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# Bibliometric analysis of abrasion and erosion disaster mitigation: trends, key themes, and potential for global policy development

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## ABSTRACT

This research aims to identify and analyze publication documents on disaster mitigation due to abrasion and erosion and current global policy development through bibliometric analysis. Research data were obtained from the Scopus database and analyzed using Vooviewer software. Scopus was chosen because it is one of the most comprehensive and extensive global academic databases, enabling in-depth analysis of various scientific fields. The analysis results show that research interest in abrasion and erosion mitigation has increased over the past few years, with a significant increase in publications in certain periods. The main research themes identified include coastal erosion, land use change, machine learning, and policy aspects related to mitigation. The study findings also highlight the potential use of new technologies, such as machine learning, in erosion modeling and prediction. The findings provide a deeper understanding of the complexity of the abrasion and erosion problem and highlight the importance of a cross-disciplinary approach to addressing it. In addition, this study also identified some themes that require more attention, such as erosion rates, which may need to have received more attention in mitigation research. These findings can support governments and stakeholders in formulating effective policies and directing resources to mitigate abrasion and erosion.

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coastal erosion;  
development policy;  
environmental policy



## SUBJECTS

Politics & Development;  
Sustainable Development;  
Development Policy;  
Political Studies; Hazards  
& Disasters

## 1. Introduction

Abrasion is a serious problem affecting coasts around the world (Rashidi et al., 2021; Tampubolon, 2022). Abrasion is a process of coastal morphological change caused by erosion due to friction between waves, seawater, and materials on the beach (Saidmurodov et al., 2022). Meanwhile, erosion is a natural process in which soil, rock, or other earth's surface is eroded or eroded by water, wind, ice, or other natural factors (Borrelli et al., 2021). These events unfold slowly but can significantly impact the shape and structure of the soil and the surrounding environment. While this process occurs naturally, human activities such as coastal development and climate change have exacerbated the problem. Abrasion can cause serious environmental damage. Coastal erosion threatens the sustainability of coastal ecosystems, including mangroves, coral reefs, and breeding grounds for many marine animals. It can also lead to increased ocean sedimentation, damaging deep-sea ecosystems (Acuña-Piedra & Quesada-Román, 2021; Borrelli et al., 2021; Toimil et al., 2020; Veas-Ayala et al., 2023).

Abrasion can damage coastal infrastructure, including houses, roads, and public facilities. This threatens the lives and livelihoods of coastal residents, especially in areas dependent on tourism (Melet et al., 2020; Mutaqin et al., 2023; Quesada-Román & Pérez-Briceño, 2019). In addition, property losses due to abrasion can impact the banking and insurance sectors. Climate change that causes sea level rise increases the risk of abrasion. Coasts degraded by abrasion will be more vulnerable to extreme effects caused by severe weather and ocean storms (Zhang et al., 2022). Preventing abrasion involves measures such as restoration of coastal ecosystems, wise coastal management, and strict regulations on coastal development pesisir (Liu

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et al., 2020). Technical options such as installing coastal protection structures and reducing land use in coastal areas can also help (Rashidi et al., 2021).

Increasing community understanding of abrasion and erosion, including their impacts, is an important step. Public education and awareness can encourage individuals to take more sustainable actions in managing coastal (Aronson et al., 2020; Mustafa et al., 2019). Effective mitigation efforts are needed in the face of potential disasters due to abrasion and erosion threatening coastal areas (Bergado et al., 2017; Yasir et al., 2024). Mitigation is a series of preventive actions and treatments designed to reduce the risks and impacts (Malik et al., 2023). These mitigation efforts include understanding, planning, and concrete actions that can be taken by governments, scientists, communities, and other relevant parties (Cai et al., 2022). Coastal management also requires a holistic approach involving various stakeholders (Stammer et al., 2019). By recognizing the urgency of abrasion and taking appropriate action, we can protect vulnerable coastal ecosystems and ensure coastal sustainability for future generations.

One important step in disaster mitigation is a better understanding coastal ecosystems and the abrasion and erosion process. This involves in-depth scientific research to understand the factors influencing disaster in a particular region, such as wave patterns, ocean currents, and local geology (Hossain et al., 2023; Zhou et al., 2022). This information is needed to plan and implement appropriate mitigation measures. In addition, restoring coastal ecosystems, such as mangrove forests and coral reefs, can help reduce abrasion by strengthening the coast's natural defenses (Jadin & Rousseau, 2022). These programs should be supported and managed sustainably. Mitigation is a proactive measure to protect coastal areas from potential disasters.

Although two different processes, abrasion and erosion, are significantly related in their environmental effects, abrasion, which relates to the erosion of beaches by ocean waves and currents, and erosion, which involves the shifting and accumulation of soil and rock by factors such as water, wind, and human activity, both have serious impacts on the environment. Climate change, for example, can affect the intensity and extent of abrasion and erosion in different regions, exacerbating their vulnerability to natural disasters such as landslides. Concurrent research in this domain can yield better insights into how physical, biological, and human factors influence abrasion and erosion rates.

The research gap in this study is the need for a comprehensive understanding of implementing global policies in abrasion and erosion mitigation practices in different countries. While a wealth of literature discusses global policy frameworks related to coastal management, it remains unclear how these policies are adopted, adapted, or ignored by countries and local communities facing different abrasion risks. There is, therefore, a need for more in-depth research involving comparative analysis of global policy implementation in different geographical contexts and evaluation of their practical impact on reducing abrasion risk and protecting coastal communities. Such research will help guide the development of more effective and adaptive policies in abrasion mitigation efforts globally. This research is to fill the gap of previous research by maximizing bibliometric analysis to assess publication documents covering abrasion disaster mitigation and global policy development.

This research aims to identify patterns in the global adoption, adaptation or policy of abrasion and erosion mitigation practices in various countries and to evaluate their practical impact in reducing abrasion risk and protecting coastal communities. With a deeper understanding of how global policies are implemented in different geographic contexts, this research can help shape more effective and adaptive policies in global abrasion mitigation efforts. The global implications of the results of this research include providing a better view of the effectiveness of global policies in addressing abrasion challenges around the world and providing a more solid foundation for developing mitigation that is more responsive to local conditions. Thus, this research has the potential to make a significant contribution to coastal protection and abrasion mitigation efforts globally.

## **2. Material and methods**

### **2.1. Bibliometric methods**

Bibliometric methods are used to identify current research trends, contributing researchers, and map topics that influence this discussion.

## **2.2. Data source**

In addition to the broad coverage and availability of in-depth bibliometric metrics, the choice of the Scopus database as the main data source in this study was based on several additional reasons. First, Scopus has a rigorous curation process and high-quality standards to ensure data accuracy and reliability. This provides additional confidence in the reliability of the information found in the database. Second, Scopus often provides additional information, such as indexation of various documents, including journals, conferences, and books, allowing researchers to access various information sources on one platform. Third, Scopus offers sophisticated analysis tools and data visualization features that make it easier for researchers to analyze trends, patterns and research impact. This advantage makes it easy to explore data in depth and comprehensively. Thus, compared to other databases, Scopus stands out for its broad coverage, data reliability, accessibility to various document types, and advanced analysis features.

## **2.3. Data filtering**

In document searches using the keywords “(Abrasion OR Erosion) AND (Mitigation OR Reduction) AND (Policy OR Regulation)” in the Scopus database, data filtering was carried out to obtain the most relevant documents. The inclusive approach includes all document types, affiliations, subject areas, and publication years, while the exclusive approach is carried out based on specified keywords. Inclusion criteria included all document types without limitation, all relevant affiliations, a wide range of relevant subject areas, and the entire range of publication years. Exclusion criteria are carried out by eliminating documents that do not meet certain search criteria, such as those that do not include specified keywords, thereby ensuring focus on the information most relevant to the searched topic.

## **2.4. Analysis tools**

The data obtained is then imported into an analysis tool such as Vosviewer. Vosviewer is analysis and visualization software used to understand research network structures in scientific documents.

## **2.5. Analysis and conclusion**

Through the steps above, this research aims to provide a deeper understanding of how existing global policies can be translated and implemented effectively in various regional contexts and help fill relevant knowledge gaps in more efficient abrasion and erosion mitigation adaptive.

Figure 1 shows the stages of literature searching and filtering using keywords for relevant documents. The total number of documents found was 78, consisting of various documents after a screening process. The types of documents included after filtering were articles (62 documents), conference papers (9 documents), book chapters (6 documents), and reviews (1 document). This research data visualization relies on the results of manual analysis in the Scopus Database to map the number of documents per year, number of documents by author, author affiliation, author country affiliation, and frequently cited documents. Another visualization is using Vosviewer to map relevant research themes.

# **3. Results and discussion**

## **3.1. Number of documents by year of publication**

Analyzing the number of documents by year of publication is an important step in understanding research development over time. It helps identify evolving research trends, the focus of research in a particular period, and the starting point or peak of interest in a field. In the context of abrasion or erosion mitigation research and global policy, understanding research history can provide valuable insights into how these issues have been explored and addressed over the past decades.

In this analysis, data has been collected on the number of documents based on the year of publication related to abrasion mitigation and global policies. The following is the distribution of the number of documents:

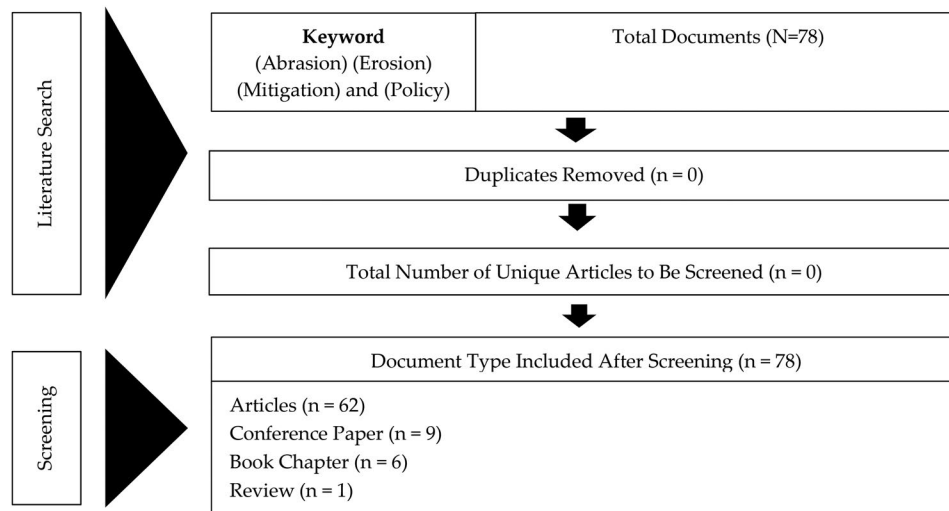


Figure 1. Literature search and screening.

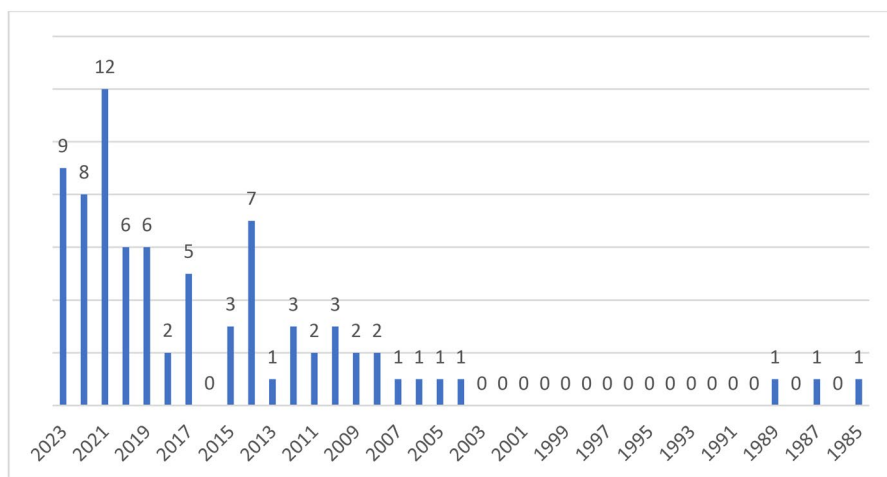


Figure 2. Number of documents by year of publication.

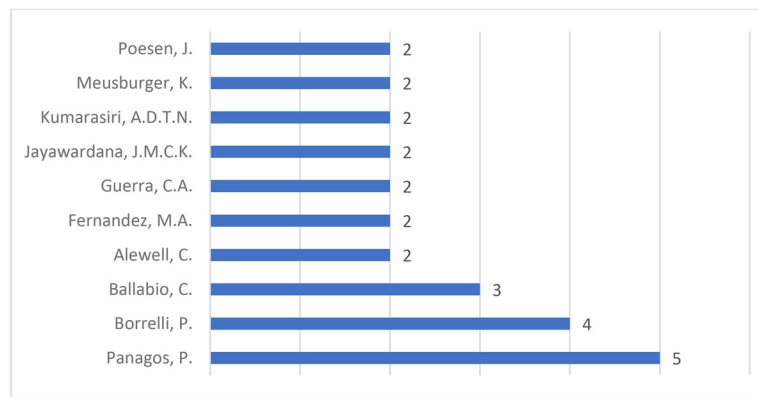
Figure 2 shows the number of documents by year of publication. The distribution of the number of documents by publication year shows diverse trends in research related to abrasion and erosion mitigation, including global policies. A significant increase in publications can be seen from 2017 to 2019, reflecting increased interest and attention to this topic. However, there are fluctuations in the number of publications from year to year, with some years having lower contributions. In recent years, such as 2020 and 2023, the number of publications stabilized again after the peak in 2019. This data reflects the dynamics in scientific research and may reflect changes in research focus or trends affecting the interest of researchers.

### 3.2. Number of documents by author

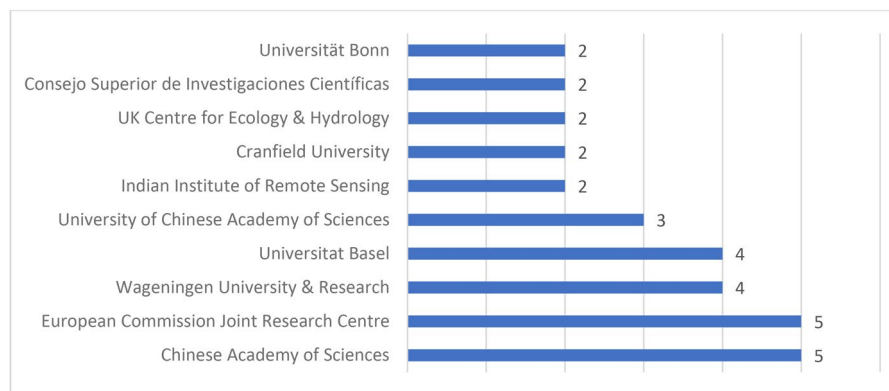
Analysis of document counts by the author is an important component in understanding individual contributions to abrasion or erosion mitigation research and global policy. It provides insight into the research conducted by specific authors in this domain and their contributions to the scientific literature.

Below is the distribution of the number of documents contributed by some of the main authors in this domain:

Figure 3 shows the number of documents by each author. In analyzing the number of documents by the author, several authors have made significant contributions to abrasion and erosion mitigation research, as well as those related to mitigation policies. Author Panagos, P. has the highest contribution



**Figure 3.** Number of documents by author.



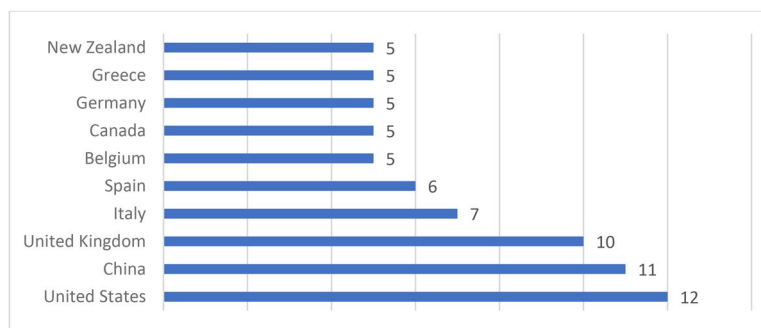
**Figure 4.** Number of documents by author affiliation.

with 5 documents, followed by Borrelli, P. with 4 documents, and several other authors who have made valuable contributions in lower numbers, such as Ballabio, C., Alewell, C., Fernandez, M.A., Guerra, C.A., Jayawardana, J.M.C.K., Kumarasiri, A.D.T.N., Meusburger, K., and Poesen, J., each with 2 documents. These authors' contributions reflect the diversity of research and perspectives in abrasion mitigation and global policy.

### **3.3. Number of documents by affiliation and country**

Analyzing document counts by institutional and country affiliation is important in understanding the geographic distribution of global abrasion mitigation and policy research. It helps identify major research centers, countries that play an important role in this research, and the relationship between geographical location and research interests. In this context, the distribution of the number of documents by institutional affiliation and country of origin of the authors will be examined.

Figure 4 shows the number of documents by author's institutional affiliation. In analyzing the number of documents by institutional affiliation, several leading institutions have made significant contributions to abrasion and erosion mitigation research and those related to mitigation policies. The Chinese Academy of Sciences and the European Commission Joint Research Center, each with 5 documents, are the two leading institutions in the number of publications. Wageningen University & Research and Universitat Basel have 4 documents each. In addition, some other institutions have also made significant contributions in lower numbers, such as the University of Chinese Academy of Sciences, Indian Institute of Remote Sensing, Cranfield University, U.K. Centre for Ecology & Hydrology, Consejo Superior de Investigaciones Científicas, and Universität Bonn, each with 2 documents. This distribution of the number of documents by institutional affiliation reflects the diverse contributions of leading institutions in different countries in abrasion and erosion research and those related to mitigation policies



**Figure 5.** Number of documents based on author's country of origin.

Figure 5 shows the number of documents produced by author's country affiliation. In analyzing the number of documents based on the author's country of origin, several countries have made significant contributions to abrasion and erosion mitigation research and those related to mitigation policies. The United States is the highest contributing country with 12 documents, followed by China with 11 documents, and the United Kingdom with 10 documents. In addition, several other countries have also made significant contributions, such as Italy with 7 documents, Spain with 6 documents, and Belgium, Canada, Germany, Greece, and New Zealand with 5 documents. This distribution of the number of documents by country reflects the active participation of different countries in abrasion and erosion mitigation research, creating diversity in the perspectives and approaches applied in this field.

### 3.4. Frequently cited documents

Analysis of frequently cited documents is one way to identify scientific works that significantly impact abrasion mitigation research and global policy. Highly cited documents are likely to make a strong contribution to the development of knowledge and can provide guidance for future research (Baharuddin et al., 2022; Ibrahim et al., 2023; Malik et al., 2023). In this context, we will look at frequently cited abrasion and erosion mitigation documents.

Table 1 shows that there are several documents that have important contributions based on the number of citations. The document "Erosion hazard vulnerability of U.S. coastal counties" has been cited 305 times. This document is highly relevant in the mitigation of coastal disasters due to abrasion and erosion, as it analyzes the vulnerability to erosion hazards in coastal counties of the United States (Boruff et al., 2005). The results of this study can be used as a basis for developing more effective mitigation policies in coastal areas. The document "Gully erosion susceptibility assessment and management of hazard-prone areas in India using different machine learning algorithms" has 169 citations. This document highlights the use of machine learning algorithms to assess erosion susceptibility, particularly gully erosion in India (Gayen et al., 2019). The results of this research can contribute to better erosion mitigation policies.

Another document, "Can control of soil erosion mitigate water pollution by sediments?" has 154 citations. This research explores the link between soil erosion control and water pollution mitigation by sediments (Rickson, 2014). It has important implications for policy development to maintain water quality and reduce the impact of erosion. While another document, "Human vulnerability, dislocation and resettlement: Adaptation processes of river-bank erosion-induced displacement in Bangladesh," has 116 citations. This document explores the impacts of river erosion in Bangladesh and the adaptations and policies related to the displacement of affected populations. It highlights the importance of social adaptation policies in the face of erosion (Hutton & Haque, 2004).

The document "Assessing soil erosion in Europe based on data collected through a European Network" has been cited 86 times. This document focuses on assessing European soil erosion using data from a European network (Panagos et al., 2014). The results of this study can support the development of erosion mitigation policies at the regional level. "Susceptibility mapping of soil water erosion using machine learning models" has 82 citations. This research demonstrates the application of machine learning models in mapping groundwater erosion susceptibility (Mosavi et al., 2020). The results of this mapping can help in planning erosion mitigation policies in various regions.

**Table 1.** Number of frequently cited documents.

Document title	Authors	Cited
Erosion hazard vulnerability of US coastal counties	Boruff, B.J., Emrich, C., Cutter, S.L.	305
Gully erosion susceptibility assessment and management of hazard-prone areas in India using different machine learning algorithms	Gayen, A., Pourghasemi, H.R., Saha, S., Keesstra, S., Bai, S.	169
Can control of soil erosion mitigate water pollution by sediments?	Rickson, R.J.	154
Human vulnerability, dislocation and resettlement: Adaptation processes of river-bank erosion-induced displacements in Bangladesh	Hutton, D., Haque, C.E.	116
Assessing soil erosion in Europe based on data collected through a European network	Panagos, P., Meusburger, K., Van Liedekerke, M., ...Hiederer, R., Montanarella, L.	86
Susceptibility mapping of soil water erosion using machine learning models	Mosavi, A., Sajedi-Hosseini, F., Choubin, B., ...Rahi, G., Dineva, A.A.	82
Projections of soil loss by water erosion in Europe by 2050	Panagos, P., Ballabio, C., Himics, M., ...Poesen, J., Borrelli, P.	78
Mapping Soil Erosion Prevention Using an Ecosystem Service Modeling Framework for Integrated Land Management and Policy	Guerra, C.A., Pinto-Correia, T., Metzger, M.J.	61
Costs and benefits of erosion control measures in the UK	Posthumus, H., Deeks, L.K., Rickson, R.J., Quinton, J.N.	57
Soil erosion and sediment dynamics in the Anthropocene: a review of human impacts during a period of rapid global environmental change	Owens, P.N.	55

The research document “Projections of soil loss by water erosion in Europe by 2050” had 78 citations. This document shows potential soil loss by water erosion in Europe up to 2050. The results of these projections can help formulate long-term mitigation policies (Panagos et al., 2021). The other document, “Mapping Soil Erosion Prevention Using an Ecosystem Service Modeling Framework for Integrated Land Management and Policy,” has 61 citations. This document highlights the mapping of soil erosion prevention using an ecosystem service modeling framework (Guerra et al., 2014). It has implications for the development of integrated land management policies.

The document “Costs and benefits of erosion control measures in the U.K.” has 57 citations. This study examines the costs and benefits of erosion control measures in the U.K (Posthumus et al., 2015). This cost-benefit analysis can help formulate efficient policies. The last document, “Soil erosion and sediment dynamics in the Anthropocene: a review of human impacts during a rapid global environmental change” has 55 citations. This document reviews human impacts on soil erosion and sediment dynamics during global environmental change (Owens, 2020). It provides important insights into the complexity of erosion issues in the Anthropocene.

### 3.5. Research theme mapping

Research theme mapping is an important step in understanding the diversity of foci and topics explored in research. It helps identify key trends, dominating issues, and areas that may require more exploration in the future. This study conducted research theme mapping in the abrasion and erosion mitigation domain to provide insight into the diverse topics researchers have studied.

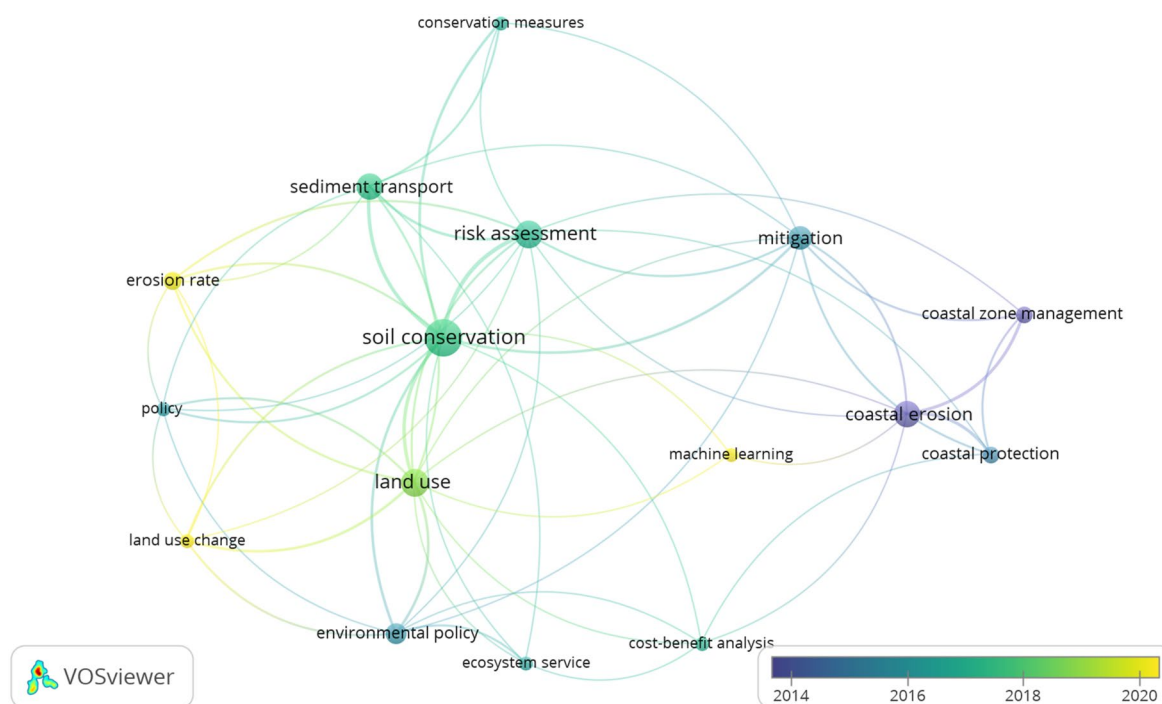
Figure 6 shows that discussions about abrasion and erosion disaster mitigation are quite diverse. Among the above research themes identified, new topics still require further development related to abrasion and erosion mitigation, namely erosion rate, land use change, and machine learning.

### 3.6. Implications for formulating abrasion and erosion mitigation policies

The findings related to the number of documents in this analysis have important implications for formulating abrasion and erosion mitigation policies. The increase in publications in 2019 shows that abrasion and erosion mitigation is getting greater attention in research (Figure 2). This is a positive indicator that illustrates awareness of the issue’s urgency. The main implication is that mitigation policies should consider the latest developments in this research and emerging trends in mitigation understanding and approaches.

However, fluctuations in the number of publications from year to year should also be noted. This highlights the presence of factors that influence research interest, such as changing policy priorities or





**Figure 6.** Linkage of research themes.

evolving challenges in understanding erosion and abrasion issues. The implication is that mitigation policies should be flexible but adaptable to the complexity of erosion and abrasion changes. This emphasizes the importance of continuous monitoring and responsiveness to research trends so mitigation policies remain relevant and effective in addressing evolving environmental challenges. As such, the findings on the number of documents provide a valuable basis for guiding smarter and more sustainable policy decision-making in abrasion and erosion mitigation efforts.

Findings related to the number of documents by the author have substantial implications in the context of abrasion and erosion mitigation policy formulation. Analysis of the number of documents by the author identifies individual contributions to this mitigation research, which can provide valuable insights into key stakeholders in policy development (Figure 3). Researchers who consistently contribute with many publications may deeply understand the issue and can be a valuable resource in the decision-making process. Mitigation policies should, therefore, seek to engage and support these researchers, creating a strong collaboration between research and policy. In addition, monitoring the progress of this research over time can assist in evaluating the impact of existing policies and identifying areas that require further attention in mitigation efforts.

On the other hand, the fluctuations in the number of publications seen in this analysis also highlight the challenges researchers face in carrying out abrasion and erosion mitigation research. This may reflect changes in research interest or changes in research project funding. Mitigation policies should take note of these fluctuations and be able to provide consistent support for ongoing research to address erosion and abrasion challenges. In addition, recognizing researchers who may experience obstacles in their research journey can help devise more effective support strategies. As such, these findings provide a foundation for responsive, collaborative, and sustainable policies in erosion and abrasion mitigation.

The findings regarding the number of documents by affiliation and country in this analysis have significant implications for developing effective abrasion and erosion mitigation policies. Information on author affiliation can identify institutions or organizations that have been instrumental in this mitigation research (Figure 4). This demonstrates the potential for strong collaboration between the academic, government, and private sectors in mitigation efforts. In developing policies, involving stakeholders from these affiliations is important to ensure comprehensive support and effective implementation.

In addition, findings on the distribution of the number of documents by country provide important insights into the role of different countries in abrasion and erosion mitigation research (Figure 5).

Countries that emerge as major producers of research in this domain can be strategic partners in developing and implementing effective mitigation policies. In addition, this information also reflects the different levels of awareness and attention to abrasion and erosion issues around the world. Mitigation policies must consider these differences in identifying challenges and opportunities related to abrasion and erosion mitigation in different regions.

Identifying countries contributing significantly to research in this area can pave the way for strategic cooperation in formulating and implementing impactful mitigation policies. For example, previous study findings suggest continued growth in geomorphological mapping research over the past two decades, supported by advances in data analysis, GIS technology, and collaboration across agencies and countries. Although Europe leads the way, significant contributions come from Latin America and Asia. However, research concentration is still predominantly in Europe, highlighting the importance of investment and geographic diversity in formulating impactful mitigation policies, emphasising understanding landscape geomorphology and cross-cultural collaboration (Quesada-Román & Peralta-Reyes, 2023).

Another study also identified significant research growth in methods and resources supporting geo-conservation and geo-tourism worldwide, emphasising countries such as Italy, Poland, Brazil, Russia and China. Key methods include geomorphological mapping and economic value studies, while resources include UNESCO Geoparks and educational programs. The implication for the development of abrasion and erosion mitigation policies is the need to strengthen geo-conservation and geo-tourism-based approaches in designing mitigation strategies, with a focus on better understanding landscape geomorphology and the use of natural heritage resources to strengthen coastal protection and management of abrasion risks and ongoing erosion (Quesada-Valverde & Quesada-Román, 2023).

The main findings from other studies also explain that dendrochronology in tropical and subtropical regions has experienced significant improvements in the last four decades. Some tree species in tropical and subtropical areas have been shown to form growth rings in a regular pattern, sometimes even annually, which is influenced by the species' sensitivity to climate, ecology, or geodynamic variations. The implication for the development of abrasion and erosion mitigation policies is that a better understanding of tree growth in these areas can provide valuable insight into identifying and understanding environmental factors that influence coastal vulnerability to abrasion and erosion. By paying attention to tree growth patterns affected by climate and geodynamic changes, mitigation policies can be designed to effectively reduce the impact of abrasion and erosion in tropical and subtropical areas (Quesada-Román et al., 2022).

The studies mentioned provide a comprehensive overview of various abrasion and erosion mitigation research, from geomorphological mapping to dendrochronology in tropical and subtropical regions. These findings highlight countries' important role in this research and demonstrate the need for cross-country cooperation in developing effective mitigation policies. The implication is that a better understanding of the geomorphological environment and tree growth in tropical and subtropical regions can help formulate more adaptive and sustainable policies to protect coasts and reduce the risk of global abrasion and erosion. By considering the various methods and resources identified, mitigation policies can be designed to take advantage of cross-cultural and geographic knowledge and increase global awareness and attention to the problem of abrasion and erosion.

Furthermore, looking at the regional implications of these findings, countries at the forefront of abrasion and erosion risks may need to take a more active role in developing effective mitigation strategies. On the other hand, countries that have less research in this domain can draw inspiration from emerging best practices from more experienced countries. Effective mitigation policies should create strong regional cooperation to address abrasion and erosion challenges that cross national boundaries. Strong regional cooperation in the development of abrasion and erosion mitigation policies is essential to ensure a coherent response to transboundary challenges. This can include exchanging knowledge, resources and technology to enhance collective capabilities to protect coastal areas and effectively reduce the impacts of abrasion and erosion (Salokyová, 2015; Sari et al., 2022; Skilton & Dooley, 2010).

Frequently cited documents in the context of abrasion and erosion mitigation reveal several key findings that provide valuable insights (Table 1). First, frequently cited documentation highlights that this research has reached a significant point in developing abrasion and erosion mitigation knowledge. Documents such as "Erosion hazard vulnerability of U.S. coastal counties" and "Gully erosion susceptibility assessment and management of hazard-prone areas in India using different machine learning algorithms"

show that the research has identified vulnerabilities and developed analytical tools that effectively address these issues. However, the analysis also highlights that most of the research still focuses on specific case studies, such as the United States and India, and there is still a need to expand the geographical coverage and explore abrasion and erosion vulnerability in various global contexts.

Furthermore, the documents highlight the importance of looking at erosion from a broader perspective. Documents such as “Can control of soil erosion mitigate water pollution by sediments?” remind us of the impact of erosion on water quality. It shows that abrasion and erosion mitigation involves protecting soil from erosion, preserving water quality, and controlling sediment pollution. These are important aspects that need to be taken into account in the formulation of effective policies.

However, a criticism that may be directed at these findings is that some of the frequently cited documents may need more regional coverage, which may overlook abrasion and erosion mitigation challenges in other regions. In addition, several documents highlight solutions that may focus on technical aspects, such as machine learning algorithms, without placing enough emphasis on the policy and social aspects associated with mitigation. Therefore, while these documents provide a valuable starting point in developing abrasion and erosion mitigation policies, it is important to consider various aspects and contexts in addressing these challenges holistically and inclusively.

The mapping of research themes in abrasion and erosion mitigation provides a comprehensive overview of the diversity of topics that researchers have studied. Some of the identified research themes include coastal erosion, coastal protection, coastal zone management, conservation measures, cost-benefit analysis, ecosystem service, environmental policy, erosion rate, land use, land use change, machine learning, mitigation, policy, risk assessment, sediment transport, and soil conservation. The identified research themes in abrasion and erosion mitigation show the diverse focus researchers have explored. However, three topics are quite new and require more abrasion and erosion mitigation development: erosion rate, land use change, and machine learning (Figure 6).

First, erosion rate is an important aspect of understanding erosion. Accurate measurement of erosion rates is necessary to identify areas most vulnerable to erosion damage and to plan effective mitigation measures (Salesa & Cerdà, 2020). However, the focus on erosion rate is not as popular as other topics in abrasion and erosion mitigation research, so there is still room for further development in understanding and measuring erosion. Second, land use change is an important factor affecting soil erosion rates. Human activities such as deforestation, conversion of land to urban zones, or changes in agricultural practices can exacerbate erosion (Maronedze & Schütt, 2021; Riquetti et al., 2023; Yan et al., 2022; Zarrinabadi et al., 2023). In the context of mitigation, a better understanding of how land use change contributes to erosion and how mitigation measures can be adapted to these changes is essential.

Finally, machine learning is a technological development with great potential in soil erosion modeling and prediction. Machine learning algorithms can analyze complex data and identify patterns that may be difficult to find through traditional methods (Bammou et al., 2024). However, the use of machine learning in abrasion and erosion mitigation may still be in its infancy, and further research is needed to explore the full potential of this technology in dealing with erosion challenges.

While many research themes have been explored in abrasion and erosion mitigation, topics such as erosion rate, land use change, and machine learning emerged as areas that still require more attention and development in the future. Further development in understanding and addressing these aspects can help formulate more effective mitigation policies and strategies for protecting the environment and natural resources from erosion impacts. The government can adopt various policies and explicit measures for disaster mitigation due to abrasion and erosion, taking into account the three themes that have been identified: erosion rate, land use change, and machine learning.

First, in terms of erosion rates, the government can implement a policy of regularly monitoring and measuring erosion rates in vulnerable areas. This could include establishing a network of erosion monitoring stations, using satellite monitoring technology, and working with research institutions to develop accurate modeling methods. With better data on erosion rates, the government can identify areas that require special attention and plan appropriate mitigation measures, such as soil erosion control and environmental restoration.

Second, the government can adopt sustainable land use management policies about land use change. These can include restrictions on deforestation, regulation of land use change for urban development,

and incentives for environmentally friendly agricultural practices. The government can promote practices that support sustainable land management and reduce erosion pressure by engaging various stakeholders, such as local communities and the agricultural sector.

Third, in the context of machine learning, the government can support research and development in using this technology for abrasion and erosion mitigation. This could include investment in training human resources in data analysis, using machine learning algorithms, and developing technology-based erosion monitoring systems. The government could also adopt a data-driven approach to policy formulation, utilizing modeling derived from machine learning analysis to understand the potential impacts of changes in land use or other factors on erosion.

It is important to note that the success of abrasion and erosion mitigation policies relies heavily on collaboration between the government, communities, and the private sector. The government needs to play the role of regulator, monitor, and key stakeholder in ensuring that appropriate mitigation measures are taken, sufficient resources are allocated, and the latest scientific understanding is utilized to meet the increasingly pressing erosion challenges.

## Conclusions

The findings in this bibliometric analysis illustrate the complexity and importance of abrasion and erosion disaster mitigation efforts and the development of appropriate policies to deal with them. Overall, the analysis provides a clear picture of research trends, key foci, and potential future development directions in abrasion and erosion mitigation. The study shows that research interest in abrasion and erosion mitigation has increased significantly over the past few years. This reflects a growing awareness of the impacts of erosion on the environment and society. The study also helped to provide a deeper understanding of the causes and consequences of erosion and the various mitigation strategies that can be implemented. The study also identified several key themes: coastal erosion, land use change, and machine learning. The findings show that abrasion and erosion mitigation involves not only geological or ecological understanding but also social, technological, and policy aspects that are important in addressing these issues holistically.

The findings underscore the potential of using new technologies, such as machine learning, to develop mitigation solutions. These technologies have great potential in accurately modeling and predicting erosion, aiding in more effective policy planning. Finally, the findings also encourage exploring other key topics, such as erosion rates, which may need more attention in mitigation research. Further development in understanding and measuring erosion and implementing policies that focus on factors such as land use change are also key in meeting future abrasion and erosion challenges. Overall, the findings provide a strong foundation for the government and other stakeholders to develop effective policies for disaster mitigation due to Abrasion and erosion. With a better understanding of research trends and key foci, governments can formulate policies that are more relevant and responsive to these challenges while continuing to support research and innovation to protect the environment and communities from the increasingly serious impacts of erosion.

## Authors' contributions

Conception and design: Sylvina Rusadi and Rahman Mulyawan. Data analysis and interpretation: Sylvina Rusadi, Rahman Mulyawan, and Utang Suwaryo. Preparation of papers: Sylvina Rusadi and Neneng Yani Yuningsih. Final approval of the version to be published: Sylvina Rusadi, Rahman Mulyawan, Utang Suwaryo, and Neneng Yani Yuningsih.

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## Data availability statement

The data that support the findings of this study are available from the corresponding author, [SR], upon reasonable request.

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