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Interrelations Between Transportation Development and Congestion: A Bibliometric Analysis Using VOSviewer

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Abstract

The development of transportation has become one of the important indicators of regional progress, especially amid rapid urbanization. Congestion can be defined as a condition when the transportation system does not function smoothly. This study aims to explore the relationship between transportation development and congestion through a bibliometric approach using VOSviewer. VOSviewer is a software tool designed for creating and analyzing visual maps based on bibliometric or text data. Data were collected using the Publish or Perish software, which is connected to the Google Scholar academic database, with relevant publications from 2020–2025. The collected data were then exported and analyzed using VOSviewer software to perform keyword co-occurrence analysis, network keyword on relation, co-occurrence author, and visual mapping of the research network. The highest number of year publications was in 2024, with 248 articles. the keywords "traffic congestion" and "transportation" are linked through related keywords such as smart city, machine learning, intelligent transportation system, and artificial intelligence. These keywords represent the relationship between transportation and traffic congestion. This research can also provide scientific literature in the field of transportation planning and spatial planning so that as transportation develops and grows, sustainable spatial planning can be implemented.

Keywords: Transportation, Bibliometric Analysis, VOSviewer, Traffic Congestion

1. Introduction

The development of transportation has become one of the important indicators of regional progress, especially amid rapid urbanization and economic growth. The rapid economic development in Indonesia has caused traffic congestion to increase [1]**.** Traffic congestion is a global phenomenon influenced by economics, population growth, transportation infrastructure, and the ever-increasing availability of ridesharing and delivery services [2]. The construction of road infrastructure, the increasing number of vehicles, and innovations in public transportation modes have shown significant progress in the past decade. However, as accessibility and movement volume increase, new problems emerge in the form of traffic congestion. Traffic congestion occurs due to high traffic volume caused by the mixing of through traffic, regional and local traffic [3]**.** The congestion case is familiar to developing countries [4]. Numerous variables can contribute to traffic congestion, including a growing population, construction of high-rise structures, traffic restrictions, and ongoing road and bridge construction [5]. The rapid economic development in Indonesia makes traffic more congested [6]. The most negative impact on road users are time loss, energy wastage, health problems due to vehicle pollution, to stress and a decrease in people's productivity in their activities [7]. There is no doubt that congestion is, above all, an urban phenomenon, either in the core of large cities or on the interurban roads accessing and connecting urban hubs [8].

Transportation systems are an indispensable part of people's daily life [9]. Public transportation is a means to move people and goods from one place to another [10]. The activity of moving people and goods requires an excellent level of road service [11]**.** A transportation system can be defined as the combination of elements and their interactions [12]. Rapid development in major cities in the world, especially in developing countries resulted in increased community activities [13]. The transport system has become a fundamental basis for the economic growth of all nations [14]. A transportation system is a complex dynamic system composed of different modes of transportation [15]. Transportation infrastructure plays a pivotal role in shaping spatial connectivity [16]. The operations and performances of the transportation system have a profound effect on all three pillars of sustainability including environment, society, and the economy [17]. The availability of transportation facilities

and infrastructure is one of the essential elements in supporting community activities in urban areas [18]. Road user safety is a crucial aspect of effective transportation infrastructure management [19]. One of the parameters of road performance is road capacity [20]**.** Transportation is the backbone of local, regional, and global economies, with goods and people continuously moving around the world [21]. Organizing Intelligent Transportation System in developed countries is carried out jointly by the government, police, transportation operators and industry [22]. Facilities and infrastructure are crucial for smooth and comfortable operations [23]. Motor vehicle transport of urban residents contributes to a wide range of today's most intractable urban problems, such as high cost of traffic crashes, millions of hours because of traffic jams [24]**.** Transportation facilities and infrastructure are mutually supportive factors [25]. The development and the improvement of public transportation positively impacts the economy of the city and the country [26]. Furthermore, the integration of research in transport helps inform academic researchers, urban designers, developers, authorities, the public, and other stakeholders [27].

Congestion can be defined as a condition when the transportation system does not function smoothly, becomes stuck, or disrupted [28]. Traffic congestion occurs due to high traffic volume caused by the mixing of through traffic, regional and local traffic [29]. Road performance is whether the road responds well to human movement [30]**.** Every year the growth of motorized vehicle users has increased relatively high [31].Traffic congestion is one of the primary issues influencing the socio-economic activities of developed countries around the world [32]. Congestion and long queues generally occur at intersections, both intersections with signal and non-signal [33], Roads are built and maintained to provide services, such as the capacity to move people and products within a predetermined period, with the probability of goods being damaged and people injured or losing their lives relatively low [34].The availability of transportation facilities and infrastructure is one of the essential elements in supporting community activities in urban areas [35]. To address roads congestion problem, two main options are considered to either construct more roads or maximize utilization of the existing ones [36]. Advanced traffic management and control methods have recently become effective approaches to improving urban transportation efficiency and preventing traffic congestion [37]. Traffic Congestion may be categorized into two types, i.e. recurring type, which is primarily taken place due to capacity and behavioral issues or non-recurring type, which is because of accidents, construction, or emergencies [38]. In logistics transporting, both the route and the vehicle itself have a dependent relationship with each other [39]. Trains are considered to play a role as strategic public transportation because of their ability to reduce congestion in urban areas [40]. Traffic congestion is a global issue that challenges the development of a resilient and sustainable transportation system [41].

This study aims to explore the relationship between transportation development and congestion through a bibliometric approach using VOSviewer. VOSviewer is a software tool designed for creating and analyzing visual maps based on bibliometric or text data [42]**.** It can extract bibliographic networks from data files downloaded from WoS, Scopus, Dimensions, PubMed, and RIS format [43]. Bibliometric analysis uses data on the number of publications, authors, and citations to measure the productivity of researchers, institutions, and countries [44]. Rapid computational methods and digital information have transformed the researcher's ability to quickly and cheaply collect data [45]. The co-occurrence of keywords clearly illustrates the disciplinary structure, hot topics, research gaps, and global trends in TOD (Transit-Oriented Development) and related transportation fields [46]. VOSviewer as a bibliometric analysis method provides effective visualization using the VOS mapping technique [47], and it enables easy exploration of bibliometric patterns [48]. With the use of different software tools, knowledge mapping enables comprehensive and interdisciplinary insights in a short timeframe [49]. Bibliometric analysis is an innovative tool for tracking research outputs over time and helps identify emerging themes, geographical patterns, and under-researched areas [50]. More data means potentially better processing capabilities, leading to improved, data-driven decision-making [51]. Although there are numerous studies on equity in transport and mobility, few have conducted bibliometric analyses specifically in this field [52]. As such, a systematic review can offer a balance between comprehensively identifying a larger pool of publications and systematically identifying a smaller set of studies that fit criteria for inclusion and can inform research agendas [53]. Advances in the complexity of large cities, highly complex systems, and intelligence science, intelligent city technology, have demonstrated remarkable capabilities in helping to reduce traffic congestion in developing cities [54]. Moreover, the complex relationship between transport influence and sustainability, and the difficulties in evaluating sustainable transport, academia needs detailed research on the relevance of sustainability studies to the transport sector [55]. The study also provides a detailed analysis using VOSviewer related to key authors, keyword occurence, publications and citation and co-citation analysis on the topic [56]. High-quality public spaces must be present throughout the city, and any new construction must adhere to sustainable urban planning principles [57]. The results will provide new insights into the direction and focus of global research on transportation and congestion issues with artificial intelligence.

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2. Research Methods

This study uses a bibliometric approach to analyze the relationship between transportation development and traffic congestion. Bibliographic data were collected using the Publish or Perish software, which is connected to the Google Scholar academic database, with relevant publications from 2020–2025. Publish or Perish helps to collect similar journals around the world that have links to the research under review [58]. Google Scholar was chosen because it covers various academic publications, including journal articles, conferences, proceedings, books, theses, and other academic documents from multiple disciplines [59]. The keywords used were ""artificial intelligent", "transportation", "congestion", "public transportation", and "middle city" a total of 999 English-language articles related to these keywords published between 2020 and 2025 were identified. The collected data were then exported and analyzed using VOSviewer software to perform keyword co-occurrence analysis, network keyword on relation, co-occurrence author, and visual mapping of the research network. VOSviewer is a software tool for creating and exploring maps based on network data [60]. The results of the analysis are used to identify research trends, concept relationships, and research gaps in the study of transportation development and traffic congestion, as well as potential research directions for further development.

4. Results and Discussions

Based on Google Scholar database with data search using Publish or Perish, 999 articles were found using the keywords "artificial intelligence," "transportation," "congestion," "public transportation," and "middle city" within the time frame of 2000 to 2025, as shown in Figure 1. Number Based on Year of publication articles 2000 – 2025 Figure 1.

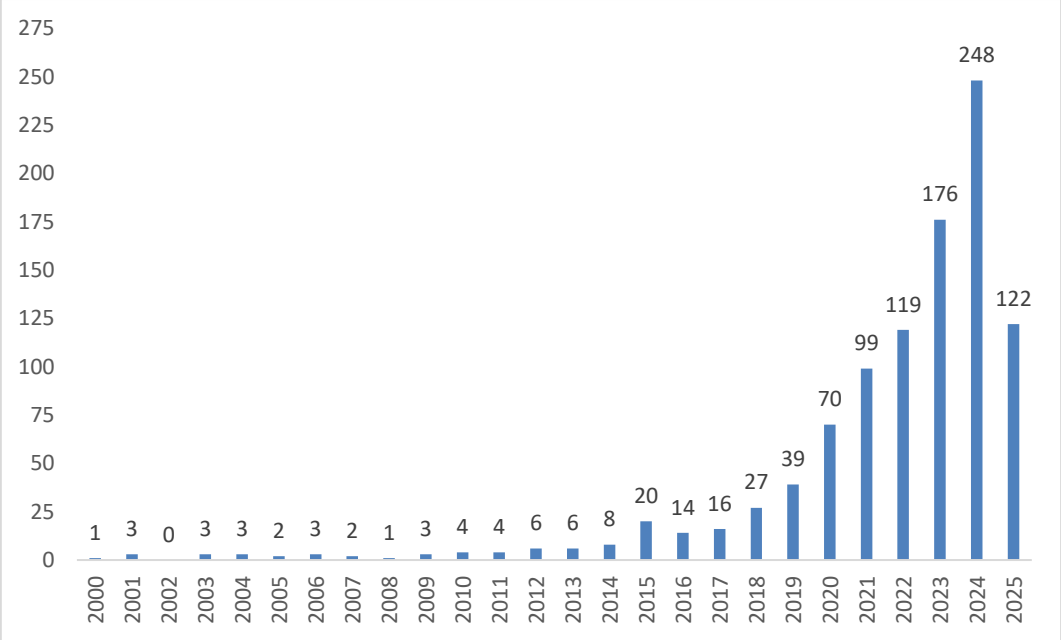

Figure 1. Number Based on Year of publication articles 2000 – 2025
Source: Publish or Perish

In Figure 1 above, data is shown based on the years 2000-2025 with a total of 999 articles. Based on the keyword, the lowest number of articles was in 2002, with no articles published that year. The highest number year of publication was in 2024, with 248 articles. There are some unique trends, with the number of published articles continuing to increase from 2017 to 2024.

After creating a graph Number Based on Year of publication articles 2000 – 2025, the next step is to group them by publisher. There are more than 20 publishers that have published articles based on the keyword. The grouping is based on the top 5 publishers out of 999 articles, including Elsevier, the Institute of Electrical and Electronics Engineering (IEEE), Multidisciplinary Digital Publishing Institute, Springer, and Wiley. As shown in Figure 2 below.

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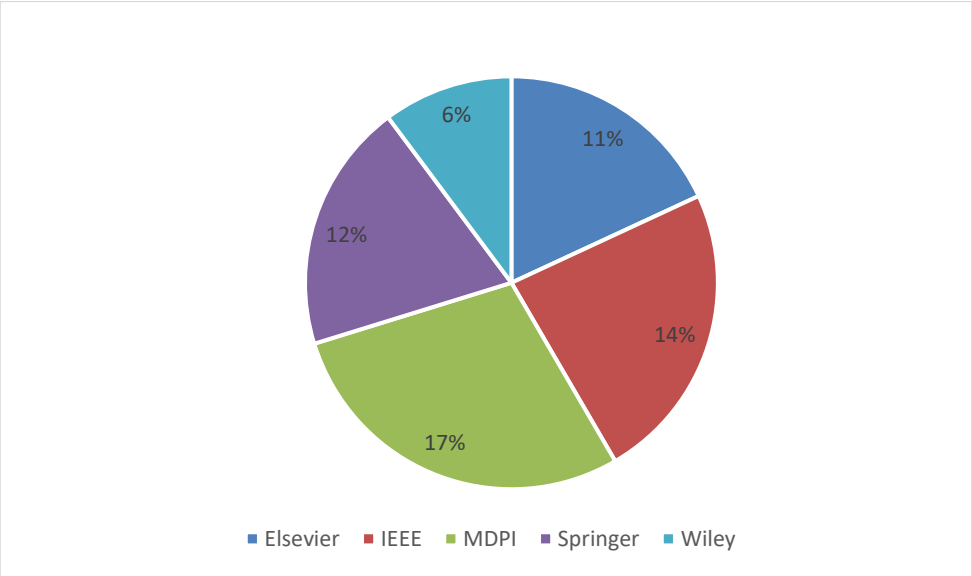

Figure 2. Publisher most articles based on keywords
Source: Publish or Perish

Based on the graph above, it can be seen that from the dozens of publishers included in the keyword category, the number was narrowed down to the 5 publishers with the most articles. The publishers with the most articles are MDPI with 17%, IEEE with 14%, Springer with 12%, Elsevier with 11%, and finally Wiley with 6%. In addition to these publishers, there are other publishers with percentages smaller than the five publishers above..

After that, the publish or perish data in RIS file format was entered into VOSviewer by analyzing network keyword visualization, with a minimum occurrence of a keyword being 3 out of 612 keywords in total, resulting in 39 keywords meeting the threshold. Next, the relevant keywords were reselected, resulting in 25 keywords. These 25 keywords were divided into 6 clusters. Cluster 1 (Red Color) contains six keywords: Internet of Things, smart city, smart transportation, sustainability, traffic congestion, and traffic management. Cluster 2 (Green Color) has five keywords: applications, intelligent transportation system, logistics, transportation, and urban air mobility. Cluster 3 (Blue Color) has four keywords: autonomous vehicle, security, sensors, and survey. Cluster 4 (Yellow Color) has four keywords: artificial intelligence, cybersecurity, machine learning, and urban planning. Cluster 5 (Purple Color) has three keywords: edge computing, object detection, and tracking. Finally, Cluster 6 (Cyan Color) has three keywords: environment, public transportation, and travel behavior. Network visuallizing of keyword on Figure 3

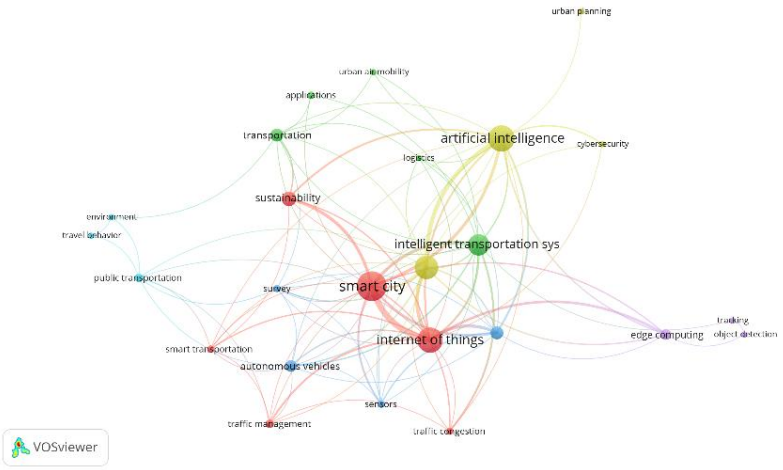

Figure 3. Network Visualization of Keyword
Source: VOSviewer

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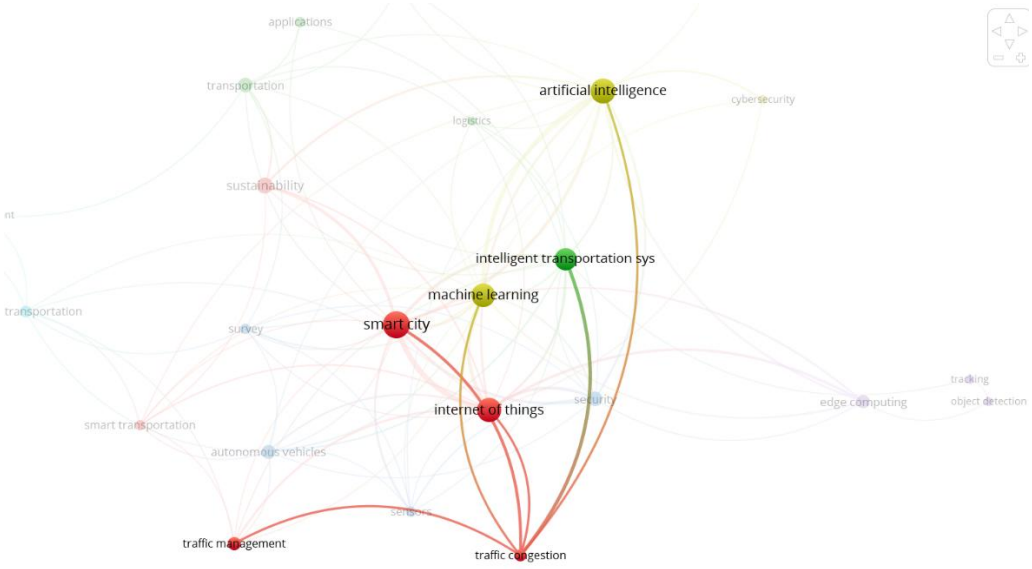

Figure 4. Network Selection Keyword "traffic congestion" Related
Source: VOSviewer

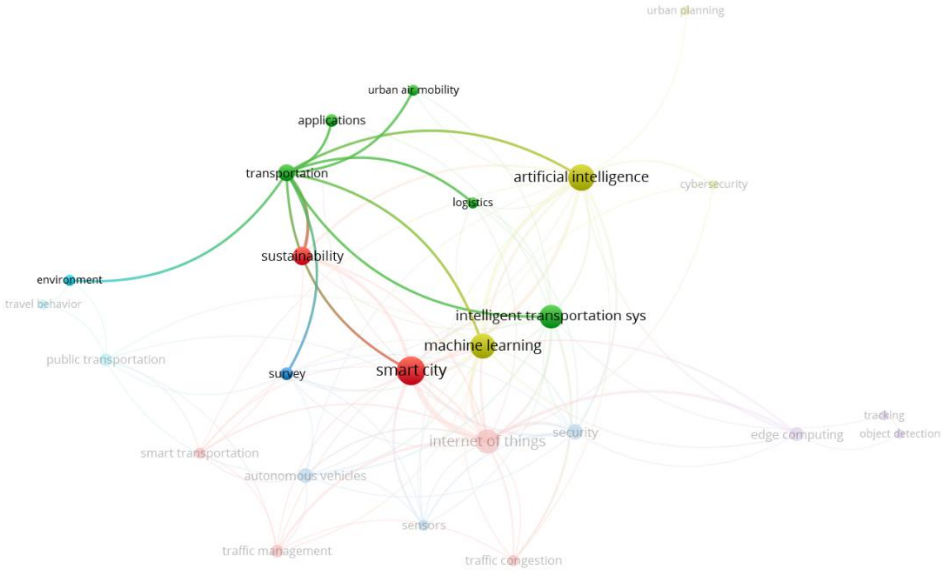

Figure 5. Network Keyword "transportation" Related
Source: VOSviewer

From the Figure 4 and Figure 5 above, two keywords were selected, namely "smart transportation" and "traffic congestion," to represent the keyword selection. Under "traffic congestion," there are several links to other keywords, including traffic management, smart city, Internet of Things, machine learning, intelligent transportation system, and artificial intelligence. Furthermore, "transportation" has links to applications, urban mobility, environment, logistics, sustainability, artificial intelligence, intelligent transportation system, machine learning, smart city, and survey.

Thus, the keywords "traffic congestion" and "transportation" are linked through related keywords such as smart city, machine learning, intelligent transportation system, and artificial intelligence. These keywords represent the relationship between transportation and traffic congestion.

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Figure 6 shows the years of publication of articles with the keyword, starting from 2000 to 2025, with colors ranging from dark blue to bright yellow. The yellow color dominates the image, which means that the publication of these articles was concentrated in the years 2023–2025.

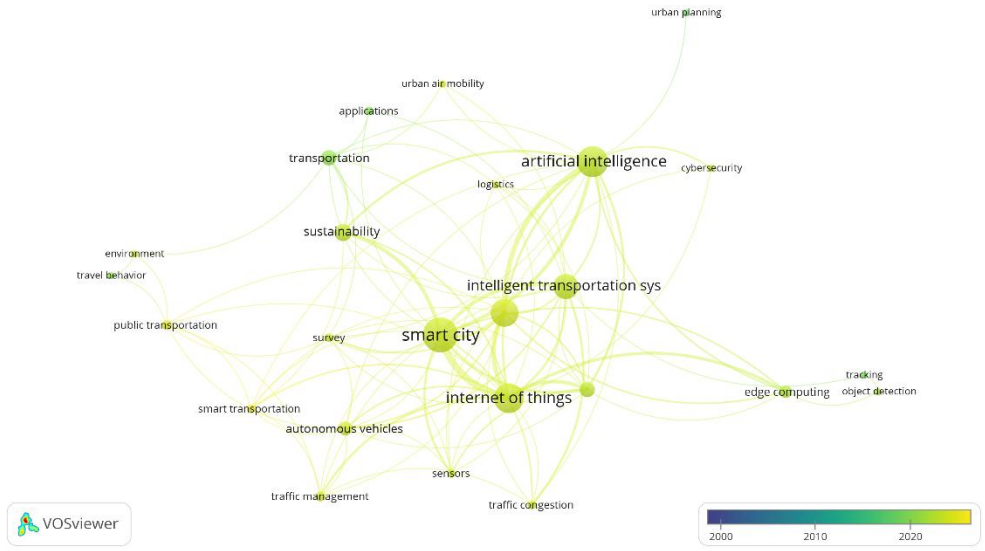

Figure 6. Overlay Visualization of Keyword

Density Visualization of Keywords is shown in Figure 7 the higher the occurrence rate, the deeper the color, indicating a higher number of occurrences. The three most frequently occurring keywords are smart city, artificial intelligence, and internet of things. This can inspire new research ideas. For example, in Figure 5, the lowest density is for "urban planning," indicating that research related to urban planning is still rare. Such research could be conducted using keywords input into Publish or Perish which are then processed using VOSviewer to determine co-occurrence of keyword.

Figure 7. Density Visualization of Keyword
Source: VOSviewer

Of the 999 articles, there are several co-occurrence authors with a maximum number of authors per article of 5 and a minimum number of articles per author of 2 resulting in 138 meeting the threshold with a total of 2.399 authors. Figure 8 below shows the author network of keyword.

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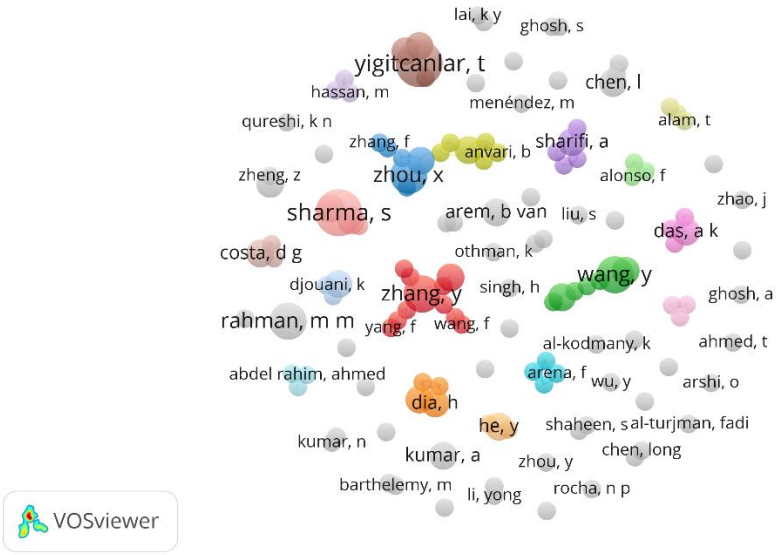

Figure 8. Author network of keyword
Source: VOSviewer

From the Figure 8 above, in the author network with a minimum of 2 articles per author, there are 138 authors. There are 65 clusters, with 36 clusters of authors having only 2 articles with related keywords, but the co-authors and authors do not meet the requirement of 2 articles, and the other 29 clusters have more than 2 documents. Out of the 138 authors, there are 4 authors with the highest link strength, which is 7 link strength..

4. Conclusion

Interrelations between transportation development and congestion is very important for research development in the globalization process. In this study, by analyzing the relationship between transportation development using VOSviewer as a network mapping of 999 articles from 2000 to 2025, six clusters were obtained from the keywords “artificial intelligence,” “transportation,” “congestion,” “public transportation,” and “middle city.” There are 138 authors who have at least two articles in their research related to these keywords. There are more than 20 publishers, with MDPI being the most prolific, accounting for 17% of the 999 articles. The keywords representing the relationship between transportation development and congestion are “transportation” and “traffic congestion,” which are interconnected. Related keywords include smart city, machine learning, intelligent transportation system, and artificial intelligence. The years 2023 and 2024 dominate in publications related to these keywords. One keyword that can still be developed for future research in this study is urban planning. Bibliometric analysis using VOSviewer has implications for researchers in adopting strategies for appropriate publication and collaboration among researchers based on related keywords. It can also develop related research to provide broader insights into the relationship between transportation development and traffic congestion with artificial intelligence and smart transportation systems. This research can also provide scientific literature in the field of transportation planning and spatial planning so that as transportation develops and grows, sustainable spatial planning can be implemented.

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