

# Bibliometric Mapping and Research Development Strategies on Ensemble Spatial Regression Models

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**Abstract:** In previous research, bibliometric analysis has been widely applied to various research topics, but there has been no research specifically discussing the development of ensemble spatial regression model research. This study aims to analyze the development of research in order to formulate strategies for future research on the topic of ensemble spatial regression models. The method used is a bibliometric approach to research publications on ensemble spatial regression models. The dataset consisted of 1,311 documents retrieved from the Scopus database for the 2007–2026 period and was analyzed using a bibliometric approach through the bibliometrix package in R, while bibliometric network mapping was visualized using VOSviewer. The results of the study indicate that the number of publications has increased significantly year over year. The United States of America and China are the countries with the highest number of citations in this study. Bibliometric network mapping shows that research on ensemble spatial regression models is frequently conducted using machine learning, spatial analysis, and regression analysis approaches. Based on the research results, the topic of ensemble spatial regression models holds potential for further development, particularly in approaches that integrate spatial analysis with ensemble methods which have not yet been widely utilized within a single study. This provides insights for formulating strategies to advance future research on ensemble spatial regression models, with a focus on topics that have not yet been extensively addressed.

**Keywords:** Bibliometric Analysis, Ensemble Spatial Regression Models, VOSviewer, Research Development Strategies

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## 1. INTRODUCTION

Advances in information technology have driven the growth of scientific publications across various disciplines. The availability of large and complex datasets, including spatially patterned data, demands the development of analytical methods capable of capturing spatial patterns more accurately. Therefore, spatial regression models have been developed to address spatial dependencies in the data. As the complexity of spatial data increases, the use of a single spatial model still has limitations, namely parameter instability, low accuracy, and the potential for heteroscedasticity in the model [1]. To overcome these limitations, ensemble techniques have been employed by performing resampling that adds noise to the model. The use of this method produces an ensemble spatial regression model by simultaneously combining the strengths of several spatial models to achieve better model accuracy [2].

The rapid growth of scientific publications has created new challenges in evaluating and mapping scientific development [3]. The approach used to evaluate and map the development of science is bibliometric analysis [4]. According to Passas [5], bibliometric analysis is a systematic study of scientific literature to identify patterns, trends, and impacts within a research field. Bibliometric visualization can be used to observe collaborative relationships and interactions among researchers within a research field [6]. In this research, bibliometric network analysis was performed using the VOSviewer software. According to Ullah *et al.* [7], VOSviewer is used to analyze and visualize author collaboration networks (co-authorship), keyword relationships (co-occurrence), and author citation patterns (co-citation) from the scientific publications under study.

Through 2026, there were 1,311 publications related to ensemble approaches in spatial analysis and modeling. Meanwhile, the number of publications related to spatial regression in the Scopus metadata reached

80,096 through 2026. This significant difference in the number of publications indicates that research on ensemble spatial regression models has not yet been extensively studied.

In previous research, bibliometric analysis has been widely used to analyze scientific literature and identify trends and patterns across various research fields [8]. In 2021, Danese and Gioia [9] conducted a bibliometric analysis on the topic of spatial analysis for landscape changes, concluding that research in spatial analysis has experienced rapid development, marked by an increase in the number of publications and the dominance of quantitative methods and spatial statistical approaches to examine landscape changes. In 2023, Ming et al. [10] analyzed the development of research on digital leadership using R Studio through the “Bibliometrix” and “Biblioshiny” packages by analyzing the growth rate of publications, citation analysis, and research productivity. Al Barra et al. [11] used VOSviewer in a bibliometric analysis to map trends and developments in spline regression research strategies from 2015 to 2024. In the same year, Lubis and Mulyadi [12] conducted a bibliometric analysis on the topic of digital transformation in the business field using VOSviewer, concluding that research on digital transformation saw a significant increase in publications and was dominated by the themes of digital transformation, business models, and innovation. In 2025, Akbar *et al.*[3] using VOSviewer and Open Knowledge Maps software in bibliometric analysis of kernel regression models, which concluded that bibliometric analysis can be utilized as a basis for trend Based on previous research, bibliometric analysis has been widely applied to various research topics, but to date no study has been found that specifically discusses research developments in ensemble spatial regression models. Therefore, this study conducts a bibliometric analysis of publications on ensemble spatial regression models to map research development and formulate future research strategies.

## **2. METHOD**

This study employs a quantitative approach with a descriptive-analytical study design using a bibliometric approach. Data were collected from the Scopus database by searching the article title, abstract, and keywords fields using the keyword “spatial ensemble regression model”, utilizing secondary bibliographic metadata from journal articles and conference proceedings published between 2007 and 2026. The data were retrieved on March 7, 2026. Bibliometric methods were used to collect scientific publication data. Trend mapping and research development strategy analysis were performed using VOSviewer software. A total of 1,311 documents were obtained within the timeframe from 2007 to 2026. The steps of the research carried out, namely

1. determine search keywords in the Scopus database,
2. conducting a keyword search in Scopus to obtain research metadata,
3. downloading research publication metadata obtained from the Scopus database,
4. conducting descriptive analysis using R software to obtain general information about the data, such as main information about data, top author production over time, and most cited countries, by visualizing and interpreting each of these indicators,
5. analyze publication trends using the indicators of annual scientific production and average citations per year, visualized in graph form,
6. mapping and visualizing bibliometric networks using VOSviewer software based on co-word, co-authorship, and co-occurrence analysis.,
7. interpret the results of the bibliometric mapping, and
8. conclude the analysis results.

In this study, a bibliometric approach was used to analyze the relationships among authors, the number of citations across countries, and the relationships among research categories. Strategies for research development were formulated based on the study’s findings regarding the field of study under investigation.

## **3. RESULTS AND DISCUSSION**

This section presents the results and discussion provide a detailed examination of the development of research on ensemble spatial regression models. The research results are presented in the form of figures and graphs to facilitate the identification of patterns, trends, and characteristics in the analyzed publications. The discussion is conducted step-by-step and organized into several subsections, namely descriptive data analysis

using R software, trends in ensemble spatial regression model publications in Scopus metadata, and bibliometric network analysis with VOSviewer.

### 3.1. Descriptive Analysis of Data Using R Software

A descriptive analysis was conducted to provide an overview of the characteristics of the published data on the topic under study [13]. The Scopus database was analyzed using R software with the “biblioshiny()” package, which generated output on general information, average citations, top author productivity over time, and the most cited countries.

DOCUMENT TYPES			AUTHORS COLLABORATION	
article	1123		Single-authored docs	34
book chapter	9		Documents per Author	0.18
conference paper	121		Co-Authors per Doc	7.06
conference review	27		International co-authorships %	33.26
data paper	7			
erratum	1			
review	22			
DOCUMENT CONTENTS			AUTHORS	
Keywords Plus (ID)	9032	9032	Authors	7270
Author's Keywords (DE)	3936	3936	Author Appearances	9250
			Authors of single-authored docs	33

Figure 1. Main information about data

Figure 1 shows the output of a bibliometric description generated by the “summary()” function in the “bibliometrix” package in R. As shown in Figure 1, the majority of research publications on ensemble spatial regression models are articles (1,123 publications), while other types account for a relatively small number. In terms of content, the number of Scopus-added keywords (9,032 keywords) is greater than the number of author-provided keywords (3,936 keywords), indicating that the Scopus system adds broader terms, resulting in a more diverse set of keywords compared to those provided by the authors. Additionally, there are 7,270 authors contributing to these 1,311 documents, with a total of 9,250 author name occurrences across all documents. This indicates a high level of collaboration among authors, with an average of 7.06 authors per document, and there are 34 documents written by a single author. The international collaboration rate is 33.26%, indicating that research on this topic involves cross-national cooperation.

In bibliometric analysis, the number of publications is used as an indicator of productivity to identify the most productive authors in a given field [14]. Therefore, an analysis of top author production over time is used to calculate and display an author’s publication productivity over time based on the number of publications and total citations each year [15]. The visualization of top author production over time in the ensemble spatial regression study for the years 2007–2026 is shown in Figure 2.

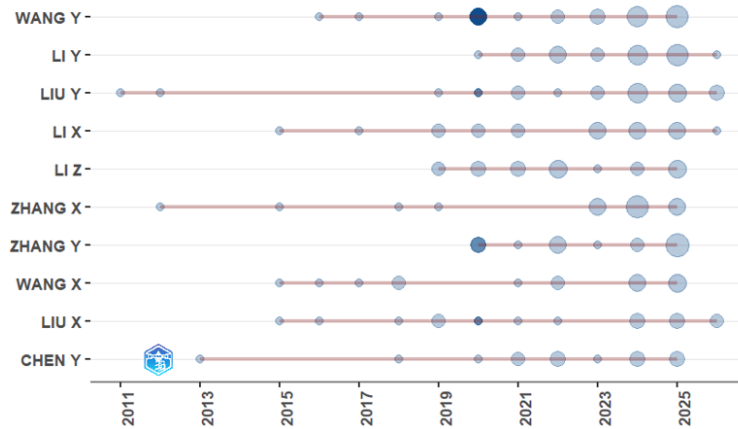


Figure 2. Top author production over the time

Figure 2 illustrates the authors’ publication output over the years. In this figure, the larger the circle, the more articles the author published in that year; the darker the color, the higher the number of citations the article received in that year. Based on Figure 2, Wang Y and Li Y are the authors who have published the most articles in the last five years compared to other authors. Additionally, Liu Y and Zhang X have contributed to this research since the beginning of the study period, namely 2007. In 2020, Wang Y had the highest number of publications among the years 2007–2026.

A country’s scientific publication impact is closely linked to its involvement in international collaboration, which significantly enhances its global citation impact. Countries with high levels of collaboration and citations tend to play a central role in the global research system [16]. The most influential countries in ensemble spatial regression research are presented in Figure 3.

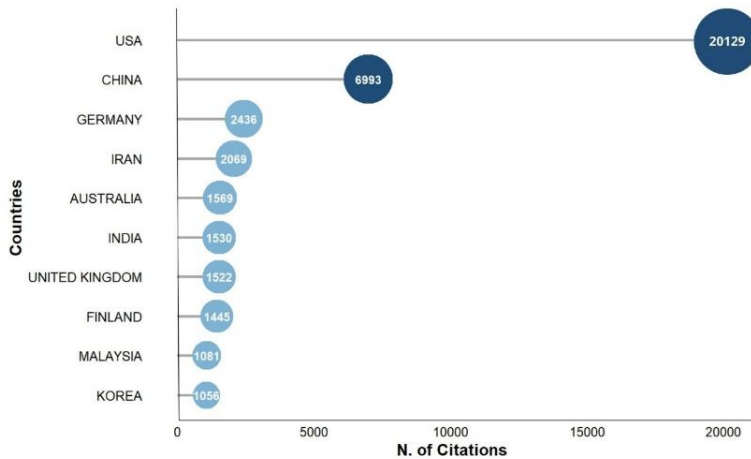


Figure 3. Most Cited Countries

Figure 3 shows the ten countries with the highest number of citations regarding ensemble spatial regression. As shown in Figure 3, the United States of America (USA) has the highest number of citations, with a total of 20.129 citations, while China ranks second with 6.993 citations. Several countries below them have lower citation counts, ranging from 1.000 to 2.500 citations. This disparity indicates a significant difference in citation counts between the top two countries and the others.

### 3.2. Trends in the Publication of Ensemble Spatial Regression Models in Scopus Metadata

Research on regression model development has been widely published in the Scopus metadata. According to Ruiz-Pomeda *et al.* [17], Scopus is the largest abstract and citation database covering peer-reviewed literature in the natural sciences, engineering, medicine, and the social sciences. Scopus contains over 80 million

documents from more than 25,000 peer-reviewed journals, including articles, conference proceedings, books, and patents [3]. Scopus metadata can be used for mapping and developing research strategies.

Annual publication trends can be observed through metrics such as annual scientific production, which tracks the growth in the number of publications released each year within a specific research field [18]. Additionally, the average citations per year is used to measure the annual impact of research by dividing the total number of citations by the number of active publication years. Using R software, the results for annual scientific production are shown in Figure 4.

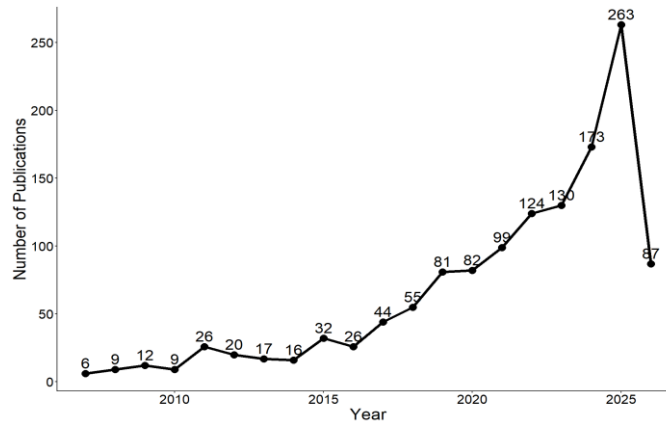


Figure 4. Annual scientific production

Figure 4 shows that the number of publications on ensemble spatial regression models has been on an upward trend year by year. In 2007, there were six publications, and this number continued to increase significantly until 2025, reaching 263 publications. In 2026, publication data is still provisional because the research was conducted in March 2026, so the number of publications in that year is expected to continue to increase until the end of the year.

In addition to analyzing annual scientific output, the development of a research topic can be assessed through the success rate of a scientific article. One method used to visualize this is the analysis of average citations per year. The analysis of average citations per year is a metric used to measure the impact of a scientific work by calculating the average number of times the article is cited each year since its publication [19]. This is done because the average citations per year analysis is a better predictor for measuring the success of a scientific article over time than looking at the total citations alone [20]. Using R software, the average citations per year results shown in Figure 5 were obtained.

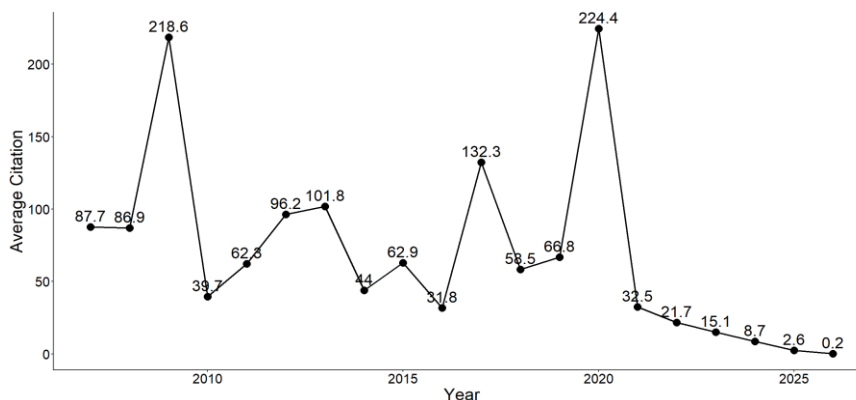


Figure 5. Average citation per year

Based on Figure 5, the graph of average citations per year shows that the average number of citations for publications on ensemble spatial regression models fluctuates significantly. From 2007 to 2020, the average

number of citations per year fluctuated drastically, with the highest number reaching over 200 citations per year. This indicates that during that period, the topic had a significant impact and was frequently cited in research. However, the average citation value from 2021 to 2026 experienced a significant decline from 32.5 in 2021 to 0.2 in 2026.

### 3.3. Bibliometric Network Analysis with VOSviewer

In this study, bibliometric analysis was used to map research patterns and identify research trends based on the analyzed publication data [21]. This mapping was used to examine the relationships between research topics through keyword networks and clusters formed from bibliographic data [22].

An understanding of the scientific concepts in a publication can be achieved through co-word analysis. Co-word analysis can help identify conceptual structures and relationships between research themes based on keyword co-occurrence [23]. Co-word analysis plays a crucial role in identifying research trends by grouping keywords that frequently appear together, thereby revealing the focus and direction of research development [24]. One of the most widely used software tools for visualizing bibliometric networks is VOSviewer, which is used to create co-occurrence networks based on keywords, author patterns, and citation relationships, thereby helping to visually identify thematic clusters and research structures [25].

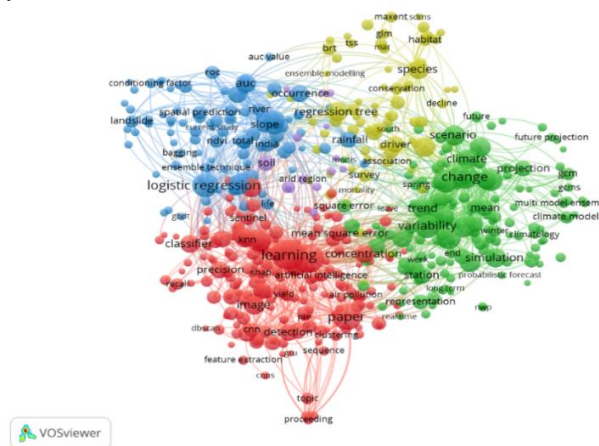
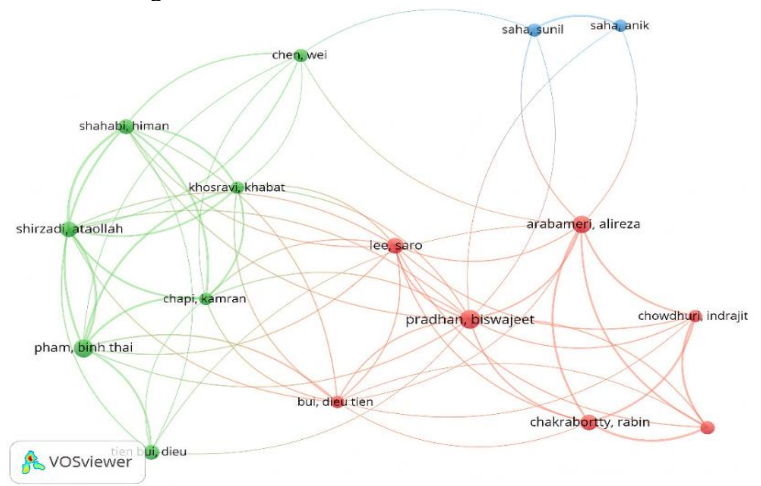


Figure 6. Visualization based on titles and abstracts

Figure 6 shows a bibliometric visualization of variables frequently appearing in spatial ensemble regression. Based on the mapping results, four clusters have formed, indicated by differences in circle color, with the largest circles representing variables most frequently used in the research. Based on Figure 6, the terms frequently used in each cluster are logistic regression, learning, change, and regression tree. Overall, the largest circle represents the term “learning” in the red cluster. Bibliometric analysis can also visualize collaboration among authors, as presented in Figure 7.







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