

## CLUSTER ANALYSIS OF RISKS AND VULNERABILITIES FOR ENVIRONMENT SUSTAINABLE MANAGEMENT

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**Abstract:** *The purpose of this paper is to explore the way scholars have approached the role of concepts like 'risks and vulnerabilities' within the framework of environment sustainable management. We developed this bibliometric exploration on a period of 10 years including papers indexed in Scopus database and used the specialized VOSviewer software. A strong argument for the importance of this investigation is that the concept of risks associated to the environment sustainable management is frequently encountered in research papers but the concept of vulnerabilities approached in the same context has not been the focus of too many studies yet. Considering the basic premises that in any domain, organization, or system, vulnerabilities represent the sources of potential risks thus we should have the capacity to timely identify these and prevent them from becoming real risks. The analyses developed through VOSviewer software reveal several types of conclusions. Findings show that there is a strong interest for publishing papers on subjects like "environment risks", "risk analysis" or "environment sustainability" but very low ratings of papers dealing with "vulnerabilities" in this area which results in a knowledge gap for the field. We shall present in detail the journals' clusters and their focus in the area of environment sustainable management. A major contribution of this paper comes from revealing this knowledge gap in the scientific literature between the concepts of risks and vulnerabilities in the field of environment sustainable management. Another useful contribution might be considered the detailed journals' cluster analysis revealing the most popular topics and their networks. Also, an important outcome is the chronological evolution of publications on the key concepts thus depicting the scholarly trend.*

**Keywords:** cluster analysis, environment, risk management, sustainable management, sustainability, vulnerabilities.

**JEL classification:** M21, G32, Q01, Q54.

### 1. Introduction

This paper seeks to explore how the authors approached the concepts of "risks" and "vulnerabilities" in the current context when it became a necessity to approach environmentally sustainable management. We focused on identifying the connections between the two concepts and the field of sustainable environmental management, similar to the existing connections in general risk theory (Massingham, 2010) as well as in studies focused on climate change (McCarthy et al., 2001). By "vulnerabilities" we mean the weaknesses of some systems in relation to certain external forces that can generate physical, financial, operational or human damage. Vulnerabilities are often the ones that

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lead to different reactions of systems to changes in the external environment. In the study of climate change, the concept of vulnerability is described as "the extent to which a system is susceptible or unable to cope with the effects of climate change, including variability and climate extremes" (McCarthy et al., 2001, p. 995). On the other hand, the concept of "risks" means those extreme events that could occur with serious negative consequences on a system. The link between the two dimensions, both in theory and in practice, is that reducing the vulnerability of a system will reduce the likelihood of risk (Tiberius et al., 2020). Even though it is closely interdependent, the relationship between vulnerability and risk is not symmetrical, so "reduced vulnerability always means reduced outcome risk, but reducing outcome risk does not always reduce vulnerability" (Sarawitz, Pielke & Keykhah, 2003, p. 809). The topic of "risks" becomes attractive to researchers, especially during economic or complex crises such as the recent COVID-19 pandemic, and growing interest in the resilience of organizations, which is becoming crucial (Baldwin & Weder di Mauro, 2020; Bratianu & Bejinaru, 2021; Kraus et al., 2020; Sapountzaki, 2012).

Currently there are a multitude of papers in the literature dedicated to sustainable environmental management systems but also an uncertain perspective on the connection between risks and vulnerabilities in research. Thus, a bibliometric analysis with VOSviewer can contribute to the understanding of semantic clusters and publication clusters that scientifically outline the two notions (Van Eck & Waltman, 2010, 2011).

## **2. Literature review**

Until now, risk management has been discussed in various fields, but mainly in the financial, climate, health and social fields. In the recent context, more attention is directed to the field of sustainability risk and thus there is an intensified development of risk management systems in the field of data, information and knowledge management. Nowadays, knowledge risk management is expanding rapidly "providing solutions to problems already known to conventional methods of risk management" (Massingham, 2010, p. 465). In the literature it can be easily seen that the attention of researchers has focused on the potential risk of loss of knowledge being already known the negative effects of this phenomenon at the organizational level, especially in the case of retirement of experienced employees (Durst & Wilhelm, 2013; Durst, Hintereger & Zieba, 2019; Durst & Henschel, 2020; Jennex, 2014). We also identified more precise perspectives on knowledge loss, according to DeLong (2004), who argues that managers lose control of "knowledge retention" in the organization, as opposed to other processes such as knowledge creation, transfer, or management. To this end, managers must act effectively as they may at any time lose the critical skills they are already dependent on (DeLong, 2004, p.8). Here we bring to attention the theory according to which the most effective method of retaining knowledge is the stimulation of intergenerational learning (Bejinaru et al., 2018; Bratianu & Leon, 2015; Bratianu et al., 2011). In a systematic review of the literature, the idea is argued that "knowledge risk refers to the probability of knowledge loss in the processes of identifying, storing or protecting them which can decrease the operational or strategic benefit of a company" (Durst, 2019, p.21). The risks most frequently discussed are: loss of knowledge, forgetting knowledge, outsourcing of knowledge, leakage of knowledge, concealment of knowledge, spill of knowledge, accumulation of knowledge, unlearning and inadequate skills of some employees (Durst & Zieba, 2018). In addition to identifying these risks related to the internal organizational dimension of work, we should also evaluate the risks that are generated by the external and contextual dimensions, which can represent significant negative effects on employees. It is already obvious that we need to pay close attention to more and more types of knowledge-related risks that may arise during organizational

changes, changes in strategies, or global changes such as the health crisis and the war crisis (Ahmed, Qin & Martinez, 2019; Yu et al., 2020).

The concept of risk is discussed in the literature in many areas with considerable practical implications. Through this paper we set out to draw attention to a new "buzzword", namely "vulnerabilities". Advanced research in the field of risk management could benefit from the perspective of substantiating this theory because the source of risk is in fact a vulnerability of the system, organization or processes. Early identification of vulnerabilities and their reduction or even elimination will bring important and beneficial results in the continuous and unpredictable fight against risks. The notion of vulnerability has not been as intensely and advanced studied as the notion of risk. However, there is a solid argument for which vulnerabilities should be studied in conjunction with the risks being closely interconnected. In this regard, we can say that vulnerabilities are potential elements of risk triggers (Sapountzaki, 2012; Sarawitz et al., 2003). In this sense, we bring to the fore the comprehensive remark of Fuchs et al., (2012), according to which "vulnerability assessment requires an ability to identify and understand the susceptibility of elements exposed to risks and - in a broader sense - of society to these dangers" (p. 1969). Continuous measurement and monitoring of vulnerabilities is essential for strengthening the resilience of sustainability management systems (Belsis & Kokolakis, 2005; Yu et al., 2020). Knowing the vulnerabilities of the knowledge management systems helps in mitigating the potential consequences of knowledge risks and in increasing the organizational knowledge entropy (Bratianu, 2019). The difficulty in working with knowledge vulnerabilities and knowledge risks comes from their nonlinear nature (Bratianu & Vasilache, 2009) which in practice means increased uncertainty.

### **3. Methodology design**

We consider that using this type of analysis with the help of VOSviewer software has the following foundation. Dealing with risks and vulnerabilities is a reality in all areas of life. Moreover, in the field of sustainable environmental management, their forecasting and counteracting is a priority. In this sense, it is useful to analyze the connections that exist in theory and that have a direct relationship with practice. With the help of the bibliometric analysis from VOSviewer it is possible to structure the already existing knowledge in the literature, of the theories that are outlined in this space as well as to formulate specific policies based on the analyzes.

We designed our research, using the specialized software VOSviewer version 1.6.16, into two stages: a) a network analysis based on published papers of the concepts "risks" and "vulnerabilities" to identify the specific way of using the concepts environment management systems; b) a bibliometric cluster analysis integrating the journals' thematic interests (Van Eck & Waltman, 2010, 2011). For the VOSviewer analysis we used SCOPUS as the database, and searching expressions like "vulnerabilities", and "risks" which generated significant results and satisfactory leads for our investigation. We couldn't exclude neither avoid keywords like "risk management", "environment risk management" or "risk management and vulnerabilities". We performed several analyses such that we could capture the links between the semantic clusters of these concepts (Zupic & Cater, 2015). The first search was for "risk management" keyword and obtained a total of 135624 results which we further filtered introducing also "vulnerabilities" keyword. The resulted database is analyzed through network analysis, density map, overlay map, and clusters table in the following sections.

### **4. Concepts bibliometric analysis**

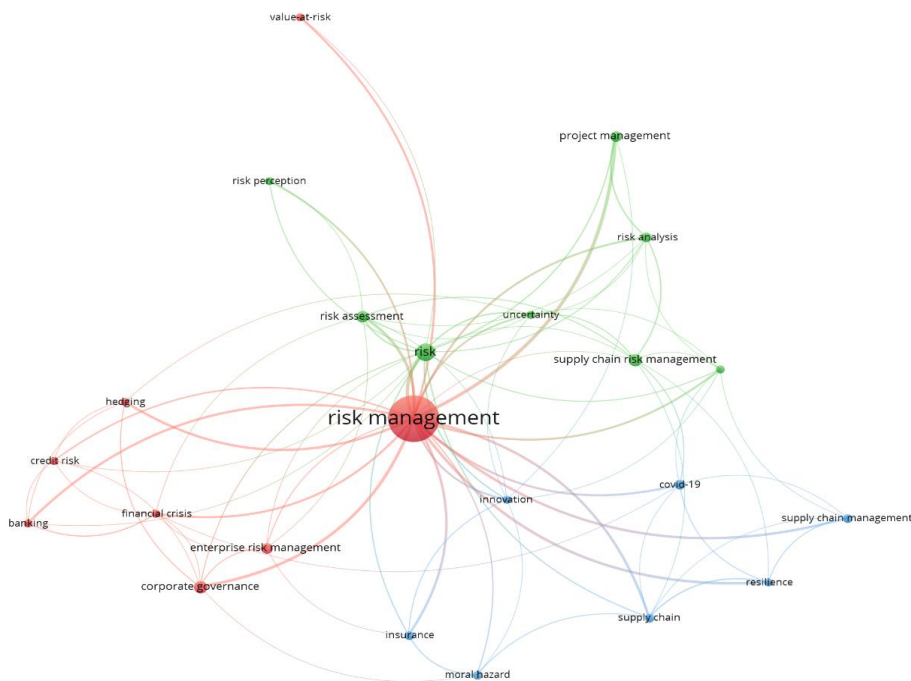
The network analysis in VOSviewer extracts from the total amount of literature and shows the following information: the most frequently used keywords in published papers and also

the links between them which leads to the formation of clusters. Interpreting these thematic clusters can reveal important information for future research in the field.

From figure 1 it can be seen that the 3 clusters, red, green and blue are very well defined and homogeneous which offers a lot of clues and similarities with "organizational risk management". The red cluster highlights risk management in organizations through representative key terms: "enterprise risk management", "corporate governance", "banking risk management", "financial crisis", "credit risk", "hedging" and "value at risk". It is interesting to observe the position of the red item "Value-at-risk", i.e. at the upper limit of the chart but at the greatest distance from the center of the network. This item could symbolize a particular theme, or a sub-theme of the field of risk management, namely risk awareness on "value". In this context, the term value can cover several meanings: financial resources, human resources, natural and environmental resources, innovation and know-how, opportunities and any other aspect considered "valuable" and which becomes vulnerable at some point.

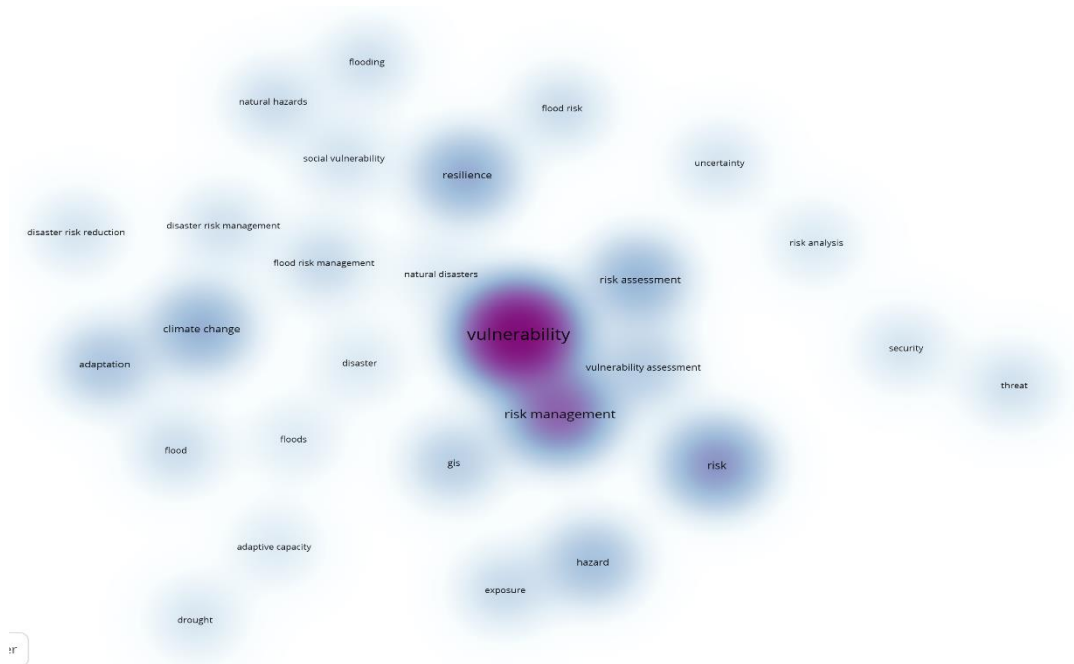
The green cluster highlights the process, methods and strategies of risk analysis in organizations and contains 8 items. Thus, terms such as "risk assessment", "risk analysis", "risk perception", "project management", "supply chain risk management" and "uncertainty" - all reveal the organizations' continuous focus on forecasting, preventing, assessing potential risks coming from the future, from the present context or backfiring from past decisions and actions.

The blue cluster is the smallest, containing only 7 items, namely: "innovation", "insurance", "moral hazard", "supply chain", "covid-19", "resilience" and "supply-chain-management". Rather, they highlight various directions of response - protection - resilience and reconstruction through innovation in the probability of major adverse events. Thus, we consider that this cluster has as its thematic core the strategies of risk management, insurance, innovation and resilience in problematic situations such as the COVID-19 pandemic or the disruption of supply chains (Bratianu & Bejinaru, 2021).



**Figure 1.** Network analysis of "risk management"  
Source: author's elaboration

Another output of the VOSviewer software, the density map, in figure 2, shows which terms are the most invoked by placing them in the center of the figure with larger purple halos, which are the terms connected to each other revealed by the short or large distance between the shapes and also which are the novel items and less approached during the analyzed period as they are located towards the edges and have very light blue color. We consider these bibliometric outputs useful for practice and further research as it brings to light the concentration of existing knowledge and also the knowledge gaps in the field, which in some cases are more important and interesting to explore (Prelipean & Bejinaru, 2021).

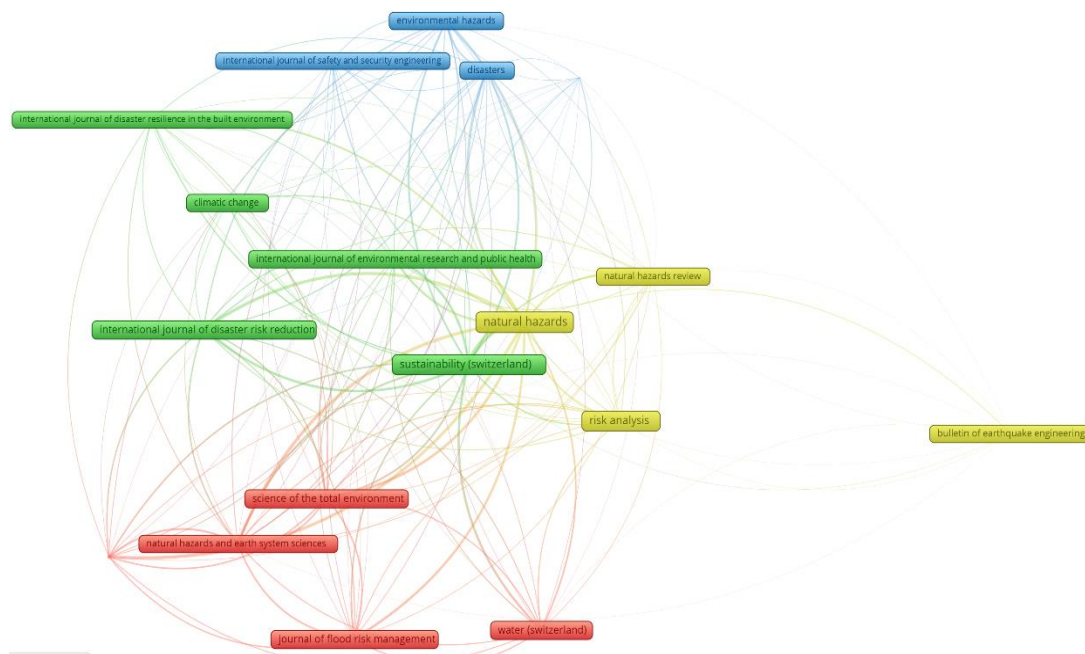


**Figure 2.** Density map for “vulnerability” during 2010-2020  
Source: author’s elaboration

### 5. Journals’ cluster analysis based on network visualization

A relevant analysis for an emerging topic, like “vulnerabilities” in the field of risk management, is based on the co-citation criteria. Thus, in this case, clusters are formed according to the co-citation principles (Korte et al., 2021). Journals which include the most cited papers within the SCOPUS database – on the topic of “vulnerabilities” are identified and connected to each other in the network. These clusters are truly relevant for the purpose of identifying which journals focus the most on the topic that we are investigating and which is their connection to other journals (Alayo et al., 2021). Applying this protocol of analysis, we reached to a *Network visualization of journal clusters* like in figure 3. In order to obtain compact clusters, we applied the limitations of 20 (items) for minimum number of documents of a source and 20 (items) for minimum number of citations of a source. We applied such a high threshold in order to obtain only the most relevant journals for our essential keyword, which is “vulnerabilities”. The network visualization in figure 3 is really eloquent for this stage of the analysis and the compact clusters are indeed relevant for our debate. In the following we discuss Table 1 with composition of journals clusters.

Throughout the network visualization of journal clusters, in figure 3, we can observe 4 clusters out of which three have many strong connections while the yellow one is quite separated on the right side of the picture. The position of the yellow cluster suggests a different approach of the “vulnerabilities” topic and we shall further discuss its composition. The center of the network is dominated by journals with focus on “hazards”, “environment & public health” and “sustainability”. This insight is important as it reveals the exact journal titles which incorporate the most research papers on “vulnerabilities”. The four clusters are somehow associated to different specialized areas according to the journals’ aim and scope.



**Figure 3.** Network visualization of journal clusters  
 Source: author’s research

We built the clusters table 1, according to the items’ values for the parameters: total link strength, occurrences and links. We considered as the first cluster, the yellow one, because it comprises the item with the highest total link strength value, namely, the journal Natural Hazards = 3620 and its central position is also relevant in this sense. This journal impact is the greatest as it is its existence of 34 years under the edges of Springer Link Publishing. Natural Hazards journal is dedicated to research papers in the thematic areas of natural hazards, forecast and risk management of catastrophic events, the type of precursors of natural and/or technological hazards. Adding up this knowledge to the cluster visualization we could say that the journal definitely promotes and enables research of “vulnerabilities” and “risk management”. Also in cluster 1 we have the journals:

- *Risk Analysis* – is a journal ranked 10<sup>th</sup> in the ISI Journal Citation Reports, in the category of social sciences - mathematical methods and is a journal of major interest for research in the field of risk analysis;
- *Natural Hazards Review* – is a journal with interdisciplinary approaches that incorporates research on a series of events, processes and effects that occur when natural hazards intersect with the physical, social, economic and engineering dimensions of society in which people interact with and use them.

- *Bulletin of Earthquake Engineering* – it publishes original research, verified in a peer-review system, in the field of earthquake engineering; the coverage includes studies on seismic hazards and risk mitigation methods; presents the mechanisms generating earthquakes and the detailed description of the phenomenon as well as the implementation within the engineering applications; earthquake scenario and vulnerability analysis; earthquake codes and other improvements.

**Table 1:** Composition of journals clusters

| ITEMS   | Cluster 1  | Link strength | Occurrence | Links      |
|---|--|---------------|------------|------------|
| <b>Natural Hazards</b>  | Cluster 1 – YELLOW<br><br><b>Natural Hazards</b><br><br>(3620 total link strength)                     | <b>3620</b>   | <b>55</b>  | <b>117</b> |
| Risk Analysis   |  | 588           | 34         | 17         |
| Natural Hazards Review  |  | 379           | 15         | 17         |
| Bulletin of Earthquake Engineering                                    |  | 34            | 13         | 10         |
| ITEMS   | Cluster 2  | Link strength | Occurrence | Links      |
| <b>Sustainability (Switzerland)</b>                                   | Cluster 2 – GREEN<br><br><b>Environmental Sustainability</b><br><br>(2360 total link strength)         | <b>2360</b>   | <b>42</b>  | <b>17</b>  |
| International Journal of Disaster Risk Reduction                      |  | 1125          | 21         | 16         |
| International Journal of Environmental Research and Public Health     |  | 731           | 14         | 17         |
| International Journal of Disaster Resilience in the Built Environment |  | 390           | 10         | 16         |
| Climatic Change   |  | 249           | 13         | 16         |
| ITEMS   | Cluster 3  | Link strength | Occurrence | Links      |
| <b>Natural Hazards and Earth System Sciences</b>                      | Cluster 3- RED<br><br><b>Natural Hazards &amp; Flood</b><br><br>(1158 total link strength)             | <b>1158</b>   | <b>14</b>  | <b>17</b>  |
| Science of the Total Environment                                      |  | 991           | 23         | 17         |
| Journal of Hydrology  |  | 946           | 10         | 16         |
| Journal of Flood Risk Management                                      |  | 809           | 24         | 16         |
| Water (Switzerland)   |  | 668           | 25         | 17         |
| ITEMS   | Cluster 4  | Link strength | Occurrence | Links      |
| <b>Disasters</b>  | Cluster 4 – BLUE<br><br><b>Environmental Disasters &amp; Security</b><br><br>(788 total link strength) | <b>788</b>    | <b>16</b>  | <b>17</b>  |
| Environmental Hazards   |  | 788           | 13         | 17         |
| International Journal of Safety and Security Engineering              |  | 220           | 10         | 16         |
| Wit Transactions on Ecology and the Environment                       |  | 104           | 10         | 16         |

Source: author's research

Journals in cluster 2, the green one, reflect predominantly the area of environmental sustainability and climate change. The central journal of this cluster is *Sustainability*



(Switzerland) with a total link strength = 2360. It is interesting to note that this journal has a “cross-disciplinary scholarly, open access approach of environmental, cultural, economic and social sustainability of human beings, which provides an advanced forum for studies related to sustainability and sustainable development”. The message of the journal’s high scores is that cross-disciplinarity might be a new lead of better research outcomes. The second cluster in green color, comprises four more journals:

- *International Journal of Disaster Risk Reduction*: is a specialized journal for researchers, policymakers and practitioners in various disciplines, such as: earth sciences and related issues; environmental sciences; engineering; urban studies; as well as geography and social sciences. Furthermore, it is interesting to notice that among its key topics there are included: *vulnerability analysis and vulnerability trends*, together with multifaceted disasters, emerging risks, resilience against disasters, etc. Thus, also this journal particularly encourages papers that approach risk from a multi-disciplinary perspective.
- *International Journal of Environmental Research and Public Health*: publishes interdisciplinary research in the field of environmental health sciences and public health.
- *International Journal of Disaster Resilience in the Built Environment*: is focused on the development of knowledge and capacity in the strategic and practical fields aimed at reducing the risk of disasters, response and reconstruction in order to reduce the potential impact of natural and anthropogenic hazards. Among the key topics of this journal, we identified: *empowerment of women and vulnerable groups*.
- *Climatic Change*: this journal devotes its full content to the problems of climate change and climate instability from the perspective of describing the causes, the implications and the interactions between them.

According to the above presented, the purpose of these journals is to promote research on environmental and climate change issues from analytical and strategic perspectives in order to foresee, to prevent, and to build resilience regarding the negative phenomena (Bejinaru & Baesu, 2013; Vogel & Güttel, 2013). This approach is based on the acknowledging of several types of system vulnerabilities in this domain and this leads to a major focus on solutions generated throughout research.

Third cluster, the red one, we called *Natural Hazards & Flood*, as it is suggested by the titles and purpose of the comprised journals:

- *Natural Hazards and Earth System Sciences*: embraces a holistic Earth system science approach and targets a numerous community of researchers, practitioners and policy makers who are interested due to their competencies to detect natural hazards, to monitor and evaluate vulnerability and to assess risks in order to design and implement mitigation and adaptation policies, involving economic, social and educational issues.
- *Science of the Total Environment*: it is a journal with a great interdisciplinary openness that includes innovative research which will develop a high impact on the environment, at the interface between atmosphere, lithosphere, hydrosphere, biosphere, and anthroposphere.
- *Journal of Hydrology*: through its works reflects political and management issues with impact on the economic and social environment; the articles are either original research or comprehensive reviews within the subfields of hydrological sciences.
- *Journal of Flood Risk Management*: it is an international platform focused on flood risk and offers the possibility of exchanging information globally.
- *Water (Switzerland)*: the journal scope encompasses several research themes: -Water resources management; -Water governance; -Hydrology & hydraulics; -Flood risk; -Urban water management and other topics in the field.



The main conclusion after analyzing this cluster is that these life domains face continuously multiple risks and vulnerabilities and thus research is intense and the interest is never decreasing but rather increasing due to the emergence of new difficulties that need new solutions and policies.

The fourth cluster, in blue color, that we called *Environmental Disasters & Security* has the lowest representation on the network and the lowest values for all indices. However, it provides certain insights on the security field. Thus, the cluster contains the following journals:

- *Disasters*: it is a well-established, quarterly peer-reviewed journal that provides reports on all aspects of disaster research, policies and management.
- *Environmental Hazards*: highlights the human and political dimensions of hazards in an innovative, interdisciplinary and international research manner.
- *International Journal of Safety and Security Engineering*: includes a range of related areas such as crisis management; security engineering; natural disasters and emergencies; terrorism; IT security; man-made hazards; risk management; control; protection and mitigation issues.
- *Wit Transactions on Ecology and the Environment*: -offers an international platform for debates on the impact of various environmental issues encountered today, taking into account scientific, economic and social aspects; a major theme is how to ensure sustainability.

At this point we may say that the journals are opened to research on risk and vulnerabilities management, as stated by their Scope and Key topics, but scholars have not focused their research towards such an intensive and specialized topic as “vulnerabilities”. Presently, this key issue is related more to natural, environmental, health, engineering sciences and only partially to knowledge management field.

It is critical to acknowledge the gap, in the sense that academic editors of prestigious journals, have launched the “vulnerability” paradigm (as demonstrated through their scope) but from the amount of research papers there is little focus on the specific idea of “vulnerability” and it is approached mainly in relation to other traditional issues like: natural hazards, climate change, engineering security or social risks.

Throughout this paper we want to show the gap (in academic literature) and argue the need for a better approach towards “vulnerabilities” in the organizations’ management. We define this new paradigm as vital for any organization – just as human life, wildlife or nature’s life is vulnerable to disasters and different levels of risk, the same way, the organizational life is vulnerable to many known or unknown risks. In this sense, any organization should have strategies to minimize their vulnerabilities or to block, avoid, or diminish threats.

## **6. Journals’ cluster analysis based on overlay map and chronological evolution**

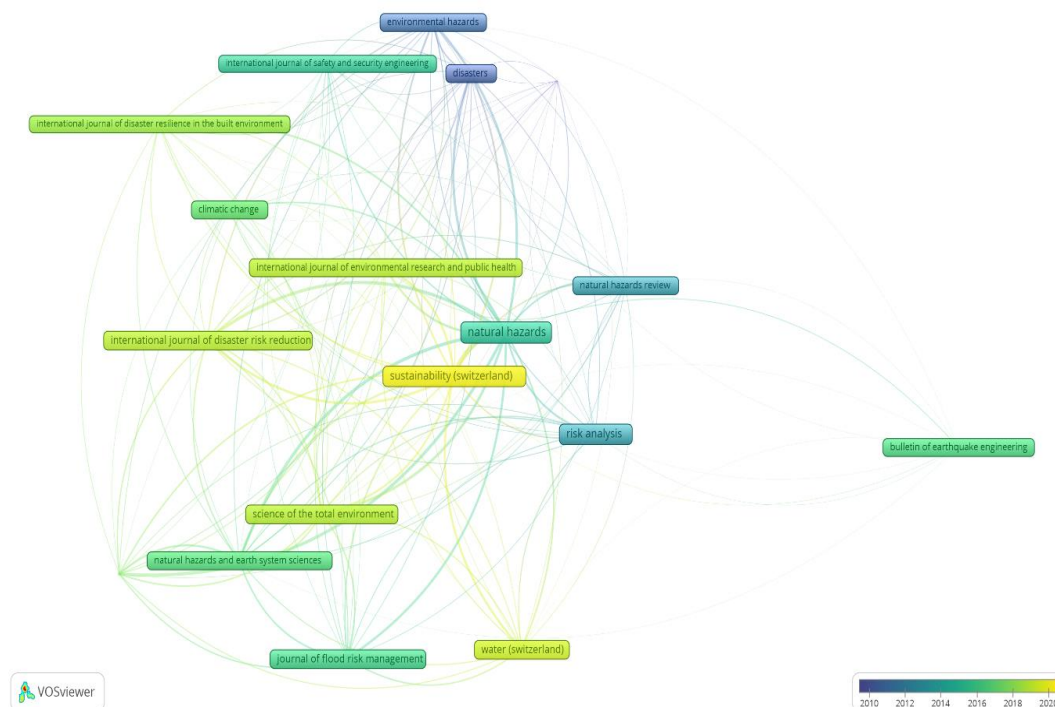
Appreciating that journals’ orientation has an important contribution to the evolution of research we extracted from VOSviewer an overlay map for bibliographic coupling by sources during 2010-2020. This overlay map, in figure 4, is relevant as it shows the chronological evolution of the scientific discourse across the fields of natural hazards, risk management, climate change and sustainability.

It is interesting to observe that clusters from 2012, 2014, 2018 are represented by specialized journals as *Environmental Hazards* (2012), *Natural Hazard Review* (2014), *Journal of Flood Risk Management* (2016), while in the latest (2020) the journal *Sustainability* has the greatest number of publications and more exactly *Avg.pub.year. 2019,52*. Looking at *Sustainability* journal we could assume that having a multidisciplinary field represents an advantage for scholars interested to publish interdisciplinary and cross-disciplinary research works.

The Overlay map, in figure 4, is showing the academia interest in publishing papers related to the knowledge management risk field but relating also to vulnerabilities – according to the search formula:

( TITLE-ABS-KEY ( "risk\* management" ) ) AND ( vulnerabilit\* ) AND ( LIMIT-TO ( EXACTKEYWORD , "Vulnerability" ) OR LIMIT-TO ( EXACTKEYWORD , "Vulnerability Assessments" ) )

Having already reviewed the journals' scopes and topics we can now understand the authors' motives of choosing a certain publication.



**Figure 4.** Overlay map of journals 2010-2020 from bibliographic coupling by sources  
 Source: author's research

The chronological systematization of the journals shows an oscillatory dynamic of the topics on risk management and vulnerabilities. As we can observe from Figure 4 and from Table 2, in 2010 the discussions on these topics started in the research filed of ecology with evidences in a single journal marked only by a dark purple dot at the right upper corner of figure 4, published in the WIT journal. Later in 2012 the interest increased towards journals specialized on major topics like hazards and disasters. In 2014 we can observe into the focus, at the center of the overlay map, two important journals, which are also intensively connected to many other journals on the map.

Starting with 2016, we notice that both the number of journals and the topics addressed have multiplied. Several profile journals have appeared, with topics that have a common basis but are diversified into various other related fields. Thus, we have topic associations between: engineering and earth sciences; risk management and flood; safety and security engineering. In this sense, we can say that the publishing area has expanded through interdisciplinarity but the main purpose has remained risk management.

Later, the year 2018 brings to attention a new range of topics associated with risk management, namely: disaster resilience and public health; and risk reduction and environment. These themes are highlighted through 4 journals that can be seen in the shade of lime green on the overlay map in figure 4.

The year 2020 brings to the fore a dramatic change and a concentration of publications in a multidisciplinary journal, namely Sustainability. We insist that this journal with a central position is proof that it has the largest number of articles including the keywords we researched upon and also has the highest number of links and quotes compared to other journals in the overlay map. Next to it, another important journal stands out, called Water. In conclusion, this diversification and intensification of the publishing activity represents a real support for science and practice through the added value that ultimately benefits the society as a whole.

**Table 2:** Chronological systematization of journals

| YEAR | COLOUR     | JOURNAL TITLE  | RESEARCH FIELD                       |
|------|------------|--|--------------------------------------|
| 2010 | Purple     | Wit Transactions on Ecology and the Environment  | ECOLOGY                              |
| 2012 | Dark Blue  | Environmental hazards Disasters  | HAZARDS & DISASTERS                  |
| 2014 | Light Blue | Risk Analysis Natural Hazards Review   | RISK ANALYSIS & HAZARDS              |
| 2016 | Green      | Bulletin of Earthquake Engineering, Natural hazards and Earth System Sciences, Journal of Flood Risk Management, International Journal of Safety and Security Engineering  | RISK MANAGEMENT & FLOOD              |
| 2018 | Lime Green | International Journal of Disaster Resilience in the Built Environment, International Journal of Environmental Research and Public Health International Journal of Disaster Risk Reduction Science of the Total Environment | DISASTER RESILIENCE & RISK REDUCTION |
| 2020 | Yellow     | Sustainability (Switzerland) and Water (Switzerland).  | SUSTAINABILITY                       |

Source: author's research

## 7. Conclusions

Through the analyzes carried out with VOSviewer and interpreted, we wanted to bring to light the study and research framework of the most relevant topics regarding the environmental risks and the journals in which these scientific papers appear. The idea of the research started from the association of the two concepts of "risks" and "vulnerabilities" and investigated their development in the profile publications. Thus, with the help of the VOSviewer program, we managed to identify 4 thematic clusters in the field of risk and vulnerability management, especially dedicated to the environment: 1.Natural Hazards, 2.Environmental Sustainability, 3.Natural Hazards & Floods and 4. Environmental Disasters & Security.

Through the same program we also elaborated an overlay map of the publications that highlights a chronology in terms of topics and issues analyzed over the course of 10 years.

The usefulness of such an analysis lies in the fact that we can understand, with concrete results, how the research in the field has evolved, year after year. Moreover, an up-to-date analysis, up to the current year, can facilitate a forecast on emerging topics based on the observation on the map of the latest publications. From the analyzes we can conclude that from 2010, until now, this field has known a significant advance and it has been sequential on various topics, as follows: 2010-ecology; 2012 hazards & disasters; 2014 risk analysis & hazards; 2016 risk management & flood; 2018-disaster resilience & risk reduction; 2020-sustainability. For all these topics we have identified the priority journals.

Our results show that there is an increased interest in publishing papers on topics such as "environment risks", "risk analysis" or "environment sustainability" but very few of these publications bring into question the concept of "vulnerabilities" which leads to the conclusion that there is a lack of knowledge in this area. Through our research we have highlighted the areas of intense risk study such as: - risk management in organizations, with focus on "enterprise risk management", "corporate governance", "banking risk management", "financial crisis"; - analysis of process, methods and strategies of risk in organizations with focus on terms such as "risk assessment", "risk analysis", "risk perception", and "project management"; strategies of response, protection and resilience highlighted by keywords like "innovation", "insurance", "moral hazard", "resilience" and "supply-chain-management".

Moreover, an important result is that of journal clusters as they represent a very important and useful database for both practitioners and researchers in the field. Another result obtained in our research is the chronological evolution of the investigated keywords as it shows the oscillation and evolution over time of publications signaling certain global or regional trends that may or may not be aligned with global or regional contexts.

Across this research we could confirm that although the concept of risk is well represented in the literature on sustainable environmental management, the concept of vulnerability is less analyzed. However, risks are strongly linked to vulnerabilities because, in any system, vulnerabilities are the potential triggers. Vulnerability monitoring is essential in designing resilient security systems for environmentally sustainable management systems. The limitations of the research refer mainly to the selection of a single database from which were extracted the analyzed papers and this could be extended and cumulated with papers extracted from other databases, like WOS, Emerald, Springer. Another important limitation is the accelerated rhythm of publications which induced a relatively short period of validity for the obtained analysis.

Risk management considers operating with intangible organizational resources. Organizations operate in a dynamic economic and social environment, with rapid and unpredictable changes, which generate a high level of uncertainty. This represents a high-risk potential that can generate multiple negative consequences on organizational performance. In order to mitigate possible adverse effects, managers have a responsibility to identify as many of the causes of environmental risks as possible and to develop measures to eliminate or mitigate them. In this context, we can say that the generic concept that defines these causes is that of vulnerability.

What we can conclude from our analysis is that research interests focus more on the concept of risk, such as climate and environmental risk, and on the operations needed to mitigate its negative consequences. In this regard, we propose that an even more effective approach to environmental risks should include the spectrum of vulnerabilities in these systems.

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### **Bionote**

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