Review Article

Bibliometric analysis and trends on energy and sustainability in the field of transportation

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Abstract: Sustainability and energy are frequently used concepts today. This is due to climate change, which has been linked to rising carbon emissions. The transportation sector is one of the sectors that increase carbon emissions. The aim of this study, determined in this direction, is to evaluate the progress of research and applications qualitatively and to share the results by examining the scientific outputs in the field of transportation of the keywords containing the concepts of sustainability and energy. The studies in the Web of Science database were evaluated for this, yielding a total of 611 studies. As a research method, Bibliometric Analysis and a review of the top 10 prominent studies were included. It has been determined that the studies focus on political regulation, searching for the most effective solution with a mathematical model, and city logistics; it has also been determined that technological and academic solutions are still needed in the field.

Keywords: Transportation, Content Analysis, Sustainability, Energy

Ulaştırma alanında enerji ve sürdürülebilirlik konusunda bibliyometrik analiz ve trendler

Özet: Sürdürülebilirlik ve enerji günümüzde sık sık kullanılan kavramlar olarak karşımıza çıkmaktadır. Bunun sebebi artan karbon salınımına bağlanan iklim değişikliğidir. Ulaştırma sektörü de karbon emisyonunu arttıran sektörlerden biridir. Bu doğrultuda belirlenen bu çalışmanın amacı da sürdürülebilirlik ve enerji kavramlarını içeren kilit kelimelerin ulaştırma alanında ortaya konulan bilimsel çıktıların incelenmesiyle araştırma ve uygulamaların seyrini nitel olarak değerlendirmek ve sonuçlarını paylaşmaktır. Bunun için Web of Science veri tabanındaki çalışmalar incelenmiş toplamda 611 araştırmaya ulaşılmıştır. Araştırma yöntemi olarak ise Bibliyometrik Analize ve öne çıkan 10 çalışmanın analizine yer verilmiştir. Çalışmaların politik düzenleme, matematiksel model ile en etkin çözümü arama ve şehir lojistiği üzerine odaklandığı tespit edilmiş; alanda hala teknolojik ve akademik çözümlere ihtiyaç olduğu görülmüştür.

Anahtar Kelimeler: Ulaşım, İçerik Analizi, Sürdürülebilirlik, Enerji

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1. Introduction

Climate change is one of the most important global problems. Various gases, which are named as greenhouse gases, can occur naturally as well as man-made. Human-induced greenhouse gases are mostly caused by the use of fossil fuels. Transportation systems are one of the prominent industrial areas with the high carbon emissions they emit. To put it more clearly, transportation consumed the most fossil fuels in 2020, accounting for 37% of CO2 emissions from end-use industries (IEA, 2021). In addition, the increasing trend of carbon emissions in the sector cannot be reduced, in fact, it continues to increase (Foster et al., 2021). In order to examine this negative situation, firstly, the concepts of "sustainability" and "energy" for transportation were examined, and then a bibliometric analysis of the studies in the field of transportation that included these concepts is conducted. Then a literature review is included in order to discover what the most cited, in other words, the studies with high impact focus on. In the study, firstly the concepts of sustainability and energy are examined, then the bibliometric analysis, the examination of the most cited studies and finally the conclusion section.

1.1. Sustainability and energy

In recent years, natural disasters have been frequently on the world's agenda. As an example of a few of these disasters, the biggest flood disaster of 200 years in Germany in 2021 is one of the prominent disasters (TRT Haber, 2021). It is estimated that the fires in Brazil in 2020 caused the death of 17 million animals (Gill, 2021). Similarly, it took 240 days to extinguish all the fires in Australia in 2020 (NTV, 2020). In fact, extreme weather events have grown fivefold in the last 50 years, according to the World Meteorological Organization, the UN's weather and climate agency (WMO, 2021). In 2007, the United Nations' Interstate Panel on Climate Changes (IPCC) emphasized that the biggest cause of climate change and the extreme conditions is carbon dioxide gas (IPCC, 2007; United Nations, 2023). This situation has become an internationally accepted factor in reducing carbon dioxide emissions and preventing climate change. Sustainable solutions are among the prominent solution methods.

Since the concept of sustainability is used in different fields, it appears as a concept that can have different meanings depending on the field it is used. Even from the point of view of transportation, it is not easy to make a single definition. However, in its most widely accepted form, sustainability has been defined by the World Commission on Environment and Development as meeting the needs of today's citizens without compromising the ability of future generations to meet their needs (World Commission on Environment and Development, 1987). After this definition, it has started to be used in a broader framework as economic, environmental and social sustainability in order to ensure justice between ourselves and future generations over time (Lautso et al., 2004). The opening of the way for the use of sustainability in many areas has actually been thanks to this expansion of meaning. The Secretary-General's High-Level Advisory Group, which defines sustainable transportation, explains the concept as the provision of infrastructure and services necessary for the mobility of people and goods, considering the benefit of today and the future. It is stated that the way to ensure development in this way should be safe, affordable, accessible, efficient, and flexible by minimizing carbon and other emissions and other environmental impacts (United Nations Secretary-General High-level Advisory Group on Sustainable Transport, 2016). When it comes to transportation, it is understood that the concept of sustainability means that future generations should not consume their resources and that they should improve today's conditions and make them reasonable for everyone.

Once the Covid-19 restrictions were lifted, the world's transportation sector began to grow, which resulted in an 8% increase in CO2 emissions in 2021 over the previous year. From 1990 through 2021, the yearly average growth rate of transport emissions was roughly 1.7%, higher than that of any other end-use industry (IEA, 2022). According to ExxonMobil's Outlook for Energy, there will be a 25% increase in the amount of energy required for transportation by 2040 (Exxonmobil, 2020). Efforts are being made to increase the efficiency of energy in transportation from various parties, such as providing this high energy use with cleaner energy sources, preferring efficient transportation models, popularizing vehicles with low fuel consumption, or raising awareness of consumers. In this study, both concepts were chosen as focus words in order to examine the current studies within the scope of sustainability and transportation.

2. Methodology

The method includes bibliometric analysis and literature review. For the use of these techniques, Web of Science (WOS) is preferred because it contains distinguished publications. In the search carried out on 28.02.2022, the words "sustain*" and "energy" were entered in the topic search section and 611 results were obtained. The results are analyzed through R studio. It has published an average of 8.5 studies per year since 1995. Each study received an average of 12.2 citations, and each publication received an average of 1619 annual citations.

2.1. Bibliometric Analysis

Studies with a clear distinction according to their types are listed in Table 1. A total of 1776 authors have worked on this subject by publishing in 134 different sources.

Table 1. Document Types

Document Types	No:
Article	306
Book Chapter	29
Proceedings Paper	144
Book	2
Editorial material	3
Review	16
Other	151

Table 2 shows the number of articles published by year. We can observe that interest in this topic was minimal until 2001, and then, as interest in general grew, the majority of studies were completed in 2016. Following that, the number of studies completed declined slightly.

Table 2. Annual Scientific Production

Year	Articles	Year	Articles	Year	Articles
1995	2	2005	5	2015	37
1996	5	2006	6	2016	77
1997	3	2007	6	2017	67
1998	5	2008	8	2018	64
1999	3	2009	17	2019	48
2000	4	2010	16	2020	53
2001	3	2011	24	2021	43
2002	6	2012	41	2022	8
2003	9	2013	35		
2004	15	2014	44		

It is noteworthy that the studies are generally published in environmental and sustainability journals in the field of transportation, as well as in transportation policy journals (Table 3). Table 3 lists journals that have accepted at least 10 publications on at least the subject.

Table 3. Journals that publish studies on the subject

No	Sources	Articles
1	Transportation Research Part D-Transport and Environment	114
2	Transportation Research Record	69
3	International Journal of Sustainable Transportation	41
4	Transport Policy	33
5	Transportation Research Part A-Policy and Practice	24
6	Journal of Transport Geography	21
7	Transport Research Arena Tra2016	21
8	Transport Research Arena 2012	15
9	Research in Transportation Economics	11
10	Sustainable City III: Urban Regeneration and Sustainability	10
11	Transportation Research Part E-Logistics and Transportation Review	10
12	Transportation Research Part F-Traffic Psychology and Behavior	10

When the thematic evaluation, which is created within approximately 10-year periods, is examined (Figure 1), it can be seen that environment, sustainable transport, sustainability, and sustainable development were the prominent author keywords in the years 1995-2006. Between the years 2006-2015, the key words climate change, sustainable transport, sustainability and China were used. Independent from the previous period, the newly added key words to the field were city logistics, energy efficiency, carbon footprint, life cycle assessment, alternative fuels, and road safety. The keyword chosen as sustainable development in the previous period has evolved into the words climate change and China. The emergence of China as a keyword at this stage was realized with its admission to the World Trade Organization (WTO) in 2001. In the last period (2016-2022), the key words electric vehicle, green gas emissions, sustainable mobility, literature review, air pollution, transport, travel behavior, and electric mobility have been added. In the last period, it may seem normal to mention that China has evolved into air pollution and sustainable mobility, because in the first years it was on the agenda with a much more uncontrolled production and energy consumption. Again, in the last period, electric vehicles have started to take place in key words after being seen as an alternative in transportation. When the thematic evaluation is examined in general, we see that the first period is simpler, the concepts are getting deeper and their relations with each other are getting stronger over time.

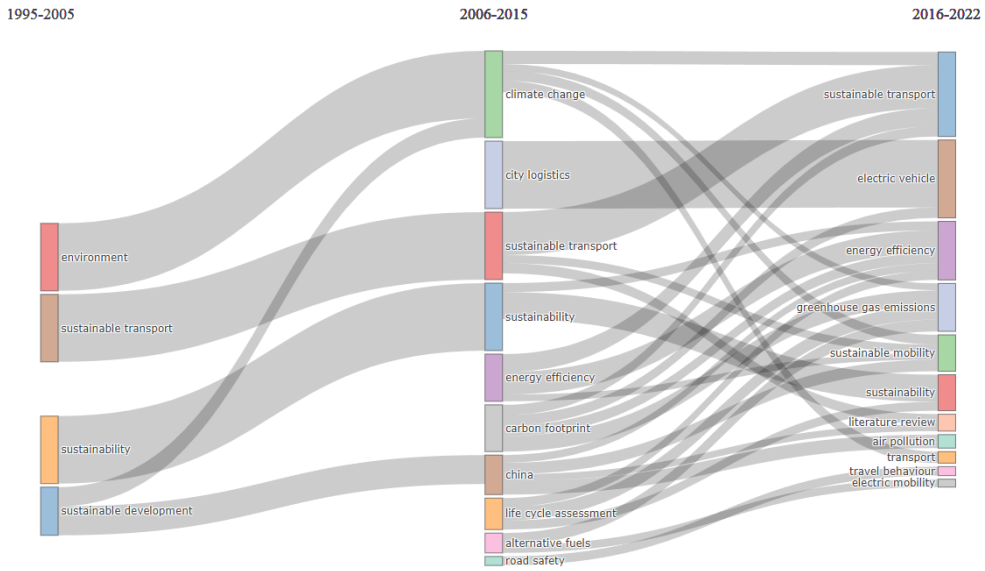

Figure 1. Thematic Evaluation

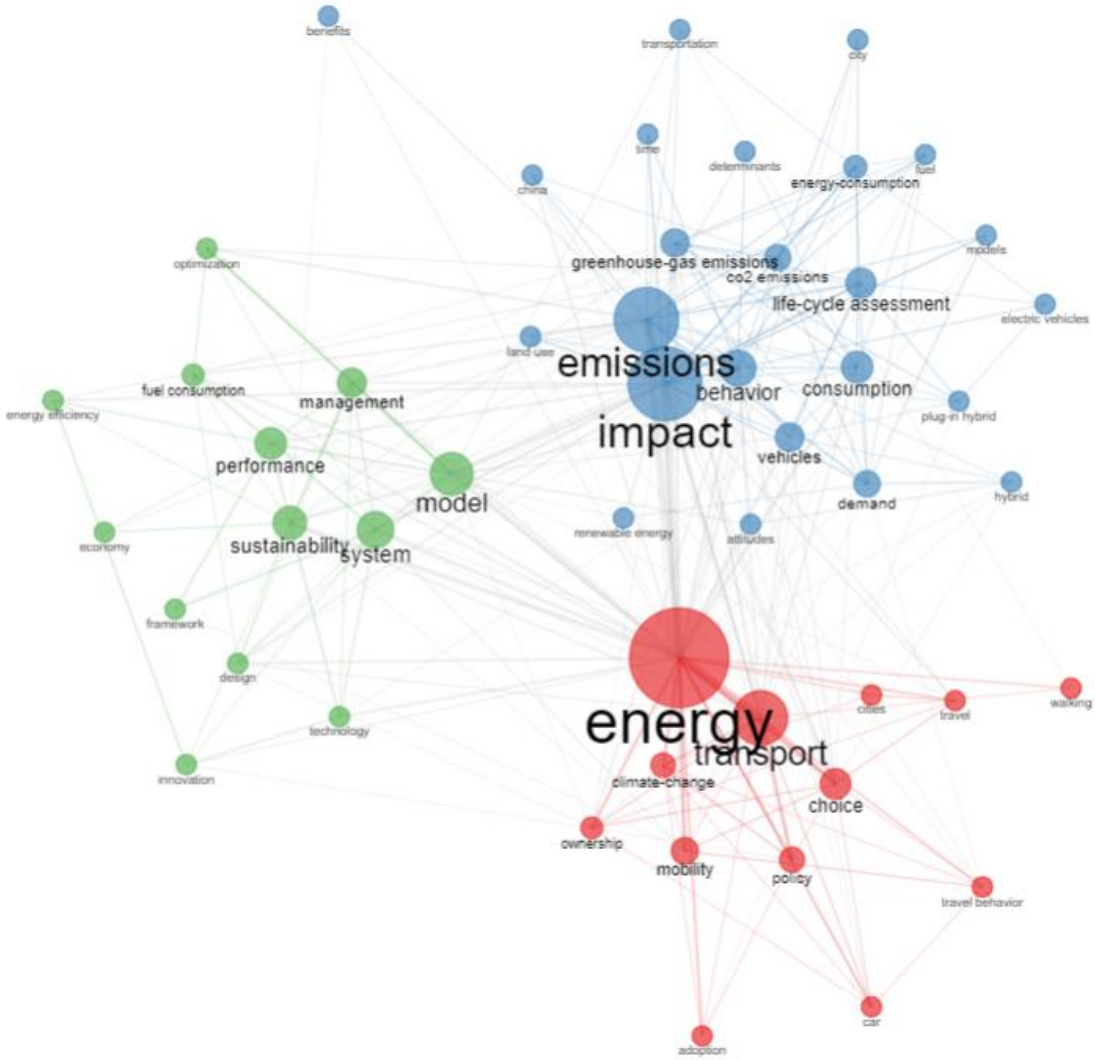

Figure 2. Co-occurrence Network

When the co-occurrence network in figure 2 is examined, it is seen that three main groups emerge. While energy and transportation are the key words of a main group, travel and transportation preferences are included in the sub-headings. The group dealing with environmental negative impacts is differentiated in blue. Here, there are keywords such as consumption, demand, and fuel types used. In the last group, it is seen that there are more technological or model-oriented solutions for more efficient use in sustainability and energy saving issues.

According to Figure 3, studies on these topics are gathered in two different clusters regarding consistency between variables. It is seen that the studies carried out in a group are those that try to offer solutions for more effective use, such as model, technology, optimization. The other group, on the other hand, is more comprehensive and focuses on the results of transportation, namely on issues such as emissions and pollution, and on the search for alternatives to the current transportation. Finally, another feature of the second group is that it includes city logistics, so it is seen that subjects such as vehicle ownership, attitudes of people, policy, public transportation, land use are included here.

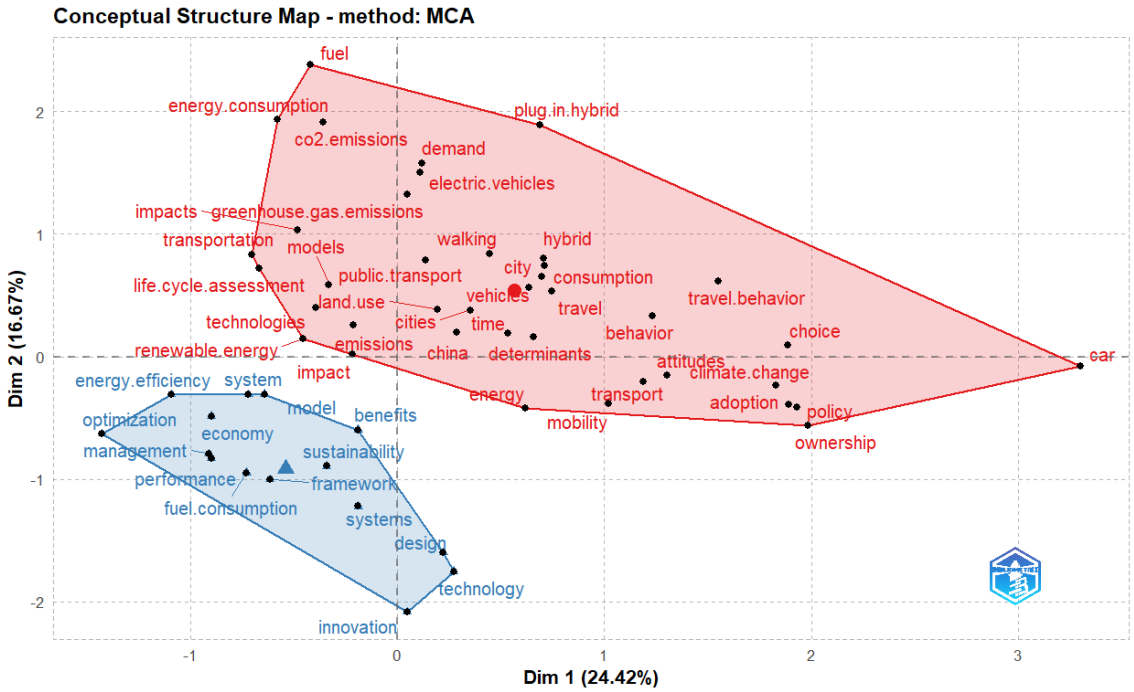

Figure 3. MCA Results

2.2. Review of highly cited articles

In this study, in which the bibliometric analysis of the concepts of sustainability and energy in the field of transportation is being carried out, the analysis of the most cited studies is included in this section in order to reveal the areas of interest in the literature.

The most cited study is the literature review in the field of transportation and climate change (Chapman, 2007). Another literature review examines the environmental sustainability of transport and logistics service providers (Centobelli et al., 2017). The last literature review included in the ranking is the literature review in the field of green port and marine logistics. When examined in other highly cited studies, it is seen that there are optimizations made on the use of bioethanol in the supply chain (Chen & Fan, 2012; Yongxi Huang et al., 2010). Since the use of biofuels is sustainable due to the fact that it reduces CO2 emission, fossil fuel use, and is produced from waste, it is becoming widespread and interest in studies on this subject is increasing. The other research area that attracts the attention of researchers is sustainable transportation systems in a city or a certain region (He & Chen, 2013; Kennedy, 2002; Murray et al., 1998; Wu et al., 2016; Yedla & Shrestha, 2003). These studies focus on how to improve transportation and make it sustainable by choosing a specific region as a study area and restricting their investigation to the relevant area. Especially after the carbon emission target determined in European Union 2011 White Paper, it is seen that these studies have increased. They jointly focus on what can be done to encourage the use of public transport, and in some cases, the use of bicycles. Similarly, after the goal of reducing carbon emissions, studies on hybrid and electric vehicles are highly cited. In these studies, the behavior of users to charge their vehicles (Franke & Krems, 2013), the motivation and determination of obstacles to motivate the spread of electric vehicles in Europe (Biresselioglu et al., 2018), and in a study conducted in Portugal, the rate of increase of 35% to 65% in case of encouraging the use of electric and hybrid vehicles in car sharing. It is being researched that carbon emissions will decrease (Baptista et al., 2014). One of the current studies is on the smart city concept. Similarly, this study is recommended because of the difficulty of achieving the goals of the White Paper. It reveals that transformation in the energy sector will be required in order to achieve these goals, and the smart city is presented as a solution (Zawieska & Pieriegud, 2018). A study examining the concept of sustainability in transportation from a different perspective underlines that the perspective on the concepts of distance, speed, and time should be changed and that the understanding that transportation should be fast is not sustainable (Banister, 2011). Another study investigates the effect of road maintenance works on carbon emissions in the UK (Yue Huang et al., 2009). In a different study

on road construction, the materials used and their effects on the environment are also investigated (Horvath & Hendrickson, 1998). In a tourism-oriented study, the growth and CO2 effects of tourism between Eastern and Western Europe for regions are examined (Paramati et al., 2017). In a supply chain focused study, closed-loop location-routing-inventory supply chain network under mixed uncertainty is studied with a sustainable design (Zhalechian et al., 2016). Another supply chain focused study examines the competitiveness of green supply chains (Hafezalkotob, 2017).

As a result of the examination of the studies that most attract the attention of the researchers, it is seen that the literature reviews attract attention in terms of showing the gaps in the literature. In addition, it has been determined that research on encouraging public transportation, the use of bicycles, the benefits of shared vehicles, and electric and hybrid vehicles attract attention in these studies, where city-oriented studies are carried out to reduce carbon emissions, especially after the White Paper. The smart city concept, which is presented as an up-to-date and innovative solution, is recommended for sustainable systems and is in an attractive position. It has been concluded that there is a need to further develop these new and current concepts in the field and to search for sustainable solutions not only for city logistics but also for supply chains. Finally, it has been determined that the mathematical models that biofuels, which are seen as a fossil fuel alternative, are an important alternative for sustainability, also attract attention, and this is seen as an important source by researchers in terms of carbon emissions and energy consumption. These areas are still currently attracting attention and are the focus of attention by researchers.

3. Conclusion

Sustainable and energy efficient or renewable transportation has now become a necessity. It is possible to show the reason for this as high carbon emissions and high fossil fuel consumption. In the bibliometric analysis performed via WOS, it is seen that the first studies were made in 1995. Since then, different approaches have been tried to find a solution to the issue. It is seen that the solutions are generally focused on how the effects of political regulations will be, mathematical models and energy efficiency and sustainability, and city logistics. These issues come to the fore in both bibliometric analysis and review. Although the studies conducted in recent years have decreased compared to the year in which the most studies were conducted in 2017, it is thought that the reason for this is the shift of academic interest in different directions with the effect of the global epidemic. The requirement for transportation to have less negative environmental effects, be accessible to everyone, and be cost-effective is not yet matured enough. As a result, the research area requires both technological breakthroughs and academic solutions.

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Conflict of interest statement

The author certify that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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