Dreamarks

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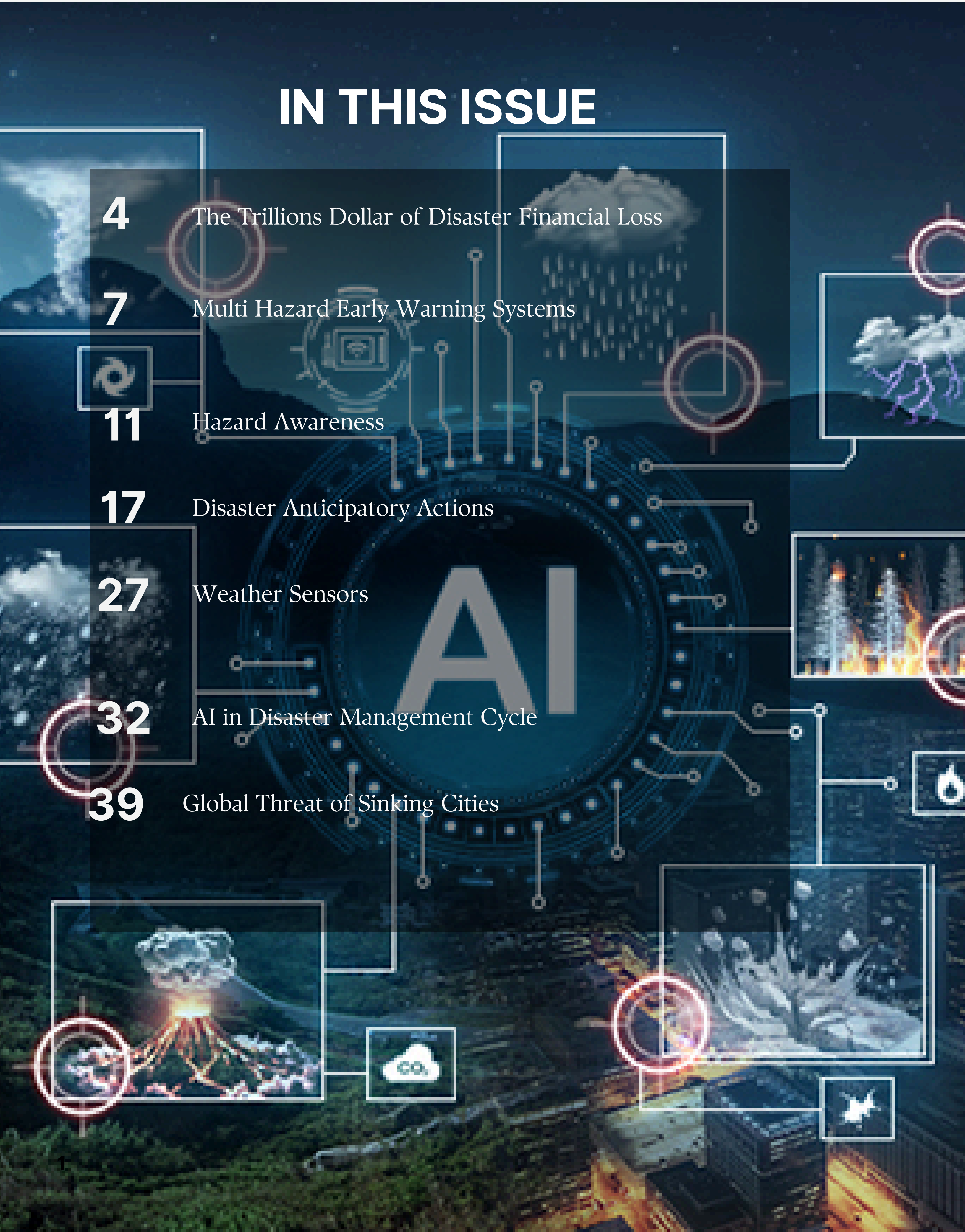
The Trillions Dollar Loss, Thousands Life Lost Due to Disaster Occurences per Year

Disaster Early Warning Systems

AI for Natural Disaster Mitigation Management



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Dreamarks Magazine

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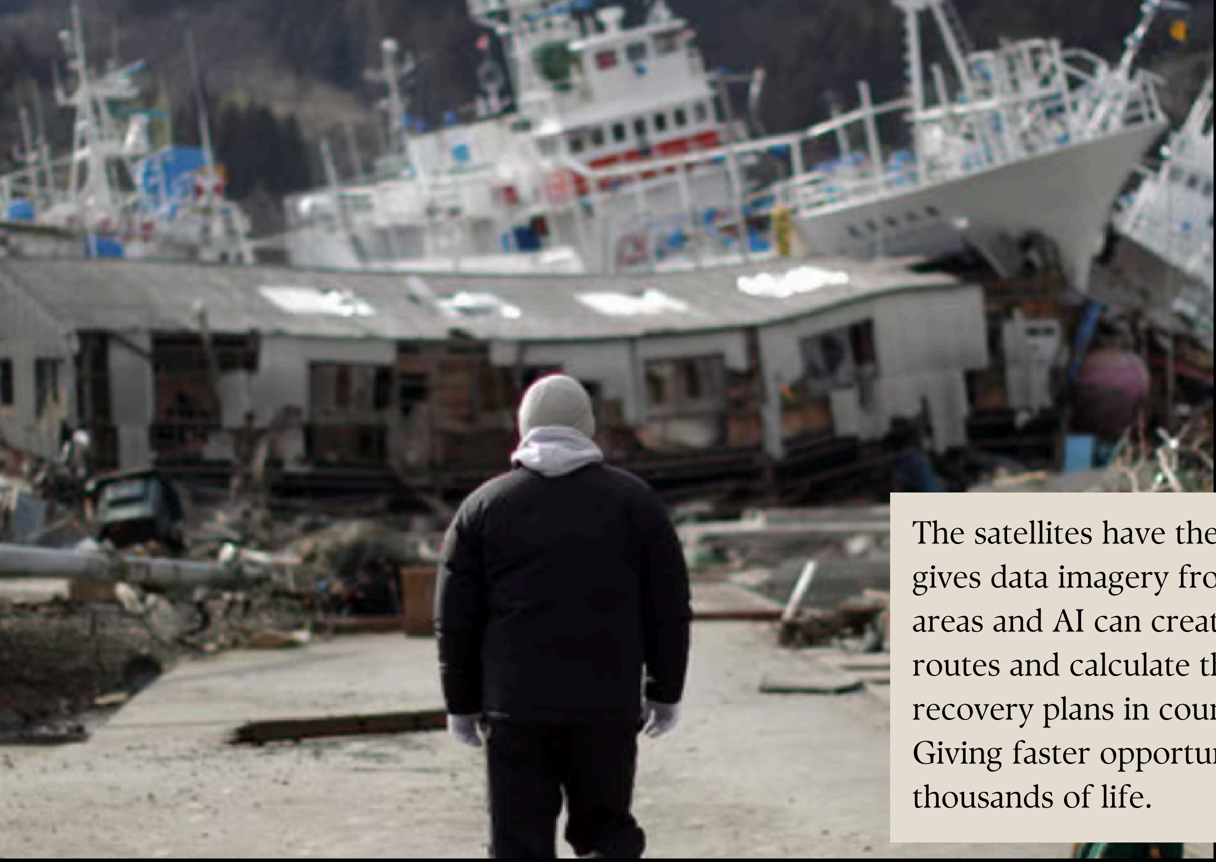


The satellites have the capability to gives data imagery from the disaster areas and AI can create evacuation routes and calculate the necessary recovery plans in counts of minutes. Giving faster opportunities to save thousands of life.

Disaster Mitigation & Recovery

There are two types of Disaster. The first is because of the climate change and natural occurences, and the second is man made disaster. The type of the man made disaster including Flood and Land Slide that happens because of the deforestation.

Trees cutting and forest burning for creating corps fields and for creating housing are include in the Deforestation. Many of the deforestations happened are done with the legitimation given by the government. These are violating the Sustainable Development Goals (SDG) efforts that should be uphold by every nations.

Because of the deforestations, many dense forest are being decreased and this affecting the forest capabilities and natural roles to act as water reservoir and land supports, and land sustenance.

Every disaster recovery efforts include rebuilding strategy and this including the roles of the private sectors needed to help by giving the necessary funding, and for further investing in the disaster sites to create economic cycles in the efforts for creating job opportunities for citizens that are victims of the disaster that are happening.

In global evaluations, various disaster that has happened are largely costing the global economy trillions of dollars per year. This economic sunk following great disaster giving us more pressure towards the required green economy application that should have been sustaining Earth capabilities for centuries to come.

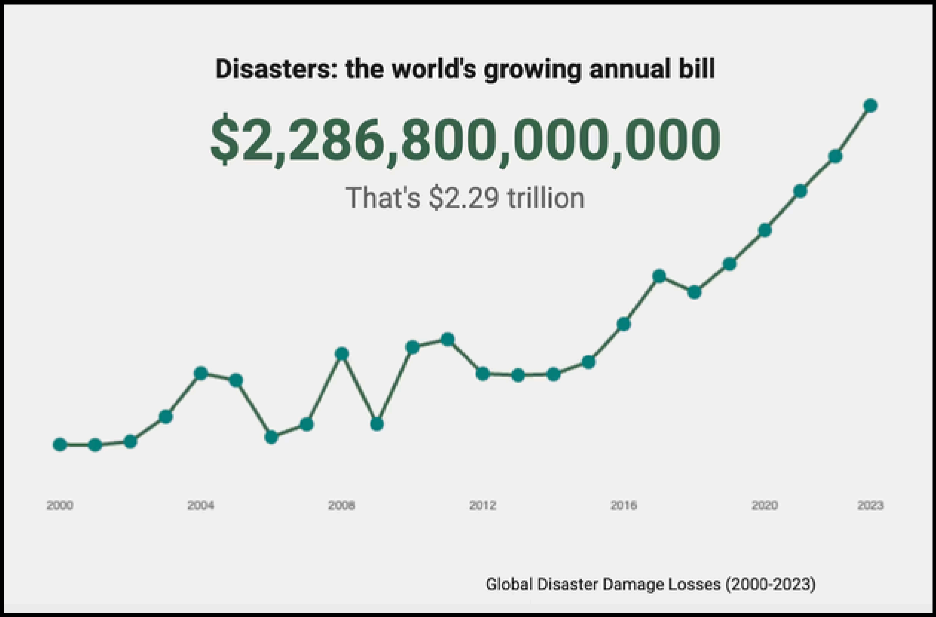
Gina Al Ilmi

Editor-in-Chief

DISASTER

The Trillions Dollar of Financial Loss

UN Global Status of Multi-Hazard Early Warning Systems 2025



Not only disaster-related mortality has been largely contained over the last decade, in 2024, climate related disasters resulted in higher financial losses than in past years, with tropical cyclones alone costing the world $135 billion. The number of disaster-affected people also continues to rise.

Disasters triggered by natural hazards claimed a high toll in the last decade, causing devastating suffering and economic hardship for individuals and communities globally. Over 40,000 people on average were reported killed or missing each year between 2015 and 2024 due to disasters, and a further 121 million people were affected each year. While these numbers underscore the severe human impacts, the Centre for Research on the Epidemiology of Disasters (CRED) estimates that the numbers could have been much higher if a major earthquake or tsunami had affected populated areas (CRED, 2025).

Across all disasters, direct economic loss has cost the world over $1 trillion since 2015, accounting for 0.3 per cent of the total gross domestic product from all reporting countries between 2015 and 2024.5 Major disaster events continue to impose heavy economic loss on some of the most vulnerable countries.

For example, tropical cyclones alone cost the world $135 billion in 2024 (Munich Re, 2025). Last year (2024) was the first year the annual global mean temperature exceeded 1.5°C above pre industrial levels (WMO, 2025).6 This is the threshold identified in the 2015 Paris Agreement that marks the limit for avoiding the most severe impacts of climate change.

Although this one-year measurement does not confirm failure of the long-term goal – measured in decades – it signifies a dangerous trend where every fraction of a degree increase in temperature can result in more damaging impacts.

Severe storms are becoming more frequent and more extreme. Studies by World Weather Attribution have shown that Hurricanes Helene and Milton were significantly coverage. However, the number of affected people per 100,000 population continues to grow across all countries, which suggests that the impact of disasters is increasing and underscores the need for all countries to have more effective Multi Hazard Early Warning Systems (MHEWS).

Mortality and number of disaster-affected people per 100,000 population, 2005–2024, by comprehensiveness of MHEWS are more severe and carried much more rainfall than they would have if they had occurred in a world without climate change. Similarly, the intense rainfall that resulted in flash floods in Valencia, Spain and the weather conditions that led to severe flooding in Brazil were both twice as likely to occur as a result of climate change

Why Communication is Key to Disaster Relief

Sebastien Turbot

WEF Curator and Global Director, World Innovation Summit for Education

When powerful earthquakes and aftershocks ravaged Nepal in April and May, social media rushed to the rescue. As aid workers, authorities and foreign agencies struggled to save lives amid devastated infrastructure, a parallel aid campaign took off on the web.

Facebook activated its Safety Check feature to help people reassure their friends and families, and victims and eyewitnesses turned to social networks to request help.

When disaster strikes, the first thing that both victims and rescue workers seek is reliable information. Yet when aid organizations and workers engage in rescue efforts in disaster zones, natural or man-made, an essential aid is often put on the backburner: communication.

Communication tools are like first aid – they save lives on the ground when leveraged at the right time. For example: non-profit software company Ushaidi's crisis maps have been helping aid workers save thousands of lives and address urgent humanitarian needs around the world. It all began in 2010 in the wake of the Haitian quake.

Eyewitnesses flooded Ushaidi with tweets, e-mails and images. Millions of "digital humanitarians" from around the world volunteered to sift and collate relevant information and plot it on a live map. The map helped rescue workers to identify areas where medical care was urgently needed, while victims used the same map to seek aid.

In the same year, a communication campaign saved lives in Afghanistan. Ribbons of asphalt roads had replaced cratered paths in Afghanistan's Panjshir valley, but the roads lacked safety signs. As Afghans zoomed along the freshly tarred roads, the rate of accidents surged, overshadowing the government's developmental feat.

MULTI HAZARD EARLY WARNING SYSTEMS

Multi Hazard Early Warning Systems (MHEWS) can only be considered effective if people and institutions are ready to act once alerts are issued. Over 80 per cent of the countries reporting the existence of MHEWS have reported preparedness and response capabilities – that is, to act on the early warnings when issued.

However, there is variation among countries reporting on the level of their preparedness and response capabilities. For the Arab States, Europe and Central Asia, and the Asia-Pacific regions, over 50 per cent of all countries have local plans to act on early warnings.

Furthermore, 25 of the 30 countries in Europe and Central Asia that reported the existence of MHEWS have indicated having comprehensive capabilities in terms of local governments that are prepared to respond and act on early warnings.

Meanwhile, the countries in the Asia-Pacific region have the highest overall level (61% of all countries), over 60% of which report comprehensive capabilities. The Americas and Caribbean region and the Africa region need considerable attention, as less than 40 per cent of the countries report preparedness and response capabilities, with only half of those countries reporting a comprehensive capability

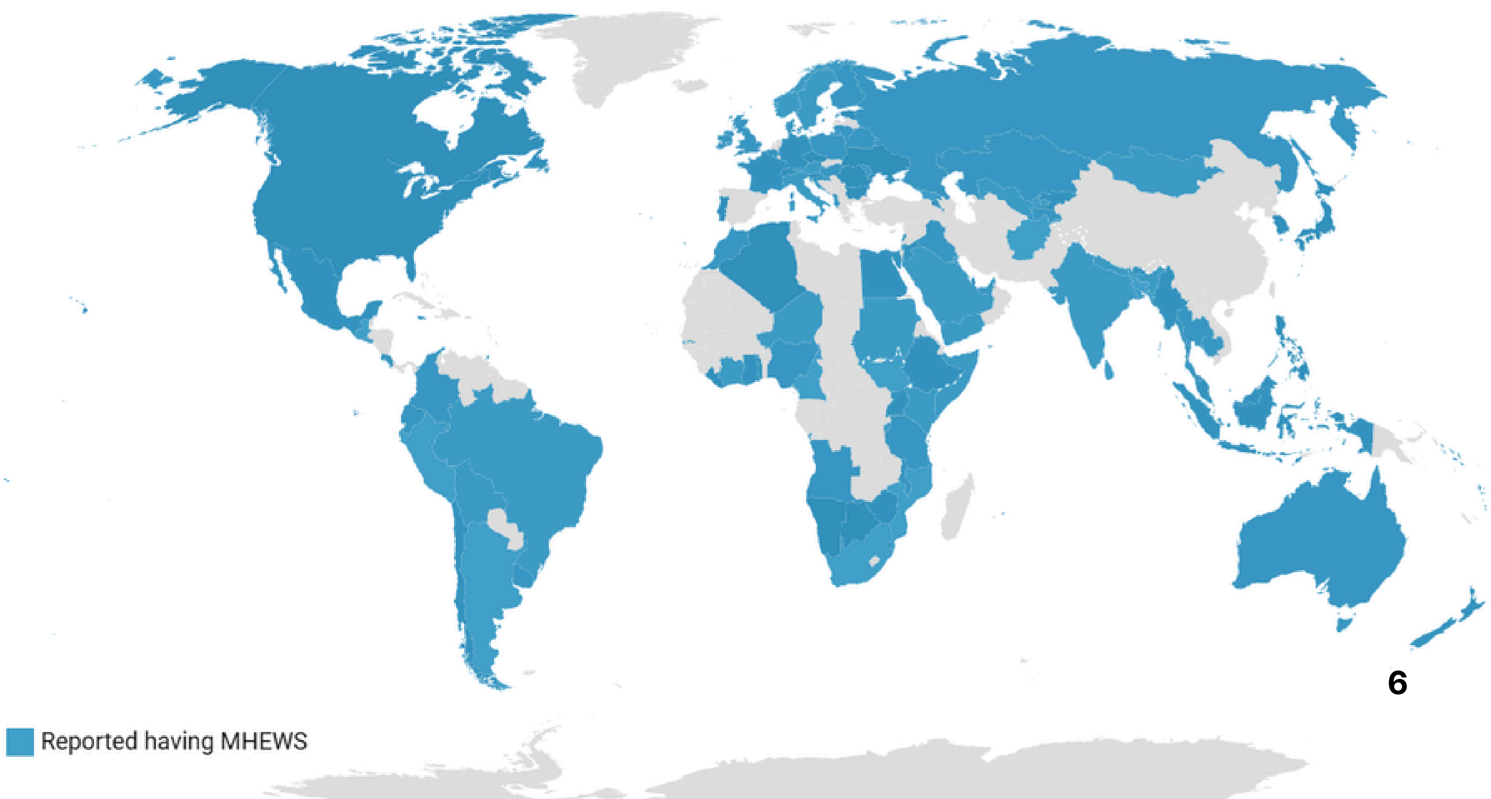
Early warnings alone do not always lead to timely and effective action.

Many of the most devastating and costly hydrometeorological disasters of this century were in fact predicted, yet the forecasts did not trigger adequate preparedness or response (Finnish Red Cross, 2024). For warnings to save lives and reduce loss, anticipatory action – pre-planned measures taken before a hazard, based on forecasts – has become increasingly recognized as essential. Anticipatory action is a faster, more cost-effective and more dignified response compared to traditional reactive approaches. It works best when the following three core components are in place:

- Pre-agreed plans or frameworks clarifying the actions to be taken in response to warnings and the specific roles of each stakeholder
- Threshold levels that are used to trigger the actions and release funds
- Tied to pre-arranged financing to ensure actions can be implemented quickly, optimizing the window of time before the hazard occurs.

Sendai Framework Target G Reported countries and areas

The 119 countries (in blue) that have reported the existence of MHEWS (i.e. SFM indicator G-1 score greater than zero)



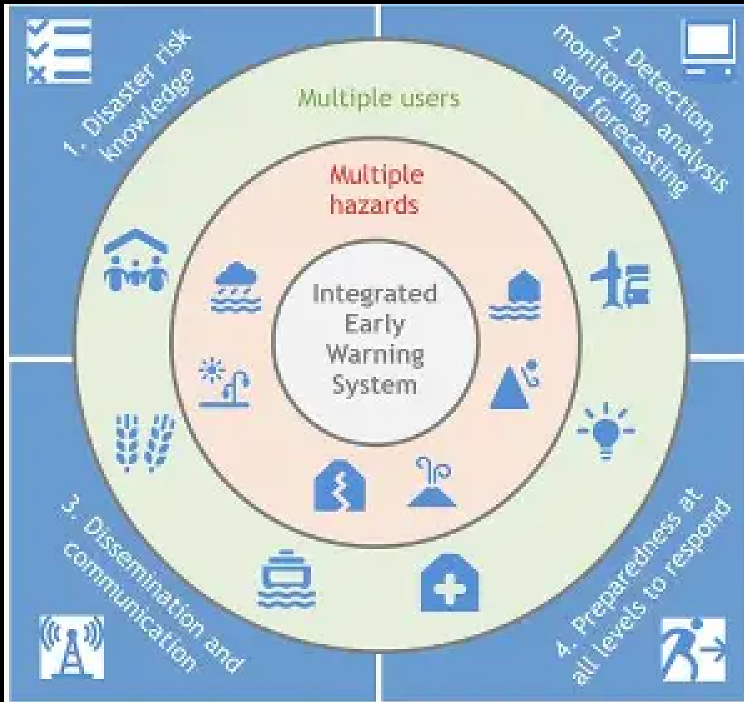
MULTI HAZARD EARLY WARNING SYSTEMS

UN Global Status of Multi-Hazard Early Warning Systems 2025

Hazards do not occur in isolation from other factors such as vulnerability and exposure, which may themselves be modified by the occurrence of a hazardous event or other factors. Examples of this include increased numbers of displaced people living in temporary shelters as a result of f looding or conflict. In addition, one hazard might occur alongside or trigger another hazard, so evolving from a single-hazard to multi-hazard EWS is crucial.

For example, storms can bring strong winds and extreme precipitation, which may cause f looding, which can in turn trigger landslides – the concept of primary, secondary and tertiary hazards. Furthermore, MHEWS should relate to overall disaster risk reduction (DRR) efforts and preparedness planning. Warnings across multiple hazards and across different timeframes can inform long-term approaches to risk management. Identification of relevant hazards to monitor should be based on continuous risk assessments.

The four pillars are interconnected; an MHEWS can only operate successfully if every pillar is connected, coordinated and working. However, a balance of capabilities across the four pillars is also important. Even in the case of countries with comprehensive MHEWS capabilities, early warnings do not automatically result in timely and effective action. Similarly, at the other extreme, while it is highly desirable for all countries to have comprehensive observation and forecasting systems, even in the absence of conventional MHEWS infrastructure, localized community-based and hybrid approaches can also deliver timely and meaningful alerts. “People-centred” MHEWS recognize that systemic pressures shape access to resources. MHEWS need to be designed around factors such as gender, age, disability, language and culture to improve how individuals and communities can take timely and appropriate actions to minimize the risk of harm and loss. People-centred MHEWS also recognize the strengths that communities bring to effective MHEWS through Indigenous and local knowledge (ILK), community-based monitoring and observations, trusted communication networks, and civil society actions – all of which can complement technology based solutions.



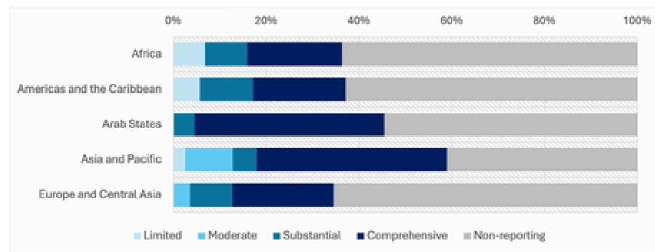


Figure 10. Coverage and comprehensiveness of detection, observations, monitoring, analysis and forecasting (Pillar 2, SFM Indicator G-2) by region (source: SFM, data as of March 2025)

The Global Basic Observing Network (GBON), which sets mandatory requirements for spatial and temporal coverage of surface and upper-air stations, continues to serve as the definition of the observational infrastructure needed to support accurate and timely forecasts.

Automating observational stations is critical to delivering early warning, as it improves data quality, frequency, and timeliness, while simultaneously reducing operational burdens and enabling broader, more efficient network coverage. Significant progress has been made in this respect through the adoption of Automatic Weather Systems (AWS). As of June 2025, one third of WMO Members have automated their infrastructure networks (i.e. more than 75 per cent of their observing stations). AWS enable more frequent measurements, including continuous night-time observations – an important step towards achieving GBON compliance – while reducing the labour intensity of network operations and cost effectively expanding coverage and efficiency.

Driving much of this advancement is the Systematic Observations Financing Facility (SOFF), which continued to scale its "readiness" and "investment" phases across an expanding number of countries. SOFF – alongside other interventions, which include the installation and improvement of hydrometeorological infrastructure – is actively enabling countries to establish GBON-compliant observation stations and integrate them into the global data exchange system through the WMO Integrated Global Observing System (WIGOS). Among those countries that have completed their readiness work, in total, 60 GBON National Gap Analyses, 47 National GBON Contribution Plans, and 56 Country Hydrometeorological Diagnostics have been finalized.

In 2025, the WMO Information System (WIS) 2.0 entered its operational phase, marking a historic milestone in global data sharing and initiating the re placement of the Global Telecommunication System, which had served as the backbone for WMO weather data exchange since 1971.

WIS 2.0 is a cloud-ready, open-standards framework using Internet of Things (IoT) technologies to share real-time atmospheric, oceanic, hydrological and cryospheric data, as well as other environmental observations. Its cloud design removes the need for costly infrastructure, enabling LDCs and SIDS to fully join global data exchange. This rich flow of high-quality observational data underpins reliable forecasts and timely warnings that protect lives and livelihoods. The system's global infrastructure – operated jointly by 11 countries – ensures efficient access, seamless sharing and continuous monitoring around the globe.

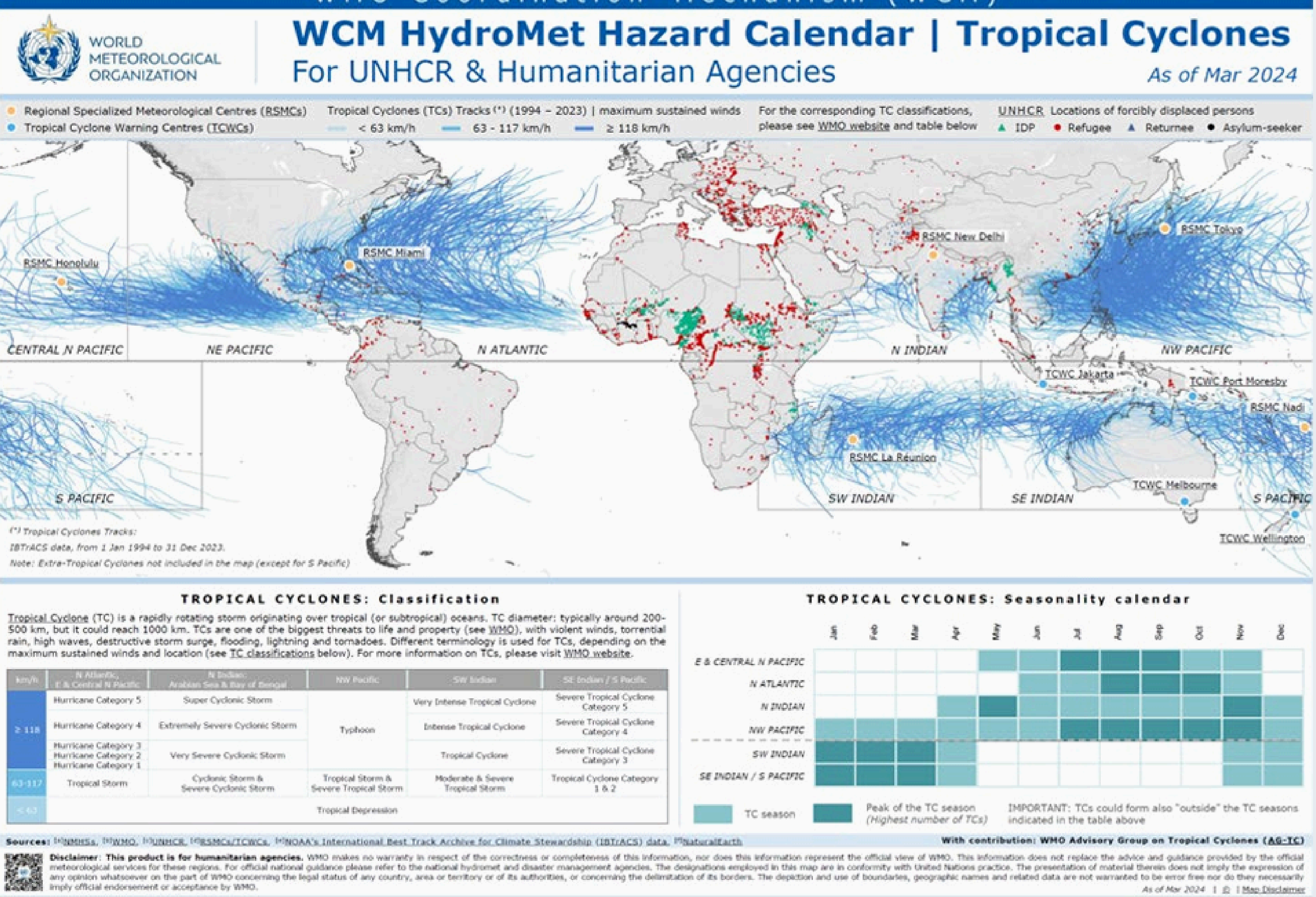
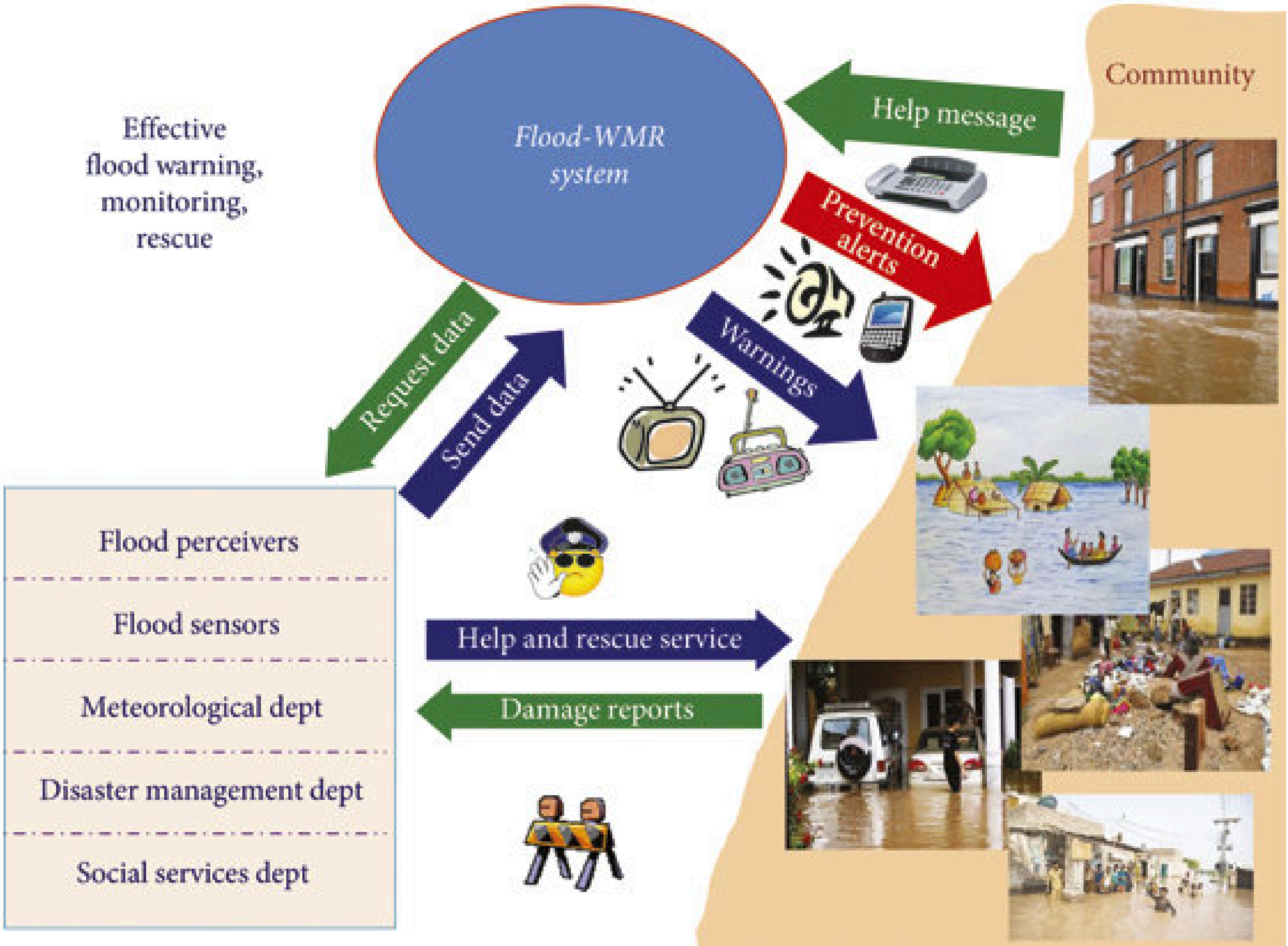


Figure 13. Examples of the WCM HydroMet hazard calendar for tropical cyclones (source: WMO)

IBF (Impact based forecasting) represents a paradigm shift where forecasters draw upon risk knowledge (from a range of stakeholders, including sector experts) to predict not just "what the weather will be" but "what the weather will do". It is an important component of a multi-hazard approach, noting that the impact of a hazard is a function of dynamic changes to vulnerability and exposure that may result from compounding and cascading hazards or other events, such as conflict or displacement. However, the very nature of IBF means that implementing it presents a multidimensional challenge. It requires Natural Meteorological and Hydrological Systems (NHMS) to be equipped with trained forecasters and context-specific modelling tools, as well as advanced software and hardware systems. In addition, IBF depends on access to detailed datasets – such as historical information on disaster impacts and hazardous events, exposure profiles and vulnerability maps – that are often held outside the meteorological community. Yet cooperation between national agencies remains weak, and decision-support tools are lacking in many countries. Indeed, the Hydromet Gap Report 2024 found that in half of the countries assessed, NMHSs receive no observational data from other institutions, and in the other half, data sharing is partial or infrequent at best. The absence of integrated data sharing policies limits the ability of NMHSs to generate timely and location-specific warnings based on expected impacts. IBF is also most effective when local populations and other users are involved in IBF processes from the outset, defining what kind of impacts are most relevant and useful for their own decision-making. This approach is consistent with best practice for people-centered MHEWS

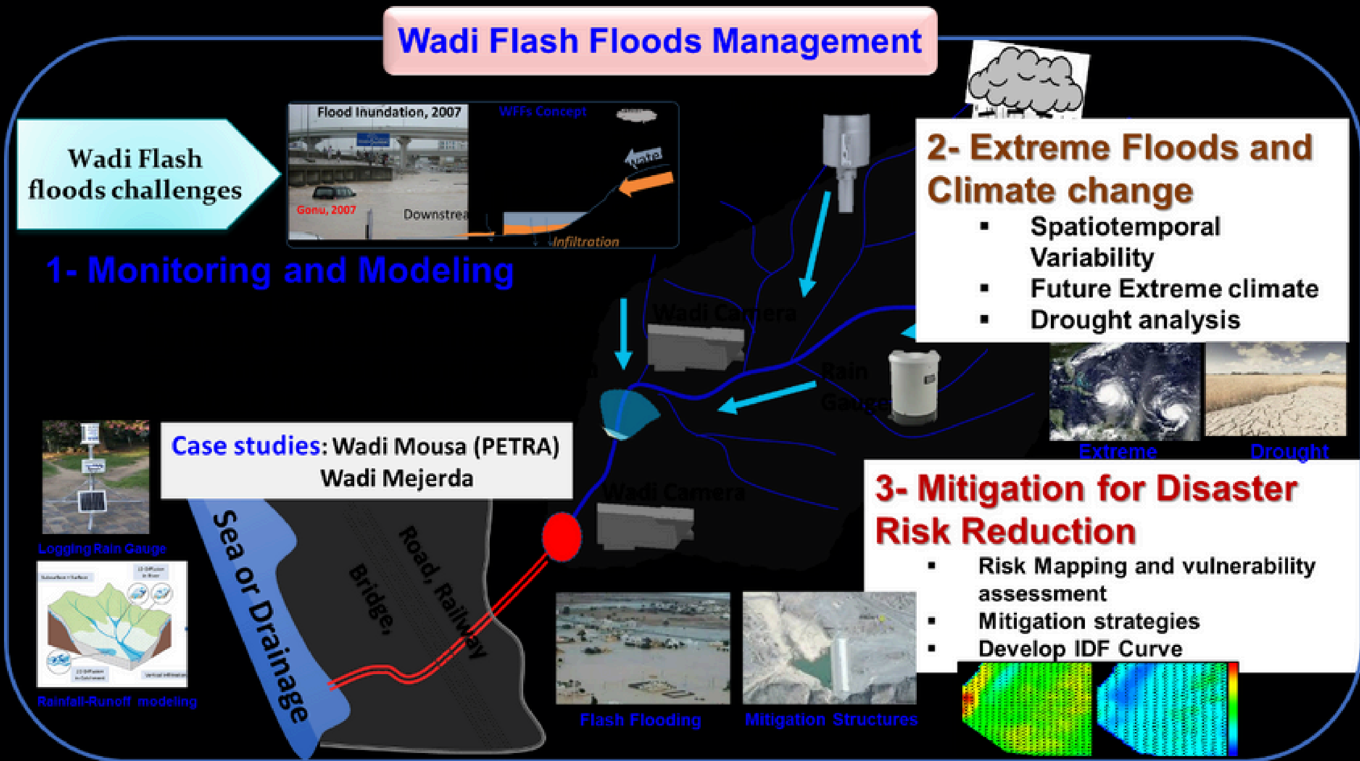


Hydrological forecasting and flood early warning capabilities are expanding steadily. Through the Early Warning Systems for Floods (EWS-F) initiative, under WMO leadership, 27 countries have completed structured assessments so far using the National Capacity Assessment Tool (NCAT), which focuses on end-to-end flood forecasting and EWS.

This comprehensive diagnostic landscape has strengthened the global evidence base on MHEWS functionality, enabling more tailored support, especially for hazard-specific applications such as flooding. These assessments provide detailed diagnostics of national hydrological services and inform investment needs, and offer targeted support around model set-up, institutional mandates, data digitization and technical workflows.

The Flash Flood Guidance System (FFGS), led by WMO and partners, is operational in over 70countries. The system leverages satellite-derived rainfall estimates, soil moisture modelling and weather forecasts to deliver real-time, location-specific guidance for flood risk. It supports immediate decision-making while fostering better coordination between national and regional agencies. More than 1,000 technical staff have been trained through FFGS to date, and regional centres continue to provide peer support and capacity development.

Recently, concerns about the long-term sustainability of the system have been raised. In response, WMO has developed a concept note on a flood forecasting framework, aimed at empowering Members and ensuring the sustainability not only of FFGS but also of other flood forecasting systems led by WMO. Together, EWS-F, FFGS and Water at the Heart of Climate Action (WHCA) represent a structured and scalable model for building flood forecasting capability aligned with national strategies and the EW4All universal coverage goal.

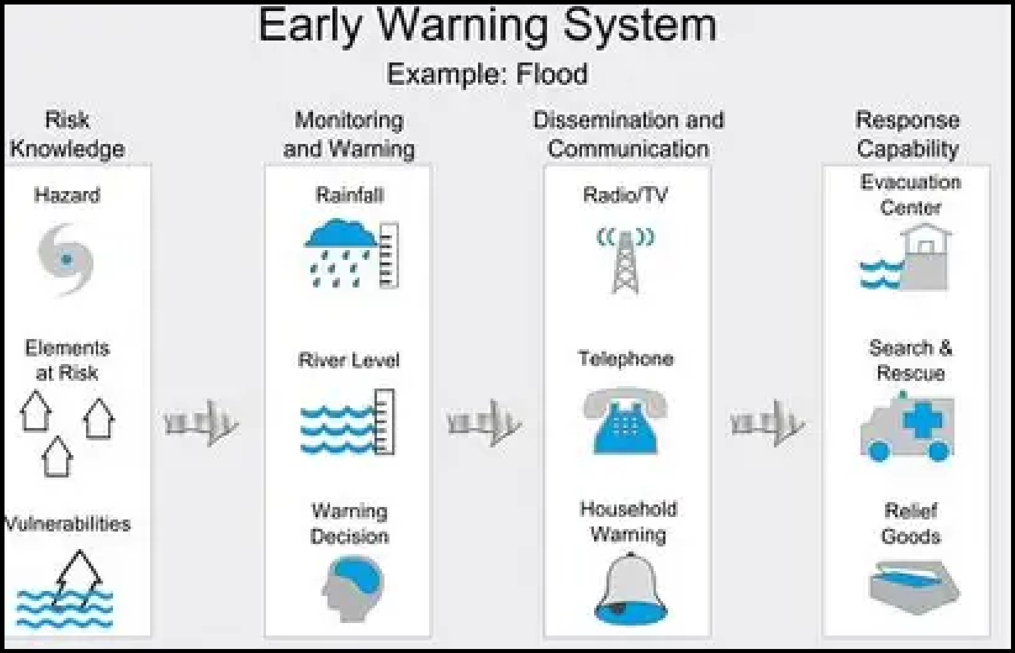


High tech, low tech, and no tech: Case studies on technology and innovation for accessibility, collaboration and local leadership in Ecuador, Haiti and India Under the CREWS Haiti programme, Haitian authorities tackled a longstanding gap in risk communication by developing 41 visually engaging hazard awareness boards in Haitian Creole. These boards – created in collaboration with UNDP, WMO, and the Haiti Hydrometeorological Unit – illustrate key hazards such as cyclones, droughts and flooding in ways that are accessible and culturally relevant.

The boards were first showcased during the inauguration of the civil protection agency's crisis room and the launch of the 2024 hurricane season. The materials are now central to national preparedness campaigns and are being distributed to regional departments. By shifting from technical, top-down messaging to locally tailored communication, this initiative aimed to make early warnings more understandable, inclusive and actionable. In Ecuador, in the Simón Bolívar neighbourhood in Quito, a community-based MHEWS was implemented to address recurring flood risks from the Caupicho river.

The initiative combined technology, collaboration and local leadership to strengthen risk communication and coordination. Municipal authorities installed surveillance cameras, a water-level gauge and a public megaphone while creating a WhatsApp communication channel between the emergency operations centre and residents. Alerts were issued in three categories –preventive, evacuation and active event – and a trained local response group supported evacuation and first aid. Crucially, residents activated alarms themselves based on official updates, demonstrating autonomous community leadership. Despite challenges aligning municipal coordination with community action, particularly in urban neighbourhoods, the initiative improved response times and highlights the value of co-designed systems and strong community–government collaboration.

In India, the Smart Access to Marine Users for Ocean Data Resources and Advisories (SAMUDRA) mobile app – launched by the Indian National Centre for Ocean Information Services in August 2023 – strengthens MHEWS by delivering real-time, geotargeted alerts for ocean hazards like tsunamis and cyclones. With colour coded warnings and regional language support, it enhances last-mile communication for coastal communities. Integrated with satellite-based GEMINI devices, it ensures offshore users also receive timely updates. Recognized with a 2024 Geospatial World Excellence Award, SAMUDRA shows how inclusive, tech-driven design can make EWS more effective and accessible.



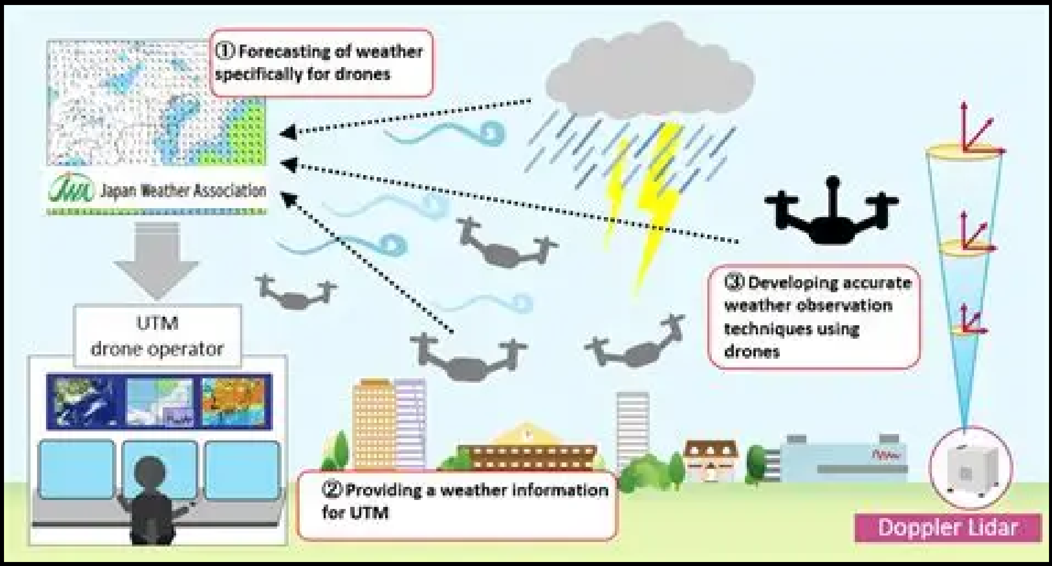
Cell Broadcast (CB) and Local Based-Short Message Services are technologies that enable mobile network infrastructure to send messages to handsets. LB SMS can send SMS messages to devices within a defined geographic area. CB can send instant, loud, distinctive alerts to millions of devices in seconds, also within a defined geographic area. Countries like Brazil, the Solomon Islands and Cambodia are strengthening MHEWS through mobile-based strategies tailored to local contexts and resource realities.

In Brazil, the integration of CB technology into the national public alert dissemination interface has significantly broadened the reach of emergency messages. CB allows geo-targeted alerts to be sent instantly to all mobile phones within a hazard zone – without requiring prior registration or Internet access. Led by the National Secretariat for Civil Protection and Defense, in collaboration with Anatel and mobile operators, this approach improved warning speed and coverage, particularly in flood-prone regions, while addressing structural inequalities in access to lifesaving information.

A similar CB approach was piloted in the Solomon Islands in 2025, supported by GSMA, the Pacific Islands Telecommunications Association and OmniTouch. By delivering real-time warnings to all mobile devices, including those without credit or registration, this system complements alerts that are already being disseminated by limited SMS, mass media, social media and traditional channels. Hosted within the Solomon Islands Government ICT services (SIG-ICT) office and integrated with the outputs from multiple warning agencies, this successful pilot has paved the way for the regional roll-out of this CB-based solution while also demonstrating the importance of stakeholder training and strong local ownership.

In contrast, EWS1294 in Cambodia showcases how a subscription-based, low-cost model can still yield substantial preparedness gains. Built by People in Need in collaboration with national disaster authorities, EWS1294 delivers flood alerts via interactive voice response calls, public loudspeakers, Telegram groups, radio broadcasts and SMS.

In Siem Reap, a local disaster officer's outreach helped register over 25,000 residents, resulting in improved response, reduced damage and a strong multiplier effect – nearly 80 per cent of those alerted helped inform others. While effective, the post-event assessments revealed gaps in coverage, particularly among remote populations, which spurred efforts to expand awareness and launch broader SMS broadcasting with telecom partners. The National Disaster Alert Portal in India – SACHET– was piloted in Tamil Nadu from 2019 to 2021 and is now operational nationwide. It was developed to address longstanding challenges in delivering timely, inclusive and geotargeted disaster alerts to over a billion people at risk. Led by NDMA and the Centre for Development of Telematics – and integrated with all 36 states, union territories and major mobile operators – the CAP-based platform combines LB-SMS and CB (still undergoing testing) to deliver multilingual alerts in 23 languages, with accessibility features for persons with disabilities. It incorporates real-time dashboards, GIS targeting, automated workflows, and multichannel dissemination across phones, sirens, broadcast media, and display boards. With over 44 billion alerts issued across 30,000 hazardous events, the system has improved speed, reach and public trust. Challenges such as device compatibility and over-alerting were addressed through training, standard operating procedures and public awareness efforts, positioning SACHET as a scalable model for digital risk communication



Youth-led, community-centred technology: Case Studies from Libya and Malawi

In climate-vulnerable regions like Malawi and Libya, Community-based monitoring initiatives are driving improvements in EWS capabilities. In northern Malawi, the African Drone and Data Academy (ADDA) – established by the United Nations Children's Fund (UNICEF) in partnership with local and international academic institutions – has equipped over 1,400 young people (60% women) from 25 countries with skills in drone operations, geospatial data and disaster risk analysis (UNICEF Malawi).

ADDA graduates are actively capturing aerial imagery, analyzing flood-prone areas and supporting the country's Department of Disaster Management Affairs with risk mapping, forecasting and rapid response. Notably, their contributions to a new flood risk mapping and forecasting system now serve over 236,000 residents. With science, technology, engineering and mathematics (STEM) training and real-world disaster applications, the program empowers youth to co-design solutions for community resilience.

In Libya, with UNICEF support, the youth-led Roaya Foundation is scaling up Libya Mozn, the country's first real time EWS. The system launched in 2022, one year before the catastrophic floods in 2023 that affected nearly 1.5 million people. After the floods, Roaya intensified efforts to collect data and provide more accurate early warnings. Using data from 45 weather stations, which was updated every two seconds, Libya Mozn monitors a range of hazards including heatwaves, floods and dust storms.

Young community members are trained as climate monitors and technicians, ensuring sustained local ownership. Mozn's visibility is also growing. More than 50,000 users of the Roaya Mozn smartphone app receive alerts and safety guidance. Roaya's Facebook page amplifies EWS alerts with 909,000 followers and reaches more than 3 million people overall (93.7 per cent from Libya; 46 per cent women), with most high-engagement posts coming from Mozn updates. A related Facebook group with 100,000 active members regularly shares local weather reports, photos and videos.

These cases illustrate how community-based approaches can dramatically improve hazard detection and response by combining local knowledge with real-time technologies for more accurate forecasting. They also support long-term sustainability by strengthening youth engagement and capacity through inclusive STEM education, fostering co-ownership between communities and institutions, and embedding monitoring tools within digital and social platforms to enhance reach and impact

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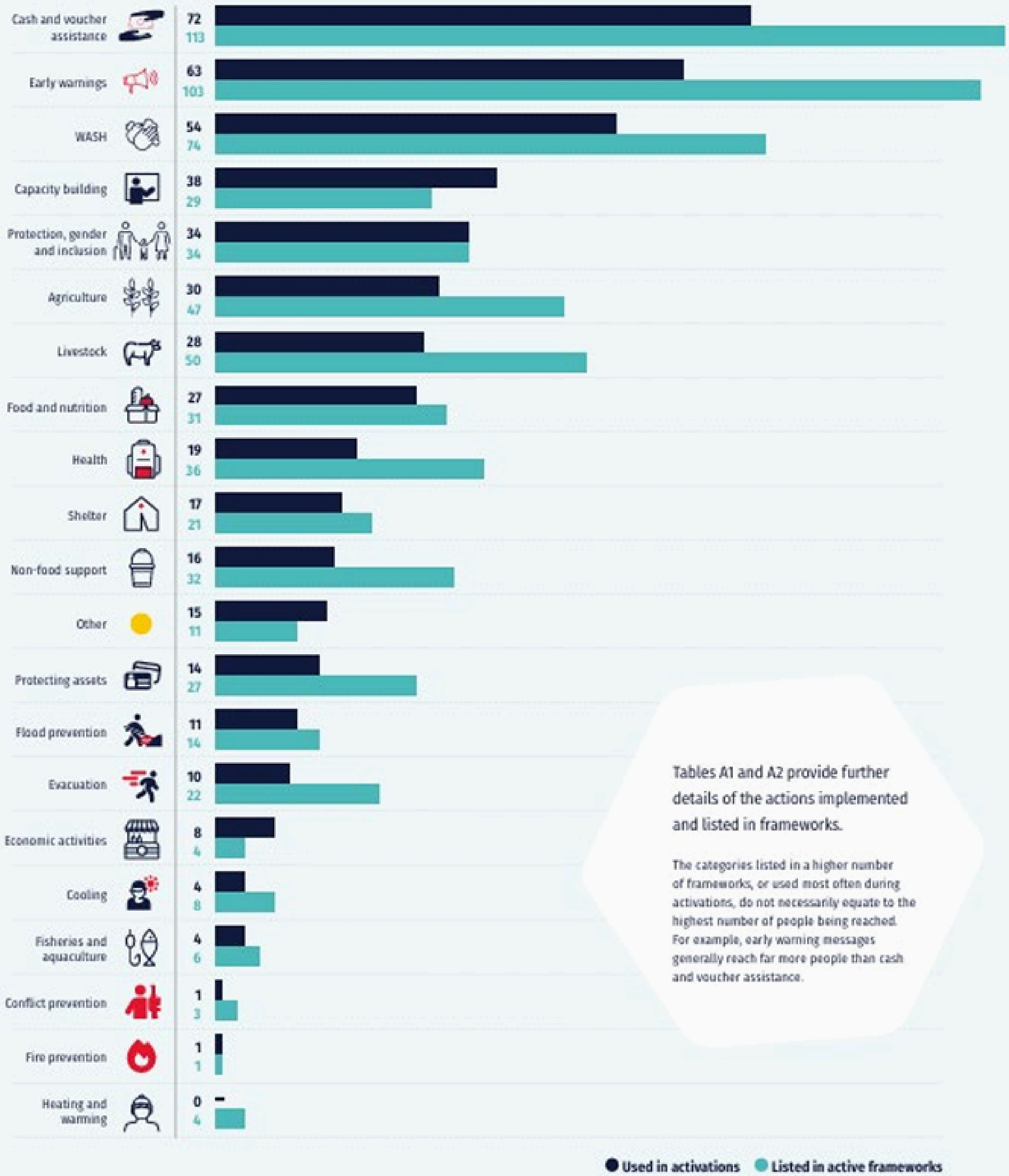
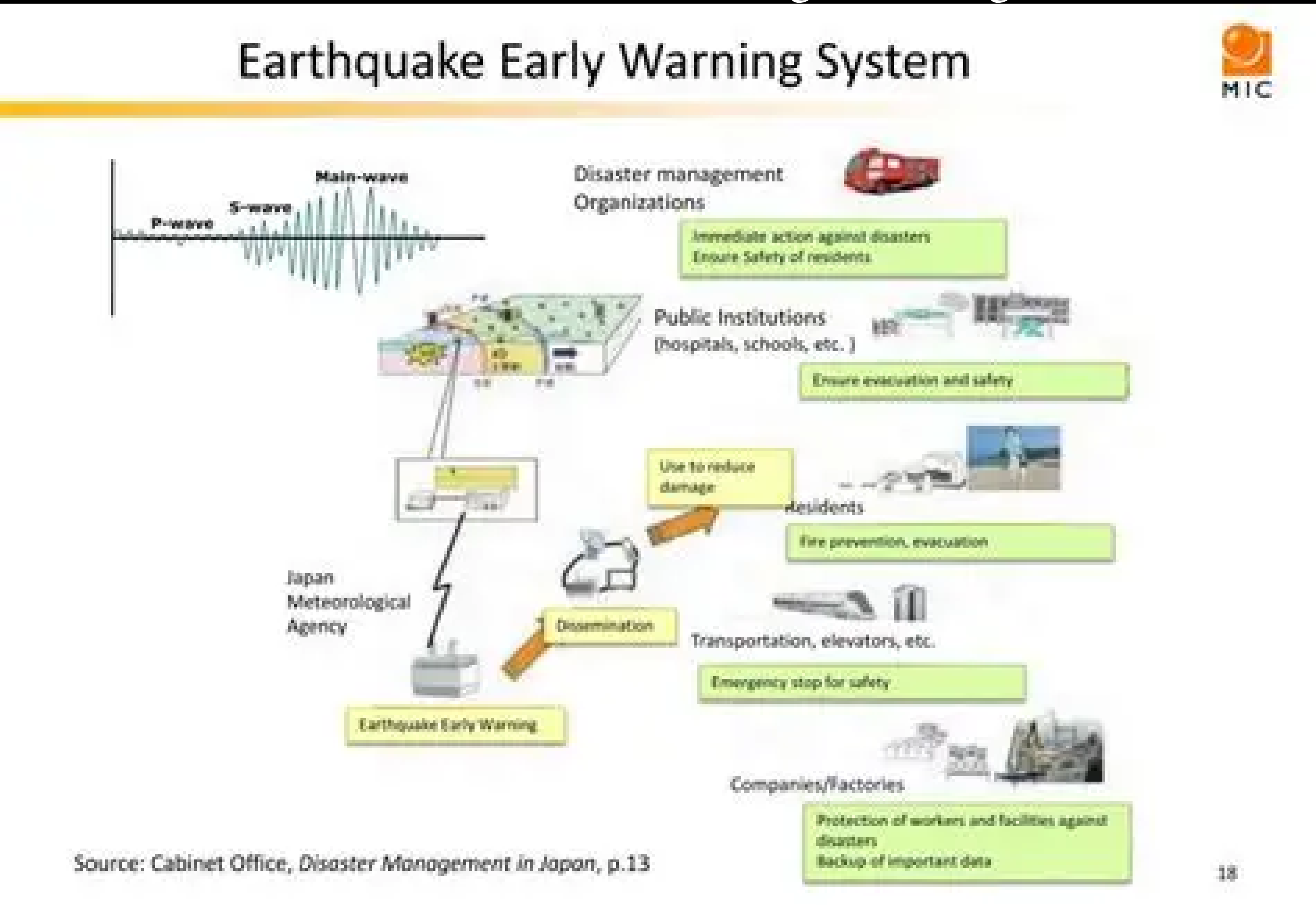
Type of Disaster Anticipatory Actions



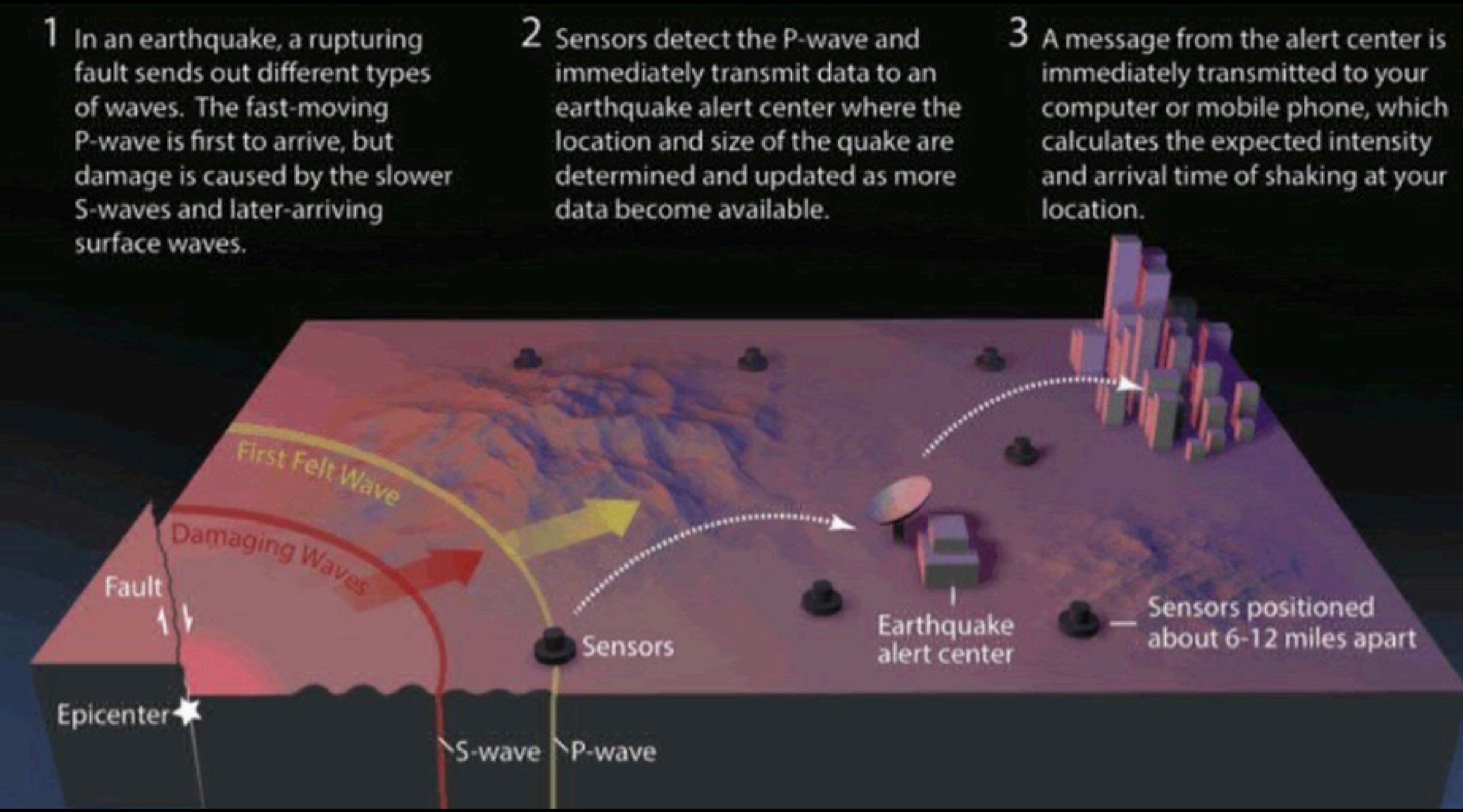


WEF Environmental events such as hurricanes, earthquakes, floods, and wildfires often leave behind widespread damage to infrastructure, communities, and the environment. Rapid damage assessment is crucial for organizing timely relief efforts, restoring critical services, and protecting affected populations. Post-disaster response methods often rely heavily on ground surveys and human teams, which can be slow, resource-intensive, and difficult to deploy in hazardous conditions.

Without timely data, decision-makers may struggle to assess the severity of the situation and prioritize areas of need. This gap in information can delay the allocation of resources during the critical early response phase, hindering the effectiveness of disaster recovery. Moreover, the lack of efficient post-disaster recovery planning can prolong the suffering of affected communities and delay the return to normalcy.

Recovery Aids in monitoring environmental recovery through vegetation health and regrowth. Together, these insights ensure informed decision-making in recovery planning and effective monitoring of progress.

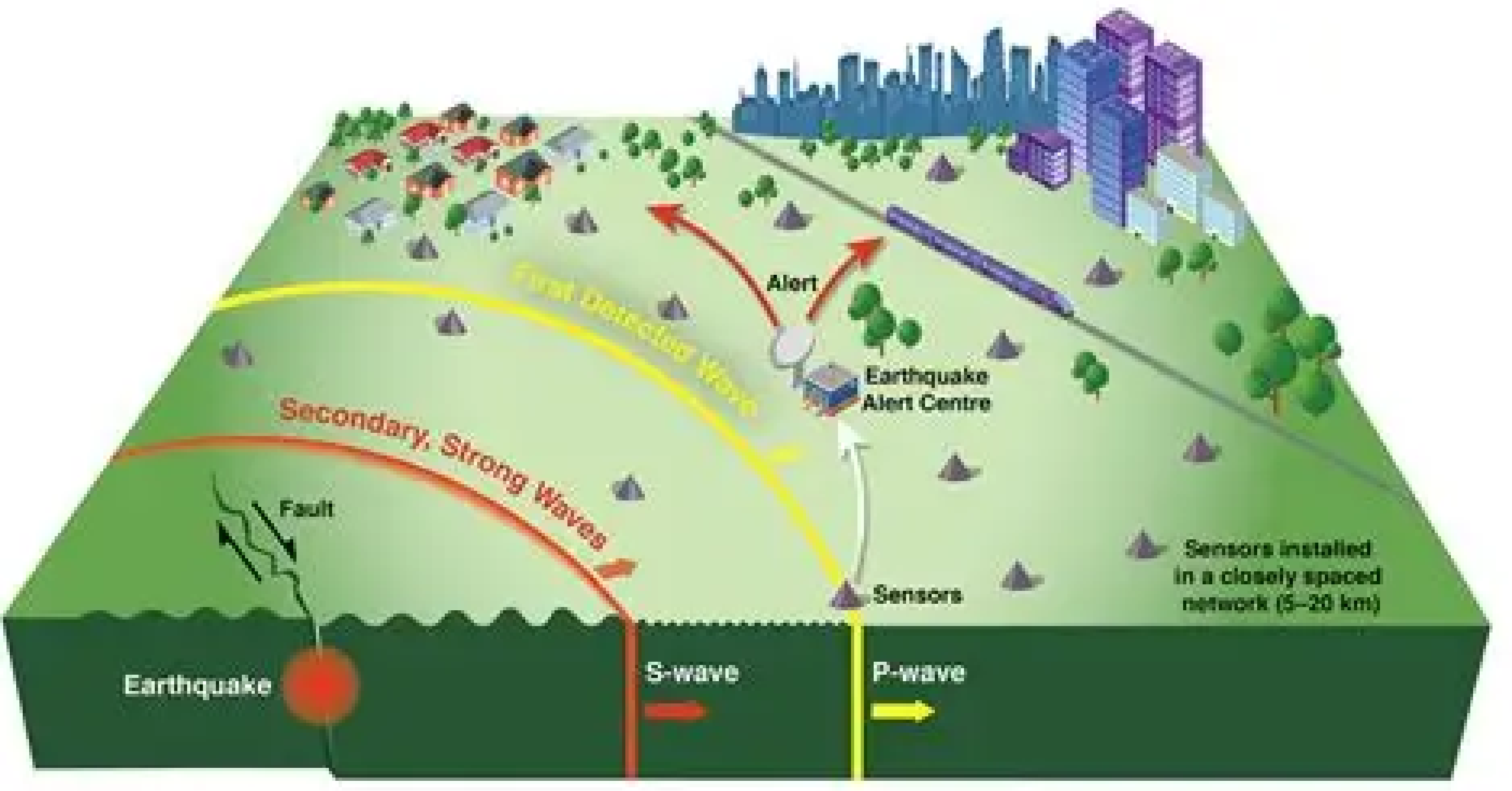
Earthquake Early Warning System By Using Wireless Sensor Networks



WEF How Earth Observation Helps

Earth Observation technologies are powerful tools for post-disaster response and recovery, offering timely, large-scale insights that are essential for efficient damage assessment, resource allocation, and recovery planning. Satellite imagery, drones, and remote sensing technologies can quickly capture high-resolution imagery from disaster-affected areas, helping responders identify damage hotspots, assess the extent of destruction, and plan relief efforts. These technologies also support long-term recovery by continuously monitoring the progress of rebuilding efforts and the restoration of critical infrastructure.

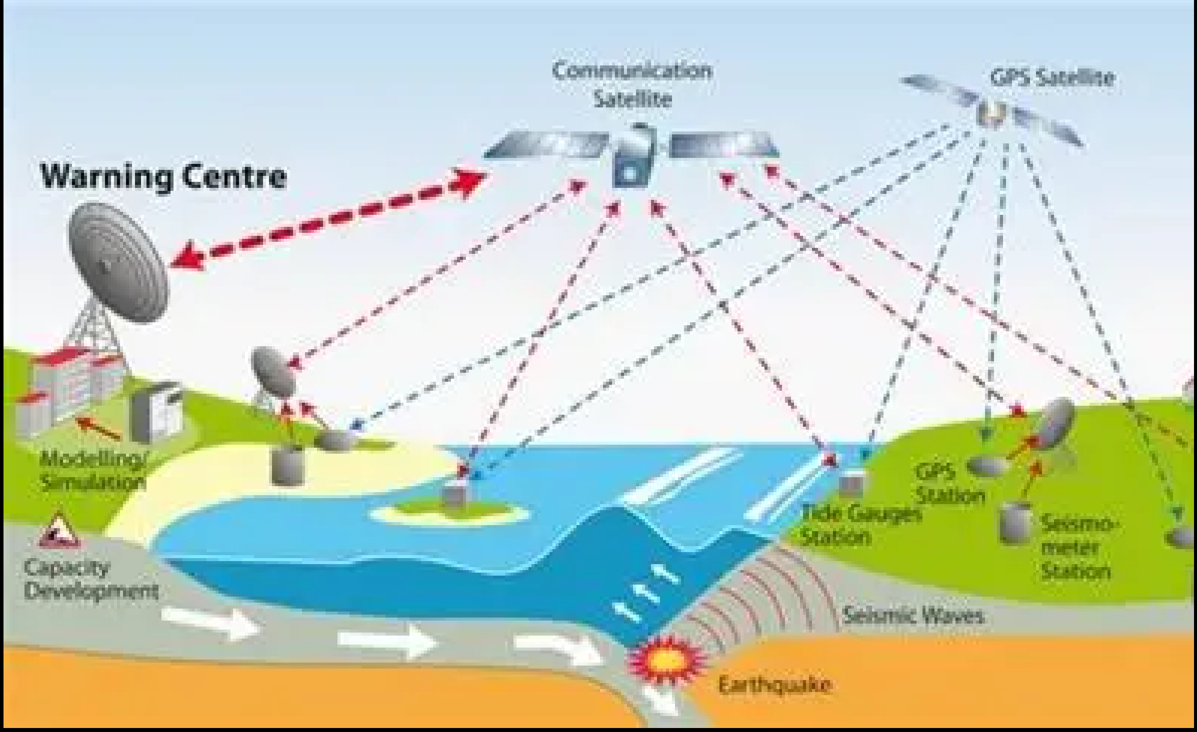
- Damage Assessment and Impact Mapping: Satellites equipped with optical and radar sensors can assess damage across large geographic areas, providing timely imagery of affected regions. Post-disaster satellite imagery allows for the identification of damaged infrastructure, including collapsed buildings, flooded areas, destroyed roads, and disrupted utilities. For example, Synthetic Aperture Radar (SAR) can penetrate cloud cover and is particularly useful in disaster scenarios with poor visibility, such as during floods or hurricanes. By comparing pre- and post-disaster imagery, EO technologies enable the creation of precise damage maps. Machine Learning (ML) further enhances this process by automating the comparison of imagery, enabling quicker identification of patterns and anomalies in the data. This automation improves the accuracy and speed of damage assessment, helping to prioritize response efforts more effectively.



WEF How Earth Observation Helps

- Rapid and Cost-Effective Response: In disaster scenarios, rapid response is crucial, and traditional ground-based assessments can take days or even weeks. EO technologies provide a timely, cost-effective alternative by offering detailed insights in hours or days. These insights enable emergency responders and governments to deploy resources more effectively, focusing on the area's most in need of intervention, and ultimately reducing the overall impact of the disaster on affected populations.

- Reconstruction and Recovery Planning and Monitoring: EO is invaluable for both disaster recovery planning and long-term monitoring. In the planning phase, EO provides pre-disaster baseline data and detailed risk assessments, enabling the identification of vulnerable areas and critical infrastructure requiring prioritization. Post-disaster, time-series satellite imagery supports the tracking of reconstruction progress for housing and infrastructure, revealing changes in the landscape, vegetation, and built environment. Techniques such as change detection analysis quantify recovery pace, while Land Use and Land Cover (LULC) change analysis highlights shifts in land use patterns, signaling the return of human activity and restored functionality.



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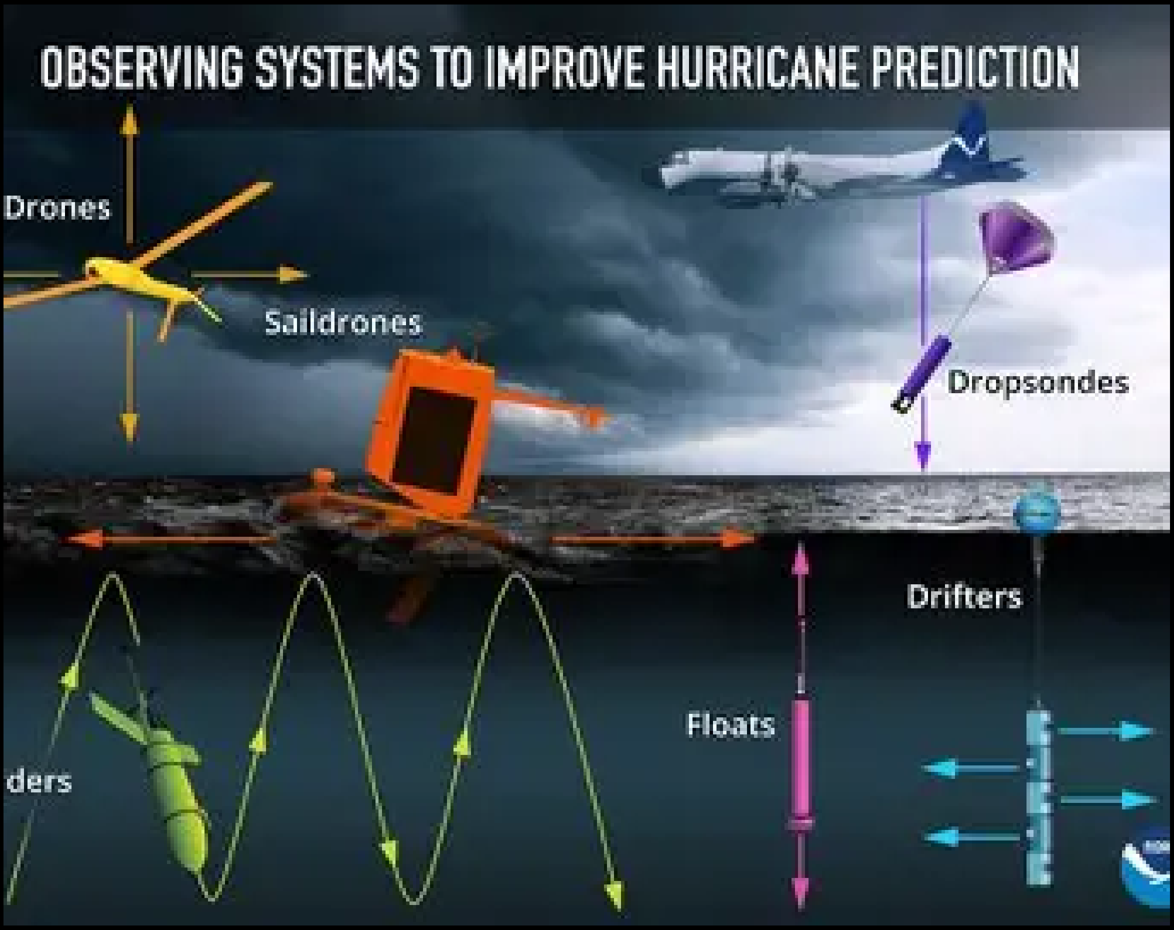
Earthquake Early Warning Systems was not available for the moment magnitude (Mw) 7.7 earthquake in Mandalay, Myanmar on 28 March 2025. The event claimed the lives of at least 5,000 people, affected over half a million more and incurred economic losses of approximately $1.7 billion. Similarly, no warning was available for the 6.0 magnitude earthquake in Afghanistan on 31 August 2025, which killed more than 2,200 and injured 3,600 (as of 9 September).

The impact of the Afghanistan earthquake was compounded by other factors, including displaced populations due to forced returns from neighbouring countries, and with the continued threat of cascading hazards (e.g. landslides) due to heavy rain. However, tsunami EWS have advanced considerably over the years, as seen following the Mw 8.8 Kamchatka earthquake on 30 July 2025.

The event triggered tsunami warnings across the Pacific region almost immediately, with millions of people actively responding to instructions to evacuate, including nearly 2 million people in Japan. Notices and evacuations at this scale were largely absent in the tsunami events of 2011 (Japan) and 2004 (Indian Ocean), which cost thousands of lives and from which valuable lessons have been learned and acted upon.

On January 1, 2024, a 6.5 magnitude earthquake struck the Noto Peninsula in Ishikawa Prefecture, Japan, causing significant structural damage and displacing numerous residents. The urgent need for damage assessment and coordinated recovery efforts was paramount.

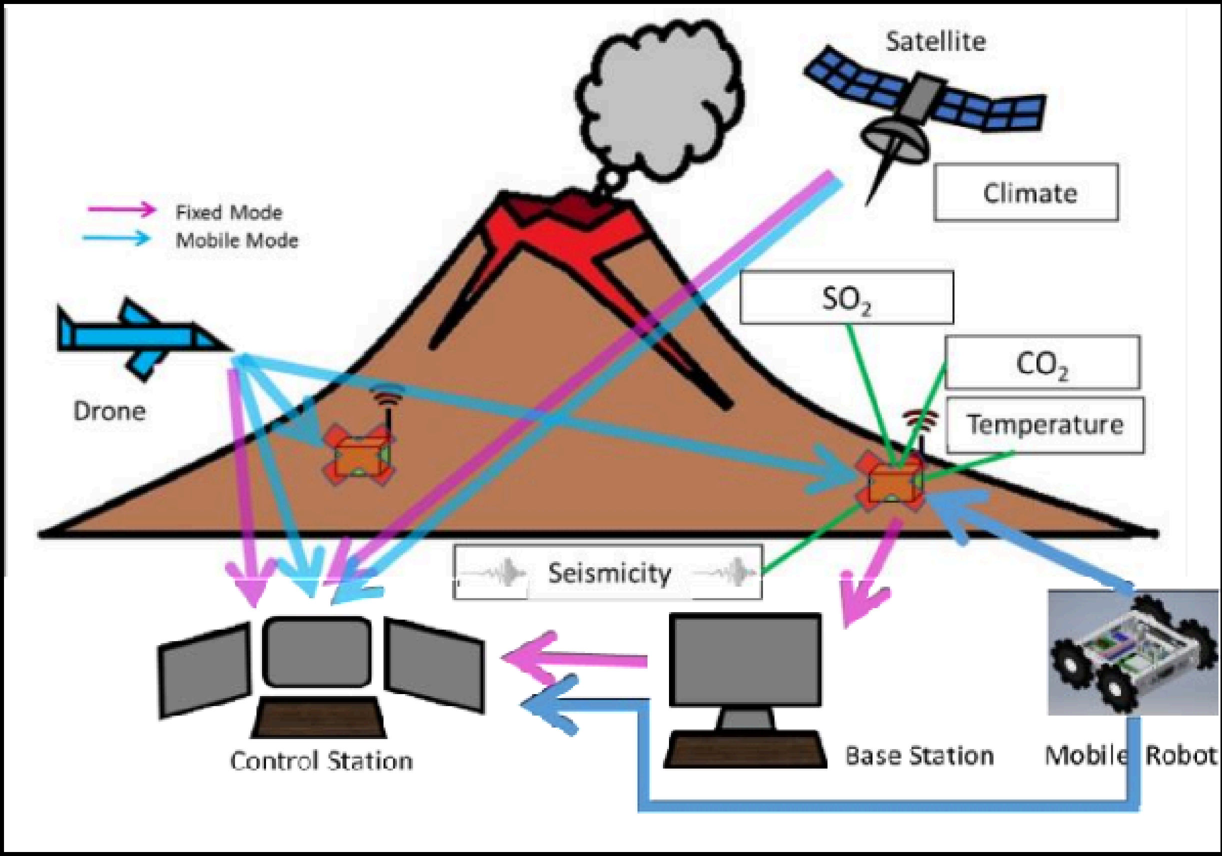
Synspective swiftly deployed its SAR satellite, StriX, to capture high-resolution images of the affected region. SAR technology was particularly effective due to its ability to penetrate cloud cover and capture detailed images regardless of weather conditions or daylight. Within three days of the earthquake, Synspective completed a full-area observation of the Noto Peninsula and automatically extracted surface deformation data. This rapid assessment enabled government and relief agencies to analyze changes in the ground surface using archived images and quickly understand the conditions in hazardous areas, facilitating more efficient planning of field investigations and relief operations. Additionally, the SAR data was made publicly available for transparency and broad access to vital information.



WEF Case Study: CEOS and the Haiti Recovery Observatory (RO)

In response to the devastation caused by Hurricane Matthew in 2016, the Committee on Earth Observation Satellites (CEOS) established the Haiti Recovery Observatory (RO) to support long-term recovery efforts through satellite data. Led by Haitian organizations including CNIGS, CIAT, and ONEV, the RO aimed to demonstrate the value of EO in post-disaster recovery. It leveraged satellite data to monitor the rebuilding of infrastructure, assess agricultural rehabilitation, and track the restoration of ecosystems such as Macaya Park and coastal mangroves. The RO also provided critical insights for improving disaster preparedness and resilience against future events.

This collaboration allowed for the integration of high-resolution imagery with other data sets, enabling timely decision-making and fostering innovation in recovery processes. The Haiti RO has since become a model for leveraging EO data in disaster management, illustrating its potential to guide recovery and enhance resilience in the face of future natural disasters.

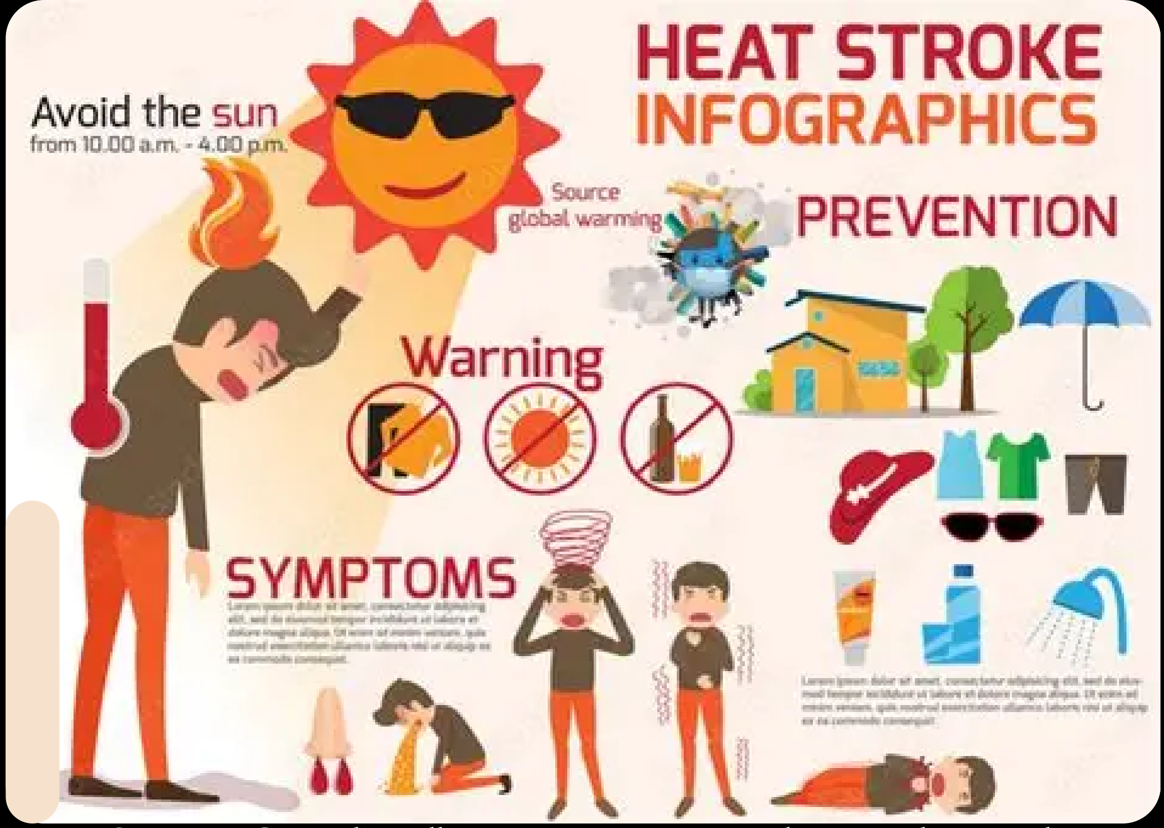


Volcanic Eruptions

Ten percent of the world's population live in areas susceptible to volcanic eruptions, which can trigger other hazardous events. Small-scale eruptions can present major issues for local communities, while large-scale events can cause disruption across wide areas. In rare cases, extreme events can have climate impacts (Brown, and others, 2017).

In November 2024, eruptions from Mount Lewotobi Laki-laki volcano in Indonesia killed at least 10 people and put more than 10,000 people in temporary shelters. Meanwhile, populations faced f lash floods and lahars (dangerous mudflows comprised of volcanic debris). In July 2025, further eruptions prompted evacuations for over 4,000 people, shortages of clean drinking water and flight cancellations. Volcanic hazard, exposure, vulnerability, and risk assessments have advanced significantly in recent years, driven by progress in probabilistic modelling, remote sensing and interdisciplinary research. Hazard assessments are now better able to capture complex volcanic processes across varying timeframes and spatial scales, providing valuable insights for both emergency response and long-term planning. However, important gaps remain.

Many volcanoes, particularly in low-income countries, lack sufficient monitoring, while historical records are often incomplete, limiting confidence in hazard assessments and maps. While exposure mapping has improved through high-resolution imagery and local data sources, challenges persist in capturing dynamic population movements and understanding systemic interdependencies. Vulnerability assessments in volcanic contexts also remain underdeveloped, with limited data and methodologies for quantifying social, economic and institutional factors. Promising innovations in monitoring volcanic activity include transdisciplinary approaches by volcanologists and ecologists. These include the use of NASA satellite images to approximate magma-generated carbon dioxide by observing tree leaf colour around volcanoes. Greener tree cover forewarns of an impending eruption at a much longer lead time than conventional methods.



The United Nations Secretary-General's call to action on extreme heat emphasizes the urgent need for international cooperation to address the multifaceted impacts of heat. EWS play a major role in the four critical areas of caring for the vulnerable, protecting workers, boosting resilience of economies and using data and science, as well as contributing to climate change mitigation. As 2024 was the first year the annual global mean temperature exceeded 1.5°C above pre-industrial levels (WMO, 2025). This past year also marks the tenth year in a row that temperatures have ranked among the hottest on record.

This manifested in some of the most extreme temperatures on record, reaching 50˚C in India, Pakistan, Saudi Arabia, Japan, the United States of America and Mexico, according to the Global Heat Health Information Network (GHHIN). Rising temperatures are already having an impact – in 2024, extreme heat caused thousands of deaths globally. The impacts are not the same for everyone; extreme heat adversely impacts the most vulnerable groups – babies, pregnant women, older persons, and displaced people – and people who are more exposed to heat due to the nature of their work or a lack of shelter. A new report shows that both outdoor and indoor workers face increased risks, and productivity drops 2 to 3 per cent for every degree above 20°C (WMO and WHO, 2025).

In Saudi Arabia, heat claimed approximately 1,300 lives, and in the United States, over 1,000 deaths were recorded in two cities alone (Phoenix and Las Vegas). India and Pakistan also suffered high death rates attributed to heat, with over 700 and nearly 600 lives lost, respectively (CRED, 2025). On the African continent, extreme heat events hit 42 of the 54 countries in 2024, and Europe was the fastest-warming continent. There is an urgent need for communities and countries to consider appropriate thresholds for extreme heat warnings in their local area as the basis of a future warning system. It may also be possible to develop a global system, but it would likely be based solely on generic heat-stress calculations rather than local data relating to the prevailing and expected conditions. In December 2024, an expert consultation acknowledged the need for a global common framework to address extreme heat risk, and they recommended (among other things) improved EWS with co-produced, impact-based alerts for disaster management strategies (GHHIN, 2025). At the local level, forecasting extreme heat and issuing warnings is relatively achievable for heat compared to other hazards, which are difficult to predict within specific timeframes (e.g. earthquakes) or locations (e.g. landslides). Given the increasing risks associated with extreme heat and to reduce the high levels of excess deaths it causes, a global heat EWS is urgently needed.

The United Nations has declared 2025 to 2034 as the "Decade on Combating Sand and Dust Storms", recognising the severe impacts that sand and dust storms (SDS) have on health, agriculture and socioeconomic well-being. EWS are a vital component in assessing and addressing risks to these mega hazards. The global recognition of SDS highlights the urgency of strengthening EWS as a critical mechanism for managing this transboundary hazard. Every year, an estimated 2 billion tonnes of sand and dust, an amount equal in weight to 350 Great Pyramids of Giza, enter the atmosphere. Nearly 80 per cent of this amount emanates from North African and Middle Eastern deserts. Significant emissions also originate from Central Asia, East Asia, and parts of the Pacific, affecting populations far beyond source regions. In mid-April 2025, SDS swept across southern Iraq and northern Saudi Arabia, reportedly sending nearly 4,000 people to emergency rooms across the region. Low visibility and high winds closed airports, and harmful air quality closed schools. In recent years, similar severe SDS events across Central Asia and the Arabian Peninsula have reinforced the need for regionally coordinated forecasts and alerts.

SDS pose risks across society – not only in the areas where they originate, but across borders thousands of kilometres away. Localized impacts are often the most damaging, yet remain the hardest to forecast with precision. Hundreds of millions of people are exposed to poor air quality from SDS, seriously impacting short- and long-term health, and disrupting both education and employment. The electricity sector suffers when solar production is disrupted, causing losses of hundreds of millions of dollars, and this is likely to worsen as reliance on renewable energy increases. The aviation industry must cope with harmful dust particles on aircraft engines and visibility challenges, which cause flight delays, diversions and cancellations. Agriculture is impacted by large amounts of sand and dust, often contaminated with high salt content that is toxic to plants and can lead to lower yields and failed crops. Impacts can also be indirect – for example, high altitude glaciers are also increasingly affected by SDS as dust deposition accelerates ice melt, amplifying downstream water-related risks (ESCAP and APDIM, 2021).

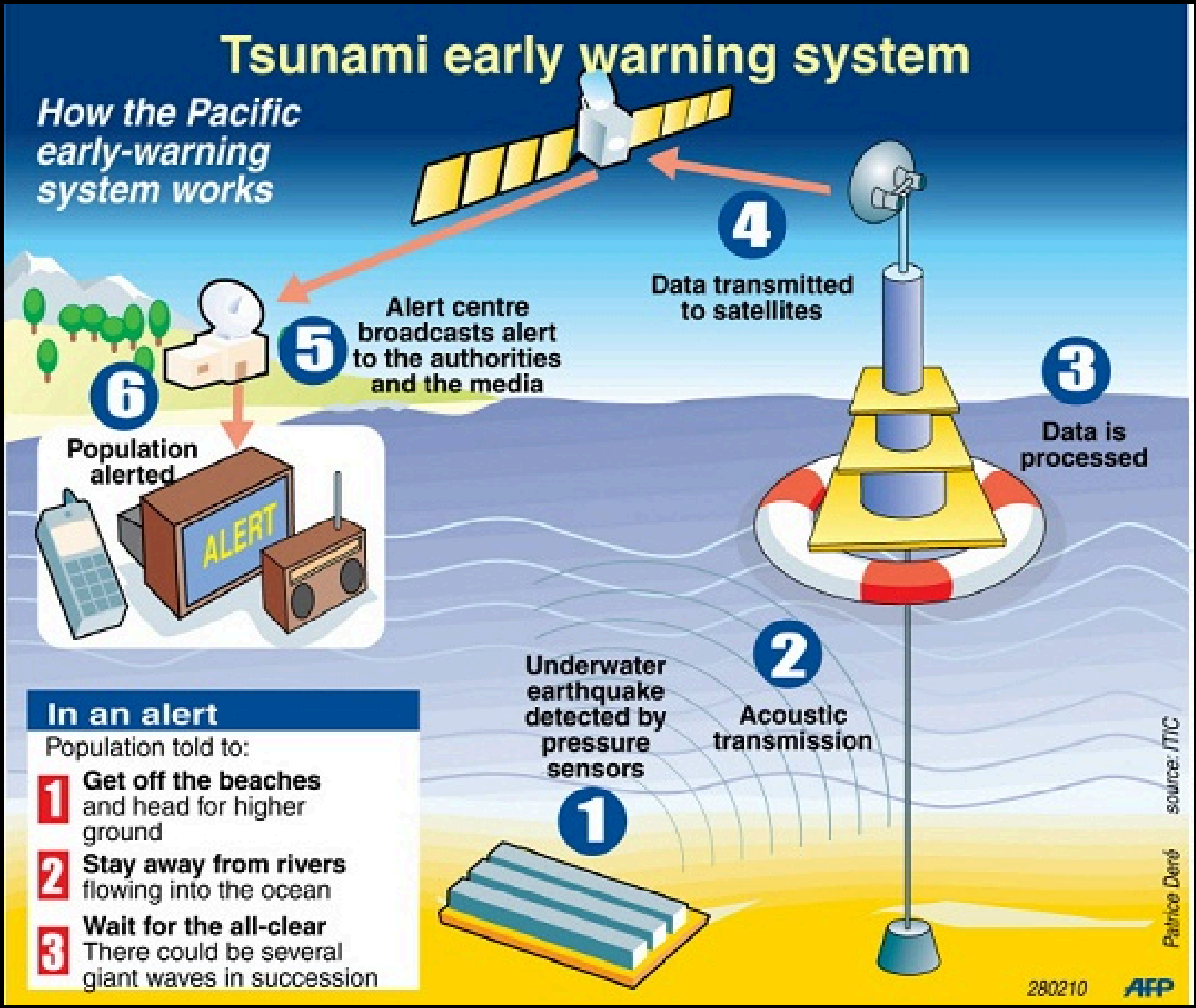
Heavy Rain, Flood & Landslide

In 2024, Afghanistan suffered from severe winter storms bringing blizzards, landslides and floods, killing nearly 1,200 people (ACAPS, 2024; CRED, 2025). Pakistan has experienced one of its most destructive monsoon seasons in decades, with cascading and compounding hazards resulting in extensive loss of human life, mass displacement and destruction of livelihoods and infrastructure. In August 2025, a combination of intense rainfall, flash floods, and localized cloudbursts devastated large swathes of Khyber Pakhtunkhwa region. The humanitarian situation escalated rapidly due to the high intensity of rains, fragile mountainous terrain and already vulnerable socioeconomic conditions of affected communities. Meanwhile, in Punjab, around 24,000 people were evacuated due to the risk of riverine flooding resulting from upstream releases and near-full reservoirs along the Sutlej, Chenab and Ravi, with similar warnings issued by the Provincial Disaster Management Authority in Sindh province. Simultaneously, glacial lake outburst floods (GLOF) on 22 August destroyed over 330 houses, with the risk of further GLOFs occurring. With heavy rain, thunderstorms and strong winds set to continue, an urban flooding warning was also issued.

Heavy rainfall in southern Brazil caused floods and localized landslides in May 2024, resulting in 184 deaths and tens of thousands of people displaced, affecting 90% of the Rio Grande do Sul state. Studies indicate that authorities issued risk alerts days in advance, but that these would have been more effective with better institutional coordination, impact-based warnings and community-centred communication strategies.

In the Enga province of Papua New Guinea, a landslide killed at least 670 people in May 2024 and marked one of the most consequential disasters in the country's history. Similarly, in southern Ethiopia, a landslide in July 2024 killed over 200 people, and a landslide in Tarsin (a village in the western Jebel Marra region of Sudan) on 31 August 2025 left hundreds missing.

In Cox's Bazar, Bangladesh – home to the world's largest refugee settlement – IOM tailored a camp-level MHEWS for landslides, floods and cyclones, where terrain degradation and dense informal shelters posed extreme risks. Over 1,600 volunteers (50 per cent women) formed disaster management units to issue warnings via sirens, megaphones and radio networks. Anticipatory measures included relocating households from danger zones, implementing nature-based solutions like bamboo slope reinforcement and pre-positioning emergency supplies. Local coordination – including partnerships with government, host communities and "Camp-in-Charge" officers – enabled drainage improvements and awareness campaigns, reducing fatalities and expanding EWS coverage to over 500,000 residents.



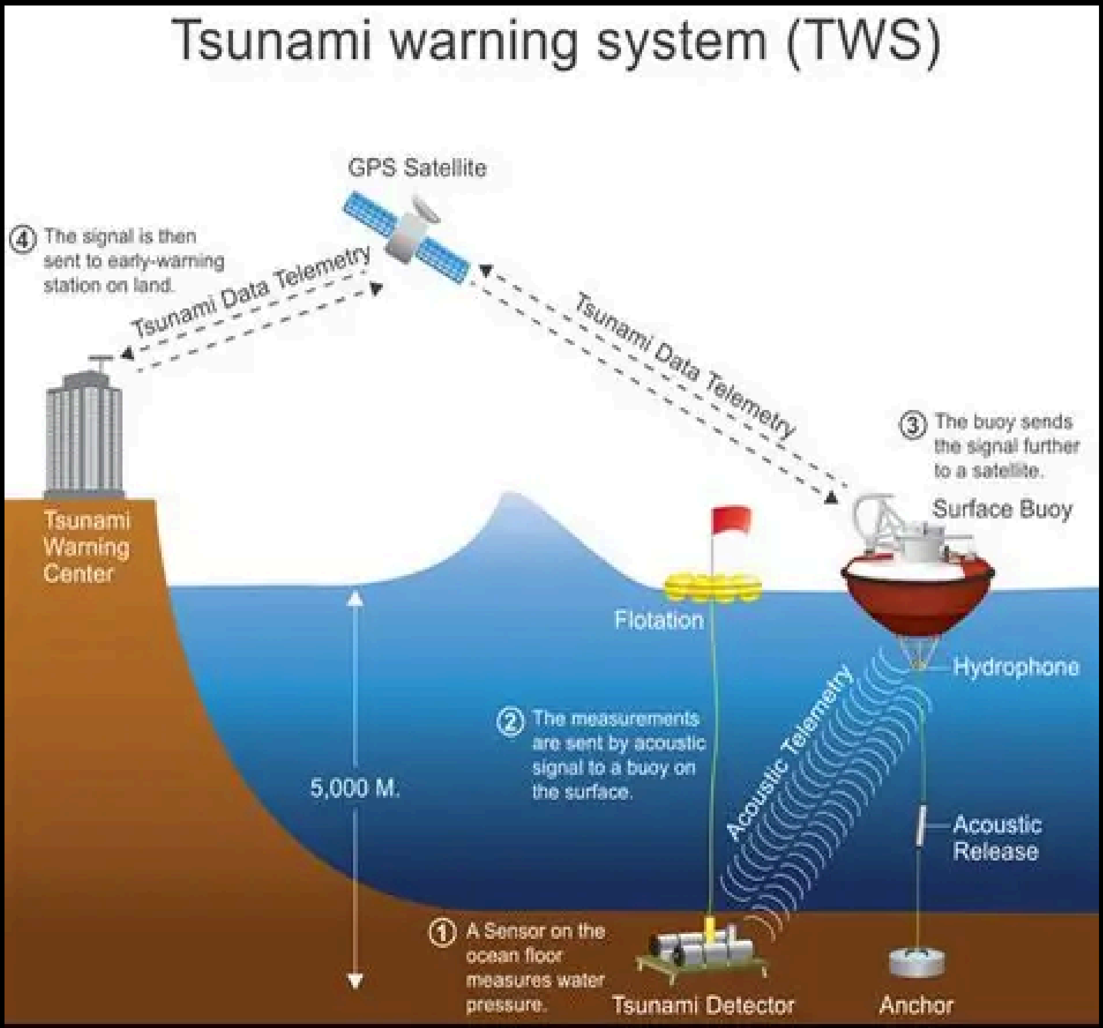
Tsunami Early Warning Systems

Latest data shows that countries with substantial to comprehensive MHEWS capabilities have a disaster-related mortality that is nearly six times lower than that of countries with limited to moderate comprehensive capabilities. A recent example is the earthquake in Kamchatka Peninsula, which triggered a tsunami alert for dozens of countries, resulting in the evacuation of millions and demonstrating the effectiveness of the tsunami EWS in the Pacific.

The coastal city of Manta in Ecuador has advanced its tsunami preparedness through a community-led approach, combining technical innovation with local engagement. Partnering with the Japan International Cooperation Agency (JICA), the Manta municipal government introduced visible communication tools in flood-prone public spaces, including "totems" with QR [Quick Response]-linked web maps showing evacuation routes and 23 designated safe zones. These efforts were bolstered by in-person outreach and social media campaigns designed to build public awareness and autonomy in disaster response.

The most devastating disasters in the past year were weather-related, responsible for 93 per cent of overall financial losses (Munich Re, 2025). Severe storms are becoming more frequent and more extreme. Studies by World Weather Attribution have shown that Hurricanes Helene and Milton were significantly more severe and carried much more rainfall than they would have if they had occurred in a world without climate change (Clarke, and others, 2024; World Weather Attribution, 2024c).

Similarly, the intense rainfall that resulted in flash floods in Valencia, Spain (World Weather Attribution, 2024b) and the weather conditions that led to severe flooding in Brazil (World Weather Attribution, 2024a) were both twice as likely to occur as a result of climate change.



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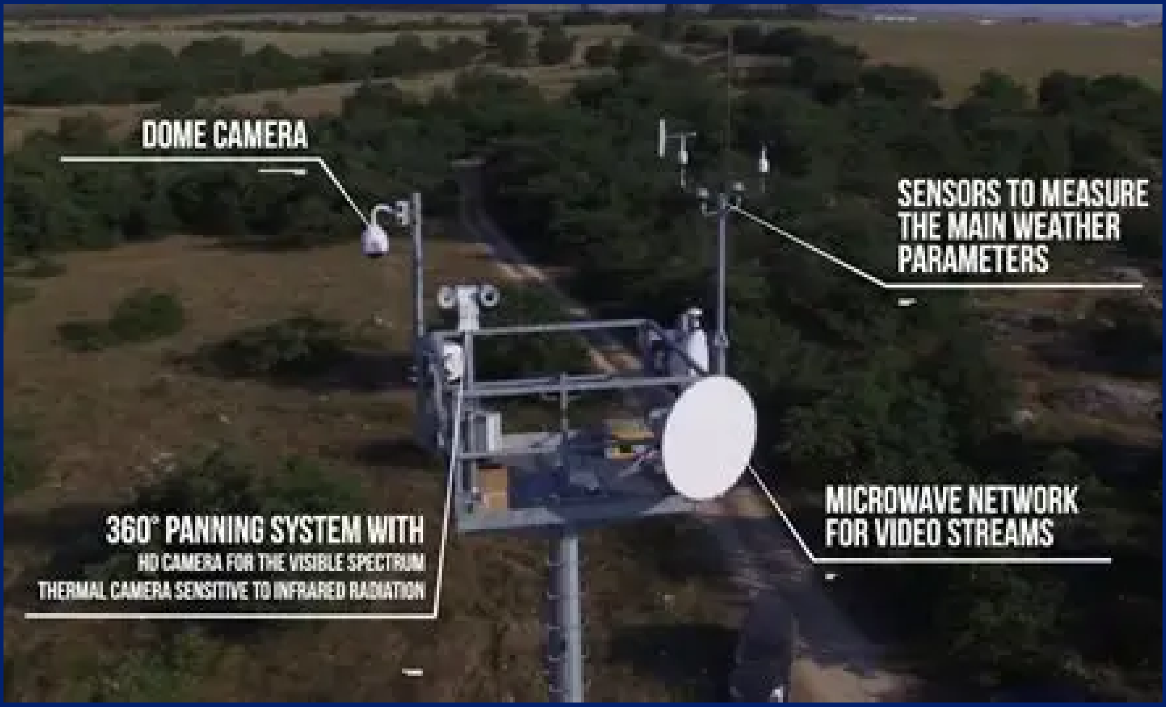
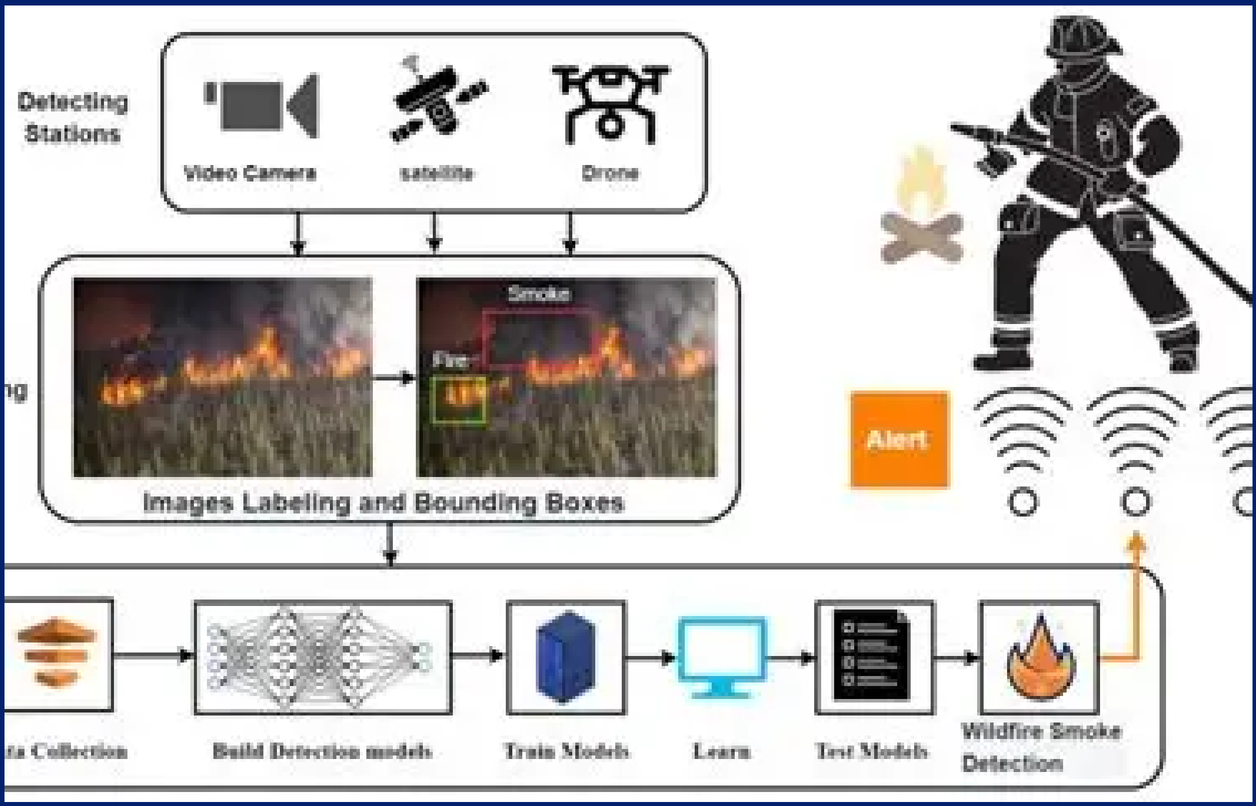


WEATHER SENSORS

Through the Early Warning Systems for Floods (EWS-F) initiative, under WMO leadership, 27 countries have completed structured assessments so far using the National Capacity Assessment Tool (NCAT), which focuses on end-to-end flood forecasting and EWS. This comprehensive diagnostic landscape has strengthened the global evidence base on MHEWS functionality, enabling more tailored support, especially for hazard-specific applications such as flooding.The Flash Flood Guidance System (FFGS), led by WMO and partners, is operational in over 70countries. The system leverages satellite-derived rainfall estimates, soil moisture modelling and weather forecasts to deliver real-time, location-specific guidance for flood risk. It supports immediate decision-making while fostering better coordination between national and regional agencies. More than 1,000 technical staff have been trained through FFGS to date, and regional centres continue to provide peer support and capacity development. Recently, concerns about the long-term sustainability of the system have been raised. In response, WMO has developed a concept note on a flood forecasting framework, aimed at empowering Members and ensuring the sustainability not only of FFGS but also of other flood forecasting systems led by WMO.

The Philippines demonstrates how decentralized and community-embedded technologies can make MHEWS more inclusive. The national Strengthening Resilience through Early Action and Impact Mitigation–Early Warning System (STREAM-EWS) initiative in Mindanao deployed calibrated flood sensors and telemetered weather stations across 12 municipalities. Aligned with existing Philippine Atmospheric, Geophysical and Astronomical Services Administration standards relating to observations, this infrastructure bridges gaps in local river basin monitoring, enhances forecast accuracy, and improves coordination among municipalities for evacuations and emergency actions. In San Miguel, Surigao del Sur, where traditional river monitoring involved manual inspection, the STREAM-EWS system now automatically triggers SMS alerts based on water-level thresholds, directly notifying local government units and communities in real time. The project's human-centred design extended beyond hardware: local officials and communities received training and conducted simulation exercises that improved real-time decision-making and strengthened preparedness. For budget-constrained local government units (LGU), affordable and maintainable technologies combined with capacity-building activities have made the system sustainable with the ability to adapt it if required to meet changes in local needs.



Monitoring Wildfires

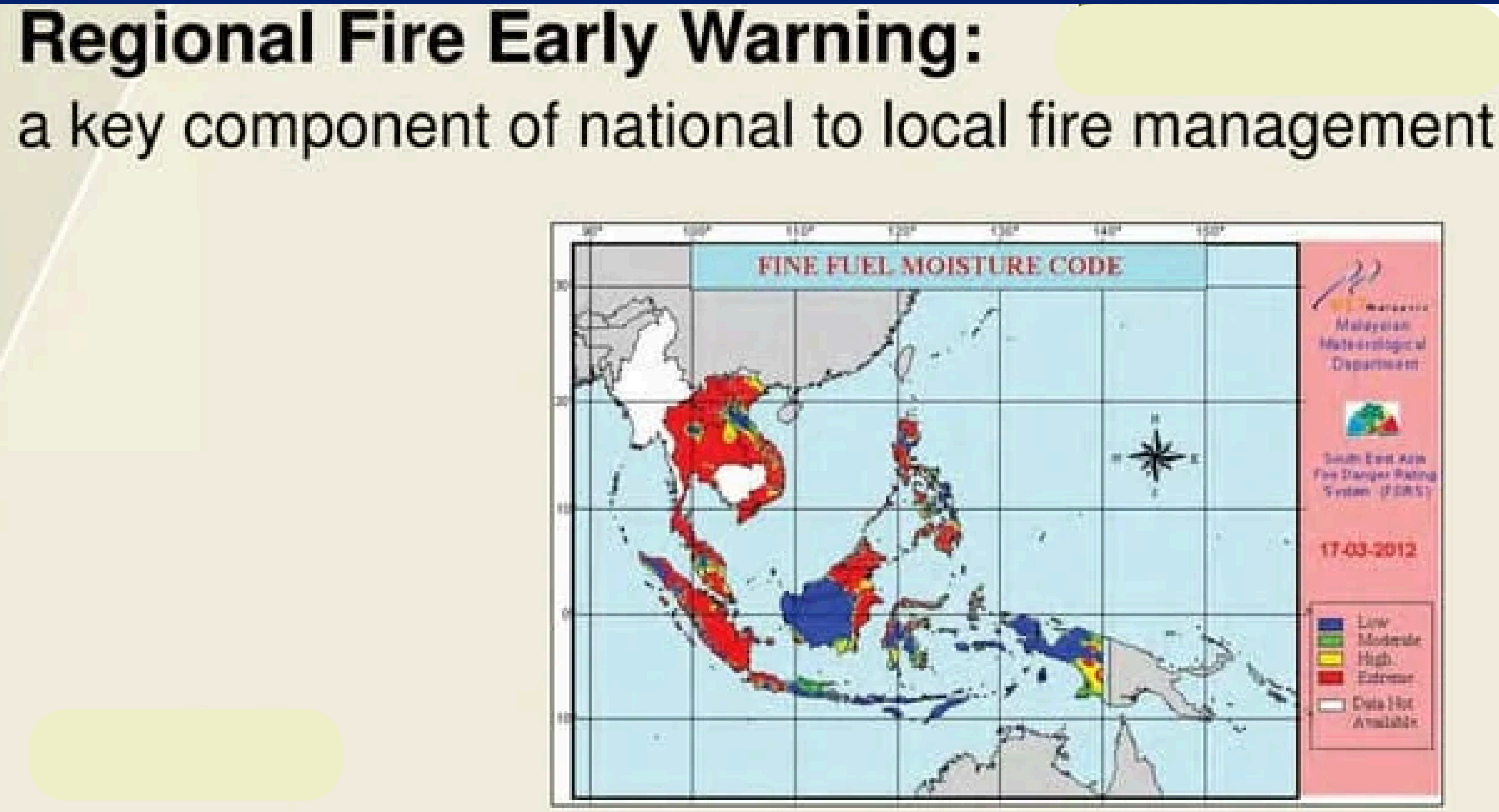
In January 2025, a combination of climatic factors fuelled intense, fast-spreading wildfires in Los Angeles, killing at least 30 people, displacing more than 200,000 residents and destroying over 18,000 structures. With economic losses estimated between $28-54 billion, it is one of the most costly disasters in California's history (Los Angeles County Economic Development Corporation, 2025).

An after action review found that a series of weaknesses, including among communication, hampered the effectiveness of the response. Massive fires throughout 2024 drove record breaking loss of tropical primary forests, destroying ecosystems critical for livelihoods, carbon storage, water provision and biodiversity. Losses were highest in Brazil, followed by Bolivia, the Democratic Republic of Congo, Indonesia and Peru (Goldman, Carter, and Sims, 2025).

In June 2025, the Group of Seven (G7) leaders resolved to boost global cooperation to recover from, prevent and fight wildfires through the Kananaskis Wildfire Charter. It includes a pledge to leverage research tools and technology to provide early warnings when wildfire threatens inhabited areas and infrastructure.

Weather and satellite data can enhance EWS through fire danger ratings, providing advance notice of severe conditions days and weeks ahead, and enabling the public and practitioners to detect threats and take early action. Other technologies that are being deployed to improve wildfire EWS include cameras, drones, mobile phone signal movement, remote sensing and mobile Doppler radar.

Recently, AI has been employed to visualize wildfire data to facilitate decision-making for wildfire risk reduction. The first Global Fire Management Hub Plenary, based at the Food and Agriculture Organization of the UN (FAO), was held in June 2025 and explored early warning and fire danger rating systems for integrated fire management, among other issues.



Wildfires Early Warning Systems Development

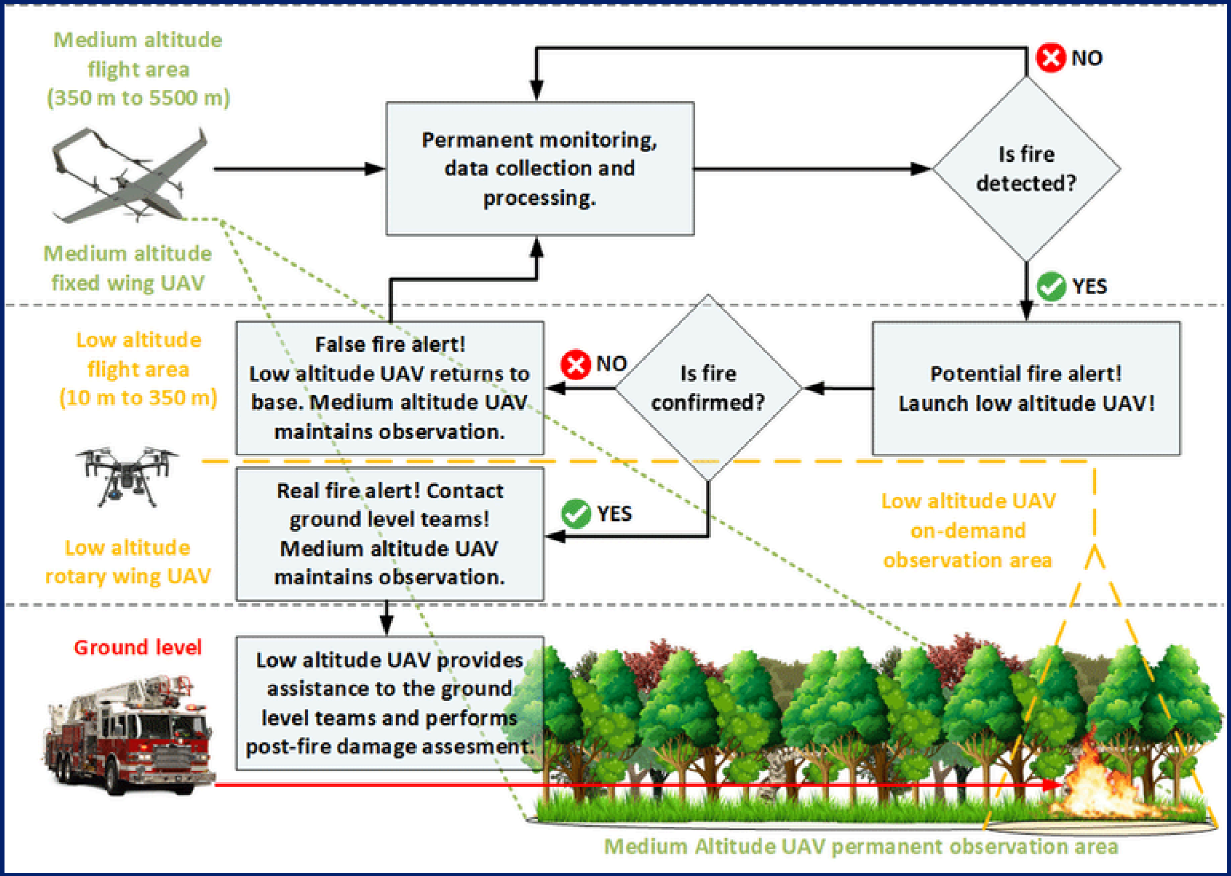
Wildfires in Indonesia happens yearly, due to the deforestation did in the rainforest region at Kalimantan. The fire smokes reached the Malaysian and Brunei territory, making the disaster occurences happens as regional matters that has been monitored also by Singapore.

The regional approach was required because of the smoke cause a vast range of area in the Malaysia, Brunei, Singapore, and in Indonesia also.

Wildfires threaten human life and property and have serious negative impacts on health, economies and ecosystems that reach far beyond the areas of immediate destruction. Early warnings about dangerous conditions can prompt populations and practitioners to take actions that reduce the risk of wildfires starting, spreading or endangering people and property.

Forecasting wildfire conditions has improved, reflecting a joint approach that includes not only consideration of high temperatures and lack of rain, but also compounding factors such as windspeed, wind direction and preceding seasonal conditions on vegetation. Early warnings are essential because once a fire has started and is spreading, it can be very challenging to issue timely warnings to affected areas due to a combination of fast changing conditions, power outages and failure of communication infrastructure.

In Guatemala, NaturAceites—a member of the ARISE and CentraRSE132 networks for the private sector in DRR—has been using satellite technology through a certified third-party provider to deliver real-time information on deforestation and potential fires in the area. The information is used to coordinate rapid response teams to contain risks. The satellite monitoring area covers a radius of 50 km around each point in the NaturAceites supply chain. Since its implementation in 2015, all incidents identified have been successfully contained.



Translating data into interactive frameworks in California wildfire are studied using game engine and AI technologies. The data and information needed to determine risk often do exist, but not necessarily in the formats that enable practitioners to translate and use that information to understand risk or inform risk-reduction decision-making. Yet it is essential that scientific data and geospatial information are synthesized into actionable and usable content. Navteca has been combining two emerging technology areas: immersive visualization using game engines and conversational AI. These technologies are combined to create an interactive visual framework for displaying 3D geospatial wildfire data as it relates to disaster risk and resilience. Both technologies enable humans to interact with data and information naturally and intuitively. In the case of immersive visualizations, while they can be viewed in a virtual reality headset, the more widespread approach is to distribute information as 360° content (images or videos that capture a full spherical view of a scene) using mobile devices, primarily cell phones or on the web. Additionally, conversational AI – using the Navteca Voice Atlas– enables humans to use natural language rather than keywords and metadata tags to ask about the visualization and find answers to queries, making the data more open and accessible.

Navteca has developed several case studies, supported in part through grants from the National Aeronautics and Space Administration (NASA) Applied Sciences Program, Wildland Fire. These projects leverage previous research to combine the immersive game engine visual interface with data from NASA, the National Oceanic and Atmospheric Administration (NOAA) and the United States Geological Survey (USGS). Meanwhile, the Voice Atlas AI component creates a robust, interactive visualization that utilizes conversational AI to answer questions and provide contextual information about the wildfires at Hermit's Peak (New Mexico), Lahaina (Hawaii), Eaton and Pacific Palisades (California). The simulations "tell the story" of each wildfire, including modelling of complex wind vectors, smoke plumes, soil moisture, burn severity, fire radiative power, active fire points and others. Several of the immersive 3D visualizations were incorporated into documentaries produced by the Public Broadcasting Service (PBS) to explain the scientific aspect of destructive wind-driven fires in the western United States, and a feature documentary about the devastating Los Angeles fires that occurred in January 2025.

Top 10 Countries by Natural Hazard Occurences (2005-2024)

Figure 1: Top 10 countries by natural hazard occurrences (2005–2024), excluding extraterrestrial and biological hazards*

* Event counts are absolute; comparisons across countries should be made with caution, as results are influenced by factors such as country size and population.

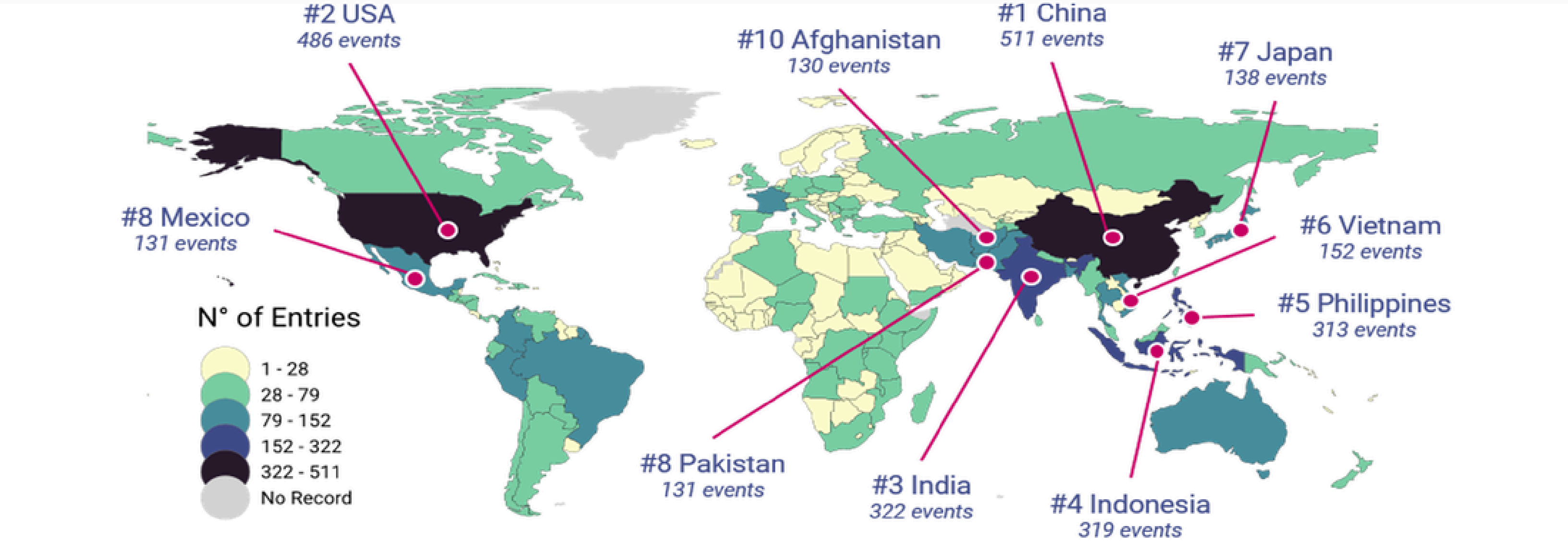
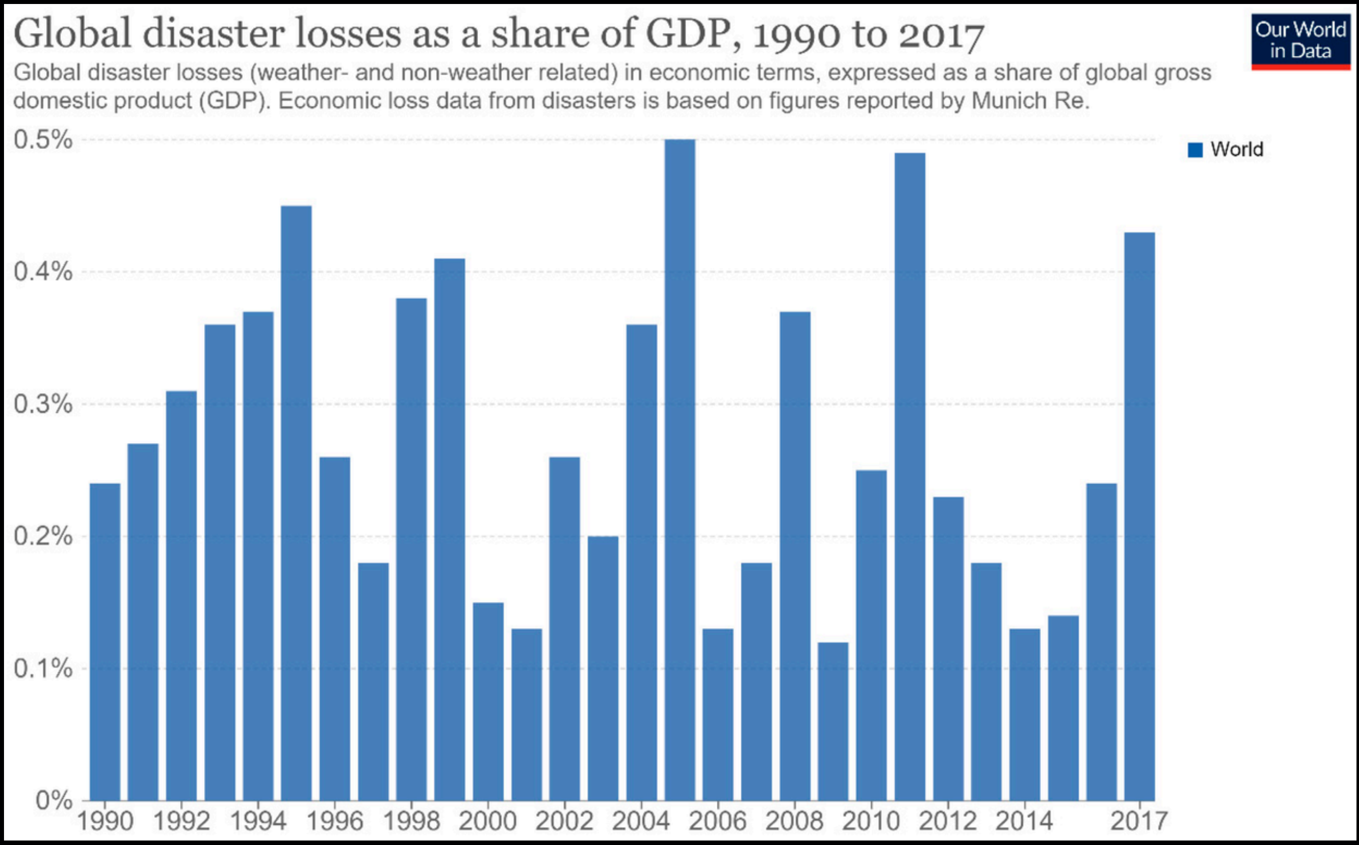


FIGURE 2.3 Global risks over the long term (10 years), by region

	Eastern Asia	Europe	Latin America and the Caribbean	Middle East and Northern Africa	Northern America
1st	Extreme weather events	Extreme weather events	Biodiversity loss and ecosystem collapse	Cyber espionage and warfare	Extreme weather events
2nd	Biodiversity loss and ecosystem collapse	Biodiversity loss and ecosystem collapse	Extreme weather events	Adverse outcomes of AI technologies	Critical change to Earth systems
3rd	Critical change to Earth systems	Critical change to Earth systems	Critical change to Earth systems	State-based armed conflict	Biodiversity loss and ecosystem collapse
4th	Cyber espionage and warfare	Misinformation and disinformation	Natural resource shortages	Natural resource shortages	Societal polarization
5th	Natural resource shortages	Involuntary migration or displacement	Pollution	Extreme weather events	Natural resource shortages

	South-Eastern Asia	Southern Asia	Sub-Saharan Africa
1st	Critical change to Earth systems	Extreme weather events	Extreme weather events
2nd	Extreme weather events	Pollution	Lack of economic opportunity
3rd	Biodiversity loss and ecosystem collapse	Biodiversity loss and ecosystem collapse	Biodiversity loss and ecosystem collapse
4th	Adverse outcomes of AI technologies	Critical change to Earth systems	Crime and illicit economic activity
5th	Misinformation and disinformation	Inequality	Natural resource shortages

Risk categories | Economic | Environmental | Geopolitical | Societal | Technological



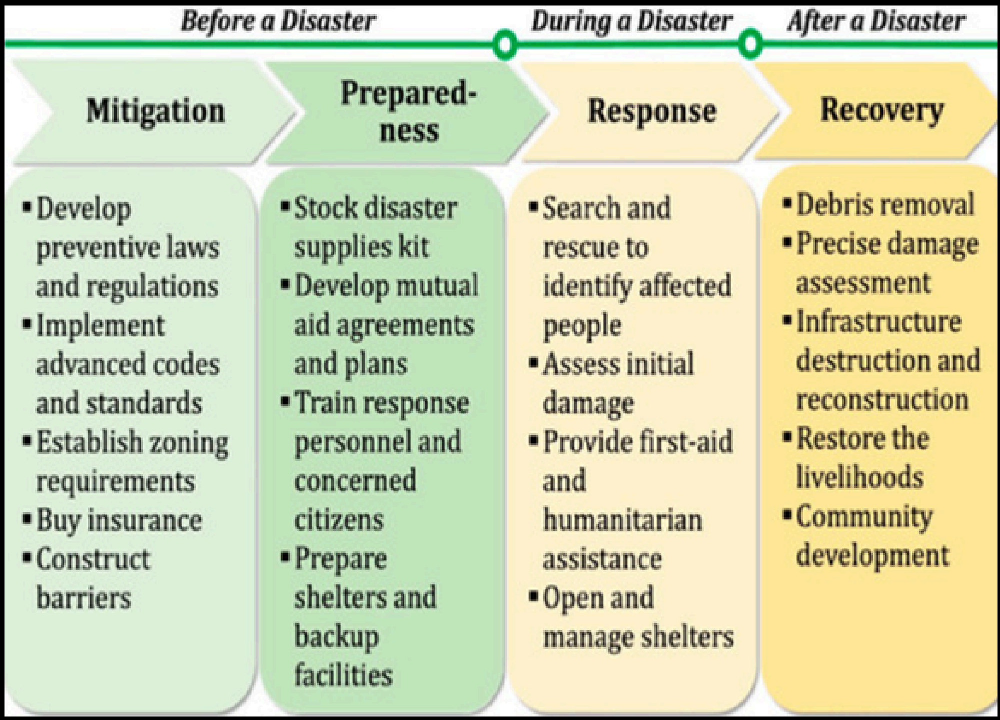
AI in Disaster Management Cycle

From Sheikh Kamran Abid in https://doi.org/10.3390/su132212560, A disaster is a phenomenon that may inflict harm on a community through loss of human life, damage to the environment, or economic loss. It is beyond the community's capacity to react. According to the Center for Research on the Epidemiology of Disasters, disaster-affected countries lost $ 2.9 trillion in economic value between 1998 and 2017.

With approximately $1 trillion in losses, the United States leads the pack, followed by China, Japan, and India. According to the UN Refugee Agency, the rate of calamities has nearly doubled throughout the last 20 years. Since 1995, the Asia–Pacific region has been the most vulnerable. As highlighted below, global disaster losses are a share of GDP from 1990 to 2017.

Technical and methodological enhancement of hazards and disaster research is identified as a critical question in disaster management. Artificial intelligence (AI) applications, such as tracking and mapping, geospatial analysis, remote sensing techniques, robotics, drone technology, machine learning, telecom and network services, accident and hot spot analysis, smart city urban planning, transportation planning, and environmental impact analysis, are the technological components of societal change, having significant implications for research on the societal response to hazards and disasters.

Social science researchers have used various technologies and methods to examine hazards and disasters through disciplinary, multidisciplinary, and interdisciplinary lenses. They have employed both quantitative and qualitative data collection and data analysis strategies. This study provides an overview of the current applications of AI in disaster management during its four phases and how AI is vital to all disaster management phases, leading to a faster, more concise, equipped response. Integrating a geographic information system (GIS) and remote sensing (RS) into disaster management enables higher planning, analysis, situational awareness, and recovery operations. GIS and RS are commonly recognized as key support tools for disaster management. Visualization capabilities, satellite images, and artificial intelligence analysis can assist governments in making quick decisions after natural disasters.



AI in Disaster Management Cycle

Disaster management is a strategic and multi-faceted procedure for mitigation, preparedness, response, and recovery to protect the vulnerable community and critical intrastate from any disaster. Researchers, decision-makers, and government officials working in the area of disaster risk reduction share a common perception of the disaster and take proactive actions before a disaster occurs. However, all disasters are linked to humans coping with their consequences. Therefore, success and failure depend on the planning and implementation of effective disaster management practices. Furthermore, a hazard also causes a secondary hazard, which has an enormous impact, such as a tsunami, which triggers coastal flooding. Thus, in disaster management, AI is a significant force multiplier in the ability to protect people and property in the face of disaster and is undoubtedly the future of disaster management.

Today's artificial intelligence systems and geospatial technology are highly developed, and they have the potential to be highly effective in crisis scenarios. Disaster response planning is significantly influenced by the area's morphology, weather conditions, ecology, other factors, and the machinery's available resources. It is recommended to use operations research and management science criteria to enhance resilience in emergency relief while considering the impact of relief resource allocation on the population. However, several papers in the literature evaluate the utility of artificial intelligence in disaster management. The crisis response situation in other countries is vastly different from that in India. As a result, there is a need to identify and prioritize the data needed for compelling crises in natural disasters. The proper ways to minimize the impact of a catastrophe are preventive and minimization, vulnerability, readiness, and resilience in disaster management.

Artificial intelligence and geographic information systems are vital tools used by many scholars to plot the spatial dispersal of flood hazards and susceptibility to flooding. A geographical information system acts as a facilitator that inputs, stores, integrates, manages, and delivers spatial data for strategic planning and real-time decision making for timely and effective hazard preparedness and flood crisis management. These systems are capable and comprehensive in flood crisis management issues. With quick and more accurate decisions, it is necessary to adopt a systematic approach in the planning process. This paper reviews the advantages of artificial intelligence and its applications in disaster management and mitigating disaster damage.

AI in Disaster Management Cycle

Artificial intelligence is the intellect expressed by computer systems as opposed to human intelligence. AI is the process of different connected machines simulating human behavior. AI deals with computer-related activities concerned with building-related intelligent machines. Over the last decade, AI breakthroughs have considerably increased our capacity to forecast disasters and provide support throughout catastrophes.

AI development can be evident in disaster preparedness, crowdsourced information systems, rescue, and humanitarian distribution. Although AI has many forms, this report concentrates on using AI such as robotics, drones, machine learning, deep learning, sensors, and algorithms utilized in the context of catastrophe prediction and facilitating speedier rescue and relief delivery activities. Robotics and robots have been around for decades, but due to the recent increasing trend in sensor and compute technology, robots have evolved from close to zero decision-making devices to truly automated and artificially intelligent machines.

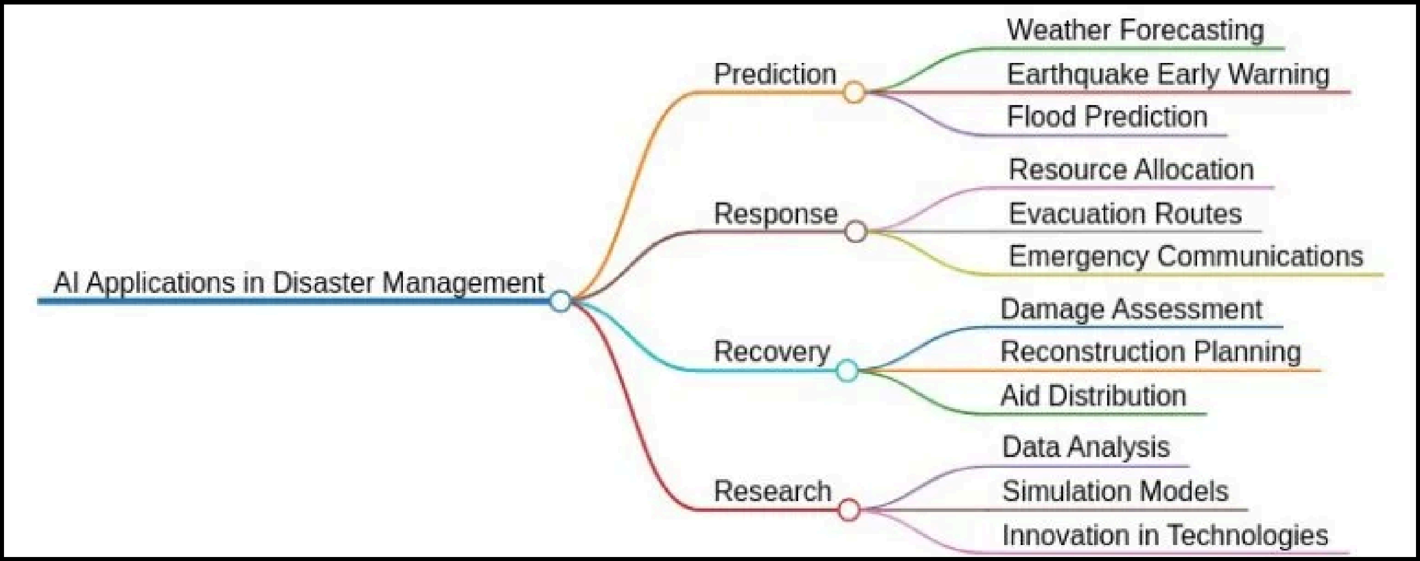
Machine learning, unlike robotics, which has been around for years, is a comparatively modern aspect of artificial intelligence. Machine learning algorithms can accomplish a particular job without any given directions, instead of learning from patterns and conclusions in the data input, and are thus categorized as AI. A model can be developed for change detection on satellite images using CNN networks, locating areas most affected by disasters and helping coordinate relief efforts.

Airborne robots travel deep into disaster zones to inspect destruction and bring help. Machine learning is a category of complicated software capable of learning. It interprets patterns from numbers, words, photos, videos, and other data collection methods and then uses that data to predict outcomes in previously unknown circumstances.

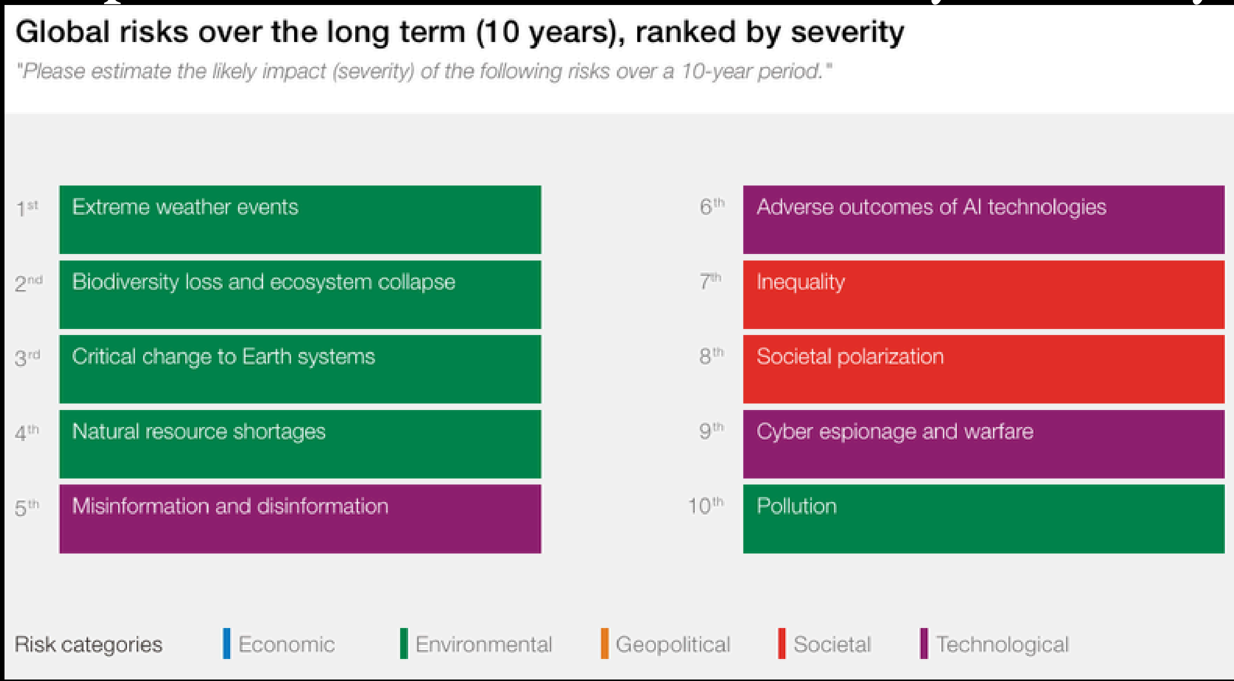
Artificial intelligence attempts to improve and increase the efficiency of the disaster management process. AI equipment, such as sensors, aid in emergencies by improving the exchange of information through ontologies, supplying information to disaster factors, and offering multi-agent platforms for real-time support and simulated scenarios.

The effectiveness of emergency management is dependent on obtaining information from disparate sources, combining it, and making sound decisions.

Artificial intelligence is a substantial force multiplier in our power to defend civilian populations in the face of disasters, and it is unquestionably the future of disaster management. However, to adopt AI in disaster management, governmental agencies must accomplish a development plan of basic requirements to guarantee that the deployment is productive and convenient.



Top 10 Global Risks Ranked by Severity



Geospatial AI for Disaster Management Prediction & Risk Assessment

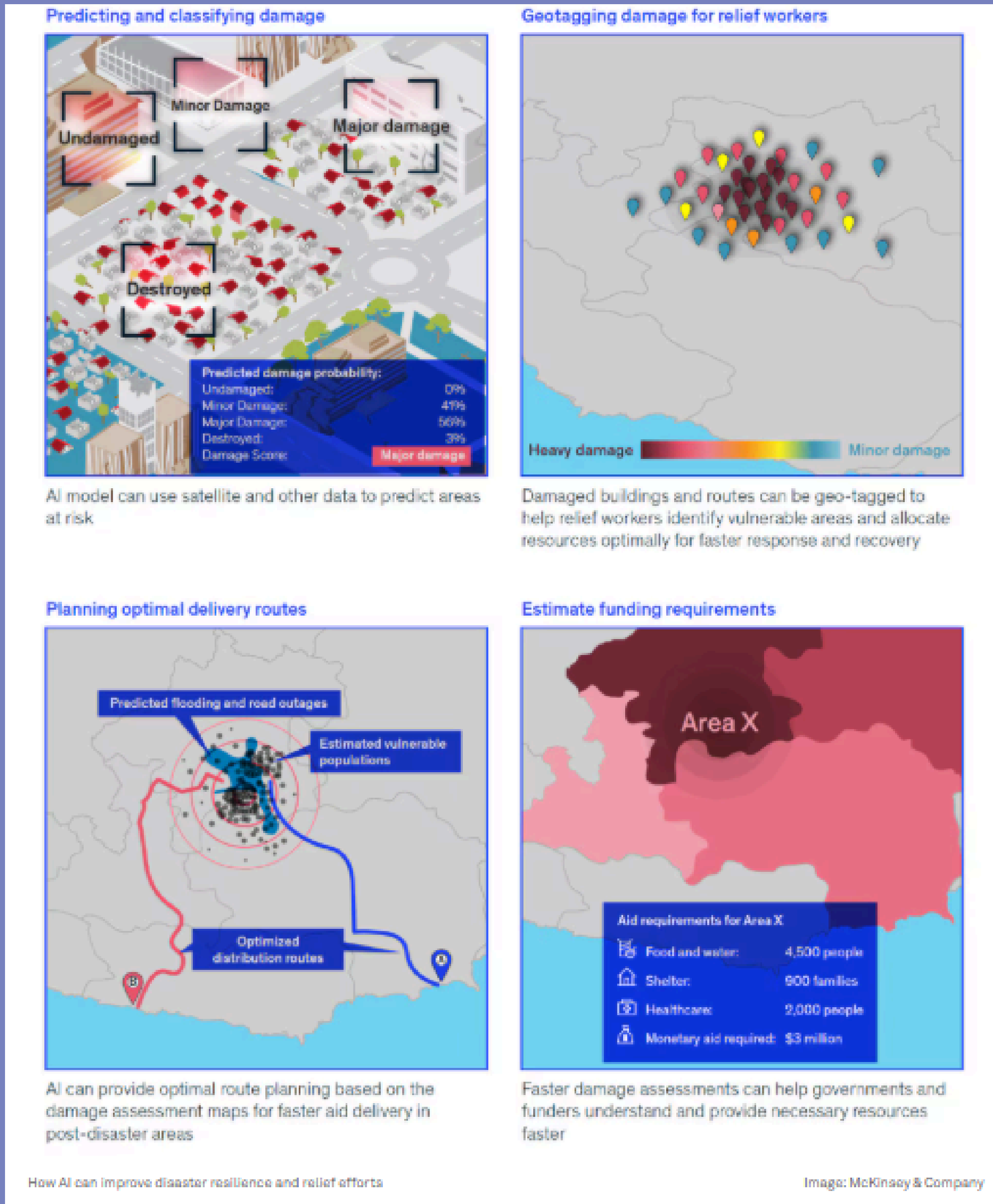
Natural disasters threaten human lives, infrastructure, and economies worldwide. The frequency and intensity of hurricanes, floods, wildfires, and earthquakes have increased recently, exacerbated by climate change and urbanization (Chaudhary & Piracha, 2021). Disaster prediction and risk assessment are pivotal in mitigating these impacts by enabling early warning systems, resource allocation, and informed decision-making. Accurate predictions can save countless lives and billions of dollars by facilitating timely evacuation plans, safeguarding critical infrastructure, and preventing cascading effects on communities and ecosystems (Šakić Trogrlić et al., 2022). However, traditional approaches to disaster management often rely on historical data, which may not accurately represent future scenarios. Furthermore, they may fail to capture the dynamic nature of hazards and vulnerabilities.

The need for more advanced, real-time, and predictive systems underscores the importance of integrating modern technologies into disaster management frameworks. Satellite technology and geospatial data have become indispensable tools in disaster prediction and risk assessment. Satellites provide a bird's-eye view of Earth's surface, capturing critical information across temporal and spatial scales.

The integration of Geospatial Artificial Intelligence (GeoAI) and data analytics with satellite technology offers transformative potential in disaster prediction and risk assessment. This paper explores the role of GeoAI in analyzing diverse geospatial datasets, such as optical, radar, and thermal satellite imagery, to predict and monitor disasters, including floods, wildfires, earthquakes, and landslides.

Key applications of GeoAI include early warning systems, real time hazard detection, and long-term resilience planning, enabling proactive decision-making and resource optimization. The paper also examines the benefits of predictive capabilities in minimizing disaster impacts, enhancing disaster preparedness, and reducing vulnerabilities.

Furthermore, it addresses the challenges of handling complex geospatial data, ethical considerations, and the need for inclusive and transparent GeoAI frameworks. Recommendations for improving GeoAI approaches, such as enhancing data integration, advancing algorithms, and fostering public engagement, are provided. The findings underscore GeoAI's critical role in building disaster-resilient societies and highlight the need for continued innovation, collaboration, and ethical practices in its deployment.



AI for Creating Relief Plan after Disaster

Identifying damage and rebuilding, for creating Relief plan after a disaster can take many months if done by manual efforts. By using Predictive AI, the relief plan can be done in minutes. AI can collect satellite data and social media data, calculating the damages and composing relief efforts requirements in order to create more precise predictions.

AI can ases data and help emergency workers to plan for giving help, delivering the necessary help, and shortening the time for giving the aid much faster. AI can improving disaster recovery, and shortening the time the disaster victims life without primary supports.

AI can calculate which routes to take in order to gives out help faster for the disaster victims. Even to create relief plan based on affected areas and analyzing which area can be the safe zones.

Tokyo, The First Sinking City to Stabilized

In Japan, Tokyo's rapid rise as a global megacity during the 20th century brought significant environmental challenges, most notably severe land subsidence. Driven by unchecked groundwater extraction due to industrialization and growth, ground levels in some areas declined up to 24cm per year by 1968. The combination of land subsidence and extreme weather events, such as Typhoon Kathleen (1947) and Typhoon Kanogawa (1958), exposed Tokyo's infrastructure gaps and led to increased flooding.

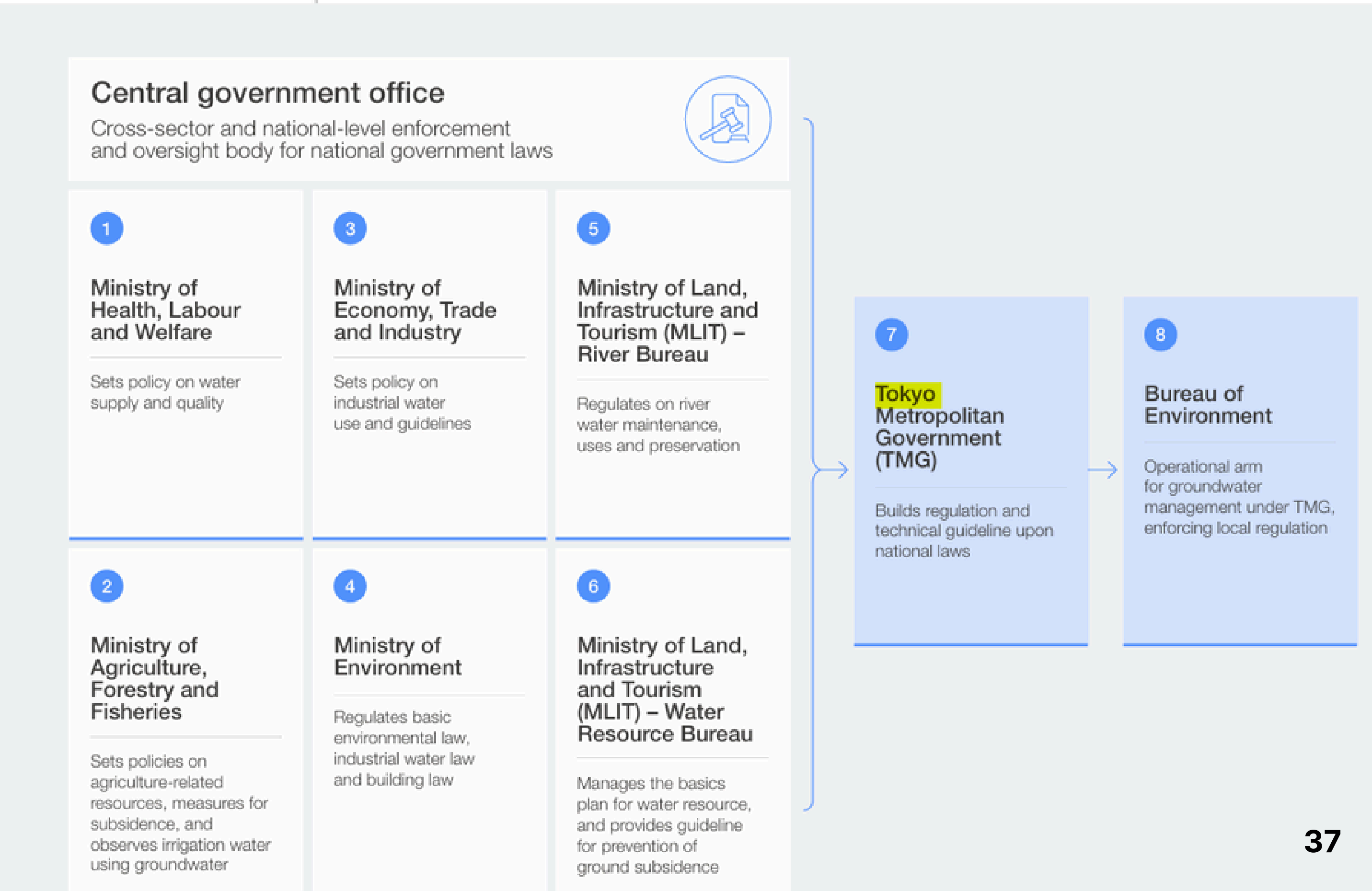
Solutions Recognizing the existential risks, the national government and the Tokyo Metropolitan Government (TMG) implemented strategies over time that combined infrastructure investment, regulatory reform and ecological planning. Their approach reduced subsidence rates drastically over the years and positioned Tokyo as a model for urban resilience for subsidence (see Figure 5).

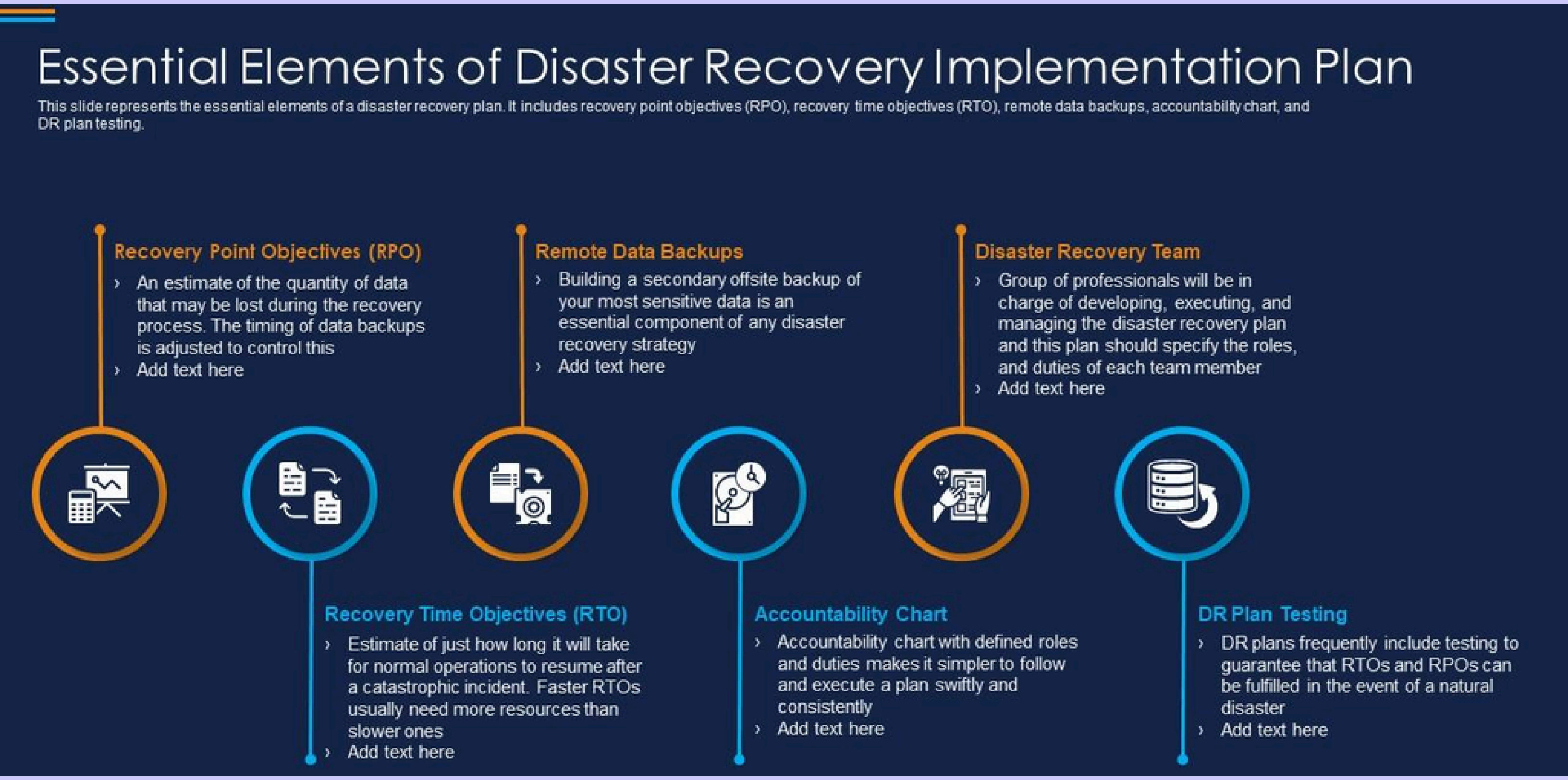
Regulatory innovation: Groundwater regulation was formulated at the national level, involving inter-ministerial coordination across areas such as water quality and supply, irrigation, river management, industrial water use and pollution control.

Legislation such as the Industrial Water Law (1956) and Building Water Law (1962) imposed strict limits on groundwater use and well construction. It introduced reporting requirements and established penalties for non compliance – e.g. up to JPY 100,000 (Japanese yen) in fines and imprisonment.

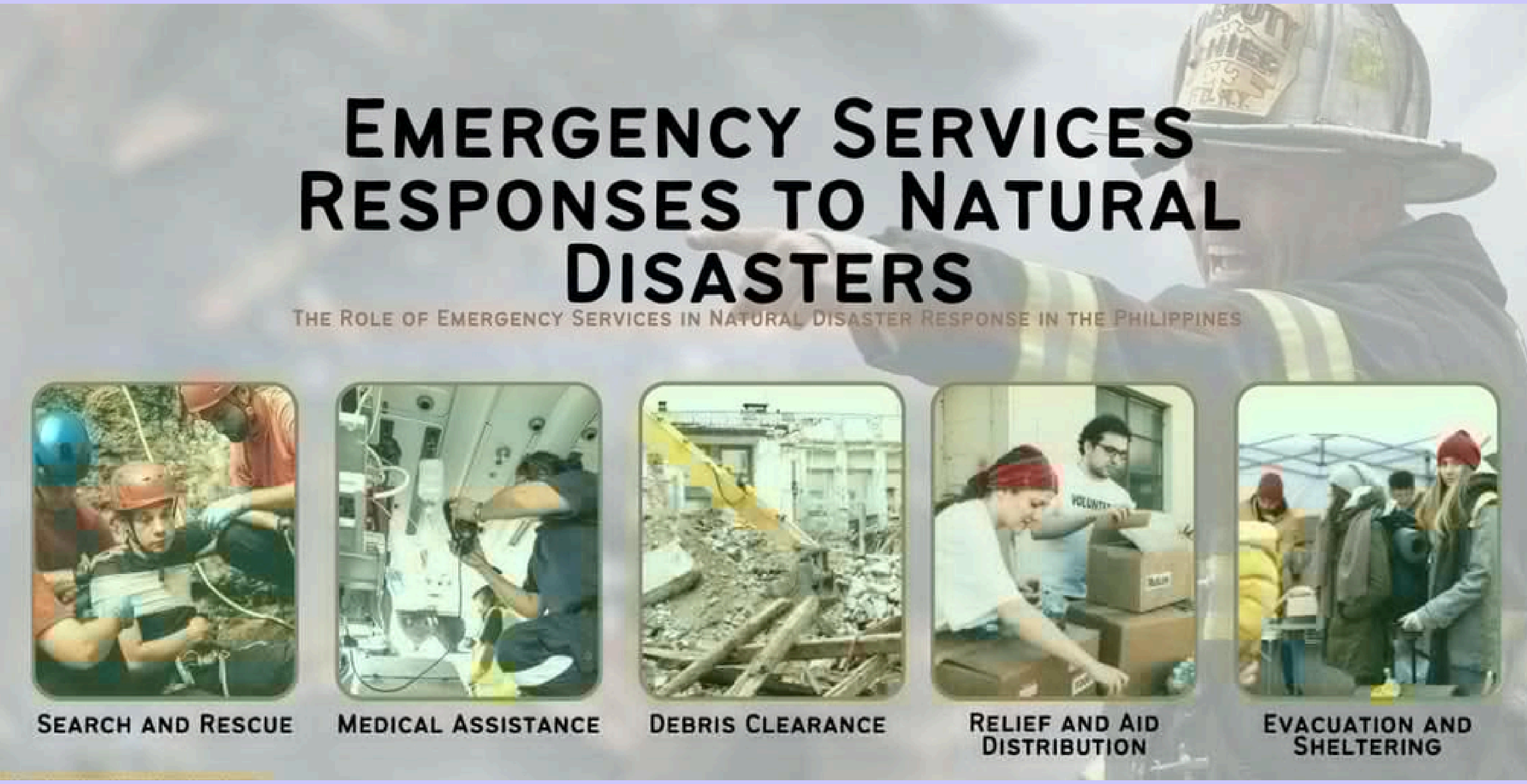
The TMG subsequently developed technical regulations and operational guidelines, with implementation led by the Bureau of Environment. Government subsidies and the Multipurpose Dams Act (1957) enabled industry transitions and the development of dam infrastructure for water supply and f lood control.

FIGURE 5 | Groundwater regulation governance in Tokyo





Disaster Relief Systems



Global Threat of Sinking Cities

The interaction between subsidence, sea-level rise and extreme weather can create threats, transforming what might have been a manageable or long-term risk into an immediate risk.

While the world's attention is often drawn to the visible impacts of climate change, another crisis is unfolding beneath our cities. From Jakarta to New Orleans, Bangkok to Mexico City, urban areas are experiencing land subsidence, sinking at rates that, in some cases, outpace global sea-level rise.

Land subsidence – the gradual or rapid downward movement of the Earth's surface – is estimated to affect two billion people worldwide. Commonly referred to as "sinking cities", when applied to urban locations, subsidence is prevalent across continents with impacts observed both in coastal and inland cities.

This phenomenon is primarily driven by human action, often resulting from a combination of unsustainable water and land use, rapid urbanization and underlying geological processes. The implications of sinking cities are far-reaching. Land subsidence alone can amplify flood risks, damage infrastructure and displace businesses and communities, resulting in economic losses.

The Scale of Sinking Cities World Wide

The economic exposure to potential land subsidence is estimated at $8.17 trillion, representing approximately 12% of global gross domestic product (GDP). Annual global economic losses attributable to subsidence are estimated to be in the billions of dollars.

Extreme rainfall exacerbates flooding in areas compromised by land subsidence. In California, US, land subsidence relative to sea-level rise is projected to impact 4.3–8.7 million people across coastal communities.

Although the root causes of these factors may vary, their impacts are converging, making it essential to integrate subsidence in urban resilience strategies, including flood and infrastructure management.7 One of the most striking examples is in Jakarta, Indonesia, where parts of the city are sinking by up to 200mm per year.

Land loss and flooding have partly prompted the government's decision to relocate the capital to Nusantara, Borneo Island. In the US, localized areas of New Orleans have subsided by more than 50mm over the past century, with hurricanes and sea-level rise compounding flood threats.

Some areas of Mexico City were built on an ancient lakebed, parts of which are sinking at a rate of 350mm per year. These places have consequently experienced land loss, infrastructure damage and service disruptions. These challenges are also mirrored in other cities worldwide, highlighting the need for coordinated action.

The scale of sinking cities is immense and uneven in its impacts across continents, countries and local economies. Today, an estimated 6.3 million square kilometres (km^2) of land globally is experiencing subsidence, an area equivalent to the combined size of India, Argentina and Japan – affecting an estimated two billion people worldwide.

Accelerating sea-level rise further compounds this issue. Over the past three decades, the rate of global sea-level rise has more than doubled, now reaching about 3.3mm per year. Projections suggest that levels could reach 16.9cm in the next 30 years.

Critically, in several coastal cities, land is sinking at rates that exceed the pace of sea-level rise, amplifying flood and other risks. Without significant attention, consensus and collective action, portions of several major cities may become uninhabitable in the coming decades. Subsidence is not a uniform phenomenon; its impacts are concentrated in specific areas.

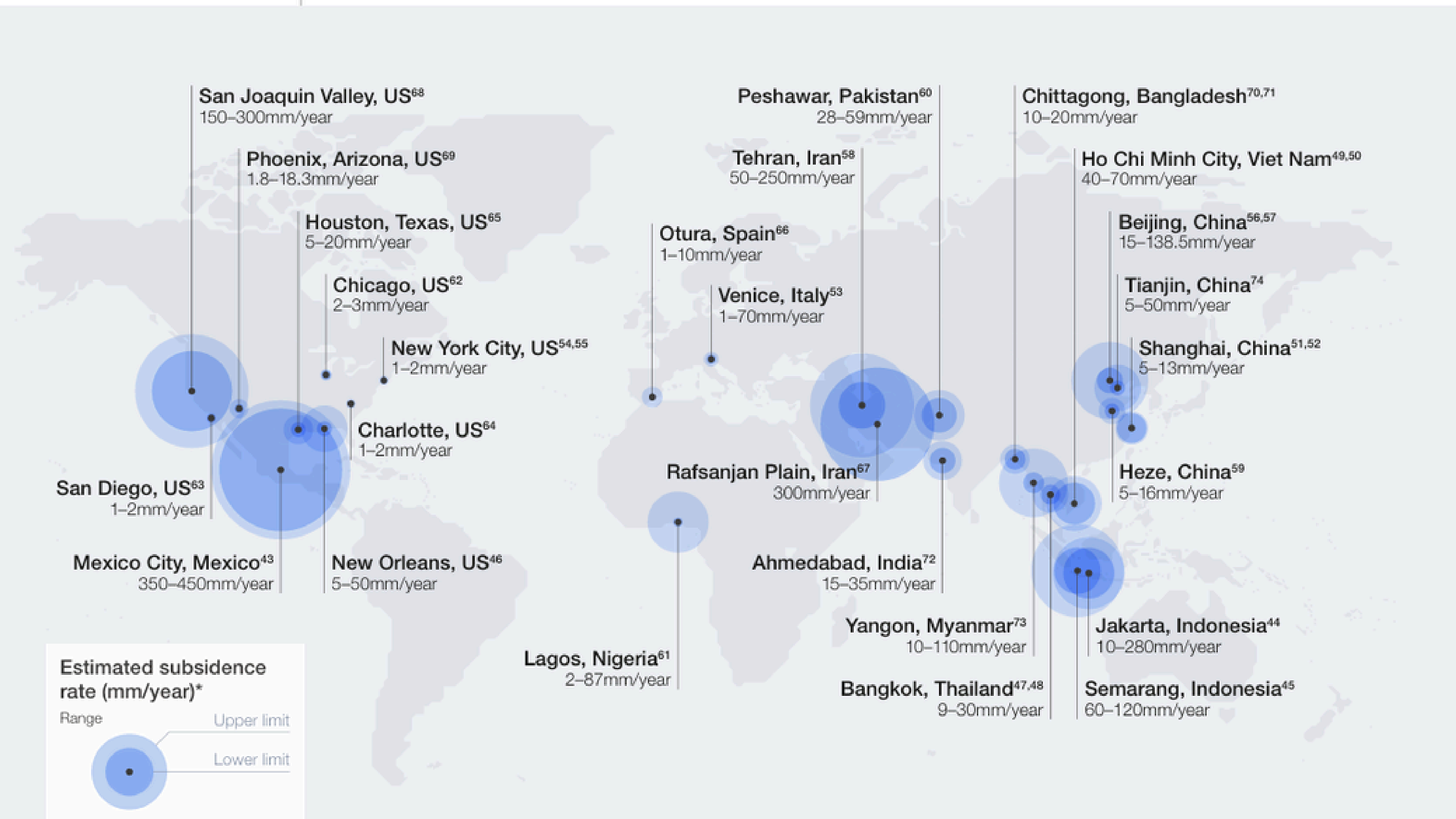
Recent analyses of 99 coastal cities, using data from 2015 and 2020, reveal that 33 cities are subsiding at rates equal to or up to five times faster than global sea-level rise. For example, coastal Shanghai has recorded areas with subsidence rates of up to 10mm per year.

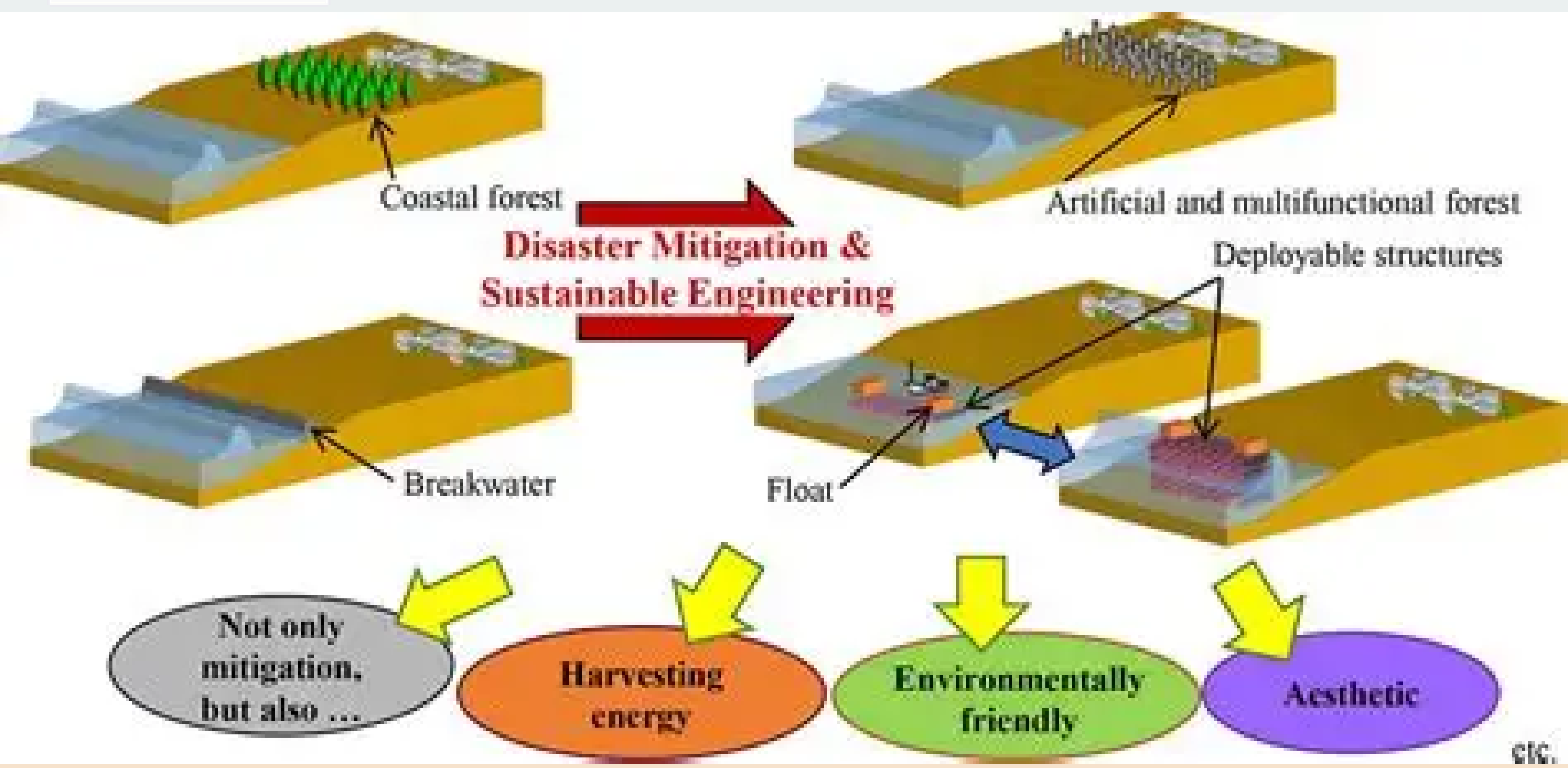
The fastest rates are observed in South, South-East and East Asian cities. In some cities, localized areas are subsiding at rates 10 to 20 times faster than sea-level rise, with extreme cases documented in cities such as Tianjin, Semarang and Jakarta.

Notably, Jakarta's northwest coast has experienced land subsidence of up to 280mm per year. While cities like Jakarta and Shanghai continue to face acute subsidence, targeted policy interventions have slowed rates in some areas, underscoring the critical role of governance and adaptive management.

The Need for Disaster Sustainable Engineering

FIGURE 2 | Examples of cities with areas experiencing subsidence





example of Disaster Sustainable Engineering for Coastal Subsidence Cities

Disaster Sustainable Engineering Planning

More than 95% of registered deaths from storms and floods between 2000 and 2013 were recorded in low- and middle income countries. If action isn't taken, sea level rises and flooding could cost coastal cities $1 trillion by 2050. Cyberattacks on urban infrastructure could cost insurers billions of dollars.

Emerging cities have to continually manage change, and often respond to natural hazards and human catastrophes like conflict and mass migration.

Demographic, economic, political and cyber shocks can also have an impact on the city environment because reduced financing abilities, different priorities and compromised systems can divert scarce funds and focus from key sustainable infrastructure and low-carbon investments. Climate change is increasing the frequency of extreme weather events, with underlying geopolitical unrest and social inequality exacerbating vulnerability to these shocks.

Cities will need to be at the forefront of averting and tackling negative impacts, from damaged infrastructure to related infectious disease outbreaks. Solutions include:

– Real-time, integrated and adaptive urban management systems and change management to better adapt to, learn from and respond to shocks

– Integrated financial, procurement and governance systems

– Enhanced risk monitoring and prediction, combined with up-to-date cyber security measures, for flexible, reliable city and utility functions as well as insurance management

– Disaster-ready urban infrastructure and buildings, and smart emergency response systems for natural and manmade disaster prevention, mitigation and recovery.

The Fourth Industrial Revolution technologies have immense potential to promote predictability and transparency in risk preparedness and responses: IoT and AI can predict and communicate potential shocks and disasters in real time, while blockchain can enhance cybersecurity, drones can deliver urgent supplies to hard-to-reach areas, and 3D printing and advanced materials can better rebuild infrastructure making it more resilient and with a lower ecological footprint.

Helping cities and communities plan, prepare and collaborate with each other, with business and government is critical.

– IoT, blockchain and advanced sensor platforms, together with predictive AI analytics, can help cities monitor tremors, sea level changes and other possible natural hazards in real-time, with thresholds for automated triggers enabling early evacuation when needed. PetaBencana.id in Indonesia combines multiple open-source sensors, AI and people's social media reports for real-time flood mapping in the capital Jakarta.

Mitigating the impacts of natural disasters is another area of Fourth Industrial Revolution innovation.

– Advanced materials such as self-healing concrete and biomimicry can help buildings withstand earthquakes and restore after such shocks. Companies such as Flextegrity have developed building materials that could reduce earthquake-related damage through ductility, energy absorption and bio-sensitive pipe support.

– VR offers opportunities for cities to simulate disasters and prepare response strategies, as trialled by the Singapore Defence Force, while game-based platforms could also be used to train citizens how to react in an emergency. Fourth Industrial Revolution innovations are also transforming approaches for responding to natural disasters, which often hit poorer communities the hardest.

– Drones have been deployed to deliver emergency supplies and assess damage after disasters. Following the devastating hurricanes Harvey and Irma in 2017, utilities and insurance companies contracted drone firms to inspect and estimate pay-outs in the southeast of the US and the Caribbean. The Government of Bosnia and Herzegovina used drones to identify displaced land mines after severe flooding in 2014.

– Portable 3D printers, powered by renewable energy to reduce reliance on possibly destroyed electricity lines, have the potential to save lives in the aftermath of disasters, both with printing urgently needed medical supplies and through the construction of temporary shelters

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