Aide-Mémoire

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ICTs and AI-Driven Solutions for Disaster Management

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Southeast Asia is one of the world's regions that are the most vulnerable to disasters (ASEAN, 2020). In just four years – between 2012 and 2018 – more than one thousand disasters occurred in the region, causing an estimated damage per year of almost USD 16 billion (ASEAN, 2020). Given such serious damage that natural disasters cause to this small but thriving region, there needs to be intervening mechanisms that could help the countries to at least minimize the impacts, if avoiding it is impossible. Experts in the field of disaster management have used a variety of terminologies to define *resilience* as "the ability to bounce back after adverse events; the critical infrastructural capacity to withstand external shocks; and recovery and rehabilitation components embedded in the concept of resilience" (Agrawal, 2018). In a world where technological solutions are shaping our lives, an interesting question to pose is: what Information Communication Technologies (ICTs) can do to help us during disaster events and thus support resilience? Artificial Intelligence (AI) driven solutions are offering numerous possibilities in many spheres of our life, and they can represent a change-maker in the disaster management sphere of interest. But how specifically can AI-driven solutions support us in disaster management?

Accounting for the increased risk of encountering natural and human-induced disasters by the ASEAN Member States, in 2009, ASEAN created a policy framework called the Agreement on Disaster Management and Emergency Response (AADMER) (ASEAN, 2020). This framework posed the foundations for programmatic pursuance of disaster management and risk reduction initiatives, both at the national and regional level, aiming to reduce disaster losses and enhance regional cooperation during disasters (ASEAN, 2020). Disasters are usually classified into two main categories: natural disasters and man-made ones (Firdhous & Karuratane, 2018). These disasters interest everyone, but they are affecting especially rural communities, who suffer from limited access to resources, poverty, and lack of adequate infrastructures and public services (Firdhous & Karuratane, 2018). Several international conventions and organizations have already recognized the importance and the power of ICTs for supporting effective disaster risk management at every phase of the disaster management cycle (Firdhous & Karuratane, 2018), namely mitigation, preparedness, response and recovery (Coetzee & Niekerk, 2012). Specifically, in terms of mitigation, ICTs can offer support in monitoring and assessing the risks for disaster occurrence, continuous research in understanding the underlying causes of disasters and improved communication, and boost awareness (Firdhous & Karuratane, 2018). In terms of preparedness, ICTs can support the dissemination of information in a quick and effective manner and can support the delivery of messages and information, something very essential during emergencies. Additionally, ICTs allow the creation of awareness and educational campaigns to train citizens to be prepared for a natural disaster and inform them of the procedure to follow in case these events happen. Furthermore, ICTs can also

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support the response phase, allowing the collection and dissemination of accurate information, an indispensable step for a rapid assessment necessary for initiating and executing response activities (Firdhous & Karuratane, 2018). Finally, ICTs also support the last phase, known as the recovery phase, by allowing the creation of new opportunities while improving the existing ones (Firdhous & Karuratane, 2018).

Diving into the pool of affordances offered by ICTs, one of them is represented by AI, which includes six different categories of applications, namely supervised models, unsupervised models, deep learning, reinforcement learning, deep reinforcement learning and optimization (Sun et al., 2020). Regarding this, Sun et al. (2020) offer a comprehensive overview of possible AI-driven solutions for supporting disaster management at each of the four steps of disaster management as discussed above by identifying twenty-six AI methods and seventeen application areas for AI-driven solutions deployed specifically for disaster management. In terms of disaster mitigation, AI-driven solutions can support decision-makers in identifying hazards and risks, predict possible impacts, assess vulnerability, and develop mitigation strategies (Sun et al., 2020). Possible applications cited by Sun et al. (2020) include analysis of a massive amount of data from physical sensors, aiming to assess the vulnerability of structures and communities, or for forecasting precipitations, possible avalanches and land-related issues. A further example is represented by the solution offered by Nguyen et al. (2019), who propose an AI-driven solution capable of forecasting people's needs during disasters using social media and weather data. Regarding data collection useful for prediction and modeling, Yu et al. (2018, p. 18) point out that “in the present age of information technology, a major objective of scientists is to analyze the varied aspects of big data and find ways of making the best of the available technologies in storing the available information in well-integrated structures and using it for the welfare of human societies”. In terms of the disaster preparedness phase, AI can quickly connect decision-makers with the public for early warning and alert dissemination, offering emergency training systems and tools, and supporting evacuation when needed (Sun et al., 2020). Additional examples of applications in this phase can be represented by the identification of abnormal patterns in the data recorded by sensors, within an Internet of Things (IoT) configuration, allowing us to estimate the probability of extreme phenomena to happen. Such solutions have been implemented in Japan by the Japan Meteorological Agency, in Europe within the Urban-Flood project and in Ontario, Canada, for localizing possible service outages prior to a disaster event (Sun et al., 2020). Furthermore, during the phase of disaster response, AI-driven solutions can be applied to facilitate relief response and efforts by developing maps of impacted areas, and thus providing vital information for planning research and rescue operations (Sun et al., 2020). Examples of such applications can be represented by the automatic generation of maps obtained from satellite images, used to assess the impact of damages and prioritize interventions based on locations. Additionally, social media and robotics can be used to find and help possible victims of disaster events. Finally, regarding the last phase of disaster management, namely the recovery phase, Sun et al. (2020, p. 25) point out how “AI can be an important module for supporting disaster recovery management in less time”, demonstrating how AI-driven solutions have been already applied to disaster recovery management, “by assessing the disaster [*sic*] induced impact in detail”, “developing recovery plans”, “tracking the recovery process”, and “estimating loss and repair cost”. Additionally, regarding this phase of disaster management, night-time light remote sensing images can fill the gap of empirical data, which is hard to obtain in vast geographical areas, for measuring community resilience in natural disasters (Qiang et al., 2020). Finally, sentiment analysis methods and image classification techniques used to analyze social media data can be essential for understanding the degree of recovery of communities after a disaster, while regression models can support the assessment of risk factors and the effectiveness of preventive interventions (Sun et al., 2020).

In addition, AI-driven solutions can also be deployed on open-source platforms. In particular, an open-source platform deploying AI has been already presented in 2014, the AIDR (Artificial Intelligence for Disaster Response). AIDR is a platform designed to "perform automatic classification of crisis-related microblog communications" enabling "humans and machines to work together to apply human intelligence to large-scale data at high speed" aiming to "classify messages that people post during disasters into a set of user-defined categories of information" (Imran et al., 2014, p. 159). But there are other emerging solutions including satellite imagery, aerial imagery, videos from drones, airborne and terrestrial light detection, crowdsourcing, social media, spatial data, mobile Global Positioning System (GPS), and simulations (Fan et al., 2021). The pool of possible applications of AI-driven solutions is constantly growing and representing a powerful set of solutions to be considered for disaster management, mostly for those countries more vulnerable to such disaster events.

In conclusion, AI-driven solutions are currently being investigated in a wide spectrum of disaster-related applications, and they are offering very interesting opportunities to use the power of technologies for serving the people during difficult times, mostly those living in the poor and more vulnerable regions in the world. More research needs to be conducted and more investments in research and developments should be prioritized mostly by those countries who are suffering the most from the effects of disasters since the opportunities offered by AI-driven applications have an enormous potential to unleash in the battle against disasters.

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