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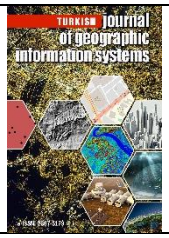

30 Years of Geographic Information Systems Studies in Turkey: A Bibliometric Analysis (1990-2020)

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ABSTRACT

Today, Geographic Information Systems (GIS) are widely used in many fields, especially in the field of geography. GIS, which provides data storage, digitization, querying and reporting in computer environment, has become an effective tool in recent years thanks to various software and hardware. Although there is a trend increase in GIS studies in the world, no analysis has been made about the literature in Turkey. The aim of this study is to determine which concepts are studied on GIS in Turkey, how the change takes place over the years, and which concepts are the future trends. For this purpose, publications with 'GIS' in the title, keyword and abstract were scanned in the Scopus database. From 1990, which was the first publication, to 2020, 1325 articles were found among the researchers from Turkey (17.10.2022). The obtained data were analysed bibliometrically with the VOSviewer program. According to the results of the research, the most prominent concepts in the GIS literature in Turkey are concepts such as remote sensing, land use, landslide, slope, forest. Concepts such as Analytical Hierarchy Process (AHP), network analysis, urban planning, climate change and multi-criteria decision-making analysis are the most studied concepts in recent years. It has been determined that the most cited studies are in the field of geology. While on the basis of countries the most cooperation is made with the USA, England, Germany and Iran, countries such as Netherlands, Sweden and China have been identified as prominent collaborations in recent years. Finally, when the collaborations between the researchers were examined on an individual basis, it was determined that the individual relationship networks were weak and the researchers conducted partnerships with the same researchers in a limited environment.

1. INTRODUCTION

Geographic Information Systems (GIS) is a tool created for data storage, digitization, querying and reporting (Liu et al., 2016). In order to solve the worlds encountered economic, environmental and social problems, systematic collection, storage, updating and processing/analysis of spatial data (including re-use for the purpose of obtaining new data) are used in spatial decision-making processes of geographical information (Özcan et al., 2021). It is possible to use the outputs obtained as a result of visualizing, querying and analysing the attribute data in research reports. As a tool, GIS includes many different query and analysis methods in the fields of maps, geology, physical geography, education, health, security, architecture, city planning and even archaeology. It is also widely used in academic, public and private sector/organizations

Even though the history of GIS goes back to the 1800s (Özcan et al., 2021; Değerliyurt & Çabuk, 2015), the use and spread of GIS has been with the development of computer technologies. The first theoretical study on GIS was conducted at Harvard University in 1966 (Yomralioglu, 2000). In addition to the computer technology that started to become widespread in the 1980s, the field continues to grow cumulatively, thanks to the GIS software developed towards the end of the 1990s. In this sense, it has been

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determined that the studies on GIS in the literature have increased both in the world and in Turkey as software and hardware opportunities have become widespread and their fees have become cheaper since the 1990s (Figure 1). Considering the widespread use of this tool, on the current state and future trends of the literature to date, Liu et al. 2016, he carried out a bibliometric analysis. According to the findings of the research, the first studies on GIS in the world started in 1975. Since 1990, there has been an annual increase of 63.7% in the number of studies. The most studied fields related to GIS are environmental sciences, earth sciences, ecology, physical geography, water resources, geography and remote sensing, respectively. One of the most striking findings of the study is related to the most productive countries in GIS. Accordingly, Turkey is the 13th country in the world in terms of productivity. On the other hand, out of a total of 416 articles by researchers from Turkey, only 41 were produced with international cooperation. In the light of these data, it is important to determine the current situation and future trends of the literature on GIS in Turkey.

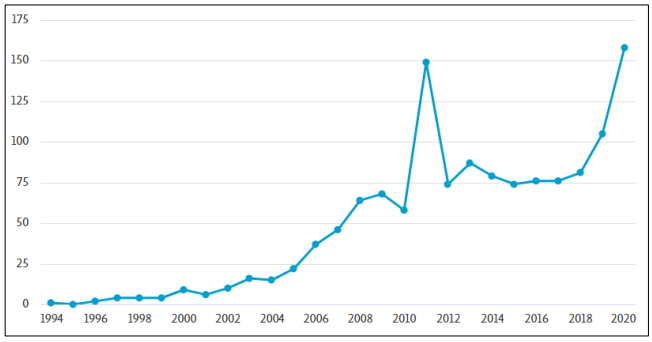

Figure 1. Studies from Turkey in the Field of GIS between 1990-2020 According to the Scopus Database
Explanatory note: The graph was obtained from the Scopus database on 07/10/2022

The development of GIS in Turkey started with service procurement from international GIS companies as a result of the initiatives of public institutions. Then, with the initiative of the same stakeholders, the establishment of GIS infrastructure in public institutions was ensured. GIS, which is used on the basis of independent projects in Turkey, has become a common tool that is tried to be standardized with the cooperation of the public and private sectors. It has been deduced that the main studies on GIS in Turkey are field-based studies, in which attribute and spatial data are analyzed and interpreted in the context of a research problem (Ateş et al. 2020; Yalcin et al. 2011; Erdogan et al. 2008; Akgün & Bulut, 2007; Şener et al., 2005; Süzen & Doyuran, 2004; Ercanoglu and Gokceoglu, 2002). However, as mentioned before, while it is known that studies on GIS in the world have increased in the 1990s, there is no comprehensive literature review regarding the development of studies in Turkey. This study is aimed at filling the gap on how the developments in the field of GIS reflect on the academic field in Turkey and the quality of the studies.

2. PURPOSE AND QUESTIONS OF THE RESEARCH

The aim of this article is to determine which concepts in GIS from Turkey are mostly studied among international academic publications, how the temporal changes of concepts occur, who are the prominent researchers, international collaborations and future trends. The research questions are:

Research question 1: Which concepts have come to the fore in recent years?

Research question 2: Which authors are most cited?

Research question 3: What is the national and international cooperation of researchers working on GIS in Turkey?

In Turkey, literature analysis is carried out with the bibliometric method, especially on tourism (Güney & Somuncu, 2020; Kocak et al., 2019; Güzeller & Çeliker, 2018; Yalcin & Yayla, 2016; Garousi, 2015; Evren & Kozak, 2014). However, there is no bibliometric study on when the GIS literature began to develop and on which subjects it was studied. With this study, the current situation of the GIS literature in Turkey will be understood. It is possible to make inferences about future trends in the context of prominent concepts, researchers and collaborations. This study is important for researchers working on GIS in Turkey to understand the current situation, current research areas, methods and opportunities. Additionally, it will make it easier for researchers in Turkey to integrate into the world's GIS literature.

In the data and method section of the article, how the data was obtained and how it was analyzed were discussed. The following findings section includes the results of the analysis in the context of the research questions. Finally, in the conclusion and discussion section, the findings are discussed and implications for future studies are given.

3. METHOD

The bibliometric data required for the purpose of the research and answering the questions were obtained from the Scopus database. Reason for choosing Scopus is in case of searching with the same criteria in Web of Science (WOS), 1210 articles were reached. Since it lists more publications, Scopus was found to be more inclusive and preferred in the literature. As in all databases, Scopus processes the title, keywords and summary sections of the articles in the journals, as a data set. This data set can be obtained from Scopus in ready-made excel environment.

On 17/10/2022, publications with 'GIS' in the title, keyword and abstract were searched in the Scopus database. Since the abbreviation GIS refers to different concepts in fields such as medicine, mathematics and psychology, article studies in this and similar fields were excluded from the research. The article was determined as the type of document obtained. The last criterion regarding the screening is the selection of Turkey as the country of origin of the authors. Thus, in Scopus on 17/10/2022, there are researchers from Turkey among their authors; written in areas related to geographic information systems; document type is article; 1325 publications with 'GIS' in the title, keyword and abstract were found (Figure 2). According to the temporal

development of the scan results, the first publication was made in 1990. The last date covered by the research is the end of 2020.

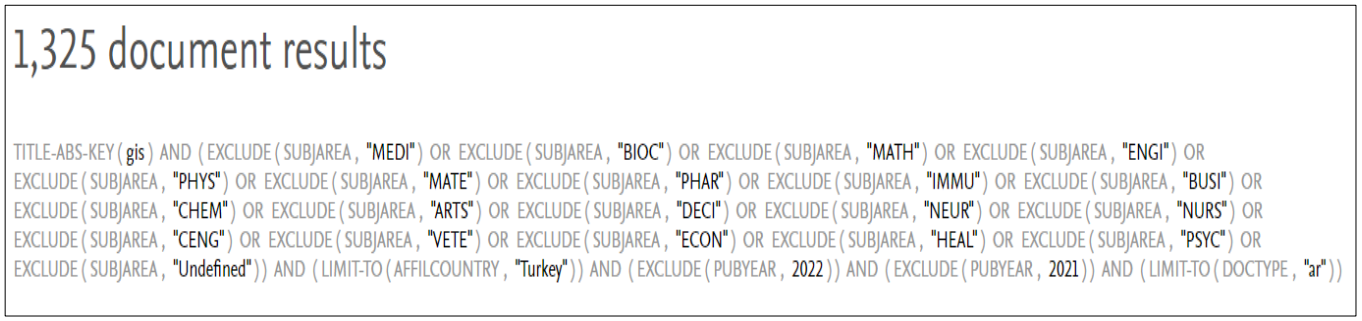

Figure 2. Search and filter criteria in Scopus

In line with the purpose of the research and the data set obtained, the method of the research was determined as bibliometric network analysis. The main purpose of bibliometrics is to quantitatively analyse scientific publication, information and communication activities and to provide generalization by revealing concrete information about the literature of the relevant subject over the whole universe or the sample. Network analysis, on the other hand, is a method of visualizing the relationships about a subject by examining their changes in formal, space and time dimensions (Tindall & Wellman, 2001). The reason for performing the bibliometric analysis with network analysis in this research is to reveal where the data related to the GIS literature are formally knotted and how they change over time. In addition, it is possible to make descriptive interpretations on the current situation and future by revealing the relationships and clusters in the literature with the outputs of the network analysis (Van Eck & Waltman, 2010).

VOSviewer 1.6 bibliometric networks visualization application was used in the research. The VOS technique used in this application is a multidimensional scaling process for visualizing the similarities between elements and has features such as presentation of ideal coordinates, indirect analogy and multidimensional scaling (Artsın, 2020).

Bibliometric data of 1325 publications obtained from Scopus were analyzed in the VOSViewer application according to various threshold values. In the analysis of the most studied concepts in the field of GIS in Turkey, which is the first of the research questions, the repetition threshold of the concepts in the keywords was determined as 5. In the analysis made on the summary text, the repetition threshold was determined as 15. The same threshold values were used for the second question, the concepts that have come to the fore in recent years. Co-citation method was used to answer the third research question. This analysis method expresses the link established between the documents cited by the same document (Kurutkan & Orhan, 2018). The important thing here is the documents cited from the same source. When examining which studies are cited in bibliographic matching, the prominent topics of the GIS literature and the change in researchers can be observed. Identifying certain common cited studies also means identifying studies that direct the GIS literature. In the co-citation analysis stage, an analysis was carried out according to the co-cited authors of the studies. The minimum citation threshold value for the authors was determined as 20. In order to answer the fourth of the research questions, it was examined which countries the authors cited the most. For this analysis, countries with at least three publications from different countries were evaluated. In this sense, the contribution of countries that have only one or two publications to the GIS literature is not considered to be weak in terms of relational and clustering. Finally, while examining the collaborations of the researchers within the scope of the authors, it was taken into account that the researchers included in the analysis had at least three publications and one citation.

As a result of the analysis, network maps were obtained and interpreted. In addition, detailed lists of clusters in the network maps were also used to interpret the analysis outputs.

4. RESULTS

In this section, each of the research questions is evaluated as a sub-title. Findings related to the research question are located under the related question.

The findings section first focuses on which concepts are used most by internationally published articles on GIS in Turkey. According to the conceptual network analyses made according to both the keywords and the words in the abstract, the temporal changes in the use of the concepts and which subjects were studied the most were determined.

Then, the most cited authors and study topics were determined. Again, the status of the national and international cooperation network was questioned in the publications of the authors.

4.1. Research Question 1: Which Concepts Are Mostly Studied In The Field Of GIS In Turkey?

Certainly, the most important finding in the bibliometric analysis of the GIS literature is which concepts are studied. Key words and summary text were analyzed separately to identify the concepts. According to the analysis made on the keywords, the first three prominent concepts in the field of GIS literature among the articles in the Scopus database are Geographical Information Systems (GIS), remote sensing and Turkey. Then comes the concepts of landslide, land use, AHP, spatial analysis and water

quality (Figure 3). According to the field study, the most repeated city names are Istanbul and Trabzon. When the relation of the most repetitive key concepts with other concepts is examined, it was observed that the GIS concept is located in the middle of the network. Regardless of the subject of the study, it can be deduced that the researchers determined the concept of GIS as one of the keywords. Remote sensing is the second most repeated keyword in Turkish. It has been determined that the concepts in the blue cluster, where the concept of remote sensing stands out, are mostly about, Corine, land use and change. The fact that the green cluster are located around the remote sensing cluster indicates that those who use the concepts here are working with remote sensing. Concepts related to urbanization, forest and landuse stand out in the green cluster. The purple cluster is dominated by the concept of landslide. Concepts in other clusters with which the concept is related are multi-criteria decision analysis, logistic regression, etc. refers to statistical tools. In this sense, it should be noted that the studies on landslides were carried out by statistical methods.

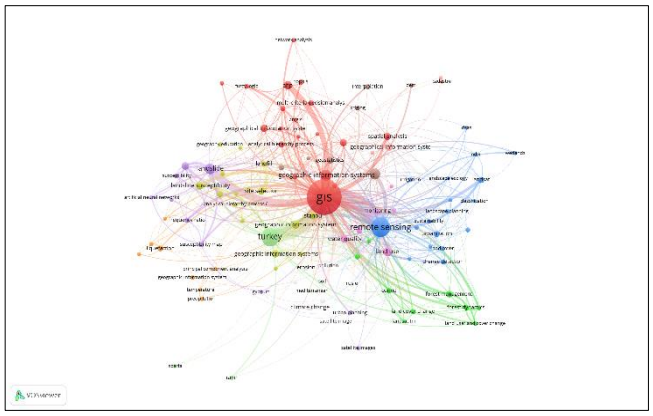

Figure 3. Analysis of the most studied concepts through keywords

According to the analysis made on the summary texts of the studies in the GIS literature, the prominent concepts differ from the keywords. According to the analysis, four concept clusters were obtained (Figure 4). It can be deduced that the concepts in the green cluster consist of 3D analysis tools of GIS and concepts related to landslides. It is possible that studies revealing the risk of landslides with various criteria can be included in this cluster. It can be deduced that the concepts in the blue cluster are mostly related to water and erosion issues. It has been observed that the studies in the aforementioned cluster calculate erosion risk with various analysis and correlations over the Digital Elevation Model (DEM). It has been determined that the concepts in the yellow cluster are related to agriculture, forestry, land use and ecosystem. It can be described that the concepts in this cluster are related to the studies on the pattern, change and period-dependent increase-decrease trends. The red cluster, on the other hand, is a more complex cluster that includes concepts from the field of social sciences. If it is necessary to evaluate the relationship between clusters, it is noteworthy that there is no relationship between the yellow cluster and the green cluster. Therefore, studies on agriculture and forestry are independent of land use and landslides. On the other hand, it has been determined that the blue cluster, which includes the concepts related to water and erosion, is a transition cluster between these two clusters. It should be noted that the red cluster is related to all clusters since it contains more general concepts.

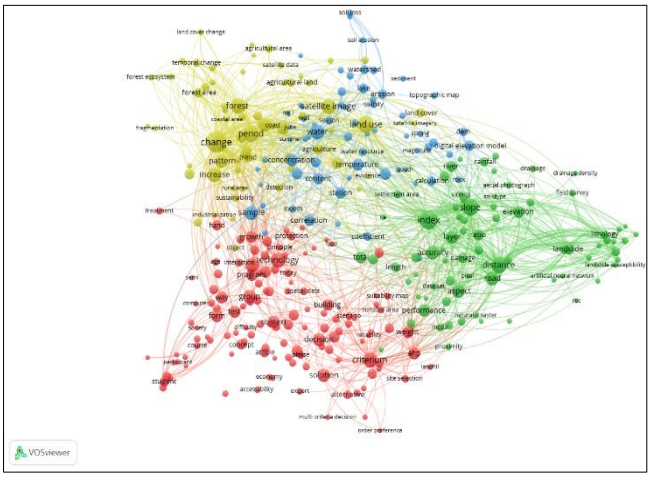

Figure 4. Analysis of the most studied concepts through the summary text

4.2. Research Question 2: Which Concepts Have Come To The Fore In Recent Years?

The analysis made according to the years, in which the most studied concepts are used, have been studied more recently. In this context, it is possible for researchers to become aware of the most up-to-date concepts discussed in the GIS literature. When the temporal distribution of the concepts was examined according to the analysis made on the key concepts, it was determined that the concepts on landslide, remote sensing and forestry were the early GIS study subjects (Figure 5). The concepts such as Analytical Hierarchy Process (AHP), network analysis, urban planning, and climate change and multi-criteria decision-making analysis have been studied more in recent years.

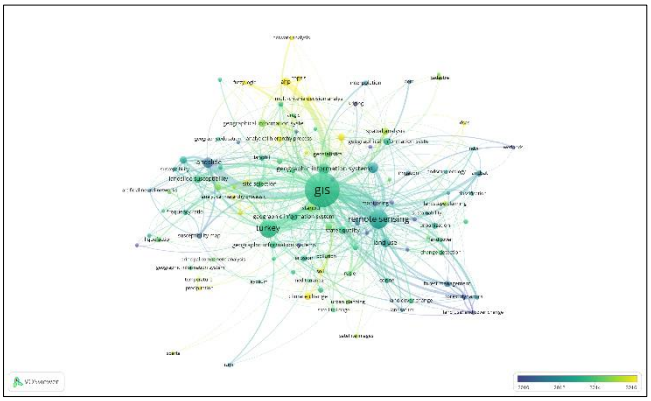

Figure 5. Analysis of the concepts that have come to the fore in recent years through keywords

According to the current concept analysis on the abstract text, the most studied concepts in recent years are concepts such as AHP, multi-criteria decision-making analysis, sustainability, weighting, and temperature (Figure 6). Subjects such as lithology and landslides and DEM are relatively outdated subjects. The fact that GIS studies were used predominantly in

the field of geology in the early periods is also evident in the temporal variation of the studied concepts. As the fields of study in which GIS is used diversify, the prominent concepts also diversify.

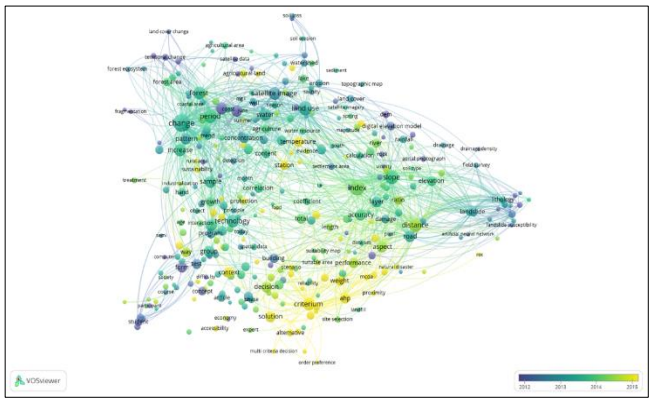

Figure 6. Analysis of the concepts that have come to the fore in recent years through the summary text

4.3. Research question 3: Which authors are most cited?

When the clustering and relationality of the most cited authors were examined, five clusters were formed (Figure 7). It has been determined that the researchers in the green cluster, where Gökçeoğlu stands out, come from the field of geology and geological engineering. Researchers in the purple cluster, which is almost intertwined with this cluster, define their study subjects directly as GIS. It has been determined that the researchers in the red cluster, which has a high correlation with the field of geology and GIS, come from different fields. Researchers such as Dengiz, Saaty, Yomralioglu, Şeker, Başkent work in the fields of surveying, forestry engineering, mathematics and geography. It has been determined that only the orange cluster, which is associated with this cluster, consists of researchers from the field of landscape architecture. Researchers in the field of landscape architecture could not find any relationship in the GIS literature with researchers working on geology, geological engineering and direct GIS analysis. Researchers such as Duman, Şengör, Doyuran, Ulusay and Erdik, who are in the blue cluster, which is not related to the orange cluster, also work in the field of geology. The striking finding here is that the researchers in the blue cluster are not researchers working directly on GIS. In other words, researchers in the blue cluster do not need to have work in the GIS literature. These researchers work in the field of geology and are often cited by researchers working in the GIS field. Since the geologists and geological engineers in the green cluster frequently refer to the researchers in the blue cluster, who are experts in their fields, the blue cluster took its place in the network analysis as a cluster that is only related to the green cluster.

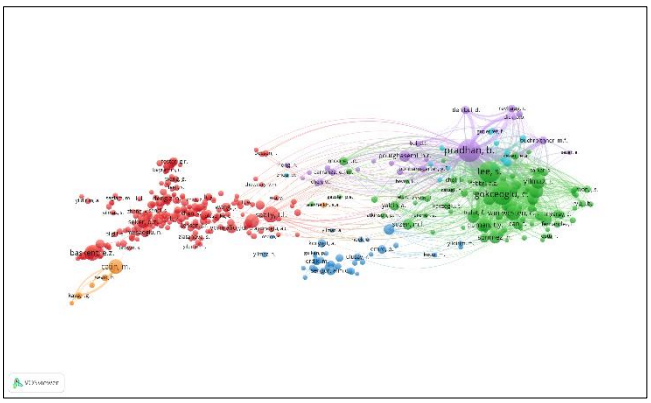

Figure 7. Network analysis of the most cited authors according to co-citation analysis

4.4. Research question 4: What is the national and international cooperation of researchers working on GIS in Turkey?

In the last 30 years, the international collaborations of researchers who have published internationally in the field of GIS in Turkey have been analyzed with researchers in which countries. According to the results of the analysis, it has been determined that the cooperation network of researchers from Turkey is narrow (Figure 8). The USA, England, Germany and Iran are among the countries with the most cooperation. Looking at the relationship clusters, it has been determined that the green cluster is Asian countries, the red cluster is continental European countries, the blue cluster is Northern European countries, the purple cluster is Eastern European countries.

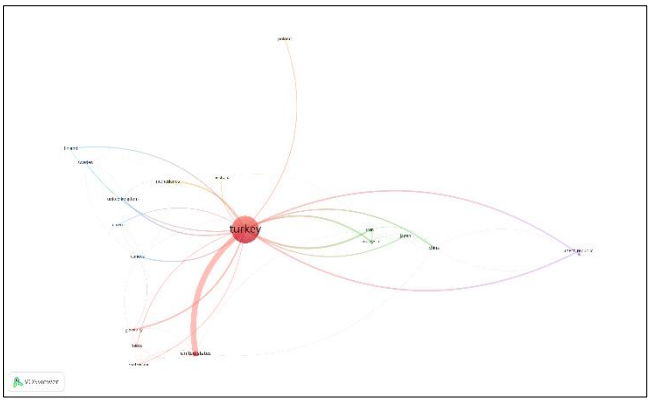

Figure 8. Analysis of the cooperation between the authors on the basis of countries

When the temporal trend of the analysis of the cooperation between the authors on the basis of countries is examined, it has been determined that the oldest partnerships are with countries such as USA, Germany, Canada, United Kingdom, Switzerland, while the new focus of cooperation is Netherlands, Sweden, Iran, China and Poland (Figure 9). In this context, it can be said that the cooperation network of researchers in Turkey has gradually expanded and joint studies with researchers from different geographies have become widespread. It has been determined that there is a development from relations with Continental Europe and the USA to relations with Asia and Northern Europe. It is thought that the most important factor in this situation is the R&D investments that accelerate the

scientific development in Asian countries. On the other hand, the use of GIS in fields other than geology in Turkey determines the countries with which we cooperate. Countries such as the USA and Germany, which dominate the geological literature in the world, express their former collaborations within the framework of changing study subjects. Multi-criteria decision analysis, sustainability, climate change, etc. Asian and Northern European countries offer important cooperation on these issues.

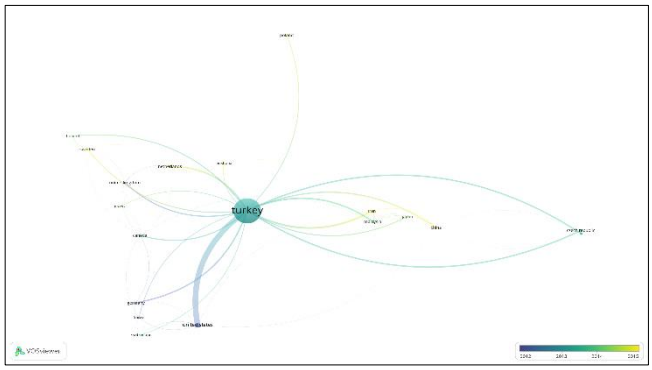

Figure 9. Temporal display of analysis of co-authorship by country

After questioning the cooperation between authors based on countries, it has been analysed with whom the authors collaborated more. According to the analysis in which the researchers working together were in the same cluster, many clusters were identified (Figure 10). The red cluster indicates forest engineers, the yellow cluster indicates geographers, and the brown and green clusters indicate geologists. The reason for obtaining an analysis output that is difficult to interpret is the collaboration of researchers with a limited number of people. For example, the fact that researchers A and B only work together and there is no collaboration with researcher C indicates that the collaboration network of researchers is narrow. Although there is not a complete network analysis output, the most important reason for including this output in the research is that it reveals the limited cooperation of researchers working on GIS in Turkey. According to the analysis findings, there are no specific researchers in the field of GIS with whom they often collaborate. Each researcher cooperates with his colleague who is influential in his field and institution. This level of cooperation shows that there is not yet an effective working group or network in the GIS literature in Turkey.

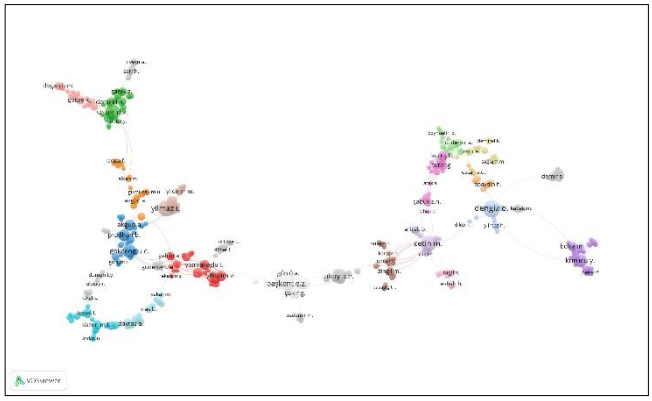

Figure 10. Author-to-author collaboration network

5. DISCUSSION, CONCLUSION and RECOMMENDATIONS

Within the scope of this research, the concepts studied on GIS in Turkey and the temporal change of the concepts and the collaborations between the authors were aimed. For this purpose, the data set was obtained by finding 1325 articles with researchers from Turkey among the authors from 1990 to 2020 in the Scopus database. The obtained data were analysed bibliometrically with the VOSviewer program. It is thought that the results obtained in the research will present an alternative perspective to the GIS literature in Turkey.

The first study in which an evaluation of the GIS literature on a global scale was made was Tian et al. (2008)'s work, covering the years 1997-2006. However, a period of 10 years is not enough to understand the literature on a subject. Liu et al. (2016) is also concerned with the analysis of the GIS literature on a global scale. In this study, a 50-year period covering the years 1961-2010 was investigated. Conducting such a study on Turkey covering a period of 30 years will also be an important reference point for researchers working on the subject in the future.

According to the results of the research, the most prominent concepts in the GIS literature in Turkey are concepts such as remote sensing, land use, landslide, slope, forest. It is known that the same concepts come to the fore in the analysis of the global GIS literature (Liu et al., 2016). The fact that research concepts in Turkey are the same as those in international research circles suggests that current literature is followed.

In recent years, interest in social issues has been increasing in the world with the effect of the postmodern period (Yanık & Öztürk, 2014). There is an increase in the number of studies on subjects that affect individuals such as population growth, migration from rural to urban, reproduction of urban space and climate change. In this sense, when the temporal development of the concepts in the GIS literature is examined, concepts such as Analytical Hierarchy Process (AHP), network analysis, urban planning, climate change and multi-criteria decision-making analysis come to the fore in recent years. From here, it can be deduced that researchers working on GIS in Turkey follow current issues in the world. On the other hand, it has been determined that the most cited studies are in the field of geology. The reason for this situation is that the subject of geology is the first studied subject in the literature. Since studies on GIS and climate change, for example, which have relatively low citations, are new studies, the number of citations is also low. Therefore, it is not correct to rank the subjects in order of importance by looking at the number of citations.

In the international GIS literature, Turkey ranks 13th among the 30 most productive countries (Liu et al., 2016). However Liu et al. (2016)`s study is far from the center of the network in terms of cooperation. Again, in the Duan et al. (2020)'s bibliometric analysis of the remote sensing literature, Turkey is at the far end of the cooperation network. Although this situation is productive, it shows that it lags behind in terms of

international cooperation. Within the scope of the findings overlapping with the analysis of the international GIS literature, when the collaborations of the researchers with each other were examined on an individual basis, it was determined that the individual relationship networks were weak. It has been determined that publications are mostly made independently or that researchers have partnerships with the same researchers in a limited environment. While the most cooperation is made with the USA, England, Germany and Iran on the basis of countries, Countries such as Spain, Sweden, Norway, China, Russia and Poland have been identified as prominent collaborations in recent years. In the findings section, it is stated that there may be a relationship between the countries with which the cooperation started to differ with the diversification of the study subjects. In addition, when Turkey's international student mobility is examined, there has been a significant increase since 2010. Both students who go abroad from Turkey and students who come to Turkey make joint publications by maintaining the academic relations they have developed when they return to their countries. In this sense, Iran ranks fourth among the students who preferred Turkey the most between 2003 and 2014 (Şimşek & Bakır, 2016). On the other hand, the USA, England, Germany, Poland and China are at the top of the countries where Turkey goes abroad the most. It is inevitable that this student mobility will determine the future focus of cooperation.

In addition to the development of hardware and software technologies in the field of GIS today, the transition of institutions and organizations in the world to a working environment suitable for GIS infrastructure will increase the importance of GIS in the near future. Therefore, it is foreseen that the GIS literature will continue to grow cumulatively. Although researchers working on GIS in Turkey follow current study topics, they are insufficient in interdisciplinary and international collaborations. In this sense, it is important that the studies aiming to have a place in the world literature have these qualifications.

Author Contributions

In the article, the processes of forming research questions, scanning the literature, determining the method, collecting data, analysing and interpreting the findings were provided with the contribution of all authors.

Statement of Conflicts of Interest

There is no conflict of interest between the authors.

Statement of Research and Publication Ethics

Research and publication ethics were complied with in the study.

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