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Transforming Disaster Risk Reduction With AI and Big Data: Legal and Interdisciplinary Perspectives

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ABSTRACT

Managing complex disaster risks requires interdisciplinary efforts. Breaking down silos between law, social sciences, and natural sciences is critical for all processes of disaster risk reduction. It is essential to explore how AI enhances understanding of legal frameworks and environmental management, while also examining how legal and environmental factors may limit AI's role in society. From a co-production review perspective, drawing on insights from lawyers, social scientists, and environmental scientists, principles for responsible data mining are proposed based on safety, transparency, fairness, accountability, and contestability. This discussion offers a blueprint for interdisciplinary collaboration to create adaptive law systems based on AI integration of knowledge from environmental and social sciences. When social networks are useful for mitigating disaster risks based on AI, the legal implications related to privacy and liability of the outcomes of disaster management must be considered. Fair and accountable principles emphasize environmental considerations and foster socioeconomic discussions related to public engagement. AI also has an important role to play in education, bringing together the next generations of law, social sciences, and natural sciences to work on interdisciplinary solutions in harmony. Although emerging AI approaches can be powerful tools for disaster management, they must be implemented with ethical considerations and safeguards to address concerns about bias, transparency, and privacy. The responsible execution of AI approaches, based on the dynamic interplay between AI, law, and environmental risk, promotes sustainable and equitable practices in data mining.

1 | Introduction

Since the 2010s, governments across the world have developed and applied various forms of Artificial Intelligence (AI) to address intersectoral priorities of legal and environmental systems. Today, the emerging frontier has morphed from implementation to regulation of the rapid roll-out of AI (Smuha 2021). Emerging data-driven technologies are rapidly transforming the ways in which we live and work. Disaster risk management is no exception. With more frequent and severe environmental disasters, AI is increasingly used as a tool for the adaptive data mining management of disaster risks (e.g., Yu et al. 2018; Chen et al. 2019; Imran et al. 2020; Fan and Chun 2022; Alizadeh et al. 2022; Chauhan et al. 2024) from developing early warning systems, providing real-time situational awareness during disasters, to assisting aid allocation post-disasters. However, AI also poses significant risks. For example, since AI systems rely on historical data to facilitate decision-making, incomplete or biased data could result in biased outcomes. This is particularly important for disaster management, given that AI-assisted decisions could potentially have high-impact outcomes on people's lives and the environment in which they live (Gevaert et al. 2021). Regulators are, therefore, urged to look beyond the benefits of AI and data mining, putting in place appropriate measures to ensure its responsible and accountable use. However, AI models have applications beyond public sector control, also informing corporate decision-making (particularly in the light of recent uptake of Taskforce on Nature-related Financial Disclosures (TNFD) and other voluntary pro-environmental measures) as well as surveillance by NGOs and other sectors of civil society.

In the field of disaster management, AI methods can be classified between two extremes: supervised learning and unsupervised learning (Guikema 2020). Under supervised learning, a correct or 'desired' answer is provided to the algorithm, providing a reference point to check through large disaster datasets. An example would be in recording higher-than-normal day temperatures over a week and then linking it to a 'correct answer', that is, a prediction of an increase in hospital admissions prior to the summer heatwave. In unsupervised learning methods, no correct or 'desired' representations are provided to the algorithm to seek to develop an in-depth understanding of the interplay between disaster management variables. Beyond supervised and unsupervised methods are a class of methods that can be grouped under 'deep learning', where methods such as 'recursive neural networks', 'reinforcement learning' in resource management, etc. have been used, which require complex sequential tasks, large amounts of training data and time for disaster risk reduction (Sun et al. 2020). In general, learning methods underpinning the application of AI are more likely to generate useful information when large amounts of data are generated repeatedly in similar locations or scenarios.

Technical limitations related to data reliability, biases, transparency, and privacy constrain AI and big data technologies for disaster risk management. Historical and real-time data quality is a significant concern, as incomplete and noisy monitoring observations and biased social media data can lead to inaccurate models and unreliable predictions (Byabazaire et al. 2020). Algorithmic bias, stemming from historical biases in training data or existing prejudices related to socioeconomic class, or flawed algorithms, can result in unfair or discriminatory outcomes for disaster management (Kumar et al. 2018). The "black box" nature of many AI models, particularly deep learning models, poses challenges in terms of explainability and transparency (Hassija et al. 2023), which are crucial in critical applications like aid distribution. Deploying AI systems in disaster-affected areas with resource-constrained environments is also challenging due to the need for substantial computational power, energy consumption, and adequate infrastructure (Cao 2023). Ethical and privacy concerns arise from the extensive use of personal data (Pina et al. 2024), raising issues around surveillance and data breaches during emergencies. Additionally, AI models may struggle to generalize to new, unseen data, limiting their adaptability in dynamic hazard environments (Aldoseri et al. 2023). Addressing these limitations requires a comprehensive approach based on principles, including improving data quality, developing fair and transparent algorithms, ensuring ethical use for accountability and contestability, and building safe and robust disaster-proof infrastructure.

Although AI has been deployed to address the global agenda for sustainable development (Vinuesa et al. 2020), the practice of AI and data mining has only started receiving attention from a regulatory perspective in support of its responsible disaster management (e.g., Siau and Wang 2020; Deltares, WB, and GFDRR 2021). Regulators at national, regional, international and supranational levels have started assessing the necessity of revising existing regulations or developing novel regulatory approaches to mitigate AI risks. As an evolving and complex technology, AI poses multiple unique regulatory challenges. These include the transboundary use of AI, making it difficult to enforce regulations, and constrictive requirements that potentially curb innovations (Coeckelbergh 2019).

To balance the protective and enabling roles of regulation, various countries are considering following a principle-based approach (focusing on the outcomes regardless of the process or means), a rule-based approach (focusing on the process regardless of the outcomes), or a mix of both approaches (Frantz and Instefjord 2018). For example, the European Commission (EC) is proposing the first-ever legal framework on AI by classifying systems into four levels of risk, ranging from minimal or no risk to unacceptable risk (EC 2023). China is also in this race with its emerging strategies and detailed regulations to govern AI (Trustible 2023). The United Kingdom (UK) is taking a pro-innovation approach by using five principles to guide the responsible development and ethical use of AI and data mining in all policy sectors (DSIT 2023). The US is in the process of reviewing its current approach to AI regulation and the development of a risk-based framework for AI (Seamans 2023). Many of these policy frameworks have been shaped by IEEE's (2019) report, 'Ethically Aligned Design', which brings to the fore ethical considerations while developing and deploying 'Autonomous and Intelligence Systems', including AI tools.

All these initiatives emphasize the need for adaptive law and policy systems. However, there is a missing conversation around how disciplines with a stake in AI and disaster management can (and should) shape the momentum towards this goal. Taking the lens of the adaptive intersection between legal and environmental systems for disaster management as a case, we present our shared insights that resulted from a series of co-production workshops. The idea was initiated at the Disaster Law Handbook launch conference at the Georgia State University College of Law in spring 2023 and was further developed with co-authors through focus groups and tested in academic forums and classrooms.[1] We analyze AI regulatory challenges and desirability in the disaster risk reduction sector based on the five principles of ethical AI (DSIT 2023), introduced in Section 2. Section 3 will then address the wider significance of these principles in disaster management across three areas: building adaptive systems for legal and physical environments, encouraging public engagement and law, and forging interdisciplinary training in disaster management fields.

2 | Principles of Responsible AI Use for Disaster Management

In this section, we describe the principles of responsible AI with a focus on disaster management in the context of environmental hazards (Figure 1). To establish a common ground for a joint conversation on AI regulatory challenges and desirability in disaster management, we followed the five principles of ethical AI introduced by the UK (DSIT 2023) comprising: (1) safety, security, and robustness; (2) transparency and explainability; (3) fairness; (4) accountability and governance; and (5)

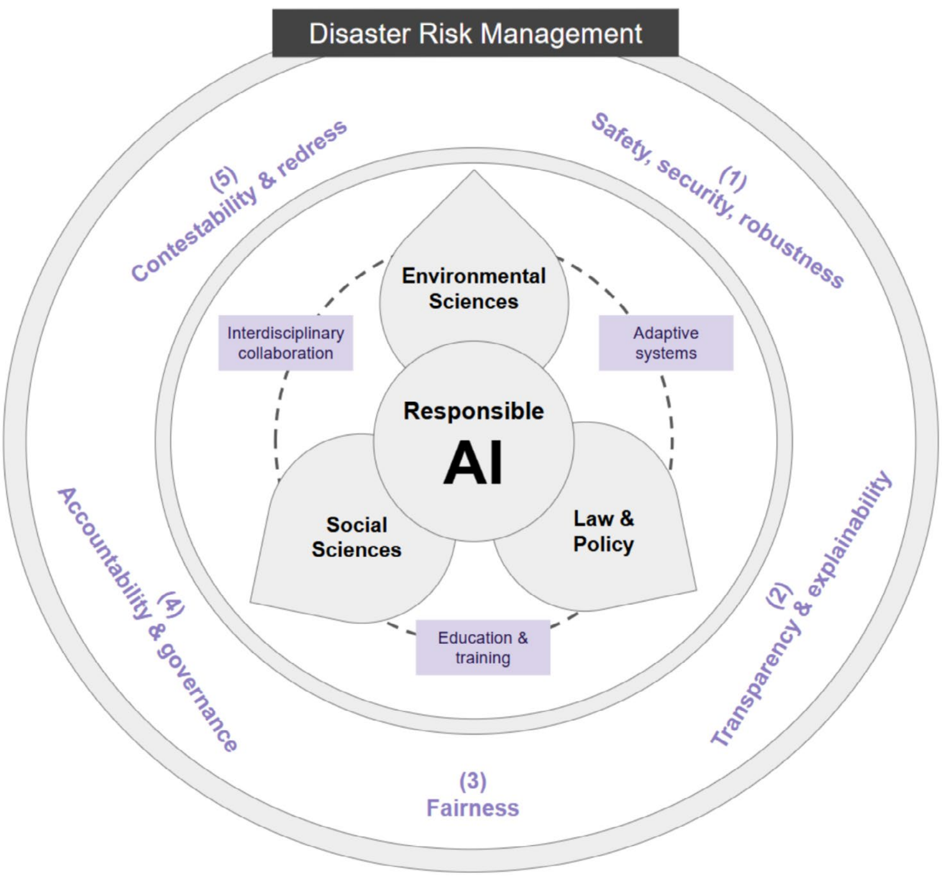

FIGURE 1 | Five principles for regulating AI use in disaster risk management. These principles should guide multi-level actors in legal, policy-making, science and innovation sectors. Significance from these principles include: (i) building adaptive data mining systems for legal and physical environments; (ii) encouraging public engagement and law; and (iii) forging interdisciplinary education and training in disaster management.

contestability and redress. This study uses the UK's approach as it is representative of emerging global positioning.[2] For example, the UK's principles overlap with the EU's principles in the ethical guidelines for trustworthy AI (AIHLEG 2019).

The principles are regarded as "soft law" that should be used to augment existing rules ("hard law") alongside industry standards and other co-regulatory tools, such as certifications and codes of conduct (CIPL 2023). Despite the varied approaches countries take in governing AI, as shown by Fritz and Giardini (2024) through analysis of OECD countries, there is a recognized need for the development of international standards and interoperable tools, as committed to during the Hiroshima Summit (G7 Hiroshima AI Process 2023).

Limitations inherent in using principles in regulating AI are acknowledged, for example, as guidance still leaves scope for local context and judgment (Goodman et al. 2020) rather than establishing concrete measures (Coeckelbergh 2019). We justify the use of this principles-based approach as the field is not yet mature, and therefore, flexibility and context dependence are necessary.

2.1 | Principle 1. Safety, Security and Robustness

Applications of AI should operate in a secure, safe, and robust manner, with risks carefully managed. Furthermore, the fact that AI systems can autonomously develop new capabilities can increase the risks to safety and security of their use. The use of AI and Big Data also raises significant privacy concerns. AI can process huge amounts of data that was not originally created for disaster management purposes (e.g., social media), and therefore, there is a need to ensure that the data are not misused (Ufert 2020). The EU General Data Protection Regulation defines rules on the protection of personal data, but due to rapid changes in AI technology, frequent updating of the regulation may be needed (Gunes Peschke and Peschke 2022).

2.2 | Principle 2. Transparency and Explainability

AI systems are often initially developed as opaque 'black box' processes that are complex and difficult to understand, especially when machine learning methods are involved (Glikson and Woolley 2020). This lack of transparency can make it challenging to determine how these Big Data and AI systems arrive at their decisions, confounding the ultimate responsibility for the derived decisions (Berber and Srećković 2023). Organizations developing and deploying AI should be able to communicate when and how it is used and explain the system's decision-making process in an appropriate level of detail that matches the risks posed by the use of AI. If AI is used to assist high-stakes decisions, such as controlling floodgates during a flood emergency, the systems need to be as transparent and explainable as possible to ensure their responsible data mining use (e.g., Papadakis et al. 2022). Nevertheless, transparency is strongly recommended to be supported by two other principles, that is, interoperability and reusability of data. They enhance the capacity to integrate and share information among administrative competencies alongside civil society initiatives using the available data to produce knowledge (Soylu et al. 2022; Morales et al. 2014).

In the event of an environmental disaster, such as the one that occurred in Valencia in October 2024, interoperable data can play a crucial role in saving lives. Days before the torrential rains in southern Spain, the Spanish Meteorological Agency (AEMET) issued warnings to citizens and authorities about the high probability of heavy rainfall due to a high-altitude isolated depression (Depresión Aislada en Niveles Altos, or DANA in Spanish) (AEMET 2024). However, in this instance, AEMET's alerts were not automatically disseminated by the Valencian government because the data systems between the central and regional governments lack interoperability. This gap means that the information collected by AEMET is subject to the discretionary decisions of regional authorities, limiting its immediate and effective reuse. Interestingly, the Japanese government accessed AEMET's warnings and promptly informed its citizens in Spain of the risks associated with torrential rains and flooding in various regions. This highlights how effective access to interoperable data can enhance disaster preparedness, even across national borders.

The DANA event in Spain illustrates the critical need for robust data interoperability and the integration of AI and big data to mitigate the impacts of natural disasters. AI-driven predictive models, like those used by the Spanish Meteorological Agency (AEMET), can significantly enhance preparedness and response efforts, aligning with SDG 13 (Climate Action) by enabling more accurate forecasting and proactive measures against extreme weather events. However, the lack of data interoperability between central and regional governments, as seen in the Valencian case, highlights a barrier to fully leveraging these technologies. Bridging this gap could contribute to SDG 11 (Sustainable Cities and Communities) from an interdisciplinary perspective by ensuring timely dissemination of critical information, reducing risks to vulnerable populations, and promoting resilient urban planning. Furthermore, AI and big data have long-term potential to align with SDGs by improving disaster risk management, optimizing resource allocation, and fostering international collaboration. For instance, the Japanese government's effective use of AEMET's data demonstrates how cross-border information sharing can enhance global resilience, a key aspect of SDG 17 (Partnerships for the Goals). Although the article underscores the importance of AI and big data in advancing SDGs, the DANA example reveals the pressing need to address systemic challenges—such as data silos and fragmented governance through different stakeholders—to unlock the full potential of these technologies in achieving sustainable development.

2.3 | Principle 3. Fairness

AI systems must comply with existing laws and not discriminate against individuals or create unfair outcomes. Some debates have been on the fairness of outcomes from AI-assisted processes, such as impacts on insurance offers (Lamberton et al. 2017) and recruitment outcomes (Albert 2019). AI use in decision-making processes, particularly for high-impact outcomes, should be justifiable and not arbitrary. An AI system might unintentionally leave some communities behind, for example, low-income, immigrant, elderly, and disabled residents, who find it difficult to access the information before and during a disaster. This is particularly likely when the AI has been trained on a dataset that is itself biased or partial in its consideration of different stakeholder groups. For example, social media data is increasingly used to provide situational awareness and support disaster response, yet it may marginalize constituencies with low digital media usage. Existing studies show uneven representation in a disaster situation and bias in social media data (Wiegmann et al. 2021).

2.4 | Principle 4. Accountability and Governance

Measures are needed to ensure appropriate oversight of how AI is being used, with clear accountability for its outcomes. Key to this principle is the clear expectation for regulatory compliance on appropriate actors involved in the AI life cycle, from research and development to deployment and use. It has been known that digital infrastructures frequently fail and are prone to security issues (Lehto 2022). For example, a flash flood in Rhineland-Palatinate, Germany, killed at least 117 people in 2021, and this was partly due to the failure of the federal government's weather warning app to notify the residents (Thieken et al. 2023; Olterman 2021). Formulating a governance mechanism that enables the identification and mitigation of potential risks is important with a growing trend of reliance on smart systems.

2.5 | Principle 5. Contestability and Redress

The AI systems should be able to be contested by experts and stakeholders to ensure they are fair and accurate, such as in predicting the likelihood of an environmental hazard. If an AI system makes a mistake (particularly false negatives), there should be clear routes to dispute harmful outcomes or decisions generated by AI. Some ways to achieve this include having humans review the system's decision, retraining the system on new data, or implementing human review checkpoints in the decision train. Given the autonomy and opacity of AI systems, it would be difficult to understand and contest the outcomes they generate or assist with. Linking it to the transparency and explainability principles, the overall governance mechanism needs to ensure that AI use is contestable, for example, in redressing failures associated with misprediction (as in the German flood case above) or unfairness in receiving disaster relief during and following disasters (Almada 2019; Lyons et al. 2021). Ultimately, some capacity for ethical override is required so that responsible people can take control of decision-making if the trajectory of the AI is perceived as leading to adverse outcomes.

3 | Implications for Disaster Management

Drawing on insights from the co-production meetings of lawyers, social scientists, and environmental scientists, and principles for responsible data mining, this section summarizes three major themes on the wider significance of the five principles presented in the previous section.

3.1 | AI for Adaptive Disaster Management: Environmental Science and Law

All phases of disaster risk management must be adaptable. It is here that AI, environmental science and technology-related applications, and law can combine to play a crucial role. AI and disaster management applications deal with engineering design and computational models that can be made inherently flexible. For example, an AI-generated early warning system designed by environmental scientists can issue warnings for potential disaster events. Similarly, measuring the scale of a disaster's impact in the recovery phase is also possible through remote sensing data that can be mined by AI. In the creation and utilization of these AI and disaster management applications, the law can provide a flexible framework on how they might be used safely, transparently, and fairly to benefit the wider community while defining liability and enforcement provisions (Francesch-Huidobro 2022; Nemakonde and Van Niekerk 2022; Villa 2022).

However, legislation governing AI or disaster management applications—or the functions of the environmental applications themselves—must realize that these processes are dynamic, iterative, and adaptive, improving their outcomes over time. For example, the design of an early warning system raises a host of issues; here we discuss three.

The first issue relates to environmental data availability and data quality for training AI. AI needs a vast amount of data to issue reliable predictions (Duan et al. 2019). However, such data are not always available in the desired quantity or quality. To mitigate this problem, one could improve the algorithms governing the application while also clearly reporting the uncertainty of the predictions (Gneiting and Raftery 2007). Data gaps, particularly in relation to key environmental parameters of stakeholder groups, must be clearly reported. Such disclosure reveals the transparency of the system to the public, potentially improving communication and trust. This can also prompt changes to the legal framework governing AI and disaster management environmental applications (Cutter 2022; Kahneman and Tversky 1979). Despite advancements in the interpretability, interoperability, and reusability of AI environmental applications, there will always be some trade-offs with their flexibility (James et al. 2013).

A second issue is that the outcomes of AI in environmental disaster management applications must also be equitable, as it is the poorest sectors of society who suffer most from environmental disasters (Matsuda 2022). Assuming the quantity and quality of data are acceptable, fairness should be integrated during the AI training phase with regulations mandating and enforcing equity of use among all social strata.

Finally, early warning systems using AI raise concerns about the automatic issuing of flooding predictions. AI outcomes need to be continuously controlled, but final decisions to trigger an early warning should be given by a responsible scientist or technical manager. How accountability, liability, redressability, and enforcement should be assigned remains open issues for law and social scientists to decide (Berber and Srećković 2023).

3.2 | Public Engagement and Law

In all phases of disaster management, social sciences, law, and public engagement play unique roles in regulating the use of AI and Big Data for environmental hazards. Social scientists and lawyers can help identify, analyze, and report to regulators the risks of using AI and Big Data for disaster management. Examples may include the violation of privacy rights in the use of Big Data from mobile apps or potential discrimination between citizens regarding training, funding, implementation, and enforcement of early flood warnings and evacuation plans (Carlarne 2022; Gable 2022; Matsuda 2022; Sherwin 2022). There is a need to ensure that AI-generated policies for promoting resilience to disasters do not conflict with prevailing local laws, geography, and historical forms of development (Marshall 2015; Finn and Marshall 2018). Social scientists, legal regulators, and the public must also work together to formulate and communicate the ethical principles (e.g., fairness, transparency, safety, accountability, and contestability) that should guide AI use for adaptive disaster management.

Public engagement is crucial for the efficacy of environmental disaster management systems. It is consequently critical that disaster management agencies and decision-makers liaise with the public frequently and clearly, as these people are on the frontlines of disaster, and individual citizens often also can identify timely, credible solutions to address immediate risks (Peliño-Golle and Baula 2022).

Social media provides multiple platforms through which the public can constantly interface with legal regulators (see Figure 2 for the social media landscape and emerging AI and Big data considerations in disaster management).'Crowdsourcing' has become a common way for interested public members

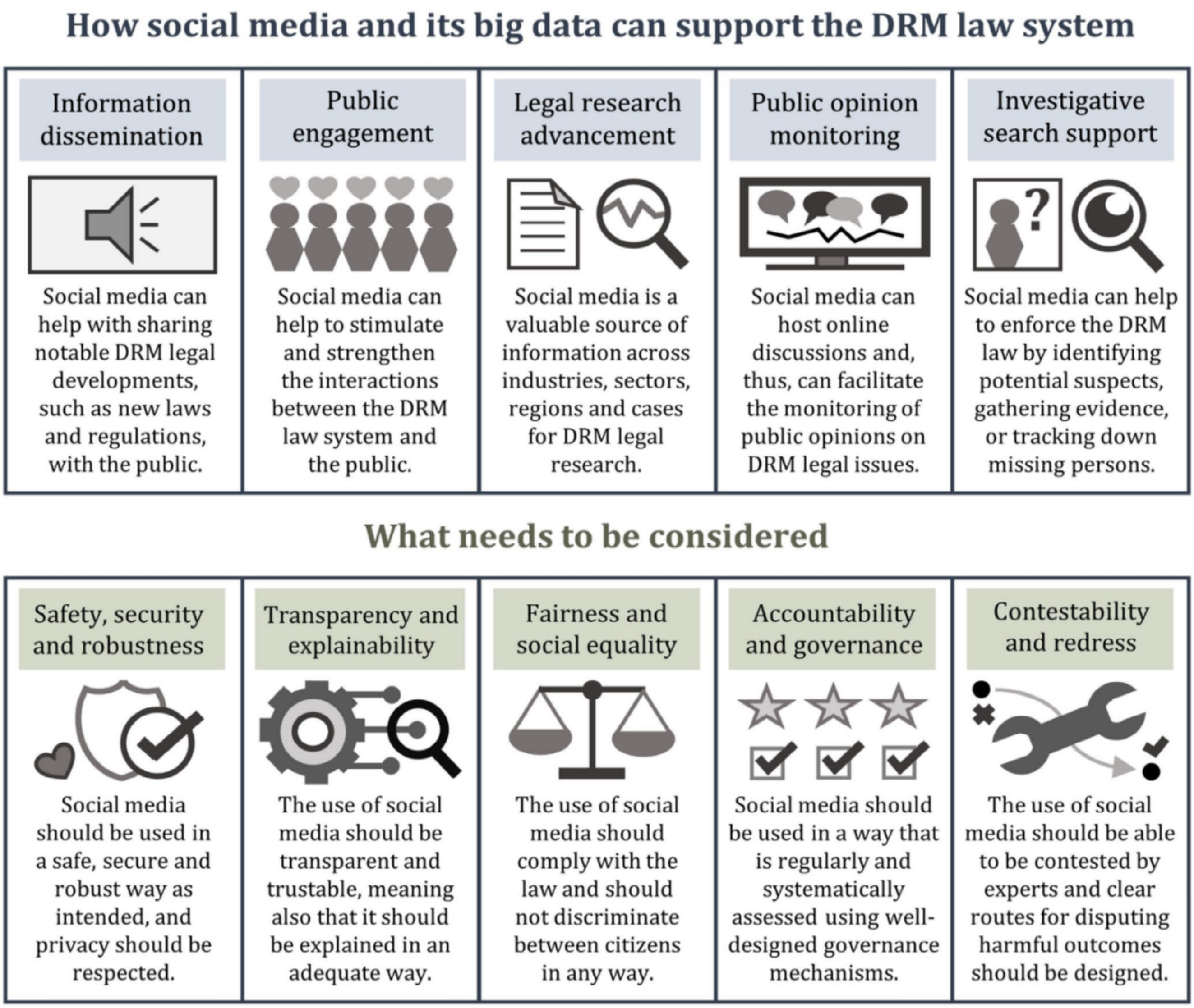

FIGURE 2 | The potential of social media and big data to enhance disaster risk management, highlighting key considerations for effective implementation.

to respond to the informational needs of organizations or agencies (Rowberry 2022). Such public-to-government exchange does, however, pose challenges. One issue is determining whether such public data is truly representative as the dataset would include only information from the digitally able (Lieske et al. 2021). Another is that such an exchange could lead to the collection of substantial volumes of data (Ghani et al. 2019), which may impact the privacy and safety concerns of the public. Nevertheless, several nations and government entities have already collected disaster data and are grappling with these legal issues. In India, the Disaster Management Act 2005 (Government of India 2005) provides a comprehensive disaster management legal framework that is compared with similar legal frameworks (e.g., Madan and Routray 2015; Mohanan and Menon 2016; Shakeri et al. 2021). India's law states that the government may collect and share personal information in the event of a disaster, but only if there is a 'reasonable' justification for doing so. The much-discussed General Data Protection Regulation (GDPR), promulgated by the European Union (see discussions by Tikkinen-Piri et al. 2018; Hoofnagle et al. 2019) is another example of how laws might regulate the processing of personal data from social media platforms for use in disaster management.

As more countries begin to use AI in adaptive disaster management, involving the public in honest, robust, representative and constant discourse will be crucial to engendering trust and, ultimately, to saving lives and reducing property damage (Cutter 2022).

3.3 | Interdisciplinary Education and Training

Disaster management for environmental hazards involves substantial technical work of a diverse nature, such as data collection and analysis, hazard modeling, and crisis management. However, disaster management cannot be successful without effective laws and policies at national, regional, or international scales (Seneviratne et al. 2010). Interdisciplinary studies are becoming more common and urgent in resolving long-standing and emerging environmental issues, particularly issues such as disaster management that span multiple disciplines. Consequently, engendering collaboration and co-learning between environmental and social scientists in conjunction with legal and policy experts is essential. One pioneering interdisciplinary collaboration is *The Cambridge Handbook of Disaster Law and Policy* (Kuo et al. 2022), which provides a foundational resource for exploring various legal and policy frameworks for managing environmental disasters, including case studies from across the globe.

International and interdisciplinary cooperation and coordination are essential for effectively managing future disasters. This is due to both the global nature of climate justice and also the contributory human influence on many contemporary disasters. Furthermore, disasters have no political boundaries, with potential cascading impacts across regional, continental and global scales (Cutter 2018; Gill 2020), including 'spillover' effects from measures in one country upon others, such as unconstrained carbon emissions, forest felling, pollutant emissions, and fish stock overexploitation. Authoritative voices, such as UNESCO, the League of European Research Universities (LERU) and the British Academy, are increasingly emphasizing the importance of interdisciplinary research and teaching to unleash the potential of universities to achieve interdisciplinarity in practice.

In an educational context, increasing the use of AI can play an important role by bringing together students from different disciplines to devise interdisciplinary solutions to disaster management problems. This can help to ensure that future professionals develop a broad understanding of the issues involved in disaster management and are better equipped to develop creative and innovative interdisciplinary solutions. Disaster law and policy should be included in the curricula of university degrees in environmental sciences and law (Baker et al. 2022). Georgia State University provides an important example of this integrated approach by offering an interdisciplinary "Urban Environmental Sustainability" program that links lawyers, environmental scientists, economists, and disaster management specialists to tackle multi-faceted climate issues facing municipalities worldwide.

4 | Conclusion

The interdisciplinary and collaborative framing of this study reflects on the whys and hows of establishing a system of practice to support and accelerate adaptive disaster management through AI and data mining, emphasizing how law and policy can help regulate its responsible and ethical use. The twenty-first century has witnessed a speedy evolution of AI technologies, coincident with the increasing global intensity and frequency of environmental hazards. AI for disaster management has achieved a certain level of technical maturity, highlighting the need for greater attention on its use in addressing issues such as bias, transparency, and privacy, which pose significant ethical and legal risks for all disaster management stakeholders at different levels of competencies and responsibilities. Although foundational precepts to inform the further evolution of disaster law and policy have been achieved, significantly including the five principles discussed here, there is still a question of how these principles can be translated into enforceable regulations. Governments are therefore strongly urged to develop regulatory frameworks to ensure that the benefits of AI can be harnessed whilst minimizing unintended negative outcomes, necessitating interdisciplinary efforts to consider the needs and rights of all stakeholders impacted by environmental hazards.

The use of AI in disaster management is a complex issue involving multiple factors related to the different views of environmental scientists and decision-makers about the usefulness and accuracy of AI for representing natural and human systems. While collaboration among professionals from relevant disciplines and communities who are affected, directly or indirectly, should be promoted, these diverse views are currently hindering the implementation of AI in disaster management frameworks. Bridging these conceptual differences may enable improved adaptation of AI technologies to reflect local contexts, laws, and needs for natural resources, considering the wider ramifications across a broad spectrum of human activities, including making progress towards the Sustainable Development Goals (SDGs) (Vinuesa et al. 2020; Costanza et al. 2023).

Ethical consideration should be part of AI development and should be undertaken appropriately, not performatively. Creating a system that allows ethical issues to be assessed proportionately will avoid seeing this requirement as a barrier to development but instead as a mechanism ensuring that risks have been identified and addressed as much as possible.

The use of social networks for mitigating environmental risks based on AI raises diverse privacy and liability concerns, requiring careful consideration before their use for this purpose. AI also has an important role to play in education, bringing together students from different disciplines to support the next generation of disaster managers. They will be prepared to challenge unfair, obscure, and unsafe AI decisions and will be equipped to develop creative and innovative solutions.

The use of AI and Big Data can enhance disaster management, but ethical considerations and safeguards are crucial to address concerns around bias, transparency, accountability, and privacy. Outreach and education are also essential in building resilient communities now and training communities to be resilient in the future. We propose to integrate an adaptive legal framework based on state indicators derived from environmental Big Data networks to inform nature-based solutions for regional planning and sustainable management decisions. Overall, these adaptive data mining approaches based on the intersectional priorities of legal and environmental systems can help reduce the impact of disasters and create more sustainable and resilient communities.

Author Contributions

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Related WIREs Articles

Artificial intelligence for climate change adaptation

Endnotes

[1] The co-production process underpinning this paper was initiated in law conferences, bringing together a lawyer network, leading to the publication of *The Cambridge Handbook of Disaster Law and Policy* in the summer of 2022, a valuable resource for understanding international legal and policy frameworks for managing environmental disasters. This study used a variety of techniques to involve different communities, including filling tables (see Supporting Information), sharing documents, and conducting focus groups. The evolving work has been presented at writing retreats hosted by the Centre for Water, Communities and Resilience (CWCR) and the School of Architecture and Environment by the University of the West of England. In the spring of 2023, we presented our work to the South American Action Group communities with the National Center for Atmospheric Research (NCAR) researchers and the Global Institute of Water Security researchers from the University of Saskatchewan. We have also tested our work in our Water and Energy Future classes for the Geography and Environmental Management programmes during the 2022–2023 academic year, designed to engage the next generation of disaster managers. The co-production processes entailed in the development of this paper emphasize the need for an interdisciplinary approach to disaster management.

[2] We use the UK's principles here as they arguably represent general positions of other countries and organizations. However, we also acknowledge that some countries and organizations may put different emphasis on their initiatives. For example, the US emphasizes the use and development of responsible AI for *their citizens*.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.