AI-Driven Climate Resilience: Forecasting Flood Before It Strikes

by Selma Fitri Ayuanshari - Sunday, 10 November 2024, 11:58 PM
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Flood Humanity's Eternal Struggle

Floods are among the most prevalent and devastating natural disasters that affect many people in the world, today and also in the past. Recent studies have found that 23% of the world population, or up to more than 1.8 billion people, are directly exposed to substantial risk during a 1 in 100-year flood event. The damages it caused are in the billions of dollars, and out of this population, 1.24 billion are located in Southeast Asia, China and India, accounting for over one-third of its global exposure (Rentschler, et all 2022 and World Bank, 2023). This issue has been faced by humanity for centuries; take for example four hundreds year ago, on January 30, 1607, a catastrophic flood in Bristol, UK, caused severe destruction that reached unprecedented heights at that time, as much as more than 3 meter tall, and this disaster that resulted in the loss of between 500 and 2,000 was even deemed as the deadliest natural disasters in British history (Risk Management Inc, 2097, Scolar Cardiff, 2014)

1607.

A true report of certaine wonderfull ouerflowings of Waters, now lately in Summerſet-ſhire, Norfolke, and other places of England: deſtroying many thouſands of men, women, and children, ouerthrowing and bearing downe whole townes and villages, and drowning infinite numbers of ſheepe and other Cattle.

Printed at London by W. I. for Edward White and are to be ſolde at the ſigne of the Gunne at the North doore of Pauls.

"Men that were going to their labours were compelled (seeing so dreadful an enemy approaching) to fly back to their houses, yet before they could enter, Death stood at their doors ready to receive them. In a short time did whole villages stand like islands … and in a more short time were those islands undiscoverable, and nowhere to be found."

Pamphlets and Quotes from the A true report of certain wonderful overflowing: The great flood of 1607 in a contemporary pamphlet. Retrieved from ScolarCardiff (2014)

So, it's not strange that historically speaking, over centuries, communities, companies, and governments around the world have relied on different observational methods to predict one of mankind's deadly natural disaster. In early history (before 19th Century Development), civilization has started on monitoring river levels, checking weather patterns, and even building different location or settlement with knowledge of local flooding patterns, but then in the 19th century leading to a better understanding flood dynamics the formal study of hydrology was born using mathematical models to predict rainfalls and river flow. By the 20th century the technology of radar and satellite imagery technology was introduced and it's up to the 1960, when 1960's hydrologists started to simulate flood scenarios more effectively (MDPI, 2023).

The real flood forecasting system was only real-time time data from the 1980’s and 1990's where data from weather satellites and sensors were used. This era is known for its FFWA or Flood Forecasting Warning System, which combined meteorological data points with existing hydrological models. But it is not until 2010's where we humans started to use the extensive datasets and model accuracy. Modern forecasts using machine learning algorithms and data analytics were achieved. Something that is now known as the AI Powered Localized Flood Risk Forecasting System (Cawood, Keys, & Wright, 2018).

Introduction to Google Flood Hub - An AI-Powered Localized Flood Risk Forecasting System

So what is this risk forecasting system? It is an advanced algorithm and machine learning technique to analyze different data that will help in predicting potential risks with high accuracy in environments where traditional data collection data methods are limited, allowing for real time assessment and localized insight (Google Research, 2023).

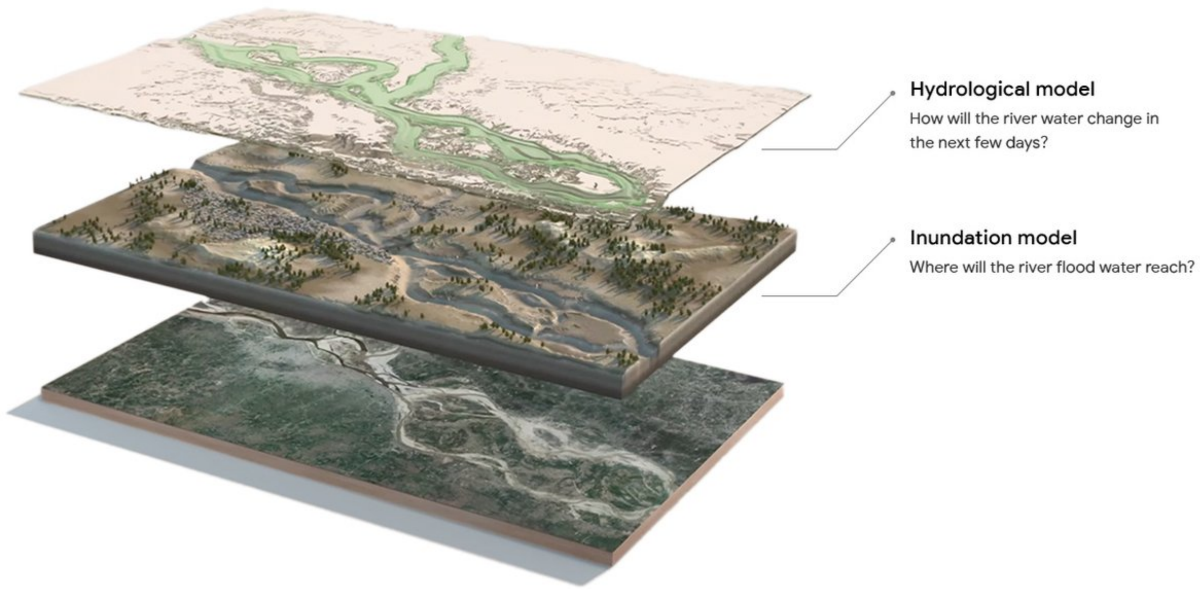

Figure 1 - Flood forecasting: AI for information & alerts.

Retrieved November 10, 2024, from https://sites.research.google/floodforecasting/

Using two AI models Hydraulic models and Inundation models (a model that was trained using meteorological data, and stream flow gauge data) which predict the areas that will be affected by flooding and the expected water levels, providing crucial information about potential impacts on communities. This system now can provide people from all over the world through their existing Google service (Google Maps, Google Search and Android notification) 7 days in advance, allowing for proper timely warning. It covers 80 countries with further expansions. Google uses hydraulic models that are trained on publicly available geophysical and meteorological data. Including from satellite or even to streamflow gauge data (Google Research, 2023).

Technological Readiness Level

Figure 2 - TRL

Retrieved November 10, 2024, from https://www.twi-global.com/technical-knowledge/faqs/technology-readiness-levels

As this new technology is introduced to existing legacy sectors and what Weiss and Bonvillian (2011) mentioned, innovation will face substantial resistance due to entrenched economic, political, and technological paradigms that resist change. As such this blog will use the nine-level model of Technology Readiness Levels (TRL) implemented by the U.S. Department of Energy (DoE) with minor variations in some levels. While there is a lot of development where the TRL framework has been modified to assess not only the readiness of technology but also the process of incremental innovation, leading to the definition of a new model legal readiness level (LRL), Organizational Readiness Level (ORL) and Social Readiness Level (SRL), (Bruno et al., 2020).

This blog will focus on TRL with an additional review to its LRL, ORL, and SRL.

TRL	Definition	Flood Forecasting Technology Assessment
1	Basic principles observed and reported	Flood impact principles and climate data analysis established as critical for early warning systems.
2	Technology concept and/or application formulated	AI's potential for flood forecasting is recognized and conceptually applied to flood-related data.
3	Experimental proof of concept	Initial pilot studies in India in 2018 (Patna, Bihar) demonstrated AI's ability to predict floods locally with high accuracy.
4	Technology validated in laboratory	AI models were validated using data from specific flood-prone areas, showcasing potential but limited to local datasets.
5	Technology validated in relevant environment	Expanded field trials in Bangladesh and India used local streamflow data, providing forecasts 48 hours in advance.
6	Technology demonstrated in relevant environment	AI models scaled to cover 360 million people in India and Bangladesh by using local government data to refine model predictions.
7	System prototype demonstration in operational environment	By 2019 Google has integrated real-time flood forecasts into Google Maps and Public Alerts, offering warnings to a broader user base.
8	**System complete and qualified**	**The global AI-based flood forecasting model launched with Flood Hub in 2022, covering 20 countries, including 15 in Africa.**
9	System proven in operational environment	Current model operates globally, now covering 80 countries and providing forecasts to 460 million people, comparable to European standards.

Table. 1 - Author personal analysis and assessment

Based on that framework, Google Flood Hub can be seen to already achieve a high TRL, likely around 8 and 9. Some of the key indicators of this level is that it is fully developed and operational usage of the global AI.While when it was first tested in 2018, the technology might only have reached 3 and 4, but six years later now in 2024 the system that has now been deployed in 80 countries is fully functional. The system can also issue flood forecasts up to seven days in advance now.

And as for the LRL, the technology showed also more favorable readiness, or around Level 6 or 7. Google Flood Hub appears to operate within legal frameworks that govern and regulates privacy and use of data such as GDPR, ensuring now more than ever the compliance with regulations in the countries it serves, although there are some countries that have yet to also fully regulates its data privacy regulation. Some aspects such as its ability to provide flood forecasting services free whlie managing still to collaborate with governments and NGOs from around the world may also help mitigate legal risks associated with data sharing and usage. However ongoing assessment of local laws in regards to data privacy and emergency response are still essential and highly recommended as the service still expands globally to the rest of the world and with this the LRL can be reached up to level 8 or 9.

As for the ORL Google Flood Hub AI could be at around Level 7 or 8. Aligning with previous reason on LRL the company collaborates actively and extensively with various stakeholders, such as government agencies and NGOs, and with it, it likely has established roles. Further assessment could be done, but If its implementation partners are fully aligned and streamlines, the technology could reach ORL 9, where all necessary organizational elements are integrated effectively.

Lastly, the SRL, Given the societal and impactful importance of flood prediction to the communities around the world and its livelihood, Google Flood Hub AI might be at an SRL of 6 or 7. That being the case the communities may be increasingly aware of the solution and its benefits, broad societal adoption and full integration might still be in progress. For SRL 9 however, it would need to have more widespread societal acceptance and integration as a trusted tool for flood risk management in various communities, in which culture and languages could be a barrier.

Is it really ready? - Assessing the Strength and Weakness with Adoption Readiness Level

While the TRL effectively demonstrates the technological maturity of Google Flood Hub, it alone is insufficient to capture the comprehensive readiness required for widespread adoption and operational resilience, in which we can then assess its weakness and strength. To further assess its strength and weakness this blog uses Adoption readiness level (ARL) framework developed by the US. Department of Energy Office of Technology U.S. Department of Energy. (2023), to further complement the TRL. The framework have further assessed the technology in four main categories, (1) The value proposition, (2) the market acceptance, (3) the resource maturity, and (4) the license to operate. By using the framework, the google AI flood was analyzed with this result.

Category	Dimension	Risk Level	Comments
Value Proposition	Delivered Cost	Medium	Significant initial investment required, but Google has a clear path to cost competitiveness through established platforms.
	Functional Performance	Low	Extends flood forecasting capability from zero to seven days, providing enhanced value, especially in underserved areas.
	Ease of Use	Low	Integrated into Google Maps and Search, ensuring easy access without extensive training for users.
Market Acceptance	Demand Maturity / Market Openness	Low	Clear market demand for flood forecasting, especially in climate-vulnerable regions.
	Market Size	Low	Large, existing global market likely to grow due to increasing frequency of climate events.
	Downstream Value Chain	Medium	Value chain alignment in underserved regions may require adjustments, such as regional partnerships for effective alert delivery.
Resource Maturity	Capital Flow	Low	Institutional backing, including partnerships with WMO, supports capital flow.
	Project Development, Integration, and Management	Low	Google's data integration and cloud infrastructure support effective project management.
	Infrastructure	Medium	While digital infrastructure exists, some physical infrastructure in rural areas may need improvement for effective alerts.
	Manufacturing & Supply Chain	Low	Primarily relies on established digital infrastructure, minimizing complex supply chain needs.
	Materials Sourcing	Low	Digital model minimizes dependency on physical materials, with data being the primary resource needed.
	Workforce	Medium	Some additional training for local stakeholders may improve effective usage, especially in remote or underserved areas.
License to Operate	Regulatory Environment	Low	Existing regulatory frameworks generally support data-driven solutions with minimal specific barriers.
	Policy Environment	Low	Climate resilience policies are supportive, especially for early warning systems like this one.
	Permitting & Siting	Low	Digital deployment avoids extensive physical siting requirements, reducing permitting complexity.
	Environmental & Safety	Low	Minimal environmental risks due to the technology's digital nature.
	Community Perception	Medium	Some regions may have data privacy concerns or resistance to new technology, though generally positive reception is expected.

Table 2 - Author personal analysis of adoption readiness level

From here, it is analyzed that Google Flood Hub Strength (low risk level) is seen in the platform to show significant potential in delivering accurate, accessible flood forecasting through its AI. In Addition to Google's ability to establish global digital infrastructure, it's also its biggest strength. But its weakness (medium to high risk) widespread adoption faces challenges related to community perception, the downstream value chain, and workforce especially in underserved regions. The downstream value chain and workforce is the one that carries the most medium risk, with a need for partnerships in underserved areas to ensure effective alert delivery. While Google has managed to establish many different partnerships with different organizations. The accuracy of its AI rests heavily on its reliance on data quality, which means that predictions may be less accurate in areas with limited data infrastructure, and in this case countries that are more affected by Flood, such as the South East Asian region. Over-reliance on this technology without proper introduction to the local communities around the world could lead to further resistance, as it also has been shown that over-reliance could lead to reduced emphasis on traditional knowledge and local preparedness practices (Iloka, 2018).

The new era for flood disaster management?

Now, with Google Flood Hub, flood forecasting has entered a new era in human battle against flood. Leveraging advanced AI models that assimilate data from weather reports, satellite imagery, and streamflow gauges have enabled Google Flood Hub to predict floods up to seven days in advance across 80 countries—a technological marvel at TRL 8-9. Yet, is this truly the answer, or is it merely another layer of the age-old flood dilemma?

On one hand, Google Flood Hub exemplifies modern and strength of new technology in flood prediction prowess. The platform's adherence to LRL and its established partnerships with humanitarian organizations highlight its compliance and operational readiness, showcasing the possibility for a world where communities have a fighting chance against floods. Yet, a closer look through the ARL reveals the looming challenges of community acceptance. Flood Hub's accuracy is impressive but inherently tied to the quality of data available—where data infrastructure that is highly relevant to community and local assessment still shows some gap.

While Google Flood Hub may offer a glimpse into a future where flood forecasting is within reach of everyone around the world with just their phone, the question remains: is this technology a lifeline that everyone needs or a technological crutch? Communities risk over-relying on this AI-driven solution, potentially sidelining traditional knowledge and local practices that have weathered centuries of floods, could hinder its acceptance and practices. As we move toward a more increasingly sophisticated flood forecasting, perhaps we as a community should also continuously use technology only as strong as its connection to the communities it serves. In the end, the fight against floods, like the fight against any force of nature, will require more than just cutting-edge technology; it will demand a convergence of human ingenuity, respect for local wisdom, and a commitment to resilience that technology alone cannot provide.

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