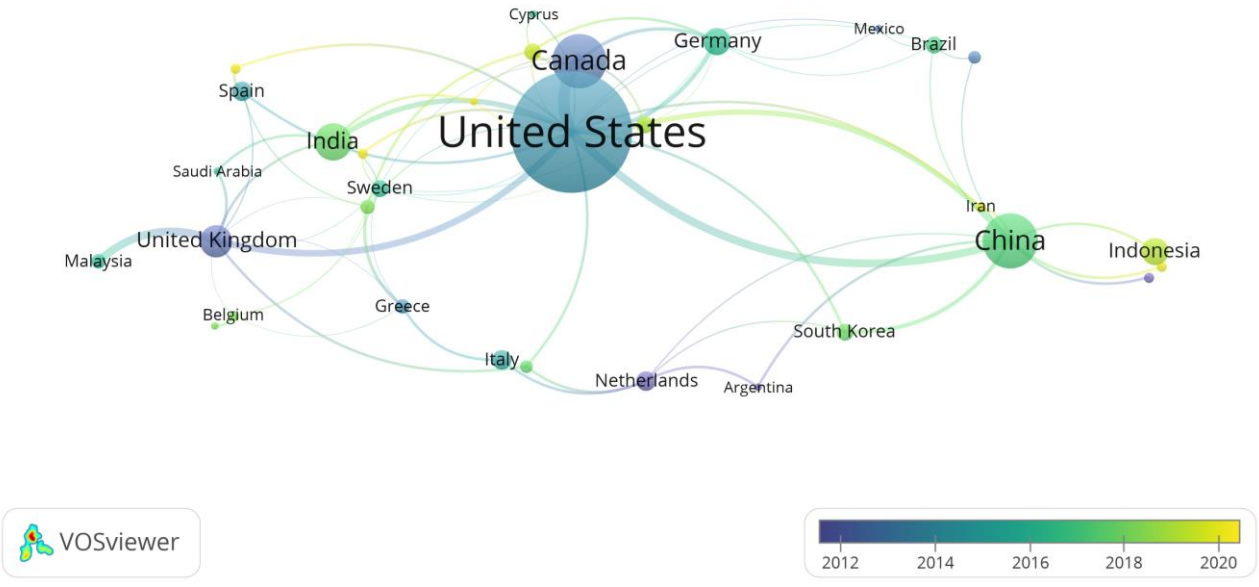


Figure 8. Countries network visualization map 2012-2020

Topical Cluster by Keyword

The third objective of this study is to identify the topical cluster in the research area related to sustainable transportation design. This topical cluster is derived by analyzing the keywords generated from the VOSviewer (Det Udomsap & Hallinger, 2020; Eck & Waltman, 2020). Table 8 shows the top keyword data extracted from the Scopus database is "Sustainable Transportation" as the highest keyword in publications (TP=124;P=48.82%), the keywords "Transportation" comes at the second-highest (TP=66;P=25.98%) and the third-highest keywords in the publication is "Sustainable Development" (TP=55;P=21.65%). The interesting part of knowing the keywords "design" with (TP=14;P=5.51%) also appeared at the top 20 of highest keywords in publication.

Table 8
Keyword Analysis

Keywords	Total Publication (TP)	Percentage (%)
Sustainable Transportation	124	48.82
Transportation	66	25.98
Sustainable Development	55	21.65
Sustainability	37	14.57
Transportation System	30	11.81
Transportation Planning	22	8.66
Decision Making	20	7.87
Urban Transportation	19	7.48
Sustainable Transportation Systems	17	6.69
Economics	15	5.91
Design	14	5.51
Vehicles	14	5.51
Urban Planning	13	5.12
Environmental Impact	11	4.33
Greenhouse Gases	10	3.94
Land Use	10	3.94
Motor Transportation	10	3.94
Public Policy	10	3.94
Accessibility	9	3.54
Climate Change	9	3.54

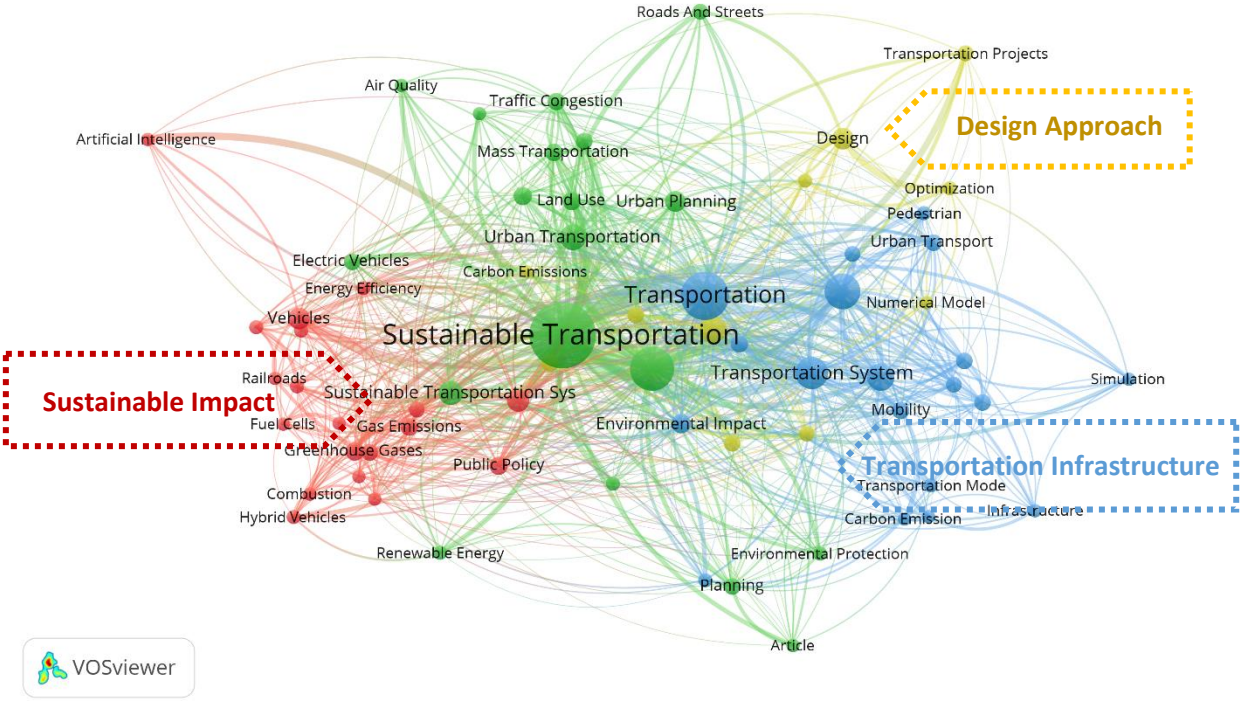


Figure 9. Network Map Visualisation of All Keyword Co-Occurrence Analysis

The author's keywords are essential to perceive the trend of research and use it in the bibliometric analysis as a guide (Donthu et al., 2021). Hence, for further analysis in this study, the keyword data was exported to VOSviewer to see the connection between keywords through visualization, as shown in Figure 9. The keyword on VOSviewer based on co-occurrence analysis used fractional counting and covers all keywords that combines the authors keyword and index keyword, suggesting a minimum number of occurrence is 5, 68 to meet the threshold out of 1906 keywords.

In Figure 9, the visualization of all the keywords indicates the color, font size, circle size, and thickness of the connected lines representing the strength of the relationship (Det Udomsap & Hallinger, 2020). Other than similar colours for related keywords, it also means the cluster as in this map, and there are four sets identified out of 68 keywords. The first cluster consists of 19 items (green) as the main topical cluster of 'sustainable transportation. In comparison, Blue as the second cluster also consists of 19 items that co-occurred under the topic ‘transportation infrastructure'. Another 19 items represented by the colour red co-occurred under topical cluster three of 'sustainable impact'. The yellow cluster with 11 items co-occurred under topic 'design approach' as the highlight of this research to scope design in sustainable transportation studies.

Title-Abstract Analysis

The map visualization could also be generated by using text data type from the Scopus database as a data source. There are three options for the fields either to extract title field only, abstract field only, or both. As the previous finding had found sustainable impact, transportation infrastructure and design approach, the title-abstract analysis has been analysed to identify the continuity of topical cluster. Binary counting has been chosen as the counting method with ten minimum number of occurrences in a term, whereby 119 words met the threshold out of the 6351 terms.

Based on 119 terms, only 71 terms were selected since the default choice is to choose 60% of the most relevant terms to generate the map. Same as the keyword analysis, the colours represents the cluster, and this study derived three topical clusters. Sustainable transportation connection was shown in green (21 Items), blue (24 items) as theme transportation sector and grey (26 item) is the third cluster of transportation design, as shown in Figure 10.

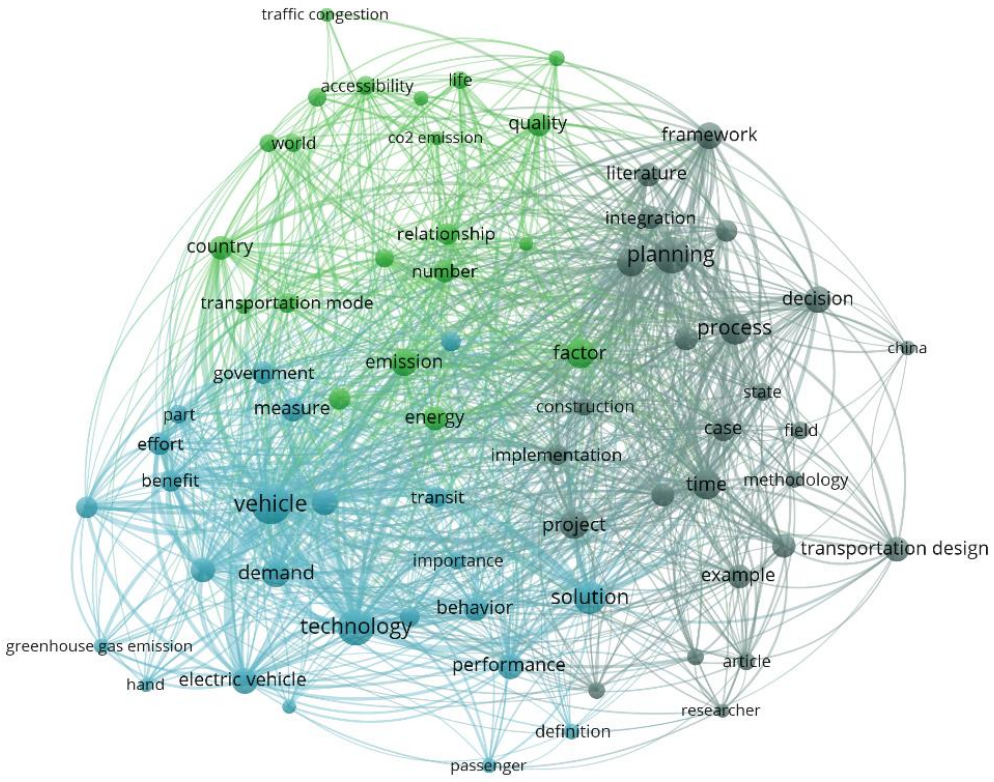


Figure 10. Network Map Visualisation of Co-Occurrence Analysis of Title and Abstract Fields (Binary Counting)

Scoping design in Sustainable Transportation

As discussed in the previous section, many researchers from multidisciplinary backgrounds have explored bibliometric analysis on sustainable studies. Chàfer et al. (2021) used bibliometric to study the trend and gaps in global research of greenery system, Meschede (2020) discovered the bibliometric on sustainable development goals, Det Udomsap & Hallinger (2020) highlighted the bibliometric on sustainable construction, while Hallinger & Chatpinyakoop (2019) explored it in ~~on~~ higher education for sustainable development.

Specifically on transportation, the study of Tian et al (2018) used bibliometric studies to analyse the trend and character of carbon emission from the transport sector and Badassa et al (2020) analysed the connection of sustainable transport infrastructure economic returns. Predominantly the field from sustainable to transportation, the closely related design study was through Braga et al (2019) research that used bibliometric analysis to identify urban mobility performance indicators. The study conducted by Tomaszewska & Florea (2018) included urban smart mobility. However, there is still no direct link to show the design connection with sustainable transportation. Hence, this last section purposely shows how the

design was scoped in sustainable transportation studies by presenting the link through the visualization study from the VOSviewer based on data from the Scopus database. According to Figure 10, the network map visualization of co-occurrence analysis of title and abstract field produced three topical clusters from 71 terms.

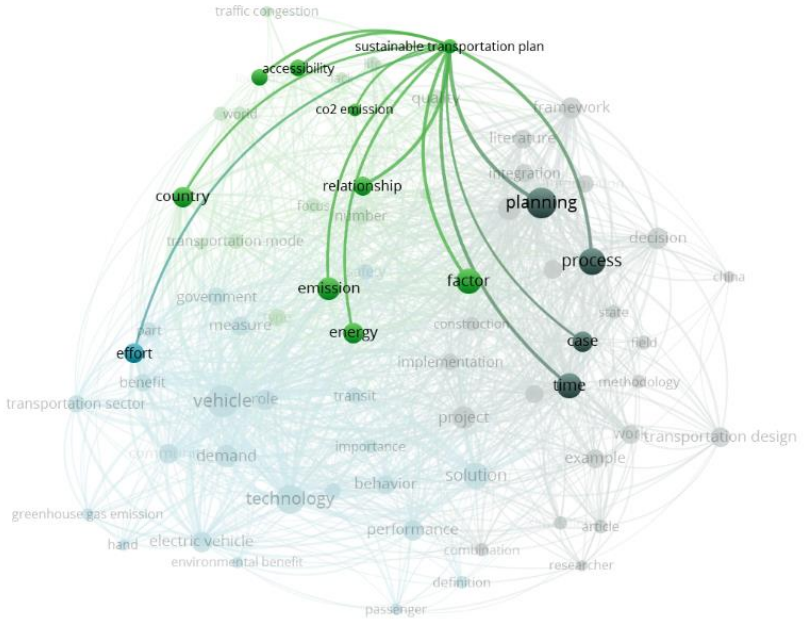


Figure 11. Highlighted topical cluster one for sustainable transportation

Based on the result from Figure 10, Figure 11 is a highlighted version of sustainable transportation with 78 weight of total link (WT) and 12 Weight of Occurrences (WO). Other top terms related with sustainable are "emission" (WT=199;WO=28), "climate change" (WT=74;WO=11) and "traffic congestion" (WT=65;WO=10). The next scoping is by looking at the transportation sector in blue.

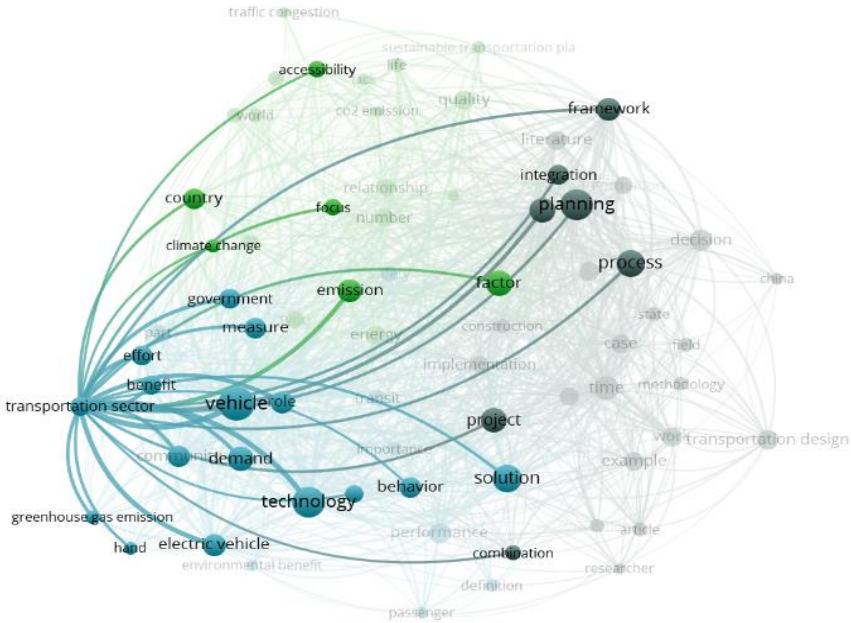


Figure 12. Highlighted topical cluster two for the transportation sector

As shown in Figure 12, the transportation sector has 148 weight of total link (WT) and 20 Weight of Occurrences (WO). There are other top terms that are related with transportation like "vehicle" (WT=427;WO=58), "technology" (WT=301;WO=48) and "solution" (WT=228;WO=40). Transportation design is the next highlighted topical cluster with grey projection.

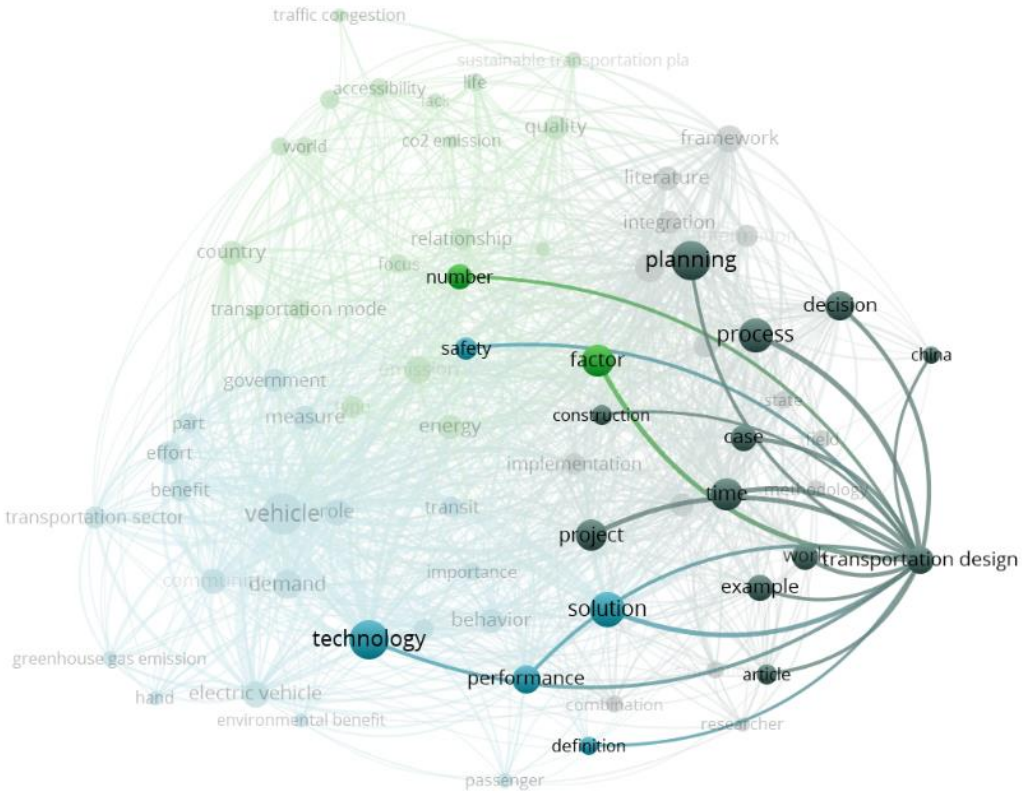


Figure 13. Highlighted topical cluster three for transportation design

As shown in Figure 13, the transportation design has 96 weight of total link (WT) and 25 Weight of Occurrences (WO). Another top term related to transportation design as in the connection are "Planning" (WT=282;WO=50), "Project" (WT=214;WO=32) and "sustainable development" (WT=157;WO=24).

To conclude, the scoping design in sustainable transportation between these three clusters showed a strong connection to focus on for having a better future transportation design. This will encourage sustainable concern and vice versa as well as to realize the importance of design in transportation and sustainability.

Discussion

This study aims to examine the trend of research on sustainable transportation and identify design connections by looking into the current state of publication, the pattern of citations, presenting the theme involved and propose the areas for future research. This paper adopts the bibliometric approach by showing the quantity and quality data based on numerical numbers of studies extracted from the Scopus database.

However, the findings presented here covered the data obtained from the Scopus database only. The data was pooled from searches using the string "sustainable

transportation design" OR "sustainable transportation" AND "transportation design " OR "design*". With this query, 254 bibliographic documents were found in the Scopus database, which allowed us to examine and visualise the current state and trends of the topic. The first document was discovered in 1969 and increased yearly until it reached 28 publications in 2023. This trend illustrates the establishment of the next research area, wherein this section, the contribution, limitation and future research suggestions will be discussed.

Contribution

It is remarkable that this paper significantly differs from any other bibliometric analysis on sustainable transportation literature by presenting the connection between design and sustainable transportation studies. The results from this study could be gained as an overview of design studies that will help specific researchers understand the worldwide trend on design contribution for sustainable transportation design, learning more and propose pathways for further studies. It suggests that sustainable transportation design will continue to become famous for the next few decades due to the mushrooming of technology, an example like virtual reality usage in transportation design which has widened the access gap amongst design practitioners.

Limitation of the Study

This study has some limitations since this study used the single Scopus database as a data source. Hence, further studies might supplement this by looking at particular secondary records in the database to discover the trends. This bibliometric overview can serve as a starting point for identifying current countries, sources and topical clusters as a theme in existing research articles addressing sustainable transportation-design studies.

Future Research

There are three significant topics for future research related to the gaps: First, performing Industrial Design studies, especially about sustainability in transportation design. Since both aforementioned are new areas of study, these could be a body of knowledge to explore more due to its contribution to maximizing the connection between transportation design and sustainability. Second, specification to focus on the type of transportation could be interesting, like air transportation (aircraft design, helicopters, private planes), land transportation (Car, motorcycle, bicycle) or water transportation (ships, boats, submarines). Third, styling study on transportation design since it is interesting to know how the styling in design transportation could contribute to embark any issues in sustainability. Due to the limitation of studies in this topic, additional content analysis could be required for the bibliometric analysis so the result could be more beneficial.

Conclusion

In conclusion, the bibliometric studies in scoping design in sustainable transportation design indicated a positive growth in research trends and citation patterns since its first publication in 1969. It reached a peak in 2015 until recently, and the citation wavered based on citation impact. Awasthi with Total Citation (TC=308), Number of Cited Publication (NCP=3) and *h*-index (*h*=3) was the top productive author. The top countries are the United States, China and Canada, while the top keyword "Sustainable Transportation" is the highest in publications with Total Publication (TP=124). "Transportation" keywords come at the second-highest (TP=66), and the third-highest keyword in the publication is "Sustainable Development"

(TP=55). It was exhilarating to know the keywords "design" with (TP=14) also appeared at the Top 20 of the highest keywords in publication. These led to the keywords, title and abstract analysis, prominent to the topical cluster that showed the connection between sustainability, transportation and design through network map visualization. This study is an overview of design connection with sustainable transportation by using bibliometric analysis through analysis of the publication, productive authorship, top countries connection and topical cluster that answered the link between design and sustainable transport. Moreover, the growth path of this bibliometric study on sustainable design suggests that it will represent one of the keys to worldwide sustainable development in future years as it believes the research could be more than double in size over the next decade.

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