IJEMD-SS, 5 (2) (2026) https://doi.org/10.54938/ijemdss.2026.05.2.682

**International Journal of Emerging Multidisciplinaries: Social Science**

*Research Paper*
*Journal Homepage: www.ojs.ijemd.com*
*ISSN (Online): 2958-0277*

# Artificial Intelligence and Big Data in Disaster Risk Management from a Socio-Legal Perspective

**Dr. Hafeez-ur-Rehman**
Postdoctoral Research Fellow, Mediterranea International Centre for Human Rights Research (MICHR), Università Mediterranea di Reggio Calabria, Reggio Calabria, Italy
Incharge & Assistant Professor, Department of Islamic Studies, Government College University Hyderabad (GCUH), Hyderabad, Sindh, Pakistan
**Email:** hafeezurrehman@gcuh.edu.pk

Research Supervisor
**Prof. Dr. Angelo Viglianisi Ferraro**
Director
Mediterranea International Centre for Human Rights Research (MICHR)
Università Mediterranea di Reggio Calabria
Reggio Calabria, Italy

## Abstract

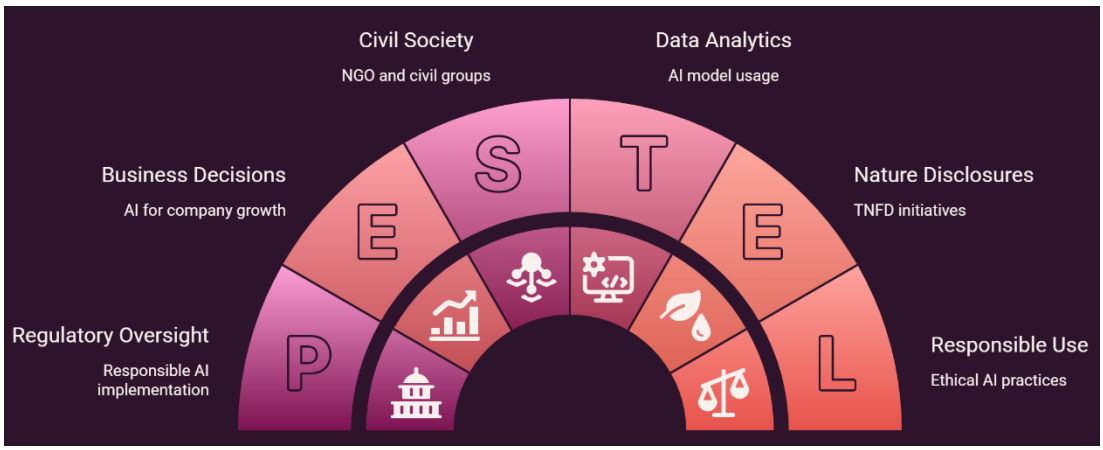
To manage complex disaster risks, it is important to develop a response that spans multiple areas of expertise. Bridging the gap between law, social sciences, and natural sciences is an important part of any disaster risk reduction. It helps systems adapt quickly as AI technologies are constantly changing and have significantly impacted where law and the natural environment intersect, influencing legal systems and environmental policies, and how legal and environmental issues can prevent AI from having a greater impact on society and the economy. As part of a participatory assessment of production, with the assistance of legal experts, social and environmentalists, the key principles of responsible data analysis are proposed. These principles focus on security, transparency, fairness, accountability, and the ability to challenge or challenge decisions. This conversation describes how different disciplines can work together to create flexible legal systems that use AI, while drawing knowledge from the environmental and social sciences. The way environmentalists and decision-makers talk about useful and accurate information leads to differences that make the use of artificial intelligence difficult due to legal issues related to the reliability, reliability, and contentiousness of disaster management systems. If social media is useful for disaster risk reduction through AI, it's important to consider legal issues related to who is responsible and how sensitive the information used in disaster management is. Ideas for a fair and responsible process focus on the environment and

encourage discussions on social and economic issues related to public participation. AI is also very important in education, as it brings together the next generation of law, social and natural sciences to jointly find solutions that bring together different disciplines in a balanced way. AI tools can be very useful in emergency management, but it's important to use them fairly and responsibly. You need to think about things like possible unfair benefits, clear explanations, and protecting people's personal data. Careful use of AI techniques, considering how AI, laws, and environmental risks interact with each other, helps create equitable and sustainable ways to collect and use data.

**Keywords:** disaster risk reduction, artificial intelligence, law, public participation

# INTRODUCTION

Governments around the world have been developing and using various types of artificial intelligence (AI) since the 2010s to address important issues in various sectors, especially in the legal and environmental spheres. Currently, the focus has shifted from the introduction of AI to the creation of regulations for its rapid spread (Smuha, 2019). New technologies that use data are changing the way we live and work. The same goes for disaster risk management. As environmental disasters become more frequent and worsen, more people are using artificial intelligence as a tool to manage disaster risk through adaptive data analytics. This includes installing early warning systems, providing real-time information on emergencies, and supporting the distribution of humanitarian supplies in the aftermath of a disaster. Studies such as Yu et al. (2018), Chen et al. (2019), Imran et al. (2020), Fang et Chun (2022), Alizadeh et al. (2022), and Chauhan et al. (2024) show how AI can be used in these areas. There are also some dangers associated with artificial intelligence. AI systems use information from the past to make decisions, so results can be unfair or wrong if they are missing or unbalanced. This is especially important for emergency management, as AI-assisted decisions can significantly impact people's lives and the environment in which they live (Gevaert et al., 2021). Regulators must not only consider the benefits of artificial intelligence and data analytics but also take the necessary measures to use these technologies responsibly and responsibly. AI models are used not only in government work but also help companies make business decisions. For example, recent initiatives such as the Working Group on Nature-Related Financial Disclosures (TNFD) and other voluntary environmental initiatives show how AI is being used in the private sector. These models are also used by NGOs and other civil society groups.



In the field of emergency management, AI techniques are generally divided into two main types: supervised learning and unsupervised learning (Guikema, 2020). In supervised learning, the algorithm receives the correct or expected answer, which serves as a guide when reviewing large disaster datasets. For example: if you record a higher record Daytime temperatures were higher than usual during the week, and then a link to the "correct answer" appears, which means that more people were hospitalized before the summer heat wave began. With unsupervised learning methods, the algorithm does not give the correct answers and the expected results. Instead, it seeks to understand how various factors in the disaster management process are interconnected and interact. In addition to supervised and unsupervised methods, there is another group of methods called "deep learning". This group includes things like "recursive neural networks" and "reinforcement learning," which are used to manage resources. These methods should cover complex steps, a volume of training data, and take a lot of time to reduce disaster risks (Sun et al., 2020). In general, how humans teach AI is more likely to generate useful information when a lot of data is created over and over again in similar places or situations. If there is not enough data, the prediction of the AI model cannot be accurate because it has not been properly trained and has not extracted enough from the data used in disaster management (Guikema, 2020).

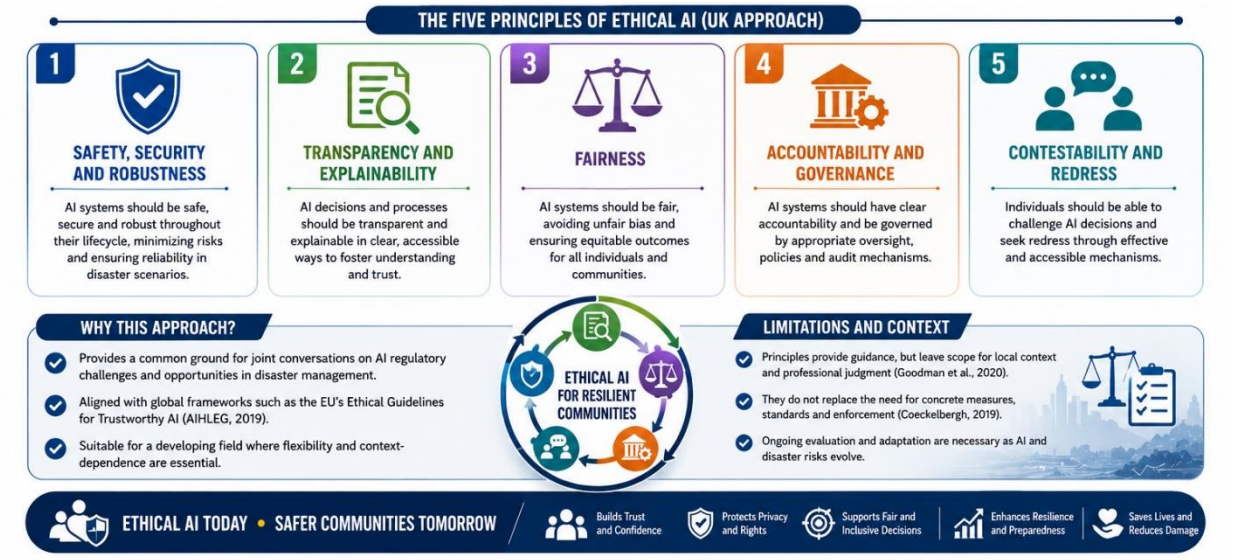

Although AI has been used to achieve global sustainability goals (Vinuesa et al., 2020), the use of AI and data analysis is still being considered by regulators. This is to ensure that artificial intelligence is used responsibly and ethically, especially in emergency management. Siau & Wang, 2020; Deltares, World Bank, and GFDRR, 2021 – Governments and organizations at all levels, including national, regional, international, and supranational, are considering the need to change existing regulations or create new ones to combat the risks posed by AI. AI is an evolving and complex technology that brings many new rules and challenges. These include the use of artificial intelligence across borders, which makes it difficult to comply with regulations, as well as strict regulations that can slow down the adoption of new ideas (Coeckelbergh, 2019). It is important to find a good balance between protection and promotion through regulation. Some countries are considering a principles-based approach that focuses on results rather than on concrete steps to achieve them. Others take a rules-based approach that takes a closer look at the process used. The European Commission introduced AI laws, creating a four-tier system for classifying AI tools according to their risk, from those with low or no risk to those considered very dangerous (EU, 2023). The UK promotes innovation by following five key principles to ensure the responsible development and use of artificial intelligence and data analytics across all areas of government, as set by the DSIT in 2023. Focus on the risks associated with AI (Seamans, 2023). Ethical questions have arisen in the way "autonomous and intelligent systems" are designed and used, and many regulations and guidelines are based on

them, as shown in a 2019 IEEE report titled "Ethically Consistent Design." All of these efforts underscore the importance of laws and policies that can be changed and adapted as needed. However, there is an ongoing debate about which fields are related to artificial intelligence and disaster management, and what they can (and should) do to achieve this goal. As an example, we look at the challenges and benefits of AI regulation in disaster risk reduction and share what we have learned from the series of workshops and focus groups on co-production described in Section 3. These insights are based on the five principles of ethical AI outlined in Section 2 of the 2023 DSIT. Section 3 will show how these principles affect disaster management in three key areas: creating flexible systems for both the legal and physical environments; promoting public participation and the rule of law; and the development of curricula covering various disciplines of disaster management.

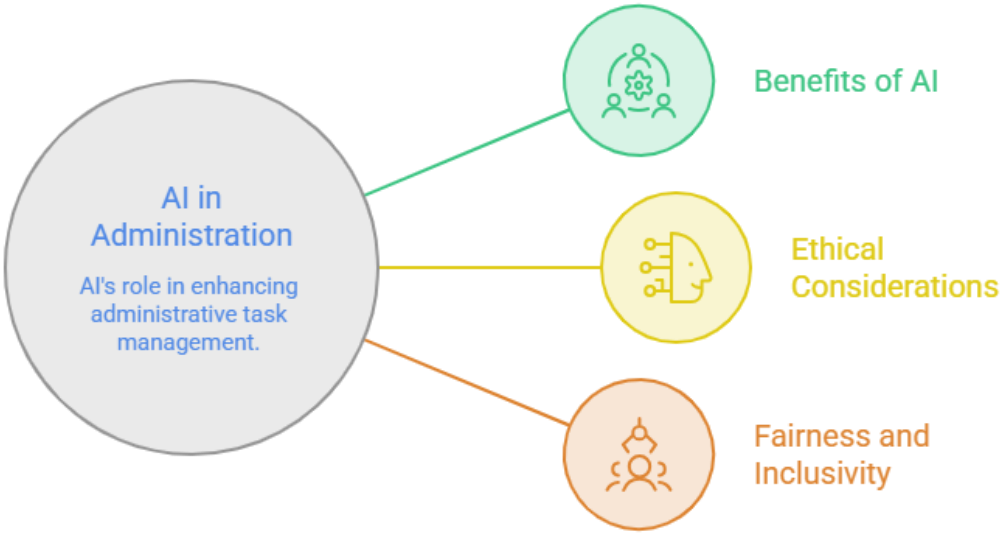
## PRINCIPLES FOR THE ETHICAL USE OF AI IN DISASTER MANAGEMENT

In this part, we explain the basics of ethical artificial intelligence, specifically how it is applied in disaster management in relation to environmental hazards, as shown in Figure 1. To start a collaborative discussion on AI regulation and its role in disaster management, we used the Five Ethical Principles for AI from the UK (DSIT, 2023). These principles are:

1) to ensure the safety, reliability, and security of artificial intelligence;
2) to be clear and explain how AI works;
3) to ensure justice;
4) Have responsibility and proper leadership; and
5) empower humans to challenge AI decisions and seek help when needed. This method is used because it shows how things are decided in the UK. Thus, the principles in the UK are similar to those of the EU Ethical Guidelines on Reliable Artificial Intelligence (AIHLEG, 2019). Some of the principles used in AI regulation have certain limitations. For example, the principles provide general recommendations but do not provide clear, specific measures (Goodman et al., 2020). However, Kuckelberg (2019) argues that principles can lead to clear and practical steps. We explain why we use this principled approach because the field is not yet fully developed, so it is important to allow flexibility and take into account different situations.

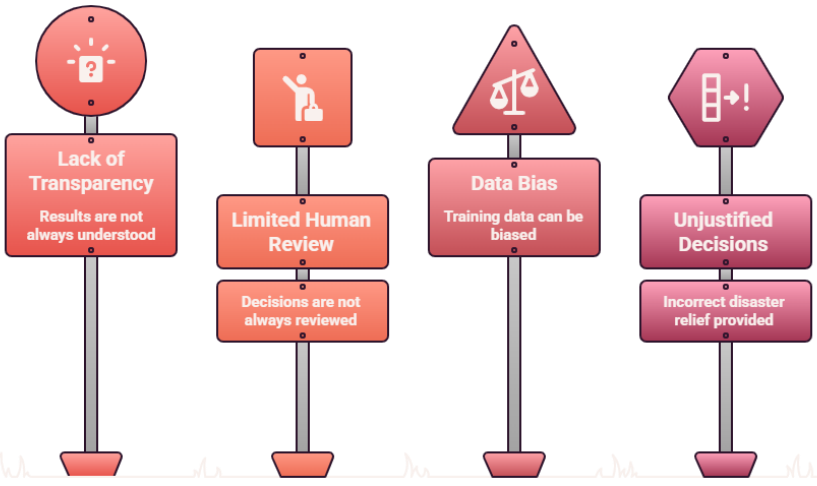


Five key rules to control the use of AI in DRM. These principles should be followed by different groups in areas such as law, policy-making, science and innovation. The importance of these principles is demonstrated: first, by the creation of flexible data analysis systems that work in both legal and physical settings; secondly, to promote public participation and raise legal awareness; and thirdly, the development of educational and training programmes that integrate the various areas of emergency management. Principle 1. Safety, security and stability. AI applications must operate safely, reliably, and reliably, with carefully controlled and managed risks. AI systems can learn and acquire new skills on their own, which complicates safety and security issues. The use of artificial intelligence and big data can also cause serious privacy concerns. The amount of information that AI can process is so large that it is impossible to develop it with emergency management in mind, for example, in social networks. Therefore, it is important to discourage the harmful use of this information (Ufert, 2020). The EU Data Protection Regulation sets rules for the protection of personal data, but with the increasing use of artificial intelligence, regulation may need to be updated regularly to keep it up-to-date (Gunes Peschke & Peschke, 2022). AI systems are often initially designed as "black boxes" that are complex and difficult to understand. A lack of transparency can make it difficult to understand how big data and artificial intelligence systems make decisions, making it difficult to identify those responsible for the results achieved (Berber & Srećković, 2023). Companies developing and using AI must be able to explain when and how AI is applied and how it solves problems, according to the level of risk associated with its application. Systems should be as clear and easy to understand as possible. They need to use artificial intelligence to make important decisions in emergencies, such as when to open or close floodgates. Papadakis et al., 2022). However, these other two principles – data sharing and reuse – are highly recommended for clarity and openness. They help improve administrative task management skills, collaborate with civic groups, and create useful knowledge based on available information (Soylu et al., 2022; Morales et al., 2014). AI systems must comply with the law and ensure that they do not treat humans unfairly or lead to unfair consequences. Some people debate whether AI helps achieve equitable outcomes in certain areas, such as how insurance companies offer policies (Lamberton et al., 2017) and how hiring works (Albert, 2019). If AI is used to make decisions, it must have a clear reason, not just a coincidence, especially if the decision concerns many people. The AI system may accidentally miss some groups of people, such as low-income people, immigrants, the elderly, or people with disabilities, as these groups may not be able to



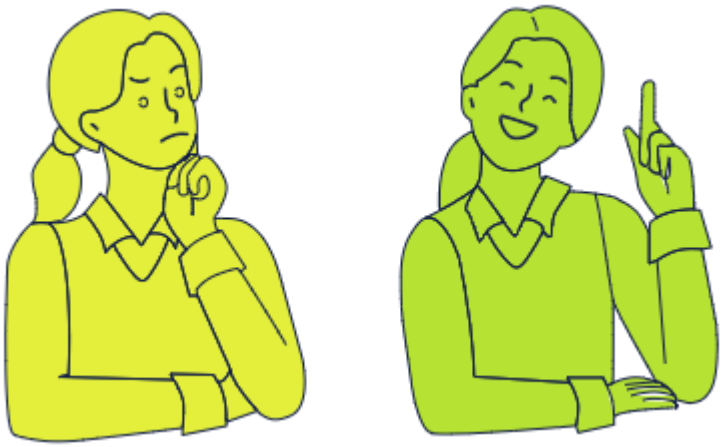
obtain information before or during the disaster. For example, social media is already being used to better understand situations and support disaster relief, but for those who use little digital media, it may be in short supply.

Previous studies have shown that certain groups are underrepresented during disasters, and social media data may be unfair or biased (Wiegmann et al., 2021). Principle 4. There must be proper control over the use of AI, and someone must be held accountable for the results. The right people must follow the rules and abide by them at every stage of the AI process, such as when it's designed, used, and implemented. According to Lehto, digital systems can sometimes fail in 2022, and security issues are at risk. In 2021, flash flooding in Rhineland-Palatinate, Germany, claimed the lives of at least 117 people. Part of the reason was that the federal government's weather warning app did not notify residents in time (Thieken et al., 2023; Olterman, 2021). As smart systems grow, it's important to create ways to manage and address potential risks. AI systems must be challenged by experts and stakeholders to ensure that they are fair and accurate, especially when predicting environmental risks. If an AI system makes a mistake, especially if it doesn't detect what it should have found, it can cause problems. There must be clear ways in which people can question and challenge bad decisions or outcomes coming from artificial intelligence. Some ways to do this are to allow people to review the system's solutions, train it with new information, or create points where decisions can be reviewed as part of the learning process. Because AI systems work on their own and are not always understood, it can be difficult to understand and challenge the results they produce or contribute. Combined with transparency and explainability, the entire management approach must be questioned. For example, if unjustified disaster relief is provided to certain people during or after a disaster, this indicates a problem. Either the disaster is caused by a forecast error, as in Almaty in 2019, or due to incorrect forecast floods in Germany, as above).




The implications for disaster management are as follows: Using insights from meetings where lawyers, social and environmental professionals collaborated, as well as recommendations for responsible data analysis, this section addresses three main points about the greater importance of the five principles previously discussed. be adaptive and adaptive as needed. Artificial intelligence, environmental science, technological applications, and law can play an important

role here. How engineers design and use computer models in AI and disaster management can be made naturally flexible. For example, environmentalists have developed a warning system that uses artificial intelligence to transmit warnings of natural disasters. Similarly, disaster recovery can be assessed using remote sensing data that can be analyzed by AI; It is also possible to measure the various stages of the disaster recovery process. The law can provide a flexible way to ensure that AI and disaster management tools are used safely, openly, and equitably for the benefit of the community. There may also be rules about who is responsible if something goes wrong and how those rules should be applied (Villa, 2022; Nemakonde and van Niekerk, 2022; Francesch-Huidobro, 2022). Laws or regulations governing the use of AI in areas such as disaster management or environmental applications should understand that these processes are not one-time measures. They change and improve over time, and the results get better over time. For example, the development of an early warning system raises many questions, and in this case we will consider three of them. The first is to have access to high-quality data and make sure it's accurate so that AI can be properly trained in the environment. Artificial intelligence needs a lot of data to make the right predictions (Duan et al., 2019). Sometimes the data you need isn't available in the right amount. One way to solve this problem is to improve the algorithms used in the app and clearly explain how uncertain the predictions are (Gneiting & Raftery, 2007.



This type of exchange aims to clearly show the system to everyone, which can help improve the way we communicate and build trust. It could also lead to legislative changes regulating the use of AI for environmental purposes and disaster management. (Cutter, 2022; Kahneman and Tversky, 1979). While there are some improvements in the ease of understanding, sharing, and implementing AI tools for environmental purposes, there is generally a balance between the clarity of these tools and their adaptability (James et al., 2013). Second, the use of artificial intelligence to combat environmental disasters must be fair, as the poor in society are usually the most affected by these disasters, as Matsuda noted in 2022. Including standards of justice that everyone must adhere to and that can be applied to all groups in society. Finally, the use of AI in early warning systems raises concerns about automatic flood forecasting. The results of AI should be reviewed regularly, but the final decision on what counts as early warning should be made by a trained scientist or technical manager. It is a question for lawyers and social scientists – who should be responsible, responsible, protect their rights, and ensure decisions should be implemented (Berber & Srećković, 2023). 3 Social sciences Social sciences, law, and

public participation are important at every stage of the disaster management process. They play a unique role in controlling how AI and big data are used to address environmental hazards. Social scientists and lawyers can help identify, investigate, and educate government officials on the risks posed by the use of artificial intelligence and big data in disaster management. This can include violating privacy rights through the use of big data from mobile apps, or treating people unfairly in terms of training, fundraising, implementation, and compliance with early warning and evacuation plans (Carlarne, 2022; Gable, 2022; Matsuda, 2022; Shevin, 2022). Ensure that AI-designed policies that make communities more resilient to disasters harmonize well with local laws, the geography of the region, and traditional methods of developing their communities over time (Marshall, 2015; Finn and Marshall, 2018). Social scientists, lawyers, and the general public must work together to create and share ethical principles (such as fairness, transparency, safety, accountability, and the ability to challenge decisions) that guide the use of AI in emergency management, which changes over time. Public participation is very important for the effective management of environmental disasters. It is therefore imperative that disaster management teams and decision-makers communicate frequently and clearly with the public, as society is the first to encounter a disaster; at the same time, citizens are important members who can quickly and reliably offer advice on responding to disaster risks (Peliño-Golle and Baula, 2022).

Social media offers a variety of platforms where the public can continue to engage with legal authorities. (See Figure 2 for an overview of social media and how AI and big data are used in disaster management.) The term "crowdsourcing" is a common approach used by people who want to help organizations or agencies by sharing information relevant to their needs. (Rowbury, 2022). There are some difficulties with this way of communication between the public and the government. One problem is that it is unclear whether the use of this public data gives a reliable picture, as it only contains information from people who know how to use digital tools (Lieske et al., 2019). Another point is that such exchanges can provide a lot of information (Ghani et al., 2019) that affects people's personal space and safety. Some countries and government organizations already have disaster data and face the same legal challenges. In India, the Emergencies Act of 2005, enacted by the Government of India in 2005, provides for a complete legal framework for disaster management. This system is often compared to other similar laws in different countries. Madan and Rutray (2015); Mohan and Menon (2016); Shakeri et al. (2021). Indian law states that the government can only collect and distribute personal information during a disaster, but only if there is a good reason. Another example of a law that can be used to manage personal data collected from social media during disaster response is the Data Protection Regulation (GDPR) introduced by the European Union (as discussed by Tikkinen-Piri et al., 2018; Hoofnagle et al., 2019). Public participation in open, strong, fair, and ongoing discussions is important to build trust and build effective disaster management that saves lives and protects property, especially as the number of countries using artificial intelligence in this area grows. As more countries begin to use artificial intelligence in disaster management, engaging the public in honest, strong, fair, and ongoing discussions will be critical to building trust, saving lives, and reducing property damage (Cutter, 2022).


Figure 2. The potential of social media and big data to improve disaster risk management and highlights key factors for effective implementation. Managing environmental hazards involves doing several technical jobs, like gathering and studying information, building models to predict dangers, and handling crises in a good way. Without strong laws and rules at the national, regional, or international level, disaster management doesn't work very well, according to Seneviratne et al.in 2010. The importance of interdisciplinary research in addressing long-term and complex environmental problems is on the rise, particularly in areas such as disaster management. It's really important for environmental and social scientists, along with legal and policy experts, to collaborate on this issue. The Cambridge Handbook of Disaster Law and Policy (Kuo et al., 2022) is one of the first books that brings together various fields to look at the legal and political sides of handling environmental disasters. It has chapters that talk about the different laws and rules used by various countries to handle disasters, along with actual examples from real situations. To handle future disasters well, countries and different areas of study need to work together. Climate justice affects the entire world, and many of the challenges we face today are human-caused. Disasters don't pay attention to where people live, and the effects can reach far beyond just one area, maybe even the whole world. Issues in one country can have effects on other countries. For example, if $CO_2$ emissions keep going up, forests get cut down, pollution moves to other areas, or too many fish are taken from the oceans.(Cutter, 2018; Gill, 2022). Words from trusted groups like UNESCO, the League of European Research Universities (LERU), and the British Academy are getting more attention. These groups are stressing how important it is to combine different subjects in research and teaching, so universities can fully use an interdisciplinary approach. In schools and colleges, using more artificial intelligence can help by bringing together students from different subjects to work on disaster management problems using methods that combine knowledge from

various fields. More individuals will gain a better grasp of disaster management issues and better equip future professionals to develop innovative solutions across various research domains. University courses in environmental science and law should include disaster law and policy, as suggested by Baker and others in 2022. The University of Georgia, which is a public university, shows how an integrated approach can work well. It provides a program that combines different fields to develop sustainable environments in cities. This program includes experts from law, environment, economics, and disaster management to tackle various issues related to climate change that cities worldwide are facing. Finally, a method that brings together different areas and encourages working as a team explains why and how to create a system that uses artificial intelligence and data analysis in emergency management. This makes it easier to handle disasters in a more adaptable and quicker way. It also reminds us that we need to make rules and laws to make sure this technology is used responsibly and ethically. In the last twenty years, AI technologies have advanced quickly, and environmental dangers have spread and gotten worse all over the world. Some new technology improvements have happened in the area of artificial intelligence used for managing disasters, and it's really important to pay attention to problems like bias, transparency, and privacy. These are important ethical and legal problems that impact all people involved in disaster management, no matter how skilled or responsible they are. Some important ideas for improving disaster laws and policies have already started being used, like the five principles discussed. Now, the next step is to think about how to turn these ideas into actual, enforceable laws. So, governments should work to develop rules that help artificial intelligence be helpful while preventing harmful outcomes. This means gathering experts from various areas to make sure that everyone's needs and rights are considered, especially people who are affected by environmental dangers. There are many different ways AI is used in disaster management, and ecologists and policymakers have different opinions about how helpful and trustworthy AI is when it comes to showing how natural and human systems function. It's important to work with experts from different areas and groups that are either directly or indirectly involved, but these differing opinions have made it hard to use artificial intelligence in disaster response systems. By using these different methods together, we can make AI tools more suitable for local conditions, rules, and the needs of natural resources. This method also considers how these changes impact various aspects of human life, which supports us in working towards the Sustainable Development Goals (SDGs) (Vinuezas et al., 2020; Costanza et al., 2023). Ethics must be thought about and handled correctly when developing AI, not just displayed. Building a system that looks at ethical problems won't stop progress, but it will help manage risks better and make sure they are found and handled in the best way possible. Social media apps that use artificial intelligence to reduce environmental dangers have raised several privacy and responsibility concerns that need to be thought about before using these apps to deal with environmental problems. AI can also help in education by connecting students from various fields to train the next generation of emergency management experts. They will be ready to fight against unfair, confusing, and risky AI solutions and can create new, smart solutions. AI and big data can help make disaster management better, but it's crucial to deal with problems like bias, transparency, accountability, and privacy. This can be done by following ethical rules and putting in place the right protection. Strong communities are already coming together and will keep growing in the future because of efforts like helping neighbors and teaching people. We suggest using a flexible model that relies on government data from large environmental data systems to help

make decisions about nature-based approaches in planning and managing resources sustainably at the regional level. These flexible data analysis methods, which handle both legal and environmental concerns, can help lessen the effects of disasters and build stronger, more resilient communities.

Funding Information: KC and TO worked together on a Royal Society project called "Spatiotemporal Variation Characteristics of Complex Dry and Hot Events and Their Impact on Vegetation Growth in Mid-Latitude Eurasia." KC is getting help from the Accelerator Program Award (2022-2024) to create artificial intelligence and big data techniques that can take climate and weather information from convection models. This support is helping to better manage the environment in cities as well as in green and blue zones. He was also working with the Managing Director and Teacher on the Vice Chancellor's Challenge Fund (2023-2024) project called "VIS-Studio: Immersive Reality Visualization and AI Data Solution to Facilitate Collaborative Decision-Making for Extreme Weather and Catastrophic Scenarios." TO was previously awarded the Rector's Professional Recognition Program Award for Responsible Artificial Intelligence.

## References


[1] AIHLEG. (2019). Ethics guidelines for trustworthy AI. European Commission, High-Level Expert Group on Artificial Intelligence. https://www.europarl.europa.eu/cmsdata/196377/AI%20HLEG_Ethics%20Guidelines%20for%20Trustworthy%20AI.pdf

[2] Albert, E. T. (2019). AI in talent acquisition: a review of AI-applications used in recruitment and selection. *Strategic HR Review, 18*(5), 215-221. https://doi.org/10.1108/SHR-04-2019-0024

[3] Alizadeh, B., Li, D., Hillin, J., Meyer, M.A., Thompson, C.M., Zhang, Z. and Behzadan, A.H., (2022). Human-centered flood mapping and intelligent routing through augmenting flood gauge data with crowdsourced street photos. *Advanced Engineering Informatics, 54*, p.101730. https://doi-org/ 10.1016/j.aei.2022.101730

[4] Almada, M. (2019, June). Human intervention in automated decision-making: Toward the construction of contestable systems. In *Proceedings of the Seventeenth International Conference on Artificial Intelligence and Law* (pp. 2-11). https://doi.org/10.1145/3322640.3326699

[5] Baker, J., Cerniglia, C., Finger, D., E. Herrera, L., & Newman, J. (2022). Creating Blueprints for Law School Responses to Natural Disasters. In S. Kuo, J. Marshall, & R. Rowberry (Eds.), *The Cambridge Handbook of Disaster Law and Policy: Risk, Recovery, and Redevelopment* (Cambridge Law Handbooks, pp. 389-407). Cambridge: Cambridge University Press. doi:10.1017/9781108770903.025

[6] Berber, A., Srećković, S. (2023) When something goes wrong: Who is responsible for errors in ML decision-making?. *AI and Society*. https://doi.org/10.1007/s00146-023-01640-1.

[7] Carlarne, C. (2022). From Covid-19 to Climate Change: Disaster and Inequality at the Crossroads. In S. Kuo, J. Marshall, & R. Rowberry (Eds.), *The Cambridge Handbook of Disaster Law and Policy: Risk, Recovery, and Redevelopment* (Cambridge Law Handbooks, pp. 511-524). Cambridge: Cambridge University Press. doi:10.1017/9781108770903.033

[8] Chauhan, P., Akiner, M.E., Shaw, R. & Sain, K. (2024) Forecast future disasters using hydro-meteorological datasets in the Yamuna river basin, Western Himalaya: using Markov Chain and LSTM approaches. *Artificial Intelligence in GeoSciences, 5*, 100069.

[9] Chen, N., Liu, W., Bai, R. & Chen, A. (2019). Application of computational intelligence technologies in emergency management: a literature review. *Artificial Intelligence Review, 52*, pp.2131-2168. https://doi.org/10.1007/s10462-017-9589-8

[10] Coeckelbergh, M. (2019). Artificial intelligence: some ethical issues and regulatory challenges. *Technology and regulation, 2019*, 31-34. https://doi.org/10.26116/techreg.2019.003

[11] Costanza, R., Fath, B., Fu, B., Hastings, A., Larry Li, B., Mackey, B., Meynecke, O.,

**Maloney, M., Mitsch, W. J., Ouyang, Z., Petrovskiy, S., Stokes, A., Thinley, J., &Zhiyun, O. (2023). EcoSummit 2023 Conference Declaration: Building a Sustainable Wellbeing Future. *Ecological Engineering 194*, 107052. https://doi.org/10.1016/j.ecoleng.2023.107052**

**[12] Cutter, S. (2018). Compound Cascading, or Complex Disasters: What's in a Name? *Environment: Science and Policy for Sustainable Development 60*, 16–25. https://doi.org/10.1080/00139157.2018.1517518**

**[13] Cutter, S. (2022). Governance Structures for Recovery and Resilience. In S. Kuo, J. Marshall, & R. Rowberry (Eds.), *The Cambridge Handbook of Disaster Law and Policy: Risk, Recovery, and Redevelopment* (Cambridge Law Handbooks, pp. 59-70). Cambridge: Cambridge University Press. doi:10.1017/9781108770903.004**

**[14] Deltares, WB & GFDRR. (2021). Responsible artificial intelligence for disaster risk management: working group summary. 44 pages. Available at: https://reliefweb.int/report/world/responsible-ai-disaster-risk-management-working-group-summary (the World Bank, the Global Facility for Disaster Reduction and Recovery, the Deltares)**

**[15] DSIT. (2023). A pro-innovation approach to AI regulation. UK Department for Science, Innovation and Technology. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1146542/a_pro-innovation_approach_to_AI_regulation.pdf**

**[16] Duan, Y, Edwards, J S, & Dwivedi Y K. (2019). Artificial intelligence for decision making in the era of Big Data – evolution, challenges and research agenda. *International Journal of Information Management, 48*:63–71. https://doi.org/10.1016/j.ijinfomgt.2019.01.021.**

**[17] EC. (2023). Regulatory framework proposal on artificial intelligence. European Commission. https://digital-strategy.ec.europa.eu/en/policies/regulatory-framework-ai**

**[18] Fan, P., & Chun, K. (2022). An Adaptive Legal Framework for Water Security Concerns in the Guangdong-Hong Kong-Macao Greater Bay Area. In S. Kuo, J. Marshall, & R. Rowberry (Eds.), *The Cambridge Handbook of Disaster Law and Policy: Risk, Recovery, and Redevelopment* (Cambridge Law Handbooks, pp. 131-148). Cambridge: Cambridge University Press. doi:10.1017/9781108770903.009**

**[19] Francesch-Huidobro, M. (2022). Climate Resilience in the Greater Bay Area of South China. In S. Kuo, J. Marshall, & R. Rowberry (Eds.), *The Cambridge Handbook of Disaster Law and Policy: Risk, Recovery, and Redevelopment* (Cambridge Law Handbooks, pp. 107-130). Cambridge: Cambridge University Press. doi:10.1017/9781108770903.008**

**[20] Frantz, P., & Instefjord, N. (2018). Regulatory competition and rules/principles-based regulation. *Journal of Business Finance & Accounting, 45*(7-8), 818-838.**

**[21] Finn, D. & Marshall, J.T. (2018). Superstorm Sandy at Five: Lessons on Law as Catalyst and Obstacle to Long-Term Recovery Following Catastrophic Disaster,**

*Environmental Law Reporter News & Analysis, 48*, pp. 10494 - 10519.

[22] Gable, L. (2022). Disasters and Disability. In S. Kuo, J. Marshall, & R. Rowberry (Eds.), *The Cambridge Handbook of Disaster Law and Policy: Risk, Recovery, and Redevelopment* (Cambridge Law Handbooks, pp. 525-540). Cambridge: Cambridge University Press. doi:10.1017/9781108770903.034

[23] Gevaert, C. M., Carman, M., Rosman, B., Georgiadou, Y., & Soden, R. (2021). Fairness and accountability of AI in disaster risk management: Opportunities and challenges. *Patterns, 2*(11). https://doi.org/10.1016/j.patter.2021.100363

[24] Ghani, N.A., Hamid, S., Hashem, I.A.T. & Ahmed, E. (2019). Social media big data analytics: A survey. *Computers in Human Behavior, 101*, 417-428. https://doi.org/10.1016/j.chb.2018.08.039

[25] Gill, B. Global Climate Emergency: after COP24, climate science, urgency, and the threat to humanity. *Economics and Climate Emergency, 17*(6), 885-902. https://doi.org/10.1080/14747731.2019.1669915

[26] Glikson, E., & Woolley, A. W. (2020). Human trust in artificial intelligence: Review of empirical research. *Academy of Management Annals, 14*(2), 627-660. https://doi.org/10.5465/annals.2018.0057

[27] Gneiting, T., & Raftery, A.E. (2007). Strictly proper scoring rules, prediction, and estimation. *Journal of the American Statistical Association 102*(477):359–378. https://doi.org/10.1198/016214506000001437.

[28] Goodman, K., Zandi, D., Reis, A., & Vayena, E. (2020). Balancing risks and benefits of artificial intelligence in the health sector. *Bulletin of the World Health Organization, 98*(4), 230. https://doi.org/10.2471%2FBLT.20.253823

[29] Government of India. (2005) Disaster Management Act, 2005. Legislative Department. Available at: https://cdn.s3waas.gov.in/s365658fde58ab3c2b6e5132a39fae7cb9/uploads/2018/04/2018041720.pdf

[30] Guikema, S. (2020) Artificial intelligence for natural hazards risk analysis: potential, challenges and research needs. *Risk Analysis, 40*(6), pp.1117-1123. https://doi.org/10.1111/risa.13476

[31] Gunes Peschke, S., & Peschke, L. (2022). Artificial Intelligence and the New Challenges for EU Legislation. *YBHD*, 1267.

[32] Hoofnagle, C. J., Van Der Sloot, B., & Borgesius, F. Z. (2019). The European Union general data protection regulation: what it is and what it means. *Information & Communications Technology Law 28*(1):65–98. https://doi.org/10.1080/13600834.2019.1573501

[33] IEEE (2019) Ethically Aligned Design: A Vision for Prioritizing Human Well-being with Autonomous and Intelligent Systems (A/IS). The IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems. Accessed from https://standards.ieee.org/wp-content/uploads/import/documents/other/ead_v2.pdf

[34] Imazon (2023). PrevisIA: principais resultados. Instituto do Homem e do Meio Ambiente da Amazo^ nia. 110 pages. Available at: https://previsia.org.br/wp-content/uploads/2023/04/PrevisIA-Principais-resultados-2023.pdf

[35] Imran, M., Ofli, M., Caragea, D. & Torralba, A. (2020). Using AI and Social Media Multimodal Content for Disaster Response and Management: Opportunities Challenges, and Future Directions. *Information Processing & Management 57*, 102261. https://doi.org/10.1016/j.ipm.2020.102261

[36] James, G., Witten, D., Hastie, T., & Tibshirani, R. (2013). *An Introduction to Statistical Learning*. Springer, New York. https://doi.org/10.1007/978-1-4614-7138-7.

[37] Kahneman. D., Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica 47*(2):263–292.

[38] Kuo, S, Marshall, J., & Rowberry, R. (Eds.). (2022) *The Cambridge Handbook of Disaster Law and Policy: Risk, Recovery, and Redevelopment*. Cambridge: Cambridge University Press. https://doi.org/10.1017/9781108770903.001

[39] Lamberton, C., Brigo, D., & Hoy, D. (2017). Impact of Robotics, RPA and AI on the insurance industry: challenges and opportunities. *Journal of Financial Perspectives, 4*(1).

[40] Lehto, M. (2022). Cyber-attacks against critical infrastructure. In *Cyber Security: Critical Infrastructure Protection* (pp. 3-42). Cham: Springer International Publishing.

[41] Lieske, S. N., Leao, S. Z., Conrow, L., & Pettit, C. (2021). Assessing geographical representativeness of crowdsourced urban mobility data: An empirical investigation of Australian bicycling. *Environment and Planning B: Urban Analytics and City Science, 48*(4), 775–792. https://doi.org/10.1177/2399808319894334

[42] Lyons, H., Velloso, E., & Miller, T. (2021). Conceptualising contestability: Perspectives on contesting algorithmic decisions. *Proceedings of the ACM on Human-Computer Interaction, 5*(CSCW1), 1-25. https://doi.org/10.1145/3449180

[43] Madan, A., Routray, J. K. (2015). Institutional framework for preparedness and response of disaster management institutions from national to local level in India with focus on Delhi. *International Journal of Disaster Risk Reduction, 14*:545−555. https://doi.org/10.1016/j.ijdrr.2015.10.004

[44] Matsuda, M. (2022). The Flood: Political Economy and Disaster. In S. Kuo, J. Marshall, & R. Rowberry (Eds.), *The Cambridge Handbook of Disaster Law and Policy: Risk, Recovery, and Redevelopment* (Cambridge Law Handbooks, pp. 48-56). Cambridge: Cambridge University Press. doi:10.1017/9781108770903.003

[45] Marshall, J.T., (2015). Rating the Cities: Constructing a City Resilience Index for Assessing the Effect of State and Local Laws on Long-Term Recovery from Crisis and Disaster. *Tulane Law Review, 90*, pp. 35 - 74.

[46] Mohanan, C., Menon, V. (2016). Disaster management in India—An analysis using

**COBIT 5 principles. In: 2016 IEEE Global Humanitarian Technology Conference (GHTC, pp. 209-212. https://doi.org/10.1109/GHTC.2016.7857282**

**[47] Morales, L. G., Hsu, Y., Poole, J., Rae, B., & Rutherford, I. (2014). A world that counts: Mobilising the data revolution for sustainable development (Report No. 1). United Nations. https://www.undatarevolution.org/wp-content/uploads/2014/11/A-World-That-Counts.pdf**

**[48] Nemakonde, D L., Van Niekerk, D. (2022). Integrating Disaster Risk Reduction and Climate Change Adaptation in the Context of Sustainable Development in Africa. In S. Kuo, J. Marshall, & R. Rowberry (Eds.), *The Cambridge Handbook of Disaster Law and Policy: Risk, Recovery, and Redevelopment* (Cambridge Law Handbooks, pp. 95-106). Cambridge: Cambridge University Press. doi:10.1017/9781108770903.007**

**[49] Olterman, P. (2021, July 19). German flood alert system criticised for 'monumental failure'. *The Guardian*. https://www.theguardian.com/world/2021/jul/19/german-villages-could-be-left-with-no-drinking-water-after-floods**

**[50] Papadakis, E., Adams, B., Gao, S., Martins, B., Baryannis, G. and Ristea, A. (2022). Explainable artificial intelligence in the spatial domain (X-GeoAI). *Transactions in GIS, 26*(6). doi: 10.1111/tgis.12996**

**[51] Pelin˜ o-Golle, C., & Baula, F. (2022). Averting Disasters through Watershed Policy Advocacy: The Case of the Philippines' Largest Highly Urbanized City. In S. Kuo, J. Marshall, & R. Rowberry (Eds.), *The Cambridge Handbook of Disaster Law and Policy: Risk, Recovery, and Redevelopment* (Cambridge Law Handbooks, pp. 353-365). Cambridge: Cambridge University Press. doi:10.1017/9781108770903.022**

**[52] Rowberry, R. (2022). Reflections on Urban Cultural Heritage, Public Health, and Public Participation. In S. Kuo, J. Marshall, & R. Rowberry (Eds.), *The Cambridge Handbook of Disaster Law and Policy: Risk, Recovery, and Redevelopment* (Cambridge Law Handbooks, pp. 468-476). Cambridge: Cambridge University Press. doi:10.1017/9781108770903.030**

**[53] Seamans, R. (2023, July 27). AI regulation is coming to the US, albeit slowly. *Forbes*. https://www.forbes.com/sites/washingtonbytes/2023/06/27/ai-regulation-is-coming-to-the-us-albeit-slowly/?sh=14d601367ee1**

**[54] Seneviratne, K., Baldry, D., & Pathirage, C. (2010). Disaster Knowledge Factors in Managing Disasters Successfully. *International Journal of Strategic Property Management 14*, 376–390. https://doi.org/10.3846/ijspm.2010.28**

**[55] Shakeri, E., Vizvari, B., Nazerian, R. (2021). Comparative analysis of disaster management between India and Nigeria. *International Journal of Disaster Risk Reduction, 63*:102448. https://doi.org/10.1016/j.ijdrr.2021.102448**

**[56] Sherwin, B. (2022). After the Storm: The Importance of Acknowledging Environmental Justice in Sustainable Development and Disaster Preparedness. In S. Kuo, J. Marshall, & R. Rowberry (Eds.), *The Cambridge Handbook of Disaster Law and Policy: Risk, Recovery, and Redevelopment* (Cambridge Law Handbooks,**

**pp. 479-496). Cambridge: Cambridge University Press. doi:10.1017/9781108770903.031**

**[57] Siau, K. & Wang, W., (2020). Artificial intelligence (AI) ethics: ethics of AI and ethical AI. *Journal of Database Management (JDM), 31*(2), pp.74-87. https://doi.org/10.4018/JDM.2020040105**

**[58] Smuha, N. A. (2021). From a 'race to AI' to a 'race to AI regulation': regulatory competition for artificial intelligence. *Law, Innovation and Technology, 13*(1), 57-84. https://dx.doi.org/10.2139/ssrn.3501410**

**[59] Soylu, A., Corcho, O' ., Elvesæter, B., Badenes-Olmedo, C., Yedro-Martí´nez, F., Kovacic, M., & Taggart, C. (2022). Data quality barriers for transparency in public procurement. *Information 13*(2):1-21. https://doi.org/10.3390/info13020099**

**[60] Sun, W., Bocchini, P. & Davison, B.D. (2020). Applications of artificial intelligence for disaster management. *Natural Hazards, 103*(3), pp.2631-2689. https://doi.org/10.1007/s11069-020-04124-3**

**[61] Thieken, A. H., Bubeck, P., Heidenreich, A., von Keyserlingk, J., Dillenardt, L., & Otto, A.: Performance of the flood warning system in Germany in July 2021 – insights from affected residents, *Nat. Hazards Earth Syst. Sci., 23*, 973–990, https://doi.org/10.5194/nhess-23-973-2023, 2023.**

**[62] Tikkinen-Piri, C., Rohunen, A., & Markkula, J. (2018). EU General Data Protection Regulation: Changes and implications for personal data collecting companies. *Computer Law and Security Review 34*(1):134−153. https://doi.org/10.1016/j.clsr.2017.05.015**

**[63] Trustible. (2023, July 18). How does China's approach to AI regulation differ from the US And EU? *Forbes*. https://www.forbes.com/sites/forbeseq/2023/07/18/how-does-chinas-approach-to-ai-regulation-differ-from-the-us-and-eu/?sh=5e4e44f351c6**

**[64] Ufert, F. (2020). AI Regulation Through the Lens of Fundamental Rights: How Well Does the GDPR Address the Challenges Posed by AI? *European Papers*. 2020. https://search.datacite.org/works/10.15166/2499-8249/394**

**[65] Villa, C. (2022). Law and Lawyers in Disaster Response. In S. Kuo, J. Marshall, & R. Rowberry (Eds.), *The Cambridge Handbook of Disaster Law and Policy: Risk, Recovery, and Redevelopment* (Cambridge Law Handbooks, pp. 408-420). Cambridge: Cambridge University Press. doi:10.1017/9781108770903.026**

**[66] Vinuesa, R., Azizpour, H., Leite, I., Balaam, M., Dignum, V., Domisch, S., ... & Fuso Nerini, F. (2020). The role of artificial intelligence in achieving the Sustainable Development Goals. *Nature communications, 11*(1), 1-10. https://doi.org/10.1038/s41467-019-14108-y**

**[67] Wiegmann, M., Kersten, J., Senaratne, H., Potthast, M., Klan, F., & Stein, B. (2021) Opportunities and risks of disaster data from social media: a systematic review of incident information. *Nat. Hazards Earth Syst. Sci., 21*, 1431–1444, https://doi.org/10.5194/nhess-21-1431-2021**