ISSUE BRIEF

INSTITUTE OF STRATEGIC STUDIES ISLAMABAD
Web: www.issi.org.pk
Phone: +92-51-9204423, 24
Fax: +92-51-9204658

ARTIFICIAL INTELLIGENCE FOR FLOOD PREDICTION AND MANAGEMENT: LESSONS FOR PAKISTAN

By
Fatima Faisal
Intern
Arms Control & Disarmament Centre, ISSI

Supervised by
Aamna Rafiq

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(Views expressed in the brief are those of the author, and do not represent those of ISSI)

Pakistan is being ravaged by the worst floods in recent history - attributed to the growing dangers of climate catastrophe. One-third of a developing country submerged in water, estimating over US$20bn loss and around 1700 deaths while affecting over 33 million people[1] is nerve-wracking. The latest disaster and its grave human, economic and environmental security implications yet again highlight Pakistan's vulnerability to Climate Change and remind us that non-traditional challenges must be addressed by innovative approaches. Furthermore, being a human-triggered disaster, it places a greater need for and responsibility upon management by humans themselves. This is where man-made technologies, namely Artificial Intelligence (AI), come into play.

AI, as an emerging technology that has revolutionised security, is frequently quoted, but relatively less understood. IEEE-USA defines it as "the theory and development of computer systems capable of performing tasks that normally require human intelligence, such as visual perception and natural language processing." [2] India's National AI Strategy Discussion Paper refers to it as "a constellation of technologies that enable machines to act with higher levels of intelligence and emulate human

1 National Disaster Management Authority, *NDMA Floods (2022) SITREP - (Daily SITREP No 118 Dated 9th October, 2022),* FFD Bulletin-B, 2022, http://cms.ndma.gov.pk/storage/app/public/situation-reports/October2022/zXFmE5LpVx34knkmZbri.pdf.

2 IEEE-USA Position Statement, "Artificial Intelligence Research, Development and Regulation," February 10, 2017, https://ieeeusa.org/wp-content/uploads/2017/10/AI0217.pdf.

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capabilities of sense, comprehend, and act." [3] While these technologies are inspired by humans and other biological beings, they vary in working and thus impact. Experts diverge in their views on the nature and scope of this impact. However, one thing remains uncontested: AI has huge, unquantified and even unrealised potential to meet evolving security needs. But given its dual-use feature, the real challenge is to harness this potential in a useful but peaceful manner. In Pakistan's context, one way of tapping this potential can be investing in AI-enabled systems for flood detection, risk assessment and management. The four key uses of AI[4] in this regard include:

1. **Data Collection, Completion and Processing:** AI gathers and processes satellite and IoT data and fills gaps in temporarily and spatially sparse data.

2. **Acceleration and strengthening of strategic planning and decision-making:** It contributes to effective policy and climate-risk analysis, modelling higher-order effects and bionic management.

3. **Support for Collaborative Ecosystems:** AI can enable vertical data sharing and improve communication tools.

4. **Stimulation of climate-positive behaviours:** It can perform climate-friendly optimisation functions and provide climate-weighted suggestions.

Incorporating AI helps strengthen and accelerate efforts for mitigation, adaptation and resilience-building. This cutting-edge technology can provide the support tools that Pakistan needs for more informed, data-driven and proactive decisions. For instance, flood-type classification, using technologies based on weather forecasts through remote sensing, can help chalk out a map for stakeholders to initiate and pace up mitigation measures in sensitive areas - areas that can then be prioritised and put under surveillance for a more agile response.

AI systems that have "limited memory" can use past experiences to guide future decisions.[5] Deep Neural Networks can be employed for predicting floods based on temperature and rainfall intensity.[6] Machine Learning (ML), a subset of AI, can analyse historic datasets and classify flood types based on

3 NITI Aayog, National Strategy for Artificial Intelligence, Discussion Paper, June 2018, http://niti.gov.in/writereaddata/files/document_publication/NationalStrategy-for-AI-DiscussionPaper.pdf.

4 Mark Minevich, "How to Fight Climate Change using AI," *Forbes*, July 8, 2022, https://www.forbes.com/sites/markminevich/2022/07/08/how-to-fight-climate-change-using-ai/?sh=3b2122652a83.

5 Ed Burns, "What is Artificial Intelligence (AI)? Definition, Benefits and Use Cases," TechTarget, accessed September 24, 2022, https://www.techtarget.com/searchenterpriseai/definition/AI-Artificial-Intelligence.

6 Suresh Sankaranarayanan et al., "Flood Prediction based on Weather Parameters using Deep Learning," *Journal of Water and Climate Change* 11, no. 4 (December 2020): 1766–1783, doi: https://doi.org/10.2166/wcc.2019.321.

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the weather forecast, location and duration of floods and (direct/indirect) damage to life and property. ML approaches to big data, gathered from the 2010 floods in Pakistan, can extract information, trace patterns and study flood behaviours for enhancing preparedness and preventing damage.[7] Interestingly, most of AI's usage in flooding has been in social media usage.[8] The content uploaded on Twitter, Instagram, etc. is used for data mining to enhance flood modelling and risk management. Collectively, data gathered through media platforms, government bodies and emergency responders can be used for flood forecasting before and impact assessment post the disaster, as well as resource allocation and societal resilience during it.

ML has shown promising results in both short and long-term flood prediction. Soft computing techniques for designing novel learning algorithms can further advance these methods. Research proves that novel hybrid models designed using ML, soft computing and statistical methods and the Artificial Neural Network (ANN) – hydrodynamic models improve prediction accuracy and lead-time and limit uncertainties, leading to more realistic flood models with better susceptibility assessment.[9] There exist various instances of AI applications that Pakistan can learn from. United Nations Satellite Centre (UNOSAT) Rapid Mapping Service, an example worth mentioning, offers satellite image analysis to provide maps during crises. It is working on deep learning models for disaster response such as flood analysis, shelter mapping, building footprints and damage assessment, etc. [10] The **UNOSAT S-1 Flood AI pipeline** uses fully convolutional neural networks to predict flooded regions from Sentinel-1 Radar imagery, then processes it into output flood vector data and updates operational dashboards.[11] The high-frequency flood reports produced have drastically improved disaster response across Asia and Africa; Pakistan must not miss out. **Google's "Hydronet" solution** detected vital vulnerable spots to prepare for floods in India and Bangladesh,[12] covering over 250 million people at risk. Pakistan must cash on these opportunities like its neighbours as Climate Change pressures start mounting.

Pakistan can develop a web portal and/or a user-friendly mobile application to make people more aware and thus prepared because the effectiveness of any proposed model is determined by the speed of communication to the masses after a flood warning. It can be AI-based, drawing inspiration from Weathernews Inc, a Japan-based weather service, which developed an **AI chatbot** for a

7 Deng-Lin Chang et al., "Artificial Intelligence Methodologies Applied to Prompt Pluvial Flood Estimation and Prediction," *Water* 12, no. 12 (2020): 3552. https://www.mdpi.com/2073-4441/12/12/3552/pdf.

8 Ibid.

9 Amir Mosavi, Pinar Ozturk and Kwok-wing Chau, "Flood Prediction using Machine Learning Models: Literature Review," *Water* 10, no. 11 (2018): 1536. https://www.mdpi.com/2073-4441/10/11/1536/htm.

10 "UNOSAT FlOODAI," UNOSAT, Accessed October 01, 2022, https://unosat.org/services.

11 Ibid.

12 Sella Nevo, "The Technology Behind our Recent Improvements in Flood Forecasting," *Google AI Blog,* September 3, 2020, https://ai.googleblog.com/2020/09/the-technology-behind-our-recent.html.

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UNESCO-supported programme[13] and worked with a messaging app to deliver disaster-related information and maintain contact with users. Studies conducted on flood risk assessment in the region, which shares similar issues, can also be consulted for better results. A study in Vietnam, for example, proposed two hybrid AI models, ABMDT (AdaBoost-DT) and BDT (Bagging-DT) with Decision Table (DT) to create a flood-susceptibility map.[14] BDT's map for flood-susceptibility, paired with one for flood consequences helped develop a map for flood risk assessment. This further facilitated hazard management in the particular area, simultaneously opening avenues in other vulnerable ones. Research on AI approaches for modelling spatial floods in Iran,[15]flood-risk analysis based on ML techniques in Yunnan, China[16] and ANN methods for real-time flood prediction in Indian-held Kashmir are some cases that Pakistan can learn from and tailor to address area-specific needs.

Given the disproportionate damage caused to it by Climate Change,[17] in return for only 1 per cent of global carbon emissions, Pakistan's advocacy for climate justice and demands for the world to help alleviate the problem are fairly valid. But it must also provide conducive environments for collaboration, aimed at predicting and preventing the crisis, instead of only asking for assistance to manage it. While the prospects of AI look bright, one must bear in mind that AI is only one tool, not a panacea for environmental disasters and any proposed model depends greatly on the will of decision-makers and the capabilities of our critical infrastructure. Various other emerging technologies to address evolving security needs exist. For instance, data mining, a supportive tool, can be applied to estimate the damage to crops and infrastructure and work alongside AI to not just identify risk factors but also work on plans to mitigate the effects. Pakistan will have to overcome challenges related to data availability and lack of resource allocation along with a dearth of relevant research - many of which stem from less acceptance towards AI in the field. To help AI-enabled systems deliver at maximum potential, greater stakeholder involvement and a combination of "AI

13 "Project Launch: Strengthening Disaster Prevention Approaches in Eastern Africa," UNESCO, October 28, 2020, https://en.unesco.org/news/project-launch-strengthening-disaster-prevention-approaches-eastern-africa.

14 Paul Munoz et al., "Flood Early Warning Systems Using Machine Learning Techniques: The Case of the Tomebamba Catchment at the Southern Andes of Ecuador," *Hydrology* 8, no. 4 (2021): 183, https://www.sciencedirect.com/science/article/pii/S0022169420312762.

15 Alireza Arabameri et al., "Modeling Spatial Flood using Novel Ensemble Artificial Intelligence Approaches in Northern Iran," *Remote Sensing* 12, no. 20 (2020): 3423, https://www.mdpi.com/2072-4292/12/20/3423/pdf.

16 Meihong Ma et al., "Flash Flood Risk Analysis based on Machine Learning Techniques in the Yunnan Province, China," *Remote Sensing* 11, no. 2 (2019): 170, https://www.mdpi.com/2072-4292/11/2/170/pdf.

17 Susannah George, "Pakistan's epic Floods show Climate Change often hits the Poor Hardest," *The Washington Post,* September 29, 2022, https://www.washingtonpost.com/world/2022/09/29/pakistan-floods-climate-change-poverty/.

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with human expertise"[18] is needed. Thus, 'Artificial Intelligence has immense potential to combat human-triggered, 'natural' disasters. What is needed is a proactive approach to prevention, adaptation and mitigation that will help prepare for the future and save lives by intervening when needed and even before needed.

18 William Sayers et al., "Artificial Intelligence Techniques for Flood Risk Management in Urban Environments," *Procedia Engineering* 70 (2014): 1505-1512, https://doi.og/10.1016/j.proeng.2014.02.165.

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