

## Lane Widening for Maintenance Sustainable Road Performance in Archipelago: A Bibliometric Analysis

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**Abstract:** This bibliometric study analyzes global research on the impact of lane widening for maintaining road performance in archipelagic regions sustainably, covering the period from 2000 to 2023. The research was collected using the Publish or Perish application and processed in the Research Information Systems (RIS) format through the VOSviewer application. The data set comprises 1,000 studies, including 551 research journals, 287 books, 114 conference components, 38 articles, 3 datasets, 3 monographs, and 4 reports. The study identifies "safety road" and "traffic data" as the most prevalent keywords, with various other related keyword networks also emerging. The analysis reveals a growing trend in research on lane widening and road performance across different global regions, indicating increasing interest in sustainable road management strategies, particularly in archipelagic and island contexts. The study highlights how the field has evolved over the last two decades by mapping the connections between key terms and studies. The findings suggest that lane widening to maintain road safety and performance is a significant area of focus in road infrastructure research. Furthermore, the study emphasizes the potential for these findings to contribute to developing future sustainable transportation solutions. The study provides a comprehensive literature source and highlights opportunities for further studies in sustainable road infrastructure development, especially within the unique challenges of archipelagic environments.

**Keywords:** Traffic data; Safety road; Road performance; Prediction; Road widening; Archipelago.



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### 1. Introduction

Global developments emphasize several aspects, one of which is transportation. Transportation is the most important function affecting the movement and flow of structures in an urban area (Mattioli, Roberts, Steinberger, & Brown, 2020). Transportation needs are increasingly diverse with time (Kalgatgi, 2018). Transportation needs are closely related to the existence of highways as a means of supporting mobilization. Mobilization is the movement from one place to another with a purpose (Domaradzka, 2018). Highways are the most important media, of course, tailored to the needs of the road user community in a country. Many developed and developing countries worldwide support road construction as a necessity for smooth transportation systems, such as the Netherlands Japan, and Malaysia (Shahu, Sivakumar Babu, & Usmani, 2020). This proves that many countries are serious about designing good transportation systems in the future (Shladover, 2018).

Indonesia, as a developing country that focuses on all fields, of course, also focuses on the development of transportation facilities (Mali, et al., 2022). Transportation is very supportive of the development and progress of the country's economy (Cullen, et al., 2021). Road construction in Indonesia generally connects regions to the needs of various sectors. The development also certainly considers the needs of road users in the present and the future (PE, PE, PE, & Shapira, 2018). Based on the plan of the Directorate General of Highways of the Ministry of Public Works and Public Housing of the Republic of Indonesia in 2023, the construction of national roads is planned to be 422.35 km long, and the realization of national road construction in 2022 reaches 468 km (PUPR, 2023). This data shows that the development of transportation facilities in Indonesia is carried out gradually and sustainably to support smooth mobilization from year to year in all regions in Indonesia.

Industrial needs are important in the region's development (McCann & Ortega-Argilés, 2018). As an archipelago with an industry that continues to develop, the development of transportation facilities continues to move to optimize the needs of many things. In addition to industrial needs, other elements in developing transportation facilities will also support various aspects such as tourism, economy, industry, and community welfare (Buhalis, et al., 2019). The construction of transportation facilities in question is the construction of roads that greatly determine the smooth running of the mobilization system. Road construction aims to provide comfort and smooth a good mobilization system (Khanna, Goyal, Verma, & Joshi, 2019).

In considering several aspects of the archipelagic region, such as tourism, economy, industry, and population growth, road conditions must be adjusted so that the mobilization system runs smoothly (Fisu, Hafid, Humang, & Natsir, 2022). For this reason, the focus in constructing this road is on widening the road lanes to accommodate future vehicle volumes due to the limited island area, which does not allow for additional road length. The widening of road lanes is carried out to optimize road performance predictions in the next few years (Yu, Zhang, Hu, & Wang, 2020). In this case, predictions are needed so that road performance in the archipelago can adjust as the years go by. In addition, this prediction also relates to road users from year to year (Lana, Del Ser, Velez, & Vlahogianni, 2018).

The development of transportation is closely related to the provision of road infrastructure. Developments in the world of transportation can increase capacity, length, and volume. This research aims to discover the latest developments in the world, especially those related to increasing road capacity in the archipelago. The review was carried out using a systematic literature review using bibliometric analysis. The analysis emphasizes the results of special concentration on the number of publications, citations, authors, and percentage of publications. Related to this research article, the analysis of the impact of lane widening on sustainable road performance will be discussed. The main source of information in research uses Publish or Perish and VOSviewer analysis to gather a wide variety of research from all corners of the world. Bibliometric mapping with Publish or Perish using reference sources from Crossref from 2000 to 2023.

## **2. Literature Review**

### **2.1. Traffic Data**

Talking about transportation is inseparable from traffic. Previous research on traffic will be the source of literature for this study. Traffic is the flow of vehicle movements that relate from one place to another (Gong & Du, 2018). Traffic largely determines the process of vehicle mobilization on the highway. Traffic is a factor in the smooth running of vehicles that will move places (Zhu & Zhang, 2018). In addition, traffic is also the most important factor in optimal movement on the highway (Chen, et al., 2018). Therefore, traffic has a major influence on the transportation mechanism system, especially land transportation. Related to previous research, of course, the transportation mechanism system cannot be separated from the existence of vehicle data (Zhu, Yu, Wang, Ning, & Tang, 2018). The data is obtained from vehicles passing on a highway with a certain period and speed. By being managed by the authorities, these data can be used for various purposes by various parties related to transportation science data systems and sources. In addition, traffic data is also used as a benchmark in planning a highway in a place by considering the number of vehicles passing by, the width of the highway to accommodate vehicles, and the level of density between vehicles (Mannering & Washburn, 2020).

Over time, vehicle data passing on a highway will certainly change (Dia, Zheng, Lu, & Guan, 2018). The change in question is either a decrease or an increase. Factors, including population growth, increased vehicle users, community attractiveness, and other human needs, certainly influence this change (Lyons, 2018). This data is the most important part used to analyze and predict possibilities that occur in the future.

Data used in traffic must also come from trusted sources, namely the government or authorities. Related to this research topic, road performance analysis is closely related to traffic data. This traffic data must be processed for various possibilities in the next few years (Lana, Del Ser, Velez, & Vlahogianni, 2018). The performance of a road under study will be concluded from various possible data analysis results. Therefore, research on road performance must have actual traffic data so that the resulting conclusions can be a benchmark in the future of road construction planning.

## 2.2. Road Safety

In the transportation world, vehicle automation requires the main medium of movement, namely road terrain. As the main element that is very related, road terrain has the most important role in determining the success or failure of a mobilization process (Dinh, 2019). The road is the infrastructure used in land transportation, which includes various parts, including road parts, auxiliary buildings, and equipment that functions as a traffic system (Rodrigue, 2020). According to previous researchers, JP Rodrigue (2020) also said that the relationship between infrastructure and transportation facilities became a single highway component. However, the mobilization process is also closely related to security and comfort conditions as an indicator of the safety of motorists on the highway. Motorists need good, comfortable, and safe road conditions to reach their destination safely (Limkar, Rajmane, Bhosale, & Rane, 2018). Previous research stated that safe road conditions in maintaining road safety must include various things, including soil conditions, types of road pavements, vertical and horizontal infrastructure, good drainage systems, and supporting factors, namely regular traffic systems. This is a consideration in road construction to consider the safety aspects of motorists on the road so as not to cause casualties due to the condition of the road itself (Thompson, Peroni, & Visser, 2019).

Heavy highways are also affected by obstacles or incidents caused by motorists. However, other things can also cause road performance problems regarding road surface conditions. This is closely related to the quality of the highway as the main medium in providing safety for motorists. Of course, road conditions that are safe from damage and obstacles will help drivers to move easily and safely (Bibi, et al., 2021). Therefore, research on road performance analysis in the archipelago will also pay attention to road safety aspects in the next few years. This aspect is also related to widening road lanes that seek to overcome vehicle density. The condition of widening the road lane will be reviewed to determine whether it affects road safety for motorists and the performance of the road itself. Data, drawings, and road planning will be reviewed, and conclusions will be drawn based on road safety (Zou, Yue, & Le Vu, 2018). Various sources of previous research have become literature on road safety that will be associated with this research.

## 2.3. Traffic Performance

In general, a flow that becomes an intermediate medium for a change in the direction of the object's speed by being influenced by the traffic system is also called traffic performance. The objects passing on this current are measured in certain units of time according to the rate of velocity and displacement (Novikov, Novikov, & Shevtsova, 2019). In civil engineering, especially in transportation, traffic performance is closely related to a displacement flow (Guo, Feng, Song, & Wan, 2019). In this context, traffic performance has the ability of the road to serve the number of vehicles moving or moving across (Arain, 2018). The level of highway service can be calculated by volume, capacity, and vehicle speed (Lu, Tettamanti, Hörcher, & Varga, 2020). Related previous research sources will become the literature for this analytical research. In the traffic performance mechanism, many factors affect the quality of road services themselves. These factors include the number of vehicles accommodated on the volume of roads, the capacity of vehicles that can be accommodated, and the speed level of passing vehicles. This is what will determine the good or bad performance of traffic (Simoni & Claudel, 2018). According to research by MD Simoni and CG Claudel (2018), who discuss traffic network simulations also consider internal road factors as above.

Previous research mentioned that assessing and reviewing traffic performance can be from various aspects above (Kessels, Kessels, & Rauscher., 2019). This, of course, must also pay attention to the condition of the width of the road in accommodating the volume of vehicles on the road. Ideally, wide road conditions will provide good space for motorists so that vehicle speeds are much faster. This condition is also similar to the case with highways that aim to shorten the distance and travel time of vehicles with sufficient road width conditions. So influential are traffic performance parameters in this study. This will, of course, significantly influence the analysis of road performance that will occur in the next few years in the archipelago. This aspect is one of the data used for data processing in the highway area studied (Tseng,

et al., 2018). The quality of traffic performance will be considered material for making conclusions based on comparisons in the year that has passed to the year to come.

#### **2.4. Development of Traffic Prediction Research**

In designing a system or work that aims to solve a problem in the future, a prediction is needed. A prediction is also called a statement of an event that will come in the future (Pan & Zhang, 2021). The prediction process includes assessing, reviewing, and measuring something that might happen in the future (Mishra, Lourenço, & Ramana, 2022). A probability generated in a prediction can be true or false. The accuracy of a prediction will be determined by events that will occur in the future. A prediction is very important in reviewing a condition that occurs in the field. Of course, a strong prediction must be linked to current data (Lana I. D., 2018). Based on research conducted by several sources, these data will later be processed and analyzed to become a hypothesis that produces various possibilities (Fellows & Liu, 2021). Predictions can be wrong if the analysis results do not match real events that occur in the future or change due to something that greatly affects future possibilities.

In civil engineering, everything related to prediction must be taken into account. The calculations carried out must also have actual data so that the planning process to development can run smoothly (Pan & Zhang, 2021). With predictions based on theory, of course, development will be successful and safe so that it can provide benefits to many people. In addition, the correct prediction is also related to the budget values used so that they do not experience losses and waste of costs. In connection with the research topic regarding road performance analysis in the next few years in the archipelago, predictions are essential to review and produce conclusions. In this prediction, you must have traffic data to process and research. Traffic data is used as a rationale for making conclusions about the condition of a road that can accommodate vehicles in the next few years (Li, Jiang, He, Chen, & Zhou, 2020). This will be considered in the planning process of widening road lanes in an area.

#### **2.5. Road Capacity Building in the Archipelago**

Related to the analysis of road performance, of course, it cannot be separated from the available road components. One of the main components in question is the volume of highways. The volume of highways is related to the number of vehicles that can be accommodated on the available lanes (Kumar, 2020). If the number of vehicles passing does not match the volume of the highway, it will cause obstacles to traffic flow. Besides being able to hinder travel, inappropriate highway volumes will also endanger motorists because they will be close to each other. The capacity of highways to accommodate the number of vehicles passing is the main reason road construction must consider this. Moreover, the limited conditions in the archipelago and the development and increase in road users are the most essential things that must be considered. This is because there will be a change in the number of riders within a certain period. It will be fine if the road capacity can accommodate the number of vehicles. The problems will be additional work that will cost a lot in the future (Arias, Hashemi, Andersen, Træholt, & Romero, 2019).

The vehicle's capacity must be adjusted to the capacity or volume of the highway (Shladover, 2018). However, if this cannot be fulfilled due to the increasing number of riders, a solution to the problem is needed. One solution that can be applied to this problem is to increase road capacity. Increasing road capacity is carried out by widening the road lanes so that the capacity of vehicles on the road can be met because it is impossible to increase the length of the road due to the limited archipelago. Besides being able to provide smooth traffic performance, a wide road will also provide safety for motorists (Singh & Kathuria, 2021). Regarding the research topic of road performance analysis in regard to the next few years, increasing road capacity will be one of the parameters used. This is certainly inseparable from previous studies related to road performance. This study will provide results and conclusions from the impact analysis of increasing road capacity that has been attempted to overcome vehicle congestion and obstacles. This will explain whether efforts to increase road capacity can be effective in the next few years.

### **3. Materials and Methods**

In this study, the methodology used is mapping various kinds of journal literature sources worldwide. The journals mapped are, of course, based on the research topic being researched on civil engineering science (Diao & Shih, 2019). In this case, research is being conducted on the impact of lane widening on-road performance in the next few years. One of the methodological techniques used in mapping this topic uses bibliometric analysis techniques that focus on the study of literature and information. These will then

be visualized in graphs and data mapping according to the rules of scientific writing (Garcia, 2020). Bibliometric analysis aims to provide a picture of the suitability of existing, popular, as well as emerging research (Dhamija & Bag, 2020).

The research characteristics mapped and cited are studied from various aspects, including authors, sources, topic suitability, citations, and countries. This data will be processed quantitatively to map and visualize data from various facets (Alfaro-Almagro, et al., 2018). Quantitative methods are very related to the analysis in this study because they discuss the amount of data collection (Nardi, 2018). In addition, keywords are used to support this research method so that the resulting mapping is by the topic studied. Keywords used include traffic, highways, road widening, road lanes, road performance, congestion, and predictions.

All research related to this topic was screened on October 2, 2023, with Crossref sources using the Publish or Perish application with provisions ranging from 2000 to 2023. This application is used by entering various keywords related to the topic. In addition, this application can also select unrelated research keywords. The data produced include the study's title, the researcher's name, the year of research, and the study's source. This data is then stored and used in the second application, VOSViewer. VOSviewer was chosen because this application is one of the mapping and visualization media applications recommended by various kinds of research (McAllister, Lennertz, & Atencio Mojica, 2022). By using the data from the network using Publish or Perish, visualization can be generated in the VOSViewer application using the Research Information Systems (RIS) format. The resulting mapping results are in the form of visualization of the relationship between research topics, the year the research was carried out, to the density between studies.

## **4. Results and Discussion**

The results and discussions discussed in this study are based on data generated by the Publish or Perish application and VOSviewer. Networking is done with the help of various keywords that are entered, including traffic, highways, road widening, road lanes, road performance, congestion, and predictions. After that, it will be generated through events and relevance accompanied by numbers and percentage values. Furthermore, the data must undergo a selection process to get screening results closely related to the research topic. By going through all the processes carried out in both applications, research data is produced which is very important to be used as data processing material. The resulting data is in the form of author name, number of citations, research title, year of research, publisher, type, and other supporting data. This data is imported into the third application, Microsoft Excel, to facilitate data processing. The data processing results are then converted into images, tables, and graphs to facilitate conclusions from the data processing results.

### **4.1. Linkage of Research Keywords**

Based on the analysis results using the VOSviewer application, a visualization of the network of linkages between keywords was found in Figure 1. This network is generated from the database after passing the Publish or Perish application selection process. The selection process in question is the selection of keywords based on events and the level of relevance attached at the time of the process. So, this also determines the size or number of networks from the visualization results displayed.



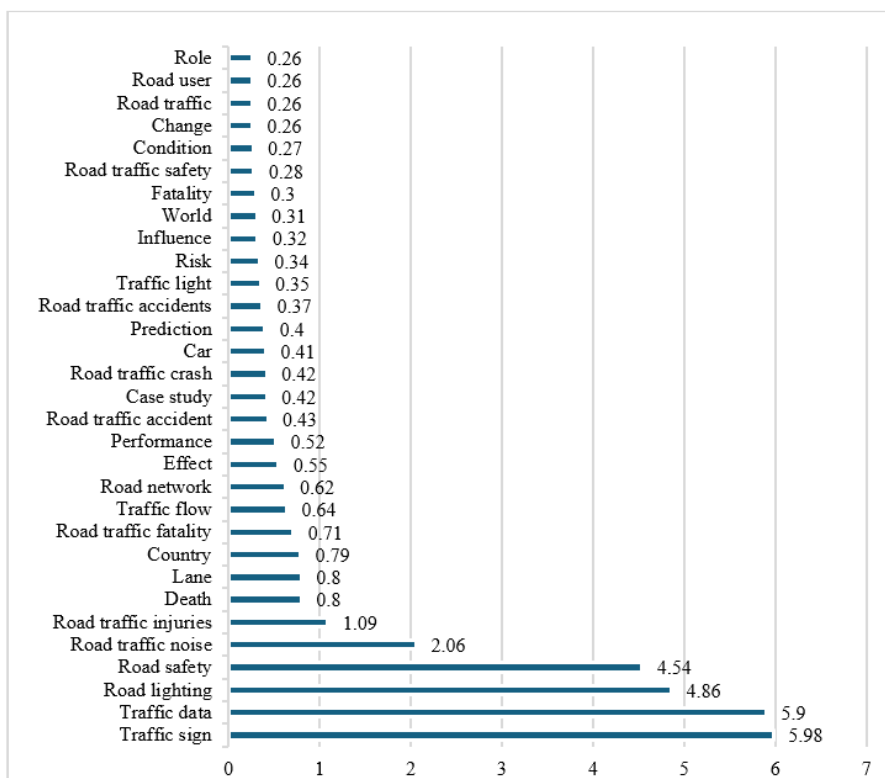


Figure 3. Keyword graph by relevance.

The visualization results in Figures 2 and 3 show keyword data that was successfully selected based on event value and relevance. Both graphic images show that road safety and traffic data are the most keywords based on events and the level of relevance. This is the background to the main keywords in research analyzing the impact of road widening in the archipelago. Also attached to the two images are other keywords with varying event values and relevance to illustrate that these keywords are still connected with this study, but the intensity is manageable.

#### 4.2. Cumulative Publications Annually

One of the analysis results using the VOSviewer application is the year of the research. This database then becomes data processed to see the number of research publications worldwide yearly. Data from the results of the selection of research journals from around the world is calculated cumulatively to make it easier to display easy-to-understand visualization results. The data processing results for this study's year are displayed as graphs in Figure 4.

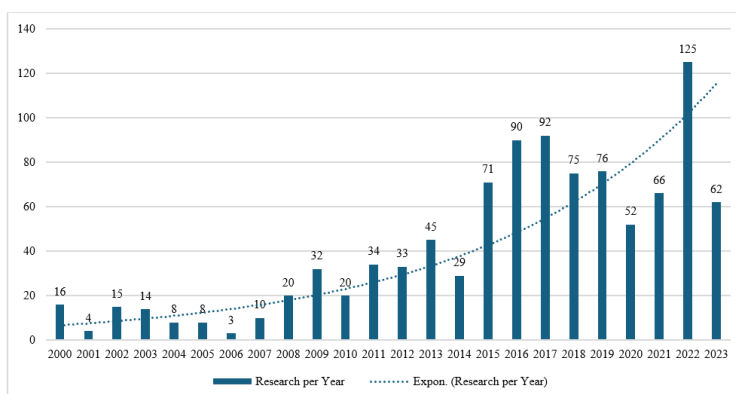


Figure 4. Cumulative data of research from different years.

The data in Figure 4 above represents 1000 studies from 2000 to 2023. The distribution of the study shows a decline and increase in the last 23 years. The fact shows a decrease that was not too significant in the early years, including 2001 to 2007, and began to increase in the following 8 years. A significant increase in research occurred in the last 9 years from 2015 to 2023, with the highest year occurring in 2022, with 125 studies. With the rise and fall of the research trend that is not too significant, the graph continues to rise because the cumulative average tends to be stable and continues to increase. The cumulative increase in publications on-road performance is gaining popularity yearly if you look at the data visualized above in Figure 4.

### 4.3. Research Keyword Density

Among the analysis results produced using the VOSviewer application is the density between research keywords. In this research, which focuses on analyzing the impact of lane widening in maintaining road performance in the next few years in the archipelagic region, the keywords include traffic, highway, road widening, lane road, road performance, congestion, and prediction. With this keyword, it collects related previous studies so that the author can use it as a source of literature. The results of the visualization of research screening from the VOSviewer application display the density between studies based on these keywords, as shown in Figure 5.

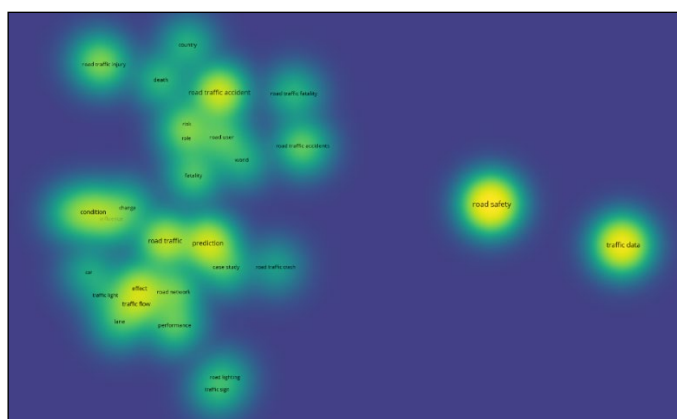


Figure 5. Density of research publications based on keywords.

On the basis of the results of visualization using the VOSviewer application, the density of research can be seen in the density of color. The yellow color visualizes research that is closely related to the keyword. It can be seen that the densest color is found in the keyword road safety, followed by traffic data, traffic flow, and prediction. These four dominant keywords total 287 studies, representing 28.7% of the most related research out of 1000 studies. Other keywords also look related but less dense than the dominant keyword. Detailed data on dominant keywords in the density figure above can be seen in Table 1.

Table 1. Research keyword density data.

Keywords	Number of Research
Road safety	150
Data traffic	86
Prediction	33
Traffic flow	18
Total	287

### 4.4. Types of Research by Publisher

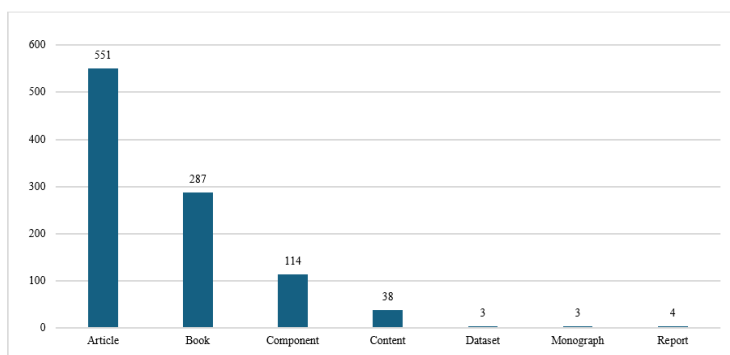
After the screening process, the studies collected came from various publishers. This shows that the diversity of publishers can support the development of science. This publisher's data certainly connects with civil engineering studies worldwide. The distribution data of the 10 most dominant publishers from networking using the Publish or Perish application can be seen in Table 2.



**Table 2.** Research publisher distribution data.

<b>Keywords</b>	<b>Number of Research</b>
Organisation for Economic Co-Operation and Development (OECD)	128
Institute of Electrical and Electronics Engineers (IEEE)	99
Elsevier	94
CRC Press	87
Informa UK Limited	35
American Society of Civil Engineers (ASCE)	29
Bloomsbury Professional	26
Springer Berlin Heidelberg	24
Routledge	22
Springer International Publishing	19

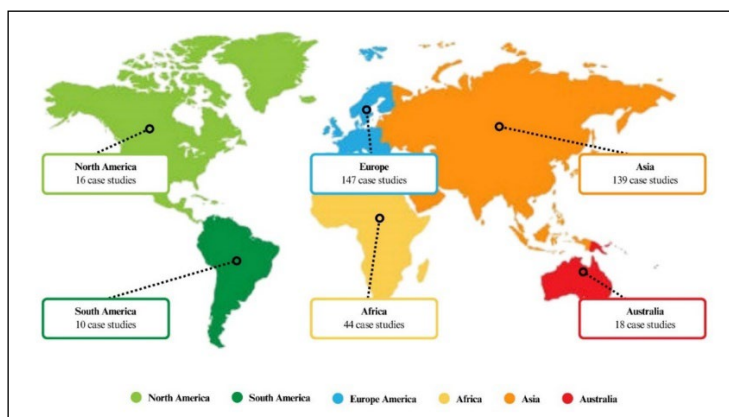
In addition to the diversity of research publishers, various types of research have been successfully netted. Various types of research include articles, books, journals, components, datasets, content, monographs, and reports. This type of publication is also related to the source of the publisher of each study. Therefore, research analyzing the impact of lane widening in maintaining road performance in the next few years in this archipelagic region takes information, references, and literature sources from various types of research based on the results of this network. Data on the many types of research can be seen in Figure 6.



**Figure 6.** Classification of research types.

#### 4.5. Case Studies by Region of Research Origin

With the diversity of research resulting from networking, there is diversity in country of origin. The diversity of the country in question is where the research takes place so that it can see the research development—based on one of the data from the analysis using the VOSviewer application, namely the country of origin of the research, which is then processed and grouped based on the country's continental origin. The picture of the case study based on the continent of origin of the study is attached in Figure 7.



**Figure 5.** Distribution of research case studies by continent.

The data in Figure 7 shows the spread of country case studies grouped by continent that discuss related research. It can be seen that the development of research related to research analyzing the impact of lane widening in maintaining road performance in the next few years in this archipelagic region is mainly found on the European continent (147 case studies) and followed by the Asian continent (139 case studies), the African continent (44 case studies), the Australian continent (18 case studies), the North American continent (16 case studies), and the South American continent (10 case studies). Based on these data, it is known that the order of countries with the number of studies includes China (49 studies); India and the United Kingdom (28 studies); Australia and Poland (13 studies); United States (12 studies); Ethiopia (11 studies); Indonesia (10 studies); Japan, South Africa, and South Korea (9 studies); as well as many other countries from different continents. This does not rule out the possibility that this research will continue to develop in these countries or even other countries.

## 5. Conclusions

This study uses bibliometric analysis to identify research topic networks, suitability of literature sources, and research updates on analyzing the impact of lane widening in maintaining sustainable road performance in the archipelago. Using the Publish or Perish application, 1000 articles were generated between 2000 and 2023, consisting of 551 research journals, 287 books, 114 components, 38 contents, 3 datasets, 3 monographs, and 4 reports. It is concluded from the analysis results that there are two dominant keywords, namely road safety and traffic data and other keywords related to the research topic. Based on data from the research year on traffic performance, it is concluded that there continues to be a development in the number of studies from 2000 to 2023, with the highest total in 2022. The number of research disseminated on-road performance topics consists of various continents in the world, including Europe (147 case studies) followed by Asia (139 case studies), Africa (44 case studies), Australia (18 case studies), North America (16 case studies), and South America (10 case studies). It can be concluded that research trends on road performance continue to grow from year to year and spread throughout the world, which will continue to grow sustainably.

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