Artificial Intelligence in Disaster Management:
Sustainable Response and Recovery

Silvio Andrae
https://orcid.org/0000-0002-8586-7812
Independent Researcher, Germany

EXECUTIVE SUMMARY

This chapter examines using artificial intelligence (AI) and deep learning (DL) in disaster management. It describes a paradigm shift towards proactive measures in preventing and managing natural disasters. Traditional, reactive methods often reach their limits. At the same time, AI-based approaches can improve early warning systems and allocate resources more efficiently through the analysis of large, heterogeneous data sets and the ability to recognize complex patterns. The article highlights the application of DL models, such as Convolutional Neural Networks (CNNs), to analyze satellite imagery and their utility in disaster response. Both technical and ethical challenges are discussed, particularly data protection, bias, and transparency in the models. Finally, a framework is presented that provides guidelines for the effective and responsible use of AI in disaster management and promotes long-term sustainability and fairness in this area.

1. INTRODUCTION

Traditionally, disaster management relies on proven methods such as emergency plans, risk analyses, and decision-making processes based on human experience. It includes the early identification of risks, preparation for possible scenarios, rapid

response to disasters and the long-term recovery of affected regions. Early warning systems, manual resource allocation and statistical hazard assessment models have long been the dominant tools. Still, limited data availability and the complexity of disaster events have often been constrained. Methods such as mixed integer programming, stochastic optimization and network theory have proven effective but are computationally expensive. It significantly limits their applicability (Murray et al., 2024).

Artificial intelligence (AI) and deep learning (DL) have changed disaster management in recent years. Due to the rapid progress in the availability of big data and the computing power of modern systems, AI-based approaches are opening up entirely new possibilities. Machine learning (ML) and DL methods enable the analysis of large, heterogeneous data sets in real-time and offer advanced predictive models that go far beyond the capacities of traditional statistical approaches (Thekdi et al., 2024). These technologies are used in disaster management, from risk prediction and assessment to optimizing emergency response and resource allocation (Yu et al., 2024; Albahri et al., 2024).

Artificial intelligence (AI) is crucial for disaster management because it can address many existing challenges. Disasters such as earthquakes, floods, droughts, forest fires and pandemics are occurring with increasing frequency and intensity, often with devastating consequences for lives, infrastructure and the environment. However, traditional methods of disaster management are reaching their limits, especially when it comes to responding quickly and precisely to complex, dynamic and large-scale disaster scenarios. This is where AI comes into play: With the ability to process large amounts of data in real-time and recognize patterns that are difficult for humans to access, AI can significantly improve the efficiency and precision of response and recovery efforts.

A central problem in disaster management is the early warning and prediction of disaster events (pre-disaster management). Conventional models often need help to adequately capture complex interactions between risk factors, such as climate data, geological conditions and human activities. AI-based approaches, intense learning and other advanced machine learning techniques can bridge this gap by enabling more comprehensive and accurate predictive models. Figure 1 provides an overview of the different methods and their use. This is particularly important for prevention, as better predictions make it possible to identify risks early and take action before disasters occur.

Another major challenge is to efficiently process the immense amount of data generated in real-time during disasters - whether through social media (Devaraj et al., 2020), sensors or satellite images - and derive actionable insights from it. Human decision-makers often need help to evaluate these volumes of data quickly enough. However, AI can help filter critical information in real-time, prioritize