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Mapping Research Trends in Remote for Post Disaster Environmental Damage Assessment : A Bibliometric Analysis

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Abstract

Remote sensing has become a key technology for assessing environmental damage following disasters due to its ability to provide timely, spatially explicit information. Despite its growing application, existing studies remain fragmented across disciplines and lack a structured understanding of research development. This study aims to systematically map the scientific landscape of remote sensing applications in post disaster environmental damage assessment using a bibliometric approach. A total of 200 publications indexed in scopus from 2015 to 2024 were analysed, comprising 48.195 citations and h-index of 142. Bibliometric analysis was conducted using VOSviewer to examinekeyword co-occurrence and to generate network, overlay, and density visualizations. The result identify four major research cluster : damage detection and assessment, environmental impact analysis, remote sensing applications, and disaster management. Network analysis indicates that remote sensing and damage assessment function as central nodes linkinginterdisciplinary research themes. Overlay visualization reveals a clear transition from conventional monitoring approaches toward data driven methods, particularly machine learning, predictive modeling, and GIS based analysis. Density analysis shows that research remains concentrated on monitoring and environmental assessment, while emerging topics such as artificial intelligence and UAV based sending remain underexplored. This study provides a structured and quantitative synthesis of research development and highlights the increasing role of remote sensing as a data driven decision support system. The findings offer new insights into research trends and identify under explored areas for future investigation.

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Keywords : Remote Sensing; Bibliometric Analysis; Post Disaster assessment; Environmental Damage; Research Trends

INTRODUCTION

Remote sensing technology is expected to support disaster management by providing accurate, timely, and spatially explicit information for environmental monitoring and post disaster recovery. Advances in satellite sensors, aerial platforms, and unmanned systems enable continuous observation of large geographic areas without direct physical interaction. This capability allows researchers and decision makers to detect environmental changes, assess damage, and monitor recovery processes in a systematic manner. The integration of remote sensingwith geographic information systems also enchances analytic capacity by enabling spatial modelling and data driven decision making (Zhang et al., 2022; kaku, 2019). Within this framework, remote sensing serves as a key tool for improving the accuracy and efficiency of environmental damage assessment following disasters. Disasters events continue to produce complex and widespread impact that challenge environmental management and recovery efforts. Natural disaster such as floods, earthquakes, volcanic eruptions and forest fires cause significant damage to ecosystems, infrastructure, and human settlements (Agarwal et.al., 2023; Kharb et.al., 2022). In parallel, human induced disasters, including industrial accidents and environmental pollution, contribute to longterm environmental degradation and increase societal vulnerability (Hsiang et.al., 2019; M & Asio, 2022). These impacts often lead to the degradation of soil, water, and air quality, as well as the loss of biodiversity and ecosystem functions (Q.Xu & Khan, 2023; Sakuntala et.al., 2022). The scale and complexity of these issues require reliable data and analytical approaches to support recovery processes and risk reduction strategis (Joakim & Wismer, 2015).

Previous studies have examinated the application of remote sensing in disaster contexts, particularly in damage detection, environmental monitoring, and risk assessment. Remote sensing has been widely used for flood mapping, forest fire detection, and land use analysis through multi temporal satellite imagery (Rahman & Di, 2020; Kurbanov et.al., 2022). Recent developments indicate a growing integration of machine learning and predictive modeling to improve analytical accuracy and efficiency (Towfiqul Islam et.al., 2021; Xu et.al., 2021). In addition, the use of unmanned aerial vehicles has expanded data acquisition capabilities by providing high resolution imagery and flexible deployment in complex environments (Chowdhury et al., 2017; Munawar et al., 2022). Despite these advances, the existing literature remains fragmented across disciplines

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and largely focuses on spesifis applications or technical approaches. This condition limits a comprehensive understanding of research structure, thematic relationships, and the evolution of knowledge in this field. A systematic and quantitative analysis is required to examine how research on remote sensing in post disaster environmental damage assessment has developed over time. Bibliometric analysis provides a structured approach to evaluate scientific publications by identifying relationships among research topics, mapping thematic clusters, and analyzing temporal trends. Visualization techniques such as network, overlay, and densitu mapping enable the identification of dominant themes and emerging research directions. The limited application of bibliometric methods in this filed indicated a gap in the literature that needs to be addresses to support more structured and evidence based research development.

This study aims to analyze the scientific landscape of remote sensing applications in post disaster environmental damage assessment using a bibliometric approach. The analysis focuses on identifying major research clusters, examining the evolution of research topics, and evaluating the intensity and distribution of scientific themes. The novelty of this study lies in its integration of bibliometric visualization and thematic interpretation to provide a structured mapping of research development. This study also highlights emerging topics and underexplored areas, particularly in the integration of remote sensing with machine learning and data driven approaches. The findings contribute to a clearer understanding of how remote sensing has evolved from a monitoring tool into a dicision support systems in disaster management and provide a basis for future research directions.

METHODS

This study applies a bibliometric approach to analyze the development of research on remote sensing applications in post disaster environmental damage assessment. Bibliometric analysis is used to examine the structure of scientific knowledge, identify relationships among research topics, and explore trends in the literature. The data were obtained from the scopus database due to its comprehensive coverage of high quality peer reviewed publications. The search was conducted using a combination of keywords, including remote sensing, damage assessment, environmental impact, and disaster, with a publication period limited to 2015 until 2024. The selection process included filtering based on relevance, document type, and subject area, resulting in a final dataset of 200 publications. The analysis was performed using VOSviewer software to conduct keyword co-occurrence analysis. Prior to analysis, the dataset was cleaned and standardized to remove duplicate terms and unify similar keywords. A minimum occurrence

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threshold was app;ied to ensure that only relevant and frequently used keywords were included in the visualization.

Several types of bibliometris analyses were conducted. First, network visualization was used to examine the relationships between keywords and to identify the overall structure of the research filed. Second, clustering analysis was applied to group related keywords into thematic clusters based on their co-occurrences patterns. Third, overlay visualization was used to analyze the temporal evolution of research topics by assigning colors based on the average publication year. Fourth, density visualization was used to identify areas of high research intensity and to highlight dominant topics within the field. The results of these analyses were interpreted to identify major research themes, emerging trends, and the evolution of scientific knowledge. This approach provides a structured and quantitative understanding of how remote sensing research has developed in the context ofpost disaster environmental damage assessment.

RESULTS AND DISCUSSION

The bibliometric profile of the dataset shows a consistent increase in academic attention over time, particularly in relation to disaster related environmental studies. A total of 200 publications were identified between 2015 and 2024, generating 48.195 citations. The average citation rate reaches 4,381.36 per year, while each document receives approximately 240.98 citations. The h-index value of 142 indicates that a considerable number of publications have achieved recognition within the scientific community. These indicators suggest that the topics has developed into an established area of research with sustained relevance. The pattern of collaboration also shows a relatively stable structure, with an average of 3.89 authors per publication. Tis indicates that research is typically conducted in small collaborative groups rather than large scale international consortia. Similar collaboration patterns have been identified in disaster related studies, where interdisciplinary approaches are often implemented within focused research teams (McKnight & Linnenluecke, 2019).

The network visualization illustrates the relationships among keywords and reveals a densely connected structure. The terms remote sensing and damage assessment occupy central positions, indicating their role as primary connectors between different research themes. Surrounding these central nodes are keywords such as monitoring, analysis, and environment, which form multiple linkages across the network. This pattern suggests that technological methods and environmental applications are frequently integrated within the same studies. The appearances of keywords such as deep learning, change detection and UAV reflects the increasing

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incorporation of advanced analytical techniques and data sources. The use of machine learning in remote sensing has been shown to enchance the processing of large scale spatial data and improve the accurancy of environmental analysis (Huang et al., 2018). In addition, UAV based data acquisition supports high resolution observation in complex and inaccessible areas, which strengthens the analytical capability of remote sensing applications.

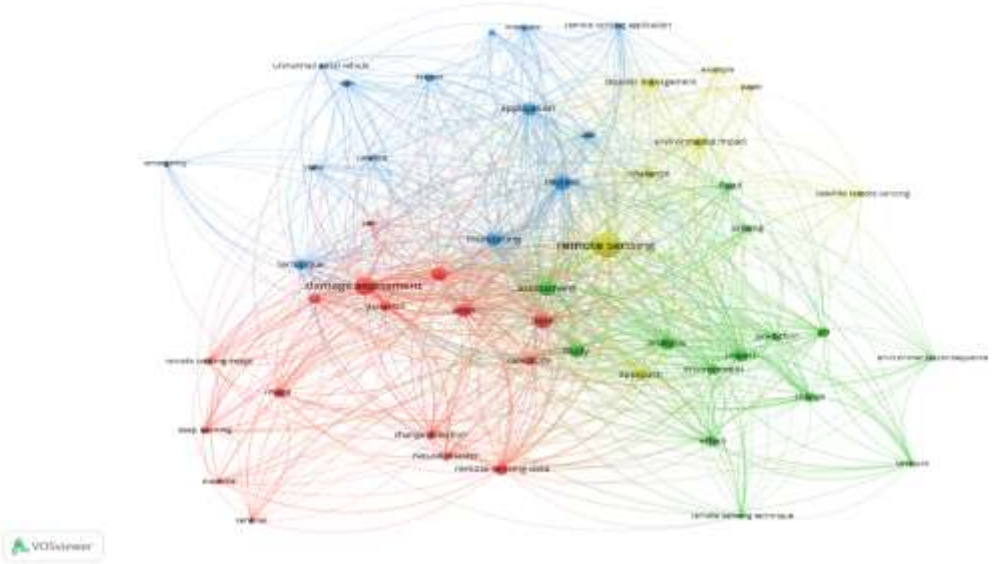


Figure 1. Network visualization

The clustering analysis identifies four main thematic groups that structure the research field. The first cluster focuses on damage detection and image based analysis, including keywords such as damage assessment, detection, and remote sensing image. This cluster highlights the importance of image processing techniques in identifying and quantifying environmental damage. The second cluster is associated with environmental impact and spatial analysis, represented by keywords such as GIS, prediction, and land use. These topics indicate that spatial modeling plays an important role in understanding the effects of disasters on environmental systems. Spatial analysis has been widely applied in flood modeling and environmental risk assessment to support decision making processes (Towfiqul Islam et al., 2021). The third cluster emphasizes remote sensing applications and monitoring systems, including terms such as sensor, satellite, and UAV. This cluster reflects the technological dimension of the field, particularly in relation to data acquisition and observation. Advances in sensor technology have enabled continuous monitoring

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of environmental changes at different spatial and temporal scales (Senf, 2022). The fourth cluster focuses on disaster management and environmental challenges, with keywords such as disaster management and environmental impact. This cluster highlights the application of remote sensing data in supporting policy development and post disaster recovery strategies. The use of remote sensing in decision making processes has been increasingly recognized in disaster management studies (Efendi et al., 2022).

The overlay visualization provides insight into the temporal evolution of research topics. Earlier studies tend to focus on fundamental aspects such as satellite, sensor, and monitoring, which represent the initial stage of remote sensing applications. These topics form the foundation for subsequent developments in environmental monitoring and disaster assessment. More recent studies show a shift toward analytical and predictive approaches, as indicated by the increasing presence of keywords such ac machine learning, prediction, and GIS. This transition reflects the growing importance of data driven methods in interoreting remote sensing data. The integration of predictive modeling technique has been shown to improve the accruracy of disaster risk assessment and environmental analysis (Li et al., 2022). This temporal shift suggests that research in this field evolves through the integration of new analytical approaches with existing observation based methods, rather than replacing them entirely.

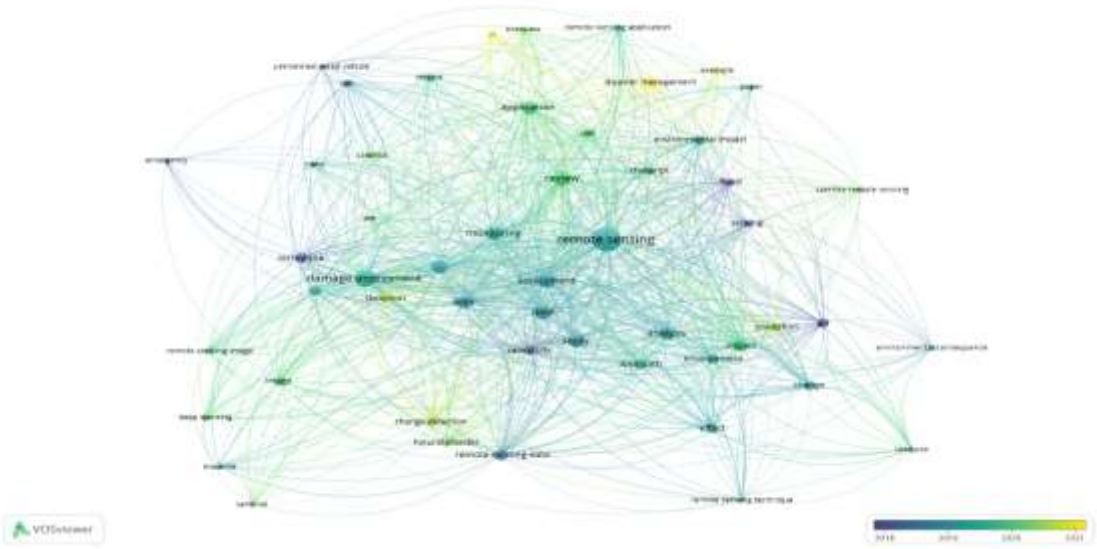


Figure 2. Overlay visualization

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The density visualization highlights the concerntration of research activity across different topics. The highest density is observed around keywords such as remote sensing, damage assessment, monitoring, and analysis, indicating that these topics form the core of the research field. These areas represent the main focus of scientific activity and are consistently explored across multiple studies, in contrast, topics such as deep learning, UAV, and change detection appear in areas with lower density, suggesting that they are still developing. The increasing attention to these topics is topics is consistent with recent studies that emphasize the integration of artifial intelligence and advanced computational methods in environmental monitoring (Ye, 2022). The distribution of density suggest that the field maintains a stable core while gradually incorporating new technologies and analytical approaches.

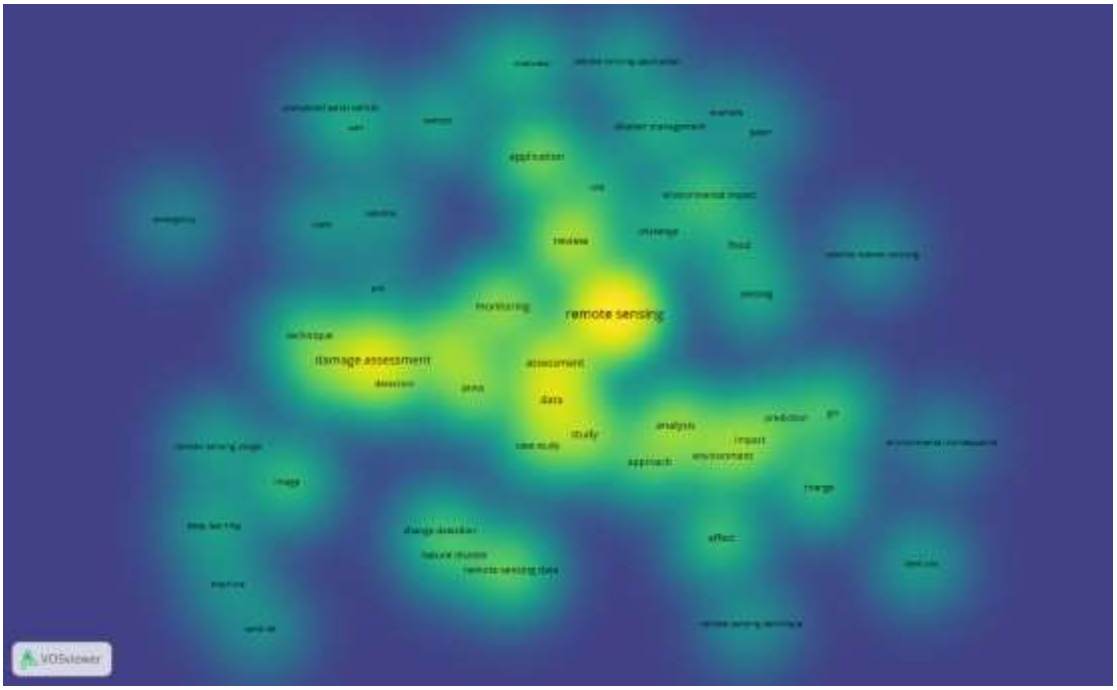


Figure 3. Density visualization

DISCUSSION

The combined results from bibliometric indicators and visualization analysis provide a structured perspective on the development of the research field. The central position of remote sensing and damage assessment indicates that these concepts act as key connectors between different research themes. The clustering results show that the field is organized into

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interconnected areas that link technological methods with environmental applications. The temporal analysis reveals a gradual shift toward data driven approaches, particularly through the use of machine learning and predictive modeling. This trends aligns with broader developments in remote sensing, where large datasets and advanced analytical technique are increasingly used to support disaster assessment and environmental monitoring (Zhao et.al., 2020). The density analysis futher indicates that while core topics remain dominant, emerging topics continue to gain attention. This pattern suggests that the fields is evolving through the integration of new technologies rather than a shift away from established approaches.

CONCLUSION

Disasters that occur in various worlds, both natural and non natural disasters. Disasters caused by natural factors and caused by human factors both have very large, extensive, and complex impacts and losses. By knowing understanding the various types of disasters that exist and the impacts that can be used, we are expected to be able to care more about others and be able to give a quick response as a form of our concern and a form of out compassion for the victims of natural and non natural disasters. Environmental damage due to disasters that occur is a very serious problem for life on earth because it has an impact on human health, economic impacts, disaster impacts to have an impact on species extinction, and biodiversity loss that can damage the balance of the ecosystem. Various types of environmental damage, such as deforestation, water pollution, air pollution, and soil pollution, have far reaching and defrimental impacts on the survival og humas and other species. Therefore, join efforts are needed from the government, government agencies or institutions, and all communities to work together and work together to overcome this disaster problem. By working together to protect the earth well, we can make future generations still able to enjoy a decent life on this earth.

Remote sensing technology is a technology used to collect information without direct contact. The information obtained is based on sensors installed in these devices, for example on satellites, drones, aeroplanes, and lidar. Remote sensing technology can help us observe changes in the atmosphere on the rapidly changing earth. Remote sensing is differentiated into passive remote sensing and active remote sensing. Passive remote sensing is sensing that uses natural energy sources such as sunlight and active remote sensing is sensing that uses its energy source. This remote sensing technology provides many uses and benefits for all of us. Examples of benefits obtained by utilizing this remote sensing technology are being able to monitor climate change, deforestation, and land, detect forest and land fires. The existence of remote sensing technology

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helps the government and related agencies in making policies and decisions regarding natural resource management, disaster management, and environmental protection. With the advancement of technology which is growing rapidly every year, remote sensing has more benefits and is increasingly important in supporting human life on earth and can also maintain environmental sustainability. Indonesia as an archipelagic country, often experiences various kinds of natural disasters that have an impact on people lives, the environment, and the economy. Major disasters that are common in Indonesia are floods, eruptions of mount Merapi, forest fires, land fires, and liquefaction. Natural disasters that occur such as floods, volcanic eruptions, forest fires, land fires, and liquefaction events are phenomena that can cause great damage to the environmental, infrastructure, and human life. Each disaster that occurs has different characteristics, causes, and consequences, but they are often interreleated. With the unique characteristics of each these disasters, handling them requires a specific mitigation approach to reduce risks and damage, reduce the number of casualties, and reduce the ectinction of species living in the forest.

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