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A Bibliometric Analysis of Mountain Research Literature on Journal of Mountain Research and Development: Current Situation and Future Directions

Mountain Research and Development Dergisi Üzerinden Dağ Araştırması Literatürünün Bibliyometrik Analizi: Mevcut Durum ve Gelecek Yönelimler

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ABSTRACT
Academic studies on mountains have increased since the 1990s. The aim of this study is to examine the current situation and development of the international literature on mountainous areas. The Mountain Research and Development Journal was determined as a sample and formed the data set of 1574 articles published in the journal. Network analysis method was applied using VOSviewer v.1.6 program. To conduct the research, only the terms in the keywords were used as the unit of analysis. In this context, frequency, relationality, clustering and time trend analyses were performed, respectively. When the clustering of the most used concepts in the keywords of the articles published in the MRD journal according to the network analysis was examined, eight clusters were determined. It turned out that the most frequently used concept among these clusters was "climate change". When the time trend is examined according to the network analysis of the concepts, studies on the effects of climate change have gained importance, especially in the last 10 years. Where there are conceptual transformations in the studies carried out on mountain slopes in certain years, anthropic emphases have come to the forefront rather than natural conditions.
Keywords: Mountain Research, Bibliometric Analysis, Network Analysis

ÖZ
Özellikle 1990'lı yıllardan itibaren dağla ilgili akademik çalışmalar artmıştır. Araştırmanın amacı, dağlık alanlarla ilgili uluslararası literatürün mevcut durumunu ve gelişimini incelemektir. Dağ Araştırma ve Geliştirme Dergisi örneklem olarak belirlenmiş ve dergide yayınlanan 1574 makalenin veri setini oluşturmuştur. Ağ analiz yöntemi VOSviewer v.1.6 programı kullanılarak uygulanmıştır. Araştırmayı yürütmek için sadece anahtar kelimelerdeki terimler analiz birimi olarak kullanılmıştır. Bu kapsamda sırasıyla frekans, ilişkisellik, kümeleme ve zaman trendi analizleri yapılmıştır. MRD dergisinde yayınlanan makalelerin anahtar kelimelerinde en çok kullanılan kavramların ağ analizine göre kümelenmesi incelendiğinde sekiz küme belirlenmiştir. Bu kümeler arasında en sık kullanılan kavramın "iklim değişikliği" olduğu ortaya çıktı. Kavramların ağ analizine göre zaman trendi incelendiğinde, belirli yıllarda dağ yamaçlarında yapılan çalışmalarda kavramsal dönüşümlerin yaşandığı özellikle son 10 yılda iklim değişikliğinin etkilerine yönelik çalışmalar önem kazanmıştır. zaman içinde doğal koşullardan çok antropik vurgular ön plana çıkmıştır.
Anahtar kelimeler: Dağ Araştırmaları, Bibliyometrik Analiz, Ağ Analizi

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1. INTRODUCTION

Mountains are defined in many different ways. In addition to slope and height, criteria such as profile, relative elevation, land use, biogeography and environmental factors are also included (Price, Arnesen, Gløersen, & Metzger, 2018). However, the indispensable criterion for the definitions is the altitude value above sea level (Sarmiento, 2011). Bevington, Brideau and Geertsema (2017) stated that a mountainous area can be defined by evaluating the absolute and relative criteria together. Hereunder, topographic shapes that are higher than sea level and have a different ecosystem compared to their surroundings are defined as mountainous areas. According to the European Charter of Mountain Region, mountains are defined as "areas with special conditions such as altitude, sloping surface structure and climate that will affect human activities" (CLRAE, 1995). Despite the difficulty of defining a single mountainous area, it is accepted that approximately one-fourth of the world is mountainous today (Scott, 2006). Mountainous areas are significant geographical regions of the world, due to biodiversity and water resources, ecological structure, cultural diversity and traditional living qualities. These areas contain vital resources not only for those living in the areas, but also for those living on plains (Borowski and Munteanu, 2011; Price et al, 2018).

Awareness of mountainous areas has increased globally since the 1990s. Considering the development of institutional importance, it should be specified that 1992 and 2002 were breaking points. The United Nations (UN) at the Rio Earth Summit Conference emphasized the issue of mountainous areas in 1992 for the first time. As an output of the meeting, in the Agenda 21 action plan, mountainous areas were included in a special section and the 13th title was named as "Management of the Fragile Ecosystem: Sustainable Mountain Development". Afterwards, 2002 was declared the "International Year of Mountains" by the UN. Moreover, suggestions have been made for countries to develop cooperative plans and policies in order to consider mountainous areas in the context of sustainable development and to change the global perspective. These developments are of great importance for both global mountainous areas and those living in these regions (Grabherr and Messerli, 2011). The rise in academic interest in mountainous areas is in parallel with the period when institutional interest increased. In a basic search in the Scopus database, the distribution of the articles with the concept of "mountain" in the keywords, title and abstract sections of the publications is seen according to years (**Figure 1a**). Nevertheless, after 1997 is the period when the interest largely increased in the subject just a short time after the 1992 Rio Earth Summit. The quantitative increase in the number of studies has been mostly carried out in the field of natural sciences (**Figure 1b**). The natural sciences followed, with studies on the field of environment and agriculture. Considering the development of mountain literature, it is obviously seen that certain fields of study gained importance in it. Still, it is not possible to draw conclusions about when the fields of study began to diversify, as well as which concepts were discussed. As a result of the overall development approach in the 1990s, interdisciplinary studies were started in mountainous areas, thus social issues were included in the research.

With the increasing importance given to mountainous areas at the international level, the quantitative development in the literature and the diversity of topics, researchers have started to focus on human issues. In addition, initiatives that support various platforms and interdisciplinary approaches have increased. In this context, the most significant activity has been the establishment of research networks to increase the cooperation of researchers interested in mountainous areas. Some of these networks are Instituto de Montana (1996), Rete Montagna (2000), The Global Mountain Biodiversity Assessment (2000), The Mountain Research Initiative (2001), Mountain Partnership (2002), Mountain Invasion Research Network (2005), Science

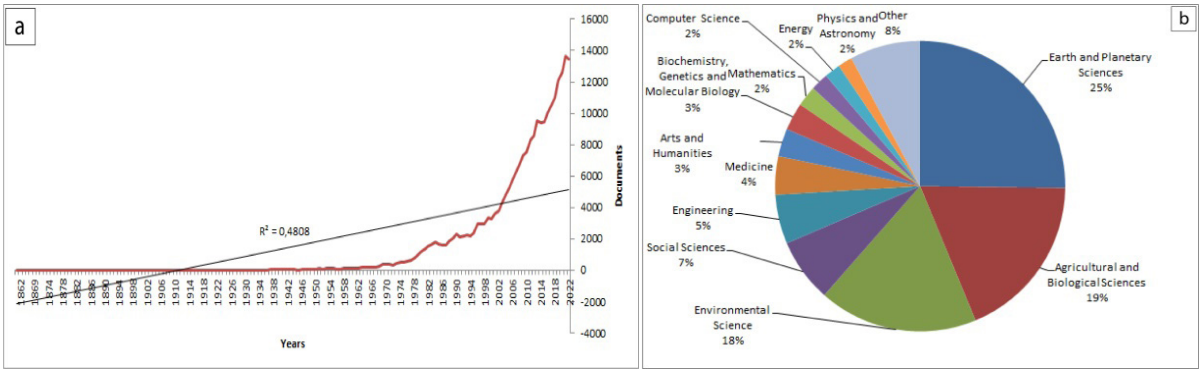

Figure 1. Distribution of publications on mountainous areas by years (a) and research areas (b) (Resource: Scopus, 2022).

for the Carpathians (2008), Our Alps Network (2011), Scientific Network for the Caucasus Mountain Region (2014) and Canadian Mountain Network (2019). The common features of prominent networks are to draw attention to the environmental, social, cultural and economic problems of mountainous areas in order to ensure sustainable development in these areas, as much as to protect biodiversity. All these efforts have led to the development of many different disciplines, methods and perspectives in the mountain range literature today.

Even though to access the quantitative change of studies on mountainous areas and general information about the study field are possible, to comprehend temporal changes of concepts and future trends ascertained from the concepts are discussed in the literature are not as possible. The main objective of this research is to understand the current situation of the mountain literature by making bibliometric analyses on the Mountain Research Development (MRD) Journal, which directly publishes studies on mountainous areas. In this regard, the aim of the paper is to examine the development, change and current status of studies in the international mountain literature, and to identify *new concepts*, *themes* or *topics* with bibliometric techniques to provide substantial suggestions for multidisciplinary concepts for future research. In this framework, the focus of the paper is to address issues in the international mountain research and seek answers for the following questions:

RQ1: What are the recent and main concepts in the field of mountain research?

RQ2: How have they changed over time?

RQ3: What will be the future studies are mostly focused on?

In order to answer the research questions, the bibliometric data were analysed by using the VOSviewer program with the network analysis technique. It is seen that the VOSviewer application, which has been used in recent years, has been used in many studies for different purposes and patterns (Garousi, 2015; Yalçın and Yayla, 2016; Güzeller and Çeliker, 2018; Kocak, García-Zorita, Marugán-Lázaro, Çakır & Sanz-Casado, 2019; Güney and Somuncu, 2020; Jiménez-García, Ruiz-Chico & Peña-Sánchez, 2020; Kumar, Sureka & Vashishtha, 2020; Rodríguez-Soler, Uribe-TorilJ. & Valenciano, 2020; Donthu, Kumar, Pandey & Gupta, 2021; Herrera-Franco, Montalván-Burbano, Carrión-Mero, Jaya-Montalvo & Gurumendi-Noriega, 2021; León-Gómez, Ruiz-Palomo, Fernández-Gámez & García-Revilla, 2021; Rosato, Caputo, Valente & Pizzi, 2021). In these papers, there are different focal points, such as the citation pattern between the authors, prominent concepts, the most studied areas, and the changes according to the years. Herrera-Franco et al (2021) analysed the geopark literature using VOSviewer as an example of bibliometric analyses made on concepts. Furthermore, Donthu et al (2021) made bibliometric analyses through the publications of the International Journal of Information Management for over 40 years, and Kumar et al (2020), did the same on the publications of the Journal of Heritage Tourism between 2006-2019. Although there has been no study conducted with the bibliometric analysis method on any journal about mountains, important guidance and determinations have been made. There are important studies on the development and future trends of mountain literature. It has been emphasized in previous studies that mountainous areas are in constant change, and it has been stated that what this process brings can be turned into an opportunity (Adler et al, 2020). In addition, many studies have been carried out in order to draw the boundaries of the concept of mountainous area and to emphasize its importance (CLRAE, 1995; Scott, 2006; Kapos, Rhind, Edwards, Price & Ravilious, 2000; Körner, Paulsen & Spehn, 2011; Price, 2015; Drexler et al 2016; Karagülle et al 2017). Despite the fact that there are important determinations regarding the literature on mountainous areas in the mentioned studies, a study based on bibliometric techniques has not been conducted yet. The proximate research to the subject carried out with the bibliometric method, was conducted by del Río-Rama, Maldonado-Erazo, Durán-Sánchez & Álvarez-García (2019) in the field of mountain tourism. The study was carried out by searching the term "Mountain Tourism" on Scopus and Web of Science. In addition, highlighting that Scopus is more inclusive regarding the concept mentioned above, it was revealed that the concepts of "climate changes", "sustainable development" and "tourist system" were the most studied subjects. Also, Zeng, Li, Nuttapong, Sun & Mao (2022) made a network analysis of the articles published in many journals on mountain tourism by citation, keywords and countries, using the bibliometric network analysis method and VOSviewer.

Conducting the research with bibliometric indicators provides more objective findings and results. Therefore, the most important motivation of this research is to be a guide for future studies by determining the gaps and implicit information in the literature based on a bibliometric analysis with substantial indicators. The prominent concepts, according to the findings of the research, allow some inferences to be made for the direction of future studies on mountainous areas. For this reason, this research might be important for researchers working on

mountainous areas to understand the current situation, opportunities, current research areas and methods. With this motivation, firstly, in the data and method section of the research, how the data was obtained and how it was analysed are discussed. In the findings section that follows, the results of the analysis are evaluated 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.

2. MATERIAL AND METHODS

2.1. Data Collection and Sample

This section explains how the data and method selection was made and how the analyses were interpreted in line with the research question and purpose (**Figure 2**). In order to answer the research questions, firstly a suitable sample is determined. Scimago Journal & Country Rank (SJR), which provide the subject area weights and impact factors of the journals, was used to determine the sample. In this ranking index, when the journals with the concept of mountain in their names are examined, a total of seven journals came to the fore. Among these journals, three important criteria were developed for the validity and reliability of the research at the stage of sampling. The first one is that it has a *long publication life*, the second is that the journal focuses on *mountainous areas* as a research topic, and, last but not least, that it is among the *most influential journals* internationally. Considering these, in this study, Mountain Research Development (MRD), one of the most important journals leading mountainous field studies, was determined as the sample (**Table 1**). It is necessary to state that in addition to the developed criteria, content-based criteria are also important for the selection of this journal as a sample. The most important factor taken into consideration in this regard is that the journal includes papers from various dimensions about the mountainous areas with an interdisciplinary approach. Hereby, the research aims to deal with mountainous areas and the environmental conditions associated with these areas in a wider context in the literature. Besides, in order to follow the latest developments in the mountainous area literature, the journals must be open access, which allows the journal to have a wide readership as well as allows researchers from all over the world to access mountain studies. Having these features, MRD was chosen as an important data repository for understanding the current situation and future perspective of the mountain literature in this study.

2.2. Statistical Analysis and Assumptions

In the third stage, the method of research is determined as network analysis in line with the purpose of the research and the data set obtained. Network analysis is a visualization method which is frequently used in many fields to examine the relations of individuals, institutions or objects in the social system formally as well as the changes of these relations in the social structure in space and time (Tindall and Wellman, 2001; Al, Sezen & Soydal, 2012). In order to answer the research questions, the bibliometric data obtained were analysed with the network analysis method using the VOSviewer v.1.61 (Centre for Science and Technology Studies) Program. VOSviewer is a scientific mapping program designed for visualizing networks of bibliometric data. In the program, many bibliometric network analyses, such as co-authorship analysis and visualization of citation networks, can be performed based on the distance-based visualization approach (Van Eck and Waltman, 2007). Within the scope of the research, the concepts in the keywords as the analysis unit were subjected to co-existence analysis. According to this analysis, the most used common concepts in the keywords section of the publications in the sample were visualized by making a network analysis (**Figure 3**).

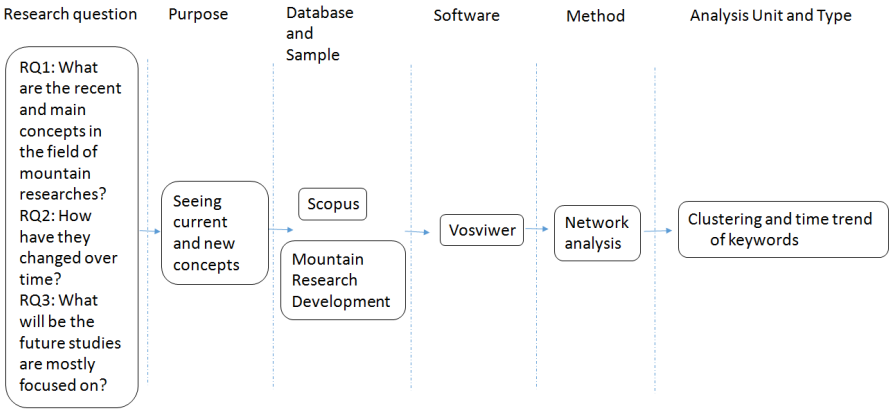

Figure 2: Research matrix (edited by using Güney et al. 2020)

Table 1: Ranking of the most influential journals in mountain range research (Resource: Scopus, 2022).

	Source title	CiteScore	Highest percentile	SJR	Publisher	Publishing since
1	Journal of Mountain Science	3.1	75% Geography, Planning and Development	0.551	Science Press	2004
2	Mountain Research and Development	3.0	75% Development	0.465	Springer Nature	1981
3	Sustainable Development of Mountain Territories	1.4	61% Sociology and Political Science	0.468	North Caucasian Institute of Mining and Metallurgy, State Technological University	2009
4	Rocky Mountain Geology	0.8	23% Geology	0.169	University of Wyoming	1998
5	Rocky Mountain Journal of Mathematics	0.8	31% General Mathematics	0.374	Rocky Mountain Mathematics Consortium	1971
6	Mountain Geologist	N/A	N/A	N/A	Rocky Mountain Association of Geologists	1964
7	Rocky Mountain Medical Journal	N/A	N/A	N/A	Colorado Medical Society	1948

In the second stage, the data set is created. The data set containing bibliometric information about 1574 works published in the MRD journal was obtained from Scopus data on 13.04.2021. In this context, the concepts used in the keywords section were determined as main data in order to evaluate the new trends towards the mountainous area phenomenon in line with the purpose of the research.

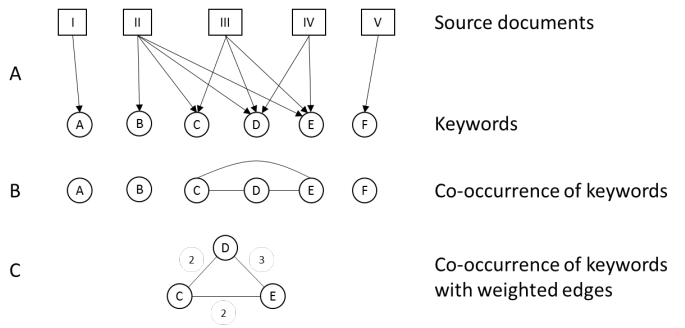

Figure 3: Demonstration of co-occurrence analysis for the concepts in the keywords section (edited by using Trujillo and Long, 2018)

The connections between the filtered concepts depending on the parameters determined during the bibliometric network analysis form cluster and time trend maps under various statistical assumptions. Within this framework, frequency, relationality, clustering and time trend analyses were performed, respectively. The statistical basis of these analyses comes from the work of Van Eck and Waltman (2010).

First of all, it is the relational score that emerges based on the frequency with which the concepts are used with each other. *Relationality* is the expression of the combination of concepts determined by the frequency assumption. It can also be given numerically or as a relational score by normalizing it, as shown in table 2. The relational score provides easier expression of high numeric expressions of the findings. Therefore, a relationality matrix is obtained by normalising the differences in the number of co-occurrence of concepts. VOSviewer first develops the similarity measure to calculate this relational score. Using power attribution, the similarity s_{ij} between the items (keywords) represented by i and j is calculated as (Van Eck and Waltman, 2010):

$$\frac{c_{ij}}{w_i w_j} = s_{ij}\ , \qquad (1)$$

Where, c_{ij} denotes the number of occurrences of i and j, and where w_i and w_j denote the total number of occurrences of i and j, or the total number of occurrences of these elements. It can be shown that the similarity between items i and j calculated using (1) is proportional to the ratio between the observed number of occurrences of items i and j on the one hand, and the expected number of co-occurrences on the other (Van Eck and Waltman, 2010).

The next step is to transfer the data into a distance-based network map. n represents the number of items to be matched. The VOS mapping technique creates a two-dimensional map in which the elements 1,…,n are placed in such a way that the distance between any pair of elements i and j reflects their similarities as accurately as possible. High-matching pairs of items should be placed close together, while low-matching items should be farther apart. The goal of the VOS mapping technique is to minimize the weighted sum of squared Euclidean distances between all pairs of elements. The higher the match between two items, the higher the weight of the squared distances in the total. Accordingly, the average distance between two items is equal to 1. Although there is no such conclusion in the Euclidean calculation, this equation is added to the algorithm as a constraint in order to prevent overlapping of nodes with high similarity in the program. In mathematical notation, the objective operation to be minimized is given as (Van Eck and Waltman, 2010):

$$V(x_1, \ldots, x_n) = \sum_{i<j} s_{ij} \left\| x_i - x_j \right\|^2, \qquad (2)$$

$x_i = (x_{i1}, x_{i2})$ vector specifies the position of i on a two-dimensional map, where $\| \bullet \|$ specifies the Euclidean norm. Therefore, downscaling is performed subject to restriction because the results are understandable.

$$\frac{2}{n(n-1)} \sum_{i<j} \left\| x_i - x_j \right\| = 1. \quad (3)$$

The constrained optimisation solution for the problem of reduction (2), which is the subject of (3), the majorization algorithm used by VOSviewer, is a variant of the multidimensional scaling SMACOF algorithm. To increase the probability of finding a globally optimal solution, the majorization algorithm can be run multiple times using a randomly generated initial solution each time (Van Eck and Waltman, 2010).

Findings from the first and second stages of the analysis give us the network maps. Therefore, in the first stage, the most used concepts among the keywords, which are the unit of analysis, were obtained. Secondly, the concepts with the highest relationality were calculated and the network map emerged. In other words, within the keywords section, a network analysis of the most used common concepts was created. To interpret these network maps, it can be stated that the program transfers units with high relationality to the network map, while excluding units with low relationality. In this way, concepts with low relevance are excluded, and concepts with high levels are filtered out and passed to more specific and more informative concepts about the general view of the literature. Concepts with high relevance tend to represent specific topics/areas and trends, while concepts with lower relevance on the map are subsidiary concepts. The distance between two related elements reflects the strength of the relationship. Nodes at closer distance are more closely related (Van Eck and Waltman, 2010, pp. 525).

In the third stage of the analysis, *cluster analysis* was carried out. Relationship networks connecting the concepts/units forming the nodes were clustered according to their spatial proximity. The clusters consist of the relationship between a set of all nodes and binary nodes, called a social network. Relations are the joint work or coexistence of these nodes with each other (Tindall and Wellman, 2001; Al et. al., 2012). In this visual analysis, first of all, the substance density $D(x)$ of a point x= (x1, x2) was calculated as (Van Eck and Waltman, 2010):

$$D(x) = \sum_{i=1}^{n} w_i K(\|x - x_i\|/(\bar{d}h)), \quad (4)$$

Here K: [0, ∞→[0, ∞)] represents the kernel function and creates the parameter called h>0 kernel width. w_i indicates the weight of the element i, that is, the total number of occurrence or co-occurrence. The kernel function K must be non-increasing. Hence, the VOSviewer Gaussian kernel function is used (Van Eck and Waltman, 2010):

$$K(t) = \exp(-t^2), \quad (5)$$

The substance density of a point on a map was calculated separately for each cluster. For a cluster p denoted by $D_p(x)$, the matter density of a point x is defined as (Van Eck and Waltman, 2010):

$$D_p(x) = \sum_{i=1}^{n} I_p(i) w_i K\left(\|x - x_i\|/ (\bar{d}h)\right) \quad (6)$$

Here $I_p(i)$ specifies an indicator function that is equal to 1 if i belongs to the cluster p. It shows the Gaussian kernel function given by K(5), as in the ordinary density view. At the end of this process, finally, cluster maps are generated (Van Eck and Waltman, 2010).

After calculating the elements' intensities, the colour of a point on the map is determined in two steps. Each cluster is associated with a colour. In the first step, the colours of the clusters are mixed with each other. This is done by calculating the weighted average of the colours, where the weight of one colour is equal to the element density for the corresponding cluster, as given in (6). In the following step, the colour obtained in the first step is mixed with the background colour (black or white) of the cluster density view. The ratio at which two colours are mixed depends on the total substance density of a point given by (4). The lower the total substance density of a dot, the closer the dot's colour to the background colour (Van Eck and Waltman, 2010). The results of the stage are interpreted on the map as follows: The density of a concept depends on both the number of neighbouring elements and the weight of these elements. VOSviewer uses a colour scheme by default. Accordingly, red has the highest intensity and blue the lowest.

In the final stage of the analysis, eventually, the *time trend* analysis, and the progress of the periodically prominent issues in other periods and the thematic areas created are shown on the map. The publication dates of the articles containing the concepts are used to determine the thematic areas that stood out here. In this case, temporal longitude analysis is possible. A thematic area can be defined as a group of themes that develop over different periods. A development map, for instance, enables the thematic areas to identify the conceptual link between the

research themes of different periods in four consecutive periods. Relationships between the year of publication and keywords are examined by time trend analysis. The analysis reveals which concepts came forward in which periods within the changing and transforming structure of the literature. Therefore, the temporal longitudinal analysis of the concepts is possible in this way, and this provides the opportunity to make important predictions about the future of the literature (Yıldız and Aykanat, 2017).

3. RESULTS

In this part of the research, answers to the following secondary questions are sought: RQ1: What are the main issues in mountain research according to the keywords or title? What kind of a pattern does their use together and their use over time reveal? In this regard, the keywords of the articles published in the MRD journal are the unit of analysis related to which subjects and concepts have been examined in mountainous field studies because, at this point, researchers give information to the reader about which concepts the work is built on. Although this section is limited to five or six words, compared to the title section, it conveys much more specific information or concepts about the work (Kozak, 2018).

3.1. Co-occurrence Network of Keywords: Cluster and Time Trend

The textual data in the keywords section of 1574 articles published in the MRD journal in the Scopus database were analysed according to their co-occurrence. In order to determine the words with conceptual value in the research, 144 concepts were found that were repeated at least 4 times out of 2512 words used in the keywords section of 1574 documents. In the analysis, the frequency and co-occurrence of the concepts, in other words 144 concepts with the highest correlation, were included in the network mapping (**Figure 4** and **Table 2**). The words that exist structurally and the words related to copyrights in the title section were ignored in the analysis. The findings regarding the frequency and concomitant use were analysed in two different dimensions. These concepts formed 9 different clusters according to their coexistence (**Figure 4** and **Table 2**). Moreover, the temporal trend of the network analysis consisting of 144 concepts was created (**Figure 5**). The results obtained from this analysis can be listed as follows:

3.1.1. Cluster One and Two: Climate Change, Protected Areas and Europe

The first cluster is represented by the colour red. There are 27 concepts in total. The basic concept in this cluster is "climate change" due to its central location and frequent use. The spatial context of this concept is continental Europe. When the other concepts in this cluster were examined, the density of spatial regions expressions such as "Switzerland", "Alps", "Austria", "Italy", "Europa" are seen (**Figure 4** and **Table 2**). The most important social phenomenon in the analysis of the concept of "climate change" in continental Europe and the Alps plane was "tourism". Once the analyses were examined, the density of the concepts such as "snowmaking", "regional development", "adaptive capacity", which are the auxiliary themes for the concept of tourism, can be seen (**Figure 4** and **Table 2**).

The closest cluster to the first cluster—the cluster of climate change—is the second cluster indicated by green. It can be said that the key concept among the 25 concepts in this cluster is "gender". Additionally, there is the concept of "women" in the cluster, which is commonly used together with gender. In the first cluster, the key concept is climate change. It can be explained by the fact that the red and green clusters are very close and intertwined, and by the concept of "climate change" is very close to the green cluster. Other frequently repeated concepts in this cluster are "conservation" and "mountains". It is seen that "protected area(s)", which are used closely with the concepts, are used intensively in the cluster too. Therefore, this gives an idea about another spatial context for the first and second clusters (**Figure 4** and **Table 2**).

3.1.2. Third, Fourth and Ninth Clusters: Spatial Analysis and the Continent of Asia

According to the analysis, the third cluster of concepts is represented in blue and there are 24 concepts. The prominent concepts in this cluster are "Pakistan", "Kyrgyzstan", "Tajikistan", "Tibetan Plateau", "Central Asia", "Tibet", "Georgia", "Karakoram". Therefore, it is seen that the spatial context of this cluster is formed by the studies in the Asian Continent and especially in the Turkic Republics (Figure 4 and Table 2). The fourth cluster is represented in yellow and there are 20 concepts. This cluster is closest to the blue cluster. This indicates that these two clusters are studied in very close areas or places. The concepts in the most central position in the fourth cluster, thus, are "Nepal", "China", "India" and "Himalaya". Factual concepts discussed in the third and fourth clusters are "migration", "remote sensing", "land cover change", "human disturbance", "soil", "species diversity" and "vegetation". Furthermore, the closest cluster to these two due to their connections and location on the network map is the ninth cluster, represented in pink. In this cluster, while the spatial context is

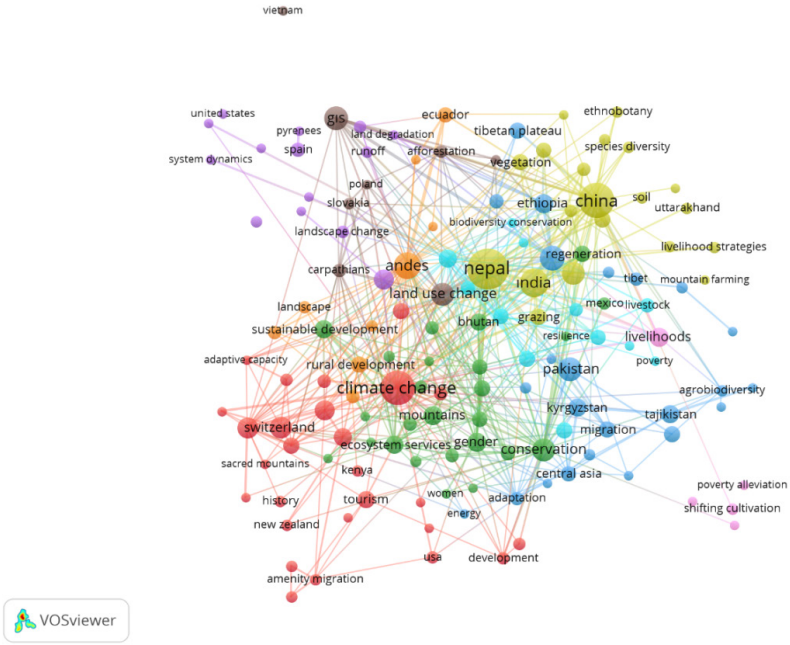

Figure 4: Clustering of the most used concepts in the keywords of the articles published in the MRD journal according to the network analysis

"Thailand", the main concept is "livelihoods". Therefore, it is seen that the studies on the Asian continent are subjects within the natural sciences in general (**Figure 4** and **Table 2**).

3.1.3. Fifth, Sixth, Seventh and Eighth Clusters: Spatial Analysis and Europe

The regional segregation in the network analysis, on the one hand, clearly shows that some research topics are also segregated regionally. On the other hand, there are studies that are common for both regions. In this sense, clusters five, six, seven and eight have been the common subjects examined in both regions due to their position and connections in the network analysis. These clusters show that the fifth cluster, which is represented in purple, has 20 concepts, and three of them stand out as key concepts, namely, "landscape change", "soil erosion", and "natural resource". Other clusters supporting this are the seventh with 12 concepts and represented in orange and the eighth represented in brown. When the concepts in these clusters are examined, it is seen that "GIS", "landscape", "land use change", "forest cover" are the main ones. As a result, clusters five, seven, and eight represent a group working with GIS-based techniques. The sixth cluster, represented in turquoise, showed little divergence from these clusters. This area is a cluster where joint agricultural studies are predominant for both continental European and Asian research (**Figure 4** and **Table 2**).

3.1.4. New Trends

The use of the concepts over the years also illustrates the change in the research focus in the literature. According to the analysis, the use of concepts such as "GIS", "landscape", "vegetation", "grazing" and "afforestation" are intense in 2006 (**Figure 5**). In 1995, the Council of Europe prepared the European Charter on mountain regions to create the concept of "European Highlands" and to develop policies for solving problems through cooperation in bordering mountain regions in the 13th Congress of Local and Regional Authorities of Europe (with the Resolution no. 202) (CLRAE, 1995). Afterwards, 2002 was declared the "International Year of Mountains" by the UN. Suggestions have been made to develop plans and policies based on cooperation between countries in order to address the mountainous areas in the context of sustainable development and to change the global perspective. These institutional movements have increased the studies in the literature to define mountainous areas, to draw their borders and to determine threshold values in this context. Moreover, the fact that geographic information systems (GIS) allows easy queries and macro-scale applications in the classification systems has made necessary changes in the criteria and threshold values used. The first global digital mapping work on the distribution of forests was held in 1996 by the UN World Conservation Monitoring Centre (WCMC) (Kapos et al, 2000). On top of this study, different criteria and threshold values are included in GIS, and the boundaries of mountainous areas are determined. Therefore, it should be emphasised that one of the

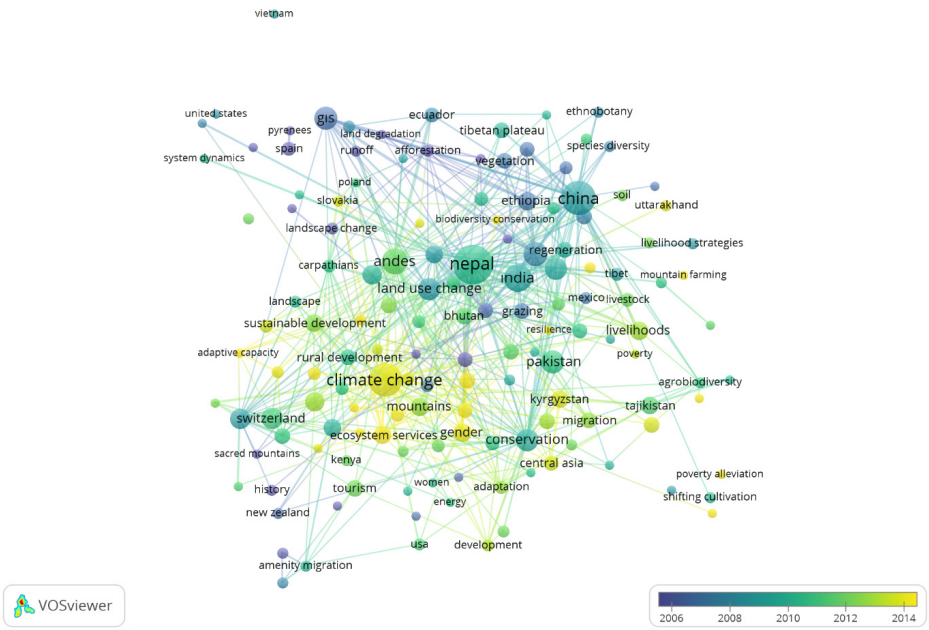

Figure 5: Time trend according to the network analysis of the most used concepts in the keywords in the articles of the MRD journal

most debatable concepts in mountain literature has been GIS and the studies related to the technique (Kapos et al, 2000; Blyth, Groombridge, Lysenko, Miles & Newton, 2002; Körner et al 2011; Karagülle et al, 2017).

Considering the development of the importance given to mountainous areas, it should be noted that 1992 and 2002 were the breaking points. Previous studies on mountainous areas were dealt with only in terms of geology and physical geography. Since these breaking points, the focus shifted to human problems in mountainous areas. In the following years, the importance given to mountainous areas at the international level has increased, and support is provided to encourage researchers to work in these areas. According to the report of the European Economic Area (EEA), which was published in 2010 and includes 10 messages for mountainous areas in Europe, the mountainous areas are both very fragile as well as rich. They are seriously affected by changes in factors such as agriculture, tourism, deforestation, climate change and natural disasters. This is interpreted as the low resilience of mountainous areas. In order to protect and develop the sensitive structure of mountainous areas, the necessity of strengthening the local with international cooperation is emphasised. In this context, mountain studies focused on local and regional development have increased in these years. New mountainous areas studies have emerged, resulting in keywords such as "China", "Nepal", "Switzerland" and "Pakistan". The diversification in the field of study is also reflected in the theoretical concepts. Accordingly, especially the concepts of "conservation", "ecosystem", "land use change" draw attention (**Figure 5**).

It can be said that the most discussed problem in mountain studies in the analysis is climate change and related risks because the areas are sensitive ecosystems and vulnerable to climate change. The climate has begun to change globally since the last quarter of the 20th century, due to factors such as the use of fossil fuels as an energy source after the Industrial Revolution, the inability to reabsorb the gases released into the atmosphere, the greenhouse effect of the world system, and intense urbanization (Stocker et al 2013; Swinburn et al 2019). According to the Stocker et al (2013), anthropogenic pressures have increased the intensity of extreme weather and climate events since 1950. The change poses a huge threat to clean water resources, biodiversity, economic activities and social structures in mountainous areas. At this point, instead of perceiving mountainous areas as isolated, marginal, forgotten or excluded places, their water basins, military and strategic locations, the positioning of observatories and communication tools should be evaluated all together with the sheltered opportunities they offers for an alternative future (Sarmiento, 2011). In the light of these sensitivities, concepts such as "climate change", "gender", "biodiversity" and "adaptive capacity" have been used more frequently in the period after 2014. Another finding is that these most recent concepts are specific to Europe, which creates a spatial context for the first and second clusters (**Figure 5**).

Table 2: Statistical results of the most used concepts in the keywords of the articles published in the MRD journal

No.	Keywords	Frequency	Frequency of connection	Cluster	No.	Keywords	Frequency	Frequency of connection	Cluster
1	climate change	45	76	1	**73**	grazing pressure	4	6	3
2	Switzerland	19	29	1	**74**	Karakorum	4	7	3
3	Alps	18	36	1	**75**	Pamirs	4	8	3
4	Italy	16	28	1	**76**	water management	4	7	3
5	European alps	13	24	1	**77**	Nepal	66	113	4
6	tourism	12	22	1	**78**	china	49	65	4
7	Austria	10	17	1	**79**	India	32	57	4
8	sustainability	10	21	1	**80**	Himalaya	21	45	4
9	policy	7	17	1	**81**	grazing	10	21	4
10	water	7	14	1	**82**	vegetation	10	18	4
11	development	6	10	1	**83**	Yunnan	10	28	4
12	Ladakh	6	9	1	**84**	land cover change	9	19	4
13	USA	6	9	1	**85**	medicinal plants	7	17	4
14	water governance	6	12	1	**86**	disturbance	6	9	4
15	amenity migration	5	10	1	**87**	ethnobotany	5	9	4
16	Canada	5	5	1	**88**	human disturbance	5	11	4
17	history	5	12	1	**89**	livelihood strategies	5	6	4
18	Kenya	5	7	1	**90**	pasture management	5	10	4
19	mountain communities	5	9	1	**91**	soil	5	5	4
20	New Zealand	5	7	1	**92**	species diversity	5	10	4
21	adaptive capacity	4	8	1	**93**	Uttarakhand	5	5	4
22	Europe	4	9	1	**94**	mountain farming	4	6	4
23	regional development	4	7	1	**95**	nature conservation	4	9	4
24	resettlement	4	6	1	**96**	plant diversity	4	7	4
25	sacred mountains	4	7	1	**97**	Peru	16	33	5
26	snowmaking	4	10	1	**98**	Spain	8	14	5
27	urbanization	4	7	1	**99**	landscape change	6	11	5
28	conservation	21	47	2	**100**	soil erosion	6	11	5
29	gender	15	37	2	**101**	forest management	5	8	5
30	mountains	14	19	2	**102**	runoff	5	7	5
31	sustainable development	13	27	2	**103**	land degradation	4	16	5
32	ecosystem services	13	26	2	**104**	mountain development	4	6	5
33	Bhutan	12	16	2	**105**	mountain tourism	4	7	5
34	sustainable development goals	10	32	2	**106**	natural resource management	4	4	5
35	regeneration	10	20	2	**107**	Pyrenees	4	10	5
36	community forestry	9	20	2	**108**	system dynamics	4	5	5
37	agenda 2030	9	30	2	**109**	united states	4	3	5
38	participation	8	19	2	**110**	water quality	4	7	5
39	protected areas	7	11	2	**111**	biodiversity	13	30	6
40	global change	7	13	2	**112**	land use	11	29	6
41	agroforestry	7	13	2	**113**	vulnerability	10	17	6
42	natural hazards	6	9	2	**114**	deforestation	9	25	6
43	Mexico	6	7	2	**115**	Himalayas	9	22	6
44	protected area	5	12	2	**116**	agriculture	8	27	6
45	perceptions	5	11	2	**117**	livestock	8	19	6
46	women	4	12	2	**118**	land cover	7	15	6
47	transdisciplinary research	4	12	2	**119**	biodiversity conservation	4	4	6
48	resilience	4	10	2	**120**	farming systems	4	9	6
49	Norway	4	7	2	**121**	fuelwood	4	8	6
50	family farming	4	7	2	**122**	poverty	4	9	6
51	environment	4	10	2	**123**	Andes	28	59	7
52	Argentina	4	5	2	**124**	rural development	11	30	7
53	remote sensing	24	45	3	**125**	Ecuador	9	15	7
54	Pakistan	23	34	3	**126**	Bolivia	7	11	7
55	Ethiopia	14	29	3	**127**	Chile	7	6	7
56	Kyrgyzstan	13	24	3	**128**	landscape	6	17	7
57	Tajikistan	13	24	3	**129**	perception	5	11	7
58	migration	11	24	3	**130**	mountain agriculture	4	11	7
59	food security	10	23	3	**131**	Paramo	4	10	7
60	Tibetan plateau	10	8	3	**132**	GIS	23	47	8
61	Central Asia	9	16	3	**133**	land use change	20	51	8
62	precipitation	8	9	3	**134**	Carpathians	7	22	8
63	adaptation	7	20	3	**135**	afforestation	6	16	8
64	Tibet	7	8	3	**136**	Slovakia	5	14	8
65	agrobiodiversity	5	10	3	**137**	forest cover	4	17	8
66	elevation	5	10	3	**138**	Poland	4	13	8
67	pastoralism	5	10	3	**139**	Vietnam	4	1	8
68	species richness	5	13	3	**140**	livelihoods	15	36	9
69	sustainable mountain development	5	8	3	**141**	shifting cultivation	5	5	9
70	capacity building	4	4	3	**142**	Laos	4	4	9
71	energy	4	6	3	**143**	poverty alleviation	4	4	9
72	Georgia	4	3	3	**144**	Thailand	4	2	9

4. DISCUSSION AND FUTURE DIRECTIONS

In this paper, the evolution and bibliometric structure of mountainous areas studies, which is an interdisciplinary field, were examined.

Within the framework of the main objectives of the research, three main research questions were formed and the answers to these questions were reached within the scope of the research. In this context, the outputs of the findings obtained from the research can be summarized as follows:

First of all, it turns out that many researchers examine different subjects in the mountainous area literature. As a research area, the majority the studies focused on natural sciences, environment and agriculture. The names "Nepal", "China" and "India", which give information about the research field in the thematic issues discussed, reveal the dominant locations in their studies. In addition to the spatial distribution, the concepts of "climate change", "remote sensing", "GIS" and "land use change" constitute thematic distribution in mountainous area studies. These concepts also show which themes the future studies in natural sciences will be based on. When the temporal development of the literature is examined, this research determined that the study subjects of mountainous areas have diversified and the field of natural sciences has remained in the background, within the scope of the increasing number of studies and interdisciplinary collaborations. In this sense, this study found that certain fields of study have come to the fore since the 2010s, and concepts such as "climate change", "gender", "biodiversity" and "adaptive capacity" have been increasingly used. This shows that researchers from social sciences as well as natural sciences are articulated in mountainous area studies. This shows that research on "climate change" is diversified in terms of subject. In addition to the physical findings of climate change, gender, sustainability, etc. are now mentioned in the literature. This shows that it is often associated with concepts.

An analysis of the journal also allows an evaluation of the performance of the journal. Paper type and methods used were determined. In this sense, the results of the research can give an idea about the concept of the special calls that the journal will open in the future. This evidence will be helpful in developing the field as the scholars will be able to identify the topics currently being researched by further analysing the issues.

As a result, it should be underlined which concepts should be emphasized for future research. We see that interdisciplinary studies are gaining importance in mountainous areas. However, it would be beneficial to focus on the concepts of climate change, ecosystem, biodiversity and sustainability.

This paper deals with the development of mountain literature through a journal in terms of its findings. It should be noted that the research was conducted using only the Scopus database, thus it has limitations. For future research, it would be useful to correlate the findings of the research, which is conducted on solely one journal, with the findings of a more comprehensive study to be conducted by evaluating different sources. In other words, besides the studies obtained merely through MRD, journals such as Journal of Mountain Science, Sustainable Development and Mountain can be added to the analysis to achieve more comprehensive results about the topic. Apart from this, the research was carried out only on keywords. No evaluation was made regarding the words in the title and abstract. In conclusion, considering the limitations of the study, it can be stated that this study could be a start for future research.

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