Sigma J Eng Nat Sci, Vol. 43, No. 2, pp. 513–522, April, 2025

Sigma Journal of Engineering and Natural Sciences
Web page info: https://sigma.yildiz.edu.tr
DOI: 10.14744/sigma.2025.00040

Research Article

The scientific outputs of earthquakes in Türkiye: A bibliometric analysis

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This paper was recommended for publication in revised form by Editor-in-Chief Ahmet Selim Dalkilic

Published by Yıldız Technical University Press, İstanbul, Turkey
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ARTICLE INFO

Article history
Received: 29 April 2024
Accepted: 12 June 2024

Keywords:
Bibliometric Analysis; Disasters; Earthquake; WOSviewer; Türkiye

ABSTRACT

Earthquakes, as a type of disaster, have become a prominent subject in scientific studies in Türkiye and around the world with their devastating effects. This study aims to sketch out a general panorama of the field, and to guide future research by analyzing the earthquake studies conducted in Türkiye in the last thirty years through bibliometric analysis. In addition, the study aims to foresee the way in which the scientific approaches on earthquakes would shape in the near future relying on the academic articles written on the earthquakes so far 10 months following the February 6 earthquakes.

The statistical data and bibliometric analysis of the literature show that in recent years, the topic of "earthquakes in Türkiye" has become a widespread field of study, not only limited to the field of engineering but also including other social science disciplines. Furthermore, the study reveals a situation in which scientific institutions in Asian countries have come to the fore in shaping the existing literatüre, and multidisciplinary approaches are more important.

Cite this article as: Yılmaz S, Acar U, Akbaba MF, Akbulut T, Akgün C, Akın O, Akpınar B, et al. The scientific outputs of earthquakes in Türkiye: A bibliometric analysis. Sigma J Eng Nat Sci 2025;43(2):513–522.

INTRODUCTION

In the historical process, the nature of disasters makes the defense mechanisms of all social systems ineffective, as it is unpredictable where and when they can occur [1]. Among the disasters with high impact power in social, political, and economic terms, earthquakes occur more frequently than other types of disasters and cause great losses. For these reasons, earthquakes take place in academic studies quantitatively more than other natural disasters. The fact that earthquakes cause loss of life and property at high rates, -especially in geographical regions defined as earthquake zones- makes it necessary to examine them not only as earth crust events but also as phenomenon that has fundamental social and economic consequences. The earthquake by nature erupts suddenly, cause serious casualties and economic losses. Thus, the social desperation causing by this disaster led to the intensification of studies focusing on what should be done before, during, and after this disaster take place.

The impacts of the earthquakes are not limited to the damages in the social lives of people but they have also negative impacts on the psychological and physiological conditions of individuals. In this respect, earthquake investigations have not been limited to engineering and applied sciences, but in recent years, they have become the subject of a wide range of sciences, including almost all social sciences as well as urban management, civil defense, and applied sciences. In this respect, scientific models and analyses have been developed in various disciplines about what can be done to cope with earthquaks when they happen.

Türkiye is one of the countries located in the earthquake zone and under the threat of this type of disaster. However, social sensitivity and scientific interest in earthquakes gained momentum after the 1999 disaster. A considerable number of publications on earthquakes in Türkiye have been produced both nationally and internationally within the framework of interdisciplinary studies. In this context, studies on where and how earthquakes can occur and to what extent they can have an impact are noteworthy. Until recently, engineering disciplines that focuses on the technical side of the story have dominated the literature and thereby the social and economic aspects are relatively neglected. Considering Türkiye's economic scale, population, and urbanization structure, it is necessary to conduct more studies in the field of social sciences to predict the possible effects of this disaster. Especially the earthquake that occurred in the center of Maraş on February 6, 2023, caused a great loss of life and property. However, the effects of the earthquake were not only limited to the regions where it erupted, but also caused a certain degree of concern all over Türkiye and even in countries located in the earthquake zone. These concerns have become a problem that needs to be analyzed by different disciplines in individual and social dimensions.

This situation has naturally shaped the scope and direction of earthquake research. In particular, recent studies have shown that the sociological, economic, ecological, and psychological dimensions of the issue are worth examining as much as engineering in terms of quality and quantity. This study provides a comprehensive overview of earthquake studies conducted worldwide in Türkiye over the past thirty years, aiming to guide future scientific research on the social dimensions of earthquakes in Türkiye, while considering the current trends in scientific literature.

The study maps out the realm, disciplines, keywords, and contexts in which the qualified studies on earthquakes in Türkiye, that were recently published in distinguished science portals. Secondly, focusing on the Maraş earthquake, which took place in February 2023 -and immediately found its place in the scientific world as a scientific publication- this article examines similar questions and develops and analysis to this earthquake. By doing so, it aims to provide

a comprehensive overview of the recent literature and make a modest contribution to the future production of scientific studies in Türkiye.

RESEARCH METHODOLOGY

The wide scope of the subject to be researched, the fact that many studies have been carried out on earthquakes in Türkiye until today, and the fact that it is a field that is constantly up-to-date have played an important role in determining the study method. The fact that the subject of earthquakes is analyzed within the framework of various disciplines and sometimes handled in an interdisciplinary and multidisciplinary framework has led to a systematic but scattered literature. Under current conditions, it is very difficult to present the complete picture of earthquakes in Türkiye with a conventional systematic literature review. Considering this situation, the study has adopted the bibliometric method instead of systematic literature in order to make it possible to identify the active studies in this field, the classification of related publications, and the institutions, organizations, and countries interested in the field. To reveal a panoramic view within the scope of studies on earthquakes in Türkiye, we deemed it appropriate to apply the bibliometric analysis method.

Bibliometric analysis makes it possible to systematize the disorganization that inevitably arises in the literature by using increasing information technologies and software. In academic literature implementation of this king of traces back to the early twentieth century [2]. As Naveen Donthu et.al truly sketches out, bibliometric analysis allows the academics to indeed identify the gaps in the literature and to "position their intended contributions to the fields" [3].

Undoubtedly, this method is not a substitute for a systematic literature review, which is a sine qua non condition for scientific studies, but it reveals the results that will guide and incline these studies and help in determining the target subjects and questions. In addition to this, as in any other field today, concerns about important points such as sorting out studies on earthquakes and determining the reliability and timeliness of the sources are eliminated by bibliometric analysis. Researchers extensively use this study method to classify the mass of data in the field and enhance its understandability.

Bibliometric analysis can be defined as the analysis of all scientific studies in any field through quantitative analyses and statistical indicators [4]. Thanks to this analysis, all sources, such as articles, journals, books, proceedings, and editorial materials published in a certain period, can be classified separately according to their years, and the studies of the authors or researchers on the subject can be classified depending on the country or institution they belong to (Zeren & Kaya, 2020: 37). The data obtained as a result of this classification is visualized through software packages, and quantitative data is made meaningful.

The study aims to determine the general trends in earthquake studies by taking into account the articles indexed in the Web of Science database. Undoubtedly, earthquake studies in Türkiye are not limited to the articles scanned in this index. However, we preferred the Web of Science as it is the most reputable citation system that provides the data that will enable us to make a general bibliometric analysis most appropriately. A total of 6862 articles on the subject were identified in Web of Science, and the database containing the content and tags of these articles was transferred to the VOSviewer program, where the analyses were intended to be performed. As a result of the applications, several analysis methods have been developed in order to measure the effectiveness of studies, researchers, institutions, and countries related to earthquakes. Considering the target and data limitations of this study, co-occurrence-author keywords, citations-organizations, and citations-countries analyses were considered appropriate. At this point, we are trying to find answers to the questions mentioned above based on a dataset consisting of scientific publications that have emerged around the keywords "Turkey" (including "Türkiye") and "earthquake" in the last thirty years. Due to the large number of studies on earthquakes, and to reach the current issues in the field, only the studies between 1990 and 2023 were taken into consideration in the process of creating the database.

Before indicating the details of the findings specific to Türkiye, it can be useful to have a look at Türkiye's place in earthquake studies around the world from the most general perspective as can be seen in Figure 1. In 1990, a total of 200,000 publications on earthquakes were available for citation worldwide. Türkiye has an important place in the distribution of publications. Although it ranks 12th with 3.1% in the publication ranking, there is not much difference in quantitative terms with Germany, Iran, Canada, and Russia, which are working in this field.

Comprehensive Analysis of Earthquakes in Türkıye in Scientific Literature

In world literature several bibliometric studies have been done on the world earthquakes in general and on Turkish earthquakes in particular. Xingjian Liu et al. using a substantial dataset consisting of more than 84,000 publications, presented the research performance on earthquakes in the world throughout the twentieth century [5]. Fernando Morante-Carballo et al. [6] concentrated on American peninsula while analysing scientific production on earthquakes. Dal et al. [7] bibliometric study on the Turkish earthquakes particularly focuses on its affiliation with architecture. Taşkın [8] develops a citation analysis on Marmara earthquake (1999) relying on more than a thousand articles by Turkish scholars.

As an earthquake-prone country, scientific studies have been carried out in Türkiye since very early times. This chapter provides an overview of the studies carried out in Türkiye in the last thirty years and tries to reveal the levels



Figure 1. Country distribution of studies on earthquakes between 1990 and 2023.

of accumulation in earthquake studies, where the publications focus on this subject, and where the scientific articles are clustered.

The earliest publications on earthquakes in Türkiye that are indexed in international information sources were found in 1992. Researchers can obtain a processable time series between 1998 and 2023. Undoubtedly, the global increase in publications on earthquakes is expected to continue. Naturally, the increase in publication opportunities and the accumulation of scientific knowledge will have an important effect on triggering new publications. Figure 2 shows a noticeable increase in the studies on earthquakes in Türkiye in 2002 and 2021. It is possible to think that the 1999 Gölcük earthquake and the 2019 earthquakes in Istanbul had an impact on this. Since earthquakes are instantaneous events and it takes a period of time to feel and measure their effects, there has been a noticeable increase in the number of publications one or two years after the earthquakes. Therefore, scientists typically consider earthquakes as a lagged variable in time series analysis within their research studies. In the 2023 Great Maraş earthquake, the temporal process of the disruption was quite short. In other words, the publications started to come one after the other immediately after the earthquake occurred. The relatively shorter duration of the broadcasting processes and the fact that this earthquake disaster was at the top of

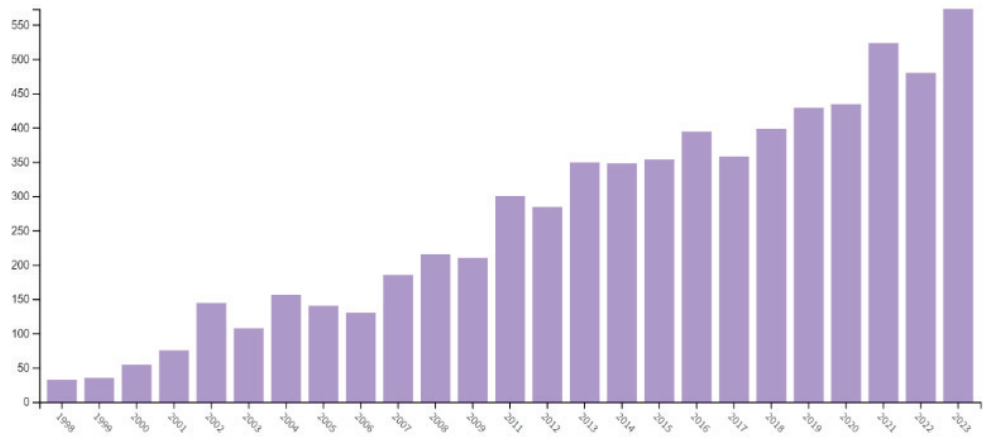


Figure 2. Time series of studies on earthquakes in Türkiye.

almost the entire world agenda may have contributed to the immediate succession of publications.

Turkish academia dominates the realm on Anatolian earthquakes. The number of articles published in Türkiye among the 6862 studies conducted in total is 5581. The ratio of the studies conducted in Türkiye to all studies is 81.56 percent. After Türkiye, the country with the highest number of publications on earthquakes in Türkiye is the United States of America, with a ratio of 13.44%. The United Kingdom follows with 4.85% (and 332 publications), while France and Italy closely trail with 4.84% (and 330 publications). Another remarkable situation in this ranking is that the countries that have conducted research on earthquakes in Türkiye in the last thirty years are not from the earthquake zone countries but from other countries with strong academic institutions. Another remarkable result of the publications is related to the language of the articles. The number of publications written in Turkish was limited to 333, while 6496 publications in our data set were written in English. Croatian had 12 publications and Chinese had 9 publications following the Turkish publications.

Figure 3 shows that technical universities generally dominate the distribution of publications. In this context, we observe that the highest number of qualified publications comes from Istanbul Technical University, with 830 articles. This university is followed by Boğaziçi University, with 722 publications. Although Boğaziçi University is not a technical university, it can be considered that it has the capacity to produce a large number of publications due to the fact that it has an institution such as Kandilli Observatory. METU, which is also a technical university, ranked third in the publication ranking of the institutions, followed by Istanbul University, Karadeniz Technical University, and Yıldız Technical University. Of course, these data represent the total number of articles produced by each university on the subject. Therefore, the number of academic staff working in the institutions may affect the ranking and the number of articles.

It has been inferred that the publications on Türkiye and earthquakes are mainly concentrated in engineering sciences, both from the distribution of publications according to disciplines and from the indexes in which the articles are cited. Accordingly, 86.5 percent of the publications are indexed in the Science Citation Index (SCI) and 8.5 percent in the Emerging Source Citation Index (ESCI), while only 6.3 percent of the publications are indexed in the Social Science Citation Index (SSCI) (Fig. 4). We see a similar picture in the interdisciplinary distribution. According to this, almost one-third of the studies have emerged in the field of multidisciplinary geoscience. Since "earthquakes" is considered a subject that requires the contribution of many different engineering fields, interdisciplinary studies have naturally come to the fore. Considering the fields of specialization, the earthquake issue makes itself felt most in the field of civil engineering. This field is followed by geophysics and geological engineering, respectively. This situation



Figure 3. Distribution of studies on earthquakes in Türkiye among universities.

Select All	Field: Web of Science Index	Record Count	% of 6.850
☐	Science Citation Index Expanded (SCI-EXPANDED)	5,932	86.599%
☐	Emerging Sources Citation Index (ESCI)	592	8.642%
☐	Social Sciences Citation Index (SSCI)	432	6.307%
☐	Conference Proceedings Citation Index – Science (CPCI-S)	231	3.372%
☐	Arts & Humanities Citation Index (A&HCI)	86	1.255%
☐	Book Citation Index – Science (BKCI-S)	86	1.255%
☐	Book Citation Index – Social Sciences & Humanities (BKCI-SSH)	23	0.336%
☐	Conference Proceedings Citation Index – Social Science & Humanities (CPCI-SSH)	11	0.161%

Analyze Data Table

Figure 4. Index distribution of studies on earthquakes in Türkiye.

is parallel to the distribution of earthquake publications in the world literature, which consists of 200,000 publications.

The co-occurrence-author keyword analysis of keywords in the studies on earthquakes in Türkiye reveals certain results. This analysis shows the keywords used by the authors in the obtained dataset and the associations between these keywords. The keywords Türkiye and earthquakes, which we have entered in this image, are naturally located at a central point. The sizes of the balls representing the frequency of keywords (that indicate how often the keywords are used) and the colors indicate when they are used. Accordingly, the most aggregated keywords in the context of Türkiye and earthquakes are "strong ground motion," "seismicity," "earthquake damage," and "active faulting." In addition, there are also peripheral terms that are not included in the map but have relevance in the context of earthquakes in Türkiye. On the periphery of the lexicon are words such as "afad-Türkiye," "disaster management in Türkiye," "co-sysmic deformation," "long-term humanitarian cooperation," and "agricultural design flows" (Fig. 5). It is noteworthy that these words are generally non-engineering expressions. It is instructive in terms of showing that, until recently, there has not yet been a strong working partnership between engineering and management sciences in

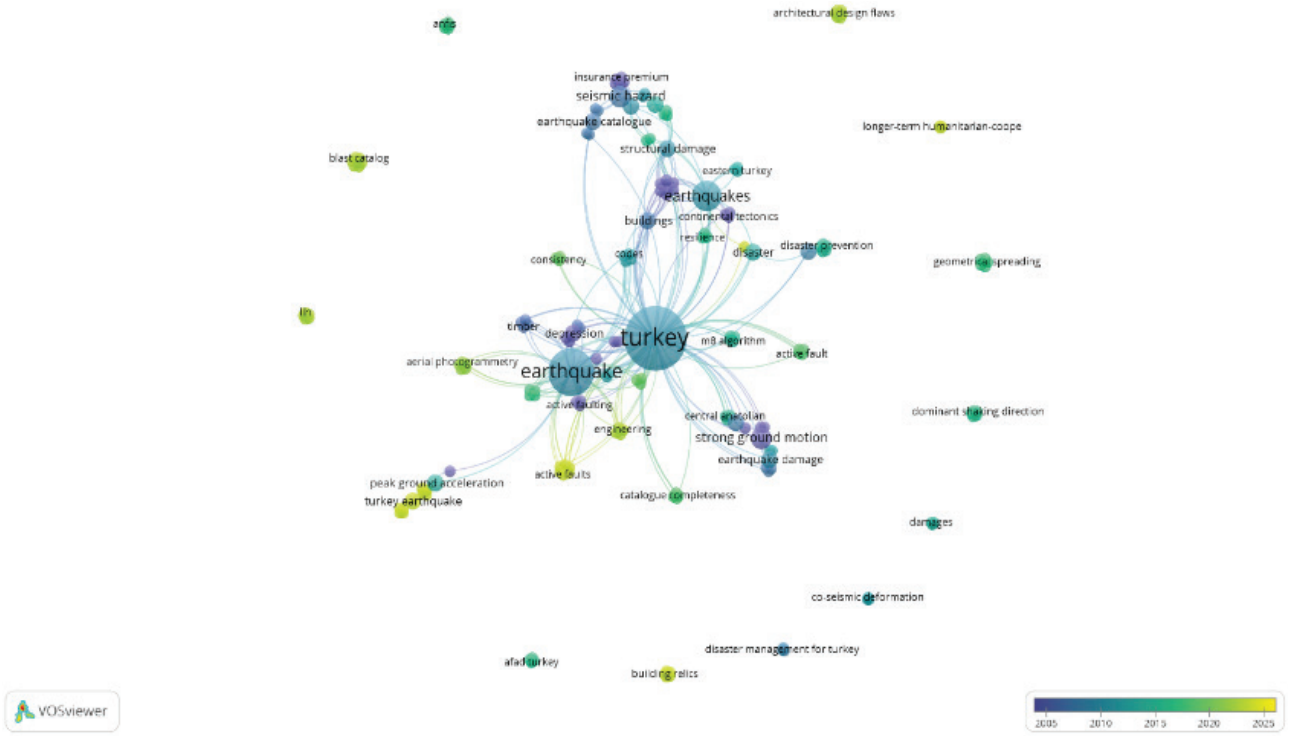


Figure 5. Cooccurrence-author keywords distribution of studies on earthquakes in Türkiye.

Türkiye. Further examination is needed to determine if this is a Turkish-specific fact or a worldwide situation.

Pre-Scientific Implications of the February 2023 Earthquakes

On February 6, 2023, the earthquake that occurred in the center of Kahramanmaraş Pazarcık was recorded as one of the largest and most destructive earthquakes in the history of Türkiye. As a result of this earthquake, more than fifty thousand people lost their lives, and many buildings, including historical buildings that had survived for hundreds of years, were destroyed. The magnitude of the earthquake and its devastating impact, as well as the precautions taken or not taken before the earthquake, remained on the agenda throughout 2023. The building stock in the eleven provinces affected by the earthquake and the resilience of the cities formed the center of the discussion process.

In particular, the demolition of newly built residences while the earthquake regulations were in force has been a subject of debate among the public, city administrations, and urban planners. These earthquakes were given great importance not only due to the significant destruction they caused, but also because of the anxiety caused by the predicted dimensions of destruction from another expected earthquake in the Marmara region.

Scientists have started including February earthquakes in their studies at a speed that can be called almost instantaneous in the scientific world. The first chapter stated that major earthquakes occurring in Türkiye required a process to be included in academic studies. However, in the recent February earthquakes, all aspects of the earthquake, along with their findings, have begun to be extensively studied in academic research. In the ten-month period until November 2023, more than 200 studies directly related to the subject found a place in the scientific system. A total of 121 studies were published scientifically. The descriptive statistics of the 121 studies reveal an increase in the occurrence of social science-based studies compared to previous periods. As a matter of fact, it is seen that there are 31 articles in total among all articles that can be evaluated within the scope of the social sciences.

Another noteworthy point about the articles published about the February earthquakes is related to the countries where the publications were carried out. The overwhelming majority of the studies on earthquakes in Türkiye (79 of them) were carried out in scientific institutions in Türkiye. Compared to the general outlook in the last thirty years mentioned above, we observe that Turkish academia has maintained its dominant position on the subject of earthquake events within its borders. Another noteworthy aspect of country distribution is the involvement of countries conducting studies outside Türkiye. While the United States, the United Kingdom, and France came to the forefront in the previous earthquakes in Türkiye, it is observed that China and Russia gained weight in the February earthquakes (Fig. 6). The above-mentioned situation also makes itself felt in the distribution of the institutions to which the scientists producing the studies belong. As a matter of fact, when this distribution is considered, it can be noted that the Russian Academy of Sciences ranks first with six articles. The Russian Academy is followed by Ankara, Bitlis Eren, Çanakkale On Sekiz Mart, Hacettepe, and Health Sciences Universities with 5 articles each.

However, researchers consistently write all studies in English. This situation arises as a result of the international character of the field of study and the need for scientific information flow and sharing. It is important to note that English language is no longer a language belonging to a



Figure 6. Country distribution of publications on the 6 February earthquakes.

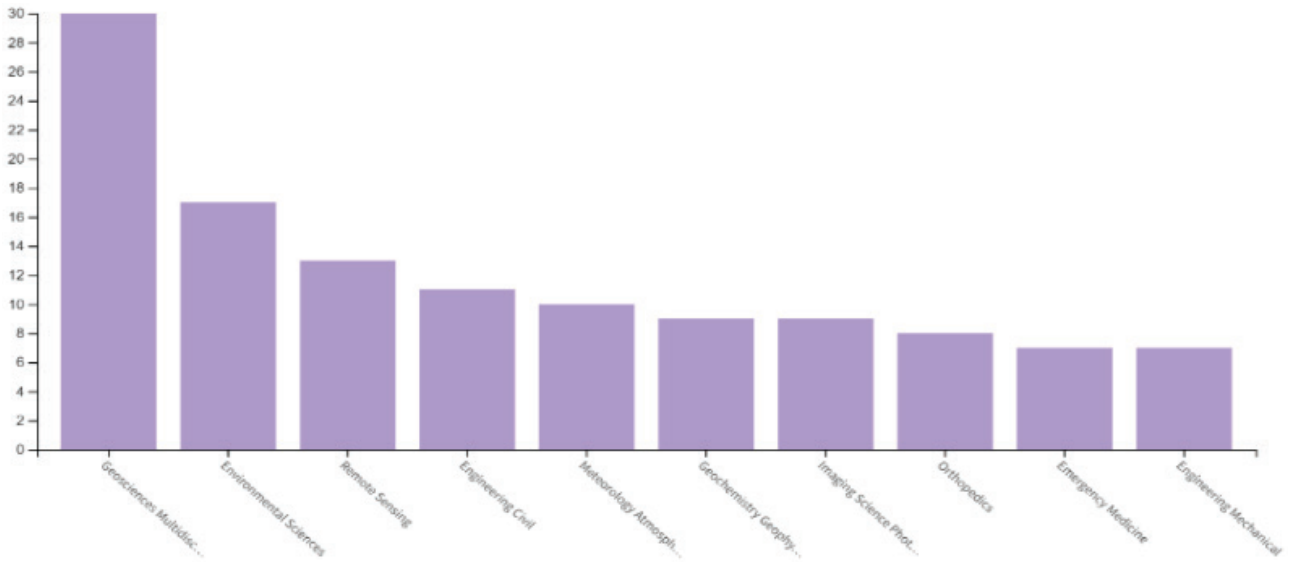


Figure 7. Distribution of the studies on "6 February Earthquakes" according to disciplines.

single nation but a global communication language used by every nation. When looking at the distribution of the studies on "6 February Earthquakes" according to disciplines, it is possible to state that new disciplines that include new technologies and come to the fore. In this context, geology (30 publications) and engineering (28 publications) take the first two places (Fig. 7). However, it is very interesting that fields such as environmental sciences, ecology, remote sensing, and metaphysical sciences, which were not previously included in the ranking, have emerged as the fields with the highest number of publications. Compared to the studies carried out in Türkiye in the last thirty years with those carried out after February, it can be observed that the interdisciplinary studies have not lost their importance due to the nature of earthquakes, but the base of interdisciplinary studies, which were previously carried out in engineering, has now expanded to include other fields (such as social sciences, health sciences, and applied sciences).

The scale of the current dataset does not allow for depicting a bibliometric map. In order to do this, perhaps it will be necessary to wait for a while and follow the accumulation of publications. However, following the character of this literature at the starting point can shape and predict the characteristics of the studies to be carried out later. Therefore a basic citation analysis seems to be the best alternative which can suits the dataset on hand [9]. At this point, firstly, citation-countries analyses reveal meaningful schemes with the available data. When the details of the representation in Figure 8 are analyzed, it is seen that there is a partial clustering around China and Russia in the word citations in the studies on earthquakes in Türkiye. When the cross-country

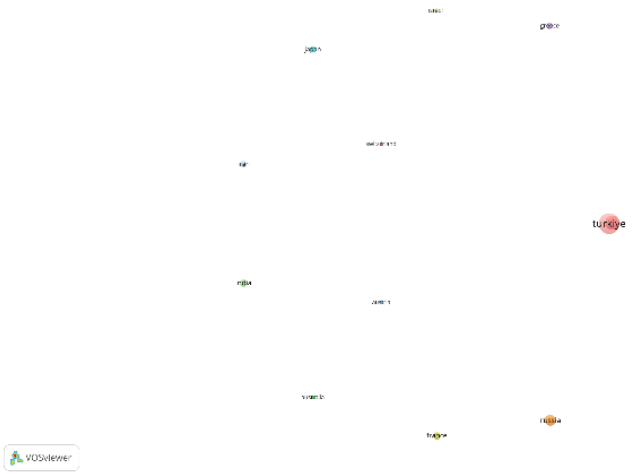


Figure 8. Citation-countries distribution.

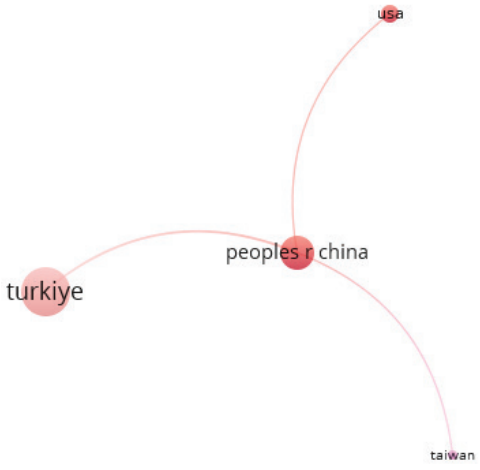


Figure 9. Cross-country citation distribution.

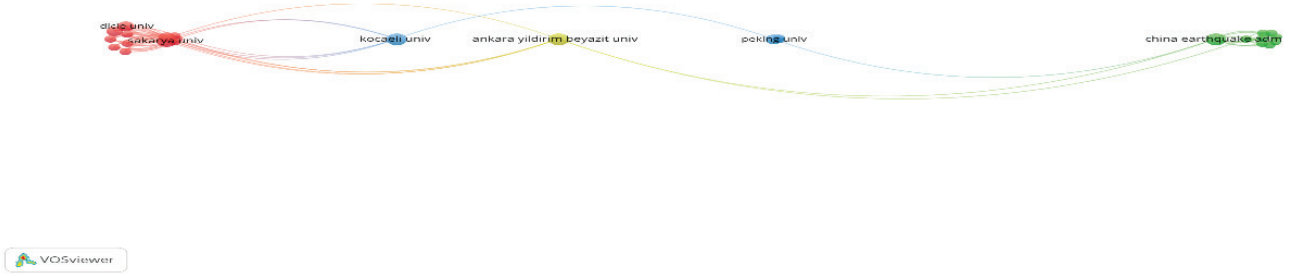


Figure 10. Citation-organization distribution.

citation schema related to Türkiye is analyzed, it is again seen that China has a central role (Fig. 9).

Based on the small number of publications that have emerged within nine months, it is noteworthy that the publications produced by scientific institutions in Türkiye are already cited more than the publications of Chinese institutions in the pattern emerging from the citation-organization application (Fig.10). It is remarkable to consider whether this situation will continue in future publications and if citations to publications from institutions in different countries will alter the existing pattern.

CONCLUSION

The earthquake issue has entered the agenda of almost all countries due to the fact that its economic and social dimensions affect the whole world as well as the countries located in the earthquake zone. As a natural consequence of this, earthquakes have started to be included in the scientific literature as one of the most serious types of disasters. In Türkiye, which is one of the countries most exposed to this type of disaster, studies on earthquakes have been addressed since early years. The devastating effects of the 1999 earthquake triggered the emergence of more studies. The February 6, 2023, earthquakes, on the other hand, carried the country's scientific interest to a different dimension due to the fact that they covered a very large geographical area and caused many casualties.

The bibliometric analysis of earthquakes in Türkiye reveals the orientations of the qualified studies conducted so far and also reveals the changing character of the field of study. In this respect, the study aims to serve as a guide to give an idea of where future studies in different disciplines can be directed.

Three striking points can be concluded from the detailed numerical breakdowns and bibliometric maps of the study. First; the weight of the social and health sciences in earthquake studies has increased in recent years. Especially the pioneering studies on the earthquakes of February 6 clearly show this tendency. The loss of life in these earthquakes, the process of rescuing those trapped under the rubble, and the subsequent discussions on the reconstruction of cities have made it necessary to examine the issue more within the scope of not only engineering but also social, economic, and health sciences.

Second; the interdisciplinary studies have gained more prominence in recent years. An earthquake, which is the subject of different disciplines in terms of its character, has passed to a more complex but qualified dimension with the contributions of social and health sciences. Future studies on earthquakes in Türkiye will inevitably have a multidisciplinary character. In this context, technical universities with faculties of economics and health sciences seem to be promising in contributing to the literature.

Finally, there is a growing interest from more countries in the geography of Türkiye in terms of earthquakes compared to previous periods. Especially in recent years, the emergence of Asian academic articles on earthquakes in Türkiye is remarkable. It is also possible to observe a similar situation in academic publication citations. The expansion of the country's base for conducting research on Türkiye can be considered a harbinger of a wider range of international cooperation opportunities in the long term.

ACKNOWLEDGEMENT

This work was supported by Yildiz Technical University Scientific Research Projects Coordination Unit under project number FBG-2023-5734.

AUTHORSHIP CONTRIBUTIONS

Authors equally contributed to this work.

DATA AVAILABILITY STATEMENT

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

ETHICS

There are no ethical issues with the publication of this manuscript.

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