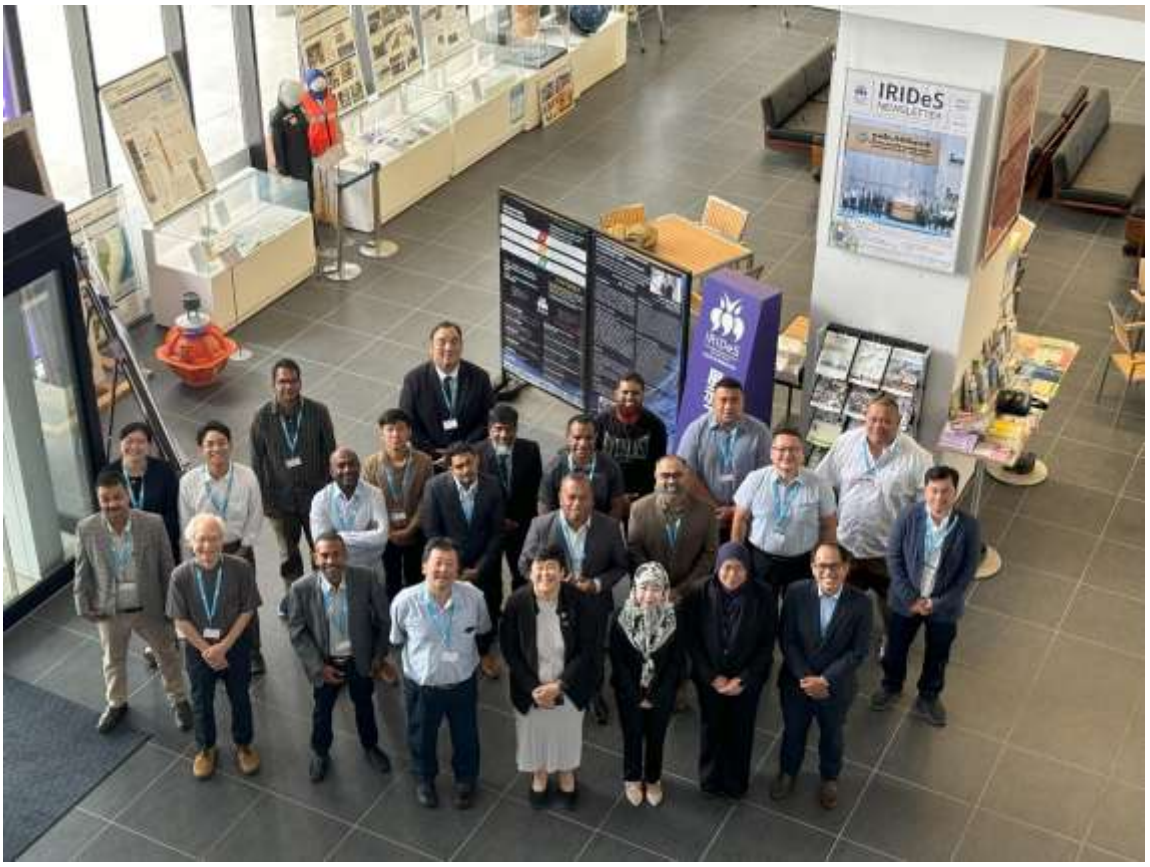


REPORT

Workshop on Resilient Infrastructure for Effective Early Warning Dissemination

10 – 12 September 2025

Sendai, Japan

1. Introduction

The International Telecommunication Union (ITU), in collaboration International Research Institute of Disaster Science (IRIDeS), Tohoku University, convened the Workshop on Resilient Infrastructure for Effective Early Warning Dissemination in Sendai, Japan, on 10-12 September 2025. The event, supported by Ministry of Internal Affairs and Communications (MIC) of Japan, was held in Sendai, the host city of the Third UN World Conference on Disaster Risk Reduction and the framing of the Sendai Framework.

The workshop focused on the pivotal role of information and communication technologies (ICTs) in building end-to-end, multi-hazard early warning systems (EWS) that are inclusive and effective. Discussions centred on how robust, redundant, and interoperable communication networks can ensure that early warnings reach everyone, everywhere, at the right time, particularly the most vulnerable communities. The event brought together regulators, policymakers, disaster management agencies, network operators, and technology experts from across the Asia-Pacific region and beyond to share best practices, showcase technological solutions, and foster international cooperation.

The detailed agenda and meeting content is available at the event webpage: http://itu.int/go/ASP2025.

2. Workshop Summary

The event commenced with opening remarks from **Professor Yuichi ONO** director of International Research Institute of Disaster Science (IRIDeS) of Tohoku University and Founder of, World Bosai Forum Foundation. He welcomed participants to Sendai and introduced the work of IRIDeS in disaster resilience and early warning systems. He highlighted the importance of international collaboration and the role of ICTs as a backbone for building a resilient society, stressing that "no one should be left behind" in receiving life-saving alerts. He advocated for disaster-resilient societies and introduced research areas of IRIDeS in all facets of disaster risk reduction. A key focus of this work is on strengthening the resilience of Information and Communication Technology (ICT) networks, recognizing them as the critical backbone for emergency response, early warning systems, and community recovery. He advocated that the initiatives like the World Bosai Forum Foundation works towards "Build Back Better" principle, promoting robust, redundant, and quickly recoverable ICT infrastructure as a cornerstone of modern disaster preparedness, ensuring that vital communication lines remain operational when they are needed most.

Ms Atsuko Okuda, Director, ITU Regional Office for Asia and the Pacific, in her address underscored the ITU's mandate to leverage technology for disaster risk reduction. She cited the alarming statistic that nearly half the world's population is still not covered by multi-hazard early warning systems. Her address emphasized to explore cooperative pathways for resilient connectivity solutions that strengthen early warning systems

Ms Atsuko's presentation on role and work of ITU highlighted the key strategic areas to leverage digital technologies for sustainable development. The core work of ITU was presented that revolves around supporting member states in expanding digital infrastructure, promoting inclusive and secure digital ecosystems, and developing human and institutional capacity. This involves initiatives related to policy and regulation, expanding connectivity, spectrum management, and cybersecurity to ensure that the benefits of digital transformation are widely accessible across the region. She emphasized that central theme of the ITU's mission is to ensure that no one is left behind in the digital age. The Regional office actively works to bridge the digital divide by fostering innovation, building resilience in digital networks, and implementing programs that promote digital inclusion for all segments of society. This includes a strong emphasis on multi-stakeholder

partnerships and collaboration with other UN agencies, governments, the private sector, and academia to achieve common development goals and harness technology for social and economic progress. Her presentation highlighted the global initiative for Early Warning Systems for All (EW4All) and Target G of the Sendai Framework, which aims to substantially increase the availability of and access to multi-hazard early warning systems. The presentation established the critical enabling role of ICTs and resilient digital infrastructure in achieving these global goals, framing them not as a luxury but as a necessity for saving lives and protecting livelihoods in an era of increasing climate-related disasters.

Session 1: Towards a Resilient National ICT infrastructure

Mr Shunichi Koshimura introduced a real-time, impact-based tsunami forecasting system called TsunamiCast, developed in response to the lessons from the 2011 Great East Japan Earthquake and Tsunami. The system leverages high-performance computing, GNSS data, and pre-computed tsunami scenarios to provide rapid, high-resolution forecasts of inundation depth, arrival time, building damage, and population exposure. It represents a paradigm shift from traditional height-based warnings to detailed impact assessments, supporting emergency response and evacuation planning for specific users like government agencies.

The research work by IRIDeS contributes directly to global initiatives like Early Warnings for All (EW4ALL) and Tsunami Ready by offering actionable products for hazard assessment, evacuation planning, and emergency response. It solution uses a digital twin approach, integrating real-time data and machine learning for exposure mapping and short-term population forecasting. The presentation also highlighted international collaboration efforts, such as modelling Cascadia subduction zone scenarios, and advocates for public-private partnerships to bridge the gap between scientific advancement and practical disaster risk reduction.

Mr. Aamir Riaz of the ITU shared the key insights of the regional study that focused on building resilient national ICT infrastructure in Asia and the Pacific to enhance disaster preparedness and response. It provided a comprehensive evaluation framework centered on four key pillars: Network Resilience, Affordability of ICT, Emergency Preparedness, and Early Warning Systems. The framework was designed to help member states identify gaps, share best practices, and implement strategies to strengthen digital connectivity and ensure continuous communication during disasters.

The insights highlighted common challenges such as limited network diversity, affordability barriers, and insufficient emergency protocols, while recommending solutions like infrastructure sharing, non-terrestrial networks, and the adoption of national emergency telecommunication plans. The study underscored the critical role of affordable, reliable, and inclusive ICT infrastructure in supporting early warnings and fostering community resilience against natural disasters and other emergencies

Session 2: Leveraging digital networks and innovations for Early Warning dissemination

The presentation by **Mr NISHIMURO Yosuke,** Director FDMA(Fire and Disaster Management Agency), outlined Japan's National Early Warning System (J-Alert), which was designed to instantly transmit critical disaster information from the national government directly to residents. It detailed the system's operation, including its use of satellite and terrestrial networks to push alerts via municipal disaster management radios, mobile emergency emails, and other means, ensuring coverage even during holidays or nights without requiring local staff intervention.

The document also highlighted the legal framework obligating municipalities to warn residents, the importance of having multiple, resilient information transmission

methods, and provided case studies where J-Alert had been effectively used in past disasters, such as the 2011 Great East Japan Earthquake and a 2024 North Korean missile launch.

The presentation from **Mr Aamir Riaz**, ITU addressed the critical role of information dissemination and communication as Pillar 3 of the Early Warnings for All (EW4ALL) initiative. It emphasized the global gap in multi-hazard early warning system coverage and highlighted the Common Alerting Protocol (CAP) as an essential international standard for interoperable, all-hazard, all-media alerting. This session intervention also explored mobile-based dissemination—particularly Cell Broadcast—for its speed, reach, and reliability, and discussed the integration of AI and geospatial mapping to identify uncovered populations and improve targeted warning delivery.

Furthermore, the presentation outlined the importance of partnerships, regulatory frameworks, and public-private collaboration to implement resilient warning systems. It showcased ITU's tools—such as Disaster Connectivity Maps and Early Warning Connectivity Maps—used to visualize coverage gaps and support evidence-based investment. The session concluded with a call for national policy action, technological integration, and multi-stakeholder cooperation to ensure timely and inclusive early warnings for all.

The session 2 presentations brought us to the end of Day 1.

Session 3: Lowering the Disaster Risk profile

Day 2 opened with a session that explored strategies to reduce the overall disaster risk profile of communities and infrastructure by enhancing preparedness, improving early warning systems, and implementing proactive mitigation measures.

Professor Hiroki Nishiyama of Tohoku University presented his research on using smartphones as emergency relay stations. His work focuses on creating ad-hoc networks that allow devices to connect directly when cellular infrastructure fails. This technology enables communication during disasters and represents a practical step towards building more resilient societies. He shared real-world pilot deployments and trials, emphasizing that this grassroots approach represents a vital, scalable, and readily available complement to conventional telecommunications, significantly enhancing societal resilience by empowering citizens to become active nodes in their own survival network.

The presentation from **Mr Shoichi TATENO** outlined Weathernews Inc.'s (WNI) role in innovating weather services and early warning systems (EWS) through public-private engagement. It described WNI's origin, global operations, and its collaborative model in Japan, where private sector companies play a key role in disseminating warnings and collecting user feedback under a supportive legal framework. The company deployed its own observation networks, forecast models, and AI technologies to provide risk alerts and nowcasting services across Asia and other global markets. Furthermore, presentation highlighted several innovations, including co-developing an AI-powered nowcasting tool with Google, launching a weather agent for natural language queries, and developing services for CO2 monitoring in shipping, drone operations, climate risk analysis, and forest fire forecasting. The presentation concluded by emphasizing the need for trusted

collaboration, effective data sharing, and sustained community engagement to enhance EWS and reduce global weather-related risks.

Professor Fumiyuki Adachi of Tohoku University presented on creating resilient mobile communications through multi-layered networks. His intervention highlighted the work on integrating different types of networks—such as satellite, aerial (drones), ground cellular, and device-to-device links—into a cohesive, redundant system. This "multi-layered" approach ensures that if one layer fails during a disaster, others can automatically compensate to maintain connectivity. Professor Adachi highlighted how these efforts create a robust and survivable communication infrastructure, fundamentally enhancing disaster resistance and ensuring that vital information can flow when it is needed most.

Mr KITAGAMI Yutaka, Director, Network Safety and Reliability Division, Telecommunication Bureau, MIC Japan detailed Japan's experience with restoring mobile communications following the 2024 Noto Peninsula earthquake, where approximately 70% of services were disrupted. Restoration efforts were conducted through public-private partnerships, which involved deploying emergency equipment like mobile base stations and satellite links, prioritizing road clearance and fuel supply, and dispatching government support teams.

It also outlined strategic measures implemented to enhance future disaster resilience. These included government subsidies for emergency equipment, new regulations mandating 24-hour power backup for critical base stations, and initiatives to ensure communications at evacuation centers. Furthermore, the promotion of systems like inter-carrier roaming, L-Alert for public information dissemination, and joint training exercises with various stakeholders were highlighted as key steps to strengthen Japan's communication infrastructure against large-scale disasters.

Session 4: Group Exercise - Identifying key risk drivers in their regions and proposing mitigation strategies

One of the features of the workshop was an interactive session to engage participants in analysing critical risk factors that hinder effective early warning dissemination at national level. Participants were arranged into 3 groups to brainstorm and identify vulnerabilities and propose practical mitigation strategies to strengthen Digital infrastructure resilience based on an assumed scenario.

The first task of the tabletop exercise was to assess vulnerabilities in national Early Warning Systems (EWS) and design resilient strategies for future threats. The scenario setting was driven by the recognition that a previous near-miss event exposed critical gaps, and diverse geography faces an increasing frequency of compound disasters. Groups conducted a risk assessment to identify single points of failure and underserved communities and reported accordingly as group to ensure timely, actionable warnings reach every person during a crisis. Reports from three groups are summarized in Annex.

Though a second task was also planned to develop mitigation strategies for a layered scenario of concurrent flooding and an extreme heatwave, focusing on solutions that are robust, redundant, and resilient to cascading failures. However, due to lack of timing the task could not be completed.

Site Visits

Following the sessions multiple site visits were arranged in the afternoon of Day 2 and Day 3. The site visits included:

- NICT- National Institute of Information and Communications Technology (NICT)
- NTT DoCoMo – Sendai Disaster recovery monitoring establishment and cell on wheels-based solution.
- Visit Ruins of the Great East Japan Earthquake: Sendai Arahama Elementary School (https://www.city.sendai.jp/kankyo/shisetsu/documents/guide.pdf)
- Sendai City's drone-based EW dissemination solution at Arahama beach

3. Key Takeaways

Following were key conclusions of the sessions

- **Resilient and Redundant Hybrid Networks are Non-Negotiable**. No single technology can guarantee 100% coverage. The workshop strongly advocated for a multi-channel, hybrid approach that seamlessly integrates terrestrial networks (Cell Broadcast, mobile networks), satellite systems (for backhaul and Direct-to-Device alerts), and community-based systems (sirens, radio) to create a resilient safety net that remains operational even when primary infrastructure fails.

- **Policy and Regulation are Critical Enablers**. Technology deployment must be supported by strong, proactive regulatory frameworks. Key recommendations included mandating Cell Broadcast capability on all networks and devices, allocating and protecting spectrum for disaster relief (PPDR), promoting infrastructure sharing for redundancy, and establishing clear national protocols for alert origination and dissemination.

- **Inclusivity Must be Designed into the System from the Start.** An effective early warning system is an inclusive one. Ensuring that alerts reach and are understandable by persons with disabilities, the elderly, and linguistic minorities is not an add-on but a core requirement. This involves adopting accessible formats, multiple languages, and community engagement in the design and testing of systems.

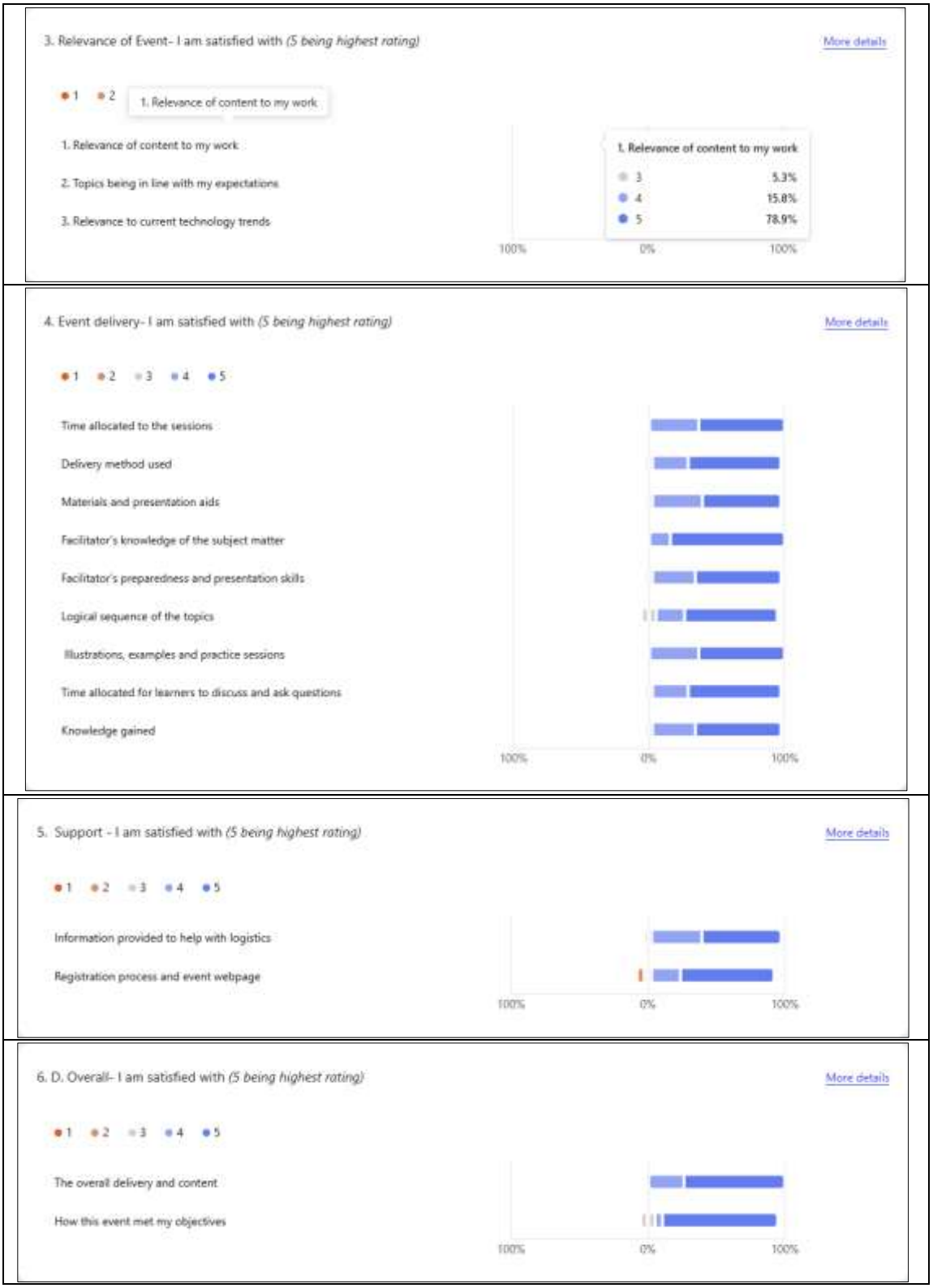
- **Regional and International Cooperation is Essential.** Disasters do not respect national borders. Participants emphasized the need for strengthened regional cooperation for cross-border alerting, knowledge sharing on best practices, harmonization of technical standards, and joint investments in shared satellite-based alerting infrastructure to maximize efficiency and coverage.

- **Capacity Building and Community Awareness are Fundamental**. The best technological system is useless if people do not understand the warnings or know how to respond. The workshop highlighted the equal importance of continuous public education campaigns, training for first responders and officials, and community drills to ensure everyone is prepared to act decisively when a warning is received.

4. Event feedback

An online feedback form was developed to collect participants' evaluations of the workshop. The responses were overwhelmingly positive, indicating that participants were satisfied with the content and delivery, and that the workshop met its stated objectives. This

evaluation provides essential insights for future improvements, refining planning, enhancing content, and defining the scope of future similar events.



What other topics should be considered in future events?
Technology gaps for the EWS including case studies.
Policy guideline in Cell Broadcast and ICT for disaster Management.
Policy documents on emergency services, trainings and arrangements for emergency services for third world countries and island nations.

Digital network and innovation and lowering the disaster profile.
Updated technologies in the aspects of EWS system.
Interoperability of data services and multi-channels Dissemination for multi-hazards.
A new system that uses mobile phones to transmit messages to nearby devices without relying on a mobile network. This is a great solution in areas with limited mobile coverage.
Latest technology to be used collaboration between all the agencies involved in an EWS.
Factors that negatively affect the power supply of the equipment.
Using artificial intelligence for EWS.
Legal and policy frameworks for EWS.
Psychology of Disaster Response.
Networking and collaboration opportunities.
Cheaper early warning system for developing countries.

5. Conclusion and Outcome

The Workshop on Resilient Infrastructure for Effective Early Warning Dissemination successfully highlighted the indispensable role of digital infrastructure in safeguarding communities from disasters. Held in the symbolic city of Sendai, the event reinforced the commitment to the Early Warnings for All initiative and provided a platform for knowledge exchange on practical technological solutions, regulatory frameworks, and strategies for inclusivity.

The event brought together over **35** participants from more than **19** countries, including representatives from government ministries, regulatory authorities, disaster management organizations, mobile network operators, and international organizations. The key takeaways and recommendations will contribute to ongoing efforts to strengthen national and regional capabilities, ultimately working towards a future where everyone is protected by effective, reliable, and inclusive early warning systems.

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Annexures

A. List of participants

List of present Participants - Works

B. Group TTX presentations

Task 1 TOP EW Risks Group - 1

S.No	Category	Identified Risk	Why It's Critical (Brief Impact Statement)
1	Technological Gaps	- Outdated warning system - Single point of failure - Lack of categorization of warning system base on peak activities	- no redundant power, backhaul - limited interoperation between telecom operator. - Lack of categorization can lead to missed warnings.
2	Physical vulnerabilities	- exposure of critical infrastructure during disaster - power grid failure	- flood, fire, cyclone, landslide damage infrastructure and affect the EWS. - EWS system don't have any power to generate the signal or warning message to the public.
3	Socio Economic Barriers	- vulnerable group - digital device	- elderly, disable, tourist left behind and EWS notification doesn't reach them on time. - people don't have the resources to received the EWS
4	Governance and institutional	- lack of coordination between different agencies - lack of regular testing and updating of EWS Protocol - lack of funding	- NDMO, Fire Department, Police etc are not coordinated in providing information. - disaster occur the protocol cannot apply to practice - without proper funding, EWS not available.
5	Capacity Building and Human Resources	- lack of training	- Staff turn over, expertise is no longer available. - As technology evolves human capacity need to be upgraded to keep up.
6	Climate change impacts	- Changing rain pattern - Increasing frequency disasters	- affect the signal - affect to the analyze system and decision-making
Our #1 Priority Risk: Technological Gaps			

Task 1 TOP EW Risks Group – 2

S. No	Category	Identified Risk	Why It's Critical (Brief Impact Statement)
1	Technological Gaps	- Fragile communication towers and power grid failures	- If towers collapse or the grid fails, early warning messages cannot be transmitted, leaving communities unprotected.
2	Physical vulnerabilities	- Outdated early warning systems and poor interoperability	- Old systems delay alerts, and lack of multi-channel dissemination reduces coverage and timeliness.
3	Socio Economic Barriers	- Marginalized groups with limited access to warnings	- Vulnerable populations may miss life-saving alerts, increasing casualties and inequality in disaster response.
4	Governance and institutional	- Weak coordination between disaster agencies and lack of funding	- Poor governance slows response, creates duplication, and undermines trust in early warning systems.
5	Climate change impacts	- Increasing frequency and intensity of disasters	- Existing systems can be overwhelmed, making it harder to provide reliable and timely warnings.
6	Time & Responsiveness Risks	- Delayed alerts - Slow data processing - Inefficient decision-making timeframes	Many hazards give **little or no time** to respond. For example: - **Tsunami**: You may have 10–30 minutes after an earthquake. - **Flash floods**: Can occur within minutes of intense rainfall. - **Landslides**: Triggered suddenly by rainfall or earthquakes. - **If the warning is late — people die.** The window for evacuation or action is *tiny*
7			
Our #1 Priority Risk:		4	

Task 1 TOP EW Risks Group – 3

S. No	Category	Identified Risk	Why It's Critical (Brief Impact Statement)
1	Technological Gaps	- power failure - rural area coverage	not enough power
2	Physical vulnerabilities	- Strom flood, base station need to a litter higher - teachlogy stay in the city not out of city	may be hit by earthquake, Small Island, many Island: Teachlogy stay in the city not out of city
3	Socio Economic Barriers	- less population - affordability - smartphone expensive - social gender	biggest problem , no investment just only cable and microwave, affordability, some country not allow women use social mobile
4	Governance and institutional	- policy - political issues - subsidies - regulators	No mandatory cell broadcast, disaster equipment
5	Climate change impacts	- strom - flood	Increasing frequency/intensity of disasters overwhelming existing systems
6	...		
7	....		
Our #1 Priority Risk:		*[Government policy, Climate change]*	