

SADR

South Asia Disaster Report

2025



Putting the Last Mile First:
Ensuring Inclusive and Effective Early Warning
to Mitigate Natural Hazards

Published by Duryog Nivaran and All Indian Disaster Mitigation Institute (AIDMI)



ALL INDIA DISASTER
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In Collaboration with



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UNOSSC
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SOUTH-SOUTH COOPERATION



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Foreword

By Jorge Chediek,

Formerly the Director and Envoy of the Secretary-General on South-South Cooperation,
UNOSSC, Bangkok, Thailand



I am pleased to join the World Meteorological Organisation (WMO) and the United Nations Office for Disaster Risk Reduction (UNDRR) in congratulating the *Duryog Nivaran* network of individual members and institutions that have worked in South Asia since 1995. As authors and contributors to the South Asia Disaster Report (SADR) on “Putting the Last Mile First: Ensuring Inclusive and Effective Early Warning to Mitigate Natural Hazards”, the *Duryog Nivaran* members have shared knowledge within their stated objective to reduce the vulnerability of communities to disasters through a diversity of views on present early warning systems in South Asia. I also congratulate the All India Disaster Mitigation Institute (AIDMI) for coordinating the contributions of the *Duryog Nivaran* members and other key institutions and experts from the Asia region. Since 2010, UNOSSC has been actively promoting South-South Cooperation in the area for disaster risk reduction and climate change adaptation in collaboration with AIDMI.

The countries whose early warning systems are subject of analysis in the report, (Afghanistan, Bangladesh, Bhutan, India, Maldives, Myanmar, Nepal, Pakistan and Sri Lanka) are all key members of the Global South. The Paris Agreement, the Sendai Framework for Disaster Risk Reduction, the New Urban Agenda and other relevant United Nations conferences and summits on the economic, social and related fields were cited in the preamble to the Outcome Document of the Second United Nations High-level Conference on South-South Cooperation (20-22 March, 2019) with an emphasis that South-South cooperation has a strong role in ensuring achievement of their targeted outcomes. In the aftermath of the Conference, UNOSSC is stepping up its support to Disaster Risk Reduction and Climate Change Adaptation, particularly in the Asia-Pacific Region, which has a prevalence of major natural hazards. Furthermore, occurrence of these disasters has been on an upward trend in recent decades.

The South Asia Disaster Report (SADR), states that “research shows that for every dollar spent on disaster early warning systems, the benefits range from USD 2 to USD 10”. Early warning is therefore a key aspect of disaster reduction. The analysis of existing early warning systems and sharing knowledge thereof in this report is important for South Asian countries to mitigate their vulnerability to hazards and reduce disaster consequences in lives lost and economic damage. We in the UN Office for South-South Cooperation would welcome the opportunity to share the report beyond the forums such as the Conference on Disaster Reduction (WCDR) and the Asia-Pacific Conference on Disaster Reduction 2020. We invite the members to upload this report and other reports in the South-South Galaxy (a knowledge-sharing, matching and experts listing portal).

I am particularly pleased the mix of stakeholders from governments, civil society organisations and the private sector who have contributed to this report. Furthermore, we take note of the acceptance of diversity of views, expertise and experiences in the report and that authors were afforded the opportunity to review each other’s drafts. We look forward to continue working with you in sharing knowledge on Disaster Reduction among the Global South countries.

Key Messages

By Hans Guttman,

Formerly the Executive Director, Asian Disaster Preparedness Center, Thailand
Independent expert/consultant



Following the unprecedented damage and losses from the Indian Ocean Tsunami in December 2004, Asian countries have taken the effort of strengthening Multi-hazard Early Warning System as one of the lead avenues towards disaster risk reduction and making people safer in their respective communities, countries, and in the region as a whole.

Improved end-to-end early warning systems has been instrumental in reducing the casualties during disasters, especially so for hydrometeorological extreme events as is evident in the cyclones and floods affecting South Asia in 2019, where loss of life, whilst always tragic, has been relatively limited in comparison to the scale and intensity of the disasters. It is encouraging that the number of fatalities in each event are trending downwards, but we should not be complacent and need to remain vigilant and work further on improving the early warning, access to the information as well as prepared actions to protect life and property.

The South Asia Disaster Report is bringing up the very timely theme of ‘Putting the Last Mile First: Ensuring Inclusive and Effective Early Warning to Mitigate Natural Hazards’ and the Asian Disaster Preparedness Center (ADPC) is proud to contribute to the South Asia Disaster Report having been actively involved in the development of all aspects of early warning in the region.

ADPC was requested to coordinate the early warning centers throughout the Indian Ocean and Asian countries at the Ministerial Meeting on Regional Cooperation on Tsunami Early Warning arrangements in 2005. This ultimately led to ADPC facilitating the establishment of the Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES) as a regional mechanism to support National Meteorological and Hydrological Services (NMHS) operationally. Since then, there have been great strides in the development and reliability of early warning, and the latest iteration of global guidance through the recommendations of the Global Platform for Disaster Risk Reduction and the Second Multi-Hazard Early Warning Conference (MHEWC-II) which ADPC is actively involved in operationalising the recommendations.

In partnership with the NMHS and the National Disaster Management Organizations (NDMO), ADPC continues to support the enhancement and efficiency of the early warning systems, leveraging the expertise of global and regional agencies such as World Meteorological Organization (WMO), Intergovernmental Oceanographic Commission (IOC/UNESCO), the United Nations Strategy for Disaster Risk Reduction (UNDRR), space agencies such as NASA, JAXA and ESA.

ADPC recognises that the linkages in a functioning end-to-end early warning system is not only dependent on good communication and coordination, but also often spans administrative boundaries (different ministries) and governance structures (national, local and community levels) which need to be considered if the system is to function as intended.

ADPC welcomes the effort in completing the SADR and looks forward to cooperating with other partners in making the conclusions and recommendations operational for a safer and prosperous South Asian region.

By Gareth Owen,

Humanitarian Director, Save the Children, UK



Children in South Asia continue to suffer in the absence of adequate healthcare, nutrition, education and protection during normalcy. When hit by a humanitarian crisis – be it nature induced or human induced, they suffer even more and become extremely vulnerable to other risks such as neglect, abuse, domestic violence, corporal punishment, trafficking, child labour and so on. Therefore, it is imperative to protect children and their rights at all times and at any cost.

Nature-induced disasters claim the lives of thousands of people including children in the South Asia region every year. Post-disaster analysis often reveals inefficient early warning system as one of the key contributing factors to such deaths. These deaths could have been prevented with a more evolved early warning system. Thus, from a child's perspective, early warning and emergency responses have always been at the heart of Save the Children's mission.

Save the Children was founded over 100 years ago to protect children caught up in conflict, and we continue this work today. In 2018, we responded to 113 humanitarian emergencies in 58 countries. With 25,000 dedicated staff across 120 countries, Save the Children responds to major emergencies, delivers innovative development programmes, and ensures children's voices are heard. In a humanitarian emergency, it provides emergency relief and healthcare, psychosocial support, temporary schools and cash grants to help families rebuild their lives. Early Warning System and Early Action are becoming a leading agenda for the future.

It would be most appropriate to remind ourselves about what a 10-year-old British girl (Tilly Smith) was able to achieve with the right information. Her geography lessons helped her save 100 tourists from a Thai beach hit by tsunami. We all must remember that children do, and can, play an important role both in an enabling early warning system as well as early action agendas. And this is an area where we need to invest more in coming years.

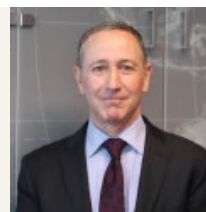
I would like to congratulate the All India Disaster Mitigation Institute and the *Duryog Nivaran* Network for producing an excellent report on early warning systems in South Asia, which recognises vulnerability as well as potential of youth and children in strengthening early warning systems. The report offers many voices at many levels for many agendas; and yet tells us that children are both, the best beneficiary as well as the best leader of Early Warning System and Early Action in South Asia.

With the new climate change risks and vulnerabilities forecasting bigger and major crises in our world, we are often confronted with this burning question: what is the legacy that we are transferring for the next generation of Children and Youth? Or, more contrastingly, are we eating into their future? It is predicted that more than 175 million children will be at risk due to climate induced risks and disasters in the future. Hence, it is critical to take a new posture and innovative approaches in re-imagining our Early Warning Systems and Early Action Agendas with bigger and better foresight and forecasting.

I hope recommendations of this report will be widely disseminated and applied in future Asia-Pacific Ministerial Conferences with direct focus on children as leaders of risk reduction and resilience building in South Asia.

By Dr. Robert Glasser,

Formerly the United Nations Secretary General's Special Representative for Disaster Risk Reduction; Visiting Fellow,
Australian Strategic Policy Institute



It is no accident that one of the *Sendai Framework's* seven global goals is to “Substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to the people by 2030.” Early warning systems have played a fundamentally important role in reducing loss of life from natural hazards. These systems, and the science and technology underpinning them, have proliferated rapidly over the past decades. They now include traditional roles, such as cyclone/hurricane early warning, as well as emerging and improved systems in earthquake, drought, food security, flood and pandemic early warning – hence addressing both sudden and slow-on-set disasters and even the consequences of their interactions.

This rapidly changing environment makes it highly appropriate and important that this *South Asia Disaster Report* focuses on multi-hazard early warning systems. South Asia is one of the most hazard-prone regions in the world. Coastal areas and river systems are highly exposed to extreme flooding, many densely populated cities are situated on hazardous seismic fault lines and climate change is rapidly amplifying hydro-meteorological risks, increasingly with cascading impacts¹ on regional agriculture, food and water security and population displacement.

The editors and authors of *SADR* have done a great service to the disaster risk reduction community by combining in one, well-organised edition a comprehensive, multi-disciplinary review of early warning systems across the region's many diverse countries. *SADR's* contribution to sharing knowledge and experience in this critical area takes us one step closer to achieving the ambitious objectives of the *Sendai Framework*.”

1 Glasser R, 2019. Preparing for the Era of Disasters. https://s3-ap-southeast-2.amazonaws.com/ad-aspi/2019-03/SR_135_Preparing_for_the_Era_of_Disasters.pdf?DWvHu1e1M0UMbiuK5_A8qhOIZJr1z0qD

By Petteri Taalas,

Former, Secretary-General, World Meteorological Organization (WMO),
Geneva, Switzerland
Director General of the Finnish Meteorological Institute



Early warnings followed by early action can prevent a hazard from turning into a disaster. Ahead of Cyclone Fani in April and May 2019, timely evacuations significantly reduced the death toll compared to the 1999 Odisha cyclone. Over the past 20 years, the majority of disaster fatalities have not been caused by hydrometeorological events but by geophysical ones, mostly earthquakes and tsunamis. This achievement can be partly attributed to the improved capacity of National Meteorological and Hydrological Services, which play a pivotal role in early warning. Still, during the same time period, nine in ten disasters triggered by natural hazards have been caused by weather, water and climate events², such as the devastating floods in the southern Indian State of Kerala in 2018 and 2019. With climate change, we are seeing an increasing frequency and magnitude of extremes, as well as changing spatial patterns. These challenges are aggravated by environmental degradation, urbanisation and social inequalities.

It is clear that meteorological and other scientific information alone cannot reduce disaster impacts and risks. Such information needs to be embedded in ‘systems of systems’ that integrate earth data observation; monitoring, forecasting and warning systems; systematic

2 Wallemacq P, et. al. 2018.: Economic Losses, Poverty and Disasters 1998-2017. UNDRR and CRED 2018. https://www.preventionweb.net/files/61119_credeconomiclosses.pdf.

loss accounting and disaster risk assessments; communication systems; and preparedness and response capabilities that enable individuals, communities, governments and businesses to make informed decisions and take timely action prior to hazardous events.

This systemic approach underpins the recommendations of the Second Multi-Hazard Early Warning Conference (MHEWC-II)³, hosted by WMO in May 2019 and co-organised by the partner organisations of the International Network for Multi-Hazard Early Warning Systems (IN-MHEWS):

1. Make the 'last' mile the first: To be effective and sustainable, early warning system design needs to actively involve the communities at risk and start with the people.
2. Strengthen early action: To be useful, usable and used, warnings need to include information on likelihood, impact and response guidance, backed by social science research on risk perception and warning interpretation, and be communicated through multiple and redundant channels that people use every day.
3. Build risk knowledge: Assess the risks from multiple - simultaneous, cascading or cumulative - hazards to determine priorities at a given level and for issuing impact-based forecasts and warnings.
4. Improve data availability and accessibility: Promote stock-taking, archiving, sharing and assimilation of (real-time) data from different sources, scenarios and models through respective portals, especially in transboundary and river basin contexts, and use recognised formats and standards to ensure the widest possible deliverability and interoperability.
5. Apply combined scientific and technological developments and societal innovations: Leverage new technologies such as remote sensing from space, telemetry, cost effective in situ sensors, big data or artificial intelligence for data gathering, monitoring, risk and impact assessments and for reaching vulnerable communities and ensure that especially developing countries can benefit from these.
6. Ensure adequate governance at all levels: Develop legal and policy frameworks which clarify roles and responsibilities within and between nations, reinforce coordination and accountability and foster effective partnerships between and among scientists and practitioners, public and private sectors, and humanitarian and development actors.
7. Measure effectiveness, benefits and progress: Increase the confidence of national and international institutions, donors and investors in sustained resourcing multi-hazard early warning systems, including capacity development and infrastructure investments (especially in hydrological observation networks), through demonstrating their value in loss and damage reduction and increased resilience.

WMO is committed to work with its partners to strengthen early warning systems in South Asia, including through its Global Multi-hazard Alert System (GMAS) and WMO Cataloguing of Hazardous Events (WMO-CHE) initiatives and a WMO Coordination Mechanism (WCM) that supports humanitarian action⁴.

WMO welcomes the South Asia Disaster Report on Putting the Last Mile First: Ensuring Inclusive and Effective Early Warning to Mitigate Natural Hazards. We encourage more such efforts to document the impacts of natural hazards by national entities like the All India Disaster Mitigation Institute and regional networks such as *Duryog Nivaran* as a prerequisite to reporting on and achieving the targets set under the Sendai Framework and the Paris Agreement.

3 World Meteorological Organization (WMO), 2019. The Second Multi-Hazard Early Warning Conference (MHEWC-II). <https://mhews.wmo.int>.

4 World Meteorological Organization (WMO). N.D. Disaster Risk Reduction (DRR). <https://community.wmo.int/activity-areas/drr>.

By Michael Mosselms,

Head of Humanitarian Programme Practice, Policy and Advocacy, Christian Aid, UK



Christian Aid and Change Alliance are very happy to be one small part of the large network that has worked on this rich, comprehensive and educative collection of important and thoughtful analysis, experiences and recommendations around the relevant, timely and topical theme of early warning systems (EWS) in the context of disasters induced by natural hazards. The remarkable achievements of South Asian disaster management actors in reducing disaster mortality so markedly in recent years do not always attract the credit they richly deserve. At the same time, they should not distract our attention from the very serious economic, environmental, human, livelihoods and psycho-social impacts that disasters induced by natural hazards in South Asia and beyond continue to wreak. The immense challenges that climate change brings us only serve to highlight the growing importance of investing in people-centred community-led anticipation, disaster risk reduction, early warning, preparedness and resilience interventions that will help to mitigate, prevent and reduce economic and human disaster impact.

The unique mix of approaches, theories and practices of early warning systems in South Asia described in this report provide a huge amount of learning and food for thought for us all as we try to further improve the art and science of early warning systems from a strong base. This provides an excellent toolbox of knowledge and learning to inspire our thinking about how the disaster management sector and Governments can better deliver against the actions and aspirations set out in the Sendai Framework. Within the report, we find a strong emphasis on the very important issues of leaving no-one behind, making sure that our early warning systems and approaches reach and prioritise the most vulnerable hardest-to-reach populations and groups, including for example people living with disabilities, women and girls and the elderly, and reminding us of the importance of listening carefully to the voices of those hard-to-reach and vulnerable communities to inform our ongoing thinking and actions.

I hope the huge amount of work that has gone into gathering these diverse ideas, experiences and recommendations on early warning systems will help disaster management actors across the region and beyond to improve our capacities to be more resilient to the impacts of the many and grave disasters that we currently face and that we are sure to face in the years to come.

Christian Aid welcomes and appreciate coordinated efforts from organisations such as AIDMI and networks like *Duryog Nivaran* around EWS. It is very important and useful to voice out and share knowledge and information from local (institutions) to regional and global level for the benefit of communities at last mile facing direct impacts of climate change.

By Sanjaya Bhatia,

Head of Office Incheon,
UN Office for Disaster Risk Reduction (UNDRR),
Republic of Korea



The SADR focus on early warning systems is timely and welcome. Cities are at the forefront of reducing risks of disasters, including by means of better preparedness and early warning. The critical importance of early warning is recognised by the Sendai Framework for Disaster Risk Reduction 2015-2030 and the Making Cities Resilient Campaign. From UNDRR we hope more cities from South Asia can join the Making Cities Resilient Campaign and its successor in 2020, and gain access to resources and knowledge on improving early warning systems. Integrating climate scenarios at the local level to the early warning systems and projections, and ensuring the last mile linkage through better dissemination and preparedness at community level are important areas for strengthening.

Preface

By **Achyut Luitel**
Chair, DN steering Committee



The South Asian region - comprising Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka - exists within a complex reality. It is a vibrant engine of economic growth and cultural heritage, yet it remains one of the world's most significant 'hot spots' for disasters. From the sudden devastation of cyclones and floods to the prolonged distress of droughts and heatwaves, the region's stability is being increasingly tested by the intensifying realities of climate change as well as political and economic circumstances.

The Landscape of Risk and Resilience shows a sobering trend: data show that both the frequency of disasters and the resulting economic losses are rising in South Asia. The region will be hit even harder by natural forces in the coming years, undermining the developmental gains for our citizens.

While we have seen much-improved risk governance at both national and sub-national levels, it is vital to acknowledge that significant gaps remain. The work of respective governments together with development partners, civil society and communities must be congratulated for achieving results of the Hyogo Framework for Action (HFA) and now towards the global commitments of the Sendai Framework. However, a lot remains to be done, especially when multiple hazards pose a range of additional challenges due to their differing characteristics. The challenges are emerging faster than our abilities to predict and prepare and be protected.

Since 1995, **Duryog Nivaran** as a network of individuals and organisations, have promoted an 'alternative perspective' – one that views disasters not just as natural events, but as consequences of social and economic vulnerability. The **South Asia Disaster Report (SADR)** has been our primary vehicle for this advocacy. Since our first report in 2005, through to our focus on climate risk in 2010 and "Building Back Better" in 2016, our goal has remained steady: to reduce community vulnerability by integrating local voices into policy and implementation.

The **SADR 2025** focuses specifically on the state of Multi-Hazard Early Warning Systems. It is important to note that the conceptualization of this report began during the 2018 steering committee meeting in Delhi and was refined at the Asian Ministerial Conference in Ulaanbaatar.

The information and data presented here represent a "pre-COVID-19" view, with datasets primarily originating from before 2019. While the world has changed drastically, this data remains an essential baseline. It captures the status of our systems before the pandemic and subsequent catastrophic events, providing the necessary benchmark to measure how much progress we have or have not made in the years since. In the report's concluding chapters the lessons learnt are reviewed in light of the present day to improve inclusive early warning systems that put the last mile first.

Acknowledgements

By Mahbuba Nasreen,

Duryog Nivaran Steering Committee,
Dhaka, Bangladesh



The *South Asia Disaster Report (SADR) 2025: Putting the Last Mile First: Ensuring Inclusive and Effective Early Warning to Mitigate Natural Hazards* is a flagship publication of the **Duryog Nivaran Network**. Moving away from a singular, top-down analysis, this report serves as a mosaic of over 75 diverse perspectives, incorporating insights of leading actors and thinkers dedicated to building resilience in South Asia.

We extend our sincere gratitude to the global leaders who provided the framing for this work. We thank Jorge Chediek (formerly of UNOSSC) for the Foreword. For their invaluable Key Messages, we thank: Hans Guttman (Independent Expert; formerly ADPC), Gareth Owen (Save the Children, UK), Dr. Robert Glasser (Australian Strategic Policy Institute; former UN SRSG for DRR), Michael Mosselmans (Christian Aid, UK), Petteri Taalas (Finnish Meteorological Institute; former Secretary-General, WMO) and Sanjaya Bhatia (UNDRR, Republic of Korea)

Special thanks are due to our support group members: Aslam Perwaiz (ADPC, Thailand), Ray Kancharla (Humanitarian & Resilience Expert, India), and Shivani Rana (Christian Aid, India). Their motivation, strategic focus, and financial support were instrumental in bringing this project to fruition.

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This publication was made possible through the leadership and perseverance of Mihir R. Bhatt (AIDMI, India), alongside Achyut Luitel (Practical Action, Nepal), Aslam Perwaiz (ADPC, Thailand), and Muhammad Taher (Bangladesh), who provided essential technical support, thematic contributions and review and synthesis support.

Our heartfelt thanks go to the team at AIDMI - Mehul Pandya, Kshitij Gupta, Manish Patel, and Jyoti Agrawal – who worked relentlessly on the collection, editing, and coordination of contributions. We also thank Tushani Kalugalagedera for final compilation and editing, and Krishan Jayatunge for the professional design and layout.

Finally, we acknowledge the Duryog Nivaran Steering Committee for their advisory support. This report demonstrates how Duryog Nivaran works across borders - both geopolitical and conceptual - to champion diverse pathways toward effective Early Warning Systems in South Asia.

Abbreviations

ADPC	Asian Disaster Preparedness Center	DFID	Department for International Development
ADRRN	Asian Disaster Reduction and Response Network	DHM	Department of Hydrology and Meteorology
AIDMI	All India Disaster Mitigation Institute	DMC	Disaster Management Committee
AKAH	Aga Khan Agency for Habitat	DN	Duryog Nivaran
AMCDRR	Asian Ministerial Conference on DRR	DPRP	Disaster Preparedness and Response Plan
ANDMA	Afghanistan National Disaster Management Authority	DRM	Disaster Risk Management
APELL	Awareness and Preparedness for Emergencies at Local Level	DRT	Disaster Response Team
APCC	Asia-Pacific Climate Centre	DRR	Disaster Risk Reduction
APMCDRR	Asia-Pacific Ministerial Conference on Disaster Risk Reduction	EOC	Emergency Operation Center
AQI	Air Quality Index	EPRP	Emergency preparedness and response planning
ARP	Asian Regional Plan	EWS	Early Warning System
ASEAN	Association of Southeast Asian Nations	EEWS	Earthquake Early Warning System
ASPI	Australian Strategic Policy Institute	EPS	Ensemble Prediction System
AS	Alert System	FFD	Flood Forecasting Division
BDP	Bangladesh Delta Plan	FFEWS	Flood Forecasting and Early Warning System
BDRCS	Bangladesh Red Crescent Society	FFWC	Flood Forecasting and Warning Center
BIMSTEC	Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation	GAR	Global Assessment Report
BMD	Bangladesh Meteorological Department	GFCS	Global Framework for Climate Services
BWDB	Bangladesh Water Development Board	GIEWS	Global Information and Early Warning System
CBDP	Community Based Disaster Preparedness	GMAS	Global Multi-hazard Alert System
CBDRR	Community Based Disaster Risk Reduction	GLOF	Glacial Lake Outburst Flood
CBFEWS	Community Based Flood Early Warning System	GPSVS	Ghoghardiha Prakhand Swarajya Vikas Sangh
CBO	Community Based Organisation	HFA	Hyogo Framework for Action
CCR	Coastal Community Resilience	HW	Heatwave
CDD	Centre for Disability and Development	HYCOS	Hydrological Cycle Observing System
CFGORRP	Community Based Flood and Glacial Lake Outburst Risk Reduction Project	ICHARM	International Centre for Water Hazard and Risk Management
CFS	Child Friendly Spaces	ICIMOD	International Centre for Integrated Mountain Development
CHS	Core Humanitarian Standard	IDS	Institute of Development Studies
CPP	Cyclone Preparedness Program	IIT	Indian Institute of Technology
CRED	Centre for Research on the Epidemiology of Disasters	IMD	India Meteorological Department
CROPC	Climate Resilient Observing-Systems Promotion Council	IMEP	International Master of Environmental Policy Program
CSO	Civil Society Organisation	INCOIS	Indian National Centre for Oceanic Information Services
CSR	Corporate Social Responsibility	IN-MHEWS	International Network for Multi-hazard Early Warning Systems
DDM	Department of Disaster Management	INSPIRE	internet-based Simulation Platform for Inundation and Risk Evaluation
DDMP	District Disaster Management Plan	IoT	Internet of things

IOTWS	India Ocean Tsunami Early Warning Systems	SAWS	Simultaneous Announcement Wireless System
ISRO	Indian Space Research Organisation	SDGs	Sustainable Development Goals
IVR	Interactive Voice Response	SDMA	State Disaster Management Authority
JMA	Japan Meteorological Agency	SFDRR	Sendai Framework for Disaster Risk Reduction
KMC	Kolkata Municipal Corporations	SHGs	Self Help Groups
LRWHF	Lanka Rain Water Harvesting Forum	SMART	System for Multi-hazard Potential Impact Assessment, Alert, Emergency Response Planning and Tracking
MEWS	Multi-hazard Early Warning System	SOD	Standing Order on Disasters
MMS	Maldives Meteorology Services	SOP	Standard Operating Procedure
MoDMR	Ministry of Disaster Management and Relief	TBCF	Transboundary Citizen Forum
MoEF	Ministry of Environment and Forest	TB-EWS	Transboundary Early Warning System
MoHA	Ministry of Home Affairs	TEC	Tsunami Evaluation Coalition
MoU	Memorandums of Understanding	TROSA	Transboundary Rivers of South Asia
NDMA	National Disaster Management Authority	UMS	Unified Messaging System
NDMC	National Disaster Management Center	UNDP	United Nations Development Programme
NDMP	National Disaster Management Plan	UNDRR	UN Office for Disaster Risk Reduction
NGOs	Non-Governmental Organisations	UNESCAP	United Nations Economic and Social Commission for Asia Pacific
NIDM	National Institute of Disaster Management	UNFCCC	UN Framework Convention on Climate Change
NSET	National Society for Earthquake Technology	UNISDR	United Nations International Strategy for Disaster Reduction
PID	Provincial Irrigation Department	UNOSSC	United Nations Office for South-South Cooperation
PGVS	Purvanchal Garmin Vikas Sangathan	USAID	United States Aid for International Development
PMD	Pakistan Metrological Department	USGS	United States Geological Service
RCY	Red Crescent Youth	VNMS	Volunteer Network Management System
RFIS	Regional Flood Information System	WHO	World Health Organisation
RIMES	Regional Integrated Early Warning System for Africa and Asia	WIS	World Meteorological Organization Information System
RMTC	Regional Meteorological Training Centre	WLMS	Water Level Monitoring System
RSMC	Regional Specialised Meteorological Centre	WMO	World Meteorological Organization
SAARC	South Asian Association for Regional Cooperation		
SADR	South Asia Disaster Report		
SAFAR	System of Air Quality Forecasting and Research		
SAR	South Asia Region		
SATARK	System for Assessing, Tracking, and Alerting Disaster Risk Information based on Dynamic Risk Knowledge		

Key Features of SADR 2025

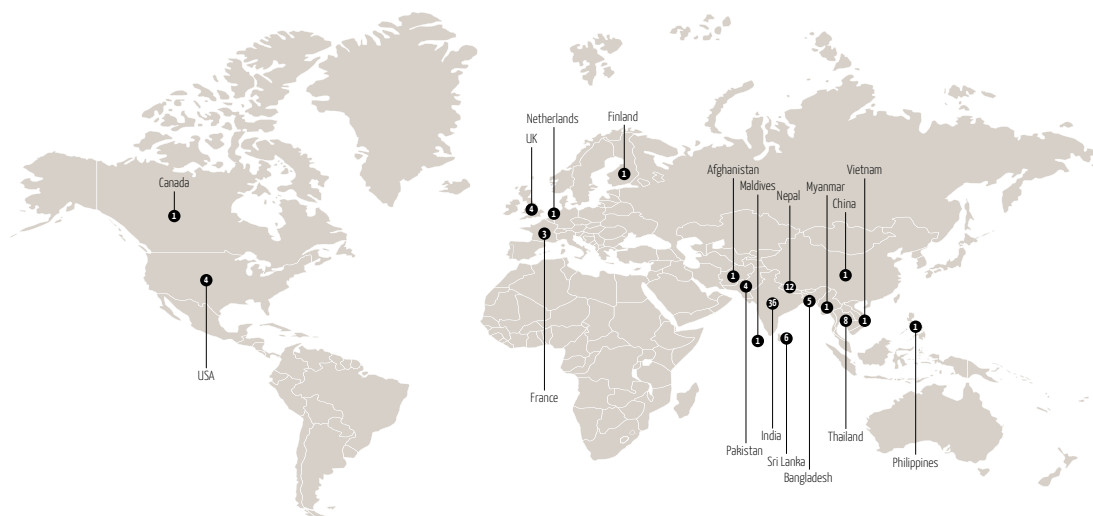
Evolution and Purpose: The outline for the SADR 2025 was conceptualised following the 2016 Asian Ministerial Conference on Disaster Risk Reduction (AMCDRR) in Delhi. At the time, literature on multi hazard early warning systems – especially bottom-up approaches from South Asia were not widely available. This report synthesises a vast pool of research and articles collected from policy makers and practitioners over multiple years. It is designed for quick reading and high-impact decision-making, catering to the evolving needs of regional leaders and practitioners.

Release of the report: Though released in 2025, ***the content in this report was generated in 2019***. The year 2019 is considered an important benchmark, reference point, and baseline for understanding the state of early warning systems at that time, against which current progress and remaining gaps can be viewed. This is particularly important because 2019 stands as a useful pre-Covid reference point, before major shifts in risk, response systems, and policy attention. The report offers early evidence of challenges that have since become even more visible, including the need for anticipatory action and next-generation early warning systems. Subsequent experiences such as Covid-19 and extreme heat have further shown the limitations of earlier systems and the importance of revising them to address evolving and compound risks.

The nature of the report: Unlike traditional reports that utilise a rigid analytical framework, SADR 2025 intentionally adopted an open structure. This approach captures a wider, more valuable range of insights from diverse stakeholders that a standard framework might overlook. Furthermore, the report strives to be bottom-up and also engages a mutual peer-review process, with authors evaluating each other’s work to extract key lessons and conclusions. This process ensures the publication celebrates a diversity of expertise rather than being restricted to the views or feedback from a few experts.

Thematic Focus: The report focuses on Early Warning Systems (EWS) structured around the four key pillars of a comprehensive EWS, as identified by the UNDRR and the World Meteorological Organization (WMO). It covers 1) Risk Knowledge, 2) Monitoring and Warning Services, 3) Dissemination and Communication and 4) Response Capacity. Within these themes the SADR 2025 explores disaster preparedness for effective response and to “Build Back Better “ with a strong people centred approach that highlights vulnerabilities, gendered and social inclusion perceptions over physical assets.

Contributor Profile and Geography: SADR 2025 draws on the voluntary contributions of 91 distinguished authors representing a broad spectrum of organisations, including international agencies, national and local governments, the private sector, and Civil Society Organisations (CSOs) from across the region and beyond as shown in the map below.



A periodic publication of Duryog Nivaran, the SADR remains a premier resource – that showcases experiences and expertise from the regions towards better disaster risk reduction in South Asia and the Asia-Pacific.

1. Introduction to Disasters and Multi-hazard Early Warning Systems in South Asia



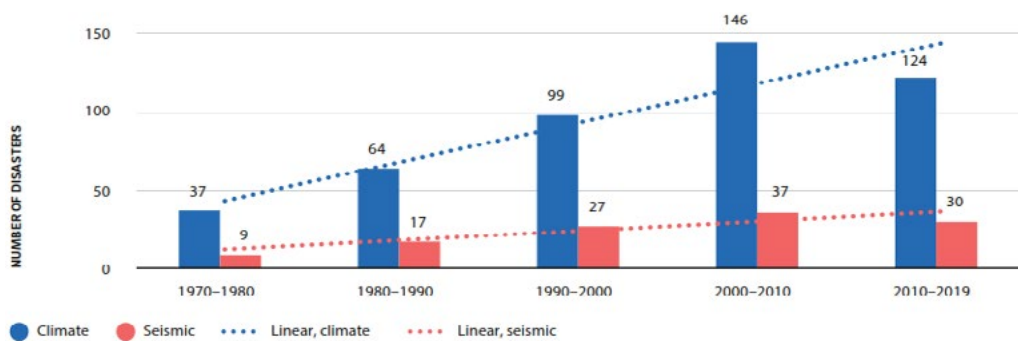
1.1 Disasters and Multi-hazard Early Warning Systems in South Asia: An Overview

– Dr. Hans Guttman, ADPC, and Mihir R. Bhatt, AIDMI

South Asia, Disasters Induced by Natural Hazards and Climate Risks

The countries of South Asia, namely Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka are exposed to a wide range of natural hazards, particularly cyclones, floods, earthquakes, and landslides. All countries in South Asia are exposed to and affected by challenges and risks posed by climate change, with 3 out of the 5 of the most vulnerable countries to climate change in the world are located in the South Asia Region (SAR)⁵. The prevalence of major natural hazards results in high vulnerability, which is steadily increasing. Unplanned human settlements, unsafe building practices, high population densities, growing economies, accumulation of assets and communities' vulnerabilities have dramatically increased cities' exposure to hazards and increased disaster loss. The effects of climate change and rising sea levels place an additional burden of risk on SAR's coastal cities. During 2010-2018, a total of 322 events were reported in South Asia claiming around 42,121 lives and affecting over five hundred million people, causing heavy economic losses of over seventy billion dollars for developing South Asian economies.⁶

According to the United Nations Economic and Social Commission for Asia Pacific (UNESCAP), the overall number of disasters is on an upward trend, largely towards an increase in the number of climate-related events such as droughts, extreme temperatures, floods and storms.



Source: ESCAP, based on EM DAT (Accessed on 30 May 2019).

Note: seismic hazards are composed of earthquake, landslide triggered by tsunami, and tsunami.

Figure 1.1: Disaster events in Asia-Pacific region — average per decade⁷

5 Climate Change Vulnerability Index. <https://maplecroft.com/about/news/ccvi.html>

6 EM-DAT. 2019. Country-wise natural disaster occurrence in South Asia from 2010-2018. https://www.emdat.be/emdat_db/

7 UNESCAP. 2019. Asia-Pacific Disaster Report 2019. https://www.unescap.org/sites/default/files/publications/Asia-Pacific%20Disaster%20Report%202019_full%20version.pdf

The economic losses from weather and climate related disasters have increased over time. “EM-DAT⁸ recorded losses totalling USD 1,891 billion from weather-related disasters between 1995 and 2015, equivalent to 71% of all losses attributed to natural hazards”.⁹ Between 1995-2015, about 90% of disasters have been caused by natural hazards such as floods, storms, heatwaves and other weather-related events.¹⁰ Globally, deaths and destruction due to hydro-meteorological hazards are accelerating. An average of 335 weather-related disasters were recorded by EM-DAT per year between 2005 and 2014, an increase of 14% from 1995-2004 and almost twice the level recorded during 1985-1994, with Asia being the hardest hit region.¹¹ Both, natural hazards and a changing climate pose a significant risk to South Asia’s economy and its citizens.

Importance of Multi-hazard Early Warning

Early warning is one of the key elements of disaster risk reduction (DRR). “Research shows that for every dollar spent on disaster early warning systems, the benefits range from USD 2-10.¹² The open-ended inter-governmental expert working group on terminology relating to disaster risk reduction defines Early Warning as: “An integrated system of hazard monitoring, forecasting and prediction, disaster risk assessment, communication and preparedness activities systems and processes that enables individuals, communities, governments, businesses and others to take timely action to reduce disaster risks in advance of hazardous events”.¹³

It is recognised worldwide that an early warning system (EWS) has the potential to reduce loss of life and damage to economic and ecological assets. The Sendai Framework has pinpointed EWS as a key to reducing mortality. Asian Regional Plan (ARP) has indicated EWS as a low hanging fruit where initial DRR work is done and more work is needed to consolidate the gains of reduced loss of life and damage to assets. Ulaanbaatar Declaration of Asian Ministerial Conference on Disaster Risk Reduction 2018 (AMCDRR 2018) clearly highlighted the need to review and revitalise EWS in Asia Pacific. These initiatives have thrown up a wide range of issues, including impact of EWS on local labour market; right to EWS information; avoiding communal divide of EWS; role of EWS in higher education; and transport or transfer of EWS technology from West to South Asia, top to bottom and citizen-to-citizen.

The 2030 Agenda for Sustainable Development as well as the Paris Agreement recognise the key role of early warning to minimise loss of lives and property and build resilience.¹⁴ The seventh target of the Sendai Framework for Disaster Risk Reduction (2015 – 2030)¹⁵, is to “substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to people by 2030.” To achieve this, at national and local levels the Sendai Framework has recommended:

- “to invest in, develop, maintain and strengthen people-centred multi-hazard, multi-sectoral forecasting and early warning systems, disaster risk and emergency communications mechanisms, social technologies and hazard-monitoring telecommunications systems;
- develop such systems through a participatory process; tailor them to the needs of users, including social and cultural requirements, in particular gender;
- promote the application of simple and low-cost early warning equipment and facilities; and
- broaden release channels for (natural hazard induced) disaster early warning information”.

8 The Centre for Research on the Epidemiology of Disaster’s Emergency Events Database (EM-DAT)

9 UNISDR. 2015 The Human cost of weather-related disaster 1995-2015. https://www.unisdr.org/files/46796_cop21weatherdisastersreport2015.pdf

10 UNISDR. 2015 The Human cost of weather-related disaster 1995-2015. https://www.unisdr.org/files/46796_cop21weatherdisastersreport2015.pdf

11 UNISDR. 2015 The Human cost of weather-related disaster 1995-2015. https://www.unisdr.org/files/46796_cop21weatherdisastersreport2015.pdf

12 Pillai. P. World Bank Blogs. 2018. Managing climate risks in South Asia: A “bottom up” approach. <https://blogs.worldbank.org/endpovertyinsouthasia/managing-climate-risks-south-asia-bottom-approach>

13 https://www.preventionweb.net/files/50683_oiewgreportenglish.pdf

14 World Meteorological Organisation. 2018. Multi-hazard Early Warning System: A Checklist. 2017. https://reliefweb.int/sites/reliefweb.int/files/resources/Multi-hazard_Early_Warning_Systems_A_Checklist.pdf

15 UNISDR. 2015. Sendai Framework for Disaster Risk Reduction 2015-2030. <https://www.unisdr.org/we/inform/publications/43291>

At global and regional levels, the Sendai Framework require stakeholders “to promote the further development of and investment in effective, nationally compatible, regional multi-hazard early warning mechanisms, where relevant, in line with the Global Framework for Climate Services, and facilitate the sharing and exchange of information across all countries”.

State of National EWS in South Asia

Afghanistan

Afghanistan is vulnerable to hazards such as floods, earthquakes, droughts, sandstorms and so on, including wars and civil conflicts. The Afghanistan National Disaster Management Authority (ANDMA) is the principal institution at the national level with the mandate to coordinate and manage all aspects of national disasters. Afghanistan had reported a few localised single hazard-oriented EWS managed by the Department of Meteorology and some INGOs in a few places but acknowledged lack of systematic early warning system in its national progress report on the implementation of the Hyogo Framework for Action (HFA) (2013-2015).¹⁶ The Afghanistan Meteorological Authority (AMA), after years of neglect during the Taliban rule has been revived and weather database has been restored with the help of World Meteorological Organisation since 2003. The country has also received support from United States Aid for International Development (USAID) in the form of training and technical collaboration through the Agro-Meteorology (Agromet) Programme (for the analysis of hydro-meteorological and agricultural information) of the United States Geological Service (USGS).¹⁷ In Afghanistan’s Sendai Framework Data Readiness Review Report, it is reported that data on the number of people who have access to early warning information through local governments or national dissemination mechanisms is not collected.¹⁸ However, ANDMA has reported on the Sendai Framework monitor (SFM) on Target G/indicator G3 in 2017 and 2019, on the number of people per 100,000 covered by EW information through local governments or through national dissemination mechanisms. To report, they have used a proxy on penetration rate or coverage of primary media and local communication system including siren, public board and phone to self-score their penetration rate.

Bangladesh

Bangladesh is extremely prone to floods and cyclones. The enactment of the 2012 National Disaster Management Act and the five-year National Disaster Management Plan (NDMP) 2016-20 provided a new legislative framework and revised institutional arrangements. The Ministry of Disaster Management and Relief (MoDMR) (previously called the Ministry of Food and Disaster Management) functions as the government’s focal point for disaster management and coordination. The Bangladesh Meteorological Department (BMD), Ministry of Defence has the mission to provide effective meteorological and seismological services. The Regional Integrated Early Warning System for Africa and Asia (RIMES), funded by the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) trust fund has supported the country in the development of long-lead flood forecasting and concurrent monitoring of depressions and cyclone formation on the Bay of Bengal. The BMD and Flood Forecasting and Warning Center (FFWC) have been the recipient of new technology, which has been integrated into their operations.¹⁹

Bhutan

Bhutan is vulnerable to Glacier Lake Outburst Floods (GLOF), earthquakes, forest fires, droughts and flash floods, including landslides. As per the Disaster Management Act of 2013, the National Disaster Management Authority (NDMA) is the highest decision-making body on disaster management in Bhutan. The Department of Disaster Management, which comes under the NDMA

16 Afghanistan National Disaster Management Authority. 2015. Afghanistan: National progress report on the implementation of the Hyogo Framework for Action (2013-2015). https://www.preventionweb.net/files/42575_AFG_NationalHFAprogress_2013-15.pdf

17 Afghanistan National Disaster Management Authority. 2011. Afghanistan Strategic National Action Plan (SNAP) for Disaster Risk Reduction: Towards Peace and Stable Development. <http://extwprlegs1.fao.org/docs/pdf/afg152361.pdf>

18 Afghanistan National Disaster Management Authority (ANDMA). 2017. Afghanistan. 2017. Sendai Framework Data Readiness Review Report. https://www.preventionweb.net/files/53148_afghanistanafg.pdf

19 Center for Excellence in Disaster Management and Humanitarian Assistance. 2017. Bangladesh Disaster Management Reference Handbook. June 2017. https://reliefweb.int/sites/reliefweb.int/files/resources/disaster-mgmt-ref-hdbk-bangladesh_0.pdf

is the nodal National Coordinating Agency for disaster management in the country. The Department of Hydro-Met Services (DHMS) is a key technical department in the country providing weather, water, and climate data, services and forecasts for sustainable planning and development and facilitating early warning systems for GLOFs, floods, landslides, droughts and other climate related hazards. However, except for the GLOF EWS in the Punatsangchu river basin there are no other EWS established. GLOF EWSs for the Mangdechu and Chhamkhar river basins are currently being established. There is a need to also establish EWS for other impending hazards such as landslides, flooding and windstorms that affect parts of Bhutan on a recurrent basis.²⁰

India

India is vulnerable to multiple hazards such as earthquakes, floods, cyclones, droughts, landslides and so on. The Disaster Management Act 2005 has provided the legal and institutional framework for disaster management in India at the national, state and district levels. Under the Act, the National Disaster Management Authority (NDMA) is given the responsibility for formulating policy and guidelines for all disaster management work in the country. The Government of India has designated²¹ specific agencies to monitor the onset of different natural hazard induced disasters, set up adequate EWS and disseminate necessary warnings/alerts. For example, India Meteorological Department (IMD) is designated for natural hazard-specific early warnings for cyclone and earthquakes and Central Water Commission (CEC) for floods. Similarly, for droughts and epidemics Ministry of Agriculture and Farmers Welfare (MoAFW) and Ministry of Health and Family Welfare (MoHFW) are designated agencies. For tsunami, Indian National Centre for Oceanic Information Services (INCOIS) is given the responsibility. These agencies provide inputs to the MHA, which will issue alerts and warnings through various communication channels. The Disaster Management Division of the MHA communicates and coordinates with designated early warning agencies, various nodal Ministries, and State Governments.

Maldives

The Maldives is exposed to natural hazards such as storms, floods, tsunamis, and high waves caused by cyclones in the South Indian Ocean. Disaster risk reduction actions in the Maldives are guided by the Disaster Management Act, 2006. On December 2018, National Disaster Management Authority (NDMA) was established by President Ibrahim Mohamed Solih as per the Disaster Management Act (28/2015), which resulted in the transfer of all staff, assets, ongoing work and so on of the National Disaster Management Centre (NDMC) to NDMA. The current structure of NDMA divides the organisation into three units:(1) Early Warning and Emergency Operations, (2) Disaster Preparedness and Risk Reduction, and (3) Cooperate Affairs. The unit on Early Warning and Emergency Operations within this set up “serves as a central coordination and control facility responsible for carrying emergency management functions at a strategic level in an emergency situation and ensuring the continuity of the relief and recovery operations during emergencies”.²² End-to-end early warning system is one of the key areas identified in the Strategic National Action for Disaster Risk Reduction and Climate Change Adaptation 2010-2020. The document acknowledges that the work by the Maldives Meteorology Services (MMS) requires advanced systems to upgrade its warning services.²³

Nepal

Nepal is regularly exposed to natural hazards such as floods, landslides, cold waves, including the risk of earthquakes. Disaster Risk Reduction and Management Act 2017 (DRRMA 2017) has been endorsed by the Government of Nepal. The Ministry of Home Affairs is working as a nodal agency of disaster risk management both at the national and international level for Nepal. Development and expansion of multi-hazard early warning system is one of the key

20 Department of Disaster Management. Ministry of Home and Cultural Affairs. Royal Government of Bhutan. 2016. Disaster Risk Management Strategy. [http://www.ddm.gov.bt/download/Final_NDRMS\(NDMA\).pdf](http://www.ddm.gov.bt/download/Final_NDRMS(NDMA).pdf)

21 National Disaster Management Authority (NDMA). 2016. National Disaster Management Plan (NDMP) <https://ndma.gov.in/images/policyplan/dmplan/National%20Disaster%20Management%20Plan%20May%202016.pdf>

22 National Disaster Management Authority, Maldives. N.D. Organizational Structure. <https://ndmc.gov.mv/about/divisions/>

23 The Republic of the Maldives. 2014. Strategic National Action for Disaster Risk Reduction and Climate Change Adaptation 2010-2010. https://www.preventionweb.net/files/60595_maldivesstrategicnationalactionplan.pdf

objectives of Nepal's National Policy for Disaster Risk Reduction 2018.²⁴ The Government of Nepal's Disaster Risk Reduction National Strategic Plan of Action 2018-2030 has stated that, "the current experience on flood early warning system needs to be expanded to other major and small river basins. This requires investment in developing, operationalising and strengthening multi-sectoral impact based, multi-hazard forecasting and early warning systems".²⁵ For floods, which is a major cause of concern for the administration in Nepal, the Department of Hydrology and Meteorology (DHM) is made responsible to issue flood forecasts and flood warnings. "Despite DHM's efforts in developing a flood forecasting and warning system, substantial capacity building is still needed for the forecasts to have reliable accuracy as well as for effective dissemination of flood warnings".²⁶

Pakistan

Pakistan is prone to natural hazards such as floods, droughts, earthquakes and cyclones. The National Disaster Management Act (2010) in Pakistan provided the institutional and regulatory framework for comprehensive disaster management in the country. The National Disaster Management Authority (NDMA) established in 2007 acts as the executive arm of the National Disaster Management Commission, the highest policymaking body in the field of disaster management, chaired by the prime minister. Pakistan's National Multi-hazard Early Warning System Plan (NMH-EWS-P) is part of NDMP. As per the NMH-EWS-P, agencies responsible for monitoring disaster related data should broadcast warnings and alerts. For instance, in the case of a potential hydro-metrological event, the Pakistan Metrological Department (PMD) would issue a warning to District Disaster Management Authorities of vulnerable districts. "The NMH-EWS-P of Pakistan, when compared with the guidelines of Sendai Framework, reveals that a lot of emphasis is given to the element of monitoring and warning services."²⁷

Sri Lanka

In Sri Lanka, floods, cyclones, droughts, wind storms and landslides are the main causes for natural hazard induced disasters. The country is also extremely prone to the risk of tsunamis. The Sri Lanka Disaster Management Act was enacted in May 2005, under which the National Council for Disaster Management was established as the apex body for disaster risk management in Sri Lanka. The Disaster Management Centre (DMC) is the national-level nodal agency responsible for coordinating all aspects of disaster risk management including policies, plans, and post-disaster reconstruction. DMC is the main focal point responsible for coordinating early warning. It has established an effective early warning system for disasters through the Emergency Operation Centre of the DMC.²⁸

Existing Trans-border Flood EWS in South Asia

The role of effective early warning in this regard becomes extremely important for saving lives, livelihoods and economic assets. Early warning systems need multi-faceted approaches to reach communities with messages that are understandable and enable an appropriate decision-making process. Transboundary approach is one such facet of early warning in South Asia, which can be useful in mitigating the risk of floods from China to Nepal and India, Nepal to India and from India to Bangladesh. However, existing water treaties and data sharing agreements on rivers at trans-border level between and among the countries are not sufficient to avert flood catastrophes at scale.²⁹

24 The Government of Nepal. Ministry of Home Affairs. 2019. National Policy for Disaster Risk Reduction 2018. <https://app.adpc.net/sites/default/files/public/publications/attachments/DRR%20Policy%20%28Nepal%29.pdf>

25 Government of Nepal. Ministry of Home Affairs. 2018. Disaster Risk Reduction National Strategic Plan of Action 2018-2030. <https://app.adpc.net/sites/default/files/public/publications/attachments/DRR%20National%20Plan%20of%20Action%20%28Nepal%29.pdf>

26 Government of Nepal. Ministry of Energy, Water Resources and Irrigation. Department of Hydrology and Meteorology. 2018. Standard Operating Procedure (SOP) for Flood Early Warning System in Nepal. http://hydrology.gov.np/cm/files/Soft%20copy%20EWS%20SoP_1534225888786.pdf

27 Mukhtar R. 2017. Review of National Multi-hazard Early Warning System Plan of Pakistan in context with Sendai Framework for Disaster Risk Reduction. <https://www.sciencedirect.com/science/article/pii/S1877705818300365>

28 Disaster Management Centre. 2014. Sri Lanka National Disaster Management Plan 2013-2017. <https://groundviews.org/wp-content/uploads/2018/12/NDMP.pdf>

29 Gurung G. B. et al. Practical Action. 2018. Promoting Trans-border Flood Early Warning System in South Asia.

Table 1.1 Trans-border Flood EWS in South Asia

No.	Existing trans-border flood EWS	Key highlights of trans-border flood EWS ³⁰
1.	<p>Poiqu/Bhote Koshi/ Sunkoshi in Koshi River (China - Nepal): Flood in Bhote Koshi River is mainly attributed to intensive rainfall in the windward side of the Himalaya, mostly towards Nepal and the Glacial Lake Outburst Flood (GLOF), which is mainly from Tibet (China).</p>	<ul style="list-style-type: none"> • Upper Bhotekosi Hydroelectricity Project in Nepal side had installed an early warning system with five sensors near the Nepal-China Friendship Bridge with automatic sirens at four locations while people living in the project area were trained and signboards about the siren system were placed. But the lead time between the monitoring site (near international border) and the location of major infrastructure (dam) is very short (around 6 minutes). There is a need to increase the lead time by placing monitoring station upstream on the China side. • No practice of upstream flood monitoring system exists for this river on the Chinese side, constraining communicating flood information to downstream communities across the border in Nepal. • Joint institutional mechanism between the Government of Nepal and China does not exist to share river information that travels across the border.
2.	<p>Karnali River (Nepal - India): The main cause of flood in this river is rainfall that occurs in the mountains and hills of Nepal.</p>	<ul style="list-style-type: none"> • There are monitoring stations inside Nepal along this river. The information coming from these stations are shared with the Indian government at provincial and central level through a bilateral agreement. The Nepal government provides daily flood information to India during the high flood season while the communication frequency is relatively low during non-flood season. However, the information is basically shared for water management, not necessarily for flood early warning purposes. • At the community level, there is a community-to-community early warning communication practice. The Nepalese communities provide flood information to Indian communities and when needed the Indian communities also enquire flood information to the Nepalese communities. There are identified focal persons in the communities for flood-related communication across the border. The communities have developed a communication channel with focal communication points along with contact telephone numbers. • Informal communication between the local government in Nepal and India across the border does exist when a flood in Nepal reaches high levels. The border security authorities at local level meet informally and visit each other during such times. But there is no formal channel yet established to communicate flood information through local government for early warning.
3.	<p>Brahmaputra River (India - Bangladesh): Floods in Brahmaputra River affecting India and Bangladesh are mainly due to rainfall in the southern slope of the Himalaya.</p>	<ul style="list-style-type: none"> • Under the existing bilateral Memorandums of Understanding (MoU), China provides hydrological information of the Brahmaputra and Sutlej River to India during the flood season between May 15 and October 15 every year. The Bangladesh Flood Forecasting and Warning Centre also receive river discharge data from China for the Brahmaputra River. • There is no real time trans-border information exchange at community level leaving flood forecast in Bangladesh at a limbo. Similarly, in the case between the local governments; information exchange at the border even including flood information is considered sensitive from a security point of view. • The Assam Government (India) provides two days flood forecast on their website. This information is used by the Flood Forecasting Division (FFD) of Bangladesh which gives five days forecast for the communities in Bangladesh to prepare for floods.

https://infohub.practicalaction.org/bitstream/handle/11283/621154/Promoting%20Trans-border%20Flood%20EWS%20in%20S%20Asia_Summary%20Report.pdf;jsessionid=320A4760D3F03D9F70B673F5A5016E98?sequence=1

30 Gurung G. B. et al. Practical Action. 2018. Promoting Trans-border Flood Early Warning System in South Asia. (Excerpt) https://infohub.practicalaction.org/bitstream/handle/11283/621154/Promoting%20Trans-border%20Flood%20EWS%20in%20S%20Asia_Summary%20Report.pdf;jsessionid=320A4760D3F03D9F70B673F5A5016E98?sequence=1

Regional and International Initiatives

ESCAP Trust Fund for Tsunami, Disaster and Climate Preparedness: The Fund continues to evolve in line with changing needs for enhanced early warning, last mile connectivity, new investment and better application of science and technology for disaster risk reduction within the Asia-Pacific region. The Fund is currently strengthening tsunami early warning in the North West Indian Ocean region through regional cooperation and implementing Phase II of Implementation of Synergized Standard Operating Procedures (SSOP) for Coastal Multi-hazards Early Warning System in 10 countries of Asia.³¹ Key achievements of the Fund are³²:

Indian Ocean Tsunami Warning System: The Trust Fund contributed to the establishment of the Indian Ocean Tsunami Warning System, which entered into operation in October 2011 with Australia, India and Indonesia as the designated regional service providers. It is estimated that the system will contribute to the saving of 1,000 lives per year, on average, over the next 100 years. The Trust Fund's support for the development of the Indian Ocean Tsunami Warning System included adaptation of Standard Operating Procedures (SOPs) for tsunami warning and emergency response.

Regional Integrated Multi-Hazard Early Warning System for Africa and Asia: The Regional Integrated Early Warning System for Africa and Asia (RIMES) was established as a result of Trust Fund-supported projects. RIMES, a collective resource for member countries, provides a range of cost-effective early warning and climate application services. These have led to improvements in early warning systems and capacities, especially in low capacity countries throughout the region.

Synergized Standard Operating Procedures: Standard operating procedures (SOPs) for tsunami early warning have been developed and improved in many countries following the Indian Ocean tsunami of 2004. Because of a lack of understanding of the characteristics, similarities, and differences among diverse coastal hazards, synergies between the SOPs for other coastal hazards such as storm surges, high tides, and floods were missing. To make early warning systems operational for use in a multi-hazard context, the Trust Fund has supported the development of integrated, effective SOPs to simultaneously address multiple hazards.

Contributions to transboundary EWS by Asian Disaster Preparedness Center (ADPC): ADPC has worked significantly for multi-hazard and multi-country efforts including: a) coastal hazards early warning systems across the Asia-Pacific (under UNESCAP's Trust Fund for Tsunami, Disaster and Climate); b) building transboundary flood early warnings in Mekong (under Mekong River Commission supported efforts); c) transboundary early warning systems and resilience in India-Nepal (under Global Resilience Partnership); d) drought monitoring and virtual rain-gauge tools development for Mekong region (under SERVIR Mekong); e) establishment of regional multi-hazard early warning systems (RIMES) for the Asia and Africa; f) supporting the establishment of the India Ocean Tsunami Early Warning Systems (IOTWS) and many other endeavours of a transboundary nature.³³

South Asia Program on Hydromet, Climate Services and Resilience: Supported by the Global Facility for Disaster Reduction and Recovery (GFDRR), the objective of South Asia Program on Hydromet, Climate Services and Resilience is to strengthen institutions, facilitate knowledge exchange and enhance cooperation on Hydrological and Meteorological (hydromet) risks and climate services across South Asia. Since the project was approved in 2016, 373 government officials from South Asia, including 57 women, have received hydromet training through various workshops, activities and events organised across the region. The project is already yielding results in terms of expanding the service coverage of hydromet services. For example, in Nepal, farmers in all 25 target districts are now receiving agro-advisory bulletins that are helping inform decision-making at the farm level.³⁴ The program has two action areas:³⁵

31 Economic and Social Commission for Asia and the Pacific. N.D. Projects. <https://www.unescap.org/disaster-preparedness-fund/projects>

32 Economic and Social Commission for Asia and the Pacific. N.D. Achievements. <https://www.unescap.org/disaster-preparedness-fund/achievements>

33 Guttman. H. et. al. 2019. ADPC's Role in Transboundary Early Warning Systems and Risk Management in the Asia-Pacific Region. [southasiadisasters.net](https://www.preventionweb.net/files/63600_63600180transboundaryewsinasia.pdf). Issue No. 180. January 2019. https://www.preventionweb.net/files/63600_63600180transboundaryewsinasia.pdf

34 Pillai P. 2018. South Asia Regional Program for Hydromet Services and Resilience. <https://www.gfdr.org/sites/default/files/publication/FINAL%20-%20Results%20in%20Resilience%20-%20South%20Asia%20Regional%20Program%20for%20Hydromet%20Services%20and%20Resilience%20-%202010.29.18.pdf>

35 The World Bank. 2017. South Asia Program on Hydromet, Climate Services and Resilience. <https://www.>

Table 1.2 South Asia Regional Program for Hydromet Services and Resilience: Key areas of action

1. National level Preparedness, Resilience and Services	2. Regional Cooperation to Strengthen Resilience
<p>The main objective is to strengthen the capacity of national/sub-basin institutions to manage hydro-meteorological hazards — floods, droughts — and the delivery of weather-based information.</p> <p>Some activities include:</p> <ul style="list-style-type: none"> • USD 113 million IDA <u>Bangladesh Weather and Climate Services Regional Project</u> approved in June 2016 • USD 3.8 million <u>Bhutan Hydromet Services and Disaster Resilience Regional project</u> approved in September 2016. • Bank-supported USD 31 million investment project in Nepal (under implementation) • <u>Modernizing, Weather, Water and Climate Services: A Roadmap for Bhutan</u> (Technical Assistance) • Afghanistan Roadmap to develop and design early warning systems and strengthening hydromet services (Technical Assistance) 	<p>The main objective is to strengthen disaster preparedness and climate resilience through cross-border and regional dialogue, sharing lessons learned and best practices and scaling up ongoing sub-regional collaborations.</p> <p>Activities include:</p> <ul style="list-style-type: none"> • Regional Capacity Strengthening of Hydromet Institutions in collaboration with India Meteorological Department (IMD). • Sub-Regional Consultations • Report on Transboundary Flood Early Warning Systems • Improve hydromet services in Africa region. The availability of global and regional weather and climate monitoring forecasting systems means that, with relatively modest investment, African countries can substantially improve their provision of such services.

Box 1.1: Global systems of early warning and hazard monitoring

- The World Meteorological Organization Information System (WIS) is the single coordinated global infrastructure responsible for managing free exchange of weather, climate and water information around the globe. WIS provides an integrated approach to meet the requirements for routine collection and automated dissemination of hazard monitoring data and products, as well as data discovery, access and retrieval services for all weather, climate, water and related data, including warnings, produced by World Meteorological Organisation's (WMO's) 191 Member countries.
- The Global Framework for Climate Services (GFCS) is a joint program of the WMO and the World Health Organisation (WHO) which was established to “enhance resilience in social, economic and environmental systems” by improving climate information and weather systems in selected regions of the world.
- Established in 2005, The Group on Earth Observations (GEO) is dedicated to the application of earth observation information to a wide range of humanitarian needs. GEO is creating a Global Earth Observation System of Systems (GEOSS) that will link Earth observation resources world-wide including for hazard monitoring and early warning applications.
- The United Nations Platform for Space-based information for Disaster Management and Emergency Response (UN-SPIDER) was established in 2006 to provide information for humanitarian aid and emergency response, with a particular focus on assisting developing countries to gain access to satellite data for emergency preparedness and response needs.
- The International Health Regulations (IHR) (2005) is a legally binding agreement adopted by 196 countries. Through the IHR, WHO keeps countries informed about public health risks, and works with partners to help countries build capacity to detect, report and respond to public health events.
- The World Animal Health Information System, (WAHIS) is an internet-based early warning system that processes data on animal diseases in real-time and disseminates information to the international community whenever an important epidemiological event occurs in a Member Country.
- The FAO Global Information and Early Warning System (GIEWS), which was established in the wake of the world food crisis of the early 1970s, provides information on food production and food security. GIEWS a worldwide network which includes 115 governments, 61 Non-Governmental Organisations (NGOs) and numerous trade, research and media organisations
- UNESCO's Intergovernmental Oceanographic Commission Tsunami Program, which facilitates the global coordination of regional tsunami warning systems and information.

2. Disaster Risk Knowledge: Systematically Collect Data and Undertake Risk Assessments



Risks arise from the combination of hazards and vulnerabilities at a particular location; risk knowledge is considered a key element of early warning system (EWS). “Risk knowledge is defined as the interplay between establishing organisational arrangements, identifying natural hazards, community vulnerability assessment, risk assessment, and information storing and sharing.”³⁶ The element of disaster risk knowledge is the foundation of early warning system, which shapes various activities to be undertaken subsequently in the other three EWS elements.

This section of the report presents a collection of experiences on prior knowledge and identification of risk for effective early warning. It highlights the importance of establishing a systematic process of hazard and vulnerability assessments, data collection and development of maps, including consolidation of the information (repository, standards for data disaggregation, process for maintaining, reviewing and updating risk data) and the incorporation of risk information into the EWSs for understanding impact trends.

2.1 Early warning systems and the role of the community

In addition to collaborations across boundaries, EWS should also ensure that the knowledge collected takes into consideration the particular role of community, the needs of marginalised groups and the types of hazards faced. The following papers highlight these aspects – from transboundary to local systems, and gender and child sensitive systems – they look at how EWS knowledge collection processes can reduce vulnerability and empower communities.

2.1.1 Community in The Context of Transboundary Early Warning System

– **Mihir R. Bhatt**, AIDMI, India

Transboundary Early Warning Systems (TB-EWS) are set in a context. And the context – geo, political, economic, social, and ecological – makes a major difference in terms of the design and performance of such systems.

The All India Disaster Mitigation Institute (AIDMI) has been working on TB-EWS for over seven years across India and South Asia. The following actions on TB-EWS have been drawn from AIDMI’s work as well as debates at the Asian Ministerial Conference on Disaster Risk Reduction (AMCDRR) 2018 held in Ulaanbaatar, Mongolia.

- It has been found that wherever TB-EWS is set up in a just and reality-oriented context with the participation of communities at risk, it performs better in terms of saving lives and reducing damage as has been seen in TB-EWS arrangements between Nepal and India.
- It has been observed that TB-EWS must reach both, men and women, and is more effective in saving lives wherever women, children and other marginalised communities have been empowered to respond to EWS.
- In any TB-EWS both the communities and the river are important. Often, the focus of riverine floods EWS is rightly on communities. But rivers need attention as well. Initiatives such as embanking, cleaning bank plantation and more will be a welcome step. Whenever TB-EWS have a focus on both the community and river ecology the performance is more robust and lasting.

What makes TB-EWS work? Knowledge collection is the launching point for any effective EWS. Thus, a TB-EWS works well when it is community driven, where the community has a substantial and sustaining share in the decision-making process for resource allocation. Communities help provide real-time flood warning and disseminate information through a network of communities and government bodies. A TB-EWS works better when working in partnership with a wide range of organisations across diverse sectors coupled with regional cooperation, to share information and facilitate effective disaster preparedness and response initiatives. For instance, community-

³⁶ United Nations Development Programme (UNDP), 2018: Five approaches to build functional early warning systems. <https://www.eurasia.undp.org/content/dam/rbec/docs/UNDP%20Brochure%20Early%20Warning%20Systems.pdf>

based flood early warning system (CBFEWS) is an integrated system of tools and plans managed by and for communities, providing real-time flood warnings to reduce flood risks. CBFEWS is based on people-centred, timely, simple and low-cost technology. It disseminates information to the vulnerable communities downstream through a network of communities and government bodies. A properly designed and implemented system can save lives and reduce property loss by increasing the lead time to prepare and respond to a flood at ground level.

Regional cooperation across countries of the South Asian region, primarily India, Nepal and Bangladesh, on riverine floods is a major concern that merits immediate attention. Often the

destruction on account of the floods occurs due to the inability to obtain timely information from the various institutions that are designed to generate, analyse, disseminate and communicate the information to a range of stakeholders at different levels on a transboundary basis.

TB-EWS are now set to grow from pilot phase to a more mainstream stage addressing humanitarian needs and demands. It is now up to the leadership of the communities and countries of South Asia to facilitate the spread of TB-EWS by allocating better human and financial resources for its growth, making the context of TB-EWS as important as the TB-EWS itself.

This contribution draws from the following sources:

1. ICIMOD: Community Based Early Warning Systems
2. Flood Resilience Portal, Regional collaboration for better flood early warning and resilience in India
3. United Nations ESCAP: Initiatives on Multi Hazard Early Warning Initiatives



2.1.2 Need for Child Centred and Gender Sensitive Early Warning Systems and Early Action

– Ray Kancharla, Humanitarian Development & Resilience Expert, India

The United Nations International Strategy for Disaster Reduction (UNISDR); now renamed UN-DRR, defines EWS as “the set of capacities needed to generate a meaningful warning information and disseminate timely and meaningful warning information to enable individuals, communities, and organisations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss” (UNISDR/UN-DRR, 2009). Therefore, a functional EWS is a chain of information communication systems comprising sensor, detection, decision, and other subsystems to prepare resources and response actions to minimise the adverse impact on people and their property by a hazard.³⁷

It has been clearly and emphatically established that different types of crises and their contexts require different types of Early Warnings and Early Action approaches with evidence generation and scalability. Rapid Humanitarian Crises demand a different set of EWS and Early Action strategy; while slow building, chronic, protracted and forgotten crises (including conflicts) require another set of differently modulated strategic EWS and Early Action.

Earthquake Early Warning: Governments have invested huge amounts of resources in technology for satellite-based zoning, embedding under-ground movements of tectonic plates. Several regions of the world are facing extremely high seismic activity. Taking the earthquake in Mexico in 1985 as an example, there was very little time for warning with the earthquake taking less than a minute to reach the city, killing 6,000 persons³⁸ and despite a high-technology system warning failed to reach the communities. Going forward – “**More to the More approach**”, economics of affordability determine the state of the issue, of course. Controls by government set up sensors, alerts and access to these by civil society is a crucial aspect to be discussed and ameliorated.

Fire Hazard Early Warning: This is one of the regular weather-related occurrences in rural and urban habitations. In most cases, it is human induced, in popular parlance, it is called “man-made” (*human-induced, in inclusive language*) disaster. While governments invest in fire services units which are progressively modernised and with competent trained teams, general experience has revealed ‘it is too little and too tardy’. The concept of early warning is not a point of focus in most instances. Instead, early action is being intrinsically embedded in habitations, institutions, industries, critical infrastructure (roads, bridges, schools, hospitals, etc.), power infrastructure, public transport. The governing concept is one of ‘safety and security’. Extreme events in Delhi, India where buildings where migrants live and work caught fire and markets were engulfed, resulted in unprecedented losses of lives and assets. Similarly, the Amazon Fire and Australia Fires have engulfed thousands of kilometres of land causing enormous loss of wildlife, human lives as well as homes, crops and other assets. In such a scenario, detrimentally, early warning and early action for the vulnerable children, youth, women and other deprived and marginalised, has hardly been a subject of focus.

Conflict Early Warning Systems: EWS as mechanisms to anticipate and respond to conflicts before their outbreak or escalation, are considered prerequisites for effective conflict prevention. While early-warning mechanisms are ideally established and implemented before the outbreak of conflict to ensure greater preparedness, their principles can also be used to contain conflict once it has erupted in order to minimise human suffering and avoid a spill-over effect. During the post-conflict phase, EWS can be applied to prevent the resurgence of conflict.³⁹

Climate Induced Risks: In this case, we are stepping into an area that is least studied but where *seamless* exposure to ‘*harms way*’ is evident. Air Quality and Water Quality issues will probably impact the future of humanity, especially children, girls and boys, in a very disaggregated proportion and intensity. Approximately, 4 million lives are lost annually due to air pollution; and it is estimated that the next generation of children born in these areas will be born with respiratory

37 Practical Action. 2018, *Review of Flood Early Warning System in South Asia – TRANS-BORDER FLOOD EARLY WARNING SYSTEM IN SOUTH ASIA – Practices, Challenges and Prospects*, ISBN 978-9937-9219-7-8

38 Hernandez, D. & Whelan, R., 2019. The Next Generation of Earthquake Early Warning Systems. The Wall Street Journal podcast. <https://www.wsj.com/podcasts/wsj-the-future-of-everything/on-the-alert-the-next-generation-of-earthquake-early-warning-systems/a8088390-d137-418e-830b-26d5a7c9d3f1>

39 OSCE. 2009. Gender and Early Warning Systems An Introduction, <https://www.osce.org/odihr/40269?download=true>

disorders. Research and technological advances have highlighted its harm and damage; but has not looked adequately at forecasting and its prevention. Climate Science has been issuing warnings and alerting governments and other key players; yet, what can communities, especially, children, youth, disabled, women and other vulnerable sections do before and after, has never been the key agenda

Landslide Early Warning: In recent times, we have seen some good practices and strong evidence concerning the effectiveness of landslide EWS (LEWS). One such example in South Asia is Nepal, as reviewed published by Thapa and Adhikar in the journal of Mountain Science – vol 16: ‘In the central Nepal Himalaya, landslides form the major natural hazards annually resulting in many casualties and damage. Structural as well as non-structural measures are in place to minimise the risk of landslide hazard. To reduce the landslide risk, a LEWS as a non-structural measure has been piloted at Sundrawati village (Kalinchowk rural municipality, Dolakha district) to identify its effectiveness. Intensive discussions with stakeholders, aided by landslide susceptibility map, resulted in a better understanding of surface dynamics and the relationship between rainfall and surface movement. This led to the development of a LEWS comprised of extensometers, soil moisture sensors, rain gauge stations, and solar panels as an energy source that blows siren receiving signals via a micro-controller and interfacing circuit. The data generated through the system is transmitted via a Global System for Mobile Communications (GSM) network to responsible organisations in real time to circulate the warning to local residents. This LEWS is user-friendly and can be easily operated by a community. The successful pilot early warning system has saved 495 people from 117 households in August 2018. However, landslide monitoring and dissemination of warning information remains a complex process where technical and communications skill should work closely together.’⁴⁰

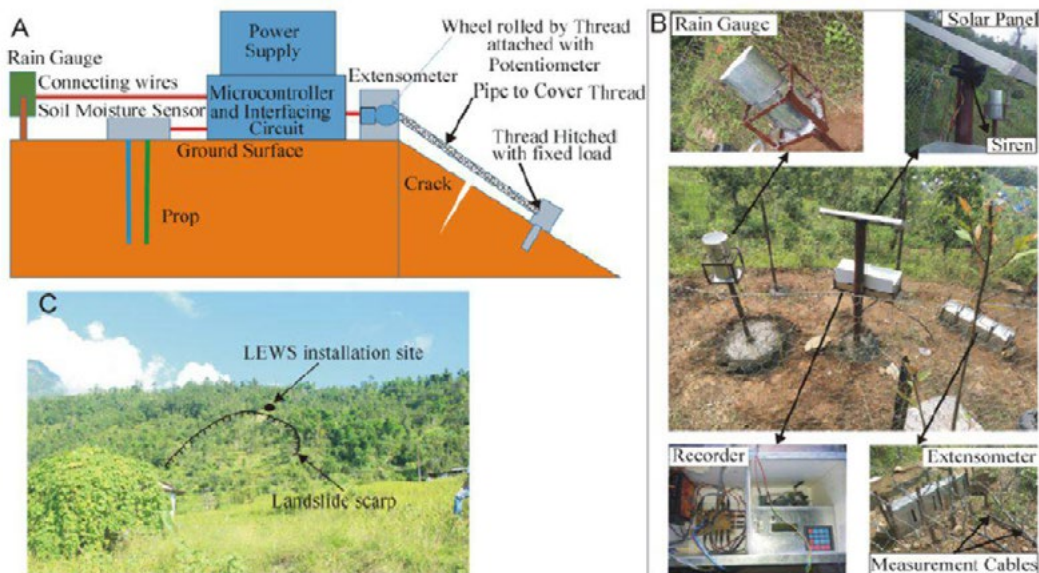


Figure 2.1: Different parts of monitoring systems. A Schematic diagram of automatic extensometer; B. Installed extensometer showing different parts; C. The landslide scarp. The 50W solar panel is oriented towards SW direction and the Tipping box rain gauge is installed with concrete. The recorder is connected with Soil moisture, 4 automatic extensometer and rain gauge.

40 Thapa, P.S. & Adhikari, B.R. J. Mt. Sci. 2019. Development of community-based landslide early warning system in the earthquake-affected areas of Nepal Himalaya. 16: 2701. <https://doi.org/10.1007/s11629-019-5586-5>

“Child Centred Early Warning Systems and Early Action (CC-EWS-EA) saves and protects lives and critical assets”, which are essential for maintaining and sustaining a lifeline for children, youth, women and other vulnerable sections of society. Generally, the human tendency is to say – “let the disaster come, we will manage it!” This can no longer be acceptable given the increasing rapid and chronic disasters taking place.

Technology handling capabilities are highly diverse in remote areas. Child Friendly Spaces (CFS), a key innovation for child centred warnings as well as early action and early recovery, have been mainstreamed in some of the climate fragile and severely vulnerable zones in Assam by Save the Children; however, its incorporation from local governance to district and state level needs closer attention and action. At the level of the administrative departments of the district / state governmental departments, the entire Early Warning Agenda is more about local evacuations and disaster relief, with Last Mile Connectivity not being adequately evident; though a considerable impact has been visible.



The overarching questions still remain – are we prepared? Is the nation prepared? Are Children and other vulnerable sections such as disabled, women, aged, etc. form a priority focus group in early warning and early action? In the current new media scenario, is there adequate effort to navigate from oral tradition to digital domain? Children, though, they are about 38 to 40% of the population in a country, are generally ignored in policy and planning at a broader level or they are included as part of the adult population. And in all disasters, almost 70% of all those who are impacted happen to be Children and Young (SAARC Framework for Care, Protection and Participation of Children in Disasters, 2011). Children as per their age and gender are impacted differentially; hence, need a very specific focus and attention.

When it comes to gender, longstanding discriminatory practices can bar women from being included in decision making structures throughout the conflict cycle and in shaping important response mechanisms. As a result, women’s contributions to informing, planning and benefiting from such efforts as EWS are missed.



For an EWS to integrate gender there must also be a gender balance among those that plan the EWS, collect the data and formulate the responses⁴¹, which in numerous cases is either non-existent or ignored. Social exclusion has been an important indicator in this regard. Numerous examples surfaced during the 2004 Tsunami experience where *dalit* / Scheduled Castes women were ‘seen as *nobodys*’, in the list of persons when the data of the village was being developed. Social, cultural, economic and political factors have generated discrimination against women; aspects that make it is possible to better understand how women suffer disproportionately from some human rights violations, disaster / crises impacts; and how to respond better. ‘Gender is a critical consideration in ensuring effective EWS *leave no one behind*’.⁴² It is a ‘*conditio-sine-qua-non*’ to ensure that EWS are gender sensitive and gender transformative. A recent UNDP study on Gender, Climate Change Information and Early Warning Systems in Africa, has pushed this further towards making women small farmers as visible actors in this process and management as a critical notch towards resilience building at the local level.⁴³

41 OSCE. 2009. Gender and Early Warning Systems. -<https://www.osce.org/odihr/40269?download=true> – p.9
 42 Brown et al., 2019. Gender Transformative Early Warning Systems: Experiences from Nepal and Peru, Rugby, UK: Practical Action
 43 <https://www.adaptation-undp.org/gender-climate-information-and-early-warning-systems-africa>

Current Debate

Integration of science and technology with people friendly methods can give much better results for early warning investments. US Geological Survey research has invested in understanding this across several vulnerable countries. More sensors in more places better the efficiency of the early warning alerts. Sensor density helps better capture the occurrence and dissemination time. Rich data and minimising the algorithm (automatic) is essential to get the signal out. Alerts going out to the public is where the cooperation with the public sector comes in. Getting the message out to the last mile requires critical efforts in enhancing this cooperation. Residents trained to use 'shake alert' signal is the grounding of knowledge into practice. Hospitals, schools, trains and stations, other critical infrastructure, need ground level amelioration of the sensors and public warnings. Obsolete old-school methods and approaches must die. The future is "decentralized approach" to the EW. It needs to be embedded in our culture and behaviour as well as habits. Public Utilities and transportation need these alerts in order to keep people safe in diverse locations⁴⁴. Within these systems and processes children (girls and boys) and women need a uniquely modulated approach through the schools and also their incorporation into educational technologies. EWS are not merely life-saving systems, they are value-based assets, where the digital world must be centred around public access and respecting privacy. Technology domain has much to contribute towards this with the recent developments of drones, it has become even more of a recent imperative. Further, it needs to be converged with the resilience agenda, especially in the area of Family Resilience Planning (FRP), which needs to be entirely women-led.

2.2 EWS for emerging challenges such as Air Pollution in South Asia

Increased disruptions from climate, geo-political and technological triggers require Early Warning Systems to adapt in order to effectively respond to new challenges. The types of disasters that are viewed as most concerning for South Asia in the future are discussed in this section. One of the emerging challenges in the region is air pollution, and papers in this section highlight the existing EWS for air pollution and the scope for improvement, requiring further knowledge transfers, increased investment and improved information dissemination in the sector.

2.2.1 Early Warning of Atmospheric Pollution in Bangladesh: A View

– **Dr. Ahmad Kamruzzaman Majumder**, Professor and Chairman, Department of Environmental Science, Stamford University, Dhaka, Bangladesh

Air pollution is a major environmental issue affecting people across the world. Air Visual reports that Bangladesh, Pakistan and India are some of the most polluted countries in the world with cities sometimes being enveloped by a blanket of smog that blocks visibility. According to WHO, air pollution ranks as one of the top 10 killers in the world, with 65% of all air pollution deaths occurring in Asia. The pollution is worst during the winter season, due to less rainfall in the Indian subcontinent, with vehicles and brick kilns being major influencing factors.

In Asia, many countries have continuous monitoring stations to measure the levels of different pollutants in the air which are operated by governmental or international organisations. Apart from this, the US Embassy has its own Particulate Matter station in almost every country to monitor and evaluate the present situation in each country. These networks are fundamentally structured around a country's regulatory obligation to report monitored air quality data and modelled predictions in accordance with requirements of national or international demand.

Air Quality Index (AQI) and alert systems sourced by monitoring sites are always going to be limited by location, spacing and density. In Bangladesh, only the US Embassy provides the hourly AQI for Dhaka city alone, with many other polluted cities not having a forecasting system, though 11 monitoring stations have been set up under the government. Within urban areas, the reliability of forecasts will improve by increasing the number of sites but monitoring networks will, however, rarely achieve a density that reflects the special distribution of pollutants in a city.

⁴⁴ Thapa, P.S. & Adhikari, B.R. J. Mt. Sci. 2019. Development of community-based landslide early warning system in the earthquake-affected areas of Nepal Himalaya.16: 2701. <https://doi.org/10.1007/s11629-019-5586-5>

People deserve a greater use of sophisticated mapping incorporated into proactive alert services which enable them to gain feedback as to the outdoor activities appropriate to be undertaken during a given day or what route their children should take to and from school. Currently Air Visual provides this information and it has reached the user in a proactive way and is linked into real-time air quality measurements. Apart from the introduction of more sensors within communities, combining current big data with parameters such as proximity to roads with known traffic frequencies is a possible way forward. Future warning systems should include providing data to users by means of maps, a snapshot of air pollution episodes and consequently for exceeding limits issue warnings via e-mail and mobile phone messages. International air quality standards could be used for the interactive warning system.

2.2.2 Early Warning System for Extreme Climate Events such as Air Pollution

– **Dr. Suzanne Bartington**, Clinical Research Fellow in Environmental Health and Honorary Consultant in Public Health, University of Birmingham, UK

Early warning systems are a critical component of climate change adaptation, disaster risk reduction and sustainable development. When effectively implemented, such systems may establish awareness, enable action and protect vulnerable populations against the impacts of environmental hazards and climate-related disasters. There are significant challenges associated with designing such systems, including technical air quality assessment considerations and the arising complexity in public communication of air pollutant exposure information. Furthermore, many low-income countries at present have inadequate infrastructure capabilities for monitoring, forecasting and reporting and therefore rely upon only basic provision of early warning systems. However, future mobile air quality integrated systems, which could provide dynamic information, have exceptional potential in such settings, particularly when developed to empower people to modify individual and collective behaviours.

Consistent epidemiological research has identified adverse impacts of ambient air pollutant exposure upon human health, primarily due to increased cardio-respiratory disease risk.^{45,46} Alongside health impacts arising from chronic exposure to concentrations of air pollutants, specific episodes of abnormally high concentrations of one or more outdoor air pollutants may occur as a consequence of disasters or specific atmospheric conditions. Events such as dust storms, wildfires, construction and long-range air pollution can all generate such 'episodes' which are recognised to be associated with excess morbidity and mortality.^{47,48} Examples in high temperatures are photochemical smog arising from the action of sunlight on nitrogen dioxide (NO_x) and hydrocarbons released from vehicle exhaust, resulting in elevated ozone and particulate matter (PM) concentrations. In cold weather suspensions of PM, NO₂, and sulphur dioxides are recognised and associated with excess morbidity and mortality from respiratory and cardiovascular causes.

Many countries have air quality monitoring networks but most are developed around the need to comply with regulatory obligations. In addition, a combination of monitoring and modelling may be used to assess air quality across a greater area than possible with monitoring alone, assisting in the development of forecasting approaches enabling the prediction of air pollution composition for a given location and time. With regards to human health, the pollutants of most interest for short-term health effects are O₃, PM, NO₂, SO₂ and carbon monoxide (CO). Others such as benzene and heavy metals may present long-term carcinogenic risks, although they are less relevant for short-term alert systems.

Advantages of EWS include increased levels of awareness among the wider public about the health impacts of pollution, therefore facilitating action towards positive policy changes to improve air quality. Systems may also facilitate research, providing a more detailed

45 Committee on the Medical Effects of Air Pollutants (COMEAP). 2009. Long-term exposure to air pollution: effect on mortality. [Accessed 21 June 2019.]

46 Cohen et al. Estimates and 25-year trends of the global burden of disease attributable to ambient air pollution: an analysis of data from the Global Burden of Diseases Study 2015

47 Kang JH, Liu TC, Keller J, & Lin HC. Asian dust storm events are associated with an acute increase in stroke hospitalisation. *J Epidemiol Community Health*. 2013;67(2):125-31. doi: 10.1136/jech-2011-200794.

48 Kang JH, Keller JJ, Chen CS, & Lin HC. Asian dust storm events are associated with an acute increase in pneumonia hospitalization. *Ann Epidemiol*. 2012;22(4):257-63. doi: 10.1016/j.annepidem.2012.02.008.

understanding of the extent to which environmental regulations are effective and providing a mechanism for tracking pollutant episodes associated with extreme climate events. Outputs can provide real-time data allowing individuals and organisations to instigate actions and reduce impacts of pollutant episodes.

Information must be conveyed in an accessible format and be scientifically robust. A range of media routes may be used to communicate these outputs to different audience groups – such as television, radio, newspapers, internet, text messaging. National Air Quality Index (AQI) (providing pollution scales for people to assess their own sensitivity and likelihood of experiencing adverse effects) as well as public health advice to reduce pollution impacts. Yet the differences between bands are essentially arbitrary, as no research has shown a population level threshold of effect for common air pollutants. Furthermore, daily variations can have long-term, or delayed health impacts therefore high values for a short duration may result in symptoms occurring several days or weeks after the episode. It is widely recognised that this ‘lag time’ is the case for mortality effects of hazardous pollutants and to a certain extent hospital admissions. Furthermore, forecasts may be influenced by local pollutant sources and AQIs do not generally consider mixes of pollutants. Therefore, such systems can only provide a guide as to the levels of air pollution an individual will experience.

From a public health perspective, the ultimate aim should be to empower people to modify their behaviour in a way that protects their health as well as the quality of the air they breathe. Studies are required to understand how public understanding is optimised through such processes and how the messaging and action taken is influenced by personal experience of air quality. Clear and concise communication characterising the relationship between air pollutant exposure and ill health is essential in providing effective early warning information systems, be they national AQIs or more localised proactive alert services. Added to this, output must be accessible, easy to interpret, informative and engaging. Visual tools and mapping applications will encourage people to check an index on a regular basis and therefore integrate understanding and usage with daily life.

The ultimate goal of such systems is to secure a cleaner environment, a reduction in health-care burden and costs arising from such events, and a healthier population.

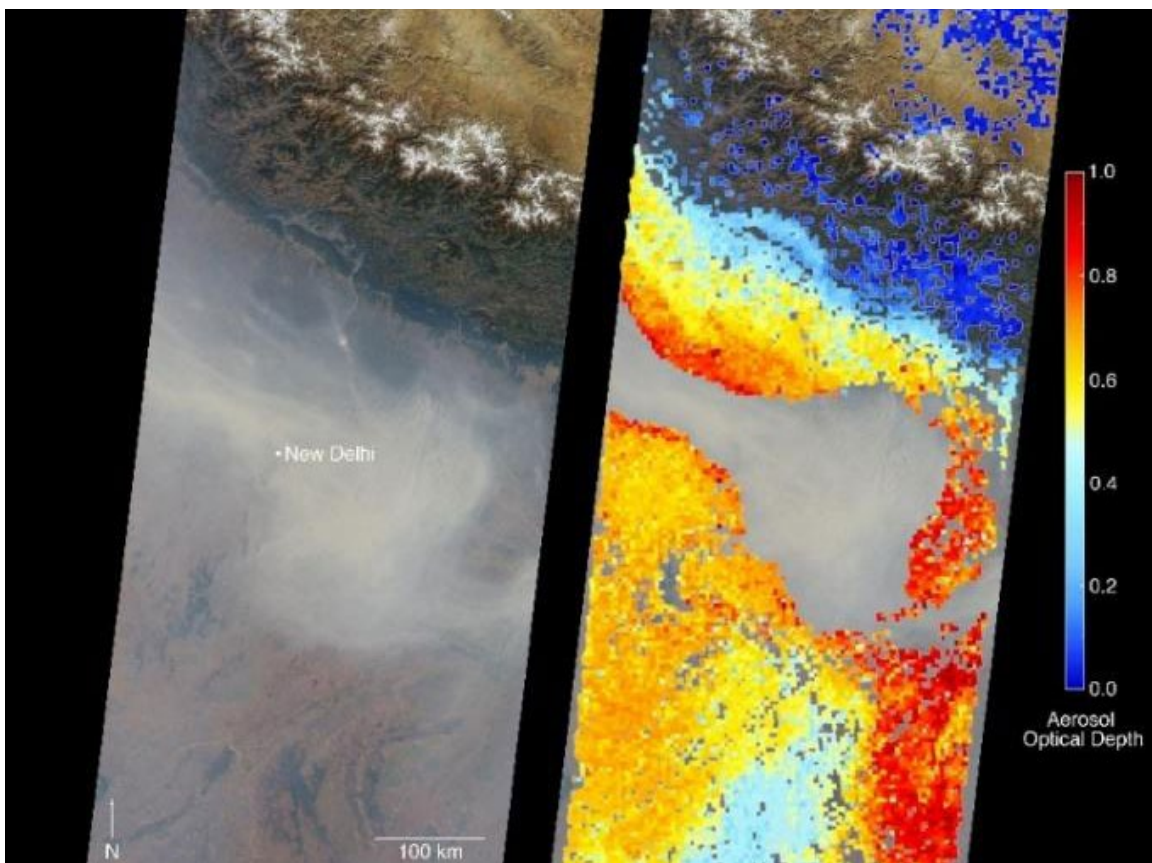


Image credit: NASA/GSFC/LaRC/JPL, MISR Team.

2.2.3 Early Warning System in South Asia: A European View

– **François Grunewald**, Executive and Scientific Director, Groupe URD, France

From Europe, South Asia is seen as a very complex, risk prone but highly promising area. It is watched and observed through many angles as it is an area attracting investments and tourism. Any events in the sub-continent can affect Europe directly (death of citizens, destruction of property) or indirectly (relations between European and Asian friends, economic effects). In addition, the risk of social destabilisation that can accompany large-scale catastrophic event, especially those resulting from the combination of climate change, accelerated urbanisation and demographic growth, is deemed serious enough to require sufficient geopolitical screening of the 'disaster scene'.

Political disorders, wars, disasters caused by a multitude of natural and non-natural events are bringing the largely populated sub-continent into the News in Europe. South Asia is also seen as a land of opportunities: while conflicts keep part of the area under strain, other areas of the sub-continent are developing rapidly. Institutions in most of the subcontinent are very strong. The development of National and sub-national disaster management agencies has been remarkable while the role of civil society networks involved in risk management, including the National Red Cross and Red Crescent Societies, in preparedness, response and recovery have grown significantly. The armies of the region are playing a key role in disaster response, often enshrined in the national constitutions (as seen after the earthquakes in 2005 in Pakistan and in 2010 in Nepal and different episodes of floods over the last decade). The private sector itself is becoming a key player in response, and sometimes even in preparedness (apart from doing so to protect its investments and staff).

Three specific issues linked to EWS and rapid response are at the centre of European interest towards South Asia.

The first one relates to the increased risk of major climate events. Droughts in India and Pakistan, massive floods in all the plains where the upper part of the water basin in the Himalayas Ranges is significantly degraded, where ice and snow are melting in an accelerated manner and where the degraded mountain forests no longer hold much water. Meteorological and scientific cooperation on the trends (dynamics of events through satellite imagery, early detection of ecological vulnerability) exist between Europe and South Asia either at the bilateral level or at the European Commission's level but are far from sufficient in terms of the massive challenges ahead.

The second one relates to the tectonic risk. Cooperation in seismology has existed between European countries and countries such as Nepal for decades. Himalayas' geology and seismicity have attracted European scientists and many geographic/mathematic models on seismic risks have been developed through these cooperation efforts. Yet, the science of early warning for earthquakes is still at its infancy worldwide so 'zones at risks' can be identified and mapped, but incoming tremors are hard to predict.



Fragilized buildings in Kathmandu.

The third one relates to technological risks, especially in the rapidly growing urbanised industrial areas of Pakistan, India, and Sri Lanka. The fact that security standards are still too low and often not followed, the installation of dangerous chemical production and storage in areas at risk on river side, coastlines and inland shore and the behaviours of some investors frequently accused of being predatory (from China, Europe or US) makes the risk of grave technological and environmental disaster very high. The experience of the Bhopal drama is still haunting some of the observers, including the author of this article. Early warning signals in this sector are hard to develop, beyond the bells and the siren alarms when the disaster takes place. Here prevention through regulation and control is the only asset in the hands of the stakeholders. Europe, with its rather elaborated regulatory systems can contribute to the development of a body of laws useful for South Asia



Kokhana, near Kathmandu.

In our increasingly intricate systems and cross planet relations, cooperation between regional institutions, for instance between EU, ICIMOD, and SARC is key. It is certainly the case, but still largely untapped, in disaster science and management.

2.3 State of Early Warning in Bangladesh

– Muhammad Taher, Duryog Nivaran, Dhaka, Bangladesh

Bangladesh has made significant strides in reducing disaster vulnerability through different policy measures and program actions. This brief paper tried to reflect how an improved Early Warning System (EWS) has evolved over the years with improved knowledge, public awareness and response capabilities.

Context

Bangladesh has taken disaster early warning seriously, as is reflected in its various initiatives. In the past, the lack of early warning and disaster preparedness claimed a huge toll on human lives and property, particularly the poor and vulnerable. The super cyclone Bhola that struck the coastal districts of Bangladesh in November 12, 1970 can be used as a contrasting example for lack of early warning and preparedness. This particular disaster event claimed approximately half a million lives⁴⁹. There is no record of any noteworthy action having been taken prior to the event and the national media (print and radio) reported about it almost 24 hours after the cyclone and tidal surge had devastated the coastal districts (SADR 2016)⁵⁰. A totally shocked nation was about to participate in a historic General Election (a month later on December 7, 1970) and their absolute frustration from this disaster, among a number of other reasons, were clearly reflected in the election results.

However, the country continued its struggle against poverty and underdevelopment, with recurring calamities of cyclones, floods, and droughts hindering its achievements during the next two decades. Such events were not only responsible for exacerbating the vulnerability of about half of the country's population who lived below the poverty line, it also caused social and political instability. The situation started to improve from the late 1990s, with the country learning to better cope with hazard impacts and consequently gaining improved economic growth. It has now successfully reduced disaster related mortality and has experienced a steady economic growth rate (average GDP approximately 6% p.a.). The poverty rate is now around 24% with about 12% living in extreme poverty.

49 The official figure of death is 300,000 though, in the absence of any proper assessment of the event, many people believed that the figure could be much higher: from 500,000 to a million.

50 Duryog Nivaran. 2017. "Before the Next Cyclone Comes: Is Bangladesh Building Back Better?" Article by Muhammad Taher in the South Asia Disaster Report 2016, p-60

Bangladesh is one of the world's most vulnerable countries to the risks posed by natural hazards. According to the *Global Climate Risk Index 2018*, Bangladesh ranked 6th of 182 countries most affected by extreme weather events from 1997 to 2016. It is regarded as the fifth most risk-prone country by the world risk index 2012. Bangladesh has recognised 32 different hazards for early warning and preparedness - the major ones that receive attention include recurring floods, cyclones, droughts, salinity intrusion and earthquakes. Disaster management which was mostly limited to providing relief and rehabilitation assistance, has now shifted to a more holistic approach of disaster risk reduction (DRR) at all levels and at all times. Efforts have been focused on mainstreaming the DRR concept in all different plans and procedures of the government. A notable mention of EWS is also found in the largest ever long-term perspective plan of the country, known as Bangladesh Delta Plan 2100⁵¹.

To explain the state of EWS in Bangladesh, we will briefly review some of the key hazard risks, the public's risk-related knowledge and awareness, warning services, and response mechanisms that are in place.

The Key Features of EWS in Bangladesh

Risk knowledge

Climate change has recently added many new risk dimensions and increased the frequency of floods, cyclones and other hazards. Thus, the challenges for an effective EWS have also increased. Concerned institutions and individuals are working to adopt need-based appropriate EWS and DRR measures to combat the situation. Its improved resilience and the declining rate of fatalities from different hazards. is considered to be a direct outcome of the government's resolve: "To achieve a paradigm shift in disaster management from conventional response and relief to a more comprehensive risk reduction culture ...ensuring the resilience of communities to hazards"⁵².

In order to professionalise disaster management, the country now has many different capacity building training programs for government and NGO officials offered by trained disaster management professionals. About half a dozen public and private universities are now offering advance courses (Graduate/Masters) on disaster management.

Many policy makers, public administrators and development workers can now see poverty as a risk factor, though there may still be limited understanding among many about the underlying causes of poverty and vulnerability. Work towards mainstreaming DRR is progressing well, though social exclusion, gender discrimination and marginalisation of particular social groups (e.g., women, people with disability and ethnic minorities) have not yet receiving the attention they deserve.

Nonetheless, community-based disaster preparedness and early warning dissemination are being effectively handled by the relevant NGOs and government agencies. Apart from forming local level disaster management committees (DMCs), community members are being trained to identify their local risks through community-based participatory risk reduction assessments and development of risk reduction plans. However, one of the challenges identified is that these local risk reduction plans become quickly outdated due to the increased mobility of people, impact of climate change and change in the socio-economic situation of people.

The Right to Information Act (RTI Act, 2011) has raised a lot of hopes among the development workers and disadvantaged community groups. While the Act have helped many people gain access to useful information (which was previously denied to them) about different opportunities and provisions that are earmarked for the poor and marginalised peoples, the lack of cooperation from some government officials and members of the law enforcing agencies has reduced its effectiveness⁵³.

51 GoB. 2018. Disaster and Environmental Management: Baseline Study Vol-2, Bangladesh Delta Plan 2100. General Economics Division, Ministry of Planning, Government of Bangladesh, Dhaka

52 This is the Mission Statement of the Ministry of Disaster Management and Relief (MoDMR), Government of Bangladesh (<https://modmr.gov.bd/site/page/f47fd607-91d6-4e82-bdc5-0a3d2079ccc4/Vision,-Mission>).

53 Research Initiatives Bangladesh (RIB) <https://www.rib-bangladesh.org/>

The treasure of indigenous technological knowledge about hazards and how to cope with them with local resources are being revived by some specialist NGOs (e.g., BARCIK, Practical Action, CNRS et al). Although, rapid changes caused by the impacts of climate change made the practice of indigenous technological knowledge difficult at times, some of them still remain relevant and effective. For example, the re-introduction of salinity resilient traditional variety of paddies, cultivation of drought resistant crops in unused sandy shoals as well as different food processing and preservation techniques are helping vulnerable people eking out a bare existence.

Use of digital technology

At the other end of the spectrum, advance cell phone technologies are being used to disseminate hazard-related early warnings, as well as services such as micro-finance and transferring Social Safety Net (SSN) allowances from the government. An Interactive Voice Response (IVR) service through the mobile phone system has been introduced by the government to disseminate weather forecasts and early warning messages for cyclone and floods. The electronic information services provided to the public includes:

- Short Message Services (SMS/ mobile phone) for early warning and preparedness;
- Cell Broadcasting Services (CBS/mobile phone) for early warning and preparedness;
- Web based online damage and need assessment after any disaster;
- Development of hazard and risk maps through satellite and GIS;
- Micro-zonation map of the country;
- Online database for cyclone and flood shelters;
- Online database of volunteers.

Box 2.1 shows how the mobile phone based IVR system works.

Box 2.1: Weather Forecast and Hazard Warning by Mobile Phone

IVR (Interactive Voice Response) Technology

This is being used to promote awareness and give the public easy access to disaster related information. People can now access the pre-recorded weather/disaster related information from their mobile at any time of the day (on a 24/7 basis). Teletalk, the state-owned mobile phone company, has procured equipment for routing this service to the other 5 telecom operators, expanding coverage to the whole country.

Under the arrangement, one can dial (toll-free) 10941 or 1090 from any mobile phone and receive information on the following by pressing the number shown below:

1. Weather forecast for the sea-going fishers;
2. Warning messages for the river ports;
3. Daily weather bulletin;
4. Cyclone warning signals and messages;
5. Information related to floods and water levels (rise or fall of water level) in all major rivers.

Source: *www.MoDMR*, Archive date: 14 March 2019

Regional data sharing

Bangladesh has long faced constraints in obtaining space-based hazard warnings and data from regional and international sources. The country has suffered from a lack of access to real time data on rainfall in the upstream states in India/Nepal and water levels in the international rivers which flow through the Bangladesh territory. Due to lack of access to satellites, data on precipitation was unavailable in advance, and the country would often be caught unprepared by the sudden rush of flood water. However, the situation appears to have improved with the improved capability to monitor hazard risks, particularly for cyclone and floods. This has been possible due to an enhanced level of cooperation and collaboration with India and other countries. According to a government report⁵⁴, Bangladesh has developed a hazard ranking system using risk assessment matrices to measure the effect of disasters on the coastal areas, hills and river entry points in the northern districts. Official protocols have been signed between the Flood Forecasting and Warning Centre (FFWC, Bangladesh) and India Central Water Commission to exchange hydrological and meteorological data on transboundary rivers. Similarly, arrangements were also made to share information on the outbreak of Avian Influenza in the border districts of Bangladesh and India in 2014-15 (GoB 2015, op cit).

Bangladesh has now ratified the SAARC (South Asian Association for Regional Cooperation) agreement for rapid response to natural disasters (effective since 2016) under the integrated framework for disaster risk management (DRM) adopted in 2006. This has opened a window of opportunity to foster regional cooperation between Bangladesh and the other member countries. With the entry of Bangladesh into the “space age” through the launching of its own Satellite (BS 1)⁵⁵ in May 2018, it is expected that the country will now have an improved access to weather related data and further enhance its EWS and response capability.

Response Capability

Over the years, Bangladesh has improved its capacity to respond to disasters, both at institutional and community levels. The introduction of structures, systems (i.e. standing orders, policies, plans) and allocation of increased amounts of resources have enhanced the coping capacities of all concerned. For example, Standing Orders on Disaster (SOD, updated in 2010), with detailed instructions on how people, responsible organisations and committees should prepare themselves and swing into action in the face of disasters, has already proved to be an effective instrument for its EWS.

Box 2.2: Some of the Key Policy and Plan Instruments on DRR/EWS

List of Key Policy and Plan Documents on DRR/EWS

- Disaster Management Act 2012 enacted.
- National Plan for Disaster Management (NPDM) 2016-20
- National Policy for Disaster Management 2010-15
- Standing Orders on Disasters (SOD), 2005
- Bangladesh Climate Change Strategy and Action Plan (BCCSAP) 2009
- National Adaptation plan of Action (NAPA) 2005 (updated in 2009)
- National Environment Management Action Plan (NEMAP) 1995
- Cyclone Preparedness Programme (CPP) On-going since 1972
- DRR integrated in the Sixth (national) Five Year Plan (2011-15)
- Bangladesh Delta Plan (BDP) 2100

While the list (Box 2.2) shows the key policy and plan documents on disaster management, the list of capacity building documents including local level plans and communication materials is too long to accommodate here and no inventory of this exists. Thousands of local volunteers have also been registered and trained (both women and men) to help with disseminating hazard warning signals/messages as well as helping people to move out to safety before a disaster strikes. All of these actions have resulted in the reduction of casualty figures from disasters. According to one estimate, the death toll from cyclones (with similar ferocity) has come down, for

54 GoB. 2015. National Progress Report on the Implementation of the Hyogo Framework of Action (2013-2015), Ministry of Disaster Management and Relief, Dhaka

55 The Bangabandhu Satellite-1 is the 1st Bangladeshi geostationary communications and Broadcasting Satellite. It was manufactured by Thales Alenia Space and launched on 11 May 2018

example, from 300 thousand in 1970 and 130 thousand in 1991 to 227 only in 2016⁵⁶.

Apart from the natural disasters mentioned, the country's EWS needs to particularly take into account the dangerous consequences of ecological damage through natural and human-induced activity. This includes the dumping of toxic effluent and other wastes into open water bodies (i.e., rivers and canals), air pollution by industrial and vehicular emissions and reckless deforestation of the reserve forests for constructing housing and industrial units. Unless immediate and strict measures are taken, much of the EWS efforts will be wasted and the future of the country will become bleak.

How it is Different for Different Hazards

As far as the two major hazards, floods and cyclones, are concerned, the EWS appear to be well developed and largely effective. The FFWC and the Bangladesh Meteorological Department (BMD) produce and disseminate hazard warnings through the mass media and local level institutions. After piloting a community-based flood early warning system in three districts, the government has now been disseminating early warning information through the Department of Disaster Management (DDM) and different DMCs (Disaster Management committees) around the country. During the recent cyclones (Mahasen 2013 and Fani 2019) information updates on the movement of the cyclones were disseminated through the IVR as noted before. The DMCs also received instructions through short message service (SMS). Likewise, weather forecasts were sent out by BMD through the Department of Agricultural Extension (DAE) using their respective official websites (DDM and RIMES).

There is a plan to extend the services to 156 Climate Field Schools in 52 sub-districts (Upazilas) through an ICT based EWS. Geological Survey of Bangladesh (GSB) has established a Landslide early warning system in the hill districts of Chittagong, Cox's Bazar and Teknaf. The MoDMR has allocated 30 community radio stations to different organisations (mainly NGOs), who use them to disseminate early warning messages and instructions to local communities living in disaster prone areas⁵⁷.

NGOs in different parts of the country have mobilised thousands of youth volunteers to disseminate EW messages and offer rescue and relief operations. The biggest among them is of course, the CPP (Cyclone Preparedness Programme) volunteers (50,000), under the MoDMR, mainly working in the coastal areas. In addition, a technical partnership has been made between the government and NGOs under an ESCAP supported project named, Regional Integrated Multi-hazard Early Warning System (RIMES)⁵⁸. The key objective of this technical collaboration was capacity building in early warning at all levels. The key activities of the project included a) expansion of the 1-10 day flood forecasts, b) Pilot flash flood forecasting and application, and d) Operationalise 20-25 day seasonal forecast (RIMES, op cit).

The following expands on the state of EWS in Bangladesh in relation to a few key hazards.

Storm Surge and Tidal Flooding

Bangladesh now has an improved cyclone early warning system (at BMD) with access to advanced satellite-based cyclone forecasts. With the help of mobile telephone technology, it has become easier to send warning messages to people in the coastal areas. Moreover country's CPP volunteers not only help disseminate warnings, but also help evacuate people to safer places and cyclone shelters. However, forecasting and warning for cyclonic storm surge and monsoon flood inundation is still considered insufficient. The Delta Plan envisages strengthening of modelling system and possibly undertaking a pilot program that can forecast and warn people at community level during spring tide in the coastal areas. The plan also envisages building an increased number of cyclone shelters and developing effective monitoring measures for the coastal embankments with adequate funds to undertake emergency repairing of any breaches. However, some specialists urge the government and donors to re-consider building any more

56 Duryog Nivaran. 2017. "Before the Next Cyclone Comes: Is Bangladesh Building Back Better?" Article by Muhammad Taher in the South Asia Disaster Report 2016, p-57 (Figure 4).

57 MoDMR. 2016. National Progress Report 2013-15 for HFA.

58 RIMES. <http://www.rimes.int/>

cyclone shelters because they are often seen as underutilised for various practical reasons. Instead, they suggest helping the poorer households build individual concrete houses that can withstand cyclonic winds.⁵⁹ (Wahra, Gawhar Nayeem, 2018)

Floods

As a deltaic low land, Bangladesh experiences floods almost once every year with varying severity. Monsoon floods affect more people in the country (34%)⁶⁰ than any other hazard. Flood forecasting and warning are delivered at certain points of the rivers by means of mathematical flood modelling. Work is in progress to extend the forecasting services to community levels for the safety of crops, homesteads, livestock and property. Flood shelters are being built in different parts of the country, but are not yet available at all high-risk flood prone areas. So far, BMD built 99 shelters and 156 were being constructed. There is a plan to construct more shelters as well as formulate a policy and plan for flood shelters ⁶¹.

Currently forecasting is made at 54 points on 29 rivers with a lead time of up to 5 days since June 2013, an increase from 38 points on 21 rivers. According to Bangladesh Delta Plan (BDP) 2100, the lead time is planned to be gradually increased to 10 days for better disaster management. These services need to be expanded to more river points on more rivers. Manpower resources and state-of-the-art technology in FFWC should be further improved, for more efficient and timely forecasting and flood warnings.

Landslide

Severity of landslide disaster is increasing day by day in the hill districts (South-east of Bangladesh) and the EWS for it does not seem to be very effective. The situation is such that despite the knowledge and awareness of the potential hazard risks, the poor and vulnerable people living on the hill sides or at the foot of the hills are either unwilling or unable to move to safer places. Attempts by the authorities to forcibly evict the poor families from these hazard-prone areas drew public outcry. Because, without making alternative arrangements it is not acceptable to require people to move. Landslides regularly threaten lives and property of the most vulnerable groups in these areas, including the Rohingya refugees who live in the makeshift camps of Cox's Bazar District. Landslides occur every year during the peak Monsoon rainy days (in June-August). The worst of them occurred in 2007, 2011 and 2017. The landslide in 2007 affected 1.5 million people and claimed 135 lives, while in 2017, the disaster affected 42,000 people and killed 135 (ACAPS Disaster Summary Sheet, 5 June 2018)⁶². Currently, the Rohingya refugee camps that shelter a few hundred thousand displaced Myanmar citizens on the denuded hills at Kutupalong, Cox's Bazar, are known to be at great risk of landslides.

In a country with high population density (8th most populous in the world with 1,115 people living per square kilometer in average) and a high rate of poverty, it is sometimes not so easy to avert disasters. For instance, some people in the coastal areas would defy cyclone and landslide warning and refuse to move to the safety of shelters. This is because they are afraid of leaving behind their possessions even if the value of those are very little compared to their lives. This requires strong motivation and thoughtful arrangements to save lives of these desperate, yet helpless people. We think the greatest challenges for an inclusive EWS lies there.

Droughts

Droughts affect both landowners as well as the poor labourers, when lack of rain and irrigation during the dry seasons render the agricultural fields uncultivable in parts of the country. Agriculture in Bangladesh accounts for about 15% of GDP, but employs approximately 40%

59 The Daily Star, 21 July 2018, p-12, Dhaka.

60 According to a Daily Star report (27 June 2016), referring to government (BBS) statistics, the percentage of households affected by hazards stood as follows in rounded figures: flood 34%, cyclone 21%, thunder storm 15%, drought 15%, water-logging 14%, hailstorm 12%, tidal surge 9%, and river erosion 5%.

61 Bangladesh Water Development Board (BWDB) <http://www.ffwc.gov.bd>

62 ACAPS. Briefing Note Bangladesh Landslides. 21.06.2017. 20170621_acaps_start_briefing_note_bangladesh_landslides.pdf



Photo: AIDMI

of the workforce, who are mostly poor and landless⁶³. As a result, when particular areas of the country (mainly North-West) experience seasonal droughts (locally known as *Monga*) it creates a famine-like situation in the area. EWS for droughts, particularly based on hydrological and agricultural data analysis remains inadequate, particularly compared to neighbouring India which has access to advanced satellite based international data sources on droughts. Hence, the Government of Bangladesh (GoB) plans to undertake studies to identify causes and distribution of drought risks. The BDP 2100⁶⁴ notes that it would undertake a fresh assessment of physical and social factors that affect vulnerability of people to droughts.

The intensity of *Monga* droughts has decreased in recent years, thanks to a major drive by the government and NGOs. In fact, some claim that it has been completely eradicated: “Following successful implementation of massive social safety-net programs (SSNPs) and other effective efforts by the government, the poor are not experiencing any ‘*monga*’ during the past nine years,” said the Divisional Commissioner of Rangpur, Kazi Hassan Ahmed (The Daily Independent, 2017)⁶⁵. According to development experts, the socio-economic condition of the poor in the area has improved remarkably through various income generating activities, involving collaborative efforts by the government, NGO and private sector organisations. Some of the Social Safety-Net Programs undertaken by the government include: Test Relief (TR), Food for Work (FFW), Cash for Work (Kabita), Vulnerable Group Development (VGD), Vulnerable Group Feeding (VGF), employment generation schemes, and the provision of cluster housing for the poor. Some of the income earning activities introduced for the poor include homestead-based aquaculture, horticulture, rearing of poultry birds and animal husbandry.

63 UNDP/UNEP Global Support Programme. <http://globalsupportprogramme.org/nap-gsp>

64 GoB 2018. Disaster and Environmental Management: Baseline Study Vol-2, Bangladesh Delta Plan 2100. General Economics Division, Ministry of Planning, Government of Bangladesh, Dhaka

65 “No existence of Monga: NGO Officials”. The Daily Independent, Dhaka, 12 October, 2017.

Inclusive EWS

The inherent 'exclusive' nature of society in Bangladesh with highly hierarchical social structures makes it difficult to establish an inclusive EWS. Although the excluded groups with many of their disadvantages continue to be among the most vulnerable to hazards, benefits from the disaster responses do not often reach them first. Although the disaster management systems, plans and programs are increasingly becoming aware about the need to be inclusive, the situation on the ground does not seem to be always favourable for such efforts. For example, the social safety-net benefits intended for the excluded groups often end up in the pockets of local power elites. As a result, women, children and persons with disability continue to remain deprived and vulnerable.

The most vulnerable are often forced to live near risk-prone places and are often the most affected by hazards. For example, poorer people living in low-lying areas near a river, or those living close to the coastlines have to bear the worst brunt of cyclone or floods. Some of them develop disability from the injuries received from storms or water surges. We have noted how poor people living in the 'unauthorised' areas on the sides of the hills get killed or injured by sudden landslides; despite being fully aware of the risk. The EWS cannot always force these people to keep away from the high-risk zones.

It is however, quite encouraging that some of the specialised NGOs in Bangladesh are very active in sensitising policy makers and the general public on the importance of giving increased attention to the needs of the excluded groups of people. Among many different activities undertaken by these organisations, our attention was drawn to this example as presented in the Box 2.3.

Box 2.3: Exercise to Promote Inclusion

Located in the coastal area of the Chittagong District in Bangladesh, Baharchora Union is prone to various natural hazards including storms, tropical cyclones, flash floods, storm surges and salinity.

The Centre for Disability and Development (CDD) collaborated with community members and local authorities in Baharchora to organise a multi-hazards simulation exercise. This activity was aimed to raise awareness and prepare the community for disaster through a series of disaster scenarios, and promote inclusion of persons with disabilities in local disaster management processes. Roles of persons with disabilities and the local disabled people's organisations (DPOs) were highlighted throughout the activities.

Taking place in April 2019 at Baharchora Ratnপুর High School (the main evacuation point in the Union), the simulation exercise was divided into five sections where key stages in disaster emergency management were demonstrated. Critical procedures such as risk assessment, identification of the most-at-risk groups, accessible early warning mechanisms and evacuation to shelter as well as shelter management were practiced. This exercise provided opportunities for local authorities and community members to identify 'who does what' if an emergency situation occurs. It was also pointed out during the exercise that priority assistance for the most-at-risk groups, particularly persons with disabilities, the elderly, pregnant women and children, is highly required during an emergency situation.

Source: Disability inclusive DRR Network: <http://www.didrrn.net/inclusive-disaster-preparedness-in-baharchora/internal/>

Conclusion

Bangladesh appears to have all the required tools and qualifications for an effective EWS. It has good knowledge about the country's hazard risks and vulnerabilities. Warning services for different hazards are well developed and they are now more easily disseminated through multiple communication channels to the target audience. The response capability of the communities, NGOs and government officials and local government actors are well developed. They are well informed about the hazards and the concerned people know how vulnerabilities can be reduced. However, the existence of a high level of socio-economic vulnerability among the disadvantaged groups of people impedes their capacity to effectively respond to disaster warnings. Bangladesh may not be a very technologically advanced country, but its community-based EWS is robust and largely effective. Many people in the country have become accustomed to floods, cyclones, droughts and know how to live with such seasonal hazards. However, some of the hazards continue to cause pain to groups of poor and disadvantaged people. Thus, the focus for the new EWS initiatives should be to help ease such pain.

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2.4 Key Conclusions on Disaster Risk Knowledge.

This section draws from peer reviews and contributions for this chapter from:

- **Professor Dr. Ahmad Kamruzzaman Majumder**, Director, Center for Atmospheric Pollution Studies (CAPS) and Chairman, Department of Environmental Science, Stamford University Bangladesh
- **Ali Tauqeer Sheikh**, Development Sector Activist, Islamabad, Pakistan
- **Col. Sanjay Srivastava**, Convener, Lightning Resilient India Campaign; Chairman, Climate Resilient Observing-Systems Promotion Council (CROPC), New Delhi, India
- **Dr. M. Mohapatra** and **M. Sharma**, India Meteorological Department, New Delhi, India

EWS helps people to receive relevant accurate and timely information in a comprehensive way prior to a disaster, enabling people to take effective action to minimise harm to people and property. Knowledge of EWS helps in building an awareness about the risk and resilience profile of a place. Many South Asian countries (e.g., Bangladesh, India, Pakistan) have been trying to strengthen their monitoring capacity and modelling, hand-in-hand with effective information dissemination to the people. (Majumder)

The transboundary nature of hazards presents challenges in monitoring and prediction but also present opportunities for collaboration. For instance, developing countries are facing various challenges (e.g., instrumental capacity, skilled manpower, high cost) to provide information to individual communities. Under these circumstances, the collaboration with neighbouring countries or other developed countries in South Asia could be an effective solution to overcoming such limitations (Majumder, Mohapatra & Sharma). Bi-lateral treaties and transboundary cooperation and early warning systems play a key role in assimilating and sharing data. Collaboration between scientists and organisations working on different types of disasters should be facilitated and governments should have cohesive early warning systems – multi-hazard EWS - for the different types of hazards in the region.

The Sendai Framework for Disaster Risk Reduction (SFDRR 2015-2030) has urged regional coordination on EWS for weather, water, climate change and DRR as key component of disaster risk reduction. There has hardly been any attempt to operationalise EWS in SFDRR in the South Asian transboundary contexts. No wonder the responses in the South Asian region have been ad hoc and fragmented, if not reluctant and erratic, as amply shown in this special publication.

Articles contributed by different authors shows how uneven the progress across the region has been and how this gap can potentially offer windows of opportunity for mutual learning, technical support and collaboration. It also shows how, instead of working in their disciplinary silos, the scientific communities working on air-quality systems have lessons for those working on transboundary flood or drought management.

On Bangladesh, Mohammad Taher has argued that the country is now well-equipped with appropriate strategy, processes and plans for national and local levels. Bangladesh probably offers a good case where flood preparations have moved to second generation of interventions of investing in resilience rather than on relief and rehabilitation services by leveraging, among others the use of digital technology including mobile phones. The experiences potentially have stronger relevance for flood management in other regional countries. It is in this context that the Community-based EWS needs to be tested, as is pointed out by Mihir Bhatt and used more widely. But, as he has highlighted, this will work well if these initiatives are better integrated, community-driven, community-managed in real-time. (Sheikh)

The different types of hazards and their impact on the marginalised was also an area highlighted in this chapter. How knowledge is received and communicated plays a role in its effectiveness in risk mitigation, with EWS needing to be impact based, considerate of the local language/s used, and provide adequate reaction time.

Early warning has evolved as a key factor in demystifying the mystery of fury of natural hazards in terms of understanding the risk, prevention preparedness and response. Since the times of Super Cyclone 1999, Tsunami 2004 to Cyclone Fani, Higgs to Kyarr, it has been a progressive journey, well augmented by technology and minimising the human loss to double digits, yet economic losses remain a challenge even today. Nonetheless, EW has brought in a paradigm shift from Disaster Management to Risk Management thereby stressing now on resilience.

The risk knowledge is of paramount importance as the short-lived climate change extremities like very heavy rain, flash flood, cloudburst, lightning, thunderstorms don't give luxury of tiered response like routine flood, heatwave or drought. In such sudden events, the individual has to react and spontaneously, hence the importance of risk knowledge. (Srivastava)

Thus, in order to minimise lives lost/personal harm individual/community capacity building is required. The inclusion of women, children, elders and those with disabilities in the knowledge collection process will ensure their needs are incorporated into the EWS. This will also facilitate the inclusion of indigenous knowledge into the EWS. As mentioned by Taher, some NGOs are also working towards including proven indigenous knowledge within the disaster management process.

Many countries' warning systems often include protocols such as closing the schools to protect children or shutting down polluting factories. So, there is a need for coordination between the government entities, non-government entities and local communities to promote the EWS within these countries. An effective EWS may lead to a reduction of damages and loss from any natural or anthropogenic threat. Eventually, the accurate real time data on an individual threat may help in taking a critical decision in building effective resilience to it. (Majumder)

Considering the transboundary nature of many of the hazards, there are challenges in continuous monitoring and prediction, transfer of role and responsibility from one country to another and hence the response. There is still scope to improve regional cooperation for exchange of real time data and information, building up capacity of early warning service providers, disaster managers and the community as a whole. Considering the diverse socio-economic conditions and transboundary nature of the hazards, it is recommended to have (i) continuous investment for upgradation of EWS, (ii) improved regional mechanism and cooperation for exchange of data and information, and capacity building, (iii) international support for technology and knowledge sharing for various sectoral applications of early warning. (Mohapatra & Sharma)



Photo: AIDMI

3. Detection, Monitoring, Analysis and Forecasting of the Hazards and Possible Consequences



Predicting and forecasting hazards on a reliable basis lie at the core of the early warning system (EWS). Thus, risk monitoring and warning is a crucial element of EWS, which requires constant monitoring of a hazard to issue timely warning signs and signals. 'Monitoring is the act of collecting information along with a set of proxy variables related to risk, such as rain (correlated with floods/droughts), or seismic waves (correlated with earthquakes). This can be done through direct observations, e.g. through seeing an approaching wildfire or landslide.'⁶⁶

This section of the report presents a collection of experiences on monitoring and forecasting hazards and designing effective warning systems. It explores how forecasting technology changes with the types of hazards, using examples from India. The role of Big Data and Machine Learning in data collection, analysis, monitoring and forecasting is also discussed. The importance of forecasting and warning dissemination from the perspective of Environmental Justice is discussed, followed by case studies from India of community participation in the data collection and monitoring process. The chapter also explores the need for/ improvement of transboundary cooperation in Myanmar, Nepal and Pakistan and highlights successful transboundary EWS in India and Nepal.

3.1 EWS detection, monitoring and forecasting for different hazards – experiences from India

Different hazards require different responses and EWS, as well as multi-hazard EWS, to tackle them effectively. Natural disasters come in the form of Geological/Geophysical hazards which are earth-driven (such as earthquakes, tsunamis, and volcanic eruptions), Meteorological/ Climatological hazards which are weather-related (such as heatwaves, tornadoes, and hurricanes), Hydrological hazards which involve water-related events (such as floods and tsunamis) and Atmospheric hazards which occur in the atmosphere (such as lightning and thunderstorms).

3.1.1 Earthquake Early Warning System and forecasting

– **Sangeeta Baksi**, Scientist, New Delhi and **Akarsh Mishra**, India

The term 'earthquake early warning' (EEW) is used to describe real-time earthquake information systems that have the potential to provide warning prior to significant ground shaking. It is based on a simple concept that telemetry data travels at a speed of light whereas the seismic waves travel at much less speed. Thus, if data about an upcoming earthquake could be collected near the epicentre then this information could be transferred at the speed of light, improving lead time. Warnings are issued with lead times that range from a few seconds to a little more than a minute, primarily based on the distance of the user from the earthquake epicentre (see Figure 3.1).

The whole EEWS is based on the community response and preparedness when the warning is issued, as there is no purpose of an EEWS if the community is unaware of the things which should be done once an official warning is issued. It is also important to educate communities about an earthquake; education is the key for awareness and plays an important role during a disaster.

Microzonation has generally been recognised as one of the most accepted tools in seismic hazard assessment and risk evaluation. It is defined as zonation with respect to ground motion characteristics taking into account source and site conditions. The basis of microzonation is to model the rupture mechanism at the source of an earthquake and evaluate the propagation of waves through the earth to the top of the bedrock to determine the effect of the local soil profile. Thus, developing a hazard map indicating the vulnerability of the area to potential seismic hazards.

⁶⁶ United Nations Development Programme (UNDP), 2018: Five approaches to build functional early warning systems. <https://www.adaptation-undp.org/resources/manual/five-approaches-build-functional-early-warning-systems>

Development of Earthquake Early Warning in India

Areas that have been identified as severe seismic regions include the Himalayan belt in the north from Kashmir to Manipur, Gujarat in the west and Andaman and Nicobar Islands in the southeast. The faults in these areas are capable of generating large magnitude earthquakes that would subject the neighbouring areas to significant ground shaking. High population density and poor adherence to earthquake resistant practices have substantially increased the seismic vulnerability of these regions. However, in the case of a large earthquake in the Himalayas, most of these earthquake vulnerable places can have a lead time of 30 to 70 seconds before the damaging seismic waves arrive. If this real-time seismological information is adequately tuned to the operational requirements of technical systems, life and industrial loss could be significantly reduced. The EEW Network of *Indian Institute of Technology, Roorkee (IITR)* covers the Garhwal Himalayan with an approximate area of 100km x 40km wherein 100 sensors have been installed.

Discussions and Conclusions

Tremendous strides made by our country in communication technology, opening up several frontiers which were inaccessible in the recent past. Connectivity and rapid information are the most important parameters in today's generation development of EEWs. Recent studies have shown that the severity of ground motion in several parts of Delhi would be quite high in case an earthquake of magnitude 7.5 to 8 hits Garhwal. Thus, in the event of a big earthquake (magnitude 7 and above) in the Himalayas, a successful EEW system could surely get credit for giving a second life to a large population of northern India including Delhi. Further, availability of real time strong motion data will substantially boost the information database and research which is being pursued by IITR after big earthquakes. Real time recording would also open avenues for use of this data for disaster management.

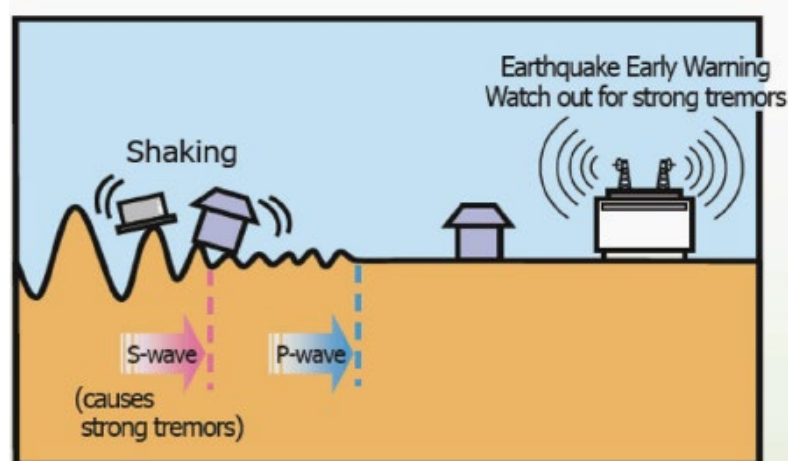


Figure 3.1: Basics of an EEWS.

3.1.2 Achievements of IMD in Heatwave Warning

– **Dr. M. Mohapatra**, Scientist, India Meteorological Department, New Delhi, India

There is a significant warming trend over India in annual mean temperature as well as a trend of significant increases in seasonal temperatures. Climatologically March, April and May are the summer months in India. Hot winds known as “loo” are the marked feature of summers in northern India. During April, temperatures greater than 38°C covers large parts of India with a small pocket of central India having temperature greater than 40°C. During May, the maximum temperature increases and exceeds 40°C over large parts of India, covering north-western parts of the country extending towards the Indo-Gangetic plain and remains more than 40°C in the north-west during June. During summer, most areas of India experience episodes of heatwaves (HW). The new definitions used by India Meteorological Department (IMD) for heatwave for inland and coastal stations are given in Table 3.1.

Table 3.1: Present Criteria used by IMD for defining Heatwave

Heatwave is considered if maximum temperature (Tmax) of a station reaches at least 40°C or more for Plains, 37°C for coastal stations and at least 30°C or more for Hilly regions.

Based on Departure of Tmax from Normal

Heatwave (HW): Departure is 4.5°C to 6.4°C

Severe Heatwave (SHW): Departure is > 6.4°C

Based on Actual Tmax

Heatwave (HW): Actual Tmax ≥ 45°C

Severe Heatwave (SHW): Actual Tmax ≥ 47°C

Past studies indicate that there is an increasing trend in all India Heatwave Days. Many areas of West Rajasthan, Punjab, Haryana, northern parts of East Rajasthan, Madhya Pradesh, Chhattisgarh, Vidarbha, western Uttarakhand, East Uttar Pradesh, western parts of Jharkhand and Bihar, Gangetic West Bengal, northern parts of Odisha, Telangana, Coastal Andhra Pradesh, eastern parts of Rayalaseema and north Tamil Nadu on an average have experienced 8 HW Days per year.

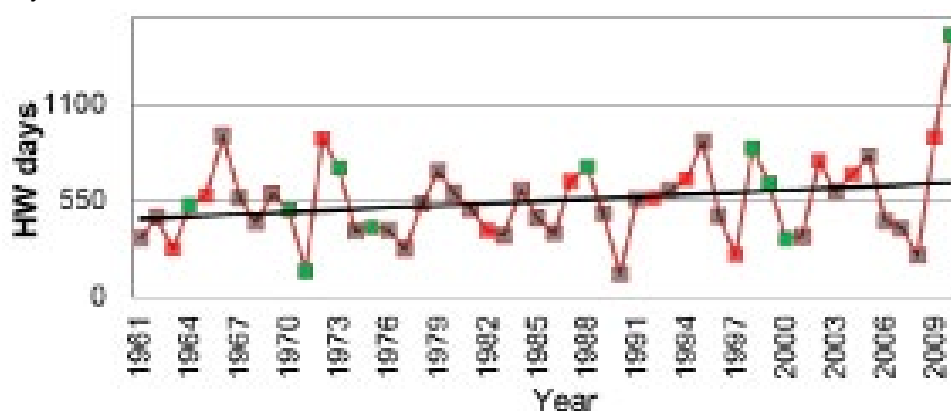


Figure 3.2: All India Heatwave Days from 1961 to 2010.

There are several meteorological conditions which can be responsible for severe HW conditions over India: (i) stronger than normal anticyclone leading to subsidence of air, (ii) clear sky conditions leading to high solar radiation, (iii) hot air advection from the northwest of India, (iv) formation of intense low pressure system over the Bay of Bengal and consequently weakening the High Pressure Cell affecting moisture incursion over east coast, prevalence of north-westerly wind and hence HW conditions, (v) below normal or subdued thunderstorm activity, (vi) late setting or cutting-off of sea breeze from coastal regions, (vii) late arrival of southwest monsoon in the region (in the month of June).

IMD is constantly engaged in providing forecast products and early warning for hot weather conditions at different spatial and temporal scales. Since 2016 the IMD issues forecasts on different time scale during the hot weather season (March to June) including HWs. The different time scales range from ‘Now’ casting (few hours) at city level, short to medium range (up to 5 days) at district levels, extended range (up to 4 weeks) at meteorological sub-division level and long-range forecast (seasonal outlook on maximum temperature and heatwave) at sub-divisional scale. There has been significant improvement in HW warning with a lead period of up to 5 days in recent years with the introduction of the high resolution global model for short to medium range forecasting. There were also significant improvements in the extended range (up to two weeks) and season (up to 3 months) forecasts of maximum temperature and HW in 2016 and 2017 with the introduction of coupled Climate Forecasting System model.

Daily a special bulletin is prepared in both text and graphic form indicating past heat conditions in the country and the forecast and warning on HW for the next five days. The warning on HW is disseminated to the general public and disaster managers at national and state level through IMD headquarters and state level Meteorological and Regional Meteorological Centres. For warning dissemination, a special web page has been created for the dissemination of HW information from the IMD website (www.imd.gov.in). The press and electronic media are briefed twice a day

and a special press release on the HW condition for the next two weeks is issued on a weekly basis. In addition, the HW bulletin is also issued to various stakeholders like health, surface transport, municipal corporations, power sector, etc. by different offices.

This accurate and higher lead period warning on HW by IMD along with the preparedness and response measures of state and central level disaster management agencies and major roles played by NGOs and press and electronic media have resulted in a reduction in loss of life by almost 50% in 2017 compared to 2016. Further, the death toll was restricted to less than 100 in 2017 summer season (by the end of April).

3.1.3 Early Warning System for Lightning: A View

– **Col. Sanjay Srivastava**, Convener, Lightning Resilient India Campaign and Chairman, Climate Resilient Observing-Systems Promotion Council ((CROPC);
Thomas Prasad V, Director, CROPC; and
Samam Srivastava, CROPC, New Delhi, India

Early warning system has to be at lightning speed or the warning validity is out of context. This has seen a revolution in modern times, especially with the abundance of ground-based lightning detection devices and satellite based sensors enabled weather forecast being available from International and local weather agencies. Even modelling based forecasting systems are progressing rapidly to cope with the need to predict lightning at least a day ahead. These forecasts are available even over your smart phone. However, how reliable they are depends on the sensors network of their parameters.

Lightning is defined as a flash of light that is caused by the discharge of electricity in the atmosphere. Due to convection the moisture moves up rapidly within a thundercloud up to the sky and converts to many small bits of ice (frozen raindrops) which collide with each other resulting in an electric charge and low VHF sound. When the lighter positive charges and heavier negative charges in a cloud grow large enough, a giant spark – lightning – occurs between the two charges within the cloud called inter-cloud or intra-cloud (IC) lightning producing flashes and electromagnetic currents. There are Low VHF signals generated in the range of 01-30 mhz. lightning. The negative charge which is present at the bottom of the intra-cloud gets attracted towards the positive charged earth through a conducting medium which is generally provided by damp clouds and hence has a zig zag field. This is called cloud to ground (CG) lightning which strikes with current, flash and sound (thunder) at the nearest point on earth that is the highest point on earth be it building, tree, tower on any other structure. Lightning strikes vertically first followed by lateral/parallel strikes.

Therefore, to detect lightning it's ideal to detect the electric charge, light and sound (Low VHF sound). One of the forecasting methods is based on Low VHF Lightning Detection frequencies which are in the range of 1-30 MHz The IC signals are in the range of 13-30 MHz. followed by CG signals in the frequency range of 01-12 MHz. The Lightning which strikes the ground through CG strikes are preceded by IC strikes. Thus, detection of IC plays a critical role in lightning forecasting. Therefore, the Lightning Detection Sensor (LDS) chosen by stakeholders should cover a complete range of frequency from 1-30 MHz for comprehensive coverage of Lightning VHF spectrum and precision in Lightning forecast.

Lightning occurs mainly in six phases: Phase 1-Good weather, 2-Initial phase, 3-Growth phase, 4-Mature Phase, 5-Dissipation phase and 6-Good weather. It is during phase 4 and 5 when lightning strikes the ground and hence must be monitored.

There are different types of lightning warning systems in the market. It is important for users to select the right type of lightning warning system to achieve the desired purpose.

It is ideal for a country to set up its own lightning detection and forecast systems along with efficient and prompt actionable dissemination systems. Countries like U.S.A., China, and Europe meteorological agencies have deployed satellite based Geostationary Lightning Mapping sensors in addition to the countrywide network of ground based LDS. A good lightning EWS can reduce deaths by 90%. The chart below shows the importance of Lightning EW system along with lightning strike rates and average fatalities and so the importance of Lightning Early Warning in saving fatalities.

Most of the developed countries like U.S.A., European countries, Singapore, Japan, China etc. have ground-based sophisticated radars, electric field meters, Low VHF detectors, satellite based sensors to detect and monitor thunderstorms and lightning. India too has evolved similar systems and IMD has started issuing sensor network based early warnings. India is also following ensemble model based 24 hours lightning forecast.

The discrete and random nature of lightning makes it particularly suitable for the **probabilistic predictions** provided by ensemble forecasts.

An ensemble forecast⁶⁷ is a set of forecasts that represent the range of future weather possibilities and their likelihood of occurrence is being used by many countries including India. Ensemble forecasts are being used to create maps on the probability that lightning flash density will exceed a certain threshold. It has been found very useful as it gives adequate time for preparedness. (Figure 3.3).

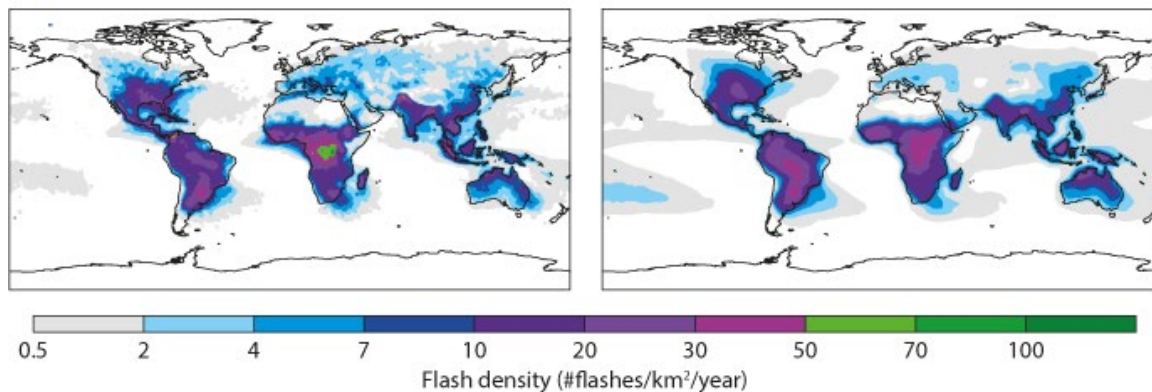


Figure 3.3. Lightning zones in world. Annual mean lightning flash densities from the LIS/OTD satellite climatology (left) and from ten one-year-long ECMWF model runs (right), both at 80 km resolution.

There are various local **traditional lightning EW** which should also be publicised as they are based on visible natural phenomenon and their impact on human body/surroundings is apparent, providing adequate warning of impending strikes. For example, the 30-30 Rule of counting the seconds between seeing lightning and hearing thunder is an easy way to determine the threat of lightning in your area. Similarly, black cumulonimbus cloud with moderate to heavy wind indicate lightning in the area and so do the lightning flashes in the sky. Their cognizance must be taken and those at risk should find safe shelter as soon as possible. (Figure 3.4).



Figure 3.4. Lightning warning signs.

With the abundance of sensors and growth of communication and technology, lightning in developed countries has been well tracked and an effective forecast system has evolved. The essence of Lightning EW lies in its operationalisation up to last mile along with supporting program of capacity building through education, training and awareness and installation of Lightning Protection devices.

This contribution draws from the following sources:

1. ECMWF – European Centre for Medium-Range Weather Forecasts.
2. Europe Met Service
3. IMD, IITM Network
4. Lightning as Atmospheric Electricity, Jason GU and K Srinivasan, Dalhousie University
5. Lightning Detection, Forecasting and safe grid system- Sanjay Srivastava
6. NOAA – National Oceanic and Atmospheric Administration
7. UCAR – The University Corporation for Atmospheric Research

⁶⁷ European Centre for Medium-Range Weather Forecasts (ECMWF). <https://www.ecmwf.int/en/about/media-centre/fact-sheet-ensemble-weather-forecasting>

3.1.4 SAFAR Mechanism: In A New Frame

– Arindam Upmanyu, Scholar, Indian School of Public Policy, Delhi, India

The SAFAR⁶⁸ (System of Air Quality Forecasting and Research) system introduced in India, introduced AQI (Air Quality Index) in 2010 – a colour-coded system to inform the citizenry of air quality. It has standardised particular nomenclature reflecting the prevailing level of air quality in a specific city/location. The SAFAR India report explains the system in the following manner:

‘These are six categories, namely: Good, Satisfactory, Moderately Polluted, Poor, Very Poor, and Severe. Each of these categories is decided based on ambient concentration values of air pollutants and their likely health impacts (known as health breakpoints). AQ subindex and health breakpoints are evolved for eight pollutants (PM10, PM2.5, NO2, SO2, CO, O3, NH3, and Pb) for which short-term (up to 24-hours).’⁶⁹

The existing structure of the AQI needs to be further enhanced to make it more comprehensive. Listed below are a few novel ideas/ research which could be adapted to in the Indian context:

1. David Marquez-Viloria, J. S. Botero-Valencia, Juan Villegas-Ceballos in their paper titled ‘A Low Cost Georeferenced Air-Pollution Measurement System Used as Early Warning Tool’ (2016) propose a specific low-cost geo-referencing measurement system for measuring air pollution and offering information on the degree of presence of particulate matter PM1, PM2.5 and PM10 in real time. The whole system is connected to a low-cost microprocessor with integrated Wi-Fi capabilities which allows data to be sent to the cloud in real-time using MQTT (Message Queuing Telemetry Transport) protocol. This data can be georeferenced and published on an open access platform and used for Internet of Things (IoT) related applications and other forms of visualizations and analysis. In this way, the information is public and the residents of a particular area can look for the nearest measure of the environmental conditions.⁷⁰
2. In China, a hybrid forecasting model, ICEEMD-WOA-SVM (improved complete ensemble empirical mode decomposition – whale optimization algorithm – support vector machine), has been proposed for forecasting major pollutants. This model rests on a fuzzy framework. This is employed for transforming forecast results into air-quality forecasts. Daily air pollution concentrations of six air pollutants from three cities in China (i.e., Taiyuan, Harbin and Chongqing) were used as case study examples to evaluate the efficiency and effectiveness of the developed air model. Experimental results demonstrate that both the accuracy and the effectiveness of the developed system are greatly superior for air quality early warning. Furthermore, the application of forecasting and evaluation enables the informative and effective quantification of future air quality, offering a significant advantage, and can be employed to develop rapid air quality EWS. The performance of the proposed ICEEMDWOA-SVM model has proved to be superior compared to the four benchmark models [ARMA (Autoregressive Moving (Integrated) Average), PSO-SVM (particle swarm optimization – support vector regression), WOA-SVM (Whale optimization algorithm) and CEEMDSVM – WOA (complementary ensemble empirical mode decomposition – support vector regression – Whale optimization algorithm)] in these three cities. In consonance with this particular study and other such research being conducted world over – this should be seen as a strong reason to push the Indian air quality innovation community to reframe the existing SAFAR system and improve air quality forecasting mechanisms.⁷¹

The methods listed above are macro approaches to be critiqued by technocrats, reviewed by academicians and implemented by bureaucrats. Meanwhile, what can a layperson do or advocate for?

68 SAFAR: System of Air Quality Forecasting And Research in Metropolitan Cities like Delhi | Hindi Water Portal.” n.d. Accessed September 24, 2019. <https://hindi.indiawaterportal.org/node/54927>

69 SAFAR - India.” n.d. Accessed September 24, 2019. <http://safar.tropmet.res.in>. AQI-47-12Details.

70 A Low Cost Georeferenced Air-Pollution Measurement System Used as Early Warning Tool - IEEE Conference Publication.” n.d. Accessed September 22, 2019. <https://ieeexplore.ieee.org/abstract/document/7743366>.

71 Air Quality Early-Warning System for Cities in China - Science Direct.” n.d. Accessed September 24, 2019. <https://www.sciencedirect.com/science/article/pii/S1352231016308536?via%3Dihub>

An inspiring story comes from Pimpri-Chinchwad in the extended limits of Pune, Maharashtra India. To spread environmental awareness among school children the Mayor Rahul Jadhav initiated a project called ‘SAFAR-School Flag Awareness Program on Air Quality’ - started by the Indian Institute of Tropical Meteorology in Pune along with the Pimpri-Chinchwad Municipal Corporation (PCMC). Schools participating in the project are supposed to announce the AQI daily using the six AQI categories, and six colours of flags representing them. “After announcing the AQI at the morning assembly, they will have to raise and display the corresponding colour flag at the school.”⁷² Not only would this initiative raise awareness among students but it would also encourage them to find solutions closer to them in their vicinity, and would also potentially carry a message to every household every day. This could potentially raise social capital in societies. Such an initiative must be encouraged by members in the academia and bureaucracy and suitably changed and adopted by non-government and corporate entities. After all, it takes only a spark to light a fire.

On a global scale, a ray of hope has come in with adoption of the Paris Climate Accord (2016). Meanwhile, in India, NCAP – National Clean Air Program has resurrected hope. A prospective Green New Deal in the United States, as ambiguous as it may seem today, it is definitely a welcome thought. The goal seems far, yet, reachable.

Forecast accuracy builds trust within communities, and timely dissemination of warnings saves lives. Big data and machine learning are the newest forms of data collection and analysis and are increasingly used in disaster forecasting, warning dissemination and disaster preparedness and recovery.

3.2 Big Data Innovations: Impact-based Forecasting, Risk-informed Early Warning System

– **Maria Bernadet K. Dewi**, Consultant, Asian and Pacific Centre for the Development of Disaster Information Management (APDIM), Information and Communications Technology and Disaster Risk Reduction Division, United Nations Economic and Social Commission for Asia and the Pacific; and **Sanjay Srivastava**, Chief, Disaster Risk Reduction Section, Information and Communications Technology and Disaster Risk Reduction Division, United Nations Economic and Social Commission for Asia and the Pacific, Thailand

Big Data has evolved at an unbelievably fast pace. In specific context of disaster resilience, Big Data can help in all four phases of disaster management: prevention, preparedness, response, and recovery. Two major sources of big data—dedicated sensor networks (e.g., earthquake detection using seismometers) and multi-purpose sensor networks (e.g., social media such as Twitter using smartphones) – have both demonstrated their usefulness in disasters such as the Tohoku Earthquake⁷³. However, two of the major big data challenges that continue to exist in several countries are: Variety (integration of many data sources including dedicated sensors and multi-purpose sensors), and Veracity (filtering of Big Noise in Big Data to achieve high quality information).

Big Data has opened-up promising approaches to disaster resilience. Figure 3.5 illustrates the distribution of reviewed articles and their year of publication. It can be observed that satellite imagery, crowdsourcing, and social media are becoming more popular sources of data for disaster risk management.⁷⁴ Emerging technological innovations including social media, location-based systems, radio frequency identification, and big data analytics are considered promising powerful tools that may help during the disaster management cycle. Mobile phone data, for example, can provide an incredibly detailed view of population behaviour and movement in areas

72 Pimpri Mayor Launches Project on Air Quality; Schools Taking Part Will Display Flag Indicating Pollution Level.” 2019. The Indian Express (blog). September 8, 2019. <https://indianexpress.com/article/cities/pune/pimpri-mayor-launches-project-on-air-quality-schools-taking-part-will-display-flag-indicating-pollution-level-5976865/>.

73 CERCS. 2013.JST/NSF Joint Workshop Report on Big Data and Disaster Management, C. Pu and M. Kitsuregawa Technical Report No. GIT-CERCS-13-09; Georgia Institute of Technology,

74 Yu, M., Yang, C. & Li, Y., 2018. Big Data in Natural Disaster Management: A Review Geosciences 2018, 8, 165; doi:10.3390/geosciences8050165.

that were previously observed infrequently and indirectly. Social networks like Twitter, Facebook etc. are already improving the ability of humanitarian and disaster risk reduction organisations to monitor and respond to hazards. Further opportunities are increasing significantly in high disaster risk developing countries, as mobile phone penetration and access to internet for example are increasing.

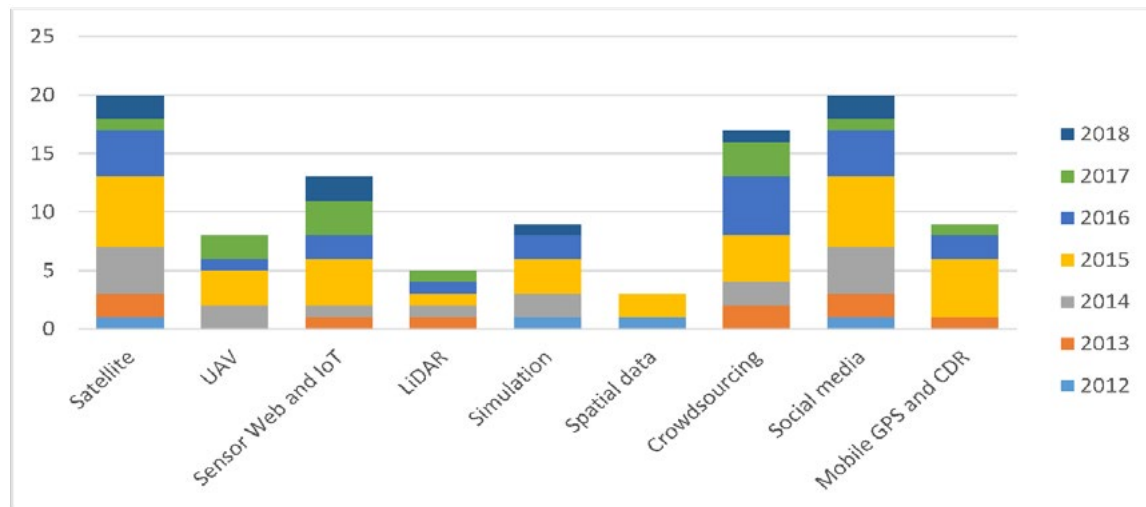


Figure 3.5: Increasing use of Satellite imagery, crowdsourcing, and social media for disaster management.

Source: Manzhu Yu and others reviewed articles by major data sources (2012-2018)⁷⁵

This growing emphasis on increasing resilience has occurred at the same time as the emergence of 'Big Data'. In fact, 'Big Data', is as an ecosystem made up of three factors: (i) data crumbs that comprise of digital data from sources as diverse as satellites to mobile phones, (ii) capacity to analyse and use that data, and (iii) community - people who produce, analyse, and/or use the data.⁷⁶

Disaster resilience calls for a wide spectrum of data driven activities and actions. For example, Big Data fills in the critical data gaps to operationalise the emerging trends in multi-hazard EWS. Helping systems to provide impact-based, risk informed, people-centred and end-to-end early warning services at different scales: regional, sub-regional, national, local, and community-level. Big Data also enables the transition from early-warning to early-action – such as forecast-based financing, forecast-based social protection and risk prevention.

Big Data enables descriptive, predictive, prescriptive and discursive analytics that addresses gaps in information flows in pre-, response and post disaster situations (Figure 3.6).

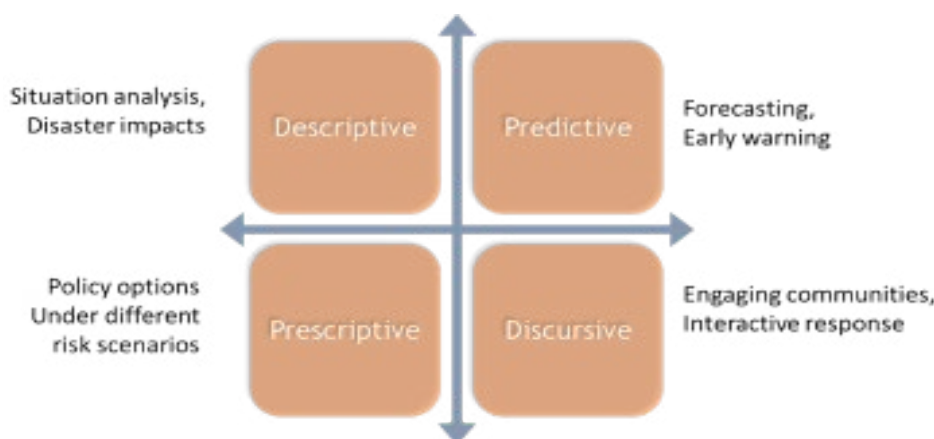


Figure 3.6: Big Data analytics functions for disaster resilience.

Source: ESCAP, based on Data Pop Alliance Synthesis Report (2015)

⁷⁵ Ibid

⁷⁶ Data-Pop Alliance. 2015. Big Data for Climate Change and Disaster Resilience: Realising the Benefits for Developing Countries. Data-pop Alliance Synthesis Report. September. Available at: <http://datapopalliance.org/wp-content/uploads/2015/11/Big-Data-for-Resilience-2015-Report.pdf>.

Predictive Analytics: Prediction and Forecasting

Predictive analytics are used for prediction and forecasting, for both geological and hydro-meteorological hazards. Floods or cyclone forecasting approaches rely on the underlying physical models and parameters. The nested modelling that couples hydrologic and climate/ weather models is increasingly becoming more effective with improved lead time forecast and better locational accuracy. Similarly, tropical cyclone simulation includes sea surface temperature, ocean state, atmospheric parameters and retrospective seasonal prediction. The model simulations thus play an important role in the predictive analysis of floods and cyclone (Figure 3.7). Earth observation satellites provide important hydrologic, land cover, atmospheric and ocean related data that are used in simulation and forecasting models. While sensor web and IoT help data gathering, communication and information dissemination, social media plays an important role in disseminating interactively early warning messages across communities at risk.

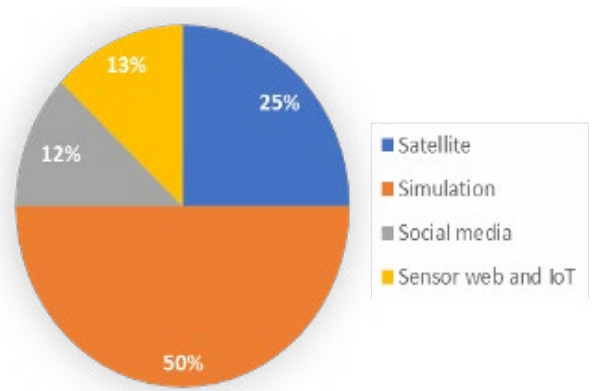


Figure 3.7: Predictive analysis that is effective in cyclone and flood forecasting.

Source: Manzhu Yu and others 2018.⁷⁷

Impact-based flood forecasting

Sri Lanka flood forecasting 2018

Big Data fills in the critical data gaps that exist in operationalising flood forecasting and early warning. The recent advances in climate modelling, such as ensemble prediction system (EPS), indicate a promising trend in flood forecasting with longer lead time. The EPS is often better than single (deterministic) forecasts, showing the possibility of severe rainfall in case the single forecast fails to capture it as well as estimating forecast uncertainty from the width of ensemble spread (Figure 3.8). The EPS helps substantially in flood forecasting and early warning in transboundary river-basins, but is often constrained by access to and availability of hydrologic data. This approach indicates benefits in incorporating rainfall predictions into the climate/ weather models from multiple weather centres, as well as rainfall and river observations from multiple platforms and institutions. For some stations, skilful forecast lead times are as long as 16 days⁷⁸.

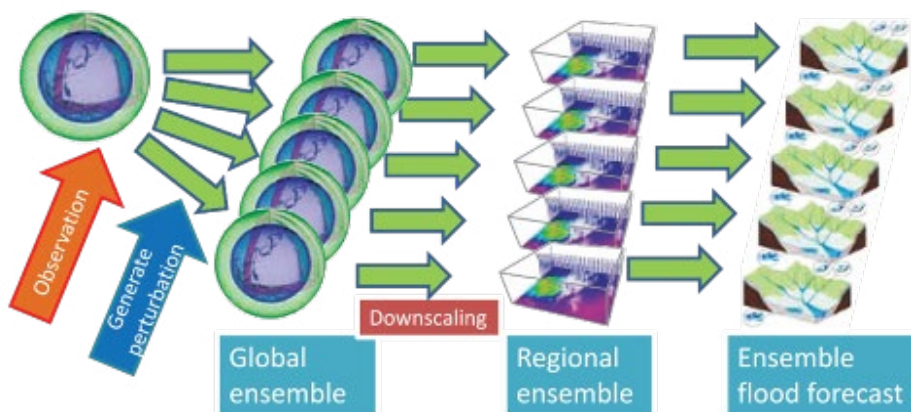


Figure 3.8: Ensemble prediction system: nested modelling for flood forecasting with longer lead-time.

Source: Tomoki Ushiyama, ICHARM 2019.

77 Manzhu Yu, Chaowei Yang and Yun Li. 2018. Big Data in Natural Disaster Management: A Review. *Geosciences* 2018, 8, 165; doi:10.3390/geosciences8050165.

78 Satya Priya Lnu and others. 2017. Flood risk assessment and forecasting for the Ganges-Brahmaputra-Meghna River basins. Washington, D.C.: World Bank Group. <http://documents.worldbank.org/curated/en/272611508255892547/Flood-risk-assessment-and-forecasting-for-the-Ganges-Brahmaputra-Meghna-River-basins>.

The experience of EPS for 2018 flood forecasting in Sri Lanka was a mixed bag of success. While it captured the intensity of torrential rain two days in advance, the forecast was not precise in its exact location (Figure 3.9)⁷⁹. Location accuracy can be improved not only with the quality of downscaling ensembles but with densification of data network and putting in place an appropriate Big Data ecosystem.

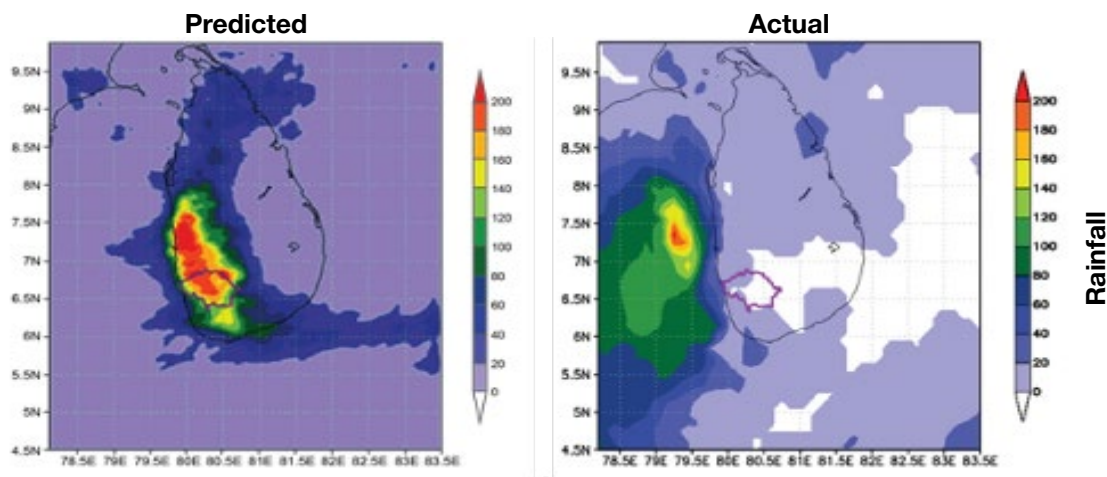


Figure 3.9: Predicted and actual rainfall in Sri Lanka, for 24 May 2019.

Source: Tomoki Ushiyama, ICHARM 2019.

Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

The emerging trend of impact-based flood forecasting is realised with the Big Data applications. The Big Data based system approach allows end users to build impact scenarios of the forecasted event by crossing real-time data on flood hazard, exposure and vulnerability. With web-GIS platform it is possible to aggregate data both in a temporal or spatial way and to build scenarios of risk and damage to develop impact-based flood forecasting⁸⁰.

Impact-based cyclone forecasting

Tropical Cyclone Fani, Puri, India, May 2019

One of the cyclone impact-based forecasts by Pacific Disaster Centre was produced for Tropical Cyclone Fani. This DisasterAWARE consists of estimated wind impacts presented in an effective way for a wide area, and the potential impacted population and economic exposure within a particular area (Figure 3.10).⁸¹ Furthermore, DisasterAWARE also counts the breakdown of potential logistical requirements and evacuation shelters for emergency response. Thus, potentially helping a timely evacuation management by local authorities and citizens to reduce casualties.

79 Tomoki Ushiyama, International Centre for Water Hazard and Risk Management (ICARM). 2019. Real time ensemble forecasting for flood early warning in Sri Lanka. 3rd Plenary Session for Platform on Water Resilience and Disaster in Sri Lanka. 20 February.

80 The Dewetra platform initiative by the WMO Commission for Hydrology and Italian Department of Civil Protection: A data sharing, multi-hazard forecasting and Early Warning System available for any WMO member. Multi-hazard Early Warning Conference. 22-23 May 2017. Cancun. Available at: <https://www.wmo.int/pages/prog/drr/documents/mhews-ref/posters-pdfs/7.101%20-%20Rossi%20L%20et%20al%20Dewetra%20Platform%20MHEWC%202017%20poster.pdf>.

81 Pacific Disaster Centre, 2 May 2019. Tropical Cyclone Fani: Puri, India – Impact Analysis, Advisory 2 May 2019. https://reliefweb.int/sites/reliefweb.int/files/resources/PDC_TC_Fani_Estimated_Impact_Analysis_2MAY_2100UTC.pdf. Accessed on 15 July 2019.

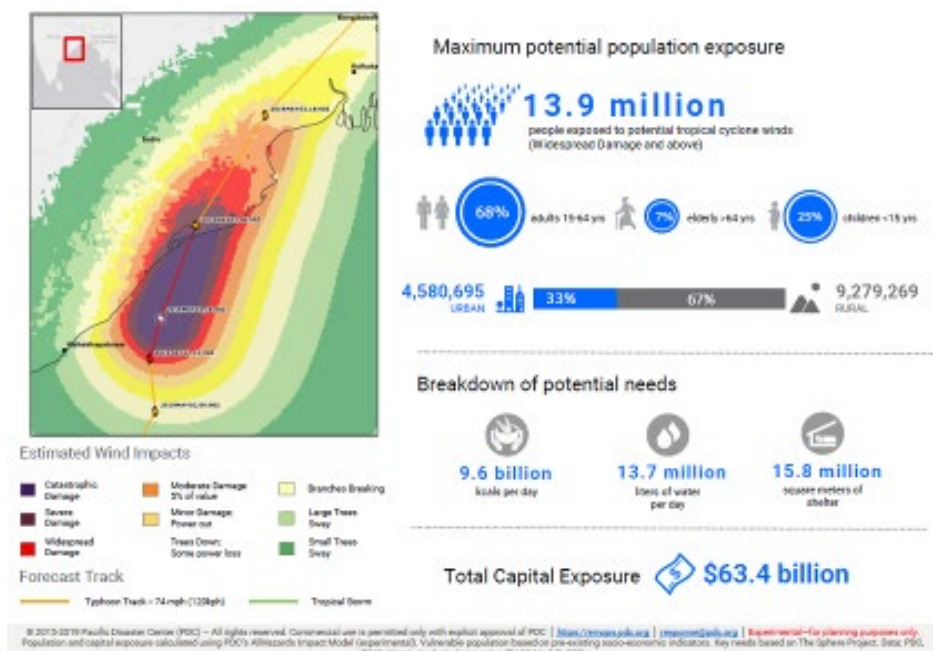


Figure 3.10: Tropical Cyclone Fani – Impact Assessment on 2 May 2019.

Source: PDC 2019.

Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

System for Potential Impact Assessment and Response Planning

For managing disaster risks effectively, efficient decision support systems are required that integrate cutting-edge technologies, big data analytics and machine learning algorithm to bring innovation to the way data is used, and to provide tailor-made actionable early warning information for informed planning and decision-making. System for Multi-hazard Potential Impact Assessment, Alert, Emergency Response Planning and Tracking (SMART) and System for Assessing, Tracking, and Alerting Disaster Risk Information based on Dynamic Risk Knowledge (SATARK) incorporate a range of weather forecast products to guide decision-makers to take action with confidence. During the Gaja cyclone in November 2018, and Fani cyclone in May 2019, both systems provided science-based information, which proved to be useful in guiding operational users in Tamil Nadu and Odisha Disaster Management Agencies in disaster preparedness and risk communication. Although the systems are designed for multi-hazard impact-based forecasting, they provide information that is also useful in development planning and long-term DRR, consequently maintaining the systems' relevance for other sectors.

SMART and SATARK were developed by RIMES to dynamically assess potential risk based on the hazard forecast, and to guide disaster management agencies with available impact management options for risk reduction and enhanced preparedness.⁸² The salient features of the systems are their one-stop comprehensive database integrating disaster related datasets with exposure and resource location as well as forecast information (Figure 3.11). The integration of hazard, exposure and resource information allows for a better understanding and forecasting of disaster risk, and identification of location-specific potential impacts and response advisories. These impacts and advisories are communicated via the Mobile Application to different users to either register and track distress calls, track alert calls, and/or evaluate risk reduction measures.

82 Regional Integrated Multi-hazard Early Warning System (RIMES). 2019. Multi-hazard Potential Impact Assessment, Alert, Emergency Response Planning and Tracking (SMART) and System for Assessing, Tracking, and Alerting Disaster Risk Information based on Dynamic Risk Knowledge (SATARK). Unpublished report.

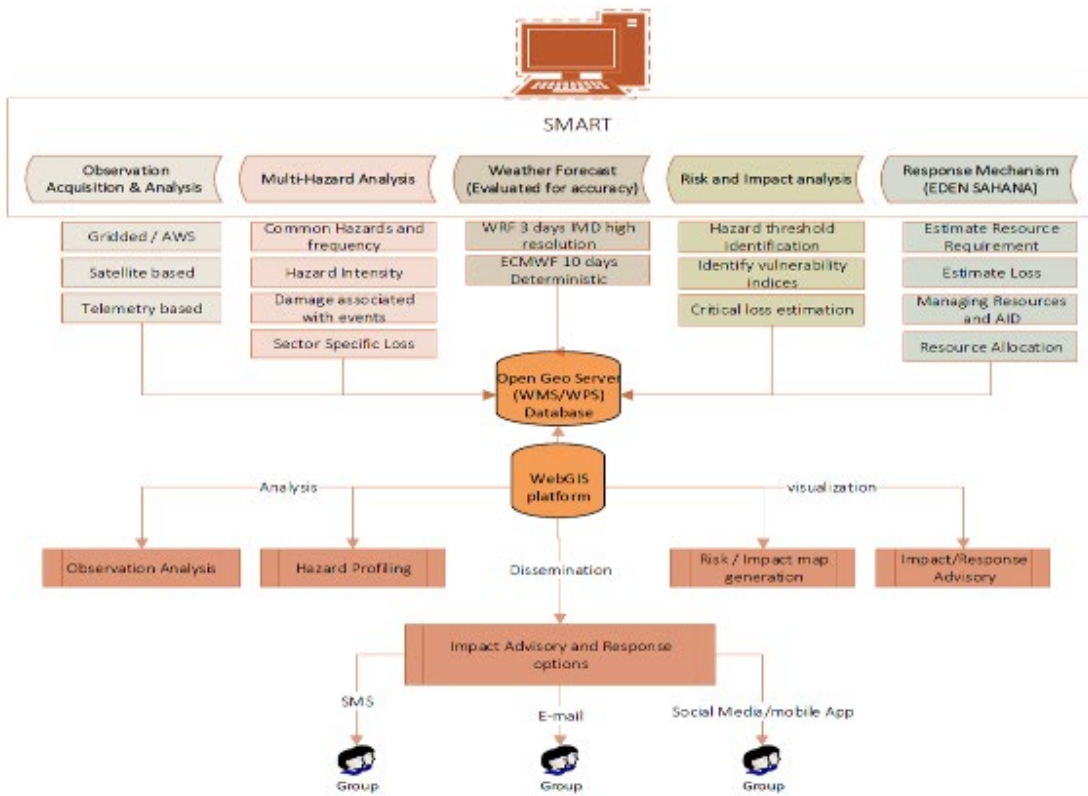


Figure 3.11: SMART.

Source: RIMES 2019.

Tsunami Risk Assessment

The identification of areas at high risk to tsunamis is crucial in DRR and preparedness. It helps guide development planning, raise awareness, establish preparedness measures and enhance the capacity of communities to respond during emergencies. This is because tsunami risk assessments help identify high risk areas from safe zones and estimate potential impacts. The internet-based Simulation Platform for Inundation and Risk Evaluation (INSPIRE)⁸³, developed by RIMES, is a web-based tool for tsunami inundation simulation and loss estimation. This tool is aimed to provide emergency managers and other officials with a timely and accurate tsunami forecast as guidance for rapid, critical decisions when lives and properties are at risk. The real-time tsunami inundation and loss estimation system has been developed using general purpose graphical processing unit (GPGPU) to enable fast simulation of tsunami inundation using INSPIRE for subsequent estimation of potential casualty and building damage (Figure 3.12).⁸⁴ The system can generate potential loss information within minutes of a tsunamigenic event. High resolution data have been integrated into the system to enhance the estimation accuracy of potential loss.

INSPIRE was initially tested against the dataset in Kamala and Patong municipalities in Phuket, Thailand and its resulting loss estimation was comparable to the actual building damage recorded for the Indian Ocean 2004 tsunami. It was also demonstrated in Myanmar, Philippines, Sri Lanka, and Thailand. In Sri Lanka, agencies like the National Aquatic Resources Research and Development Agency (NARA)⁸⁵, and the Disaster Management Centre⁸⁶ subsequently used

83 P. Srivihok, and others. 2012. Development of an online tool for tsunami inundation simulation and tsunami loss estimation. Continental Shelf Research. <http://dx.doi.org/10.1016/j.csr.2012.08.021>.

84 Regional Integrated Multi-hazard Early Warning System (RIMES) 2019. Internet-based Simulation Platform for Inundation and Risk Evaluation (INSPIRE). Unpublished report.

85 D. Weragodatenna & R.M. Jayathilake. December 2013. Modeling of tsunami inundation and hazard mitigation – A case study of Hambantota urban area. NARA Scientific sessions 2013 – Development of fisheries and aquatic resources for a quality life. https://www.academia.edu/8509316/Modeling_of_Tsunami_inundation_and_hazard_mitigation_-_A_case_study_of_Hambantota_urban_area.

86 W.A.M. Fernando, et. I. 2015. Tsunami Modeling and Risk Assessment of Hambantota, Sri Lanka

the tool to conduct tsunami modelling and risk assessment studies. A tsunami risk assessment in Myanmar, for instance, revealed the inundation zones in Aungthlaing, highlighting the need to relocate critical government facilities which were located there. Similarly, the risk assessment in Hambantota, Sri Lanka indicated a tsunami hazard due to the port construction.

INSPIRE calculates and maps tsunami travel time, amplitude and current velocity, and evaluates probabilities of human death and building damage. The tool is designed to handle multi-dimensional vulnerability data and differential levels of data accuracy, so that it can accommodate any range of data availability and accuracy. Users may conduct preliminary tsunami risk assessments using existing data with progressive improvement of results as more detailed and accurate datasets become available.

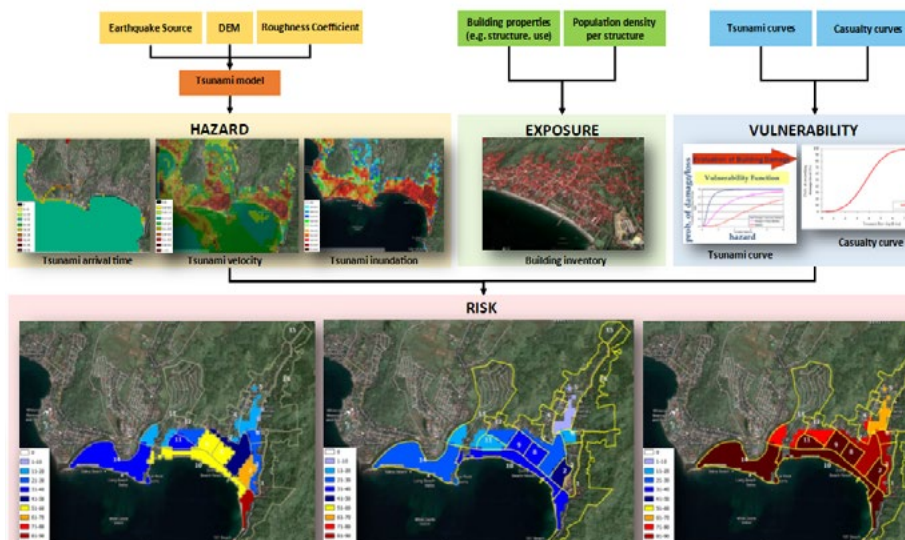


Figure 3.12: Flowchart of tsunami hazard and risk assessment within INSPIRE system.

Source: RIMES 2019.

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Machine Learning for Disaster Resilience

Machine learning is a subset of artificial intelligence (Figure 3.13). Resilience-building relies upon many different data types, information sources, and types of models to be effective. Even experts can struggle to develop models that enable the understanding of the potential impacts of a hazard on the built environment and society. The advances in machine learning offer new approaches and new ways to obtain more accurate, efficient, and useful solutions for resilience building. The machine learning algorithm is to ‘learn’ from previous data and output a result that adds information and insight that was not previously known. This approach enables action to be taken on the information gathered from the data; sometimes in near real time, like suggested web search results, and sometimes with longer term resilience building based on multiple risk scenarios⁸⁷.

Using Integrated Remote Sensing Techniques. ERE Research Conference 2015 on Earth Resource Management. https://www.researchgate.net/publication/284898802_Tsunami_Modelling_and_Risk_Assessment_of_Hambantota_Sri_Lanka_Using_Integrated_Remote_Sensing_Techniques.

87 Vivien Deparday et al. 2019. Machine Learning for Disaster Risk Management (English). Washington, D.C.: World Bank Group. Available at: <http://documents.worldbank.org/curated/en/503591547666118137/Machine-Learning-for-Disaster-Risk-Management>.

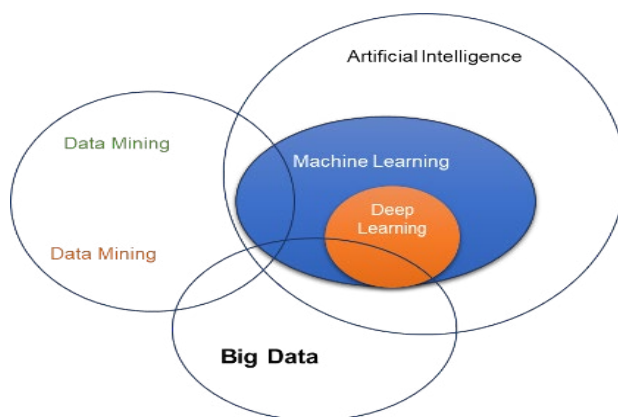


Figure 3.13: Machine learning – a subset of Artificial Intelligence and linked with data mining and Big Data.

Even though machine learning is a subset of artificial intelligence (AI), the two terms are often used interchangeably. The seamless linkage of machine learning with data mining and the Big Data ecosystem – for example from image, sound, and the voice recognition features of our smartphones – enables disaster managers to identify where people are at risk in a disaster as measured by location and type of building.

Managing disasters becomes more efficient if data is acquired from different sources in a higher spatial and temporal resolution. However, challenges emerge because of the constantly increasing quantum of image and video data. Processing and analysing the heterogeneous big disaster data requires efficient data collection, aggregation, information extraction, visualization, and efficient distribution. The growth of data and the need for efficient distribution makes the development and operation of cyber infrastructure very demanding.

Machine learning has evolved to become one of the most effective methods of helping to eliminate unrelated data and speeding up all risk analytics to identify most optimal response actions and resilience strategies. The tools of descriptive, predictive, prescriptive and discursive analytics can now leverage machine learning in a big way.

Machine learning can provide location specific flood prediction

Machine learning and significant computational power are used to create better forecasting models through Google Public Alerts, which has pilot tested location-based flood forecasting in the event of the September 2018 floods in Patna City of Bihar, India. A variety of elements—from historical events, to river level readings, to the terrain and elevation of a specific area—feed into these models. It generates maps and up to hundreds of thousands of simulations in each location to accurately predict not only when and where a flood might occur, but the severity of the event as well. Google issued flood warnings through its Google Public Alerts (Figure 3.14). Therefore, alerts are layered into apps like Google Search, Maps, and Google Now.⁸⁸

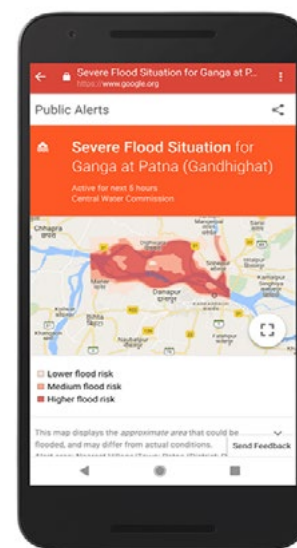


Figure 3.14: Global Google Public Alerts program.

Source: TechEngage (2018).⁸⁹

Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

88 Yossi Matias, Vice President, Google. 2018 Keeping people safe with AI-enabled flood forecasting. Available at: <https://www.blog.google/products/search/helping-keep-people-safe-ai-enabled-flood-forecasting/>. Accessed on 23 March 2019.

89 TechEngage. 2018. Google is using AI for flood forecasting in India. Available at: <https://techengage.com/google-ai-flood-forecasting-india/>.

Machine learning has enabled Google Public Alerts to cover warnings for events like hurricanes and earthquakes issued by government agencies in a dozen countries, including Brazil, Canada, Japan and the United States. Google says it has sent out ‘tens of thousands’ of public alerts viewed more than 1.5 billion times. It has also activated SOS Alerts — which indicate a higher threat level — more than 200 times.

Machine learning can map out in real time – hazard, exposure and vulnerability

The 5D-World Map System developed by Japan’s Keio University provides a multi-dimensional global knowledge platform to collect and analyse ‘real time’ data on SDGs-related indicators⁹⁰. The system integrates the analytical visualisation of sensing data into multimedia knowledge sharing (images and videos), which helps community-based data sharing, awareness building and evidence-based decision-making⁹¹. The system uses image mining and machine learning to generate hazard, exposure of critical infrastructure and vulnerable population in multi-hazard risk environment context.⁹²

3.3 Disaster risk reduction data collection, monitoring, forecasting and the community

Early warning systems are crucial for saving lives, and communities are crucial for the effectiveness of EWS. The risk of a disaster is often shaped by social and political systems and processes. The vulnerability of the community/individual is often dependent on their social situation, with poverty, inequality and marginality increasing exposure, risks and impact as described in this section.

3.3.1 Early Warning System as a Means to Environmental Justice

– **Hemantha Withanage**, Executive Director, Centre for Environmental Justice, Sri Lanka

Samarasinghe (35) a young man living in Athwelthota in Kalutara district had his own car sale. Ever since his parents had passed away, he lived with his sister in their ancestral home. An unexpected heavy rainstorm on 26th May 2017 resulted in a massive landslide in the mountain behind his land, destroyed his home together with five other neighbouring houses, killing nine people and destroying all their properties that were built over a few decades.

Constant rains during that day across Sri Lanka affected over half a million people in seven districts. Over 20,000 people faced flash floods.

According to information from the five most affected districts, the financial cost of the May 2017 floods and landslides (damages and losses) was LKR 70 billion. The most affected sectors in terms of costs were housing, agriculture, transport, industry and commerce. In addition, disaster events affected the provision of services such as health (65 centres affected), education (382 centres out of 2,122 in the affected districts), water and sanitation.⁹³

The Global Climate Risk Index 2019 prepared by German Watch reported that Sri Lanka was globally ranked as the 2nd most at risk country with 246 deaths and absolute losses of USD 3,129 Million PPP, only second to Puerto Rico where absolute losses equalled USD 82,315 Million PPP according to 2017 data.

90 United Nations, Economic and Social Commission for Asia and the Pacific (ESCAP). 2018. The 5D World Map System is globally utilised as a Global Environmental Semantic Computing System in SDG 14. Available at: https://sdghelpdesk.unescap.org/toolboxes?field_sdgs_target_id=All&title=World+Map+System+-+Keio+University. Accessed in May 2019.

91 Sasaki, S., & Kiyoki, Y., (2016). Real-time Sensing, Processing and Actuating Functions of 5D World Map System: A Collaborative Knowledge Sharing System for Environmental Analysis. Information Modelling and Knowledge Bases XXVII, vol. 280, pp. 220–239.

92 Sasaki, S. & Kiyoki, Y., (2018). Policy Coherence for Disaster Risk Reduction and Resilience. ESCAP Regional Learning Platform for Policy Coherence. 31 August. Bangkok.

93 Sri Lanka Rapid Post Disaster Needs Assessment Floods and Landslides, May 2017.

Could these damages have been avoided if there was an EWS? The answer is yes. Most people were clueless about the upcoming disaster. The forecasted rainfall was not available to any of them as there is no easily accessible forecast system available in Sri Lanka. As there was no warning some people died when the flood gates of “Kukule” Ganga (river) hydropower dam were opened to save the electricity infrastructure. In addition, some of the landslides happened not in the location where they issued warning but adjacent.

Those who die or lose properties often do not bear much responsibility for these climate disasters, with rich countries and affluent lifestyles bearing more of a responsibility for climate change. This is climate injustice. Global warming is an ethical and political issue, rather than purely environmental or physical in nature. This climate injustice is one form of environmental injustice.

Environmental justice is the fair treatment and meaningful involvement of all people. Early warning is a way to save lives and help protect hard-earned properties, and EWS is definitely a way to involve people in a meaningful way in reducing disaster damages. The losses that countries in the region bear due to disasters, for example the approximate USD 3,000 Million loss incurred by Sri Lanka in 2017, is not one that is refunded by countries more responsible for climate change, and will come out of Sri Lanka’s budget often at the expense of other services such as free education and health.

Another aspect of environmental justice is the justice for other species affected by these disasters. Human EWSs are not helpful for other living species. Overlooked perhaps is an important step of the EWS – assistance for other species who are completely innocent in the case of global warming. Early warning also needs to consider sustainable recovery strategies. Further, effects related to crosscutting issues such as DRR, gender, environment, employment and food security need to be considered in identifying those sustainable recovery strategies.

3.3.2 Early Warning System for Disaster Risk Reduction: Role of Civil Society – A View

– **Suparana Katyaini, Sarbeswar Sahoo**, Indian Institute of Technology Delhi, India; and **Margit van Wessel**, and Wageningen University and Research, The Netherlands

Taking the case of floods in Bihar, India, we studied civil society organisations’ (CSOs) perspectives on shaping their role in DRR. This paper presents their perspectives on their role in developing EWS to reduce the disaster risk of vulnerable communities.

Societal groups facing different forms of socio-economic and political exclusions and under-representation are most vulnerable to disaster risk. Vulnerability is embedded in socio-economic and political conditions of poverty, inequality, and marginality (Bankoff et al., 2004). For vulnerable people, these conditions translate into inaccessibility of resources and capacities essential to reduce disaster risk to their lives, assets, and livelihoods.

CSOs’ role in representing the needs and interests of vulnerable people through ‘speaking for’, ‘standing for’, ‘acting for’ and ‘mediating for’ becomes important in the context of high vulnerability, and high inequality, such as in India. Our findings suggest that CSOs see *themselves as mediators* between key actors to create and provides access to, resources and opportunities in order to secure lives, assets and livelihoods. Through mediations they aim to bring about the inclusion of vulnerable communities’ needs and interests into EWS such as ‘community-based early warning systems’. Consultation with communities is a crucial part of ‘community-based early warning systems’, specifically for setting the ‘critical flood level’ at which the warnings are shared with the vulnerable communities. Sharing of warnings through networks highlights the significance of collective action and cooperation between different key actors.

A second important finding is that CSOs *shape their role of mediation in diverse ways*. There are two important roles that CSOs play while engaging actively in developing and establishing EWS, acting as *knowledge brokers/partners* and as facilitators. This diversity in roles emerges from what relations, and dimensions they value, and what forms of inclusion they aim to advance. For instance, **knowledge brokers/partners** seek to integrate communities’ traditional knowledge and scientific expertise on EWS and act as a bridge to bring together these different knowledge systems. Inclusion of people’s knowledge comes with empowering the people, and accessing their traditional knowledge systems which remain largely undocumented. Inclusion of expert

knowledge in EWS policy and practice comes with making this knowledge accessible to people, which is what knowledge brokers/partners seek to do. The CSOs that see themselves as **facilitators** value negotiations between key actors on aspects such as the ‘critical flood level’ for community-based early warning systems. Their role becomes important for including different perspectives in a collaborative network, engaging the diversity in traditional knowledge systems of the people, and knowledge systems of the experts. Facilitators engage in a complex web of relations to negotiate and enhance the access of key actors to each other’s resources and capacities, and for advancing communities’ ownership of the EWS. In conclusion, CSOs play an important role in reducing disaster risk, by translating the needs, interests, and knowledge of the vulnerable groups, and mediating interactions with key actors.



Photo credits: Megh Pyne Abhiyan, Bihar, India.

References

1. Bankoff, G, Freks, G, Hilhorst, D J M (2004). Mapping Vulnerability, Disasters, Development and People, London: Earthscan.
2. Busby, J, Smith, T G, Krishnan, N, Wight, C, Vallejo-Guiterrez, S (2018). In harm’s way: Climate security vulnerability in Asia. *World Development*, 112, 88-118.
3. Lyons, M (2009). Building Back Better: The Large-Scale Impact of Small Scale Approaches to Reconstruction. *World Development*, 37, 385-398.

The following two case studies showcase EWS that monitor, forecast and enhance disaster preparedness with the direct involvement of communities and are implemented at the local/ grassroots level.

3.3.3 CASE STUDY 1: ‘A Tide Turns’ - Beach Profile Monitoring Programme, India

– **Vivek Coelho**, Social and Ecological Stewardship Program, Tata Institute of Social Sciences, Mumbai, India

Ecological monitoring tools when made accessible and inclusive have the capacity to engage vulnerable and at-risk populations to build locale specific EWSs for taking informed decisions. Such practices have the potential to initiate community-led DRR strategies which address slow and rapid onset disaster risks and hazards; building multi-stakeholder resilience; inculcating a culture of safety and preparedness.

The Shoreline Change Atlas of the Indian Coast indicates that 45.5% of the coast is eroding. As the beaches erode coastal communities face high risk and are vulnerable to losing their homes, resources and space for livelihood activities such as boat parking, fish drying, net mending, tourism related activities etc. Beaches form an essential first line of defence against the ravages of the sea by softening the impact of lashing waves and the sand restricts saline water intrusion into the groundwater in coastal regions.

The Beach Profile Monitoring Programme (BPMP) has empowered fishing and coastal communities with the data, skills and knowledge to observe and understand locale specific changes to their coastlines. This practice ensures ground truth verification of land use patterns that can be verified in the context of access to coastal commons and rights, as regional resource maps often omit entire beaches and ecological features to prioritise coastal development.

BPMP is a citizen-science initiative to observe, document, monitor and evaluate shoreline dynamics (erosion and accretion). Communities become the ‘stewards’, using ‘beach profiling’ as a tool, to help create timeline evidence of the shoreline dynamics, evolving into a community information system. The data can be used to strengthen satellite imagery and for informed negotiations/ decisions with decision- makers thereby building community resilience through the creation of community level preparedness, mitigation, adaptation strategies and protocols to address coastal hazards.



Young volunteers Recording Beach Profiling Readings at Karaikal, Puducherry.

BPMP uses the principles of the K.O. Emery Method for beach profiling and replaces the calibrated poles with PVC-U pipes, measuring tape, hair ties as viewfinders and a 5-meter rope. This method was designed, standardised and field tested by the author and is termed the 'Adapted Emery Method for Beach Profiling.' It proved to be simple, low cost, effective, lightweight, transport-friendly and easy to maintain. Anyone with a basic working knowledge of reading, writing and mathematics can record and calculate readings. The program can be set up and maintained at a cost of INR 10,000 (approx. USD 150) used to sustain the entire annual data collection process. The affordability and DIY equipment has finally made it accessible to coastal communities. A user manual titled 'A Tide Turns' is also available and can be obtained on request from the author.

The method makes use of two poles whose alignment and intersection with the horizon allow for the determination of elevation change along the profile line. The readings are taken along the profile line from a fixed structure on the beach, known as a 'control point' up to the low water mark. The width and elevation change is recorded, calculated and plotted on a graph to document the profile of the beach on the day of the lowest tide. The graphs represent the length from the control point to the low water mark and elevation change along this profile line - the contour of the beach. This data is further supplemented with data of sand grain size analysis and photo documentation.

Beach profiles can be documented on beaches where there are already specific problems, or a lack of information about the status of the coastline. Examining this data can inform how individual beaches respond to a variety of ecological phenomenon and anthropogenic activities. Coastal communities can now scientifically monitor shoreline dynamics through timeline analysis of erosion and accretion rates; generating data for informed decision-making thus functioning as a self-reliant, accessible and inclusive EWS.



Sand Grain analysis at Cuddalore, Tamil Nadu.



Plotting Beach Profiling graphs in community space.

3.3.4 CASE STUDY 2: Towards Resilience, Kolkata's Flood Forecasting and Early Warning System

- **Neeta Pokhrel**, Unit Head, South Asia Urban and Water Division, ADB with **Virinder Sharma**, Senior Urban Development Specialist, Sustainable Development and Climate Change Department, ADB and **Sourav Majumder**, Senior Project Officer (Urban), India Resident Mission, ADB, Philippines

Kolkata Municipal Corporation (KMC) is currently implementing a flood forecasting and early warning system (FFEWS) for the city with support from the Asian Development Bank's (ADB) Urban Climate Change Resilience Trust Fund (UCCRTF). It will be India's first comprehensive city-level FFEWS. For Kolkata, one of the densest megacities in the world and one that is highly vulnerable to flooding, monsoon has always brought concerns under both current and climate change projected scenarios.

Most flooding in Kolkata is pluvial flooding or surface flooding, caused when heavy rainfall creates a flood independent of any overflowing waterbody. Flat deltaic terrain, insufficient natural drainage, and tidal blockage of channels amplify flooding and waterlogging in the city. Revamping and expansion of the urban infrastructure including sewerage and drainage network and treatment capacity through an KMC-ADB partnership⁹⁴ has meant that currently flooding typically lasts about 1-2 hours in areas covered by the drainage system. However, it is still higher and longer in informal settlements and low-income areas.

The FFEWS has been designed to provide forecasts as well as real-time updates from 260 sensor nodes installed in key points throughout the city. Information generated and disseminated by the FFEWS will enable informed decision-making before and during disasters. The system includes: weather forecasts; flood models for various intensities of rainfall; real-time information on key pump status, sump and canal water levels, actual rainfall, inundation levels, among others including air quality parameters; and a messaging system to provide warnings and real-time information to city officials and citizens.

How does the Flood Forecasting and Early Warning System Work for Kolkata City?

FFEWS is a real-time model to assess rainwater flooding in all 144 wards in Kolkata. ADB is also supporting the KMC to reduce urban flood risks by improving land-use planning, developing the capacity of city officials to act, formulating effective disaster management strategies while introducing the FFEWS for Kolkata City. A consortium (comprising of consultants Taru Leading Edge Pty Ltd, PricewaterhouseCoopers, and Antea Group) is helping the KMC design and implement FFEWS.

KMC plans to launch the first phase of FFEWS around October/November 2019. The final FFEWS will have more than 400 real-time sensors across the city to monitor weather and potential flooding. The installation targets 347 vulnerable points, including in sewerage and storm water drainage system.

During the preparation and design of FFEWS, key stakeholders were consulted to understand the exact system needed. To identify the best places to install the sensors, predictive modelling was used, to be verified during the monsoon season. In addition, other sources of data collection, and consultations with citizens and borough engineers were used to choose locations for real-time data collection on rainfall and flood risk. Consultants and ADB have also used historical remote-sensing data, through ADB's partnership with the European Space Agency, to study the movement of floodwaters during major floods in the past. This data and the modelling that follows will then be combined to help identify hotspots and install sensors for flood warnings.

Sensors upload data to servers and a shared platform is accessible to city officials. "The idea is to bring everyone together on a common platform so when the rain comes, they can use SMS to alert the public and make decisions together," said Roy of the KMC's Sewerage and Drainage Department. The data is communicated to the KMC's control room and the real time status of inundation is displayed on a flood monitoring dashboard. The dashboard integrates precipitation forecasts and provides scenarios from past and expected extreme events. The dashboard is

⁹⁴ The details of ADB-KMC partnership over the last two decades was summarised by ADB in a book (see <https://www.adb.org/publications/kolkata-more-sustainable-inclusive-resilient-city>).

accessible to computers and mobile phones through the internet. It will provide location-specific SMS alerts or make announcements on radio and television to enable pre-emptive action.

With the new FFEWS citizens will receive early warnings from regular monitoring of water levels in the drainage conduits as well as forecast data for future events. The real-time and forecast data can help in diverting traffic to safe areas and help in positioning response staff and equipment at vulnerable locations to enable faster drainage of water and evacuation of people and valuables in extreme cases.

The initiative included the training of government officials, KMC and officials of various organisations. Training was in planning control and flood disaster management as well as climate change adaptation and disaster risk management; major trends and practices in risk management, preparedness, and emergency response; long-term resilience building; planned investments for climate resilience; urban planning and land-use planning for flood management; dissemination of information on flood forecasting and EWS; communication systems and strategy; and community participation in planning and emergency response.

City officials, police, and fire department staff and citizen groups are currently learning how to use the new system and incorporate it into their monitoring systems. An information-sharing platform will interface with groups from each government department and the public interface will share information and decisions almost in real time.

Key Features of Kolkata's New FFEWS:

- All stakeholders can provide support by installing and managing the sensor nodes on their premises.
- Community organisations, schools, and colleges can monitor local flooding and alert people staying in low-lying areas.
- Ownership of the EWS by people and community organisations will ensure regular data collection and sustainability of the system.
- Partnerships between different groups and organisations will make Kolkata ready to face extreme events with reduced damage and loss.
- The EWS will result in less disruptions of traffic through timely rerouting, faster management of waterlogging, and reduced disruptions to livelihoods, especially of the poor.
- By providing street- or neighbourhood-level granular information, the system enables citizens to plan their commutes better and for businesses to reduce damage to their assets from inundation.
- This hybrid network is cost-effective and will address issues of affordability, maintenance, and sustainability of FFEWS.

(Extracted from ADB Publication: *Transforming Kolkata: A Partnership for a More Sustainable, Inclusive, and Resilient City*, <https://www.adb.org/publications/kolkata-more-sustainable-inclusive-resilient-city>.)

3.4 The need for Early Warning transboundary systems in South Asia

South Asia is increasingly subject to extreme weather events that cover multiple countries in one event. As such, transboundary detection, monitoring and forecasting systems are urgently required to record and share data across countries in the region. Floods and landslides are the most frequently occurring natural hazards, and the following papers highlight the need for transboundary EWS systems in Pakistan, Myanmar and Nepal. The repercussions of not having effective early warning systems working across borders are highlighted, and the cooperation, knowledge and warning gaps at local and regional levels are identified by the contributors.

3.4.1 Integrating Disaster Risk and Climate Change Resilience

– **Ali Tauqeer Sheikh**, Development Sector Activist, Islamabad, Pakistan

Since 2007, an EWS is operational at Nulleah Lai, a seasonal stream in Rawalpindi district of Pakistan's Punjab province, adjacent to Islamabad, the federal capital. This EWS has six rain and two water level gauges, taking measurements of the water level every two minutes and the data is wirelessly transmitted to a control room for analysis by meteorologists. The forecast is then passed on to the city administrators of Rawalpindi, from where warnings can be issued to people through 10 warning stations in different parts of the city. All this is done to protect local communities and their possessions against flash floods that have very little warning time - 80 minutes.

This excellent system barely cost USD 5.5 million to set up and was supported by the Japanese government. The Fourth National Flood Protection Plan has identified 24 additional locations across the country to install somewhat similar EWS but the progress has been uneven and sluggish.

In the transboundary context, several seasonal streams and tributaries of Ravi and Sutlej such as Hadiara, Deik, Aik and Ruhi flow from India to Pakistan. An integrated EWS can be set up in this area to provide one or two days notice to warn local populations of impending hazards. The countries could also install pollution monitoring gauges and inform each other on the level of pollutants during the low flow periods. The goodwill of the Japanese government can help to improve EWS in these two countries on the tributaries of the Indus to reduce human suffering and loss to local subsistence economies.

Pakistan needs to desperately invest in EWS capacity by upgrading installed technologies in order to manage river flooding and an increasingly serious challenge of urban flooding. For now, Pakistan has only seven radars installed in different cities for weather forecasts. These radars are essential but not the only component of any EWS. Of these, only two are said to be working predictably, while others have questionable reliability. The experts argue that the country needs to install at least 13 weather radars to effectively deal with floods and other extreme events. Agreements have been signed with China under CPEC and the World Bank to fill the void.

While Pakistan moves to improve its flood warning and management capacity, it is also taking some steps to strengthen its medium and long-range weather forecasting. The improved capacity will indeed help in dealing with floods, but Pakistan will still need to focus on improving climate and disaster governance to deal effectively with a growing list of climate induced risks - ranging from glacial melt, landslides, mudslides and Glacial Lake Outburst Floods (GLOF) to droughts, heatwaves, dust storms, cyclones and Tsunamis. These meteorological predictions can be effective only to a certain extent. They need to be supported by an augmented capability in decision-making systems and the ability to implement decisions on the ground, at the community level. This will require inter departmental coordination.

At the district level, Multi-hazard and Vulnerability Assessments (MHRVA) have been designed and developed, using various methodologies, for scores of districts in each province. These assessments go beyond floods and cover a whole range of vulnerabilities including climate induced disasters. Pakistan's development partners have supported national and provincial

disaster management authorities in this undertaking. Likewise, in Bangladesh and India, international donors have helped develop community-based solutions to deal with disasters. There is a growing area of regional experiences that needs to find vehicles for mutual learning and experience sharing. Regional media centres have already been proposed in disaster-prone areas to inform the people about any threat well in advance. The World Meteorological Organization (WMO) needs to engage with its two members - India and Pakistan - and help them develop mechanisms for sharing meteorological and environmental data. This would benefit both countries as well as other neighbours from Bangladesh and Bhutan to China and Nepal.

According to some estimates over 700,000 people in Pakistan are affected by floods each year resulting in an annual loss of about 1% to the GDP - that is almost USD 2 billion. This is bound to increase as a study by the World Resource Institute reports an estimated 2.7 million people could be affected annually by river-floods in Pakistan by 2030. Bangladesh, China, India and Pakistan are four of the five most exposed countries in the world to river-based floods (Vietnam is the 5th one). Given their population density and vulnerability of their populations to floods, they need to take river-flooding as a regional and not just as a domestic national challenge.

3.4.2 The Need for Flood Forecasting and Early Warning in Transboundary River Basins in Myanmar

– **Htay Htay Than**, M.Tech in Hydrology (India Institute of Technology, Roorkee), Director, Hydrological Division, Department of Meteorology and Hydrology, Ministry of Transport and Communications, Myanmar

Flood forecasting and warning is the non-structural approach of flood disaster reduction program and the Department of Meteorology and Hydrology (DMH) is mainly contributing its services in issuing flood warning and bulletin for the major rivers. However, no comprehensive monitoring and modelling exists for the whole country especially at transboundary level.

Flooding has always been one of the major hazards in Myanmar. The flood hazard area needs to be identified for proper management and damage mitigation. River floods occur because of heavy rainfall and geomorphology. Myanmar has transboundary river basins as shown in Figure 3.15 but there is a low population density in the border area except Thaungyin River basin near Thailand, which is depicted in (4) of Figure 3.15. Thanlwin River Basin which is as shown (1) of Figure 3.15, originates from China and the flood occurred at Kunlong in 1997 and 2004 but there was no flood warning system in that area. The other transboundary river basins shown in (2) and (3) of Figure 3.15 have rivers flowing from the mountains and hills of India and Myanmar border area which enter the Myanmar border area. Heavy rainfall in the upper areas can cause flash floods and landslide in the downstream area. Though EWS have been developed at national level to provide flood information, there are gaps at the transboundary area in getting flood information to communities and observation stations for hydrometeorological data.

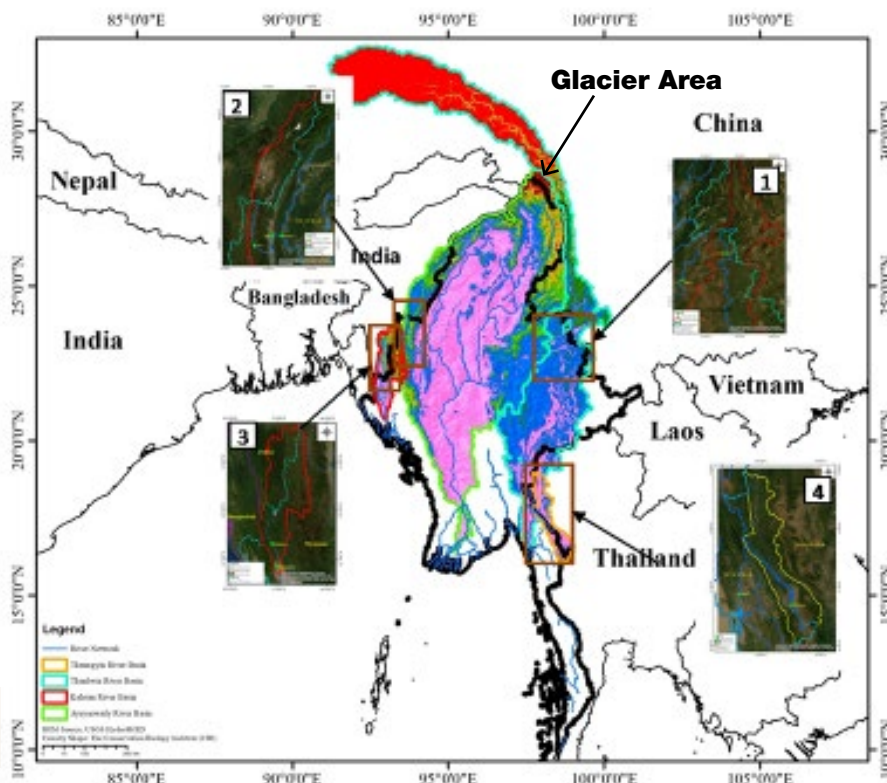


Figure 3.15 : Transboundary River Basins.

The increasing frequency and intensity of flood events in Myanmar, which is likely to continue or worsen due to climate change, reinforces the importance of regional cooperation and capacity development in flood forecasting and EWS. In 2019, torrential rains and increased river levels caused monsoons floods in some parts of Myanmar, compared to 2015 when the water level sharply rose with high velocity due to heavy rainfall together with glacial melting but did not flood.

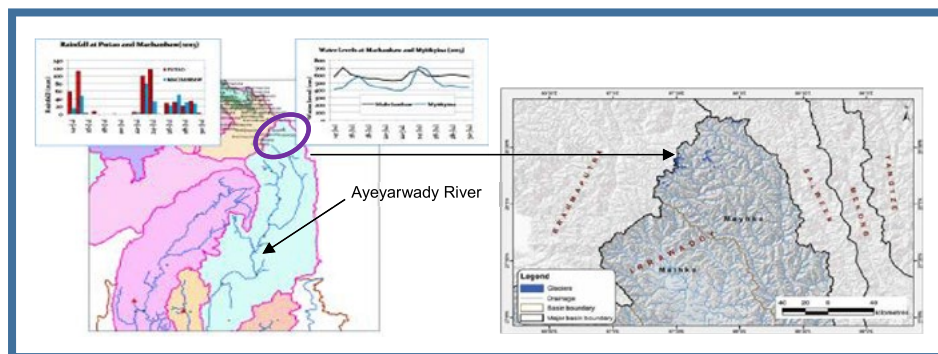


Figure 3.16: Glacier area at upper Ayeyarwady Basin.

In 2019, the country faced flooding at the transboundary river basins. In Kachin State, according to the Department of Disaster Management (DDM), more than 6,200 people were evacuated to 39 sites in Myitkyina, Bhamo, and Shwegu townships (as of 13 July 2019). The water flowed at a high velocity from the upstream Ayeyarwady basin which originates from the China and Myanmar border area and resulted in flooding within the Kachin State as shown in Figure 3.17. At another transboundary river basin, the Paletwa township of Chin State and Kyauktaw township of Rakhine State, also experienced flooding, as shown in Figure 3.18, and the water flowed from India and Myanmar border area and Chin Hills. Although flood warning systems have been established at those cities, there were no observation stations at the border area which was reportedly affected by floods, affecting evacuations in some locations.

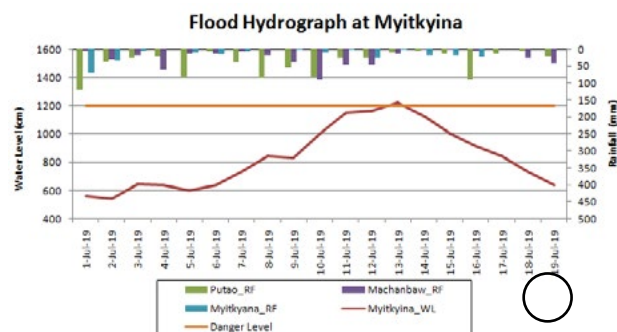


Figure 3.17: Flood Hydrograph at Myitkyina.



Flood View at Myitkyina, Kachin State (2019).

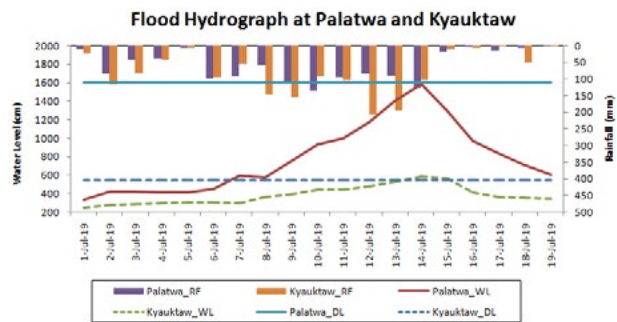


Figure 3.18: Flood Hydrograph at Paletwa and Kyauktaw



Flood View at Kyauktaw, Rakhine State.

Myanmar's efforts towards ensuring safety from floods is now in need of major upgrades using the remote sensing technologies, especially in connection to flood management decision-making at a hierarchy of levels and its inter-relationship to flood hazard assessment and planning. An immediate assessment and upgrade of the forecasting systems, including transboundary areas, is needed to forecast and assess the likely extent of damage caused by recent and future floods.

Present Status for Preparation of flood forecast

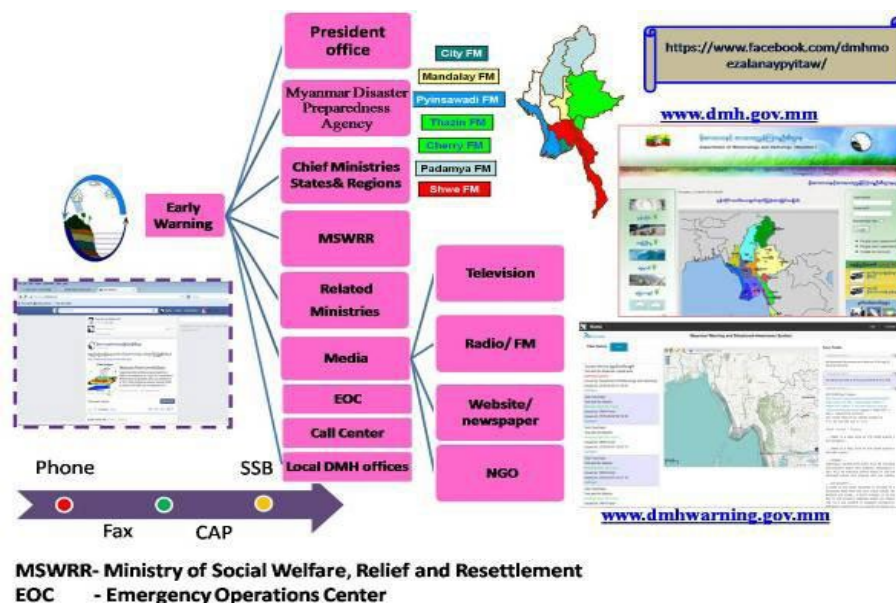
Daily river water level forecast is issued for 45 selected stations along 14 major rivers of Myanmar but there are very few stations in the transboundary areas. The department is applying empirical models based on single and multiple regression analysis for forecasting peak flood level. Stage Correlation is the method mostly used for daily river forecasting. The lead time for issuing flood warning is about one to two days for communities upstream of rivers and small rivers, and about two to three days for those downstream.

Under the guidance of the Director General of the DMH, a Section headed by the Assistant Director of River Forecasting Section had been formed to take responsibilities for issuing flood warnings. As soon as a heavy rainfall warning is issued river levels are monitored for possible flooding and the higher authorities, flood committee and other water related agencies are immediately informed if there is a threat.

Present Status for flood warning and forecast dissemination

The flood warnings and information on where flooding will occur are sent to Higher Authorities, concerned ministries and departments, Concerned Chief Minister of Region/State, radio and television stations, newspapers, enterprises and local authorities. In case of a severe flood, the department sends a hydrologist to the station where the severe flood is going to occur to help the local authority in flood alert and protection work. In such situations water level observations are done hourly and reported to flood management committees formed in those townships. At the same time the department issues daily flood forecasts and condition. If the expected flood is a severe one, the warnings are broadcast very frequently (every 3 hours) through the Myanmar Broadcasting Services.

On receiving the flood information, the flood committee discusses the possibility of the flood inundation. There are two types of floods, namely 'normal' and 'severe'. The former is the rise in water level up to the town danger level. A severe flood will inundate the flood prone areas. The flood management committee comprises of local authorities, warning providers and relevant departments, and local NGOs who collaborate for flood disaster management. The decision for evacuation is made by local authorities and flood disaster management committees. Each member/ team of the community is given specific instructions and responsibilities in case of evacuation. In order to facilitate evacuation planning, the vulnerable areas are clearly identified by using past experience in flood inundated area.



Gaps and Needs

In the case of Myanmar's flood EWS, for flood early warning to be effective the system should provide adequate lead time for institutions and communities at-risk to undertake preparatory and mitigating actions. Currently, flood warning capacity at the Department of Meteorology and Hydrology (DMH) is based on meteorological and hydrological observations, providing lead time of 24-72 hours only, which is useful for saving lives, but inadequate for preserving livelihoods, or for taking early decisions for flood preparedness and mitigation. But the catchment of transboundary area can be classified as ungauged basin, lacking rainfall data and with no stream gauging station reported. So, the functional flood warning system is not adequately in place, and no formal institutional structure has been set up for this transboundary area. The gaps in flood forecasting in transboundary river basins include low capacity in flood monitoring systems, limited data exchange and technical cooperation, and inadequate institutional and capacity development.

3.4.3 The need for Regional Cooperation: Early Flood Warning Across India, Nepal and Bangladesh Rivers

– Rajeev Jha, DRR and CCA Specialist, New Delhi, India

It is an established fact that floods occurred more than any other disaster from 2000 to 2020. The data from CRED (Centre for Research on the Epidemiology of Disasters) on the basis of four countries India, Nepal, Bangladesh and Myanmar authenticates this statement. Furthermore, among three countries of South Asia, viz. India, Bangladesh and Nepal most of the disasters happen either due to floods or storms during the aforementioned period. According to EM-DAT data, among the number of disaster events in four South Asian countries till 2017, the highest number of events were recorded from floods.

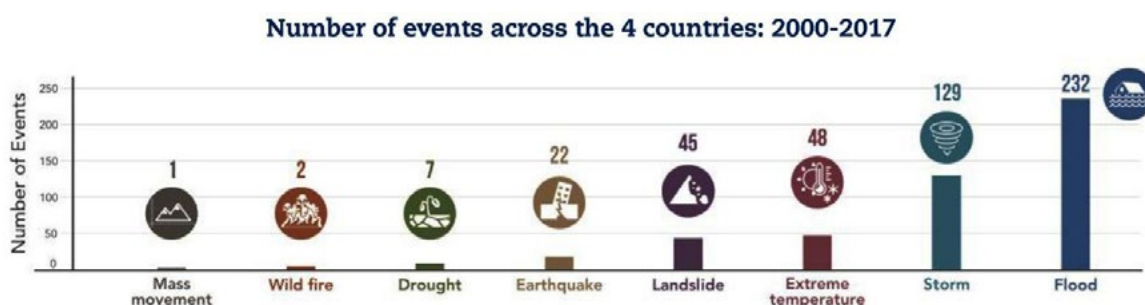


Figure 3.19: No of event from 2000–2017. Source- EM-DAT.

According to the same database in India from 2000 to 2020 among all the natural disasters the total number of floods were 158 followed by cyclonic storm 65. It is quite evident that flooding has had a major impact on communities across South Asia.

Disaster	Sub Type	No. of events	Total Deaths	Total Affected	Total Damage (USD)
Flood	--	25	2364	34,574,642	5,397,000
Flood	Coastal flood	1	80	7,200,000	275,000
Flood	Flash flood	23	2517	17,889,860	948,000
Flood	Riverine flood	108	19908	258,864,779	38,553,347

Source- Created on: April 21, 2020, EM-DAT: The Emergency Events Database - Universite catholique de Louvain (UCL) - CRED, D. Guha-Sapir - www.emdat.be, Brussels, Belgium.

Nepal from 2000 to 2020, also presents the same pattern, followed by landslide. The number of earthquake related events are fewer but the financial damages are quite high.

Disaster	Sub Type	No. of events	Total Deaths	Total Affected	Total Damage ('000 USD)
Flood	--	6	769	2,033,662	805,300
Flood	Flash flood	3	272	16,277	15,000
Flood	Riverine flood	18	1347	2,064,130	63,429

Source- Created on: April 21, 2020, EM-DAT: The Emergency Events Database - Universite catholique de Louvain (UCL) - CRED, D. Guha-Sapir - www.emdat.be, Brussels, Belgium.

One of the most important aspects of flooding in South Asia is the transboundary nature of floods that mostly generate from the Himalayan mountain range. It is widely known that recurring catastrophes/ floods in trans-border river basins of the Ganga and the Brahmaputra cause extensive damages to lives, livelihoods and properties of the communities at-risk and increase their vulnerability to external shocks.

Early Warning System

The EWS, along with other information services based on weather, water and climate data play a key role in disaster preparedness and improving the productivity and performance of climate sensitive sectors such as agriculture. Along with investments in resilient infrastructure, risk financing strategies and capacity building measures, they are a key part of a toolkit for strengthening disaster and climate resilience.

Further, the EWS in India and South Asia has been mostly run and implemented by well-established institutions i.e., IMD, Indian Institute of Tropical Metrology (IITM) which determines the mathematical model prediction on rain forecast in India, Department of Metrological and Hydrology, and other institutions are working in India and South Asia. In Bangladesh the Disaster Management Bureau (DMB), Bangladesh Meteorological Department and Flood Forecasting and Warning Centre (FFWC) under Bangladesh Water Development Board (BWDB) are key institutions which work in the area of flood based early warning. Recently the country has also signed a treaty with the World Bank, Bangladesh Weather and Climate Services Regional Project (BWCSRPP)⁹⁵. It will help strengthen the weather, water, disaster risk and climate information services in Bangladesh. The project will also pilot a community-level early warning system for flash floods, thunderstorms and droughts in four districts -Netrakona, Sunamganj, Rajshahi and Naogaon. In Nepal the ministry of home affairs is the main coordinating agency to coordinate the affairs of disaster management. It is also being supported by the Department of Hydrology and Meteorology and the Department of Water-Induced Disaster Preparedness in early warning communication and dissemination. The establishment of Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES) based in Bangkok as an outcome of the Tsunami has steered the approach of cooperation at regional level⁹⁶. In parallel, there has been civil society attempt to work with the communities living across the border of India and Nepal in order to establish the dialogue between several local and regional entities.

The need for a regional approach is necessitated by the fact that the bilateral river treaties and data sharing agreements currently in place are not sufficient to avert and adapt to flood catastrophes on a trans-border scale. Most of the national governments maintain government to government level interactions and exchange information regarding floods and other natural hazard induced disasters. India and Nepal have signed various water-sharing treaties, but most of them have been either not operative or being criticised by the people for several reasons, mostly due to public distrust. Some of the river treaty signed are Kosi (1954) and Gandak (1959) and Mahakali/Sarada in 1995⁹⁷. With Bangladesh, the current water sharing agreement is limited

⁹⁵ <https://www.worldbank.org/en/news/press-release/2017/04/05>

⁹⁶ RIMES evolved from the efforts of countries in Africa and Asia, in the aftermath of the 2004 Indian Ocean tsunami, to establish a regional early warning system within a multi-hazard framework for the generation and communication of early warning information, and capacity building for preparedness and response to trans-boundary hazards.

⁹⁷ Amit Ranjan, Contours Of India- Nepal Relationship And Transboundary Rivers Water Disputes, Journal of International Affairs Vol. 1, No. 1, 2016, pp8

to the Ganges River. India and Bangladesh signed the Ganga water treaty in 1996. An agreement on the Teesta River, a tributary to the Brahmaputra, has been discussed for many years but has not been signed. As understood, it is quite a difficult task to have river water treaty among countries as water sharing as a resource is a sensitive subject. Between India and Bangladesh, the only joint structure for water planning is the Joint Rivers Commission, but this body does not possess the independent power to formulate and implement solutions. Water planning is not coordinated across all government sectors within India and Bangladesh. On the other hand, Nepal and India have constituted three levels of joint committees for management of trans-border rivers: Joint Committee on Water Resources (JCWR), Joint Committee on Inundation and Flood Management (JCIFM) and Joint Standing Technical Committee (JSTC).

In India water is a state subject and in all the river-based treaties respective Indian states have major role to play. The institutional interaction between the countries are straightjacketed in nature and countries are bound by the bilateral treaties, hindering the information sharing process with third countries. It is clear that because of the regional nature of floods regional interdependencies between countries in terms of weather and climate is bound to happen.

The cause and effect of weather pattern mostly being generated by monsoonal rains also requires comprehensive regional planning and effective coordination among South Asian countries. While significant progress has been achieved in strengthening regional EWS for tsunamis and tropical cyclones, especially since the 2004 Indian Ocean Tsunami, critical gaps exist for other hazards, despite the technology being largely available specifically for countries in Asia/South Asia.

Involvement of Community

A regional level collaborative effort in South Asia is required to provide better access to information on data of water flow – communication and knowledge about the river flow coming from the Himalaya and affecting the transboundary communities living across the border. It may influence the key policy makers and other important stakeholders to have a better understanding of flood early warning methods and water related issues. This can be done by either formulating regional institutions with a mandate for community involvement or by promoting track II water diplomacy by having river basin dialogue on an annual basis ensuring the participation of most of the relevant stakeholders.

Governance Framework

- Prioritising regular government to government interaction in terms of developing disaster management strategy. The first level of interaction should happen within the country among the different organisations working in the space of flood mitigation.
- Promulgation of appropriate policy and EWS frameworks at regional level with effective participation of community-based organisations, research institutions, national and international NGOs should be developed and made operational. At community level the implementation of EWS is sporadic and project-specific but they do generate location and geography-based knowledge for the community. This knowledge and expertise can be used while developing an EWS framework.
- EWS are often a neglected aspect of governments due to other burning issues governments face. There is a strong need for the Public-Private Partnership (PPP) initiative in EWS and promotion of corporate social responsibility (CSR) to share the burden of government agencies.
- Understanding the risk of a flood at different points along its course is an important factor. Currently, the flood monitored in the upstream country has little or no information on risks for the downstream country. Unless the risk is assessed for the downstream country with the help of flood information in the upstream country, a Trans-Border Flood Early Warnings System (FEWS) would be difficult to operationalise. The knowledge of information on risks should be shared beyond the geographical boundaries of countries
- Updating of existing disaster management strategies and action plans is required to empower the at-risk trans-border community for better operation through CEWS. Persuasion

is required to develop bilateral and multilateral agreements that support hydro-meteorological data sharing between countries and basin scale flood forecasting in all trans-border rivers.

- Local political institutions have given less priority in the disaster risk management including the importance of EWS. It is suggested to have a compulsory provision of focal points and capacity building of local political authorities.
- Technical institutions such as hydrological, meteorological, geological, can be assigned for regional-level information generation for different hazards and to share information to the regional disaster management centre and relevant government centres at national level on a real time basis.

3.5 Different designs of transboundary Early Warning Systems in South Asia

The following section of the report describes several transboundary EWSs that are joint collaborations and/or provide warnings across the region covering storm surges, cyclones and flooding. While many of these systems are operated by National level institutions with complex technology, this section also showcases a transboundary community-based flood EWS that highlights how EWS can be designed and implemented by the community.

3.5.1 The India Meteorological Department and transboundary EWS

- **Dr. M. Mohapatra and M. Sharma**, India Meteorological Department, New Delhi, India

The India Meteorological Department (IMD) provides forecasts and warnings against various severe weather events over the South Asian region including the Bay of Bengal and Arabian Sea. For the above purpose, IMD acts as (i) Regional Specialised Meteorological Centre (RSMC) Tropical Cyclones, New Delhi, (ii) RSMC for severe weather forecasting including heavy rainfall, strong winds and sea waves apart from cyclones and (iii) Regional Centre for flash flood guidance to South Asia.

- RSMC New Delhi:** IMD acts as RSMC, New Delhi to provide tropical cyclones and storm surge advisories to 13-member countries under WMO/ESCAP Panel including Bangladesh, India, Iran Maldives, Myanmar, Oman, Pakistan, Qatar, Saudi Arabia, Sri Lanka, Thailand, United Arab Emirates and Yemen. These advisories are issued every six hours during depression stage and three hours during cyclone stage. Area of responsibility of RSMC New Delhi is presented in Figure 3.20 (a). Observed and typical forecast track in association with severe cyclonic storm Mora which crossed Bangladesh coast is presented in Figure 3.20 (b). It also acts as one among 7 Tropical Cyclone Advisory Centres (TCAC) worldwide to provide cyclone advisories on forecast track and intensity for next 24 hours and area of intense convective clouds to Asia Pacific countries and Middle East countries for civil aviation as per International Civil Aviation Organisation (ICAO) guidelines. It also provides support for Global Maritime Distress Safety System (GMDSS) for Area VIII-N covering the north Indian Ocean.
- Severe Weather Forecast Demonstration Project (SWFDP)-South Asia:** SWFDP is an ambitious project taken up with the joint initiative of IMD and World Meteorological Organisation (WMO) to monitor and predict the severe weather from tropical cyclones, severe thunderstorms and monsoons namely heavy rain, strong wind, storm surge and high waves. The project aims at providing improved warning services to disaster management agencies for effective disaster management. It is a 3-tier cascading process involving various numerical weather prediction centres at global levels including IMD, National Centre for Medium Range Weather Forecasting (NCMRWF), Indian National Centre for Ocean Information Services (INCOIS), India, National Centre for Environment Prediction (NCEP), USA, European Centre for Medium Range Weather Forecasting (ECMWF), United Kingdom Meteorological Office (UKMO), Japan Meteorological Agency (JMA); RSMC New Delhi at regional level and the National Meteorological Centres (NMCs) of the 9 member countries including Bangladesh, Bhutan, India, Maldives, Myanmar, Nepal, Pakistan, Sri Lanka and Thailand (Figure 3.20 (c)).

RSMC New Delhi is the regional centre and provides daily severe weather guidance for next 5 days to these member countries for their national level warning since May, 2016. A typical example of guidance product from RSMC New Delhi is presented in Figure 3.20 (d).

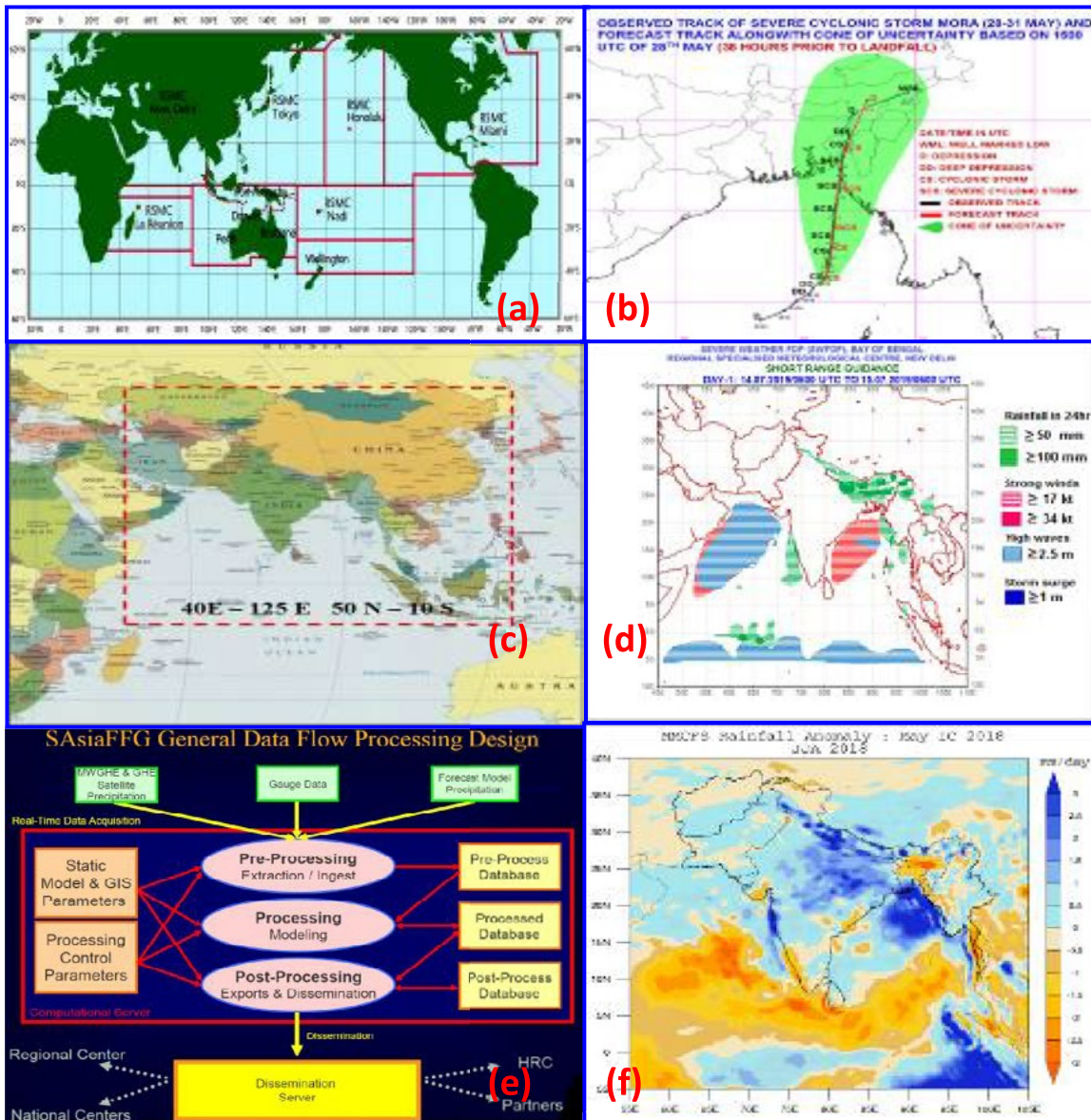


Figure 3.20: (a) Area of responsibility of RSMC Tropical Cyclones, New Delhi, (b) observed and typical forecast track in association with severe cyclonic storm Mora (28-31 May, 2017), (c) Area of responsibility for SWFDP-South Asia, (d) typical SWFDP guidance forecast for day-1 (24 hour forecast period), (e) data flow under SA-FFG system and (f) Typical rainfall anomaly guidance product for south Asia by Climate Forecast System Version 2.0 (Climate Forecasting System v2)

(iii) **Regional Centre for Flash Flood Guidance to South Asia (SA-FFG):** IMD also acts as WMO’s Regional Centre for Flash Flood Guidance at sub catchment scale over the South Asian region including Nepal, Bhutan, Bangladesh, Sri Lanka and India with a focus on hilly regions, steep terrains and urban centres to provide guidance on impact based flood warning, landslide prediction, urban flood warning, riverine/channel routing, seasonal to sub seasonal run off and flow forecasting. The data flow under SA-FFG program is presented in Figure 3.20 (e).

(iv) **Observational and modelling support:** IMD also provides the observational support through INSAT and other satellites launched by Indian Space Research Organisation (ISRO). It also provides the Numerical Weather Prediction model guidance to the South Asian countries through dedicated websites and web pages.

(v) **Capacity building of South Asia for EWS:** IMD also plays a key role in capacity building in the region and organises regular trainings for cyclone forecasters of member countries annually. It also provides trainings under SWFDP. It also acts as WMO recognised Regional Meteorological Training Centre (RMTC) (Figure 3.20 (f)) and provides training to candidates nominated by the Meteorological Services of countries within the region.

(vi) **Regional Climate Centre (RCC), Pune:** In addition, the Region Climate Centre located at IMD Pune, provides the seasonal forecast outlook for the rainfall and temperatures over South Asia under South Asian Climate Outlook Forum (SASCOF) w.e.f. monsoon season 2010.

Today, IMD is a key player in the field of weather forecasting in the region. IMD has earned accolades and appreciations worldwide for early warning advisories especially for tropical cyclones, heatwave and heavy rainfall warnings etc. It's continuous upgradation of early warning system has helped the South Asian region to improve their early warning services.

The following papers highlight the development and workings of the HKH Hydrological Cycle Observing System (HYCOS) and regional flood information system in the Ganga-Brahmaputra-Meghna and Indus Basins, developed by ICIMOD in partnership with WMO and Bangladesh, Bhutan, China, India, Nepal and Pakistan.

3.5.2. Hindu Kush Himalayan Hydrological Cycle Observing System (HKH-HYCOS)

– **Mandira Singh Shrestha**, Program Coordinator: Hi-RISK, International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal

There is an urgent need for effective cooperation between the countries sharing the Indus, Ganges and Brahmaputra basins: Bangladesh, Bhutan, China, Nepal, India and Pakistan. One such regional cooperation system that was initiated in 2010 was the Hindu Kush Himalayan Hydrological Cycle Observing System (HKH-HYCOS). Initiated by the International Centre for Integrated Mountain Development (ICIMOD), the World Meteorological Organization (WMO) and ICIMOD's partner countries Bangladesh, Bhutan, China, India, Nepal and Pakistan the project helped build the capacity of the partner countries' national hydromet services and modernised the hydromet networks in the region: a total of 38 hydromet stations (9 in Bangladesh, 9 in Bhutan, 12 in Nepal and 8 in Pakistan) were upgraded to share real-time data. A regional flood information system was established to facilitate the transboundary exchange of real-time data and know-how. The information system allows the visualization and extrapolation of real-time data from the stations to any geographical location by providing information on the river-water levels and amounts of rainfall.

The data transmitted in real-time along with global datasets are used to develop flood outlook products and to validate model results, such as in satellite-derived products. These products are used by partners to forewarn communities of increasing river-water levels, helping reduce risks. In August 2014 and 2017, for example, the flood outlook was used by Nepal's Department of Hydrology and Meteorology along with other forecasts to issue flood advisories. It did so by means of flood bulletins which were widely disseminated through its website and shared with the National Emergency Operation Centre and targeted recipients to enable timely flood warning.

The hydromet services of Bangladesh, Bhutan, Nepal and Pakistan have since been able to attract sizeable investments for the modernisation of their hydromet networks. Activities funded through HKH-HYCOS have improved the capacity of the hydromet services to take up these projects, and contributed to building climate resilience for people at risk.

3.5.3 Early Warning System for Floods: A View from Himalayas

– **Dr. Bhanu Mall**, Secretary, Purvanchal Gramin Vikas Sangathan (PGVS), Lucknow, Uttar Pradesh, India

The Himalayan region is prone to natural hazards like floods, glacial lake outburst, droughts, landslides, avalanches and earthquakes. The unstable geological conditions and steep terrain, combined with climate change and frequent extreme weather conditions, pose a myriad challenges for the communities.

The establishment of a regional flood information system (RFIS) allowed for a timely exchange of flood data and information for reducing flood vulnerability. A wide range of information is produced to support multi-scale disaster risk reduction (DRR) systems using satellite rainfall estimation, satellite altimetry-based flood early warning systems, flood inundation modelling, and model derived hydrological information. Whereas, Community-based Flood Early Warning System (CBFEWS) enabled by wireless technology [refer D. Shakya and N. S. Pradhan's paper in this chapter] is one of the promising interventions for minimising flood risk at the community level.

Flood Forecasting Capacity in the Hindu Kush Himalayan (HKH) Region

Understanding the present capabilities of hydro meteorological services in the participating countries and disaster management authorities and utilising the expertise available is necessary for the development of a RFIS.

Adequacy of hydro meteorological observation networks and quality control of observations of Hydrometric information is fundamental to the planning, operation and management of water resources and flood defence. Hydro meteorological observation networks include stage and discharge measurements as well as meteorological observations such as rainfall, temperature, humidity, pressure and wind speed.

Early flood warning for better preparedness is largely dependent on the timely availability and quality of hydro meteorological data. Collection of hydro meteorological data in real time requires a range of sophisticated sensors together with professional competence in management and operation. The first priority of the HYCO related RFIS was to update and automate existing hydro-meteorological stations to make them capable of observing parameters and transmitting the data at regular and specific intervals. A wide range of options are available for automatic in situ water-level observations, including stilling wells, pressure sensors, bubbler sensors and radar sensors.

For the HYCOS initiative, data storage is provided in three different places. At the site level, site-specific data is stored in a cyclic memory that can hold data for 2-10 years. Real-time data is transmitted simultaneously to the national servers and a regional server; the two servers are synchronized periodically to ensure that the same set of data is available on both. In addition, an automated plausibility analysis of incoming data is performed as a first-order quality check.

The Community-based Flood Early Warning System

This system has been installed and operated within the capacity and capability of the communities of the affected area to ensure the sustainability of the project. Local communities have developed flood maps, identified evacuation routes, designated evacuation sites and shelters, and implemented the Community-based Flood Early Warning System (CBFEWS) in small tributaries for flash flood.

Communication between upstream and downstream communities was promoted to enhance collaboration. Increases in river water level upstream are a good indicator of flooding events downstream. The Department of Hydrology and Meteorology (DHM) employed the local monitoring staff from the upstream community, and



Village level trained task force members.

equipped them with basic river monitoring system (solar powered for communities with no grid connectivity), and most of the activities were carried out by upstream communities themselves.

Creative use of existing resources and collaboration with various Government Agencies, NGOs and private-sector companies were key to deliver the Community Based Flood and Glacial Lake Outburst Risk Reduction Project (CFGORRP). DHM installed an automated monitoring station at the glacial lake in collaboration with the Ministry of Home Affairs and telecommunication companies (Nepal Telecom and NCELL) to disseminate warnings using SMS for people using the mountain trails who may be caught up in the GLOF.

Institutional Arrangements

The executing agency is the DHM under the Ministry of Population and Environment (MoPE), which is technically supported by UNDP. The Department of Soil Conservation and Watershed Management (DSCWM), the Department of Water Induced Disaster and Prevention (DWIDP), and the Department of National Park and Wildlife Conservation (DNPWC) are collaborating partners, and responsible for providing inputs for planning and technical oversight.

3.5.4 A transboundary wireless community-level flood early warning system

– **Dipankar Shakya**, CBFEWS SSA, ICIMOD and **Neera Shrestha Pradhan**, Senior Water and Adaptation Specialist, ICIMOD, Nepal

Community-based Flood Early Warning System (CBFEWS) is an integrated system of tools and plans for detecting and responding to flood emergencies. The system is owned and managed by communities. The CBFEWS implemented by ICIMOD and partners has four key elements of an EWS. Of the four, the second element – community-based monitoring and flood early warning – involves monitoring the river in order to generate flood early warning based on the water level in the river. Efforts have been made to introduce low-cost, people centric and innovative technologies for this purpose. To that end ICIMOD developed and implemented a Water Level Monitoring System (WLMS), which evolved into four different versions through years of research and development. The current version features a telemetry-based approach to early warning. This paper explores the evolution of the instrument used for flood monitoring and the processes involved in the telemetry-based water level monitoring system. There is a growing focus on development of a culture of risk prevention and the promotion of EWSs⁹⁸. The CBFEWS project at ICIMOD has continually explored ways to provide effective early warning to increase lead time for flood vulnerable communities. The project seeks to empower communities for preparedness and response, and employ low-cost and innovative information and communication technologies.



CBFEWS with wire (2010, Assam, India)



CBFEWS, wireless technology (2012, Assam, India).

98 Alfieri, L., Salamon, P., Pappenberger, F., Wetterhall, F., & Thielen, J. (2012). Operational early warning systems for water-related hazards in Europe. *Environmental Science and Policy*, 21, pp 35-49. <https://doi.org/10.1016/j.envsci.2012.01.008>

ICIMOD initially piloted the CBFEWS in partnership with Aaranyak along the Jiadhul and Singora river tributaries in 2010 (photo 1). The instrument featured a simple wired solution in which open conductors were aligned along a tube that would be immersed in the river. The instrument was named Water Level Monitoring System (WLMS) version 1. The wired connections threw up a set of challenges – wires were exposed to the elements and close proximity of the caretaker to the flood. Thus, a wireless solution was developed to tackle these issues.

The next version of the WLMS, developed in 2012, was the Wireless Water Level Monitoring System (WWLMS). It featured a wireless link between a water level detector, transmission unit, and a receiver unit (Photo 2). This was implemented by the District Disaster Management Authorities in Lakhimpur and Dhimaji, Assam, Aaranyak, Sustainable Eco Engineering (SEE), and ICIMOD. The device was capable of transmitting to a range of up to 300m. Soon after, the WWLMS v2 was further upgraded. Printed circuits were introduced; battery efficiency was improved through low powered RFM12 radio at 433 MHz for increased range of up to 800 m; and the sensor was modified to incorporate an immersion sensor based on conductivity and floatation switches. The new version – WWLMS v3 – was deployed in river tributaries in Afghanistan, India and Nepal from 2015 onwards⁹⁹.

(Acknowledging the impact of the CBFEWS on the ground, the UNFCCC presented the ‘Momentum for Change: 2014 Lighthouse Activity Award’ in the Information and Communications Technology (ICT) category to ICIMOD and its implementing partners in December 2014.)

In 2015 there was a complete overhaul of the wireless system which had been developed in 2012. Immersion based sensor now included an ultrasonic non-contact sensor and wireless technology for measuring the water level accurately, generating early warnings and uploading measurements to the cloud via telemetry. The telemetry based flood monitoring instrument – Telemetry based WLMS (TWLMS) v4 – was field tested in Khokana, Nepal (Photo 3) and then successfully implemented in the Koshi basin, India and Nepal. The TWLMS was used to establish a transboundary CBFEWS between India and Nepal, which proved instrumental during the floods of 2017¹⁰⁰. This was jointly implemented by ICIMOD and SEE with its partners in India (Bihar State Disaster Management Authority and Yugantar) and Nepal (DHM/Community-based Flood and GLOF Risk Reduction Project). Similarly, an improvised CBFEWS instrument that used wireless technologies were installed to monitor the Gilgit River in the Punnial valley in Pakistan (with Gilgit Baltistan Disaster Management Authority, WWF-GB, AKAH-Pakistan), and one tributary in Baghlan (with Afghanistan National Disaster Management Authority and AKAH-Afghanistan) and two tributaries of the Kabul basin –the Peshgor River and Panjshir River in Afghanistan (with the Ministry of Water and Energy and AKAH-Afghanistan).

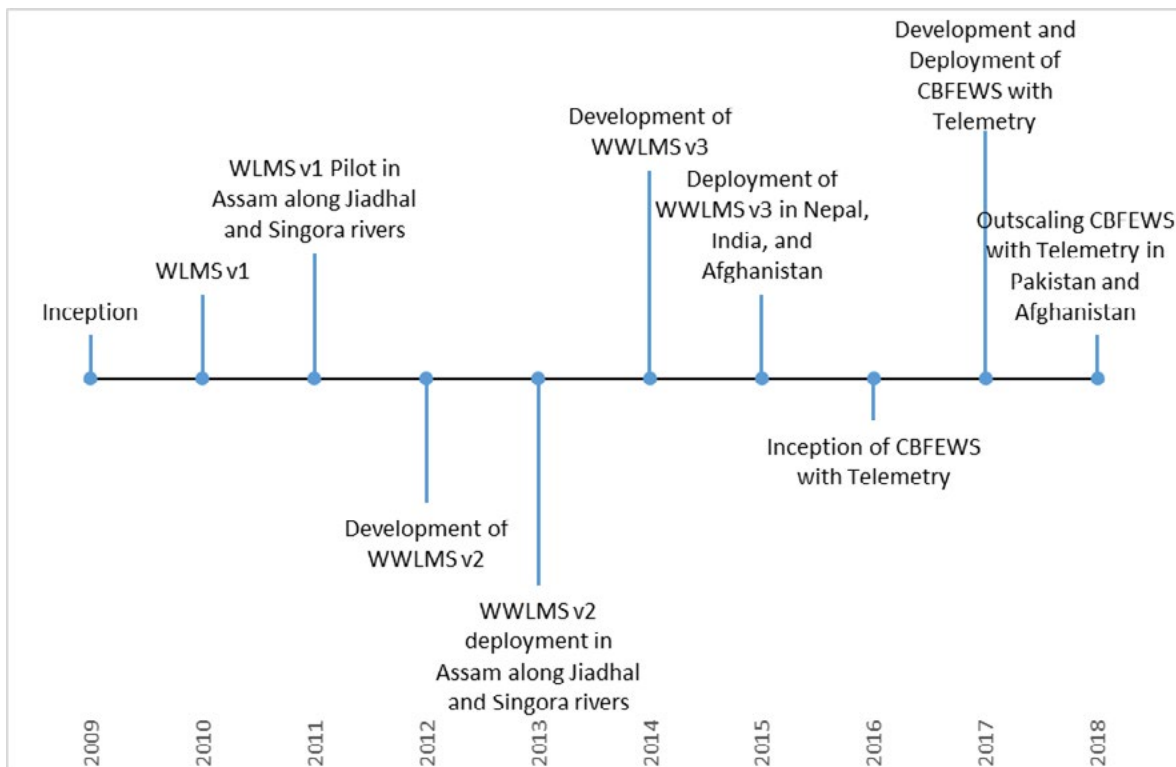


CBFEWS with the telemetry system (2017, Khokana, Nepal).

99 Pradhan, N.S, Bajracharya, N, Bajracharya, S.R, Rai, S. & Shakya, D. (2016). Community Based Flood Early Warning System for the Hindu Kush Himalaya.

100 Pradhan, NS and Pandey, S (2019). The Success of Community based Trans-boundary Early Warning System. Trans-boundary Early Warning Systems in Asia. Issue 180, pp 10-12 <https://reliefweb.int/sites/reliefweb.int/files/resources/180%20Trans-boundary%20EWS%20in%20Asia.pdf>.

The instruments of the WLMS series, including wireless and telemetry based, were manufactured by Sustainable Eco Engineering P. Ltd, Nepal, with conceptual and technical support from ICIMOD. Technical upgrades to the instrument are shown in Figure 3.21 below.



Telemetry Based Water Level Monitoring System (TWLMS) v4

The TWLMS is an ultrasonic sensor based water level monitoring system that periodically uploads the water level measured to the cloud. Three units comprise the system: the Data Acquisition (DA) unit, Data Upload (DU) unit, and Alarm Unit (AU). The DA unit measures the water level through an ultrasonic sensor and transmits the measured data to the DU unit over a 2.4 GHz wireless network. The units are able to communicate up to a range of 3km in clear line-of-sight conditions. The DU unit, upon reception of data from the DA unit, proceeds to display the measured water level on an LCD screen, generate alarm signals if required and uploads the same onto the cloud through a GPRS connection over 2G GSM. The DU unit sounds localised warning and danger sirens when the water level crosses pre-determined thresholds. The DU unit also features a remote update over-the-air capability, which enables the unit to update its firmware. During the commissioning of the system, this remote update feature of the DU unit enables control over different parameters that are site specific and require setting as per site conditions (Figure 3.22) below.

The TWLMS is program to collect data every five minutes. Once the data reaches the cloud, it is presented in a time-series chart. Furthermore, when the water level exceeds preset danger levels, warning messages are forwarded via SMS and email to relevant stakeholders and authorities through a server application. The Alarm Unit is a GSM based loud siren. It triggers the siren when it receives a specifically worded text message. The Alarm Unit is placed in downstream communities and local authorities responsible for disaster response; it may be triggered by the designated caretaker upstream or the server application after verification, thus facilitating faster and wider dissemination and helping increase the lead time.

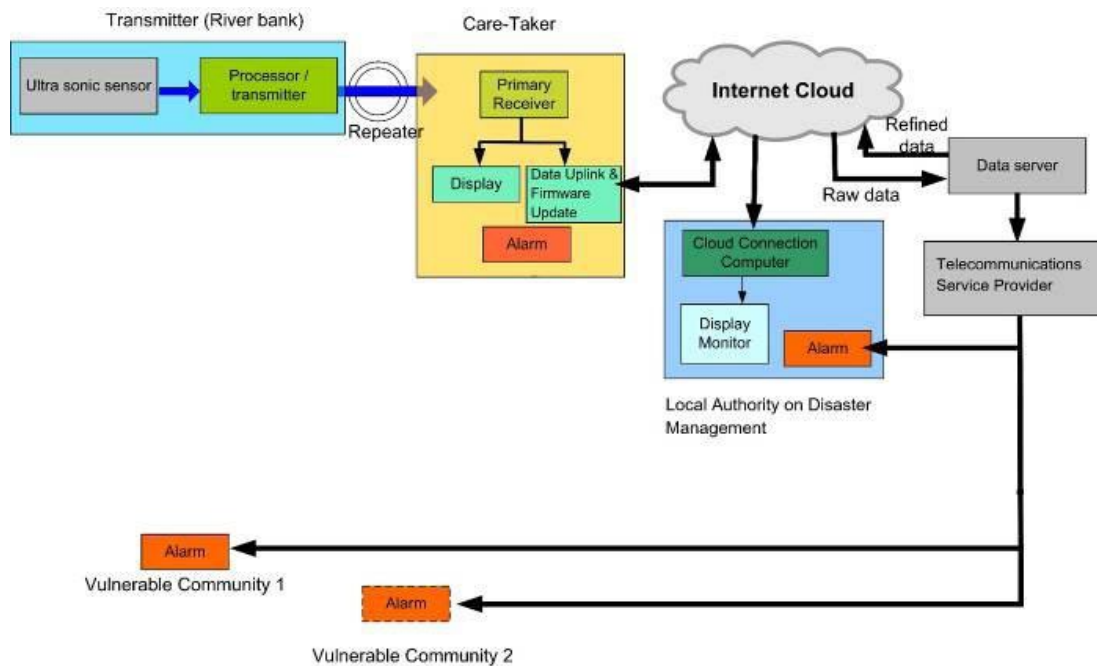


Figure 3.22 - Flow Diagram of Telemetry Based Water Level Monitoring System (TWLMS) v4.

Learning from the field

The TWLMS instrument has delivered promising results in its various deployments. However, learning from field experience and site-specific requirements, there is room for improving the wireless range between the DA and DU units, the reliability of that link, data transfer capability at minimal network strength and cost, and power efficiency and battery life. Meanwhile, including other expansive components such as a multi-sensor and multi-node network, and interoperability between different GSM and CDMA networks, would also make the instrument more reliable. Over time, the system can be steadily improved through access to better technology, improved source programming and optimisation of the system architecture.

Instrumentation alone does not make up the entirety of CBFEWS, but it is a pivotal component nonetheless. As a source of early warning information, a flood monitoring system must be able to provide reliable water level information and communicate such information to vulnerable communities, especially during flood scenarios.

Acknowledgement

The CBFEWS is supported by the Australian government through its initiatives Strengthening Water Resources Management in Afghanistan (SWaRMA), Koshi Basin Initiative, and Indus Basin Initiative under its Sustainable Development Investment Portfolio for South Asia; and the governments of Norway and Sweden through the Himalayan Climate Change Adaptation Program. ICIMOD gratefully acknowledges the support of its core donors –the governments of Afghanistan, Australia, Austria, Bangladesh, Bhutan, China, India, Myanmar, Nepal, Norway, Pakistan, Sweden, and Switzerland. We are grateful to Sustainable Eco-Engineering for their technical support and for manufacturing the instruments; and local partners, government line agencies, and communities for their continuous support.

3.6 Key Conclusions Detection, Monitoring, Analysis and Forecasting of the Hazards and Possible Consequences

This section draws from peer reviews and contributions from the following authors:

- **Raihanul Haque Khan**, Bangladesh Program Lead, Regional Integrated Multi-hazard Early Warning System (RIMES), Bangladesh
- **Suparana Katyaini and Sarbeswar Sahoo**, Indian Institute of Technology Delhi, India
- **Maria Bernadet K. Dewi** and **Sanjay Srivastava**, UNESCAP, Thailand
- **Vivek Coelho**, Social and Ecological Stewardship Program, Tata Institute of Social Sciences, Mumbai, India
- **Professor Dr. Ahmad Kamruzzaman Majumder**, Director, Center for Atmospheric Pollution Studies (CAPS) and Chairman, Department of Environmental Science, Stamford University Bangladesh

Multi-hazard and single hazard EWS systems are incorporated throughout South Asia, varying based on the geographical area and the hazard. The transboundary nature of floods in the Ganges, Brahmaputra, and Indus offers a strong basis for augmented EWS to address bilateral and multilateral needs and helps in understanding and responding to risks and disasters more effectively as discussed by R. Jha in his contribution

M. Mohapatra and M. Sharma have explained in detail how the Indian Metrological Department has matured to take several regional functions such as Regional Specialized Metrological Center (RSPC) for communicating weather forecasting, heavy rainfalls, sea waves and cyclones as well as the South Asian Climate Outlook Forum in Pune since 2010.

The contribution by M. S. Shrestha has drawn attention to the scope of regional level upgradation of Himalayan-Hindukush-Karakoram Hydrological Cycle Observation System (HKH-HCOS) that can be upgraded and further expanded. Likewise, national hydro-met systems also need to be consolidated and expanded in the HKH region. In a similar vein, A. T. Sheikh has shown in his contribution how success stories in the country can be scaled up and serve as a model for regional collaboration in EWS on the tributaries of Indus. (Majumder)

The advances in Big Data enhance the effectiveness all four EWS inter-related elements through substantial improvements in the descriptive, predictive, prescriptive and discursive capacities. The use of risk analytics: descriptive, predictive, prescriptive and discursive, helps understand, monitor and predict the risk of both extreme as well as slow onset events, and thus addresses the key challenges of addressing the unmet needs of an effective multi-hazard EWS. The substantial reductions in mortalities and economic losses due to typhoons in South Asia can be attributed to big data applications that enabled impact-based forecasting and risk-informed early warning. For example, the devastating potential of tropical cyclone Fani was minimised by Big Data applications. Further opportunities are available in flood forecasting, a recent innovation in ensemble prediction systems. Machine learning can also be used to accurately predict the location and severity of the floods. As a result, early warning systems are more precise, timely and address the last mile out issues. (Dewi & Srivastava)

There have been efforts to generate risk knowledge and demonstrate application of different dimensions of risk information including hazards, exposure, vulnerability and capacity. Seismic risk assessment in India, INSPIRE system by RIMES and CBFWS by ICIMOD are examples of such efforts. There have also been pilot applications of emerging technologies like big data, AI, social media etc. in dynamic risk assessment. Such technologies in combination with sensor networks have enhanced real-time monitoring and detection of hazards in South Asia. Forecasting systems have also improved with the introduction of Numerical Weather Prediction and Ensemble Prediction System. Location specific impact forecast has been utilised in some countries to facilitate integrated disaster management. Application of ICT is bringing about positive changes in dissemination and communication of warnings. Decision support systems (e.g., SMART and SATARK by RIMES) that integrate cutting-edge technologies have demonstrated capabilities of risk-informed planning and decision-making.

There are limited hydro-meteorological data sharing and regional cooperation for transboundary hazards. Forecasts are sometimes not accurate enough and forecast of possible consequences,

cascading effects are not always available. Communities at risk lack in response capabilities due to poor dissemination, awareness, interpretation and inaction. Capacity of both the forecasters and end users across the four elements of EWS from regional to local level needs to be equally improved.

With improved accuracy of the forecast, the users will gain more confidence. Connecting the last mile users is also essential, enabling them to interpret the impact and take early action ahead of an impending disaster to effectively reduce loss and damage. Thus, it is recommended to enhance regional and local cooperation. Simple innovations in EWS with greater impact potential should be promoted. Technologies introduced, should be appropriate for intended communities and establish a continuum of integrated risk management to tackle the new normal. (Khan)

Communities at risk may lack response capabilities due to poor dissemination, awareness, interpretation and inaction. Capacities of both the forecasters and end users across the four elements of early warning system from regional to local level need to be equally improved. Case studies of successful community based EWS (Vivek Coelho – India, Pokhrel, Sharma, Majumder – Kolkata, India) and transboundary community based early warning systems (Mall, Shrestha) reflect the ability of these systems to overcome these challenges.

The various case studies indicate the institutionalization of multi-hazard early warning systems in South Asia, and practices that are need based and context specific with respect to the risk, hazard and vulnerability profiles of the region. The risk knowledge generated through scientific and technological tools provide enhanced accuracy to ensure adequate information for decision-making thus contributing to disaster risk management.

Strengthening of disaster risk governance requires warning services to be integrated into decision support systems to ensure timely communication with decision-making authorities and stakeholders. The efficient and effective dissemination of accurate early warnings provides the critical lead time so crucial for limiting exposure to hazard risks and containing damage and loss caused by disasters.

Early warning systems require the integration of community response capabilities and a dynamic feedback mechanism for resilience building. This investment in capacity development will ensure the practice of scientific rigor within at-risk populations and bring in disciplined alertness as part of monitoring early warning parameters. Establishment of multifaceted technical monitoring tools and equipment that utilise innovative technologies need to be easy to use, accessible, and cost effective in design. This has the ability to establish ground truth verification networks ensuring wider localised and regional coverage.

People centred EWSs will require multi stakeholder collaborative partnerships that focus on enhancing disaster preparedness by exploring possibilities to engage with local communities and stakeholders through livelihood opportunities that focus on building back better, safer and resilient human settlements. Nurturing stewardship and a sense of ownership will go a long way in this endeavour. (Coelho)

Based on a review of articles presented under this section, Katyaini & Sahoo draw out the following recommendations.

Priority 1. Understanding disaster risk

- Context-specific EWS for appropriately risk-informed system
- Examining the meteorological and hydrological factors

Priority 2. Strengthening disaster risk governance to manage disaster risk

- Communities owned, managed, and governed EWS
- Collaboration between state and non-state actors
- Transboundary cooperation.
- Setting up real-time monitoring network

Priority 3. Investing in disaster risk reduction for resilience

Besides technological and structural infrastructure, there is need to invest in addressing socio-economic disparities and collective action for inclusive and effective EWS.

Priority 4. Enhancing disaster preparedness for effective response and to “Build Back Better” in recovery, rehabilitation and reconstruction

Low-cost innovative solutions for larger outreach.

Shift from early warning to early action.

Data innovation in disaster preparedness and risk communication in guiding development planning, resilience strategies.

Thus, contributions from this chapter highlight the need for continued improvement in the South Asian region for EWS collaboration and community stewardship and response. It highlights how Big Data has come to the forefront of hazard forecasting and preparedness and provides examples on the ground where community ownership and stewardship play a key role in data collection, monitoring, forecasting and preparedness within the EWS.

4.Warning Dissemination and Communication



Warnings must reach those at risk in a timely manner and in a manner they can understand and take suitable action. Without an effective early warning dissemination and communication system, an early warning system is bound to fail. Thus, ‘this component of EWS can be seen as the ensemble of risk communication infrastructure (reliable and disaster-resistant hardware, information and communication technologies) and strategies (appropriate interactions among main stakeholders, effective and customised warning messages).’¹⁰¹ Once the warning is issued, dissemination and communication go hand in hand. Simple indicators of effectiveness and performance of early warnings would be warning lead time, last mile reach, action taken rate, local preparedness coverage, false alarm learning, avoided loss and damage, and proportion of population covered.

This component of the report presents the different types of communication technology currently used in the region for disaster-related information and warning dissemination – ranging from mainstream media and unified messaging systems used as alert systems, to social platforms. Technology could also lead to disasters. The threat of technology disaster and an EWS response is also explored. Country specific papers from Nepal, Maldives, Pakistan, Sri Lanka and Bangladesh provide an overview of EWS and community based EWS and warning dissemination. Papers from Afghanistan and India subsequently provide case studies where community based EWS have been successful in this context. Contributions provide guidance on effective ways and means of communication and dissemination of alerts and warnings to at-risk communities.

4.1 Media and telecommunications in Early Warning and Alert Systems

The use of media, telecommunications, and more recently social media and warning apps, to alert the public of impending disasters and share disaster-related information form the essence of present-day early warning dissemination and alert systems. Compared to traditional word of mouth and verbal alerts systems, messages are now received instantly. With that comes a different set of challenges, in terms of reliability, trust, and adequate coverage. Aspects explored by the papers in this section.

4.1.1 Early warning, Unified Messaging Systems and Alert Systems

– **Saket Jha**, Former Director, Special projects, Unified Messaging Systems and Services Pvt. Ltd., Bangalore, India

During major incidents such as acts of terror, natural hazard induced or man-made catastrophes, warning the citizens and alerting the first responders is of utmost importance to reduce the risk of people being harmed, injured or killed, enabling people to take precautions and protect themselves and their loved ones.

‘Warning and information are just as important as food and water before, during and after the occurrence of an emergency situation.’ (Red Cross, World Disaster Report).

A system designed for this purpose **MUST WORK** during emergency situations, alerting the population through multiple communication channels (mobile phones, TV, radio, etc.). The communication that needs to be sent out to all people in a selected area, should not get stuck in the congestion of communication channels.

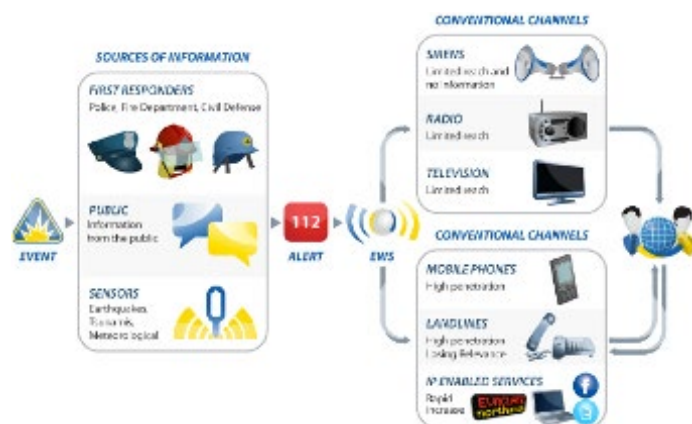


Figure 4.1: Emergency Warning System.

¹⁰¹ United Nations Development Programme (UNDP), 2018: Five approaches to build functional early warning systems. <https://www.adaptation-undp.org/resources/manual/five-approaches-build-functional-early-warning-systems>

Requirements:

- Alert all people in a certain area about situations where they are in danger.
- Respond to requests for help from the people in a selected area in times of crisis.
- Improve response time for emergency handling.
- Better co-ordination amongst first responder groups.
- Provide efficient tools to the emergency management personnel.

The Unified Messaging System (UMS) was founded in 1997 and is a pioneer and leader in the development of advanced critical messaging systems. It is a member of the UNISDR (United Nations - International Strategy for Disaster Reduction) partnership program and holds several patents and patent applications for some innovative technologies to locate and alert people and also to handle congestion in telecom networks.

The UMS solution consists of four broad components. One can pick and choose from these as per requirements of the specific scenario.

PAS (Population Alert System) of UMS: Alerts all people in a certain geographical area with customised messages. It is a centralised and comprehensive emergency alert system with a GIS based user interface. This enables the emergency authorities to simply select or draw the area to be alerted on a digital map. The system will immediately identify all cell phones present (including those of visitors) within the affected area in real time and alert them through SMS.

PAS provides detailed logistic information to the user, such as number of people within the affected area. It can identify various nationalities and configures the emergency messages accordingly, while also monitoring and locating those citizens who respond to the alert message and request help. It gives an immediate overview of the affected population across multiple telecom operators, even before sending messages, giving authorities a real-time and actionable summary of the situation.

LBAS (Location Based Alert System): In an emergency, LBAS is the only proven technology that ensures alert messages reach their intended mobile subscribers in an area by prioritising them over any other communication traffic of the telecom provider. It has the capability to even halt non-essential traffic, in/out of the affected area, thus preventing wireless network congestion.

GAS (Group Alert System) is a web-based system for alerting pre-identified individuals by simply iterating through a group database - irrespective of their geographical location - through different channels. E.g., a group of flood relief responders.

TAS (Traveller Alert System) is a system for localising and communicating through voice/SMS with national citizens traveling abroad, based on the same reliable, flexible and scalable platform as PAS and LBAS.

PARM (Population Alert and Risk Management): Pre-define risk scenarios for triggering even faster emergency responses. Through risk assessment, risk objects and scenarios are identified and this makes planning for different kinds of incidents and hazards possible.

UMS is today the leading company of automated emergency warning and notification services in the Scandinavian countries with offices in Norway, Sweden, Denmark and India. It also has operations in other countries in Europe, Asia and Latin America. It has more real-life implementations than any other organisation worldwide.

4.1.2 Twitter (X) and Early Warning Systems: Limits and Potential for India

– **Puneet Agarwal, and Jun Zhuang**, Department of Industrial and Systems Engineering University, Buffalo, New York, USA

Online social media (OSM) has become a popular platform for people to share information on diverse topics. Twitter (now known as X), a micro-blogging service, has been widely used as an information dissemination agent, particularly during crisis situations such as earthquakes, floods, hurricanes or political conflicts (Wang and Zhuang, 2017). Twitter enables its users to share text and/or multimedia content directly from the location where the incident has taken

place, thereby allowing common people to serve as news reporters. Due to this, it has become a common trend to see event updates become available on social media first and then introduced in the mainstream media thereafter. Continuous efforts are being made to use Twitter as an effective communication channel during crises and for this purpose, the platform (then known as Twitter) started a new service called Twitter alerts, designed to prioritise information from credible organisations during crises when other communication channels are not accessible.

In South Asia, the potential of Twitter to serve as a disaster response agent was first realised during the Kashmir floods of 2014, when citizen groups organised themselves entirely on Twitter to provide assistance to agencies on the ground. During this extreme event, a Twitter hashtag '# JK Flood Relief' was recognised as a ground-breaking effort that used crowd-sourced information for raising awareness as well as getting people and corporations to donate relief materials. Twitter played a vital role in ensuring connectivity among people during the 2015 Chennai flood when the entire city was suffering from power cuts lasting two to five days. It helped local people get information about how to commute from one place to another based on which roads the water had receded. National Disaster Management Authority (NDMA), an Indian government organisation, has been leveraging the use of Twitter to make India a disaster risk resilient country. During the Mangaluru floods of 2018, NDMA used Twitter to gather information about the damage caused in the affected areas and create awareness among the citizens by employing Twitter as a disaster early warning system.



Twitter as a disaster response agent.

Despite the advantages of Twitter as a disaster management tool, it has also been criticised for spreading rumours and misinformation during crises. Twitter users can respond to rumour information by spreading it, doubting it, or seeking confirmation provided that they are involved in that particular topic of rumour through their posting of tweets. A study by Wang and Zhuang (2018) found that most of these misinformed Twitter users tend to spread the rumour information, indicating the poor rumour detection ability of the platform's users. The response behaviour of rumour spreading users is a major topic of discussion since it has been found that during crisis situations a majority of these users did not respond effectively to prevent the spread of their rumours after they were debunked. However, the debunking process of rumours in itself was significantly fast during disasters, thereby playing a major role in preventing large-scale panic and economic loss. Hence, in India, people can take advantage of Twitter as a disaster EWS during extreme events; but at the same time they must be cautious and take proper steps to minimise the spread of misinformation.

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2. Wang, B., and Zhuang, J. (2018). Rumor response, debunking response, and decision-makings of misinformed Twitter users during disasters. *Natural Hazards*, 1-18, published online.

4.2 EWS Profiles from Countries in the Region

This component focuses on communication and dissemination systems and processes from different countries in the region that show similarities but are also adapted to country or more local level contexts.

4.2.1 An Overview of Early Warning System in Nepal

– **Rejina Maskey Byanju, Sudeep Thakuri, and Ramesh Sapkota,**

Central Department of Environmental Science (CDES), Tribhuvan University, Kirtipur Kathmandu, Nepal

Nepal is one of the most vulnerable countries for natural disasters. The Sendai Framework for Disaster Risk Reduction (SFDRR; 2015-2030), the Hyogo Framework for Disaster Reduction (2005-2015), and the Asian Ministerial Conference on DRR (AMCDRR; 2016) have recognised the need for multi-hazard EWSs as an instrument for addressing DRR. EWS in Nepal is in its initial stage of implementation for addressing floods, landslides, and GLOFs, and is only able to cover few locations and hazards (Kafle, 2017; Shrestha et al., 2014).

The Department of Hydrology and Meteorology (DHM), Government of Nepal is the key institution for operating and maintaining the hydrometeorological stations (weather and flood forecasting) and EWSs and is a focal organisation for RIMES. From the Academic sector, Tribhuvan University, Central Department of Environmental Science is contributing to the EWS in Nepal through research, monitoring, and generation of data. The DHM has installed and is operating around 150 hydrological and around 300 meteorological stations, most of them below 3,000m elevation in Nepal (Figure 4.2). In addition, there are also some other stations operated by individual organisations, but they are not connected with the national monitoring system of the DHM and most of them do not produce significant time series data, except the Pyramid Observatory Stations Network in upper Dudh Koshi River sub-basin (Chaurikharka, Namche, Pheriche, Lobuche, and Kalapathar stations), operated by Nepal Academy of Science and Technology, Nepal and Italian National Research Council, Italy.

In the last decades, the DHM progressed considerably in setting up the EWSs and has replaced the traditional watch and warn method by the latest technologies of flood EWSs. It has set up EWS in the major rivers for possible flood warning. All the river flow and water level monitoring for the purpose of early warning are located in the southern part of the Nepal. Furthermore, very few early warning systems are in place, particularly for the monitoring of glacial lakes and GLOFs. Although some efforts have been made in setting up EWSs in Solukhumbu and Dolakha Districts in the Koshi river basin.

Nepal has gained significant experience with successful implementation of GLOF risk mitigation measures in Tsho Rolpa Glacial Lake in 2000 and 2016 in Imja Lake by setting up a controlled drainage system to lower the lake water level and the EWS. The DHM is further improving the flood forecasting system and EWSs through mapping, computer modelling, setting Automatic Weather Stations and weather radars and radiosonde.

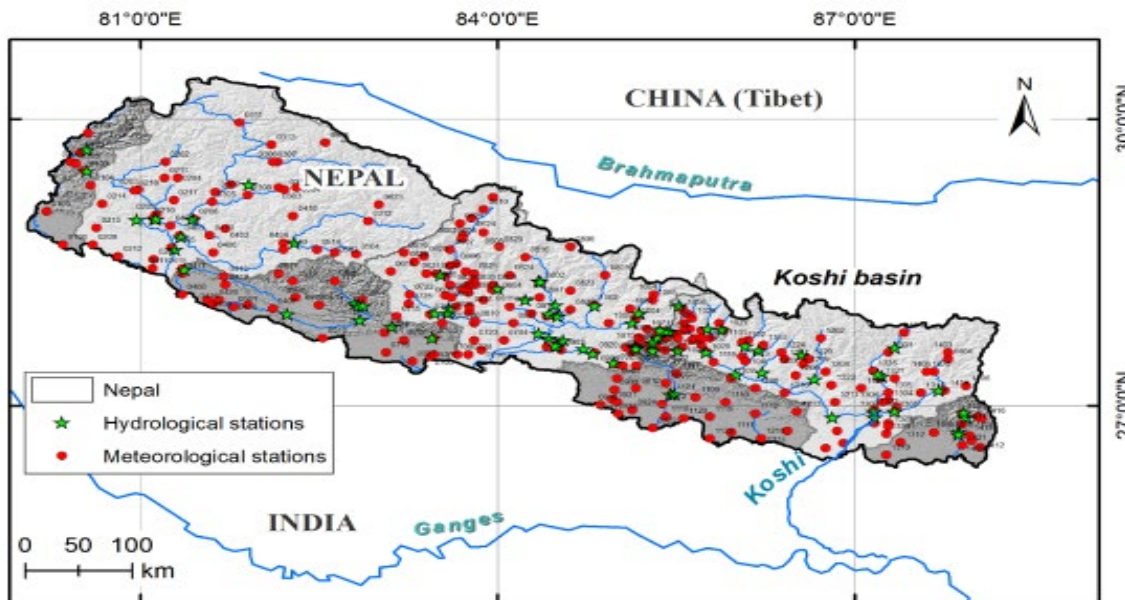


Figure 4.2: Hydrological and Meteorological stations of Nepal
 Source: DHM, Nepal.

Recently a number of government, non-government and humanitarian organisations are working on the community-based DRR and EWS in Nepal. EWS development and installation, and its effective communication mechanism through public and private partnership could further improve the EWS in Nepal. SFDRR and AMCDRR both emphasise the global and regional collaborations and partnership for multi-hazard EWS. We underline a need for scientific knowledge, instrumentation and monitoring, and providing structural design of EWS and institutional arrangements for addressing the potential risks of different disasters and safeguarding lives and livelihoods.



Figure 4.3: New technologies for EWS (Source: DHM, Nepal).

Future Considerations

Disaster frequency is increasing in recent years and is becoming a serious concern. Though initiatives are underway for the prevention and control of disasters, due to the limitation of data, budget, infrastructure and human resources, prevention of loss through EWS is not yet fully possible in Nepal. The absence of legal frameworks and lack of institutional arrangement is weakening the efforts of the establishment and strengthening of effective and functional EWS. Key challenges for effective EWS are the lack of good governance and inadequate research related to their efficiencies. Similarly, national and international collaborations and coordination are required for effective implementation of EWS. The international practices which are effective on EWS can be replicated in Nepal to reduce huge loss of life and property.

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4.2.2 Hazard Monitoring and Early Warning Systems in Nepal

– **Rita Thakuri**, National society for Earthquake Technology - Nepal (NSET); and **Amod Mani Dixit**, National Society for Earthquake Technology - Nepal (NSET); Institute of Mountain Hazards and Environment (IMHE), Chinese Academy of Sciences (CAS)

Nepal faces a multitude of natural hazards every year. Many of these annual events turn into disasters on the local, district and national scale. It is interesting to note that the everyday disasters also have significant impact at the local level, as Nepal Country Report of Global Assessment Report of 2009 (GAR 2009) reported these extensive disaster risks which annually inflicts a much wider economic and livelihood threat to the people, in comparison to intensive disaster events. Hence, establishing a credible mechanism of hazard EWS at the local level is very important to protect a large section of people from climatic and hydrologic hazards.

This study aims to review the recent initiatives of EWS that have been practiced in Nepal. It covers the efforts made in the areas of flood and landslide hazards. In comparison to the extent of the problem, these efforts may be seen as initial and inadequate. However, what we see is the a) success of these initiatives and, b) the huge potential for their replication on a wider scale. This study also describes some efforts in the establishment and operation of earthquake EWS, and argue for developing a much wider network of earthquake accelerometers in the country.

Natural hazards in Nepal

Nepal's location lies in between two active boundaries of the Eurasian and Indian plates. The main part of the country has a length of 885 kilometres east-west along the Himalayan range. Nepal's territory is subject to all-natural processes of active mountain building which is reflected in its topography, geomorphology, geology and hydrology. In addition, it is consequently reflected in several aspects of biota development, and ultimately it has a greater impact on the livelihood of people in the country's hills and mountain regions.

The topography of the country dramatically rises from the lowest elevation of 60 m amsl at Kechana in the south-east corner in the Tarai to the Mount Everest 8848¹⁰² m amsl. This rise in relief takes place within a horizontal span of 130-225 km south to north. Figure 4.4 shows the slope variation of the country from south to the north cross-section within a short distance (Hasegawa et al., 2009).

The mountain building process is still ongoing resulting in a deep incision in the river valleys and consequent erosion along the hillslopes and the river banks. Tectonic forces have rendered the geology fragile with a series of faults of continental proportions and the accompanying secondary faults of which about a hundred are active faults (BDP, 1994). Three major antecedent river systems, namely, Kosi, Gandaki and Karnali, with their numerous tributaries, render the country into a rugged topographic mosaic dividing the country into five physiological regions, namely (from north to south) the trans-Himalayan Plateau, the snow-clad High Himal, the densely populated Middle Mountains, the Chure range with dense vegetation and the alluvial plains of the Tarai.

¹⁰² Department of Survey is currently resurveying the height of Mt. Everest after the devastating 2015 Gorkha earthquake.

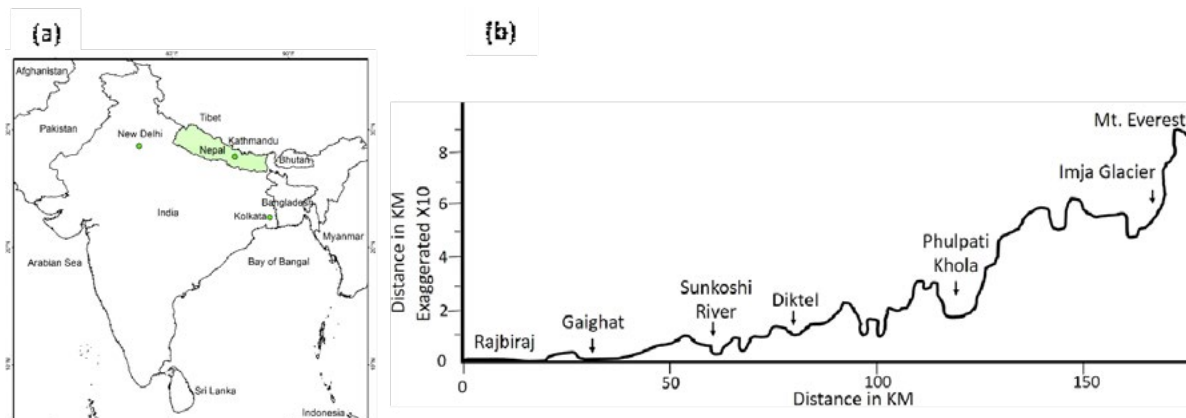


Figure 4.4: a) Location map of Nepal, b) S-N Topographic Profile of Nepal showing elevation.

Source: Hasegawa et al., 2009

The Nepal DesInventar — the database of disaster inventory records 32 types of disasters with flood and landslide as the more frequent hazards in the list of natural hazards (NSET, 2019), and earthquakes the most important in terms of its economic impact. Such secondary hazards as earthquake-induced landslide, GLOF and flash debris flow (flash flood) due to dam breaks are, however, not considered in the DesInventar system.

UNDP, 2004 ranked Nepal as the 11th in-terms of Earthquake, 32nd in terms of relative vulnerability to flood, and fourth in terms of climatic hazards (MOHA, 2015) globally. A study in 2001 identified Kathmandu valley as the number one at-risk city, in terms of potential death due to the earthquake, from among 26 highest earthquake-risk cities globally (GESI, 2001).

The following sections provide information on the EWS for floods, landslides and earthquakes established in Nepal in the past few decades, demonstrating the technical and economic feasibility of such system not only for disaster prevention but also for disaster awareness and risk perception enhancement at the community level.

Landslide Monitoring and Early Warning Systems

Landslide Monitoring Post-2015 Gorkha Earthquake

In order to understand the dynamics of the phenomenon of earthquake-induced landslides and in particular the risks that they pose in the months and years after an earthquake, scientists of IHRR/Durham University and NSET collaborated to install a real-time landslide monitoring system in the Upper Bhotekosi valley, an area severely affected by the 2015 earthquake. This project was made possible with the Urgency Grant of NERC of UK Research and Innovative. The system consisted of installing ten-sensor stations, each consisting of a rain gauge, an extensometer across cracks in the ground, and an accelerometer to capture aftershocks. The real-time data obtained by the sensors were transmitted every 10 minutes, averaging behaviour at 1-minute intervals sampled every 2 seconds. Experts of IHRR/Durham University and NSET worked on processing the data to identify how landslides were changing after the earthquake and through the 2015 and 2016 monsoon. Alarms and time-lapse cameras were installed in certain stations. This project was helpful in enhancing the institutional capacity of NSET in landslide monitoring and analysis capability leading to one of its staff undergoing a PhD at IHRR/Durham University. Further, as a prototype, this project demonstrated the feasibility of installing such a real-time landslide monitoring system and developed a methodology adapted to the Nepal situation, helping NSET to expand its focus from earthquakes, to include landslides and other related hazards. The project is now being further developed with ongoing mapping and monitoring, leading to a significant understanding of the scale of implementation. The data can be used in hazard and risk assessment at the local level while also raising awareness among local communities and local authorities (Rosser, 2019).

Landslide Monitoring in 14 Earthquake Affected Districts of Nepal

The success of the previous pilot project on landslide monitoring encouraged NSET and IHRR/ Durham University to continue the collaboration in landslide monitoring in different parts of the country including the districts impacted by the 2015 Gorkha Earthquake. DFID has provided funding support for this work through the SHEAR (Science for Humanitarian Emergencies and Resilience) program.

This project monitors yearly changes to landslides in the districts most severely impacted by the 2015 earthquakes, to show how landslides progress. This is done by mapping from freely available satellite imagery (Landsat 8 and Sentinel 2) for epochs before and after the monsoon season every year starting in 2014. The images are downloaded by IHRR, sent to NSET, and stored in a NAS-server at NSET and accessible to NSET and Durham University, a system established especially for this project. Two NSET professionals have been trained by IHRR at Durham in image processing and landslide mapping, to enable them to build the landslide inventories. This research is for studying the landslide progression dynamics, the influence of rainfall and earthquakes on how landslides change after an earthquake and how the hazard that they pose changes accordingly. The findings are expected to provide scientific evidence for appropriate policy and decision-making by the government during reconstruction (NSET, 2019).

Flood Monitoring and Early Warning Systems

Community-based Flood Early Warning Monitoring System (CBFEWS)

The DHM/Government of Nepal has successfully initiated real-time climate and hydrological data acquisition using remote sensing and mobile telephone technology (DHM, 2018). DHM currently runs 287 meteorological and 170 hydrological stations nation-wide (Shrestha, 2014) from which it collects and disseminates data for flood early warnings.

The DHM along with International Centre for Integrated Mountain Development (ICIMOD) and Practical Action/Nepal have implemented community-based flood early warning system in different river basins of Nepal where the community representatives not only conduct monitoring and issue a necessary warning, but also own the system. The boxes below present two success stories of flood monitoring and EWS established in Nepal, in brief.

Community-based GLOF Early Warning Monitoring System

There are a total of 3,808 glaciers and 1,466 glacier lakes in Nepal out of which 21 glacier lakes are identified as potentially dangerous and 6 categorised as high risk (DHM, 2019). Tsho Rolpa and Imja Lakes are considered among the high GLOF risk in several studies (DHM, 2019). Although GLOFs do not occur frequently, they can inflict huge socio-economic devastation in the communities living in the downstream areas. Due to the increasing temperature in the Himalayan region as a result of climate change, these lakes are growing rapidly and pose high flash flood risk to the local inhabitants, the tourists routes and to the assets in the downstream area (DHM, Community Based Flood and Glacial Lake Outburst Risk Reduction Project (CFGORRP), 2019).

Box 4.1: DHM – Practical Action Collaborative Community-based Early warning systems (CBEWSs)

Practical Action in collaboration with DHM had piloted the Community-based early warning systems (CBEWSs) at East Rapti River in 2002 which later extended to cover eight river basins across Nepal within 10 years namely: Karnali, West Rapti, Babai, East Rapti, Narayani, Bagmati, Kankai and Koshi Basin (Gautam, 2013). In the Karnali River CBEWSs, the trained readers disseminate warning via mobile telephone and SMS following the predefined communication procedure and protocol to the downstream community including information on the preparation of floods, contact details of the upstream reader and action to take during floods (Shrestha, 2014). Firstly, warning information is disseminated widely to the local government authorities – District Emergency Operation Centre, Community Disaster Management Committee, security forces and media for the wider information dissemination. The sub-national level government offices maintain electronic flood monitoring play board with automatic warning siren during water level rise in the respective district. Subsequently, this information is also sent to the Chief District Officers, DHM basin office as well as FM stations for wider dissemination.

Box 4.2: DHM-ICIMOD Community-based Flood Early Warning Monitoring System (CBFEWS) in Nepal

The DHM- ICIMOD collaborated CBFEWS project is part of Hind Kush Himalayas regions pilot project. In Nepal, the project has established the water level monitoring system (WLMS), this WLMS transmits the water level data to a receiver up to 800m away. If water level increased the flood signals are communicated to the downstream communities through the receiver unit at a trained caretaker's house, the caretaker is a member of the respective community. The caretaker is responsible for interpreting the alerts and relaying the early warning information to downstream communities through pre-established channels to enable flood vulnerable individuals, communities and organisations to prepare and take action to reduce harm or loss of lives and property. These WLMS are installed at Ratu River of Mahottari district, Gagan River of Siraha District and in collaboration with Oxfam in Rangoon River of Dadeldhura district of Nepal.

This CBFEWS worked well during monsoon of 2017 when Ratu River crossed the water level. The flood early warning information from Bardibas, Nepal was timely disseminated to the downstream communities across the border in Bhitthamore, Bihar of India four hours before the flood reached there. It helped the community to evacuate in time with their belongings (ICIMOD, 2018).

The DHM monitors river hydrology, climate, agrometeorology, sediment, air quality, water quality, limnology, snow hydrology, glaciology, and assesses wind intensity and pattern as well as the extent of and solar radiation. The DHM regularly provides general and aviation-related weather forecasts. DHM had successfully mitigated the Tsho Rolpa Glacial Lake by lowering the lake level in 2000. A robust sensor system was established during this time and was monitored and communicated with support from community and security forces to the community at downstream and central government. Currently, DHM is trying to replicate the knowledge and experience of Tsho Rolpa Mitigation project in Imja basin by lowering the glacier-dammed lake volume through an artificial controlled drainage system combined with a community-based early warning system under the Community-based Flood and Glacial Lake Outburst Risk Reduction Project (DHM, GLOF risks in High Mountains, 2019).

Earthquake Monitoring, Early Warning Systems and Reconstruction Efforts

Real-time Earthquake Monitoring System in Nepal

The National Seismological Centre (NSC) of Nepal that operates under the Department of Mines and Geology (DMG), Ministry of Industry, Commerce and Supplies, is the key government institution responsible for maintaining, operating and providing earthquake information, to the Nepal Government, media and security forces through to the National Emergency Operation Center (NEOC) which is under the Ministry of Home Affairs, through a system of real-time earthquake monitoring in Nepal. DMG has been conducting seismic monitoring since 1978, and currently, NSC has expanded the national networks with 21 short period seismic stations and 7 accelerometer stations located in the Lesser Himalaya and Sub Himalayan regions of Nepal. NSC has also installed 29 GPS stations to monitor crustal deformation. Data from this network is being used to develop and update the seismo-tectonic model of Nepal Himalaya and to build the national earthquake catalogue with the minimum magnitude threshold of 2 Richter local Magnitude MI. DMG is also studying active faults by trenching in most frontal thrust to reveal the historical and pre-historical earthquakes. Data and results from this network are provided to serve as scientific evidence for development planning, especially in avoiding fault lines and seismically active clusters. NSC regularly updates their webpage on the recent local earthquakes greater than Magnitude 4.0 in Nepal (Sapkota, 2019).

Earthquake Early Warning System Installed by NAST

Nepal Academy of Science and Technology (NAST), the apex body of Government of Nepal to promote science and technology in the country, has installed 10 Earthquake Early Warning (EEW) sensors in different locations of Kathmandu, Kavre and Dhading Districts of Nepal in 2015. These sensors are able to alert 10-22 seconds before a major or moderate earthquake. NAST along with the Ministry of Science, Technology and Environment has planned to install 120 EEW sensors in the country.

These sensors receive the warning of the primary seismic wave from an earthquake epicentre and this is transmitted through the radio waves to the central warning station at NAST premises in Kathmandu Valley. NAST believes that the few extra seconds are also helpful to save many lives during an earthquake (Kathmandupost, 2015).

Earthquake-related community capacity building and Awareness Programs of NSET

The National Society for Earthquake Technology-Nepal (NSET) has been working in earthquake awareness and DRM capacity building of communities, local government. Since its establishment in 1994, NSET has also been advocating for the need for earthquake risk reduction among central and local governments. NSET’s mission is to assist in linking the science to the community, bridging the gap between scientific research and practicing of earthquake engineering and technology for mitigating earthquake risk for resilient communities. For example, NSET conducts various training, workshop, programs and implements projects in different parts of the country, along with developing curricula on safer construction, house owner guidelines, building code implementation, and capacity building of national and regional program for emergency response (PEER).

NSET Assistance in the Owner-driven Gorkha Earthquake Reconstruction

NSET organised solid technical assistance to the central and local governments as well as the households in the aftermath of the 2015 Gorkha Earthquake. It is implementing Baliyo Ghar, a program to assist the owner-driven earthquake reconstruction process in the three districts, namely, Dhading, Dolakha and Nuwakot of Nepal. The program covers all the households providing earthquake orientation and knowledge on earthquake-resistant methods of constructing traditional houses using local materials and technologies by 3-member teams consisting of an engineer, a social mobiliser and a trained construction technician (trained mason). Participation of earthquake-affected communities has been phenomenal - the code compliance in the new construction has been achieved at more than 90% because of total acceptance of the novel ideas by the community!

Nepal Shaking Hazard Assessment of Kathmandu and Environment (N-SHAKE) of NSET

As a part of NSET’s objective to assist all communities in Nepal to become earthquake-safer it collaborated with the United States Geological Survey (USGS) and conceptualised and developed the Nepal Shaking Hazard Assessment of Kathmandu and Environment (N-SHAKE) prior to the 2015 Gorkha Earthquake. N-SHAKE network is established with an objective to enhance the understanding of seismic hazard to reduce seismic risk in the country. At present, N-SHAKE has installed 16 low-cost accelerometers network in Kathmandu valley and 1 accelerometer in Bhimeshwor Municipality of Dolakha District. This network is developed to build capacity in Nepal to produce shake map, to produce ground motion prediction equation (GMPEs) suitable for Nepal, and to develop probabilistic seismic hazard assessment and seismic micro-zonation. It is expected that the N-SHAKE output will be helpful in understanding the earthquake hazard and to provide scientific evidence for the government and other stakeholders in Nepal to plan preparedness activities (Maharjan, 2019). Figure 4.5 is an aftershock recorded in the accelerometer of N-SHAKE.

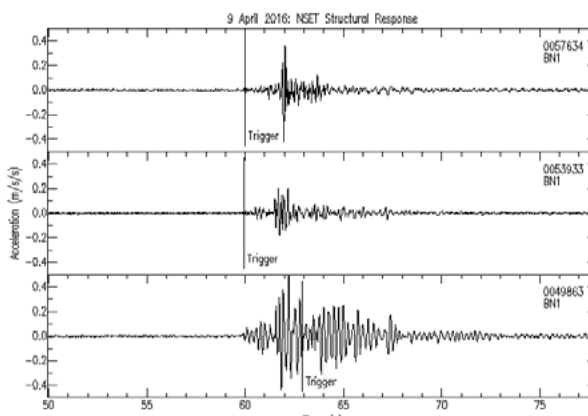


Figure 4.5: Aftershock recorded in the accelerometer of N-SHAKE. Source: NSET

Discussion and Conclusions

The foregoing write-up demonstrates that Nepal has established real-time hazard monitoring mechanisms for different hazards, and has successfully implemented several community-based EWS. While these initiatives are led and promoted by the Government of Nepal, these are examples of multi-stakeholder collaboration, including international and national non-government organisations, but the common denominator in all is the conspicuous participation of the related communities and their acceptance and ultimate ownership of the systems. This is the way Nepal is making efforts towards mitigating natural hazard risk and preparing to reduce the possible impacts of future hazards.

Such successful cases need to be replicated and proliferated to cover all of Nepal. This is especially important because the federalization process has devolved authority to manage and mitigate disaster risks to the local governments – the Nagar Palikas (urban municipalities) and Gaun Palikas (rural municipalities) and enhancing disaster resilience has been embodied in the constitution of Nepal.

In this perusal process we identified a shortcoming: the ongoing initiatives of awareness and early warning systems are yet to improve the plans to organically and consciously blend existing indigenous knowledge on aspects of disaster risk management and early warning with the knowledge and practice gained through the use of modern science and technology. For this, research to unveil and inventory indigenous local knowledge and technologies should be done and the innovation potentials of Nepalese youth should be explored and promoted so that the benefits of the newly established disaster early warning system could be integrated into the livelihood processes as used to be done by our forefathers.

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4.2.3 National Multi-hazard Early Warning Centre in Maldives

– Ali Shareef, Maldives Meteorological Service, Republic of Maldives

The Maldives is a tropical nation in the Indian Ocean composed of 26 ring-shaped atolls, which are made up of about 1,200 coral islands. Ninety-nine percent of the country’s area is sea and the average height of the islands are 2m asl. Hence, it is highly vulnerable to coastal hazards and the impact of climate change.

The National Multi-hazard Early Warning Centre (NMHEWC) is entrusted with the task of monitoring the meteorological, geological, and oceanographic hazards. It collects and exchanges information with local platforms, regional and international centres, and in the event of a disaster, disseminates all relevant information about severe weather, tropical cyclone, tidal-wave, earthquake and tsunami to stakeholders and the general public. Marine transportation is a sector where meteorological forecasts are frequently used.

The NMHEWC has a hotline established between itself and National Disaster Management Authority (NDMA), Maldives Police Service (MPS), Maldives National Defence Force (MNDF), Public Service Media (PSM’s TV and Radio) and Velana International Airport.

Capacity and Strength

With 2 broad-band seismometers and 3 sea-level monitoring gauges Maldives’ seismic/ sea-level network is linked to global networks to monitor earthquakes/ waves across the region and the globe. The meteorological network consists of 5 manned stations, operating on a 24/7 basis, and 50 automatic weather stations. The system is linked via high speed internet with Regional Telecommunication Hub (RTH) New Delhi and RTH Melbourne to exchange meteorological, oceanographic data and tsunami information. The warning centre is equipped with a high resolution satellite image receiving system, a Doppler weather radar. Numerical weather prediction models are used to predict extreme weather events and tsunami wave propagation.

Alert and Warning

The key operational components of a National Tsunami Warning Centre are to provide real-time monitoring, timely decision-making and dissemination of tsunami warnings and advisories.

Alert Level	Description	Action
1 White	<ul style="list-style-type: none"> An earthquake of 7.0 or higher in Richter scale, occurred in the Indian Ocean ring but there is no immediate threat from the event 	Earthquake Information
2 Yellow	<ul style="list-style-type: none"> An earthquake of 8.0 or higher in Richter scale, occurred in the Indian Ocean ring and has the potential to generate an ocean wide destructive tsunami in the Indian Ocean 	Earthquake and Tsunami advisory, concerning authorities and public are advised to be on alert and be ready to move safer areas and high buildings
3 Red	<ul style="list-style-type: none"> An earthquake of 8.0 or higher in Richter scale, occurred in the Indian Ocean ring and confirmation of an ocean wide destructive tsunami originated from the epicenter 	Tsunami warning. People evacuated from the danger zones
3 Green	<ul style="list-style-type: none"> The condition has improved 	Cancellation message, MMS assume that the tsunami threat does not exist to Maldives

Table 4.1: Alerts Criteria for Earthquake and Tsunami

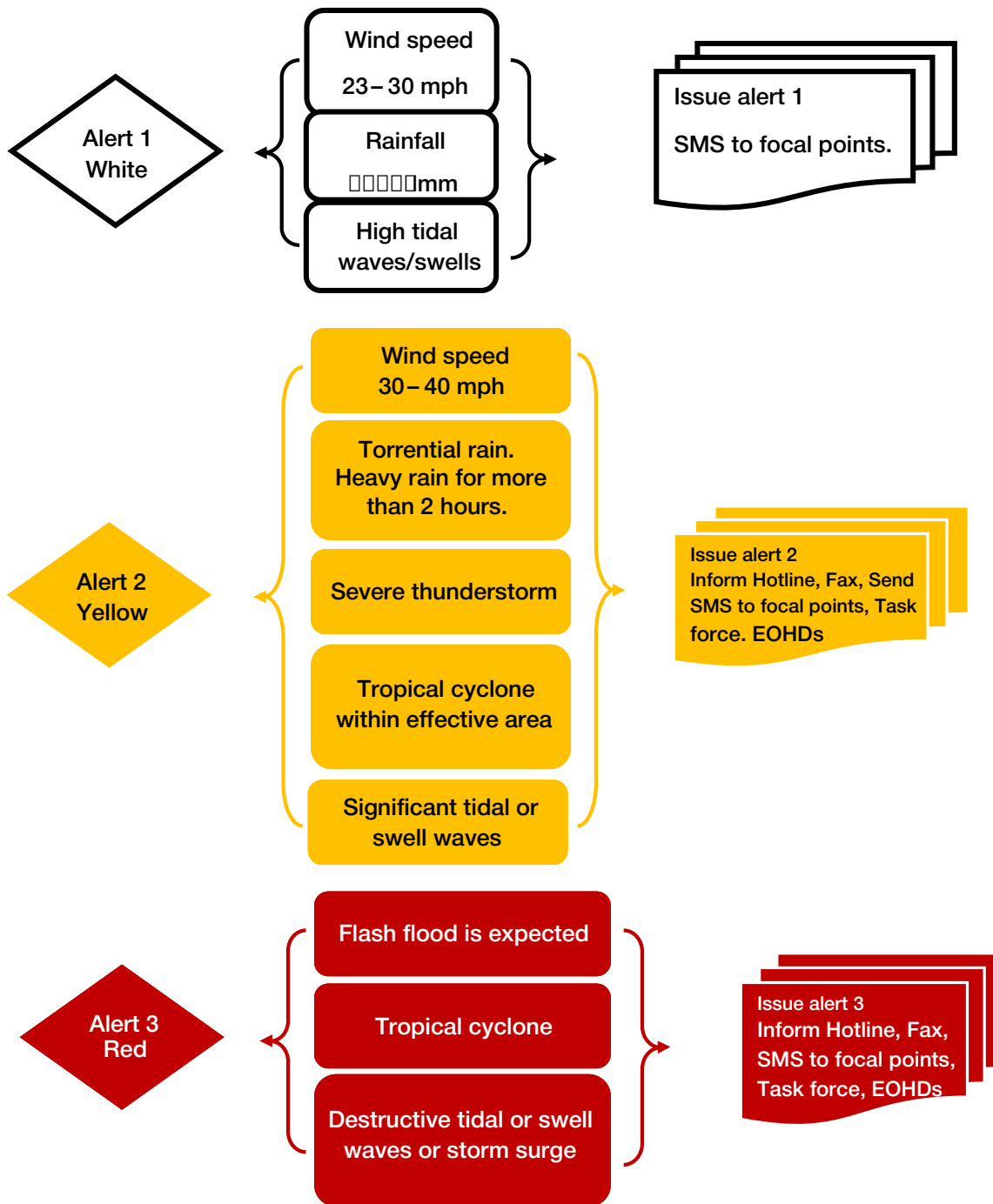


Figure 4.6: Flow chart - Weather advisories and warnings.

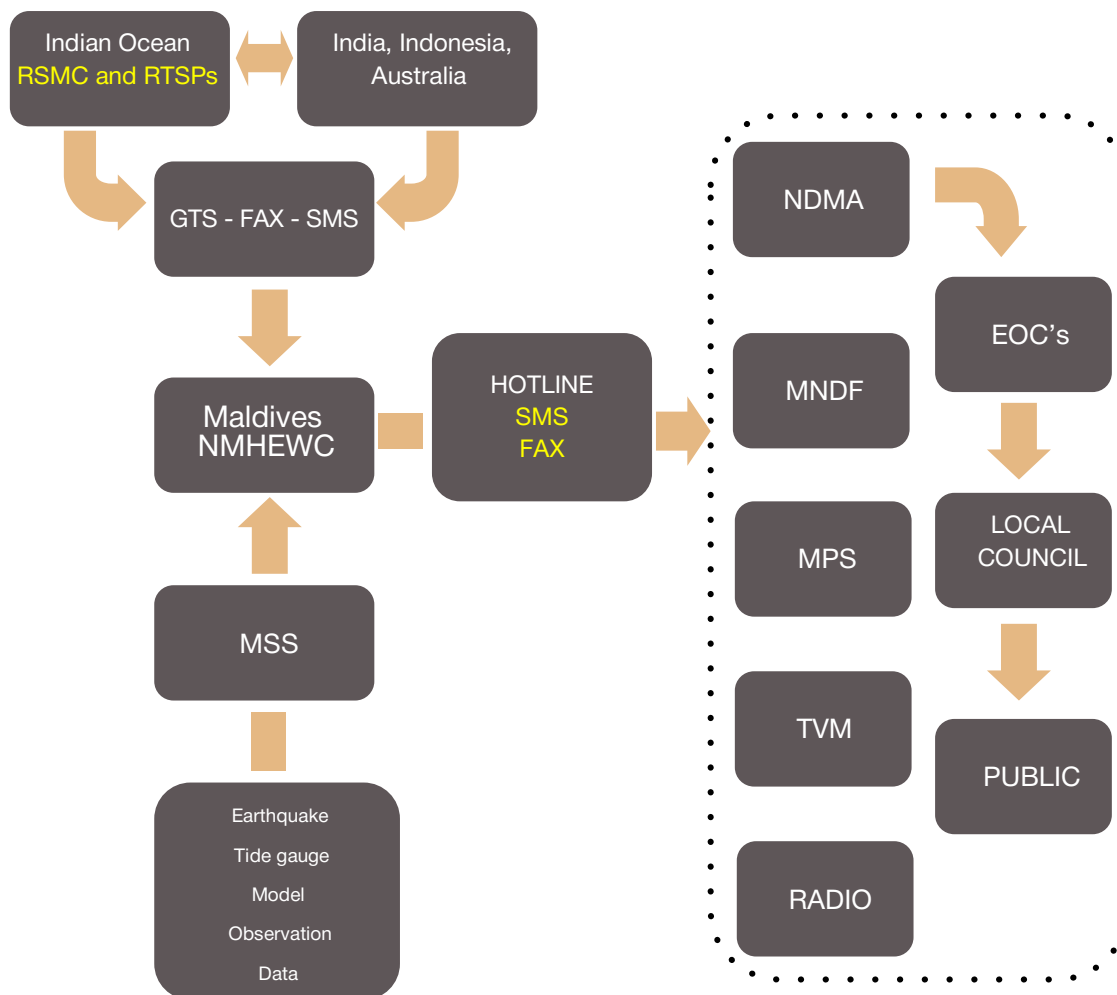


Figure 4.7: Early Warning Centre flow chart - Monitor, collect data and disseminate warning message

To provide procedural guidance and the series of action to be followed in issuing advisory or warning with respect to a meteorological, hydrological and geological hazards, the EWC follows approved Standard Operating Procedures (SOP). These measures are taken at different stages of an emergency to save lives and salvage property. It is incorporated with the DM Plan in accordance with the policies of the government.

4.2.4 Early Warning System for Cities in Pakistan: A View

– **Nasira Ahsan**, Senior Research Analyst, The Urban Unit, Pakistan

Pakistan is one of the South Asian countries that faces natural hazard induced disasters every year. Pakistan has a National Disaster Management Authority (NDMA), which was established in 2007 as a lead agency at the federal level to implement, coordinate and monitor the whole spectrum of disaster management including preparedness, prevention, mitigation, response, recovery, and rehabilitation and reconstruction program. In order to carry out the assigned tasks/ functions, NDMA is organised into three Wings each headed by a member (Table 4.2).

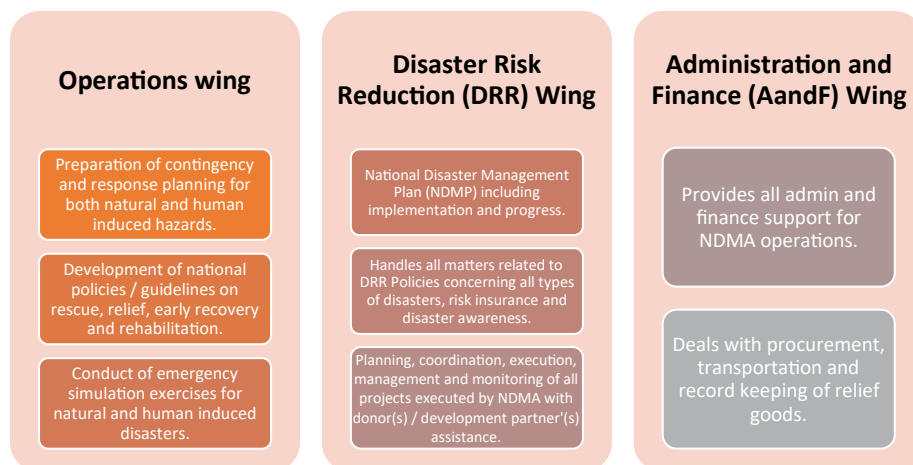


Table 4.2: NDMA

The key stakeholders that support NDMA efforts are Provincial disaster management authorities in 4 provinces, Gilgit Baltistan Disaster Management Authority and Azad Jammu Kashmir Disaster management authority, Pakistan Meteorological Department (PMD), armed forces, donors and NGOs, etc.

National Multi-hazard Early Warning System Plan

In 2012, NDMA with JICA developed a National Multi-hazard Early Warning System Plan. For the reduction of vulnerabilities and risks to disasters, a Multi-hazard Early Warning System (MEWS) was proposed as the fundamental measure against floods, GLOFs and sediment disasters, including landslides, cyclones with storm surges, droughts and tsunamis, avalanches, earthquakes and health emergencies. The establishment of an appropriate MEWS was supported by well-coordinated actions among all stakeholders. The vision of the Multi-hazard EWS Plan is to reduce the vulnerabilities and risks to future disasters, by strengthening the early warning capabilities and strengthening the institutional mechanisms to achieve the overall goal of the Disaster Management Plan.

In Pakistan, most of the early warning messages against water-related hazards are issued by PMD (Pakistan Meteorological Department). The coverage for the warning and alert issuances against each disaster are as summarised in table 4.3.

Disaster	Forecasting Agency	Remarks
(Indus River Basin) Flood	FFD-PMD ^{*1} (PID/PIPD)	Issued in accordance with SOP ^{*2} prepared for Indus, Jhelum, Chenab, Ravi, Sutlej and Kabul.
Flash Flood	FFD-PMD NWFC-PMD ^{*3}	Issued in accordance with SOP prepared for Bein, Aik, Basantar, Deg, Palkhu by FFD. Issued in accordance with Flood Relief Plan Lai Nullah by FFWMC-NWFC ^{*3} * Except for nullahs mentioned above, PMD issues General Flash Flood Warning together with weather information from NWFC.
Landslide	None (PMD)	EWS has not been prepared, but NDMA, GSP and ERRA have partly prepared hazard maps for vulnerable areas. PMD also issues general advisories on landslides due to rain.
Cyclone	TCWC-PMD ^{*4} NWFC-PMD	Issued by SOP (Draft)
Storm Surge	TCWC-PMD	Storm Surge Disaster shall be forecast in Cyclone EWS.
Tsunami	NSMC-PMD ^{*5}	Issued by SOP
Drought	NDMC-PMD ^{*6}	Forecasting System has been established. (As fortnightly advisory base)

Note: *1: FFD:Flood Forecasting Division of PMD at Lahore

*2: SOP: Standard Operating Procedure

*3: NWFC: National Weather Forecasting Centre at Islamabad

FFW&MC: Flood Forecasting, Warning & Monitoring Centre of PMD for General Flash Flood at Islamabad

FFWMC: Flood Forecasting & Warning Master Control Centre for Lai Nullah at Islamabad

*4: TCWC: Tropical Cyclone Warning Centre of PMD at Karachi

*5: NSMC: National Seismic Monitoring Centre of PMD at Karachi

*6: NDMC: National Drought Monitoring Centre at Islamabad

Table 4.3 Summary of Roles and Functions of PMD in Multi-hazard EWS

Source: JICA Study Team in association with PMD; Presentation Materials by Mr. Azmat Hayat Khan, Director of NDMC-PMD for National Drought Monitoring Centre; Concept Proposal Paper on Networking National Institutions and End Users through Electronic Media for Drought Monitoring Centre; SOP by FFD-PMD

Establishment of National Disaster Management Response Plan

The National Disaster Management Response plan is one of the key documents outlining the guidelines for managing and responding to disasters /emergencies in Pakistan. The first National Disaster Management Response plan was established in 2010 and each year this incorporates the changes/factors and other improvements with a revised version. Currently the revised version of National Disaster Management Response Plan 2019 is the 'Government of Pakistan's Multi-hazards Response Plan', the purpose of which is to enhance the country's ability to manage disasters using a comprehensive national approach, incorporating all activities from preparedness to response.

This contribution draws from the following sources:

1. National Disaster Management Response Plan, 2019
2. National Disaster Management Act, 2010
3. NDMA policy Guidelines for multi hazard vulnerability and risk assessment.

4.2.5 Early Warning System in Sri Lanka

– **Anoja Seneviratne,**

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During the last three decades disasters have destroyed lives and livelihoods in Sri Lanka, killing more than 35,000 people and fully damaging 143,362 houses, apart from impacting business and resulting in other economic loss. The impact of disasters is not entirely due to their frequency and severity of hazard, but also forecasting, warning, and the coping capacity of the vulnerable communities to resist or adapt. Therefore, Sri Lanka's DRM efforts focused on developing EWS to provide timely and effective information that enable communities to respond during disasters.

Early warning systems in the country are a combination of tools and processes embedded within the existing legal and institutional framework of the country for DRM supported by the international and national networks. An EWS consists of risk-related knowledge at national to local level, technical and monitoring and warning services supported by the technical agencies such as the Irrigation Department, National Building Research Organization, Department of Meteorology, etc., dissemination of early warning to at-risk people public and private networks and their partnerships, and public awareness and preparedness conducted at ground level. The Inter-Governmental network dedicated to communicating among the inter agencies with the National Emergency Operation Center always ensures effective information sharing among the institutions.

The country's early warning services fully depend on the sound scientific basis predicting and forecasting by the technical agencies, supported by the 24 x7 National Emergency Operation Center linked to tri-forces and the police communication network.

Sri Lanka's EWS consists of multi-hazard early warning towers equipped with VHF, HF, radio and satellite communication covering the entire coastal belt of the country. Mobile phone technology is increasingly used to communicate warnings and coordinate response activities, particularly SMS alerts for disseminating messages. The 'Disaster Early Warning Network' is implemented in collaboration with Dialog a private communication company, and this is one of the effective mechanisms used to disseminate early warnings to the ground level.

During the last decades deaths due to disasters have significant reduced due to preparedness led by early warning. EWSs are in place and have proved beneficial for a variety of intensive hazards such as tsunamis. In the case of the latter, disaster management authorities ensure the evacuation of vulnerable communities within 30-45 minutes after receiving the warning from international networks such as the Indian Ocean Tsunami Warning Center, Japan Tsunami Warning Center, etc. However, damages and financial losses are considerably high particularly due to extensive type of disaster which are not covered under the national level early warning.

However, extensive types of floods and slow on set drought warnings remain complex, as they are associated with several gaps in impact based early warning. But with the support of World Food Programme, an integrated information management system (PRISM) has been developed to enhance the early warning capacity for drought.

Uncertainties associated with early warnings, risk prioritisation, people's trust in early warning and community attitude, issues related to horizontal and vertical coordination, and the level of application of communication tools are still to be considered as gaps in the early warning domain of the country.

4.2.6 Early Warning Dissemination: Bangladesh Experience

– **Kabita Bose**, Regional DRR Adviser, Asia Region Oxfam International, Bangladesh

Bangladesh, home to approximately 160 million people in just 144,735 sq.km areas, is one of the largest deltaic countries in the world. The country faces one flooding season leading to recurring disasters almost on a biennial basis. Normal monsoon inflow/floods along with rainfall help in development, environment, ecology and the economy of the country while the extreme events of flood adversely affects those factors. In flood management, Bangladesh has been taking structural and non-structural measures. One of the main non-structural measures is flood forecasting and warning system.^{103 104} Flood Forecasting is the mandate and responsibility of Bangladesh Water Development Board and the Flood Forecasting and Warning Center acts as the focal point on flood forecasting and warning services in coordination with other ministries and agencies like BMD, DDM, Department of Agricultural Extension, etc. pre, during and post disaster time. Its goal is to alert the agencies, departments, communities and people to enhance their preparedness and to motivate vulnerable communities to undertake preparedness and protective measures. Along with government agencies, it is also coordinating and sharing information with I/NGOs, UN, donors and other networks for effective early warning dissemination.

Bangladesh has also witnessed severe cyclones for many decades. Bhola Cyclone (1970), known as one of the deadliest tropical cyclones in the history of Bangladesh, took at least 300,000 lives. April 1991 Cyclone, the more powerful one in comparison with the 1970 cyclone, took at least 138,000 lives. Due to its two effective measurements – structural and non-structural for cyclone preparedness, Bangladesh is being recognised as one of the world's champions because of its community-based cyclone preparedness and mitigation actions, appropriate early warning, and dissemination system which has ensured a decrease in losses. This also ensures appropriate early action along with search and rescue, evacuation, etc. The Cyclone Preparedness Programme contributes¹⁰⁵ to disaster preparedness, early warning signal dissemination, evacuation, sheltering, search and rescue, first aid and relief and rehabilitation etc. [Refer Rego's paper in this chapter for more details.]

Bangladesh is also at risk of the low frequency but high impact disaster such as earthquakes and tsunami, and an increasing numbers of lightning cases taking lives, at least 17 incidents in just one month (May 2019¹⁰⁶). More devastating hazards, like fire, wild animal attack, boat capsizing, landslides, building collapses, and bridge collapses, increase the risk and vulnerability of lives and livelihoods. As climate change adds another dimension of vulnerability and exposure to the country, timely and accurate information on weather patterns is needed to take appropriate actions and decisions.

To reduce the impacts of disasters and hazardous events, early warning is the key element of DRR, preventing the loss of lives and decreasing the economic and materials impact of hazardous events along with the related disasters. While the country is at risk of multiple hazards, the disaster risk management system is still a silo keeping its risk management system in a single hazard approach. To address this gap, the country needs to take important actions for developing a multi-hazard EWS with effective governance and institutional arrangements.

The SFDRR 2015-2030 recognises the benefits of multi-hazard early warning systems and enshrines them in one of its seven global targets (target (g): “Substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to people by 2030”).¹⁰⁷

103 www.fwc.gov.bd

104 BWDB Act-2000

105 <http://www.cpp.gov.bd/>

106 <https://reliefweb.int/report/bangladesh/hazard-incidents-bangladesh-may-2019>

107 International Network -of Multi Hazards Early Warning System.

A multi-hazard approach to early warning, requires the involvement of local communities and consideration of gender, age and disability and cultural diversity. Multi-hazard EWS requires a 'people-centred approach' with the full and meaningful participation of people and communities at risk to a greater range of hazards, awareness and knowledge management about risk, dissemination of messages and warning efficiently, etc. It has to also be ensured that preparedness is in place at all levels, including early action at the right time from local to national, and regional levels in case of cross boundary information and warning sharing

4.3 Ensuring that warnings reach communities

The ultimate test of an EWS is that the warnings can reach everyone and allows those who need to be able to respond to do so effectively. This section presents a range of EWSs and experiences – from community EWS to address floods and cyclones through the help of appropriate infrastructure, equipment and volunteers while also looking at the importance of warning dissemination for emerging hazards such as technological disaster. Contributions highlight both the limitations that need to be overcome and the successes that need to be scaled and improved.

4.3.1 Experiences from the Field

– **Ray Kancharla**, Humanitarian Development & Resilience Expert, India

Drones to Aid in early warning and early action - Experiences of diverse piloting agencies have shown that drones can be used for 'pre-disaster' management of planning evacuation routes and mapping areas that would require immediate action 'post-disaster'. Recently, drones have been enabled to play the role of first responder in delivering life-saving medicines, and accessing areas to bring critical information about the situation. In the growing domain of artificial intelligence, there are abundant opportunities to enable drone technologies to be efficient drivers of EWS and early action agenda. The evidence in this regard needs to be generated further.

New Android Application – Telegram - Telegram is a messaging app with a focus on speed and security; it's super-fast, simple and free. These messaging systems can be used to help spread information on hazards. It is usable on all your devices with messaging syncing across all of them, Telegram is also more secure than Whatsapp and has optional end-to-end encryption and encrypted local storage for Secret Chats. Completely secure messengers are available, such as Threema (paid app for iOS and Android) or Sicher (free app for iOS, Android and Windows Phone). Users can send files up to 1.5 GB, and all the media can be stored in the cloud.¹⁰⁸

AMRITAKRIPA App¹⁰⁹ (*Amrutanandamayi model in Sikkim for Real Time Early Warning System to drive Early Action*).

Some recent initiatives have received positive reactions from disaster managers and the affected. "AmritaKripa" mobile app is launched for aiding with flood rescue and relief operations in Kerala. People who are stranded at different locations, can share their current location and other needs to the rescue team by downloading and using the mobile app after registering in the website at https://kripa.amrita.edu/#/login_screen

¹⁰⁸ Telegram F.A.Q. – Telegram Messenger – <https://telegram.org:faq>

¹⁰⁹ Amrita Center for Wireless Networks and Applications. <https://www.facebook.com/AmritaWNA/videos/1369201166546322/>

Field Case Study 1: Child-centred EWS

Govindapalli Palem, is a village close to the sea, in the district of Nellore, Andhra Pradesh, India. The inhabitants are fisher folk. In this community, the traditional “Durai” system of local governance prevails. The Panchayati Raj Institutions (PRI) etc. is not really understood here. Whatever the “Kapu” (Headman) says, that is the law¹¹⁰. The NGO that has worked with this community from post-Tsunami days, has developed localised task forces for search & rescue, early warning, first aid, psycho-social and relief / camp management. There is a localised technology hub called “Panchayat Disaster Management Resource Centre (P-DMRC) set up jointly by Save the Children and Chaitanya Jyoti Welfare Society. The technology comprises of a desktop computer, wide monitor, solar power backup and other accessories such as batteries and internet. There are trained staff to manage this. Apart from the local risk maps of the village as well as schools; there are also disaster management plans in place. The local task force has lists with their mobile numbers which are stored and updated at regular intervals. When a hazard is imminent in the area, the system helps to send SMS alerts to the task force members and mobilise them to early action in terms of alerting the community to be ready for evacuation, etc. Children and Youth have also undergone training; and are active in disseminating early warnings and supporting early action. The neighbourhood schools too have S-DMRCs functioning through which they adhere to the early warnings.

The Fire service department of the district initially said there is no early warning system around. However, the fire department has come on board in initiating an innovation towards early action in responding to fire hazards. They have provided FIRE AMBULANCE MOTORCYCLES with innovative Japanese technology to enable access to the narrowest lanes in the quickest time possible, as soon as an alarm is raised. The challenge continues in terms of its overall adoption and replicability. The larger challenge is also about JOURNEYING from ORAL to DIGITAL in administering Early Warnings and facilitating Early Action.

Existing traditional modes of issuing warnings need to be taken into consideration when designing a system. For instance, the traditional “DURAI”¹¹¹ system adhered to by fisher folk has proved reliable in as much as the KAPU understood its relevance and verbally issued commands in real time as Early Warning and Early Action paradigms. The commands were obeyed and practiced by everyone in the community. This has positive connotations and negative challenges too. The Fire Department in Nellore District in Andhra Pradesh has been exploring options in terms of migrating from “oral commands” to “real time digital commands”; but this demands a shift in the mindset of the local governance, households and specific institutions such as health centres, etc.¹¹²

Schools in the area of Uruturu Pedda Palem, Govindapallipalem and Vakadu mandal have integrated School Disaster Management Resources (S-DMRC) in their schools. Besides managing the portal, the teachers such as Mr. Nagaraju, Ms. Ashwini Preamana have gone a step further in integrating the knowledge and practice about disasters into their local curriculum by designing innovative technology-based lessons; and strengthen awareness about early warning and early action. This needs adoption and scaling up by other teachers and the education system at large.

Field Case Study 2: Child Friendly Spaces as an early action mechanism

Majhuli in Assam is a climate fragile island. It is formed by the Brahmaputra River in the south and the Kherkutia Xuti, an anabranch of the Brahmaputra, joined by the Subansiri River in the north. The fluvial landform (a riverine delta) of Majuli Island is a unique geographical occurrence as a result of the dynamics of the vast river system. ... All of the above – the river, its tributaries, the wetlands and the chaporis along with the island of Majuli make it the largest mid river delta

110 In this case, KAPU has been participating in the community-based child centred DRR action; hence, he would provide the right directions to the community in the case of alerts and early warning signals. In addition, early warning task force would triangulate and strengthen the early action.

111 DURAI literally means the headman. In the traditional communities, his word is absolutely law; and no one dares to disagree nor avoid adherence.

112 Excerpt taken from the paper ‘Need for Children Centered Early Warning System and Early Action’ by Ray Kancharla

system in the world¹¹³. It is the largest river island in the world. The island is inhabited by Mising tribes, Deori and Sonowal Kachri tribes. The people of the island speak Mising, Assamese and Deori language¹¹⁴. There are 246 villages in total in this island. It has been declared as an independent district by Chief Minister, Sarbananda Sonowal, on June 27, 2016, carved out of northern parts of Jorhat.

40% of the population inhabit near embankments; and depend on boats for their mobility. Annual flooding is a common experience and it is assumed that the local communities know how to cope with this, which is not always the case. The suffering and losses are untold. In 2019, with Save the Children and local partner RVS (Rural Volunteers Centre), administration has established Child Friendly Spaces (CFS), as an early action mechanism; and have plans to mainstream this for future sustainability and replicability. In the last 5 years, Dhemaji district, which is also highly vulnerable to floods annually, has mainstreamed CFS into their long-term action planning and preparedness. While bigger issues such as erosion and access remain huge challenges in responding to early warning alerts, there is hope that newer approach of local early warning systems using public address system (initiated from 2018 onwards by the district authorities) is going to be a good practice.



Stuthi and Gayatri, students of Jyothi High School in Phutchang Gaon, Mowamari, Majuli emphatically stated that if they had an understanding of Early Warning earlier, they would have managed to protect their books, animals and other household belongings. The floods that hit their villages and school two years earlier, resulted in big losses; and their school was closed. Subsequently, they participated in a school safety initiative and are now fully aware of how EWS needs to be adhered to in a timely manner. Teachers as well as the RVS and a local NGO have driven forward this knowledge and practice among children in the age group of 10 to 16, so that they are able to protect themselves; and also participate in leading local early warning and early action.

Larger issues include further updation and review:

- Transboundary arrangements from 15th May to 15th October, apply only for Brahmaputra and Subansiri rivers. It is easy to predict with at least an hour-early warning alert. However, flash floods are different, especially as there are about 15 to 16 tributary rivers, for which EWS arrangements are not fully complete.
- NESAT in Shillong can provide more technical inputs in this regard, as a future course, especially, if we need to consider Children, Youth, Women, Disabled and other critical groups.
- Changing of River Course is not on the agenda of EWS. This issue needs to be considered.
- Further, the approaches for early warning vary from district to district, as preparedness has been understood more in terms of preparedness for rescue and relief measures.

113 https://www.google.com/search?q=Majhuli+island+information&rlz=1C1GCEU_enIN820IN820&oq=Majhuli+island+information&aqs=chrome..69i57j0l3.5074j0j7&sourceid=chrome&ie=UTF-8

114 <https://www.indiatoday.in/education-today/gk-current-affairs/story/majuli-largest-river-island-338957-2016-09-03>

4.3.2 Role of Early Warning System in Sustainable Development of Coastal Andhra Pradesh

– **Dr. I Satyanarayana Raju**, Senior Project Manager, AP Human Resources Development Institute, Andhra Pradesh, India

Disasters have become the order of the day especially the seasonal natural hazard induced disasters like cyclones - floods severely affect the coastal areas and as do tsunamis sometimes. Though there are no measures to control natural hazard induced disasters from occurring, they can be managed, mitigated by preparedness and proper forecasting in order to peg down human-asset losses. One such intervention of preparedness is EWS.

About Andhra Pradesh

The Geographical area of Andhra Pradesh (AP) state is 160,205 sq.km. Population as per 2011 census is 49.67 million. It has the second longest coast line of 974km and 9 out of its 13 districts have been located along the boundary of Bay of Bengal. 4-Major Rivers viz. Vamsadhara Godavari, Krishna and Penna are terminating in the state boundary at the sea confluences in Srikakulam, East Godavari, Krishna and Nellore districts respectively. There are 552 fisherman villages along the coast. Hence the state is highly prone for frequent cyclones and floods every season. Tsunami occurred during December 2004 causing loss of life and property. The state was affected by Hudud Cyclone in 2014, Titli in October- 2018, and Fani in May 2019.

Sustainable Development of Coastal Andhra Pradesh with Early Warning System

Sustainable development is the development that meets the needs of the present without compromising the ability of future generations. The experience of the AP state is that by using the system of EWS, the loss of life and properties could be marginalised as seen when comparing the occurrences of Krishna floods (2009) Hudud Cyclone (2014); Titli in 2018; Krishna floods (2019) and Fani in 2019 with earlier cyclones during 1999, 2010, 2012, 2013 when EWS was comparatively less utilised due to the lack of technology during those earlier periods. Due to the effective implementation of EWS during the major Hudud (2014) cyclone, the death toll was kept at 124, property loss as Rs.219 billion and in subsequent cyclones of Titli and Fani deaths were only in single digit and property loss drastically reduced.

Conclusion

The reduced losses during cyclones and floods in 2014, 2018, 2018, 2019 in Coastal Andhra Pradesh could be possible because of implementation of EWS. It is a way forward for Disaster Risk Reduction for sustainable development; mainstreaming in to development of Coastal AP.

The State of Andhra Pradesh has upgraded the mechanism of risk analysis to help reduce the gaps noticed in the past cyclones. In this light, the Real Time Governance (RTG) platform was created for monitoring, warning, dissemination and communication during disasters. The hierarchy of State and District mechanism has been extensively overhauled and strengthened towards Response capability of Early Warning Systems. The main challenge faced is evacuation of people who has lesser belief and confidence in technology oriented EWS and same was firmly dealt by Revenue machinery by implementation of law and order. The EWS was imbibed in the functioning of State Disaster Management Authority (SDMA) in reducing loss and damage. Within the 4-priorities implementation of Sendai framework, capacity building of departmental officials is being continuously organised and public coastal structures are being retrofitted towards resilience. RTG was strengthened and being upgraded on real time basis to manage disaster risk. Mainstreaming Disaster Risk Reduction (DRR) in the financial and Budget planning of state is under active implementation with specific allocation of funds for disaster management and risk management.

4.3.3 Role of Volunteers in Early Warning Systems in South Asia: A Special Focus on Bangladesh

– Loy Rego, DRR Expert, Thailand

Volunteers play an active role in disseminating early warnings to communities at risk in South Asia. Bangladesh pioneered a coordinated partnership which worked over 45 years, involving at-risk coastal communities in volunteering and delivering services.

Bangladesh's approximately 166 million population live in a low-lying river delta with 230 rivers/tributaries, between the Himalayan foothills and Bay of Bengal. This 9th most populous country, is among the most disaster prone globally, experiencing cyclones, floods and river bank erosion, urban floods, tidal surges, droughts, seismic tremors, cold and heatwaves, landslides, fires and building collapses.

The Government of Bangladesh (GoB) has well established Ministries with responsibilities in disaster management, health, water and sanitation, each linked to Bangladesh Red Crescent Society (BDRCS). GoB's Standing Order on Disasters (SoD) gave disaster management responsibilities at various levels to BDRCS. The Cyclone Preparedness Program (CPP), established in 1972, is a joint program between GoB and BDRCS for community level response, creating a coastal early warning system, and supporting implementation of preparedness plans and programmes. Specific areas in Bangladesh Climate Change Strategy and Action Plan (BCCSAP) 2009, are linked to BDRCS's role in CPP.

BDRCS is a volunteer-based humanitarian organisation with 68 branches, one each in 64 districts and 4 metropolitan cities: Dhaka, Chittagong, Rajshahi and Khulna. It has 55,260 well equipped CPP volunteers (36,650 males and 18,400 females) in 7 zones, 13 coastal districts, 37 Upazilas, 322 Unions and 3,291 Units; ready to respond to cyclones, well trained and networked, meeting regularly at least once a month, engaged in BDRCS disaster preparedness work, in partnership with 720,800 Red Crescent Youth (RCY) members and 3,500 active RCY volunteers. CPP ensures rapid dissemination of official Bangladesh Meteorological Department cyclone warning signals to communities; assists in sheltering, rescuing and offering immediate medical attention, and post disaster recuperation and rehabilitation. BDRCS has 140 Cyclone Shelters in the coastal belt maintained by local communities; ready Disaster Preparedness stocks in 2 warehouses in Dhaka and Chittagong, a fund for small emergencies, an international appeal mechanism for medium to large disasters, a 60-strong National Disaster Response Team, a 60-strong national WATSAN DRT (disaster response team), Unit, Ward and Community Disaster Response Teams, and longer term DRR programmes.

Vulnerability mapping based on consultations by youth/volunteers while preparing the current (BDRCS) Strategic plan (2017-2020) identified 20 categories of vulnerable populations to focus on:

1. Elderly people
2. Poor pregnant women
3. Urban slum dwellers
4. Disaster – affected poor families
5. Migrants
6. Female-headed disaster affected poor families
7. Youth addicted to drugs
8. Street children
9. Poor rural women and adolescent girls
10. Marginal farmers fisher-folk and labour
11. Persons with disability
12. Psychologically ill people
13. Snake charmer community children
14. Landless and marginalised daily wage labour families
15. People from ethnic/religious minorities
16. Brothel- based children
17. Transgender community
18. Victims of child labour and child marriage
19. Landless and Homeless families
20. People living on exposed coast, waterlogged, hard-to-reach areas

Assessing strengths, gaps and capacity needs of the 68 branches found **strengths** (% of Branches above 50%): Autonomy (92%), Branch Governance (85%), Financial Information systems/reporting (73%), National Society growth, periodic Branch General Assemblies (62%); Activity Identification (52%) and financial management (52%). The **areas needing improvement** (scores below 50%): observance of fundamental principles, emblem usage, membership base, branch planning, safety/security, staff management, volunteer recruitment, recognition, retention and records, diversity, infrastructure, costs and budgeting, record management, planning, monitoring, logistics, reporting, information sharing, external coordination and communication, community involvement, diverse resource base, Red Crescent grassroots network, activities sustainability, learning, adaptation and conflict resolution.

BDRCS's Strategic Plan 2017-2020 aspires to provide sustainable service delivery, national society development, respond to local needs continuously, sustained and diversified income, credible governance, management leadership, ability to attract volunteers of all ages/social layers. The plan balances emergency response, institutional disaster preparedness and resilience building; external partnerships (17 SDGs and 1 Billion Coalition for Resilience), uses measurable results-based approaches, national resource mobilisation, local branch strengthening and greater modern technology use.

Two of four goals focus directly on disaster management/resilience, **Goal 1:** strengthened preparedness, response and recovery to reduce disaster and humanitarian impacts and **Goal 2:** strengthened communities to become more resilient to multi-hazard, climate-induced phenomena.

Since its inception, CPP volunteers saved lives by disseminating early warning and conducting safe evacuations. Over the last 20 years, BDRCS launched 24 medium to large responses, assisting 60,000 families annually. CPP evacuated 1.1 million people in 2013 prior to Cyclone Mahasen's landfall. **Goal 1** recognises that BDRCS's **network of trained volunteers** is its driving force for response, pre-disaster preparedness plans and prepositioned relief stocks. Its specific **outcomes** concentrate on EWS, preparedness, assisting affected communities and building back better. It **targets** mobilising, building skills and equipping CPP volunteers, enhancing their EWS dissemination, taking action in vulnerable communities, expanding coverage in 20 more unions, keeping 240 NDRT and DRWRT members ready, ensuring 30 district branches have trained UDRTs; establishing permanent trust funds to cover CPP operational costs and BDT 50 million emergency fund, ensuring 10% of the national disaster caseload is assisted by BDRCS, supporting 15% of these communities to build back better, increased access to resilient shelter and livelihood support.

Bangladesh ranks second in the CC Vulnerability Index. Disasters affected 4.4 million in 2015, and 18 million are expected to be affected by climate induced displacement over the next decades. **Strengthening community resilience** under **Goal 2** builds on BDRCS's work since 1997, aligned with other actors, links with national frameworks, setting targeted **outcomes** on disaster response and CC adaptation, well maintained and accessible infrastructure, improved livelihood capacities, health and hygiene, better use of safe drinking water, sanitation and effective networking with relevant stakeholders. Specific **targets** include increased community capacity on resilient agriculture, CCA/DRR, effective multi-hazard, climate risk responsive preparedness, strengthened community infrastructure, including cyclone shelters, climate adaptive sustainable livelihood options in farm and nonfarm sectors enhancing food security and increased capacity on WASH, environmental sanitation and health.

Empowering RCVs and Youth, financial self-sufficiency, increased annual revenue through domestic individual and corporate partnership, greater advocacy and networking with the Government, movement and non-movement partners and stakeholders are key outputs in BDRCS development focused Goal 3.

Over 45 years of sustained work and partnership with the Bangladesh Government at relevant multiple jurisdictions, domestic resource mobilisation and bold future thinking are clear examples of how organised volunteering can help all South Asian countries.

4.3.4 Connecting At-Risk Communities with Community-based Early Warning Systems: An Initiative of the Aga Khan Agency for Habitat (AKAH) in Afghanistan

– Arvind Kumar Sinha, Senior Programme Manager- Partnerships, Kabul, Afghanistan

The Aga Khan Agency for Habitat (AKAH) in Afghanistan has the prime mandate of ensuring safe infrastructure, resilient communities and providing communities with services and opportunities so that they and their families can thrive. An integral part of community resilience is EWS connecting communities with key messaging and forewarning alerts so that families have the time and understanding to protect themselves against impending weather hazards.

Aligned with Target E of the Sendai Framework for Disaster Risk Reduction (SFDRR) as well as AKAH's own strategic objectives, AKAH has worked on several fronts to establish community-level EWS and emergency communication to further strengthen communities' ability to prepare for and respond to emergency situations.

Emergency Communications

AKAH has explored several ways to stay connected with risk-prone communities through an established network of communication mechanisms based at community level, including a 24x7 call centre located in Kabul. AKAH has direct connections to more than 300 villages which covers over 15,000 families and 75,000 individuals with emergency communication systems which help in the immediate response to affected communities and plans for evacuating communities to safer locations.



Calling a village via Thuraya phones, Kabul.

Weather Monitoring Post

AKAH has established 17 manual weather monitoring posts (WMP) in the most risk-prone villages of Afghanistan to monitor avalanche risk. Avalanches are one of the most severe hazards in high mountainous areas, which are responsible for a high number of deaths and injuries. For over a decade, AKAH has established the Community Emergency Response Teams (CERT) in at-risk villages across the country; some of the CERT members have been trained to collect precipitation readings of the WMPs and share them with the AKAH 24x7 Operations Call Center. This Call Center sends the information to a dedicated avalanche forecasting expert based in Montana, USA who analyses the data and shares it back with the AKAH Head of Emergency Management on the probability for avalanche occurrence, and messages are communicated to the community through the call centers. With more than 150 avalanche preparedness volunteers, AKAH works to shift communities to safer locations during avalanche warning times. Through WMPs, AKAH evacuates on average 4,000 individuals each year from active avalanches threats.



WMP installation in Baghlan province.

Community-based Flood Early Warning System (CBFEWS)

This initiative has been established with the help of ICIMOD, Nepal. Using a simple methodology, the system connects upstream communities with the downstream communities in case of riverine flooding. Upstream communities have a water installation that gauges river water levels and informs the downstream communities via a mobile network about rises in river levels. This system has proven to be a very effective approach to saving lives and assets by sending timely warnings of flooding to the often-unfortunate downstream villages who have been helped by education on early warning alerts for river flooding. CBFEWS is a pilot initiative with the Ministry of Energy and Water and ICIMOD.



Checking of Data Acquisition Unit (DAU) in Pariyan district, Panjshir.



Installation of CBFWEWS pole in Pariyan district, Panjshir

Upgrading Ministry of Energy and Water (MEW) Hydromet Stations into Early Warning Stations

A small initiative was organised in partnership with the Ministry of Energy and Water and the Afghanistan National Disaster Management Authority (ANDMA) with financial support from the KfW-sponsored PARTIP Foundation. The feasibility study recommended the installation of additional sensors that connected river level data collections with cloud-based systems on an hourly basis. Data would reach MEW Control Rooms on an hourly basis where it would be analysed and shared back to ANDMA and AKAH through a phone call and email. If the river level was shown to reach the threshold, AKAH would activate its emergency communication mechanism to inform the CERTs of the impending flooding headed their way.

The AKAH team delivered early warning trainings and conducted these drills for 50 villages in three districts, and 2,992 village members (1,496 women and 1,496 men) attended. A focal point was selected in each village to receive the messages and circulate it back to the whole community for the quickest evacuation. Many posters and learning material were also distributed to the communities.



Configuration of system in Tangshiw village of Maimai district, Badakhshan province.

Conclusion

In conclusion, as part of its resilience initiatives, AKAH has worked to establish community level EWS in collaboration with government authorities. These small demonstrative community-based models will play a role in institutionalising EWS at the national level with the partners and with national and provincial government. AKAH is also trying to support the implementation of SFDRR with increased access of the community to multi-hazard EWS in Afghanistan.

4.3.5 An Overview of community level flood warning dissemination and response in Nepal

– **Gehendra B. Gurung**, Expert - DRR and Climate Change Adaptation, Nepal

Flood EWS in Nepal started with ‘watch-and-warn’ technologies in 2001. In this system, a flood watchperson from the community monitored the river within his visibility range including upstream, and then warned the communities if there was a flood in the river through physical and manual means using local resources (as there were no telephones or other means of communication at the time). Gradually light sign and sounds were used to increase the reach of flood information in the communities. The relay of communication from upstream to downstream communities increased the lead time of warning. Later, communities were linked up with a hydrological station upstream from where they received real-time flood information through CDMA telephone. Communities then gradually received support for emergency shelters, rescue material, improvement in evacuation routes, flood mitigation structures, training and awareness activities, livelihood activities, etc. for enhancing their understanding of EWS and capacity to respond.

The government is primarily focused on developing standards, regulations and carrying out studies, whereas other stakeholders (e.g., NGOs) are engaged in developing technologies, testing and piloting technologies and strengthening the capacity of communities.

There are two critical levels of rivers as identified for EWS purpose. These river-specific levels are 1) warning level and 2) danger level. Warning level indicates situation of bank-full of river in reference to downstream flood plain and the danger level denotes the point of river overflow out of the bank. Communities downstream are made aware of these levels. They receive information at intervals concerning the warning and danger levels, including SMS, by gauge reader and district level authorities when the river reaches to these levels. There is also simultaneous physical monitoring of the flood at gauge station to ensure that any information coming out of the automatic system is reliable. Thus, people in the community check with the gauge reader to verify the SMS information. The gauge reader also makes telephone calls if she or he observes the river level reaching warning or danger levels.

Once the communities receive warning level information, they prepare to leave home as soon as they receive follow up information on the danger level. Communities pack temporary rations, their valuables and goods to take with them, and move property they cannot take with them to places in the house safe from flood. They release their livestock after they receive danger level information so that livestock can go to safer places. They will only leave home after they get the danger level warning.



River Level Display on Electronic Board in Chitwan, Nepal.

The government is now promoting forecast-based EWS by disseminating 3-day rolling weather information with potentially related hazards in different geographical areas of the country. The forecast practice uses more than one weather model that generates forecasting information for as short as 5 hours to as long as 3 days advance. However, information is mainly displayed on official websites to which many people may not have access due to lack of access to the internet. There lacks an aggressive mechanism to get such daily weather information to the people except by being broadcast by radios and TVs to the extent they have understood it.

Along with successes it is also important to acknowledge the limitations and gaps.

4.3.6 Early Warning System that Hardly Trickles Down

– **Sarwar Bari**, National Coordinator, Pattan Development Organisation, Islamabad, Pakistan

Like its South Asian neighbours, Pakistan is prone to multiple hazards; hazards easily turn into disasters when societal and structural vulnerabilities exist in plenty. As large populations suffer from layers of inequalities, deep poverty and widespread deprivations, they carry numerous vulnerabilities to both natural hazards and man-made risks/shocks. EWS or for that matter any similar state provisions are imperative to understand in that context. In a country where access to

education and information technology is skewed, and the officials are corrupt, the early warning hardly reaches those for whom it is generated. For instance, if early warning is relayed through cell phone or email, it is highly unlikely that a large number of women and illiterate populations will receive it. Hence, they are deprived of a crucial warning at the right hour.

As flood disasters happen more frequently and hit vast areas of the country, I will limit this contribution to flood related EWS. Between 1950 and 2016, the country suffered from 24 major flood disasters which caused more than USD 38 billion in economic losses, affecting on average 8,200 villages each time, mostly from the same villages.¹¹⁵ In the aftermath of each flood disaster local authorities gather information of losses and they have a treasure of information (i.e. literacy rate, distance from rivers and roads, GPS maps, number of schools and clinics, names of community leaders), as most of the affected areas, the populations, the structures were similar etc. Therefore, generalising the trends and evolving an effective EWS for these areas should have been an ‘easy’ task. Yet, it has not been done and it is highly unlikely to happen in the near future unless sufficient public pressure is built to do so.

However, Pakistan has a very elaborate (but complex) disaster governance structure and state of the art technology. And EWS should not be examined in isolation. Since, rainfall is considered one of the major cause of flooding, the Pakistan Meteorological Department (PMD) is tasked with monitoring and measuring precipitation. For quantitative flood forecasting the hydrological data is obtained through the Provincial Irrigation Department (PID) and WAPDA’s telemetric system. The PID also maintains a limited network of manually observed hydrological stations at barrages and important nullahs. The main purpose of forecasting and early warning is to ‘alert the likely damage center well in advance of the actual arrival of flood, to enable the people to move to safer places.’

Officially the flood forecast (FF) is divided into three categories: qualitative, quantitative and early warning, and is the responsibility of the Flood Forecasting Division (FFD). Flood Alerts are coloured coded. Blue, Yellow and Red. Blue signifies rains forecasted within 24 hours. Yellow means the risk of heavy flooding has increased in the next 1 to 3 days. And the Red warning means there is a very high or exceptionally high flood level building up within 7 to 14 hrs.

PMD issues just the ‘alerts’ to all the relevant departments and the media outlets. Here is an example: *In view of likely Hydro-Meteorological situation, all concerned organisations are advised to remain Fully Alert, watch the weather situation closely and take all necessary precautionary*



Showing a night vigil - sit-in of flood affected women and men [2011] in front of the Prime Minister’s camp office and house.

115 Federal Flood Commission, Government of Pakistan, “Annual Flood Report, 2017.”

measures well in time, so as to avoid loss of precious human lives and damage to private and public property. An English daily reported an alert like this – The current spell of rain is forecasted to intensify within the next 24 hours in Sindh with Karachi receiving moderate to heavy rainfall in various parts.

Karachi or for that matter big cities do get quasi-specific alerts but rural areas in general and riverine communities in particular don't have access to any information. Public policy has not only gender and class, but also evidently an urban bias. In addition, EWS remains 'jargonistic' and technical in nature even today. Moreover, the EWS must be examined in the context of disaster governance and not in isolation.

Despite decades of experiencing the flood disasters 'capacity deficits exist both at provincial and districts levels' admits an official document. It also acknowledges - 'There is a lack of coordination among institutions involved in flood management, dissemination of early warning and disaster preparedness. The local communities lack general awareness raising, sensitisation and education of the masses regularly affected by floods, focusing especially on populations residing within the active flood plains including Hill Torrents.'

It appears that officially generated flood forecasting and alerts just revolve around state institutions. Also, there are many parallels between EWS and the so-called 'trickle down' theory. Wealth concentrates in a few hands and so does information. So, what is to be done?

While elimination of the above-mentioned structural deprivation and official corruption will take time, the non-government sector should volunteer – make EWS more effective and [end]user friendly through community-based activism. Or organise the people so that they could make officials accountable.

4.3.7 Early Warning System for Technological Disaster and effective communication: A View

– **Rino Sekhar R.**, Junior Researcher, Groupe URD, France

As per some urban legends in the early morning hours of Chernobyl nuclear disaster, some of the residents of Pirpyt city gathered on a railway bridge to watch the column of light and rainbow-coloured flames from the explosion site. Unknowingly the residents were exposed to high levels of radiation. According to legend, everyone who visited the bridge that night passed away because of radiation years later, the infamous 'Bridge of death' of Chernobyl. Legends or incidents like these clearly depict how early warnings of an event of technological disaster cannot be implemented effectively without proper social awareness. An effective awareness programme along with safety precautions and early warning systems must be implemented to avert an incident of technological disaster.

A technological disaster occurs when a technological hazard resulting from industrial activities exceed the coping capacity of an industrial plant; usually resulting in immediate or delayed major emission of fire or explosion, endangering human lives and the environment and involving one or more hazardous substance inside or outside the establishment. The main notable factors contributing to technological disasters are summarised as human factor, organisational factor and technological factor. Human factors are inappropriate or undesirable human decisions which have the potential to increase the hazard by reducing the safety and the effectiveness of system performance. The organisational factor shares its vicinity with human factors as well. Factors such as the approval for decisions in reducing risk management, inadequate resource allocation, business pressure, communication failure, and inadequate emergency plans which curtail safety comes under organisational factors. Technical integrity is what ensures the intent design purpose of an industrial plant, to ensure the proper functioning of the plant without causing any damage to people or environment. It also ensures proper communication as well as updating and testing of the system to match the original technical integrity of the plant. Compromise in the technical integrity of a system will lead to the amplification of technological factors contribution to a technological disaster. Major technological disaster like the Bhopal gas tragedy, Chernobyl nuclear disaster, Deep-water Horizon oil spill, 2015 Tianjin Explosion, etc., were a result of a combination of human, organisational and technological factors. Another form of technological disaster is the combination of both disasters induced by natural hazards and industrial disaster, known as "Na-Teach" events, example the Fukushima nuclear disaster.

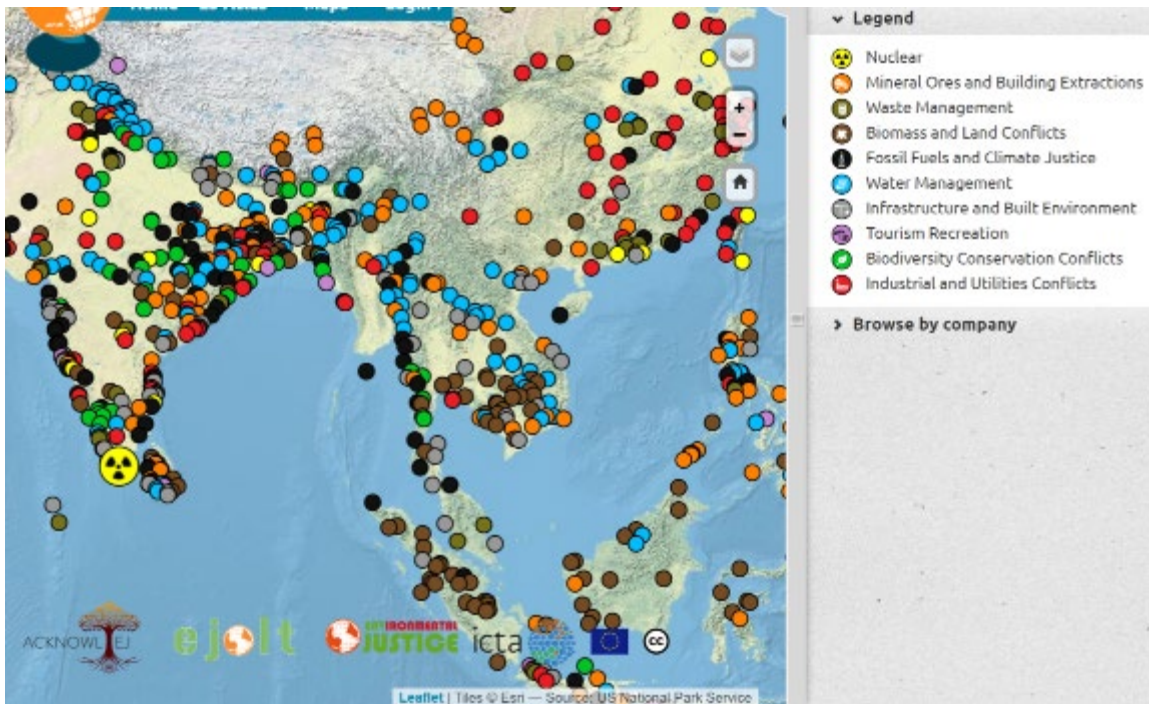


Figure 4.8: Figure showing different types of Industrial sites in Asia, Source Environmental Justice Atlas Website.

The potential impact from a disaster event varies substantially depending upon the characteristics of the community and its access to emergency response resources. Thus, EWS must be established to protect people by enabling action in advance to reduce risk and impact. An effective warning system requires a proper monitoring of all the factors which contribute to a disaster, and call for immediate response from the participating agencies - in other words detecting the issue and alerting the targeted. It is fundamentally important that an early warning centre supports a wide range of dispersal channels (such as sirens, TV broadcasts, SMS, etc.) and warning products contain clear and proper messages with understandable instructions (in different languages in multilinguals communities and different character codes).

In order to take right decision after an early warning it is necessary for the population and the authorities to have a proper understanding about the gravity of the hazard and vulnerability around the site. However, alerting people or the local community is often disregarded. Establishing a coordinating group consisting of members from the local community and different authorities will ensure improvement in emergency preparedness and response plans, globally adapted processes like APELL (Awareness and Preparedness for Emergencies at Local Level) will provide a platform for these groups to interact with each other. In India APELL has been implemented in partnership with the National Safety Council of India since 1992 - while the local government identifies the communities, the national level focuses on raising awareness and strengthening safety audit. The creation of Local Crisis Groups (LCGs) in all the industrial areas is one of the lasting outcomes from the APELL process in India. The combination of accepted public awareness processes and sufficient early warning system will aid a community to effectively deal with hazards and prosper in the modern era.

This contribution draws from the following sources:

1. APELL Handbook 2nd edition
2. Chernobyl 30 years on: former residents remember life in the ghost city of Pripyat (<https://www.theguardian.com/cities/2016/mar/07/chernobyl-30-years-residents-life-ghost-city-pripyat>)
3. Journal of Loss Prevention in The Process Industries/ Technological Disaster Factors
4. Generic Information Logistics for Early Warning Systems

4.3.8 Early Warning Systems in Disasters: Is Technology the Sole Determinant of Effectiveness in India Milieu?

– Pankaj Anand and Animesh Prakash, Oxfam India

With abrupt and erratic weather patterns as the new normal, disasters are becoming unmanageable.

The monsoon floods of 2019 have engulfed as many as nine states in India by the end of August. The reported human casualties thus far are alarmingly high. India accounts for one-fifth of global deaths. This situation warrants adoption of the principles of ‘zero casualties’ deep within the system.

The need of the hour is a much stronger adoption of two critical elements of prevention and mitigation within the disaster management framework. This calls for innovative approaches in disaster management establishing a continuum along the entire spectrum from humanitarian response to disaster prevention and mitigation.

However, it should be noted that India has taken giant strides in disaster management after the Super Cyclone of 1999. The super cyclone and every successive large disaster, like the Indian Ocean Tsunami and the Bhuj earthquake have led to some incremental system reforms. The strengthening of the EWS is one of these. The 2004 tsunami, which claimed nearly 200,000 lives, brought home the need for an architecture to coordinate EWS in the Asia-Pacific region. As a result, the intergovernmental Oceanographic commission adopted a resolution to establish a global early warning system framework for ocean related hazards. In the subsequent year, 2005, the Hyogo Framework for Action was adopted which included risk assessment and early warning as one of its five themes and upheld equal importance in the Sendai Framework for Disaster Risk Reduction

There are great examples where reforms have been adopted and actioned. Odisha has made strides from the time of Super Cyclone to Phailin to Fani. And yet among these silver linings, the death toll in some of the recent disasters in other parts of the country clearly points to the fact that there are still gaps in EWS and that it is an unfinished agenda.

Now, let us examine the state of flood forecasts and the loss of human lives. “Between 1986 and 2008, India relayed 145,349 flood forecasts with 95.35 percent accuracy. During the same period at least 34,674 human casualties were reported in floods.”¹¹⁶ Poor early warning dissemination is attributed as one of the major reasons for high casualties in disasters. The evolution of systems for dissemination of early warning to the local communities has not kept pace with the development of forecast technologies.

In 2015, Oxfam India conducted an early warning gap assessment to analyse the existing structure of EWS in Odisha and identify the areas which may result in late dissemination and negative community actions particularly in disasters with less lead time. The assessment highlighted that the ‘last mile’ connectivity to the ‘at-risk’ communities still largely depends upon manual systems. On the side of the community, it was found that the trust regarding the accuracy of early warning messages and the time of warning dissemination played a role as well. The assessment also suggested that the experiences of exclusion of the marginalised social groups play a role in the reluctance of such social groups to evacuate leaving their already meagre livelihood assets that they possess. The fear among the poor of getting further dispossessed also plays a role in rendering early warning messages ineffective.

In the end, technology is an important determinant of EWS but the less acknowledged socio-economic factors too are important determinants in the success of early warning efforts.

Low cost and low-tech solutions should go hand in hand with the existing sophisticated high-end technologies particularly in countries like India where very large number of people are at risk. Low cost solutions will enable blanket outreach. End-to-end early warning systems should place equal focus on all the four EWS stages including risk assessments, forecast, communication and dissemination and community action. The efficiency of a robust EWS is determined in the last

¹¹⁶ Oxfam India. 2018. Volunteer Network Management System Strengthening Community-Based Early-Warning System. https://www.oxfamindia.org/sites/default/files/DRR_AnimeshAprilbooklet_Web.pdf

mile which can only be actualised through collective action. And as rivers and disasters are not bound by political boundaries, transboundary approaches should also be built more strongly into the disaster management instruments at country and regional level.



Exclusion of the marginalised social groups plays a role in the reluctance of such social groups to evacuate leaving the already meagre livelihood assets that they possess. The fear among the least possessed of getting further dispossessed play a role in rendering Early Warning messages ineffective. During the 2017 floods, a man hangs on barely to tend to his assets even when everything around is inundated. Herds of cattle are stranded as the flooding is still reported to be on a rising trend on 16th of August 2017 at Elginbridge in Uttar Pradesh.

(Photo credit: Animesh Prakash/Oxfam India)

4.4 Key Conclusions on Warning and Dissemination and Communication

This section draws from peer reviews and contributions from:

- **Puneet Agarwal, Esther Jose, and Jun Zhuang**, Department of Industrial and Systems Engineering, University at Buffalo, USA
- **Rino Sekhar R.**, Junior Researcher, Groupe URD, France
- **Dr. Amod Mani Dixit, and Rita Thakuri**, National Society for Earthquake Technology-Nepal (NSET); Membership Manager, Asian Disaster Reduction and Response Network (ADRRN), Nepal
- **Sarwar Bari**, National Coordinator, Pattan Development Organisation, Islamabad, Pakistan
- **Dr. Suman Kumar Karna**, Special Advisor to CEO, National Reconstruction Authority (NRA), Government of Nepal
- **Gehendra B. Gurung**, Expert, DRR and Climate Change Adaptation, Nepal
- **Dr I Satyanarayana Raju**, Senior Project Manager, AP Human Resources Development Institute (APHRDI), India

Early Warning Systems in South Asia have improved drastically over the last decade. Various methods and processes have been implemented to bolster emergency response and recovery during crisis events. Different types of text messages and short message service (SMS) systems have driven the movement, ranging from mass alerts for the entire populace, to alerts to a

specific subset of population. There has also been a significant increase in the usage of Online Social Media (OSM) platforms, particularly Twitter and Facebook, that are directly used by the government and responding agencies for prompt dissemination of relevant information to the affected population. The traditional method of community-based warning systems which depend on eye-witnesses have also evolved to incorporate information from sensors. The vitality of a system consisting of trained volunteers has been recognised as well.

There are technical, institutional, and informational challenges while implementing these systems. First, technical challenges include the lack of integration of EWS with indigenous knowledge and practice, and the lack of multilingual support in warning systems. These challenges can be addressed by integrating the local community in the development of EWS and using their feedback to improve existing EWS. Second, institutional challenges include ineffective governmental and institutional arrangements, dissension between government agencies and local communities, and the corruption-based structural inefficiencies that plague the EWS. These challenges can be addressed by improving existing policies, grassroots lobbying, movements and activism. Finally, informational challenges such as the spread of rumours during crises can be curbed by increasing public awareness.

The most important lesson learned is the value of time as it relates to warnings. A disaster warning of 10-15 seconds is found to be more effective than no warning at all. The importance of the delivery method of warnings is also realized, as even a timely and informed warning needs to transcend lingual, cultural, and social barriers. (Agarwal, Jose, & Zhuang)

In South Asia effective studies have been carried out by governmental institutions, NGOs, universities, with international collaborations, sharing new technologies to comprehend the extent of risk/vulnerabilities faced. Several elements like political factors, socioeconomic situations, geography, etc. may hinder the proper establishment of results obtained from studies. An effective multi-dimensional hazard approach with structural and non-structural risk reduction method, ensuring the involvement of the local communities and local government bodies, would help in the implementation of a proper awareness system. The right information received at the right time along with clearer messages would aid a system to function properly; the effectiveness of an EWS system can be measured by its ability to predict or forecast a near distant hazardous event, which demands for a proper examination of all microscopic factors contributing to disastrous events. A proper utilisation of state-of-the-art technologies, involving academic studies, scientific research and studies, applied in collaboration with communities will help build awareness among the public and should enable an EWS to achieve its goal, which is to enable every region to achieve the status of a disaster risk resilient state. (Sekhar)

This section of the report presents a comprehensive picture of capacity building, hazard monitoring and early warning with description of excellent work at the ground. It is evident that effective and comprehensive disaster risk management and early warning works best when there is a comprehensive policy and legal framework in action. Technologies for effective early warning exist in South Asia, and it is effective where there is understanding, engagement and collaboration between public, private and social entrepreneurs. These articles confirm that DRM should be “for the people and the nation, by the people and the nation, and with the combined efforts of the people and the nation”.

They also confirm that effective early warning and management of disasters is possible, and point out the following areas of improvement:

- Enunciation and mandatory implementation of policies Pre-arranged agreements with the media; behavioural awareness on early warning protocols, especially for suppression of rumour and misinformation; breaking of silos in DRM efforts; multi-hazard EW coordination and integration of efforts in hazard risk assessment, monitoring, forecasting, and emergency management, with sensitivities to ground realities on societal, gender and physical vulnerabilities.
 - Special focus needs are on cross boundary information sharing on hazard monitoring.
 - Regular updating of plans and early warning infrastructure with upgrading of technology
- (Dixit & Thakuri)

The whole of South Asia appears to be in perpetual transition – migration from rural to urban and across cities and provinces, urbanisation (housing and industry) penetrating into rural areas

and population growth and industrialisation etc. build an extremely complex situation and pose serious challenges to policy makers and practitioners. Yesterday's safer area become risky today. South Asian societies are likely to remain fragile in a complex way. Hence, they are inherently simultaneously and multi-dimensionally vulnerable and they have to cope with dozens of hazards every day. Naturally, in order to remain sane people tend to suppress or ignore some risks and live with them. But states and structure can't do that.

Most South Asian states appear to be failing to comprehend the above-mentioned complexities, and lack good governance and horizontal and vertical coordination between central and provincial governments to effectively communicate risk-related information. Therefore, joint efforts must be made to evolve regional EWS. Similarly, community-based dissemination and communication centre must be established. These centres should be based on a two-way model of communication. (Bari)

Different articles presented in this section, discuss the very original and innovative early warning initiatives that have been launched and implemented in selected countries. The section deals with a large range of early warning schemes and elaborates at length on all four key elements of any EWS. The majority of schemes mentioned are profoundly practical and people-centred and therefore have categorically highlighted the role of targeted communities and their capacity to respond. The use and importance of modern and advance technologies and also the role of other stakeholders – like security forces, media, volunteers, universities, local governments – are also adequately reviewed and described. The examples from Nepal have highlighted the process of adopting multi-hazard approach to EWS and ensuring a more comprehensive and robust impact on the ground.

The system of early warning is not free of issues and challenges. All four elements of EWS must perform in chorus to save human lives and properties. Making warnings prompt, targeted and informative; before, during and after emergency is one of the biggest challenges restated by different authors. Both the population and authorities' failure to understand the gravity of hazard and vulnerability is what restrict them in taking right decisions after early warning. Similarly, the conscious blending of indigenous knowledge of DRM and early warning with the modern science and technology is still very weak. Appropriate use of imported technologies and local capacity to operate them in a meaningful manner is always a concern observed and reported in many cases. How the power of media can be elevated from mere informer to making communities listen, is another area where a more deeper collaboration is needed.

Despite successful use of online social media like twitter on many disaster events, its use for spreading rumours and misinformation is what needs to be controlled. When the country is at risk with multiple hazards, a silo approach of DRM will not work and thus developing a multi-hazard EWS with effective governance and institution is indispensable. In the absence of an immediate assessment and upgrading of forecast system (including transboundary areas), it is impossible to assess the extent of damage caused by the same disaster. Bangladesh has been significantly successful in mobilising volunteer support at different stages of EWS, however there are still many areas, where serious improvement is needed on an urgent basis. In spite of rapid advancement in the DRM field, Pakistan is still struggling in trickling-down the EWS to the end users.

The lessons learned from above the discussions are very precise and straight-forward. People-centred approach should be the fundamental of any early warning system. In addition, early warning is a multi-sectoral and multi-dimensional system and therefore effective coordination and collaboration is a pre-requisite. Also, this system is continuously evolving and hence a simultaneous improvement is needed to keep the system effective, functional and result-oriented. This initiative has plenty of scope to diversify and upgrade its capacity and functions by integration of modern and advance technologies and also by bringing new players and stakeholders into this business. The existing systems must be promoted to capture multi-hazard risk and should be part of a more holistic approach backed by appropriate governance and institution. Traditional practices and indigenous knowledge must be recognised and amalgamated with the present-day technologies and systems. The opportunity to learn from different countries' initiatives and their experiences and lessons must be utilised for localising and capacitating the multiple users of the system. Likewise, the system needs to understand the transboundary situation and accordingly adapt its operation and functions to suit the local context. The system of early warning will not work unless the knowledge, information and capacity reaches the last community on the ground. (Karna)

South Asia is comparatively more vulnerable to disasters needing implementation of MEWS in managing disaster risk reduction. States will be in isolation but not the disasters and hence transboundary data sharing as part of MEWS will certainly reduce damages and losses across South Asia, hence the need for RIMES. Kosi River and Narayani Gandak River floods of Nepal - Bihar proved community resilience through transboundary dissemination of data a step towards EWS.

December 26th 2004 Tsunami that enveloped the South Asia coastline led to the evolution of the Tsunami Evolution Coalition (TEC) towards cooperation between nations for IT enabled Multi-hazard EWS (MEWS), benefiting at large in reducing damages, loss and facilitating early recovery.[As shown in this chapter] In one way, children are most vulnerable during disasters but at the same time they will be the helping tools in DRR by educating them to develop community needed EWS through curriculum and research. Women are a doubly disadvantaged section of the community during disasters requiring proper focus as targeted-benefiting stakeholders when developing MEWS

Machine learning Prediction model with remote sensing technique for getting data from remotely placed rain gauge stations and flood levels in water bodies is an upcoming incorporation in MEWS. The 2018 Kerala floods paved the way for effective community resilience for rehabilitation, restoration and recovery during disasters and that also enabled them to be much more resilient during the 2019 flood disaster with homogeneity among the community to help each other during evacuation and sheltering neighbourhood.

The CSR funds have come in handy for resource mobilisation at a critical stage of mitigation and recovery and can also help in establishing MEWS. The State of Andhra Pradesh with 940km coastal belt has become self-resilient during recent disasters through technology implementation of MEWS and RTG. The fact is that there are lesser loss and damages in Fani-2019 by learning lessons from past cyclones-floods that occurred in 2018 and 2014 and by bridging noticed gaps. (Raju)

Providing timely warning to all beneficiaries especially the most vulnerable ones is always challenging. It is even more challenging for earthquakes, which cannot be predicted from a location, timing and magnitude point of view. As the lead-time will be too short, timely response and evacuation are equally challenging which demands high quality preparedness.

Uncertainty is an inherent characteristic in disaster management and there is always a challenge on how to minimise the level of uncertainty for effective EWS.

Challenges in community-based EWS lie in the sustainability of the system. Their legality in case of wrong information that may cause loss of lives and properties instead of saving can be challenging too. Upgrading of the system with new technologies and good practices from outside the communities' reach are also challenging.

With the development of technologies, however, dissemination of warning information by SMS through GSM and CDMA telephone system has been found to be effective in case of flood EWS. Similarly, real-time display of flood information in community centres and in offices of local authorities has become effective in information dissemination.

Building the capacity of communities and stakeholders to respond to warning information through both structural and non-structural measures as appropriate plays a vital role in ensuring the effectiveness of EWS.

There are several good EWS practices in various geographical areas for different hazards in South Asia. Such initiatives should be shared and learnt. A standardised multi-hazard EW Framework should be developed and operationalised at the regional level. EWS should be an integral part of overall DRR and development initiatives of communities, local, provincial and national governments. On top of all, EWS should be a priority agenda for regional and global efforts on the road to achieving the targets of Sendai Framework for DRR by year 2030. (Gurung)

5. Preparedness and Response Capabilities



The element of response capabilities is critical for saving lives, livelihoods and assets. This element emphasises the importance of education and preparedness at all levels. “To succeed in prompting a response to warnings, it is vital that endangered communities have trust in the early warning system”¹¹⁷. This chapter presents a collection of experiences on emergency response capabilities of various stakeholders. It provides guidance on measures to build regional, national and sub-national capabilities to respond.

Disaster preparedness is the final, and perhaps the most telling, stage of the EWS given that it is largely a result of the cumulative efforts of the previous three EWS stages. As such, this chapter starts with a description of a disaster where the community was not prepared but managed to pull through – which is a lesson in itself. It then continues the format of previous chapters exploring the important of transboundary EWS and equality and communities in the disaster preparedness process. EWS and air pollution in the context of preparedness is explored in terms of inclusion of the poor in the EWS and China’s experience in preparing its citizens for such hazards. The EWS in Sri Lanka is then discussed, where papers explore the country’s disaster management framework and provide examples of where volunteers, NGOs and students have successfully prepared for different types of hazards. With the increasing need to improve accuracy, lead time and disaster response the role of the private sector within the scope of technology provision and disaster response mechanisms are highlighted at the end of this chapter as is the role of humanitarian agencies in response to extreme climate events.

5.1 Disaster preparedness and the role of the marginalised

As expressed by many authors in this report community response is key to ensuring lives and property are saved and damage minimised during a disaster. The following papers highlight the gaps that exist within systems in ensuring community needs post-disaster are adequately met, while also highlighting cases where organisations have worked with communities to prepare disaster response plans and actions, and have built successful field-proven frameworks that effectively include the community in disaster response mechanisms.

5.1.1 The Need for Disaster Preparedness under the Light of Kerala Floods of 2018

Dr. May Jacob, Freelance Writer/Editor, Kathaa, India

A disaster that truly revealed the strength of the people of Kerala were the floods in 2018. We were brought together by the desire to survive what nature threw at us, Keralites from various walks of life united to ameliorate each other’s lives.

At the time I lived in an apartment complex by the river Mangalapuzha, a tributary of the mighty Periyar. I watched news channels telecast live visuals of the various dams being opened and people gathering around as if it were a celebration of sorts. Frantically I asked my parents and friends who live around the area about the preparations for the impending flooding. Everyone seemed sure that it wouldn’t flood and that it was just scaremongering by the media. With great difficulty I coaxed my reluctant parents to buy extra food supplies, water, etc. The deluge began, the waters rose furiously people scrambled, possessions were drowned, livestock washed away. Those who had invested their entire life savings in the dream of a home saw it inundated with foul smelling water and dirt, including valuables soaked beyond repair.

Wayanad was one of the first hit, with heavy landslides and flooding. People in Kochi collected food and other supplies, under the initiative Anbodu Kochi. Once the floods got closer to home, young men and women used social media to create a network of support and mapped the affected areas, made lists of necessary supplies, and organised distribution centres. It was a seamless operation that cut across all social divisions. Young men were visibly engaged in relief work, while women worked in medical camps and relief camps. My mother and I worked in several medical camps across Ernakulam district.

¹¹⁷ United Nations Development Programme (UNDP), 2018: Five approaches to build functional early warning systems <https://www.adaptation-undp.org/resources/manual/five-approaches-build-functional-early-warning-systems>

Within the medical camps inadequate preparations of district officials were glaring. Insufficient medicines, food supplies and other essentials in many villages led to overcrowding at the mobile medical camps organised by NGOs. Post flood cleanup was an insurmountable task. Several volunteers engaged in many hours of cleaning with supplies that were donated to the flood relief efforts.

Could the floods have been prevented? The answer to that extends beyond the scope of this article. Under scrutiny here are the measures taken by the official machinery to prepare their districts for a disaster that we may have to overcome in future due to the effects of climate change.

Creating awareness manuals for impending disasters, preparing local government officials on how to deal with environmental crises, maintaining adequate supplies of medications and other emergency supplies, organising groups like Kudumbashree and other self-help groups to come together around disaster preparedness and post crisis operations.

Self-help groups and Kudumbashree have a strong network of people, which if mobilised towards disaster preparedness and mitigation could prove to be effective local agents for creating awareness around many issues. Many of the SHG's exist solely as credit issuing groups. It would greatly benefit the sustainability of the group to move them beyond this limited scope of activity and empower them to be larger agents of change.

As I conclude this article, another inundation is washing through the land of Kerala in August 2019. People moved yet another time into relief camps, call for supplies through social media is gaining momentum. The deluge carries with it bobbing, transparent, bubbles of varied sizes - plastic bottles, islands of it; some stuck together, some floating by themselves, all moving towards the ocean.

5.1.2 The challenge of equality for Climate Resilience

– **Nadia Saracini**, Senior Adviser on Inequalities, Asia and Middle East, Christian Aid, UK

In July 2019, the UN High-Level Political Forum reviewed progress on Sustainable Development Goals 10 and 13, on inequality and climate change. The interdependencies between SDG goals and targets is a key principle of Agenda 2030. During the same week, monsoon floods hit much of South Asia, with catastrophic impacts on the homes of marginalised communities, including in Assam and Bihar and Rohingya refugees in Bangladesh. The floods bring home the real-life connection between climate change and inequality.

In international forums, the Christian Aid policy team has been vocal in arguing that climate change disproportionately affects people living in poverty. We know that the ways economic and social inequalities combine to increase vulnerability warrants more attention. What can we learn from our programme and humanitarian work in South Asia that tells us more?

Marginalisation in Early Warning and Post-Disaster Services in South Asia

In much of South Asia, caste and ethnicity shape economic opportunity. Most marginalised groups work in fishing, agricultural labour, pastoralism and gathering forest produce: some of the livelihoods most vulnerable to the impacts of climate change.

Discrimination also prevents people getting help or recovering after shocks. As explained by Shivani Rana, Christian Aid's Emergency Programme Officer, Dalits (the most subordinated caste groups) and indigenous peoples usually live in isolated settlements with limited infrastructure or services, and are very exposed to climate hazards. These settlements of 'last mile' communities are neglected in the provision of shelters and are rarely reached by EWS.

She highlighted a study co-funded by Christian Aid and Oxfam, in which National Dalit Watch and Swadhikar evaluated the inclusion of Dalit and Tribal families in the response to the 2018 floods in Kerala. This study found that 98.9% of a sample of 1,585 people from these communities did not receive proper early warning before floods; Shivani described it as, "communication channels got hit by the heavy downpour and lost all coordination during rescue operation."

“In Puri District of Odisha State, after Cyclone Fani, we saw that people belonging to the most marginalised Dalit community were not given space in cyclone shelters. About 40 families were excluded from shelters and forced to take refuge only under a tarpaulin put over a tree bent by the cyclone. In the scorching heat of summer, they relied on a pond filled with dirty water for drinking, cooking, household chores and even bathing. Some of the women excluded from shelters where people of more privileged castes [who] told me of the fear they felt, sleeping outside” Shivani Rana.

Unsurprisingly, marginalised communities also take longer to recover after a disaster. This often affects children’s education and development. Referring to a young boy from Harijan Sai of Sanapatna village in Krushnaprasad block whom Shivani Rana met during a distribution in his village she said “He worried about not being able to study for an upcoming exam as there is no electricity in his village, which is always neglected and excluded from support coming through government. He felt sure, from many years of experience, that relief assistance would not reach his village.”

A Political and Technical Challenge

Christian Aid’s experience in South Asia has been that socially excluded communities are frequently excluded from sources of assistance – both governmental as well as the international humanitarian system – and are often invisible in or underserved by national disaster management plans. They are excluded from the places and spaces of decision-making, meaning they never get to voice their needs or influence responses.

Their lack of representation means that addressing climate vulnerability and building resilience for those who need it most is as much a political challenge as it is a technical one. Meeting it means challenging entrenched, unequal social behaviours as well as pushing for change in the policies and practices of national and local governments and other humanitarian actors. Inclusion by ensuring people from marginalised communities are part of assessment teams and decision-making for relief and rehabilitation efforts should be prioritised.

Further, building inclusive resilience to climate change must be based on policies and practices informed by transparent data, disaggregated by caste, sex, age, disability and other forms of marginalisation. This would both reveal the inequalities that need tackling, and show progress in closing the gaps. It would make a substantial contribution towards the inclusive, fair and just implementation of the SDGs.

5.1.3 Emergency Preparedness and Response Planning in South Asia: The ACT Alliance Experience

– **Anoop Sukumaran**, Regional Representative: Asia and the Pacific, ACT Alliance with *Inputs from* **Cyra Bullecer**, Humanitarian Officer, Asia and the Pacific, ACT Alliance, Thailand

South Asia is a region with a myriad of natural hazards, and when the high concentration of population is taken into consideration, this makes it one of the most disaster-prone regions. It must be said however, over the last three decades, human fatalities directly as an aftermath to rapid onset disasters has reduced considerably in the region. This reduction in fatalities is directly proportional to the improvements made in remote sensing data, EWS, infrastructure and continuing strides in disaster risk reduction and recovery programmes.

ACT Alliance is a global alliance of more than 145 churches and related organisation working together in over 120 countries to create positive and sustainable change in the lives of poor and marginalised people. 76% of its member organisations are rooted on the global south, 22% in the global north and 2% have a global presence. ACT Alliance has contributed to humanitarian action worldwide, and was one of the major responders in the Nepal Earthquake, Typhoon Haiyan, and the Sulawesi Earthquake among others. ACT has contributed significantly to the development of the Core Humanitarian Standard (CHS) and engages in advocacy at the global levels, including the Inter-Agency Standing Committee.



The ACT Alliance Emergency preparedness and response planning (EPRP)

At the centre of ACT Alliance's humanitarian action are the communities it serves. It is therefore natural that the Alliance gives community resilience a central role in the life of the alliance. The Emergency Preparedness and Response Planning (EPRP) plays a central role in the Alliances vision of a resilient and empowered community.

In South Asia, the ACT Alliance through its membership is present in Afghanistan, Pakistan, India, Nepal, Sri Lanka, and Bangladesh. There are country level forums (these are forums where ACT members convene, particularly when there two or more members present) in Nepal, India, Bangladesh and Sri Lanka. Each member of the Alliance is required to develop an organisational EPRP. An EPRP template developed by the Alliance is available for members to consult and develop to suit the local needs.

One of the key elements of the organisational EPRPs has been the need for members to consult with communities they work with in its development. Given that communities are the first responders to a disaster and at the centre of the response their voices are not only critical but should be the pivot around which a response is mounted. This is therefore tied to the development of Disaster Risk awareness and planning at the community level. Understandably, there are variations from country to country and region to region, however in sum most communities are provided with support and information to incorporate their DRR plans into the EPRP.

The EPRP in itself can be broken down into some simple steps.

1. What are the possible risks of natural hazard induced disasters for the community? This provides for a good risk mapping which links into historical experience and even folklore, as many communities have an oral tradition. Also explored are the likelihood of occurrence, which will help communities plan how they are going to mitigate or prepare for their responses.
2. Constant updating of data on a community, the number of elderly, lactating mothers, women led households etc. helps communities to understand who will be the most vulnerable to their identified risks. It is important to use disaggregated data to determine the needs and gaps of the communities. It is recognised that in many communities there is an aspect of migration, both inflow and outflow, which often renders official data of communities rather obsolete.
3. Identifying where the resources are when disaster strikes through a mapping of who (civil, military, government, etc.) should be contacted when an event occurs. This includes a mapping of places that are on higher ground, structures which could possibly withstand a storm or earthquake and could be used as temporary shelters within the community.
4. Identification of key people who should be responsible for communication on the severity of an event as it occurs
5. Provision of training on developing contingency plans to be followed when different disasters unfold, both at the level of the household and also as a community.
6. Some of the actions planned by the communities include drills and training on basic first aid.

The EPRP collates this information at the community level, feeding it into the national level EPRP of the organisation which will then involve other levels, which include inter alia, coordination with government National Disaster Nodal Agencies. In some countries these agencies are quasi military, in some they are completely civilian which in turn engage with military if the need arises.

The members national EPRP feeds into the ACT Alliance National Forum EPRP which then is able to indicate areas where a member is active and what they can provide, enabling other members in the country to support and also fill a gap if one is identified. This also helps prevent duplication efforts in the immediate aftermath of a disaster. Coordination with the National Disaster Management Authorities (NDMAs) and international agencies at the national level is also identified in the Forum EPRP.

The idea of a constant flow of information, on logistics, numbers of affected people, and the state of the response in areas enables ACT members to respond better and effectively. The ACT Alliance in general focuses on communities that are least likely to benefit from a disaster response, mainly remote, marginalised communities. Members are more likely to use the EPRP in remote locations than they would in urban and easier to reach locations, which other agencies and groups are more likely to reach.

ACT Alliance remains committed to effective engagement of communities and supporting their resilience in an equitable and sustainable manner.

5.1.4 Role of Panchayats in Early Warning: Anand District Planning Experience

– **Binoy Acharya, Aditi Sharan, and Kirit Parmar**, UNNATI – Organisation for Development Education, Ahmedabad, Gujarat, India

In the present day scenario, it is important to understand disasters in the context of global frameworks like the Sendai Framework for Disaster Risk Reduction (SFDRR) 2015-30, the 2030 Agenda of Sustainable Development Goals (SDGs) and the Paris Agreement (COP21) under the UN Framework Convention on Climate Change (UNFCCC). Unnati, a NGO based in Ahmedabad, has been working on DRR policy framework at different levels, and was invited by the National Disaster Management Authority (NDMA) to prepare the National Disaster Management Plan (NDMP). Unnati facilitated the preparation and the plan document was released in 2016 by the Hon. Prime Minister of India. In 2017, consultations took place with the ministries, state authorities and technical departments for the revision of the same, in which Unnati has been engaged. While this was in process, it was suggested by the NDMA for Unnati to contribute to district level planning in the context of the global frameworks and in line with the NDMP. Unnati facilitated the revision of the District Disaster Management Plan (DDMP) of Anand District in May 2018. For building resilience of the communities against various risks, at the Panchayat level, it is critical that the Gram Panchayat Development Plan (GPDP) and development planning process include DRR concerns as well. Unnati is currently facilitating the preparation of GPDPs at some locations.

During the planning process in Anand, various consultations with officials at the district block and community level took place, and with the higher up officials, so that they can respond appropriately and take quick action. For this purpose, Panchayats have a responsibility to forward situational information at specific times to the Mamletdar/ Taluka Development Officers, for them to coordinate their course of action with the District office.

It is important that information reaches people in a timely manner. Panchayats need to make sure that there is a timely dissemination of warnings. It is proposed in the Anand DDMP that the Panchayats must hold a pre-monsoon meeting at the village level for making an action plan, in the similar way it is done at the Talukla level for contingency action planning. This would not only enable the Village Disaster Management Committee (VDMC) (which are often not functional), to be re-activated, but also prepares the other functionaries (schools, anganwadis, Gram Rozgar Sevak, Mate – MGNREGA functionaries, etc.) for the floods. In addition, a lot of people are often left out of the process due to their socio-economic status and they are the most vulnerable because of their location as well. The Panchayat must make sure to reach out to these people, by using various communication methods like speakers, phones, or getting other people who are part of the VDMC, local volunteers, and other local youth groups to help circulate the warnings. In addition, they must be proactive in coordinating with local CSOs and other agencies which may provide assistance in times of need, and activate other local capacities in the village. This may include checking the equipment in the safety kits, facilities in the safe shelters (schools, community hall, etc.) and getting other things that may be required, check with the PHC or sub-centre, gather all the local volunteers, etc. Panchayats must also



Community consultation in Anand for DDMP preparation.

take the responsibility to dispel any rumours that are often spread in such situations while also authenticating the actual information they receive.

Early warnings are not limited to the pre-disaster phase; many people are left out or unaware of the damage and loss assessment and compensation process. Thus, Panchayats must also work in the post-disaster stage to inform people about things like when the damage assessment is going to take place; when and where the various types of compensations are to be distributed; what precautions are to be taken by the people for drinking water and the like. The Anand District planning experience specified the exact roles of Panchayats in early warning and in other processes of DRR as well.

5.1.5 Reducing the Fear of Being Isolated during Disaster

– **Amitabh Behar**, CEO, Oxfam India, and **Andrio Naskar**, Manager, India Humanitarian Programme, Oxfam India, Kolkata, West Bengal, India

Innovative solution by Oxfam India to ensure active participation of women in EWS for flood

While most of us wait with bated breath for monsoon and rains, in flood-prone areas the approaching season makes people anxious and nervous about their future. The fear of being isolated during the advent of disaster terrifies the poor and marginalized families, no information or warning about the approaching disaster increases their vulnerability.

Early warning information can save lives, prepare communities and reduce the impact of the disaster. It is important to include women in establishing an early warning process as they are active and resourceful disaster responders, and their seclusion from the process increases the vulnerability of communities and families. The Sendai Framework for Disaster Risk Reduction (SFDRR) also clearly targets a substantial increase in the availability and access to multi-hazard EWS and disaster risk information to the people at the community level.

Oxfam India implements all the DRR interventions with a focus on the active participation of women at all levels of planning and implementation. Task Force Groups are formed and nurtured at community level to spearhead activities like Early Warning, Rescue, Water, Sanitation and Hygiene (WASH) and others. Women play a very crucial role in all these activities and their participation is ensured for all groups.

Our experience from the field suggests that the active participation of women in the Early Warning Group always acts as the key contributor towards ensuring efficient EWS and disaster resilience of the community. This is not only because of the fact that women take proactive steps to collect and disseminate Early Warning information, but also because women remain present at the community level while the men folk migrate outside the village for work which renders their participation in EWS highly irregular.

In order to enhance the effectiveness of the community-based EWS by using updated technology, Oxfam India has taken an initiative in Odisha by establishing a Volunteer Network Management System (VNMS). The objective is to create a platform and introduce a system that works very effectively to collect accurate information from reliable sources and disseminate the same among the community members on a real time basis. Local NGOs, CBOs and the women from Self Help Groups (SHGs) are the members of this network of volunteers. Women members in the volunteer network in the disaster-prone areas help in the continuation of EWS work related as they receive training to manage the related work.

Information regarding early warning is collected from reliable sources, mostly the government departments dealing with disaster. In order to ensure real time dissemination, a technology enabled mobile application was developed through which early warning messages are communicated via mobile messages in the vernacular language. This ensures that the volunteers who are from communities receive accurate information on a real time basis. Accordingly, they communicate the early warning among the community members.



Oxfam India's flood response in Assam in 2017.

The VNMS is a manifestation of the belief that ensuring access to the control of information by women during a disaster situation can bring discernible changes in the form of reduction of loss of life and livelihoods for the poor and marginalised communities.

“Since our village is isolated and not well-connected with the gram panchayat, we have always lived in a constant fear that the warning of flood will not reach us on time. During the 2013 floods, we faced a huge loss of life and livelihood. With the VNMS in place, we now receive regular and accurate information regarding flood. This helped us to spend a peaceful life even during rainy season, which was not possible earlier,” said Padmavati Behra, member of VNMS from Chandnamkhana village, Odisha.

5.1.6 Reaching the Most Vulnerable Riverine Communities in Mahakali Basin: Community-based Flood Early Warning Systems

– **Rajan Subedi**, Team Leader, Trans-boundary Rivers of South Asia (TROSA), Oxfam, Nepal

Mahakali a Himalayan catchment of Ghagra sub basin of the large Ganga Basin, originates from the Trans Himalayan region of Kalapani (>3600 m), flows along the Uttarakhand-Nepal border, and ultimately drains through the Terai plains of Uttar Pradesh. Numerous rivers and streams join the Mahakali from the higher, middle, lower and outer Himalayas. Its northernmost major tributary on the Indian side is the glacial Dhauliganga (E) or Darma, which meets the Mahakali at Tawaghat. Further downstream at Jauljibi is its confluence with the glacier-sourced Gori Ganga. After Jauljibi the Mahakali exits the alpine region and is joined by the Saryu near Pancheshwar. The latter, mainly a spring-fed river, is the longest tributary of Mahakali. Their confluence is also the site of the proposed multi-purpose Pancheshwar dam. The last important tributary on the Indian side is the spring-fed Ladhiya.

Flood in Mahakali Basin

The Mahakali basin is susceptible to a range of hydro-meteorological and geological conditions that contribute to monsoon floods in the region. In addition, poverty and socio-economic disparity is high along the corridor. These hazard and social vulnerability along with poor land use plan, and unplanned urbanisation have aggravated flood risks (Paudel et al. 2013).

Some of the major causes of floods in Mahakali/Sharda River include heavy rainfall and cloudbursts in the area, together with glacial melting, heavy land erosion, slides and mass movements in saturated fragile geology. Heavily loaded water flow triggers further devastation. More losses have been observed in unprotected areas and low-level settlements. Failure or opening of water bodies such as dams and barrages adds to the floods and devastation (Feasibility of TBFWS study, Oxfam, 2017).



Installation of Sensor in the Kalakot area.

Need for Early Warning System

The Disaster Preparedness and Response Plan (DPRP, 2018) of Dadeldhura district identified Ranoon as one the most disaster-prone watersheds contributing to major flood risk in Dadeldura. Hence, OXFAM conducted a feasibility study of Trans-boundary Early Warning System of Mahakali basin together with Practical Action Consulting in 2018. The study report has recommended establishing an EWS in Rangoon and Tigram area in the Mahaklai basin.

The area where the Community-based Flood Early Warning System (CBFEWS) was established has an existing hydrological station at Kainpani and a precipitation station at Jogbuda operated by DHM. However, both of them are manual and do not necessarily produce flood early warnings

with sufficient lead time downstream, for Jogbuda and Simalkhet. There are also precipitation stations at Gaira, Siradi and Simalbanda, which are important for EWS in Rangun Khola. In this situation, the CBFWS installation was envisioned in Rangoon basin with the lead time of at least 3 hours for flood warning.

Based on the reference of study, ICIMOD with its partner Sustainable Eco Engineering in consultation with DHM and Pasuram municipality established CBFWS in Rangoon area. Rural Women's Development and Unity Center (RUWDUC) being a local partner organisation of OXFAM helped in site survey and assessment, selection of site and served as caretaker.

CBFWS at Rangoon

Rangoon basin covers 481 sq. km which is 31% of Dadheldhura district and contributes to 10% of its area in Mahakali basin. The CBFWS was installed near Kalakot station to provide an early warning system to communities of the Rangoon basin. The CBFWS has provided the Early Warning Information to communities to ward number 12,5,6 of Pashuram municipality.

On July 12, 2018, a heavy rainfall occurred in the Rangoon area. The sensor at Kalakot which usually records 25 cm of water recorded a water level increase after 4 pm, increasing to 58 cm on that day. The information was shared through the municipality to Elaka Police station and Women Empowerment Center (WEC) members of Jogbudha. The information was passed to the community, including farmers and teachers, so that everyone had access to the lifesaving information. The President of Pashuram Municipality Bhim Bahadur Saud expressed his happiness that the technology has helped save lives. Yadab Bogati, the volunteer near the sensor station stated that he could disseminate information to the communities and also receive phone calls from the WEC members.

The women from WEC were also engaged in disseminating the flood information. "We informed each household members not to go to the riverside, shared the information with their family members who are coming through the way from the district headquarter. Everyone was alert and able to save life" Janaki Singh, a member of Parigau WEC during a WEC meeting.

Datta Ram Panday, in charge of Illaka Police office Dadeldhura said that the flood data information of Rangoon Khola on the display board has helped a lot in mobilising the security forces as well as the communities to be on alert. Every year, there used to be 3 to 4 casualties in the Rangoon. The technology has helped to make us alert.

However, this system does not cover the total population of the Mahakali basin and the project has planned to strengthen the data compilation and dissemination mechanism in coordination with concerned stakeholders of Nepal and India.

5.2 Preparedness within Transboundary Community Based Early Warning System

Transboundary, multi-hazard, last mile connectivity is essential for an effective response to disasters and helps create harmony between communities. The following papers explores the successes of such EWS across different countries with the cooperation of communities and local and international organisations.

5.2.1 Trans-border Flood Early Warning on Early Warning System for Last Mile Connectivity to Enhance SFDRR Target-7

– Vandana Chauhan, AIDMI, India

Early warning has been recognised as an effective approach for reducing disaster risk and the loss of life. At the institutional level, there has been a paradigm shift from single hazard to multi-hazard early warning and from providing hazard information to providing risk and impact information.

Acknowledging the importance of early warning in reducing disaster risk, the Sendai Framework's Target 7 also calls to substantially increase the availability of, and access to, multi-hazard early warning systems and disaster risk information and assessments to the people.

A disaster adheres to no political boundary. Community to community trans-border early warning of floods between Nepal, India and Bangladesh will greatly benefit all these countries. How can this collaboration and cooperation reduce the loss of life and livelihood in Asia?

Below are some of the related challenges and needs.

- Community to community communication is expensive.
- Government to Government formal communication is a big challenge.
- Country to country coordination is lacking.
- Trans-border coordinated risk assessment is lacking.
- Data accuracy vs. accuracy in observation (Accuracy of weather observatories)
- Changing rainfall patterns is a challenge to provide forecast based early warning.
- People to people networking is required for better communication and coordination.
- People centred EWS is still to be worked out.
- Better use of satellite data is required to bring accuracy in the warning.

Leveraging indigenous knowledge and modern technology is a must. Preparedness is a continuous process and bringing community at the centre can only help in building community resilience, especially in the remote areas. We need more pilot projects, upscaling of pilots and wide scaling of upscaled pilots in Asia. This will also help protect investments in infrastructure and economy.

Great harmony has been seen among the transboundary communities. Such harmony should be utilised positively for building disaster resilience with active political support and facilitation. Saving lives is in everyone's interest. Inconvenient communication across borders – physical, political, scientific, digital and others – for early warning purposes is an overwhelming liability, as the impact including loss and damage by disasters is shared by all.

Community-based risk assessment at micro level reaching out to the most vulnerable communities and individuals through better EWS and last mile connectivity must now become a reality in Asia.



AIDMI's publication of Southasiadisasters.net on 'Asian Early Warning Systems' Launched at AMCDRR 2018 Side Event on Trans-border Flood Early Warning System for Last Mile Connectivity, July 4, 2018 at Ulaanbaatar, Mongolia.

5.2.2 The Success of Community-Based Transboundary Flood Early Warning Systems

– **Dr. Neera Shrestha Pradhan**, Senior Water and Adaptation Specialist, International Centre for Integrated Mountain Development (ICIMOD), Nepal, and **Sanjay Pandey**, Executive Director, Yuganter, Bihar, India

Many rivers and tributaries flowing from the mountains and hills of Nepal enter the plains of India forming flat, flood-prone, and partially waterlogged areas. Light to heavy rainfall in the Siwalik Hills of Nepal can cause flash floods and a huge loss of lives and livelihoods downstream. Though early warning systems have been developed at the global, regional, and national levels to provide flood information, there are gaps – identified by the Hyogo Protocol and the United Nations Forum Convention on Climate Change (UNFCCC) Special Report on Extreme Events and Disasters (SREX 2012) – in getting this information to communities that are most vulnerable. To address this challenge, the ICIMOD piloted a community-based flood early warning system (CBFEWS), involving both upstream and downstream communities, which have proved effective and has resulted in the Momentum for Change Lighthouse Activity Award honouring ICIMOD and SEE - the Kathmandu-based manufacturer of CBFEWS – in 2014 for their innovative use of information and communications technology.

The objective of a CBFEWS is to enable local communities to utilise local resources and capacities to prepare and respond to and enhance their resilience to flooding risk. This system is installed in river tributaries with high flood risk. The system consists of a transmitter unit, which is placed on the river bank (at a point to which the water level rises when a river floods) and a receiver unit, which is placed in a house in the nearest village (the house owner is the CBFEWS caretaker).



CBFEWS in the Ratu River

Ratu is a transboundary river that originates in the Siwalik Hills and flows to the northern extension of the Indo-Gangetic Plain. The transboundary nature of the river, shared by India and Nepal, provides an opportunity for cooperation between the two countries at the local level to inform vulnerable communities about flood risk and help them prepare for upcoming danger. A CBFEWS with telemetry is installed at Lalgarh in Bardibas, Mahottari District, Nepal and in Bhattamore, Sitamarhi District in Bihar, India, and jointly implemented by the local communities, partner organisations, and the respective government line agencies, with support from ICIMOD.

The telemetry-based early warning system provides early flood information to 6,685 households with a population of 35,804 in four villages in Mahottari District, Nepal and 12,500 households with a population of 59,600 in six villages in Sitamarhi District, India.

Cross Border Local Level Information Flow

On 31 July 2017, a stakeholders' consultation was conducted in Bardibas and Sarpallo, Nepal.

The consultation included a discussion on CBFEWS and its significance to downstream vulnerable communities. The level of commitment from local representatives of vulnerable communities, the caretaker from the upstream community, and representatives from district government offices and other organisations working in Ratu to support the implementation and sustainability of the system was encouraging.

The cross-border upstream-downstream interaction of the Ratu River in Sarpallo, Nepal and Bhattamore, India provided an opportunity for the caretakers in the two countries as well as representatives from local communities and partner organisations to exchange knowledge and information. Community members and caretakers in Bardibas and Sarpallo promised to support downstream vulnerable communities in Sitamarhi by sharing information, which will give them time to move to safer, higher ground with their belongings and livestock.

One of the women participants from Bhitamore, Patna, India, said, “We have family relations across the border in Nepal and we are excited to share knowledge and information which benefits both communities.”

This bond was further strengthened when the caretakers, representatives from local government line agencies, and vulnerable communities gathered at ICIMOD for a regional hands-on training on community-based flood EWS. During the training, participants from Afghanistan, India, Nepal, and Pakistan shared their experiences and built contacts and communication channels that are vital to the dissemination of early warning, while they gained hands-on experience in instrument installation and maintenance.

Sustainability Matters!

The sustainability of CBFEWS depends on community ownership and continued financial and technical support for the operation of the system. Taking this into consideration, ICIMOD has involved local government line agencies, local institutions, and community members in the conceptualisation, risk assessment, scoping, and installation of CBFEWS and their regular monitoring. A network of key informants has been established to share and disseminate early warning to relevant stakeholders. The long-term goal is to integrate this system with the annual district disaster management plans to ensure sustainability and ownership at the local level.

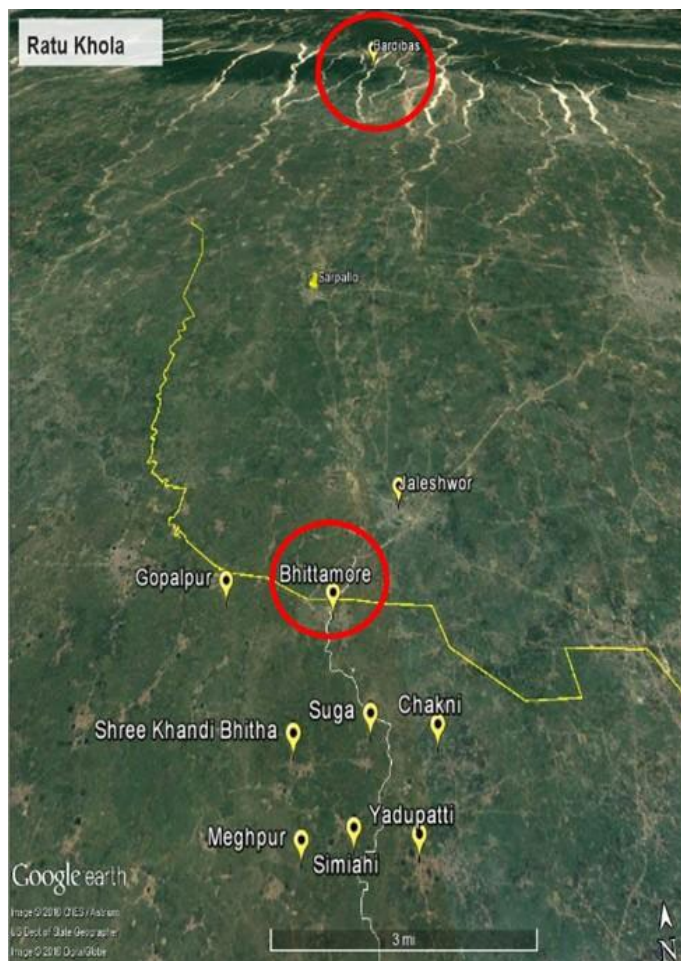


Figure 5.1: Ratu River in Nepal and India.

Does it work? – Evidence from the field

On 12 Aug 2017, floodwaters from the Ratu River reached Shrikhandi village in the Sitamarhi district of Bihar, India. The people residing in this Indo-Nepal border district were prepared. The EWS that was set up by ICIMOD-Yuganter-SEE in the Ratu River near Shrikhandi-Bhittha is different from the early warning system operated by the government.

Unlike previous years, when the flood waters gushed into their homes, this time the people had moved their cattle and other valuables to safe places. The women and children were prepared to move to safer places. The local administration of the Sursand block and Sitamarhi district had been warned about the impending floods. Thanks to the CBFEWS they had seven to eight hours of lead time to prepare for the coming flood. This was made possible because local communities and government line agencies were involved - from conceptualisation to implementation - in this initiative. In many ways, technology was given a ‘human face’.

Ranjeet Kumar Jha, CBFEWS caretaker at Shrikhandi village, had been keeping constant watch on the receiver that was telemetrically linked to the tower at the nearby Ratu River bank. He had been in constant contact with Rajkumar Mahato and Mahendra Karki, the caretakers of the systems at Sarpallo and Badribas in Ratu River, Nepal. Jha was not only able to inform his own village but also six other adjoining villages, giving them time to prepare and move. This is the beauty of a local-level, cross-border effort using a CBFEWS.

Today, Ranjeet Kumar is very proud to be a caretaker of the instrument, as his information was able to provide sufficient time to vulnerable communities to save themselves and their precious cattle and goods. Ranjeet, his fellow villagers, and communities living downstream who benefited from the early warning information have realised that information is power indeed. They hope that this system will be installed in other rivers and save more lives and livelihoods.

5.2.3 Community-based Early Warning System in India – Nepal

– **Ramesh Kumar**, Chairman, Ghoghardiha Prakhand Swarajya Vikas Sangh (GPSVS), Madhubani, Bihar, India

Early warning systems for floods comprise of four inter-related elements: **1) assessments and knowledge of flood risks in the area, 2) local hazard monitoring (forecasts) and warning service, 3) flood risk dissemination and communication service, and 4) community response capabilities.** As part of the warning, the system provides a prediction of the scale, timing, location and likely damages of the impending flood. The system uses data from sensors to measure water levels at strategic points in local water basins (Kamala River) to forecast a potential flood event. All stakeholders, including local communities, local and national government, international bodies, NGOs, the private sector and the scientific/technical community should be involved in the planning phase. Roles and responsibilities for system management and maintenance should be agreed upon, and necessary staff training should be completed prior to implementation. Implementation of each element:

At the community level, a Trans-boundary Flood Early Warning System has been formed with 9 Community Disaster Management Community members – 4 members from the India CDMC and 5 members from the Nepal CDMC. After formation of the Trans-boundary Citizen Forum (TBCF), they have visited 3 hydrology and meteorology departments in Nepal where the river has originated, and have made two visits to Ranibas, Nepal (where the Hydrology and Meteorological Department is located). TBCF members were able to establish a good relationship with the Nepal Hydrology and Meteorology Department, as result they were in regular contact. Ghoghardiha Prakhand Swarajya Vikas Sangh (GPSVS) and TBCF members continued coordinating with Nepal Hydrology and Meteorology Department. The Kamala River water level is updated by them. After receiving the data and information from the Nepal Side, the Indian TBCF members have shared the information within the Community Disaster Management Committee through mobile phone, letter and verbal communication. At the community level, information has been disseminated through the installation of a water level board (including proper sign and maintain of danger and warning level).

How the Early Warning System was Implemented during the Flood 2019

- During the monsoonal season, India TBCF members and CDMC members regularly coordinated with Nepal TBCF and were in direct contact with Ranibas.
- On 12th July 2019, in the early morning 9.46 AM TBCF members' Sri Chandeshwar Suman received a message from Ranibas that the Kamla River water level has reached 4 Mt and 15 cm which can lead to much danger in India - especially in the Jaynagar block. Chandeshwar Suman directly contacted Sita Achariya at Rabibas through mobile.
- Subsequently, TBCF shared the information at community and Local Government Administration level. TBCF members Sri Chandeshwar Suman and Sukhendra Prashad also informed the SDO, Jaynagar by official letter.
- TBCF members also disseminated the water level information with the all CDMC members via mobile, who in turn shared the information with the community.



5.3 Early Warning Systems and Air Pollution

With air pollution being one of the newer disasters being faced, countries are implementing systems to help warn the public of worsening air quality and deal appropriately with the challenges this presents. The following papers highlight the gaps that need to be considered in these prevailing systems while also providing an example of measures a country can take to respond to air pollution.

5.3.1 Early Warning Systems for Poor Air Quality: Are Poor Included in Warning?

– **Wei Shen**, Research Fellow, Institute of Development Studies, Brighton, UK

According to the World Health Organisation (WHO), ambient (urban) air pollution represents the biggest environmental risk to health, causing around 3 million deaths each year. In addition, there is a significant geographical difference regarding the exposure to air pollution, as citizens in Africa, Asia or the Middle East breathe much higher levels of air pollutants than those living in other parts of the world. One of the key instruments to reduce the health impacts of air pollution is to introduce an EWS, and many developed and developing countries around the world have such a system in place or are considering implementing one. However, the key question is, would low-income communities, which are the most exposed group in cities benefit from such a system.

It is increasingly clear that air pollution affects the poor in particular, who often have to work outdoors and lack proper means of protection. At the outset, effective protection is costly, such as high-quality face masks or indoor air purifiers. Apart from the affordability issue, there is a notable knowledge and awareness gap among the low-income communities as many are not aware of the deadly effects of toxic air and means of correct protection. Lastly, there is the issue of immobility, as poor people will have a harder time in moving away from working and living in areas with high levels of air pollution, than their wealthy counterparts. However, these affordability, knowledge, and mobility inequalities associated with urban air pollution are often neglected when designing and implementing warning system.

Most EWS contain a hierarchy of categories for different levels of air pollutions (either for PM2.5 or PM10 only, or a more comprehensive index of pollutants). If air quality reaches high risk categories, prescriptions such as reducing outdoor activities or taking precautionary actions are given to most susceptible groups of people such as the elderly, children, or people with certain health symptoms (mostly heart, lung and asthma problems). However, there is rarely any specific recommendation for those who have to work outdoors during the heavy pollution days, who face disproportional health risks as explained. There is a need for more specific instructions for people working outdoors regarding the urgency and proper protection via different communication channels.

Relatedly, in the event of extreme pollution scenario, some countries' warning systems often include protocols such as closing the schools to protect children, shutting down polluting factories, or reducing air or urban transportation as preventive procedures. However, no specific protocols are found to prevent the outdoor working class from being excessively exposed. Similarly, there is no request for employers to move their workers into safer environment or provide proper protection even when air quality reach high categories. Thus, there is a pressing need for coordination between environmental and labour rights regulators to reduce the health damage to the low-income communities.

Lastly, although forecast warnings are important for people to plan their (outdoor) activities sensibly, real-time monitoring and reporting systems can be also crucial for people inevitably being exposed to the air pollution. At present, only advanced countries like UK and Japan have combined the monitoring and forecasting system that aim to guide people's long-term and immediate reaction towards air pollution.

In general, it is clear that the ultimate purpose for a warning system for air pollution is protecting the citizens' health, and all the measures and protocols need to be designed to serve this purpose. Since different groups have different exposure levels and protective capabilities, economically and socially disadvantaged groups deserve more attention in designing and implementing such a system.



5.3.2 Early Warning System for Air Pollution in Chinese Cities: A View

– **Liuyang HE**, International Master of Environmental Policy Program (IMEP),
Duke Kunshan University, Kunshan, Jiangsu, China

In 2013, *the State Council issued the Action Plan for Air Pollution Prevention and Control*, calling for “establishing a monitoring, early warning and emergency response system for heavy polluted weather”, and including heavy pollution weather into the emergency response management system. In the same year, the Ministry of Environmental Protection (now the Ministry of Ecology and Environment) formulated normative documents to provide requirements and guidance for the formulation of emergency plans for heavy air pollution in cities nationwide. By the end of 2014, 20 out of 34 provinces (autonomous regions, municipalities) and nearly two-thirds of prefecture-level cities have prepared emergency plans for heavy pollution. The three key regions, Beijing-Tianjin-Hebei, Yangtze River Delta, and Pearl River Delta, have established the air quality early warning centre and publicly release air quality information, which covers 48-hour air quality trend, urban air quality index, air quality level, primary pollutants, impact on human health, and suggested countermeasures, etc. (Chen, 2016; Wang, 2018). In this article, the author selected three representative cases of the early warning system for air pollution – two major cities and one urban agglomeration – to generally show the recent progress in Chinese air pollution control.

Beijing municipal government rated air pollution into four warning levels with severity from the least to the most: level 4 (code blue), predicting heavy pollution in the next day; level 3 (code yellow), predicting serious pollution in the next day; level 2 (code orange), predicting heavy and serious pollution in alternation for three days; and level 1 (code red), predicting serious pollution for three days. When the orange alert is released, Beijing will stop earthwork and the demolition of buildings, and citywide fireworks and outdoor barbecues will be strictly prohibited. Besides these measures, Beijing will adopt odd-even license plate rule (OELPR), forbid dust-raising transport vehicles, and stop additional 30% official vehicles based on the OELPR when the red alert is issued. Kindergartens, primary and secondary schools will also be suspended.

Tianjin adopts three-level heavy pollution warning system: level III, predicting heavy pollution ($200 < AQI < 300$) for 72 hours; level II, predicting serious pollution ($300 < AQI < 500$) for 72 hours; and level I, predicting extremely polluted weather ($AQI > 500$) in 24 hours. Such rating is also adopted by Hebei province. During the heavily pollution events Tianjin government will order primary and secondary schools to stop outdoor activities and halt building demolition work. In addition, the city management department will increase the frequency of main road cleaning to more than twice per day.

Pearl River Delta region divided atmospheric heavy pollution into two levels: heavy pollution when AQI is more than 201 and less than 300; and serious pollution when AQI exceeds 300. Regional heavy/serious pollution is defined when heavy/serious pollution simultaneously happens in no less than three cities. When regional heavy pollution occurs and unfavourable meteorological conditions are forecasted over the next 48 hours, the regional level II warning will be initiated. When regional serious pollution occurs forecasted for the next 48 hours, the regional level I warning will be initiated. In response to the level II pollution warning, major media in the region will issue health protection warnings to remind children, the elderly and susceptible groups to stay indoors, and advocate people to use public transport. When the regional response is upgraded to Level II, coal-fired enterprises are required to implement phased rotation to limit power generation and to use high-quality coal reserved for emergency. All coal boilers that have not completed the treatment task within deadline are ordered to stop production. Meanwhile, transportation department will guide transit vehicles to bypass the area (Shi, 2013).

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5.4 Disaster Management and Early Warning in Sri Lanka

The involvement of stakeholders within different stages of the EWS are part of a governance framework that should be incorporated into disaster management; mapping out the roles and responsibilities of technical agencies, disaster management authorities, line departments, local governments, volunteers/CSOs, private telecom and media actors, basin-level and regional coordination platforms. This section of the report provides an overview of Sri Lanka's disaster management framework, mapping out the different tiers and organisations and CSOs involved. The papers also provide cases where the role of volunteers and NGOs in community based EWS have been harnessed to respond effectively to disasters and help mitigate their impacts.

5.4.1 The Role of Volunteers

– **Loy Rego and N.M.S.I. Arambepola**, Technical Advisor, Project Office: Sri Lanka

The cyclone of 1978, floods of 2003 and the Tsunami in 2004 triggered the re-organisation of National early warning and disaster management - saving lives, reducing trauma; instilling public confidence.

The Disaster Management Act, 2005 created the National Council for Disaster Management, a separate Ministry and the Disaster Management Centre (DMC); and consolidated the Meteorology Department (MD), National Building Research Organisation (NBRO) and National Disaster Relief Services Centre (NDRSC).

Disaster Management Centre (DMC)¹¹⁸ provides hazard/risk information; coordinates early warning by mandated agencies, implements Emergency Operations (EO), relief, response, preparedness and mitigation programmes; enhances community understanding of risks and resilience.

DMC works with other Ministry agencies, collaborates with other Ministries, Line Departments, Provincial Councils, Agencies, Authorities at district, division, Grama Niladhari levels, army, police, and international/national government organisations managing early warning and disaster management.

Meteorological Department (MD)¹¹⁹ established in 1850 with 14 principal meteorological and 50 rain-gauge stations – records rainfall, temperature, wind and clouds; delivers meteorological/climatological services; early warning on meteorological hazards/tsunamis; and climate change work.

National Building Research Organisation (NBRO)¹²⁰ does landslide hazard zonation/risk mapping/investigation/mitigation; building construction control/technical aspects; monitors 150 automated rain gauges and provides landslide early warning coordination with the DMC.

National Disaster Relief Services Centre (NDRSC)¹²¹ established in 1996 under the Social Services and Welfare Ministry, functions under the Disaster Management Ministry since 2010, strengthening national disaster relief capacities, conducting programmes through District/Divisional Secretariats, and assisting District DR Coordinators to provide relief and immediate recovery assistance.

Forecasting/issuing early warning alerts: Role of technical institutions, DMC and National Emergency Operations Center (NEOC)

The Government of Sri Lanka's institutions analyse impending disasters and issue early warnings within their expertise: Department of Meteorology (tropical cyclones/tsunamis), Irrigation Department (river floods), NBRO (landslides), coordinating regional and international warning centres. Available within the country's disaster management space are national hazard profiles for tropical cyclones, storm surges, tsunami, floods in four basins, droughts, landslides, lightning, sea level rise, (www.hazard.lk), water inundation by dam failure; LIDAR data for Coastal Areas with the Urban Development Authority (Colombo), Survey Department; Central Environment Authority - Environment Impact Assessments (www.isea.lk).

118 Disaster Management Centre. <http://www.dmc.gov.lk/>

119 Department of Meteorology Sri Lanka. <http://www.meteo.gov.lk/>

120 National Building Research Institute. <http://www.nbro.gov.lk/>

121 National Disaster Relief Services Centre. <http://www.ndrsc.gov.lk>

DMC's National Emergency Operations Centre and Early Warning Division coordinate with national committees/agencies up to local level with response agencies 24 hours; informs responsible offices for last mile community dissemination; establishes multi-level Emergency Response (ER) Committees, prepares National EO Plans (NEOP) for 23 disasters covering 29 agencies and multiple level standard operating procedures; verifies information from local/international agencies; operates early warning towers, disseminates equipment and information to remote vulnerable communities, communication (telephones, radio) from technical agencies to Provincial/District Control Rooms goes directly/through EOC, issues warnings, ensures redundancy when main systems breakdown; coordinates SAR operations/evacuation missions with Military/Coastguard/Police; coordinates immediate relief/medical support, NGOs/ INGOs/ stakeholders in communities, donors to strengthen early warning capacity; provides situation reports at 0900/1200/1800hrs intervals, disseminates media/press briefings and updates.

The Nationwide Emergency Communication System informs communities on impending natural hazards; floods from dam/reservoir breach, rapid opening of sluice gates; inundated areas, road closure, impassable bridges; evacuation routes and safe areas. Indian Ocean Tsunami Warning System (IOTWS) sends warnings to DMC and Meteorological Department.

Levels of government and administration: roles in EWS, Hazard, Vulnerability, Risk Assessment (HVRA), preparedness, response and community-based disaster risk management (CBDRM)

Disaster management is done by National Government Ministries, Line Departments and all levels: Provincial Councils, District, Division, Local Authorities, Gram Niladhari Administration (PDDLGN). The National Disaster Management Plan's (NDMP) Chapter 2.3 recommends decentralised disaster management and strengthened PDDLGN mandates.

Early warning from national to PDDLGN levels and identified locations is through police, military, satellite and radio communication (HF/VHF), cell broadcast/SMS, multi-hazard Early Warning Towers, CDMA/GSM/fax/normal telephone systems and media. Last mile dissemination to village communities includes police vehicle/Public Address announcements, sirens, NGOs/ CBOs, the Sri Lanka Red Cross, traditional/religious methods and early warning committees moving door to door. NDMP's Chapter 4 covers early warning agency coordination (international to local), technical institutions, and EWS for forecasting/issuing alerts.

The DMC coordinates DPRP at PDDLGN levels; health authorities on preparedness and hospital emergency response; and Ministry of Education for school preparedness.

Authorities support communities by forming DM committees, raising HVRA awareness, preparing village safe locations on routes, conducting mock drills, distributing early warning megaphones and emergency response equipment for village use.

The Comprehensive DM Programme 2014 -2018, a GoSL-UNDP partnership, has eight components, two on risk knowledge; HVRA, early warning dissemination.

The historical and spatial database www.desinventar.lk, has nine hazard profiles with high-risk areas receiving investments on risk reduction, land use policy and construction guidelines, and insurance expansion.

Improvements to hydromet early warning at Department of Meteorology (DoM), Irrigation/ Agriculture Departments and NBRO, by installing new rain gauges, strengthening riverine flood early warning, real time water level monitoring of large reservoirs/tanks and information sharing; minimising drought impacts by timely crop selection, farming extent, balancing water use and improving decision support in landslide areas.

The Sri Lanka Preparedness Partnership coordinated by the DMC, Asian Disaster Preparedness Center (ADPC) and BM Gates Foundation strengthens Emergency Response capacity of local humanitarian actors, developed several district level platforms of government agencies, local NGOs and the private sector to improve early warning dissemination, preparedness and response.

The Government revitalised CBDRM work in "DiviNeguma", "GamaNeguma" and "PuraNeguma" programmes through village committees, participatory planning, hazard profiles (www.hazard.lk); infrastructure rehabilitation, disaster resilient building guidelines; strengthened village investments and plans, engagement of agencies in agriculture, climate change, forestry, wildlife

conservation and water resources and improved agency coordination supported by Sri Lanka Red Cross, OXFAM, INGOs, Janathakshan, LSSP, UNDP, UNHABITAT and others.

Volunteerism in Sri Lanka

Sri Lanka has a long, rich cultural history and social infusion of volunteerism, largely labour donation 'Shramdhana' and promoting traditional knowledge. Diverse in-country ethno-religious traditions have many forms of volunteerism which generates well-being for people and communities and have values of solidarity, reciprocity, mutual trust and empowerment firmly embedded.

EWS is a public good, undersupplied by the market, whose responsibility falls on the Government who protects its citizens. The cost of a nationwide EWS lessens when other stakeholders contribute to its maintenance and management. Sri Lanka adopted an 'all-hazards' approach – hazard detection by subject expert entities, EWS and Common Alerting Protocol covering all hazards. This government-led multi-agency, multi-level hybrid solution, with complementary advantages of private sector (PS), civil society (CS) grassroots infrastructure for early warning dissemination, and volunteer role in delivering early warning and adequate community oversight initiatives, works well.

One example is Peralya's Community Tsunami Early Warning Centre (CTEC), on Sri Lanka's southwest coast, a site where a train toppled killing more than 2,000 villagers. CTEC covers five villages through its public address system and extends services to Galle District through its volunteer Community Focal Point (CFP) network, trained in emergency skills, basic life support, first aid and firefighting. The CTEC community contingency plan runs community-awareness on emergency preparedness, installs tsunami signs and identifies evacuation areas. It is managed by a local volunteer force in Peraliya, with support from interested stakeholders.

Other examples of promoting voluntary action and building a network are by Universities of Peradeniya/Colombo, and in Western, Central and Eastern Provinces, collaboration with British Council, V-Force and UN Volunteers.

Improved co-ordination between banks, industries and businesses, especially Small/ Medium Industries, requires interventions by Central Bank and the Treasury. Ceylon Chamber of Commerce in Colombo, Regional Chamber Offices, and other banks promote business partnerships on preparedness and risk reduction measures.

Work of volunteers in Sri Lanka Red Cross Society (SLRCS) in disaster management

SLRCS, established in 1936, has 100,000 members and volunteers throughout the island as its backbone, with over 6,500 active volunteers, assisting vulnerable people in need, and branches running successful programmes.

SLRCS mobilises staff and volunteers to carry out decentralised disaster management, improve community resilience, maintain organisational response readiness, and strengthen early warnings, recovery and livelihood development. Its national Disaster Relief Emergency Fund (DREF), regional warehouses and standard buffer stocks are used during responses. After the tsunami in 2004, it implemented CBDRM in 14 districts, reaching 285 communities and 289 schools covering 161,869 families. It also ran EW programmes in 3 districts with support from its volunteer movement, established training infrastructure and built a resource of skilled staff and volunteers. SLRCS now has over 100 trainers and multi-level disaster response teams at national, branch, divisional and community levels and a national emergency control room at its headquarters.

SLRCS collaborates with Government, DMC and other stakeholders and is a member of the NDMC with a role in "Towards a Safer Sri Lanka" – DRM Road Map.

SLRCS President Abeyasinghe appreciates the 15,000 SLRCS volunteers who "support efforts to prevent conflicts, help recover from disaster, promote development, assist in crisis and carry out numerous projects. A child wounded from floods receives drinking water, a hungry family in a temporary shelter receives warm clothes and food, a father finds his child after a devastating landslide - thanks to volunteers who give time, skills and resources for other's needs. Volunteers safeguard community's values and help people out of poverty. The humane impulse to empower others that motivates volunteers rebounds back in an enriched life, earning personal fulfilment at making a difference."

SLRC Galle Branch is the leading humanitarian service provider in Galle District and understands the importance of being self-sustaining, rather than depending on donor funding or National Headquarter's support. Galle was badly affected in the 2017 floods in Southern Sri Lanka. Within 48 hrs, SLRCS branches began distributing dry rations and non-food relief items to affected communities to help them to continue living in dignity. Together with the Galle District Secretariat and DMC, SLRC undertook Search and Rescue, First Aid and Sanitation Services, relief distribution, well clearing, drainage and latrine cleaning in affected areas. Many branches have similar initiatives.

Two crucial components within this disaster management framework are the volunteers and technology, two examples of which are provided below.

5.4.2 Role of Sarvodaya and Shanthi Sena in Disaster Early Warning System in Sri Lanka

- **Ravindra Kandage**, Vice President, Sarvodaya; Executive Director, Shanthi Sena; Global Trustee, URI; Sri Lanka

Sri Lanka is prone to both disasters induced by natural hazards and human-induced disasters and in these serious disastrous situations, Sarvodaya Mother Organization and Sarvodaya Shanthi Sena Movement promotes community-based disaster management. Sarvodaya Disaster Management Center was officially established in 2005 after the 2004 tsunami, and works under the supervision of Sarvodaya Mother Organization. When the government sends out alerts of upcoming disasters, the Sarvodaya Disaster Management team sends quick messages to their district centres to alert the villages. Sarvodaya Disaster Management Center supported by Standard Operating Procedure (SOP) has a fully equipped Emergency Operation Center (EOC) which is updated with real time data links and operated with a roster of trained professional 24x7. This center also has a Disaster Response Resource Pool with an ambulance, motor boat, modified pickup truck, generators, water pumps, chain-saws, first aid kits and rescue equipment.

Under collaborations and partnerships, Sarvodaya Disaster Management Center works very closely with the United Nation, National Disaster Management Center (NDMC), DoM, National Building Research Organization, the tri-forces of Sri Lanka, Sri Lanka Red Cross, St. John Ambulance Service and a range of research and technical organisations such as LIRNEasia, CIDA, and JICA. All these collaborations and partnerships has widened Sarvodaya's disaster management knowledge-base while also facilitating the training of thousands of volunteers across Sri Lanka in disaster response, first-aid, fire-safety, deep-sea rescue and camp management, etc.



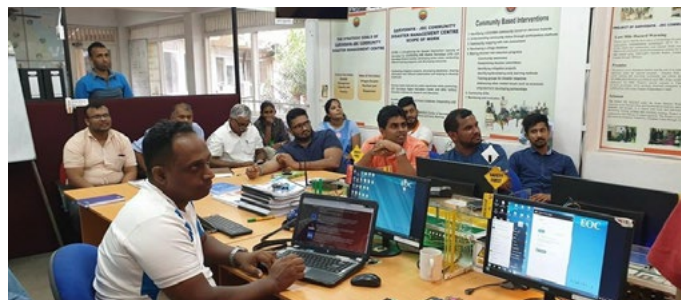
Following the Early Warning Map created by the government, our Disaster Management Center advises the villagers on how to prevent a disaster and how to safeguard themselves during a disaster. There is a Disaster Protection Shelter in each district with necessary equipment, including boats, cooking items, medicine and dry rations. The communities are advised by Sarvodaya Village Committees on what to take with them during a disaster and find their way to the closest Disaster Protection Shelter.

In each district, there are Emergency Aid Groups consisting of members from the Shanthi Sena Youth Leaders' Circle. These youth leaders at village and DS levels are well-trained by Sarvodaya Shanthi Sena Movement under 4 basic concepts and steps. They are:

1. Disaster Early Prevention Activities
2. Evacuation Plan
3. Safeguarding Affected Communities
4. Rehabilitation of People and Rebuilding of Communities

With the gained knowledge, these youth leaders educate their communities to protect nature to reduce the occurrence of natural hazard induced disasters, including holding Art and Essay competitions for school children on these themes.

The holistic approach of 5R in disaster response is practiced by our Disaster Management Center promoting the ethics of Relief, Rehabilitation, Reconstruction, Reconciliation and Reawakening in disaster response. Moreover, our Disaster Management Center is in discussions with the World Bank to create a Mobile App to report and response to disasters. This App will be operated in local languages so that the rural village communities will also have the access to necessary information to protect their lives from, during and after a disaster.



Sarvodaya Disaster Management Center, Sri Lanka.

5.4.3 Role of Rainwater Harvesting in Early Warning System of Floods and Droughts in Sri Lanka

– **Dr. Tanuja Ariyananda**, CEO, Lanka Rain Water Harvesting Forum, Pelawatta, Battaramulla, Sri Lanka

As disaster impacts are often manifested through floods or drought, water management plays an important role in building resilience in communities. Recent climate change prediction studies have indicated that Sri Lanka will experience high variability of rainfall, making it very difficult to accurately predict natural hazards like drought, floods and landslides.

Therefore, a simple solution in this case is to adopt rainwater harvesting to increase the retention of water that is received during the rainy periods to be used during the non-rainy periods. Over the last 25 years this traditional rainwater harvesting technology has been revived bringing much relief to households during times of drought, tsunami, Chronic Kidney Disease of unknown aetiology and resettlement for many people living in rural areas of Sri Lanka.

Lanka Rain Water Harvesting Forum (LRWHF), recognising its importance has established demonstration rainwater harvesting systems and weather stations in remote schools in 8 districts of Sri Lanka with the support of USAID and World Vision Lanka. The roof water harvesting system consist of a 30,000 liter ferrocement tank, first flush system and filter. During the droughts experienced between 2017-2018, the schools which had rainwater collected and stored were better off since they had readily available water at the school premises. In December 2018 during floods in Kilinochchi district, when the surface water sources and well water were contaminated, the only clean water source that was available to the community was in the rainwater harvesting tank in schools which functions as flood shelters provides water to the people until the government aid reaches them.

Low cost solar powered mobile weather stations provide weather data such as temperature, rainfall, wind direction, wind speed, pressure and humidity. This data which plays an important role in the daily lives and livelihoods of rural community members is communicated to the community through SMS enabling them to be better prepared for natural hazards and related crisis situations. This data can also be used for decision-making in regular water resource management and other climate related application. For example, in the event of heavy rains automated SMS would alert those in areas prone to landslide or irrigation officers in charge of reservoirs to prepare for intense flows of water into the reservoir system thereby prevent floods. This collected data fed into an Wunder Ground website (<https://www.wunderground.com/>) which gives 10-day weather prediction.

The weather stations are established in schools to build awareness among school children about weather and weather changes due to climate change issues. LRWHF has trained school children on how to operate and maintain them, and the weather data is shared with all students and teachers in the school through the display boards provided. These weather stations make it possible for schools to better manage the water in the rainwater harvesting tank by knowing about the rainfall patterns in the area. It will also bring about awareness on climate change issues among school children in order to be better prepared.



RWH system and weather station at Badulla School.

5.5 Early Warning Systems and the Private Sector

The private sector can be a powerful ally in disaster management, providing technology and expertise for disaster prevention and preparedness, as well as financial backing for relief and reconstruction efforts. Legislature and awareness raising in these aspects are key in building the framework for this sort of collaboration.

5.5.1 Role of Private Sector in Early Warning Systems in Myanmar

– **Katie Balmer**, Public Relations, COROBOR Systems and Campbell Scientific Europe, France

In recent years, Myanmar has felt the devastating effects of disasters induced by natural hazards – placing it as the 12th most disaster-prone country in 2018.¹²² The tsunami in 2004, the catastrophic cyclones of 2006 and 2008 and regular small-scale hazards have had severe economic and social costs. The country highest levels of displacement is associated with disasters. Death ratios and livelihood losses have been large, affecting over 4.5 million inhabitants and causing nearly USD 6 million in damages.

Climate change is now permanently impacting the seasons. Notably, the country is experiencing late and low rainfalls with increased temperatures. Where agriculture and fishing account for 38% of the GDP and employ 70% of the working population, weather conditions are vital for personal and professional security. Yet with these changing weather patterns and extreme weather events, the national response capacity has been overwhelmed. Food production, income and human safety has suffered as a consequence.

We often associate disaster mitigation with the responsibility of the government and non-profit organisations who prepare disaster response relief. Given the scale of the challenge, the private sector has had an increasing role – particularly in disaster prevention and preparedness. Private sector companies are contributing by developing disruptive technologies to improve early warning capabilities. For Myanmar, innovative technologies were needed to increase foresight and alert communities ahead of time.

In 2017, UNOPS launched a project to build Myanmar's resilience by improving Early Warning capabilities. COROBOR Systems, a French software company, provided a single solution to supply low-tech, sustainable warnings for experts and the public. The system links weather stations network and centralizes the data, providing experts with the means to make accurate forecasts for current and future conditions. Communication systems have been introduced to alert the public and contribute to risk informed decision-making for farmers and fishermen. The Early Warning communications are designed to be easy-to-read and easily accessible. In Myanmar, this was achieved with a dashboard containing a colour scale system: red (high risk) to green (low risk). If the threat is high, an alert is triggered and a warning is delivered. In a country where wired internet connectivity is not developed, but mobile data is common – the information is sent through the simplest format: SMS notification or via an online platform.

With access to weather information and timely warnings, those likely to be most affected can adopt strategies to help reduce the potential impact i.e., herd migration, change fishing location. This adaptation is leading to improved income and food security. Importantly, the clear, streamlined warnings also prevent working in unsafe environments and consequential loss of life.

Myanmar is an example of what is happening worldwide and what can happen to improve the situation with the help of the private sector working in collaboration with governments and other agencies. In many Less Developed Countries and Small Island Developing States, vulnerable communities are at risk to the impacts of climate change and their main sectors depend directly on climatic conditions. There is a pressing need for innovative technologies and strategies to reduce these risks. This can be achieved with access to information, streamlined warnings and decision-support tools. With the contribution of the private sector alongside co-operation with governments and agencies, projects such as these will foster economic development, help break the poverty cycle and save lives around the world.

¹²² Publications Office of the European Union, INFORM Global Risk Index Results 2018 (2017) pg.32 <http://www.inform-index.org/Portals/0/InfoRM/2018/INFORM%20Annual%20Report%202018%20Web%20Spreads%20v2.pdf?ver=2017-12-20-141446-540>

The above narratives demonstrate clear improvements in response capabilities throughout South Asia. Cross-regional platforms and partnerships to bring together knowledge and expertise should be prioritised. This will help achieve effective response capabilities at a community, national and regional level. The legislature required for these sorts of collaborations and cooperation often come in the form of bi-lateral agreements as well as legislature within the country that encourages it. India's 2013 Companies Act is an example of a legislature enacted to facilitate such collaborations



RWH system and weather station at Badulla School.

5.5.2 Early Warning System for Disaster Risk Reduction: Any Role for Corporate Social Responsibility (CSR)?

– **Dr. Nandini Deo**, Associate Professor, Department of Political Science, Lehigh University, Bethlehem PA, USA

The 2013 Companies Act in India is one of the recent provisions requiring companies to join public sector firms in annual donations under Corporate Social Responsibility (CSR). All firms with a net worth above INR 500 crores, turnover over INR 1,000 crore, or net profit over INR 5 crores are required under Section 135 to spend at least 2% of their annual profits (averaged over 3 years), failing which the money is to be held in an escrow account until it is allocated. The law requires that all businesses affected establish a CSR committee to oversee the spending.

The government has encouraged corporates to work with implementing partners, resulting in an increase in the number of NGO-corporate partnerships. Corporates are especially cautious about where their money is going and require partners to undergo screening processes, having strict demands when it comes to monitoring and assessing CSR projects. The main qualities corporates tend to look for in partners are capability, resources, and knowledge. With outputs rather than outcomes being a focus, initiatives where outputs can be easily quantified are preferred – often in the sectors of health and education. Thus, to obtain corporate support for long term and more complicated interventions is harder. The geographical spread of CSR projects also tends to be limited with corporates often targeting surrounding communities in areas where they operate, leading to a geographical imbalance in investments.

Potential for Collaboration in Disaster Risk Reduction:

- Corporates do like to support technology driven investments as a solution to social problems. The acute needs created by disasters induced by natural hazards offer corporates a compelling context to provide relief.
- The challenge is to educate corporates about the need for disaster risk reduction (DRR) interventions that go beyond immediate relief in the midst of crisis. If disasters are actually the result of political arrangements that fail to adequately plan for weather and seismic events, interventions must occur months and even years prior to a crisis. Professionals working in the field of DRR have to educate CSR executives about what causes a disaster, how it can be prevented, and how they can step in to help create the social and physical infrastructure that is needed.
- If that can be done, it is certainly possible that companies that already have relief operations in vulnerable areas will become part of the long-term solution.

5.6 Extreme Climate Events and Early Warning System: A Humanitarian View

– Dr. Andrew J. Cunningham, Humanitarian Researcher and Analyst, London, United Kingdom

Many aspects of humanitarian assistance are continuously debated, such as the role of humanitarian principles, the part States play in the provision of aid, and the importance of protection activities in aid operations. One relatively new point of contention has been climate change – or climate emergency as it may be called – and its impact on the provision of humanitarian assistance.

Although there remain some political voices that deny the changes in climate that are obvious to anyone paying attention, there are two points which are fully acknowledged by most: Extreme climate events will happen more often and there is a need for better EWS so that we may all be better prepared to respond to them. However, this view is not yet integral to humanitarian action and the planning of humanitarian organisations. Humanitarians must update their views and get on board, we must professionalise and use what is already out there to do a better job.

There are five points that humanitarian organisations should take into account to rectify this paucity of targeted action:

1. Integrate scenarios into planning. Integral to this will be the need to take into account EWS. Scenario planning is not very useful if there is no alarm mechanism in place to trigger action.
2. Raise awareness about the people suffering from extreme climate events. The role of humanitarian organisations is to respond to the needs of vulnerable people and organisations must know intimately what those needs are in order to understand how to respond effectively.
3. Include climate change impact into programming. Once scenarios are put on paper, EWS are put into place, and the needs of the relevant populations understood, there must be in place a set of available program responses to actually take effective action.
4. Build resilience of communities. Humanitarian organisations can only do so much, and humanitarian assistance is by definition short-term—communities must also take an active part in preparing for extreme climate events and also be integrated into EWS.
5. Engage in debates on the climate emergency. As mentioned above, the humanitarian sector has a long way to go in fully integrating the response to the increasing number of extreme climate events into normal ways of operating and the issue needs to be kept alive in discussions and debates in the sector.



The Rohingya mega camp, Cox's Bazar, Bangladesh.

It should be stressed that humanitarian organisations do not work in isolation – we should all stop working in silos. Humanitarians should not reinvent the wheel – there is a lot of data available and systems to use that have been developed by others. These initiatives should be integrated into humanitarian action and bridges built between the planetary health and climate science professionals and humanitarian actors. We all have a lot to learn from each other.

A lot of what will be happen in our changing world and environment will be unpredictable and of increasing intensity – we must all be prepared to respond effectively, and this includes humanitarians. There is still a lot of debate about this within humanitarian organisations, but time can't be lost and we need to move from discussion to action as quickly as possible.

5.7 Key Conclusions on Preparedness and Response Capabilities

This section draws from peer reviews and contributions from:

- **Mandira Singh Shrestha**, Programme Coordinator – HYCOS Initiative, River Basin Management, International Centre of Integrated Mountain Development, Nepal
- **Rajan Subedi**, Team Leader, Trans-boundary Rivers of South Asia (TROSAs), Oxfam, Nepal
- **Katie Balmer**, Public Relations, COROBOR Systems and Campbell Scientific Europe, France
- **Arvind Kumar Sinha**, Senior Programme Manager- Partnerships, Kabul, Afghanistan
- **Professor Dr. Ahmad Kamruzzaman Majumder**, Director, Center for Atmospheric Pollution Studies (CAPS) and Chairman, Department of Environmental Science, Stamford University Bangladesh

The increasing trend of disasters has become more complex in Asia Pacific hotspots like South Asia transboundary river basins, Pacific Ring of Fire and Small Island Developing States (SIDS). Hazards are deviating from their usual tracks and becoming more intense, creating greater complexity and deep uncertainty that are harder to predict (Asia Pacific Disaster Report, 2019). Looking at the frequency of disasters in South Asia, information about the possible risks to the community is the most basic requirement for the resilient communities which is only possible through Early Warning System.

Following the need to generate information about the risks, currently, there are ample opportunities to strengthen EWS in South Asia. The Asian Ministerial Conference on DRR (AMCDRR) 2016 and 2018, which is a localised document of Sendai Framework for Disaster Risk Reduction (SFDRR), emphasises the need for EWS in South Asia through collaboration and partnership at the global and regional level. The regional initiatives like Climate Risk and Early Warning Systems (CREWS) and the Regional Integrated Multi-hazard Early Warning System (RIMES) are supporting to improve the early warning systems in South Asia. The CREWS initiatives aimed that all least developed countries are expected to have weather stations, radar facilities, and at least moderate EWSs and risk information capacities by 2020. RIMES initiatives allow its 30 Member States to gather information at much lower costs than individual EWSs, particularly for high-impact, low-frequency hazards and offers decision support tools including risk assessment, interpretation and translates early warning information into impact outlooks and response options. In addition to the regional initiatives, each country of South Asia has prioritised the EWS system in its national disaster pre-preparedness plan and rolled out at the national and community levels.

Despite several initiatives, the weak EWS institutions, lack of holistic approach for the data generation, lengthy process of data exchange, the weak process of data sharing mechanism within the country and inadequate investment in the EWS are some major challenges existing in South Asia. Moreover, the shared river basins are managed based on their national interests and there are bilateral agreements which serves the limited regional cooperation and are unable go beyond two national interests. (Subedi)

While there are many EWSs in South Asia there remain gaps in reaching communities, especially the last mile, with socially sensitive and responsive information. Limited communication tools,

lack of education, training and awareness and limited risk assessments hinders effective response to early warning (Shrestha).

Alerts should be tied in with community preparedness work to ensure that communities respond effectively. Authors in this chapter have highlighted the plight of the marginalised within the disaster response structure, with challenges including not receiving adequate/timely disaster warnings and assistance, and feeling isolated during a disaster. Oxfam India's work with Odisha reflects how systems on the ground can help include marginalised groups, such as women, in the disaster response process to build a more effective and equitable EWS, through the use of Volunteer Network Management System and the incorporation of self-help groups.

Disaster risk reduction policies and plans at the national level exist however the challenge is to translate those plans to have disaster management plans at the local level. Further these plans should not be in isolation but needs to be integrated into the development planning process for it to be implemented. There are also challenges in reaching the most vulnerable for which the early warning provided has to be not only accurate and timely but also socially sensitive and/or responsive for reaching the last mile. Despite having EWS there seems to be a gap in the last mile connectivity. Limited communication tools, lack of education, training and awareness and limited risk assessments hinders effective response to early warning. (Shrestha)

An example of a legislative framework that supports early warning and community preparedness is that of Sri Lanka, with volunteers, NGOs and traditional technology adoption which focus on community involvement helping in the disaster preparedness and response

In conclusion, the above narratives demonstrate clear improvements in response capabilities throughout South Asia – yet the journey does not end here.

The array of case studies shows contributions to the four areas of Early Warning Systems, all of which are equally important in building resilience and improving coping capacities against disasters. Notably, innovative technology is vastly improving the dissemination and communication of warnings. This is illustrated in the increased use of mobile phones and SMS that reach all corners of the region and communicate an alert that can be understood and easily acted upon. A continuation of financial and technical support of the operation of these systems is a must. In terms of co-ordinating response activities, the participation of women is a repeated motif. Their engagement must be continued to ensure sustainability and ownership at a local level.

An important recommendation highlighted is the need for enhanced cooperation and collaboration. The impact of foreign phenomena on local climates and the transboundary nature of the region's geography is at the core of this need. Cross-regional platforms and partnerships to bring together knowledge and expertise should be prioritised. This will help achieve effective response capabilities at a community, national and regional level. (Balmer) Points of focus when promoting collaborative transboundary disaster plan and framework are highlighted in the article contributed by ACT Alliance.

South Asian countries have done substantially well in understanding the risk knowledge. After the promulgation of HFA and SFDRR, it provided a good platform for understanding the disaster risk. Therefore, the risk knowledge is well reported and documented in form of hazards atlas, HVRA reports, Risk Assessment report and reflected in the planning process. Hence, risk knowledge is well understood and reported through different platform. Warning and monitoring services has also been enhanced very well after the inclusion of digital systems and web-based solutions. Information communication and dissemination have also reached a certain level due to the internet and phone connectivity. However, it has not yet realised the last mile connectivity approach. Hence, local level preparedness is not sufficiently related to the disseminated alerts and warnings.

Sustainability is the biggest concerns about the running of EWS, that can be strengthened if it is tied to a government mechanism. Therefore, it is important to build this into the system, even at community level it should be part of larger government system to reduce the challenges and facilitate its credible working.

Most effective and timely dissemination of the alerts and preparation of community accordingly is the key to reducing losses. Alerts should be combined with the local level preparedness action and regular mock drills need to be conducted on this preparedness action after receiving of alerts. (Sinha)

The Chinese experience in air pollution indexing has lessons for South Asian countries in several domains such as i) the quality of plans developed for larger cities like Beijing and Tianjin but also for the prefecture level, ii) use of easy-to-understand colour codes (yellow, amber, and red) for the duration of, and the mitigation measures for, varying durations of poor air quality, and iii) the use of a regional warning system for Pearl River Delta. The regional warning system has immense practical value for clusters of South Asian cities such as Delhi-Haryana-and Amritsar in India and Lahore-Gujranwala and Faisalabad in Pakistan. In fact, in the transboundary context, an integrated Delhi-Lahore system can engage stakeholders from both countries to communicate severity of air pollution, heatwaves as well as smog that has become the “fifth-season” in the region. (Majumder)

6. Lessons Learned And Recommendations



The following presents the lessons and recommendations that have been highlighted in previous chapters on each of the 4 key components of early warning system. It consists of a recap of the key lessons highlighted by authors in each component, supported by views from fellow authors. Within this section are cases that reinforce the lessons learned/recommendations. A final perspective from practitioners in the field is also provided at the end, highlighting the important practical aspects of the recommendations, followed by succinct Key Recommendations from the report editors.

6.1 Disaster Risk Knowledge

Disaster risk knowledge is the systematic collection of data and risk assessments. As seen in previous chapters collaboration and cooperation between countries, local government agencies and communities are imperative for this process. Cross sector collaborations between scientists and INGOs/NGOs covering multiple hazards to share information across fields and cooperate to build a comprehensive database and assessments on hazards should also be encouraged. In addition, as noted by several authors in this report (M. Taher, S. Katyaini, S. Sahoo & M. Wessel, S. K. Karna, and T. Ariyananda) recognition and inclusion/adaptation of traditional knowledge is important within EWS.

6.1.1 Traditional Knowledge Can Boost Early Warning Systems

– **Dr. Tyrone Hall**¹²³, Postdoctoral Fellow at York University;
Adviser at the Alliance for Small Island Developing States (AOSIS), Canada

Traditional knowledge is a critical part of life in subsistence communities that can strengthen early warning mechanisms. Many traditional communities across the Pacific region, which is perched on the frontiers of global environmental risk, are often self-sufficient in times of disasters. These island communities routinely draw upon a wealth of vital experiential knowledge amassed over centuries to manage their resources and vulnerability. As the anthropologist Vishvajit Pandya puts it, indigenous knowledge is embedded within their worldview, enabling them to take stock of changes in the environment and react to extreme events. While experts are increasingly integrating many traditional natural resource management mechanisms, particularly in the regulation of fish and land sanctuaries, they have been slow to leverage indigenous knowledge to boost early warning systems (EWS). Gaps in existing technical mechanisms mean this should change locally and elsewhere.



Tsunami Buoy.
Photo Credit: NOAA.

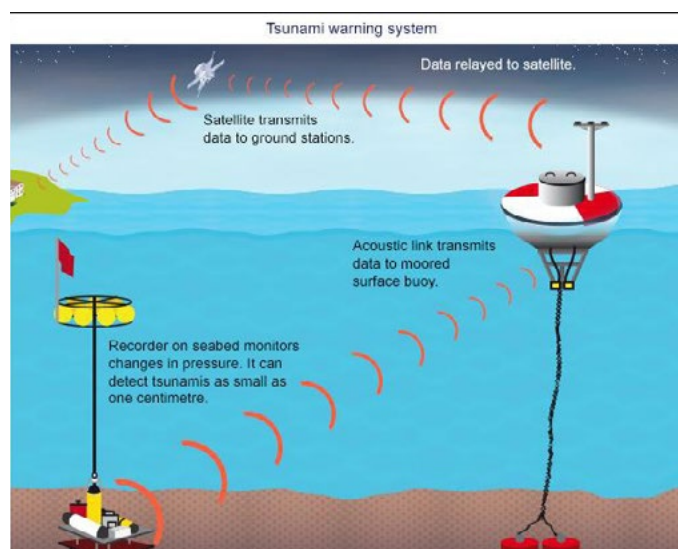


Figure 6.1: Tsunami Warning System.
Photo Credit: ABC Australia

¹²³ Dr Hall is a post-doctoral researcher at York University. His work concerns climate change policy analysis and programme design across the Americas, South Pacific and India.

Many countries invested in technical alert systems after the overwhelming Indian Ocean tsunami in 2004. However, subsequent experiences highlight that this critical infrastructure is not infallible and must be complemented by other modalities, including education and cultural know-how. Scientists take a minimum of 15 minutes to analyse earthquake data, which means coastal communities are unlikely to receive timely warnings during nearshore occurrences.

Understandably, experts tasked with determining the magnitude, depth, and precise location of earthquakes, must privilege caution to preserve the integrity of costly EWS. Frequent false alerts will erode community trust, responsiveness and cost lives. It is for this reason that planners focused on disaster risk reduction should prioritise education, embedding indigenous knowledge and disaster response mechanisms. This means taking stock of indigenous experiences and knowledge, enhancing them with a wider catalogue of natural indicators and highlighting them in community outreach across coastal and near coastal communities.

Recent events offer us a tapestry of examples from which to learn. During the 2004 tsunami, the great vulnerability of Little Andaman Island was matched by the equally high resilience of the Ongees¹²⁴. These materially poor indigenous settlers with low formal literacy levels relied on their own belief systems and experiential knowledge to accurately interpret changes in their environment and survive a calamity. The Ongees noted the exceptionally low tide as an indicator that the water would return with equal or greater force and quickly retreated to higher grounds. Without any technical mechanism in place, their culturally informed responsiveness to an immediately perceptible natural indicator (retreating to the hills) meant no lives were lost. Responsiveness to culturally understood natural indicators and worldviews have saved countless lives in the Pacific region, including during Cyclone Daman that destroyed Cibokia Island but without casualties, even in the three weeks it took for post-disaster support to arrive¹²⁵.

The knowledge and independence of these communities that routinely save lives is consistent with Chilean, Hawaiian, and Japanese accounts of survival following the tsunami caused by the largest earthquake ever measured—the magnitude 9.5 earthquake in Chile on May 22, 1960¹²⁶. This is strong evidence that indigenous knowledge enriched with broader natural indicators should be systematically leveraged to boost disaster risk reduction in an age of more frequent and intense weather events and the inevitability of more earthquakes, tsunamis, among other disasters.

Having worked across traditional communities in South India, similar traditional modalities exist that should be similarly harnessed and integrated in early warning and overall disaster risk reduction planning. My experience is that people embrace social change when the actions promoted are linked to existing community strengths, thought or belief patterns, practices and aspirations. Crucially, overall effectiveness is more likely to be realised when systems complement rather than discount traditional systems. As my research in India, the Pacific region and Belize suggests, respect for indigenous knowledge and practices is likely to boost agency and mobilise internal leadership and enforcement, which is critical for any effort to optimise EWS using enhanced cultural mechanisms and natural indicators.

The different types of disasters also affect the design and function of the EWS as expressed by Kancharla. In the case of air pollution more research is required, and EWS should provide sophisticated mapping incorporated into proactive public alert services for the public to use the knowledge collected and modify their behaviour (Majumder, Bartington)

Apart from collaboration between government authorities, development agencies and communities, there is an additional tier within the community to which special attention needs to be placed when it comes to EWS knowledge gathering. That is the marginalised. The vulnerability of the marginalised increases during disasters not only due to physiological factors but also due to power relations in society. As expressed by several authors (Taheer, Rego, Kancharla, Saracini), the participation of women, children, the elderly and the disabled in knowledge collection, planning and implementation needs to be recognised. Especially considering their special needs and roles within the community. In addition, community-based

124 Pandya, V., 2009. When land became water: tsunami and the Onge of Little Andaman Island. Website: <<http://www.andaman.org/BOOK/originals/Pandya/pandya.htm>>.

125 Rina, S. 2007. Cyclone haunts Ami survivors. Fiji Sun. National Features section and p.16, 10 December 2007.

126 National Tsunami Hazard Mitigation Program—A partnership among the States of Alaska, California, Hawaii, Oregon, and Washington, and the National Oceanic and Atmospheric Administration, the Federal Emergency Management Agency, and the U.S. Geological Survey. <https://pubs.usgs.gov/circ/c1187/>

transboundary EWS work well when there is collaboration between organisations across diverse sectors. With most of such systems currently at a pilot phase the time has come to mainstream these systems with the help of governments and other stakeholders (Bhatt).

6.1.2 Early Warning System in India: A Gendered View

- **Reetika Syal**, Assistant Professor, Centre for Research in Social Sciences and Education, JAIN (Deemed-to-be) University, Bangalore, India

The UNISDR (United Nations International Strategy for Disaster Reduction) 2006, endorses the four components that an early warning system (EWS) should have: a) Risk knowledge: where data should be systematically collected, and risk assessments and analysis performed, b) Monitoring and warning service: where the system for hazard monitoring and providing early warning services, should be put in place c) Dissemination and communication: where the information for risk and early warning should be communicated to the intended communities, and d) Response capability: where national and community capabilities should be developed to put for response to early warning (pp 2). Among these components, the last two become important because they directly involve the community members and individuals at risk. The National Institute of Disaster Management of India acknowledges that early warning systems will have limitations in saving lives, if they do not work together with people-centred networks. These systems should be understandable, trusted and relevant to the communities which they serve (NIDM, 2014:4).

It is also acknowledged that inequalities that exist in society get enhanced during disasters (Shrestha et.al, ____). Even among the vulnerable communities and sections of society, there are sections that are doubly-disadvantaged, such as women, who need to be targeted participants and beneficiaries of any EWS that is put in place. The advantages of increasing women's participation in EWS and disaster risk management programs are manifold: a) first, in emergency situations there are many more trained people to respond at the household level, b) second, the community members are also better informed and follow the lead of known people, c) third, women leaders can then take the lead and bring a change in traditional roles and stereotypes (Brown et.al, 2019).

In India, we have several examples of women taking the lead in the EWS for disaster risk reduction. A study by Oxfam indicates that women's participation in early warning groups proves advantageous for efficient system functioning and community disaster resilience, since they are proactive in gathering and disseminating information from EWS (southasiadisasters.net, 2018). Secondly, women's participation in EWS is important because the male members of many communities migrate outside the village in search of work, thus leaving the women and other members of the family vulnerable. In Odisha, women leaders have taken up many initiatives for disaster risk management, and are at the forefront of managing the program. They have emerged as leaders and have surpassed the traditional gender divide, to participate in the decision-making processes. Community preparedness for disaster risk management in Assam is being led by women trainers who are able to bring in more women for first-aid training, and search and rescue operations. Their participation in the planning process has resulted in more effective disaster preparedness. When 'development' did not reach Sitapur district in Uttar Pradesh, the local dynamics gave birth to citizen leaders, most of whom were women. These women volunteers came for trainings on-their-own, and also associated themselves with various community development activities in the village. It was found that wherever women leaders were involved, women's participation in trainings was higher than in other areas (ibid).

Several studies in South Asian countries such as Nepal and Bangladesh have analysed that EWS that do not explicitly consider gender in a gender-unequal society would lead to increases in marginalisation and vulnerability of the groups with less power and influence (Brown et.al, 2019, Practical Action, ____). Vulnerability of women increases during disasters not only due to physiological factors but also due to power relations in society. Quoting an example from Pakistan, a United Nations Development Fund for Women (UNIFEM, 2010) study states that during floods, women refused to leave their houses since they were concerned about theft or occupation of their houses, were hesitant to take girls out of the protection of their houses, and also did not believe in the flood warning system. The solution to this problem can only be achieved through awareness and integration of women into the early warning process.

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6. United Nations Development Fund for Women (UNIFEM), 2010, 'Pakistan Floods 2010: Rapid Gender Needs Assessment of Flood Affected Communities', Report Accessed on 6th September 2019
7. United Nations International Strategy for Disaster Relief 2006, 'Developing Early Warning Systems: A Checklist' at the *Third International Conference on Early Warning: From concept to action*, 29th March, Report Accessed on 5th September 2019

6.1.3 Transboundary Early Warning System: Why Children Matter?

– Rita Panicker, Butterflies, New Delhi, India

Exposure to a disaster is a traumatic experience for any person, but particularly so for a child. Grave areas of concern soon after a disaster include: orphaned and children with single parents, early childhood care, education, child protection issues such as child sexual abuse, child labour and child trafficking and integration of children with disabilities.

Experience has shown that the most important factor in successful recovery from a disaster is to seek out and rely on the capacities and resources of local communities. Given that children constitute a large proportion of the affected population, overlooking children potentially ignores a large part of local capacity at a time when it is most needed. Children's participation in decisions, which affect their lives, has a positive effect on their mental health, empowering them to regain control over their lives. Protection, emotional wellbeing, as well as the physical recovery of children should be a leading feature of every stage of any disaster response. In times of disaster, children's resilience can be strengthened by providing children with supportive and appropriate activities in community rebuilding. Involving children in the planning, design ideas and governance of 'child centred' infrastructures such as schools, crèches, parks and playgrounds will translate into a sense of ownership and stewardship of these spaces. In addition to providing immediate relief, child focused programs such as formation of children's clubs, child resource centres, children's camps, Bal Sabha's (Children's Council) and child led community health care programming, have contributed to creating positive social change. A living example of this is in Andaman Nicobar Islands after the 2004 tsunami.

Children's meaningful engagement in both needs assessment and reconstruction can help communities rebuild social and physical spaces that meet the needs of their members including children with disabilities. Given the opportunity and the tools, children are able to look closely at the fabric of their communities and begin to imagine how they could solve issues and contribute to building stronger and healthier communities. Engaging in such constructive action give them the confidence, skills and the social space to begin to explore some of their personal and emotional issues.



Children in Andaman Nicobar Islands after tsunami.

It is therefore critical that there is an overall improvement in the quality of response by broadening the consensus on children's capacity to be valuable actors in early forecast of disaster, emergency relief, and rehabilitation, thus giving them better control over their lives at times of crises. Children have to be given the knowledge and skills for disaster preparedness; it should be part of the school curriculum. It will give children better resilience and coping mechanism to take steps prior to a disaster outbreak and withstand an aftermath of disaster. What is needed is a profound change in the way children are seen, transforming them from being voiceless, passive beings to active participants in building their future.

6.2 Detection, Monitoring, Analysis and Forecasting of the Hazards and Possible Consequences

As with knowledge collection, an EWS has to establish its monitoring and forecasting system based on the type of hazard faced. The availability of real time strong motion data for earthquake forecasting, low VHF detectors, satellite based sensors to detect and monitor thunderstorms and lightning, and the improvements and the monitoring of meteorological conditions to predict heatwaves show the range of equipment, technology and systems that one country may require to do just that (Baksi, Mohapatra, Col. Srivastava, Prasad V & Srivastava). Updating forecasting systems to improve accuracy and adjust to new hazards is imperative. For example, A. Upmanyu introduces two studies that could further enhance the current Air Quality Index used in India in terms of accessibility and accuracy.

Transboundary cooperation and collaboration are essential, particularly in certain regions where disasters occur across countries. Disasters such as river basins flooding, air pollution, cyclones and earthquakes require a collaborative monitoring, analysis and forecasting approach. Gaps in infrastructure, inadequate institutional capacity development and geopolitical challenges and insufficient bilateral river treaties and data sharing agreements limit the adoption of these systems (R. Jha, Than, Sheikh)

6.2.1 Agenda for Transboundary Early Warning System in South Asia: A View from Pakistan

– **Dr. M. Hanif**, Chief Meteorologist Research and Development Division, Pakistan Meteorological Department, Pakistan

Pakistan is among most disaster-prone countries where floods are the most frequent natural hazard induced disasters with devastating impacts on the poor vulnerable communities who live along river basins. The devastating impacts can be reduced or minimised by an effective and efficient transboundary early warning system by joining hands with those neighbouring countries having common rivers basin. The sharing of real time hydro-met data on regular basis and development of tools/modelling based on local climate and geographical conditions can provide

a way forward to establish a Trans-boundary Early Warning System in South Asia. Such initiative may be a good support to poor and least developed countries of South Asia.

The concept of Trans-boundary Early Warning System in South Asia by AIDMI is highly appreciated and will be encouraged and supported through proper channels. It is suggested to invite and assure the participation of all South Asian countries to support the proposal initiated by AIDMI for this South Asia Disaster Report .

It is further suggested that presently the Advanced Research Version (ARW) of Weather Research and Forecasting (WRF) may be adapted and used by National Oceanic and Atmospheric Administration (NOAA) to operate the Rapid Refresh (RAP) and High-Resolution Rapid Refresh (HRRR). RAP-HRRR is a real-time operational hourly updating forecast system that can be beneficial by providing guidance for establishment of an effective Trans-boundary Early Warning System in South Asia. A joint project proposal in this regard may be submitted to GCF (Green Climate Fund) through SAARC platform..

Big data and machine learning is playing a pivotal role in EWS, including helping stakeholders monitor, and forecast disasters. In their paper Dewi & Srivastava describe how big data is being used for prediction and impact-based forecasting for cyclones and floods. Applications like SMART and SATARK help in disaster planning and risk communication while INSPIRE is a web-based tool for tsunami inundation simulation and loss estimation. Machine Learning can be used to develop forecast models for hazards and 5D-World Map that has used image mining and machine learning to generate (among other things) hazard, exposure of critical infrastructure and vulnerable population in multi-hazard risk environments. (Theo).

6.3 Warning Dissemination and Communication

6.3.1 Enhancing Early Warning System through Application of Machine Learning

– Do Ngoc Thao, Researcher, Vietnam Southern Institute of Social Sciences, Vietnam

EWS has been used as an effective method for hazard assessment and extreme event management. The core function of a satisfactory EWS is the capacity of sequentially providing a reliable and accurate forecast of flood inundation with sufficient lead time. Physically-based models, which were long used to predict hydrological events such as storms, rainfall/runoff, and floods, showed great capabilities for predicting a wide range of flooding scenarios. Nonetheless, they reach their limits in short-term prediction due to requirements of large size monitoring datasets and intensive computation. Data-driven models also gained popularity recently with the usage of statistical models and were reported to be more efficient when compared to physical models. However, one of its drawbacks is the inability to provide quantitative flood predictions and lack off accuracy. This requires the application of more advanced data-drive models, namely machine learning (ML).

To create the ML prediction model, the individual sets of data need to undergo training, verification and testing. The sources of the dataset are traditionally rainfall and water level, measured by ground rain gauges, or remote-sensing techniques such as satellites, multisensory systems, or radars. The major ML algorithms applied include Artificial Neural Networks (ANNs), neuro-fuzzy, neuro-fuzzy inference systems, support vector machines, wavelet networks, and multilayer perceptron. The Figure 6.2 represents the basic flow for building an ML model.

The results, then, can be shared on an interactive and user-friendly web-platform (using GIS- Geographical information systems and API-Google Maps Application Programming Interface) that can visualise flood-related data and online regional flood inundation maps and require minimal technical skills to operate, especially suitable for the public and authoritative officers. Research from Taiwan has suggested that a comprehensive flood warning platform be established, the intelligent hydro-informatics integration platform (IHIP), that could integrate data, analysis, module, and visualization to provide real time Google-maps-based

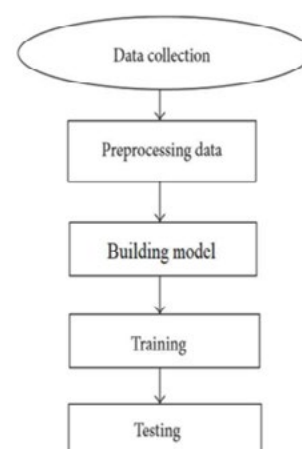


Figure 6.2: Basic flow for building ML model.

information of forecasted flood depths for urban areas. EWSs applying machine-learning techniques have been widely applied in Europe, US, Brazil, and Japan. With the initiatives of transboundary EWS, machine learning techniques aid in the process with a more accurate flood prediction model, requiring smaller size of data sets, reducing the computation cost, and can be operated with minimal technical skills, especially suitable for the public.

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Warning and information dissemination related to natural and technological hazards should be clear, accurate and cover a wide variety of communication channels to ensure all communities receive and trust the messages provided. As mentioned by S. Jha, P. Agarwal, and J. Zhuang, there should be policies and frameworks in place to ensure that the main media channels are prompt in disseminating information from reliable sources, and social platforms should have checks to deal with rumours/misinformation. New communication technology, in the form of drones, unified messaging systems and apps are increasingly being used to disseminate information on disasters and respond to disasters (Kancharla). In turn, R. Sekhar R. recommends that any weaknesses in the human, organisational and technological factors that could potentially lead to a technological disaster should be analysed and suitable precautions take to prevent such occurrences.

Adequate geographical coverage in information dissemination remains a challenge especially given the topography of some countries. For instance in Nepal, river flow and water monitoring systems are operational mainly in the southern part of Nepal and very few early warning systems are in place to monitor glacial lakes and GLOFs (Byanju, Thakuri & Dixit, and Sapkota).

In addition, societal challenges in the form of poverty, inequality and the lack of resources persist. H. Withanage point out that Environmental Justice is another aspect within the EWS where those who often bear the brunt of climate change induced disasters, but are mostly least responsible for it, have an opportunity through the EWS to be treated fairly, have meaningful involvement, and be provided with adequate warning through strengthened forecasting systems to save lives and property. The author points out that these systems, however, overlook other species who also fall victim to disasters natural or human induced.

Sarwar Bari highlights the importance of reaching the marginalised and incorporating disaster governance within the EWS. Illiteracy, lack of internet access, lack of capacity and awareness among authorities and communities as well as gender and urban biases are some of the challenges impeding Early Warning and Early Action processes in the regions (S. Bari – Pakistan, Gurung – Nepal). A. Seneviratne (Sri Lanka) states that ‘uncertainties associated with the early warnings, risk prioritisation, people’s trust in early warning, and community attitude, issues related to the horizontal and vertical coordination and the level of application of the communication tools’ remain a challenge. The role of NGOs and non-government entities is even more important in such situations to fill the gap.

A. K. Ahmed and R. Kancharla highlight the roles that communities can play within disaster information communication and response. Children’s involvement through School Disaster Management Resources and the establishment of Child Friendly Spaces (CFS) means that awareness is raised among children on hazards and preparedness/response actions while CFS are established as early action stations. A. K. Ahmed’s case study on communities living near the Koshi River and Narayani-Gandak river basin show how even when the government official communication lines prove insufficient, communities have the resilience to warn each other and work together to handle disasters. Even across country borders, such as India and Nepal, transboundary EWS and Trans-boundary Citizen Forums successfully share information and develop disaster response strategies.

6.3.2 Emerging Lessons from Transboundary Early Warning Systems and Community Preparedness Practices in the Asian Countries

– **Atiq Kainan Ahmed**, Senior Program Manager, Asian Disaster Preparedness Center, Thailand

Introduction

Community resilience is often regarded as a form of capacity that is situated at community level but can be strengthened either by community people themselves or by the efforts of internal-external stakeholders. Effective and well-designed people-centric EWS is one element which can help absorb the disaster shocks in an ex-anti manner. EWS has been proven to be a critical pillar of overall disaster risk reduction (DRR) with its key component: risk knowledge; monitoring-observation and warning formulation; dissemination-communication, and response capacity; as is the governance of these four key components in a holistic manner. These components are also applicable to any Trans-boundary Early Warning Systems (TB-EWS).

In the context of the South Asian hazard profile, transboundary hazards are on the rise. Disasters and impacts of these predominantly transboundary hazards (i.e., riverine floods, cyclones, tsunamis) are local, country-context-specific but are also sourced and extended in a transboundary context. Thus, there is a great need for establishing effective TB-EWS across the boundaries of countries, rivers, basins and coasts of South Asia, and efforts to meet this need have grown in the past few years.

Harnessing the lessons from existing TB-EWS is important for further strengthen these systems. The gradual connectivity between the TB-EWS and resilience building initiatives are growing and some good lessons have emerged from these in the past few years. This short article discusses two such promising efforts -- among many - which can shed some light on these new trends of learnings and knowledge sharing from the region.



Endeavour # 1: Trans-boundary-EWS efforts in the Koshi River and Narayani-Gandak River Basin through ‘community to community communications’.

At the Nepal-India border, two river basins – the Koshi river basin (KRB) and the Narayani-Gandak river basin – are historically affected by transboundary floods, and Lutheran World Relief (LWR) and Asian Disaster Preparedness Center (ADPC) with partners have developed a unique case of transboundary EWS and transboundary resilience building in response. These two river basins are often referred to as ‘Sorrow of Bihar’ and reflect a tough memory from the past. Colossal damages reported due to recurrent floods in these river basins calling for systematic and people-centric development of TB-EWS involving Nepal and India. A few years of focused efforts were put into developing the TB-EWS connecting the Nepal Government (Department of Hydrology and Meteorology) upstream and the downstream local governments and communities at the border side and Bihar side. The effort pioneered the ‘Trans-boundary Citizen Forum (TBCF)’ which comprises of local



Figure 6.3.

citizens from both sides of the river-basin and brings them together to solve problems. The TBCF members play an effective role in communicating the flood EW information among the communities and alert the at-risk communities ahead of time. The government formal early warning information received was not sufficient for the citizens but through their 'community to community communications' citizens have played an effective and functional role of strengthening the TB-EWS. This effort also showed that building resilience of at-risk communities through systematic community-based disaster risk reduction (CBDRR) and engaging them in the TB-EWS can result in a high level of participation and vigilance beyond the boundaries.

Endeavour # 2: Coastal hazard early warning and coastal community resilience framework in the Indian Ocean countries.

Another unique endeavour was the systematic effort made to connect transboundary coastal hazard EWS and community resilience building under the 'Coastal Community Resilience (CCR)' initiative. This initiative was initially developed under Indian Ocean Tsunami Warning Systems (IOTWS) and later widely adopted by many governments and civil society stakeholders in the region. CCR efforts have shown that EWS for transboundary coastal hazards such as tsunamis, tropical cyclone and other hazards should be developed in an inter-governmental interface but should be linked to the solid base of community resilience programming. These should be done jointly with the 'communities at risk' and 'sectors at risk'. EWS needs linkages with both 'short-term' and 'long-term' efforts such as disaster response and recovery on one side and sectoral developments (relating to coastal management) on the other. Resilience building should be planned, implemented and sustained with the communities and sectors at risk. CCR efforts provided a framework to connect communities and EWS in a systematic manner. It showed that resilience and TB-EWS are linked together when the knowledge and governance happen together.

Conclusions

These two endeavours are given as examples of how the TB-EWS and community resilience can be linked together. Success of one depends on another. Many efforts are underway in the region to find the meaningful ways to connect these two areas. In these growing practices there has been a 'healthy momentum' observed. From practitioner's perspective, the growing knowledge and lessons on transboundary EWS and resilience building need wider sharing. How these two areas can be connected, what can be done to improve-sustain, what policy advocacies are essential, what technical areas to follow up and many factors need to be further explored. This is indeed an area to move ahead through collective sharing, exchange and programming - an agenda to focus together and transcend beyond one's regular knowledge boundaries.

Box 6.1: Dissemination of Information and Warnings, the 2004 Tsunami: Advice from the TEC

Article generated from the Active Learning Network for Accountability and Performance in Humanitarian Action (ALNAP)

The Tsunami Evaluation Coalition (TEC) established after the Indian Ocean tsunami, notes that early warnings to those at risk could have saved many hit by the tsunami in 2004 had these warnings received more attention and not been considered unlikely to happen, even though the region is hazard prone*. Given the lag time between the submarine earthquake to reach Indonesia (20 mins), Sri Lanka (another 1.5 hours) and Maldives (3 hours), a warning from the Hawaii Pacific Tsunami Warning Center would have saved lives. However, while the center identified the upcoming tsunami it circulated the news among its regular lists, which did not include any of the countries hit by this tsunami**. A rapid application of traditional knowledge saved community members in the Andaman and Nicobar Islands of India.

Increasing Dependence on IT

Although local knowledge saved lives during the tsunami, the cell phone was identified by the TEC as the main means of communication throughout the disaster. According to the TEC, information technology plays a crucial role in all stages of disaster and risk management***. TEC stresses, that there is still a wide gap between those facing the risks of a disaster and the use of new technology. And wherever state-of-the-art technology is introduced, training and education of local managers may remain unfulfilled.

The TEC suggests that district levels should coordinate all use of information technology in a disaster situation. In view of that, sharable software and training tools should be prioritised as well as low-cost satellite communications, internet and GSM for UN and its partners. Media can also play an important role in early warning, as they already possess means of distributing information to a large population in a geographical area.

* Telford et al. 2006, Tsunami Evaluation Coalition Synthesis Report, p. 40.

** Financial Times, 2005 in: Telford et al. 2006, Tsunami Evaluation Coalition Synthesis Report, p. 41

*** Bennet et al. 2006, Tsunami Evaluation Coalition, Coordination of International Humanitarian Assistance, p. 66.

6.4 Preparedness and Response Capacities

The variability and flexibility of EWS preparedness systems are crucial for their success. Several authors in this report (A. Sukumaran & C. Bullecer, R. Subedi, N. S. Pradhan, and A. Behar) provide examples and tools/strategies that have been used to increase community involvement in the EWS preparedness processes. ACT Alliance's South Asia experience (Sukumaran & Bullecer) focuses on emergency preparedness and response planning (at local and national level), which is undertaken with community consultation, recognising that communities are the first responders in a disaster situation. Children and women's role in disaster preparedness are crucial not only in terms of effective decision-making and responsiveness during disasters, but also because such roles help empower and protect their emotional wellbeing and assist physical recovery (Kancharla, Panicker). Specific tools, such as Volunteer Network Management System (VNMS) used by Oxfam India, Emergency Preparedness and Response Planning by ACT Alliance in South Asia, and the building of child friendly spaces and child-centered EWS in India (Kancharla) can help communities prepare for hazards more effectively.

6.4.1 The Role and Importance of Creative Communication in Post-disaster Reconstruction

– Martina Dahm, Aalto University, Finland

In 2018, a pilot project in Kathmandu, Nepal sent five master's students at Aalto University (with backgrounds in Business, Design and Engineering) and three bachelor's students of Engineering at AIMM to focus on how organisations that work with post-disaster reconstruction transfer their knowledge to the local communities on how to reconstruct sustainably and be better prepared for future natural hazard induced disasters. We spent four days in the village of Dhungentar in Nuwakot district, followed by a two-day visit to Bungamati in Kathmandu district, interviewing several experts during our time in Kathmandu. In total our study included interviews with 25 experts and 58 beneficiaries. We referred our study to the 7.8 magnitude earthquake that struck Nepal on 25th April 2015 which resulted in approximately 9,000 casualties and half a million buildings being damaged. The reconstruction of many areas in Nepal was still actively on-going in 2018 and according to our background research, communication between the government, organisations and beneficiaries was highlighted as a factor that either hindered or advanced sustainable reconstruction of the communities. We focused our study on what means of communication organisations used to transfer their knowledge successfully to the communities they supported in post-disaster reconstruction.

Based on our observations and interviews, it emerged that the more participatory and inclusive the communication, the more likely it will result in desired action and adopted knowledge. It implies that communication should be a two-way interaction between beneficiaries and professionals from the organisations working in reconstruction. In addition, many organisations were able to transfer their best practices by using the existing social structures in communities because of the trust that already existed between community members. For example, an organisation communicated with the community in Dhungentar through their self-organised mother's committee to share knowledge on how to build better for coming disasters and training them in livelihood skills to increase self-sufficient. Another successful communication tool was a demo house that was built for a community member as an example of how to build a house that would last following earthquakes. Using a demo house on earthquake resistant housing, built by locals through training and providing them with adequate tools and communication means the organisation was not only able to transfer their knowledge but also make the local community take ownership of the reconstruction.



Photo credit: Dahm, Puikkonen.



It is important to highlight that what was learnt during our study was that every context is its own, and therefore not all communication means work everywhere. It is possible to build on the elements that make communication successful, such as inclusivity and using existing social structures, but it still needs to be aligned to the needs and practices of a specific community. Our study includes the analysis and examples of 12 different categories of communication, and we hope the report can be useful for organisations working with reconstruction in different parts of the world.

The report can be read: http://nepali.fi/project-nepali_public-report.pdf

The role of local authorities and village councils in the preparedness process are highlighted in B. Acharya, A. Sharan, & K. Parmars' paper. Disaster management frameworks should include all stakeholders, from government departments, local authorities, research institutions, volunteers and communities (Rego & Arambepola). Local authorities and communities should be in constant communications prior, during and after a disaster and capacities of volunteers and communities should be built to prepare effectively for disasters. Success of such initiatives are seen in the rainwater harvesting systems and weather stations maintained by students at schools and the NGO Sarvodaya's disaster management centre and community led Emergency Aid Groups and Youth Leaders' Circle in Sri Lanka (Ariyananda, Kandage).

6.4.2 Building Back Better after Tsunami: Sevalanka's Work on Early Warning System in Sri Lanka

– **Ajith Tennakoon**, Sevalanka Organisation, Sri Lanka

Lessons learned from the organisation Sevalanka's efforts in coordinating and building collaborative links with relevant stakeholders in disaster recovery and re-establishment processes from the 2004 tsunami were used to develop in a National EWS in Sri Lanka. One which particularly addresses climate change hazardous combined with community knowledge and advance digital communication. As a way forward and for sustainability of the programme schools and universities have incorporated disaster management and climate change components into their curriculum. Dialogs are also conducted on natural hazards and human induced disasters with local and national level political sector. (A. Tennakoon)



Youth leaders and Community Developing village calendar.



Community discussion on village seasonal hazardous plan.

6.4.3 Early Warning System at School Level: A View on South Asia

– **Chandra Bhakuni**, Structural Engineer, Ahmedabad, Gujarat, India

A school is a simple and noble institution entrusted to raise or shape a child into a responsible adult. There are approximately two million schools the South Asian region that need protection not only from large scale natural hazard induced calamities but also minor day-to-day incidental threats. Commendable work has been carried out in recent times to raise awareness on the threats they face and protection protocols. Much of this has been achieved through multilateral cooperation of various agencies and support from outside the South Asian subcontinent. A multitude of health, security and aid agencies and importantly the Indian Meteorological Department (IMD) is now entrusted with keeping an eagle's watch on any incidents that may outbreak into large scale disasters. Despite this effort, it is still impossible to completely mitigate losses from any large scale disaster due to practical lack of integration of knowhow between various existing warning mechanisms and response capacities. The safety of a typical South Asian school facility has been raised to commendable levels through continuous awareness and



A community member who is a falconer at Allapuzah region of Kerala, India.

capacity building initiatives. However, much is left to be done with its infrastructure, such as retrofitting of the buildings to withstand any disaster event and strengthening of the response mechanisms such as fire fighting and search and rescue infrastructure; and, the ‘Early Warning Systems’.

The latest such effort in development of a successful EWS has been sporadic in the region with achievements made for hazards such as man-made conflicts, tsunamis and cyclones, and work yet remaining to be done for hazards such as local floods and earthquakes.

At present, South Asia houses approximately 21% of the world population of which nearly half aren’t adults. High vulnerability in the regions is due to its high population density, political unrest and natural hazard induced disasters. The world is increasingly more lucidly connected with internet and newer technologies, providing more room for newer aspirations. In light of these developments, development of school centric EWS is the need of the hour – early warning systems that incorporate the exchange of information with school facilities enhancing their reliability and relevance so as to effectively save lives. With the way disaster education has made inroads in the school systems of South Asia, thanks to recent efforts by almost everyone, today these very schools are well positioned to not only to act as mere beneficiaries but also as contributors to the development of early warning systems, which will raise the individual safety standard of every school.

As mentioned by Chauhan, transboundary EWS helps build harmony between communities across borders. An example of this was seen in Pradhan’s paper on communities living near the Ratu River which runs through Nepal and India. Hands-on training, mock drills, and inclusive planning sessions helped build cohesiveness between communities and local authorities across borders.

Keeping in mind the gravity of climate change impacts in South Asia, particularly the floods and flash floods, there is a need to share and integrate real-time transboundary hydro-met data as a basic requirement for Impact-based Timely Decision-making Process to support the poor vulnerable communities of the region. (Dr. Hanif, Chief Meteorologist Research and Development Division, Pakistan Meteorological Department, Pakistan)

6.4.4 Beyond Ulaanbaatar: Bettering Transboundary Early Warning System in South Asia

– **Ranit Chatterjee**, Co-Founder RIKA India Pvt. Ltd., Delhi, India

An effective and timely early warning has the potential to reduce the loss of life. Realising this, the Sendai Framework for Action on Disaster Risk Reduction (SFDRR) and the Asian Ministerial conference (AMCDRR) in Ulaanbaatar has stressed on establishing multi-hazard, multi-sectoral Early Warning Systems (EWS). This article explores the current gaps in transboundary EWS in South Asia and suggests a roadmap for future improvement.

In South Asia, the management of water resources and related policy making is the prerogative of the national and subnational governments. As a result, transboundary data sharing is controlled and often influenced by geopolitical relations among different countries. In addition, the access to such data sets is limited to certain sections of the society (scientist, technocrats etc.) and does not necessarily reach down to the community. This is a serious challenge for integrating community-based EWS, traditional knowledge and state-of-the art EWS. Furthermore, many non-state actors and multilateral organisations are working in South Asia on transboundary EWS mostly at the local scale, mainly standalone pilot initiatives with a potential to be integrated into the national and regional EWS with data standardisation and built-in validation.

The EWSs lack a bottom-up feedback mechanism to understand the implementation shortcomings and actively engage the end-users. Developing a community feedback mechanism will bring on board traditional knowledge, skills and wisdom into the EWS.

Inadequate institutional capacities at the national and local levels are serious impediments to establishing an effective decision-making system to support the EWS. Training of local decision-makers on various types of warnings and local vulnerabilities should be prioritised, and should involve officials from across the borders to support future cooperation.

Last mile connectivity remains a task at the local level and is mostly taken up by the local authorities who have limited resources. Collaboration with private enterprises both for developing solutions as well as supporting such initiatives through Corporate Social Responsibility (CSR) is desired.

Risk perception and apt understanding the early warnings are important factors which influences response at the local level. Hence, along with establishing a robust EWS, awareness generation at the community level has to be prioritised to influence the community's risk perception and prepare them to act base on early warnings.

As mentioned in K. Balmer's and Dr. N. Deo's papers, private sector cooperation and assistance can help enhance EWS and community preparedness. Especially in the case of technology that increases lead time and social acceptance through accuracy and trust in the information issued. Media companies and social platforms can also help disseminate knowledge to the public, build awareness, and promote collaborative efforts in disaster management. As highlighted in Dr. Neo's contribution, legislature encouraging CSR and corporate-NGO partnerships could help fill the resource/funding gap in the sector. Corporate involvement via CSR projects involved in forecasting/ monitoring technology and disaster response relief also has potential (Neo). Creating awareness of these opportunities and educating the private sector on the need and potential for support is an area where further action can be taken.

Box 6.2: Capability to Act on Early Warning *

With a few days warning, people can evacuate their livestock and other moveable livelihood assets to higher grounds, ensuring their own safety and protecting their assets. Early warnings with longer lead time, such as seasonal climate forecasts can enable farmers to adjust their weather and climate sensitive activities to avoid losses of inputs (seeds, fertilizer) and production. Just as important as access to information is the capacity to act on it. Experience from West Java, Indonesia, has shown that to respond to climate information, farmers require a broad range of support from agricultural ministries, local agricultural services, and cooperatives. If farmers are to act upon climate information, however, they will also need resources, in the form of seeds, fertilizers, water and credit.

The content and delivery of information must be tailored to people's circumstances and capacity to respond. This is particularly important for people with physical, psycho-social and cognitive disabilities or those who have limited mobility due to advanced age. Their access to evacuation routes, public shelters, and relief distribution points must be addressed. For this purpose, when designing policy, planning and interventions the relevant agencies can collaborate with organisations of people with disabilities. Following cyclone Pam in Vanuatu, in 2015, the Government found that people with disabilities not only had limited access to evacuation shelters, but also faced barriers to access almost all services and activities.

Response to early warnings is also influenced by security of land tenure and livelihood. People living in informal settlements are less likely to evacuate before a disaster. For example, people affected by typhoon Haiyan explained they did not want to leave before the storm because they feared that landowners would take the opportunity to bar them from returning. As a result, men typically choose to stay during disasters to protect their possessions and to make sure their family members could return. Similarly, for cyclone Phailin which struck the coastal state of Odisha, India in 2013, around 95 per cent of people evacuated. Those who did not, some of whom perished, were families concerned about their livestock. This shows the importance of putting in place arrangements for securing the safety of assets during evacuation.

*UNESCAP. 2019. Asia-Pacific Disaster Report 2019. https://www.unescap.org/sites/default/files/publications/Asia-Pacific%20Disaster%20Report%202019_full%20version.pdf

6.5 Key Conclusions

1. **Rejina Maskey Byanju, Sudeep Thakuri, and Ramesh Sapkota**, Central Department of Environmental Science (CDES), Tribhuvan University, Kirtipur Kathmandu, Nepal

EWSs are well recognised as critical life-saving tools against disasters induced by natural hazards. These communication systems help in detection, monitoring and forecasting the natural hazards, analysis of the risks involved, dissemination of timely warnings, and activation of plans to reduce the risks. In South Asia, the number of innovative EWS is increasing and have started showing beneficial impacts to society. However, the approaches are still at a very primitive stage due to limitation in data, budget, infrastructure and human resources. Some of the existing EWS are techno-centric, top-down, expert-driven and have little interface with the users. All the concerned stakeholders (government and non-government) should strengthen their roles in addressing both the challenges and opportunities of EWS. Media also has an important role in supporting EWS which might foster communication at the community level. Strong political recognition, with formulation of appropriate policies and strategies, should be harmonized at national and transboundary levels. Increasing research on effectiveness of existing and proposed EWS is required. Collaboration, coordination and collective sharing is required to make EWS applicable on larger spatial scales. Sharing of lesson learned and experiences will help to strengthen the system and save the livelihood of millions of vulnerable people living in South Asia.

2. **Thao Ngoc Do**, Researcher, Vietnam Southern Institute of Social Sciences, Vietnam

The four key elements of an Early Warning System (EWS) consist of: risk knowledge; monitoring-observation and warning formulation; dissemination communication; and response capacity. Throughout the report, initiatives have been taken across the countries from India, Nepal to Sri Lanka to improve the effectiveness and performance of the EWS assisting in community's preparedness and resilience. Lessons learnt include: (1) Integrating EWS with Community-based disaster risk reduction (CBDRR) to maximise the participation of community to improve bottom-up feedback mechanism, address the information failure, and involve the community actively in the recovery programs. This can be strengthened through cross-border programmes which involve local citizens across the regions. (2) Coordination is key. Not only among governments, research institutes, NGOs, and humanitarian organisations, but private enterprises as well, e.g. technology companies are potentially becoming an important partner in the process. Public-private partnership promisingly yield improved results with the greater mobilisation of resources. At the centre of the process and key decision-makers remains the local citizens in the affected areas. (3) Application of technology can improve the early warnings functions of the EWS and the information dissemination process to the public using mobile phone, mapping, computer modelling, automatic weather, and machine learning. The scope of technology application is still under-explored areas that if exploited, would maximise the benefits of EWS.

3. **Dr. May Jacob**, Freelance Writer/Editor, Kathaa, India

The days we live in are precarious due to greater incidences of environmental disasters. South Asia is particularly vulnerable due to the large populations, the extent of damage and the pace of recovery. The 'Lessons Learned 2019' AIDMI report will remain invaluable for many theoreticians and practitioners in the area of disaster preparedness due to the momentum it can generate in the conversations and implementations of EWS in existence in South Asia.

Actions in place and Challenges: The Sendai Framework exists as a blueprint for agencies to navigate EWS, it still presents many gaps in implementation as noted in some of the articles. If there is a salient theme across the articles in this iteration of ‘Lessons Learned’ it is the preponderance for the need of community engagement in EWS. The contributors have provided an in-depth, on the ground, analyses of the existing EWS with regards to recent natural hazard induced disasters in their geographical areas of work. As Ranit Chatterjee points out, although there are EWS systems in place it remains largely distant from the grassroots operations, the wide gap between those facing the risks of a disaster and EWS needs to be addressed.

This is also pointed out in the 2004 Tsunami aftermath, where the ‘Tsunami Evaluation Coalition (TEC) noted that wherever state-of-the-art technology was introduced, training and education of local managers may remain unfulfilled.’ TEC also noted that in the Andaman and Nicobar Islands of India, ‘a rapid application of traditional knowledge saved community members’.

Chandra Bhakuni raises the detrimental issues of strained resources of land and the structural integrity of infrastructure to withstand natural hazard induced disasters. Bhakuni emphasises schools as nodal centres of EWS in the community, which need to be reinforced structurally. Data driven models are the need of the hour, Do Ngoc Thao proposes an effective model for such an approach. This model could be further enhanced by being less top-down and creating a feedback loop. During crises often times the most affected are the least equipped. Rita Panicker discusses the need for creating child-centered interventions within the EWS framework.

Realigning priorities and plans - DRR and EWS going forward: Kerala, Nepal, and Sri Lanka are recent reminders for governments and peoples of South Asia towards creating a more reflexive and, sustainable practice around EWS and DRR. Key alliances need to be forged and strengthened with the local government through continuous training and awareness session. Creating self-help groups in villages, schools, and in ecologically vulnerable spots where EWS can be reinforced. Traditional management of land and resources should be given its due while creating DRR and EWS frameworks. Towards that, the Sendai Framework needs to be reconstituted as a cyclical representation, instead of a vertical, hierarchical representation for e.g., Figure 6.4 below:

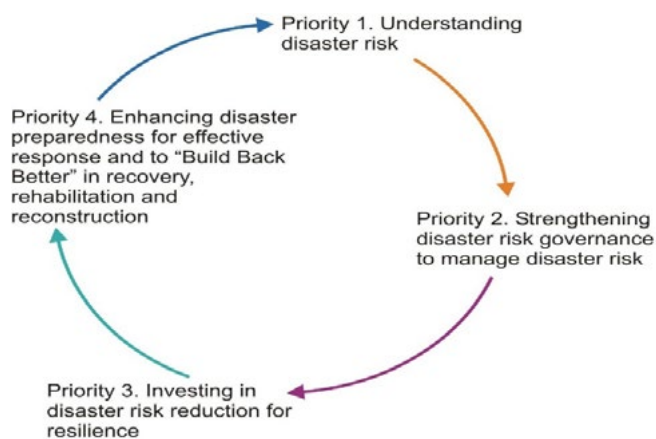


Figure 6.4: Sendai Framework revised to reflect an inclusive process of developing sustainable EWS and DRR plans

There is a greater need to remind communities of the increasing propensity of disasters induced by natural hazards. Also including awareness conversations about natural resources, reducing plastic waste, creating and implementing plans throughout South Asia for plastic waste disposal, paying attention to and implementing traditional methods of preserving ecosystems would go a long way in reviving and sustaining sustainable practices for communities.

4. Chandra Bhakuni, Structural Engineer, Ahmedabad, Gujarat, India

It is well understood that 'the system' (the EWS) requires four essential components of – 1. Knowledge of risk, 2. Monitoring and warning services, 3. Reliable and accurate warning communication, and 4. Community response capabilities. It should be noted that in the last three decades the world has changed dramatically because of the internet and climate change, and the field of disaster management has evolved exponentially. An over excitement because of availability of unlimited information and DM lessons led to an improved understanding of risk mitigation challenges among every stakeholder group who contributes to disaster mitigation, and also, an overlapping of roles and responsibilities. The varying degrees of accountability and capacities which evolved thereafter among the various DM stakeholders extended an understanding, and opportunity, that for any disaster event loss to be mitigated there is an urgent need of an EWS (or community specific EWSs) which accounts for hazard type, space, time and sectoral risks, and extends over political boundaries. It has therefore become evident that the four elements of the EWS now need true protocols and scientific tools which communicate clearly and timely in the event of a credible threat. The interpretation of risk information by the community holds the key for loss reduction; and, by keeping in mind the limitations which political and lingual boundaries give us today, continuation of capacity building efforts through climate change and DRR education and developing pilot EWS projects is one possible way forward.

5. Rita Panicker, Butterflies, New Delhi, India

The challenges faced in disaster response are that the EWS are linear and techno centric and expert driven with little interface with the communities and therefore has very little focus and acknowledgement of capacities of the communities. Lack of a system to share data, insufficient budget, infrastructure and human resources is another challenge. The following recommendations can be made.

1. The Regional Integrated Multi-hazard Early Warning System, an intergovernmental body registered under the UN, be revitalised and be the regional hub of research, compiling and sharing of data and training of resource persons in latest technical developments in EWS.
2. Application of Machine Learning (ML) advanced data-driven models can provide key complex information, with easier implementation and cost effectiveness compared with physical models.
3. Develop a community-based response mechanism, which brings on board traditional knowledge and wisdom into EWS.
4. Community base forums such as women's self-help, youth and children's groups should be part of the EWS plan.
5. Children to be given knowledge and skills for disaster preparedness. It should be part of the school curriculum and made mandatory.

6.6 Key Recommendations

6.6.1 Field Practitioner's Perspective to Improve Last Mile Connectivity

– Ray Kancharla, Humanitarian Development & Resilience Expert, India

The following recommendations are drawn from the field practitioner point of view by Save the Children, especially focusing on the Last Mile Connectivity:

- **Prioritise Children (girls and boys), adolescents, women, disabled and elderly in Early Warning and Early Action:** This is critical in saving and protecting lives and the best interest of the person, from the perspective of human rights and entitlements. Potentially, there is an opportunity to transform children (girls, boys) and adolescents as champions based on the experience of those who have earlier participated in resilience programming. They have demonstrated a huge sense of diligence in risk monitoring and being timely and accurate in disseminating early warnings. It is important to promote and advocate mainstreaming these aspects into EWS among local self-governance, district and state level authorities. Wherever CFS (Child Friendly Spaces) have been mainstreamed, it has *naturalised* the task of prioritisation of children.
- **Women to lead EWS and Early Action (EA),** embedding it into the heart of Family Resilience Planning (FRP). Save the Children and its implementing partners as well as other technical partners have generated adequate evidence to believe that it is women at the household level who have demonstrated a huge sense of diligence and timeliness in terms of learning to protect their children and household assets. Child Centred Resilience and Adaptation (CCRA) has prioritised 9 lifeline areas of children and adolescents with inclusion of women, disabled, elderly in enhancing the resilience in the midst of inter-general poverty. The sectors such as health, nutrition, water, sanitation, hygiene, education, child protection, livelihood and social protection have been the focus for resilience building through advocacy for their rights and entitlements, in an 'uninterrupted manner' during both peace / normal times and in disaster situations. The EWS and EA have the greater assurance and guarantee of transforming vulnerability to resilience building.
- **Incorporating EWS and EA in Education Curriculum:** With the growing awareness of the critical need for School Safety Planning and Practice by the Governments and Civil Society Organisations, it is now important to ensure that Early Warning and Early Action are taught as priorities towards awareness, knowledge and practice. Mock Drills at regular intervals with the heightened participation of adolescent girls and boys is an important denominator in this regard. The mantra that Save the Children advocates is '0'-D + '0'-D. This stands for '**Zero Death**' (0-D) of Students, Teachers and their Care Givers; and the second Zero D stands for '**Zero Days**' (0-D) lost in a school for a child. This mandates that prior to any early warning situation, minimum preparedness actions such as identifying locations for re-staring school within 24 – 48 hours are identified and adequate learning materials are pre-stocked, targeting children from vulnerable areas. In addition, adequate mapping of protection risks is carried out and monitored. This targeting helps to ensure that at the heart of EWS and EA, schools have learnt to integrate locally relevant adaptive technologies and practice based standard operating procedures in their school development planning. The statutory bodies such as School Management Committees (SMC) should also have the capacity to adopt this approach. Further, the department/ministry of education needs to build convergence with disaster risk management departments and resilience & adaptation national and local planning approaches.
- **Prioritise prevention approaches at the individual, household, schools and other child-centred institutional domains:** There are innumerable areas of risks in everyday life in both rural and urban areas in addition to extreme events caused by rapid and chronic crises and progressive climate change vulnerabilities. To cite a few – air pollution, water pollution, vector-borne diseases, heatwave, fire hazards et al. Air Quality has been a growing problem across the world. Some cities are at the stage of severe acute crisis (for e.g., Delhi and Ghaziabad). Similarly, several nations in the world are facing major droughts due to various factors such as rising temperature and heatwaves; with the consequent acute water stresses (water scarcity, reduction in the underground water table, etc.) and often resulting in conflicts.

Annually, there is a big disease burden including loss of lives due to dengue and other water-borne diseases. Most of these are associated as development issues and have not yet been acknowledged as disasters or climate extreme events by governments and others. Hence, there has been no prioritisation towards development of Early Warning Systems and Early Action in this context. Currently, we can witness cities such as Delhi, tracking this during the peak of the season. In addition, there are pro-active steps that can be taken in mapping these risks, monitoring them and developing EWS and Early Action Agenda. There is a carbon-monitoring tool developed by organisations such as SEEDS in India, in the context of school safety. This enables children and youth as well as the school community to map and monitor the risks of carbon/air quality and other associated risks and be prepared for it. In addition, preventive aspects can be developed and implemented. This is necessary today, in light of seamless, unforeseen and unforecasted risks impacting the well-being of children, women and other vulnerable sections of the society, especially, those belonging to the Last Mile.

After all, ***Last Mile Connectivity is as important as the First Mile Connectivity, if not more.*** It is a must to ensure that in EWS no one is left behind; and that EWSs are inclusive with specific attention to gender transformative approaches, in which adolescent girls and boys, women and men sustain a sense of responsibility with equity.

6.6.2 Key Recommendations by BIMSTEC of Bangladesh

– **Dr. Damaru Ballabha Paudel**, Director, BIMSTEC (Social Affairs Division), Bangladesh

1. Awareness raising among vulnerable communities is crucial for an EWS to undertake. Community members must be aware of the types of potential risk in the communities and the related early warning processes. For this, a public-private-people (people of the community) partnership (PPPP) approach is essential. Therefore, from Government actions to civil society, private sector to local community, awareness raising campaigns are required. For the awareness of future generations, disaster awareness and EWS related courses should be included in the school level curriculum of South Asia.
2. Plans of EWS should be based on the needs of vulnerable communities with the participation of the communities themselves. Planning and budgeting should go together. Plans should, include the clear roles of different stakeholders – real time data collectors, warning forecasters, EWS designers, technology providers, information disseminators (such as media, mobile phone companies etc.), local community leaders – and establish an appropriate coordination mechanism among them. Trans-border coordination plans including early warning communication, from first affected place to people to be affected, is needed in case of covariate disaster risks affecting two or more countries or places, such as cross-border tsunami, typhoon, cyclone, flash floods, rapid epidemic control etc.
3. Share the successful experiences, stories, lessons, knowledge, techniques, expertise and best practices of disaster prevention and mitigation among the different communities of South Asia. These will help the communities to prevent, handle, cope and survive similar situations. This sharing must be contextual and should be applied carefully only in a similar situation. The practices of developed countries, in this case, do not always suit developing countries and could sometime have negative effects (for example, the Japanese experience of prevention from the effect of earthquake was adverse when applied in Nepal in the time of Gurkha Earthquake 2015. When the earthquake occurred the people from rural village who were outside their houses went inside and hid under the bed, but due to the weaker construction of their houses unlike in Japan they died from walls and ceilings of their houses collapsing).

6.6.3 Key Recommendations from the National Institute of Disaster Management of India

- **Major General Manoj Kumar Bindal**, Executive Director, NIDM, (Ministry of Home Affairs), New Delhi, India

EWS are tools for local, national and regional institutions to manage disaster risks and reduce damage and casualties. While investment in EWS has been shown to save lives and help protect property, most preventive measures focus on critical infrastructure to prevent disasters, such as flood-control systems, strengthening building codes, construction of shelters and protecting environmental buffers. Status of Early Warning System contributed under chapter 2 may cover all the following segments:

- Hydrometeorology disaster e.g., flood, drought and cyclone.
- Extreme events like heatwaves and cold waves, frost and lightning etc.
- Atmospheric emergency like air pollution and smog episodes etc.
- Complex and second order disaster like forest fire, landslide, disease/ epidemic, pest attack.

Chapter 3 refers to monitoring and EWS wherein the current state of knowledge and initiative are reflected. However with technological advancement and application, we need to move forward aiming at the following:

- Extended early warning i.e., long term forecast for stress building and potential catastrophic/ semi-catastrophic scenarios and complex emergencies where several hazards combine consisting of natural anthropogenic factors resulting in a devastating scenario.
- In relation to the above, the need to recognise the potential of Ecological Risk Assessment, infrastructure risk assessment and social/ behavioural risk assessment by developing prototype and standard procedures to be integrated into disaster Risk Vulnerability Assessment Process.
- The sub-knowledge and dissemination of the protocol of Early Warning needs to be simplified and integrated into public channels of communication. There is an equal need to integrate climate project prediction and scenario-based forecasting in early warning along with the above reference dimension of Risk Assessment to move towards effective early warning products.

The latter part of the report, chapters 4, 5 and 6, encompass thematic context and case studies of communication networks and innovations which should be incorporated into the prototypes and guidelines for Early Warning communication narration, the language context terminology accepted, and society and stakeholder feedback mechanism aiming at enabling the last mile connectivity.

Key Observations

- Last mile connectivity is a major challenge in India, specifically in weather forecasting and warning dissemination.
- Many factors like awareness, communication, culture, lack of political will, and administrative commitments are hampering last mile connectivity.
- Lack of modern technology and application at the grassroot level remain a challenge.
- Public Private Partnership still needs more facilitation.
- EWS development is crucial for sustainable development and building resilience across rural, peri-urban and urban settlements. It is therefore important to develop an EWS framework and strengthen strategies across all levels to ensure better coordination efforts for functional EWS.
- For better coordination, networks among institutions should be strengthened, fostering partnerships and building the capacities of all key stakeholders.
- It is observed that disaster management and related activities are still response and relief -centric instead of being preventive, which necessitates a better technical capacity in understanding DRR, risk assessment and EWS at the PRI/ ULB (district) levels.

Key Recommendations

- EWS framework must be made as a functional component of the DM Plan process (national/state/district). The framework must foster areas of cooperation in data sharing and impact forecasting.
- A long-term perspective on capacity development should be envisaged.
- Technical agencies/scientific institutions must also enhance the capability to deliver timely warnings with sufficient respite time so that they support DRR functions at the city level.
- The role of technical agencies in warning formulation is increasingly being recognised. It is therefore important to strengthen institutional coordination mechanisms between technical and disaster management agencies at all levels.
- City government/Urban Local Bodies have to make significant investments towards the development of EWS and associated mechanisms such as a functional EOC. The current level of preparedness and resource allocation is not sufficient to kick-start any activity around EWS.

6.7 Bringing it to the Present: Recommendations by Report Editors

Achyut Luitel, Aslam Perwaiz, Mihir R. Bhatt, and Muhammad Taher

As noted by practitioners and contributors in their recommendations there are lessons that cut across chapters and remain challenges and action priorities to the present day. These include the importance of linking early warning to early action; the need to make the “last woman the first person warned”; the role of local institutions and small businesses in preparedness; and the value of combining science with community knowledge for effective risk communication.

The recommendations emerging from the SADR conclusions below have been organised in to the four core elements of Multi-Hazard Early Warning Systems. These recommendations have translated the report’s broader lessons into a more operational framework for institutions and practitioners. These overall recommendations focus on what is relevant now (2025 and beyond), in the face of increased disasters to improve EWS and protect lives.

1. Risk Knowledge

- Encourage multi-disciplinary, multi-level and multi-agency risk assessments for better accuracy.
- Regularly update local risk assessments and integrate social vulnerability, livelihoods, disability, age and gender into warning design.
- Improve availability and access to open-source data for decision-makers.
- Use and combine climate predictions for better accuracy forecast and possible impact of natural hazards, with forecast inclusion into early warning systems, city planning and local resilience strategies.
- Address growing concerns about lack of risk informed decision making about clean air, forest fires and heat and cold waves across Asia-Pacific region.

2. Monitoring and Early Warning

- Detailed and stage-wise information on hazard such as likelihood, impact, response guidance is key for confidence building.
- Improve availability of real time data and information, especially to address transboundary hazards such as floods and cyclones and strengthen integrated multi-hazard early warning systems.
- Improve governance arrangements for effective coordination and cooperation within the country and between nations.

- Monitor and measure success and benefits of early warning system for continued improvement.
- Promote affordable, appropriate and accountable use of technology that strengthens public systems and local action rather than bypassing them.

3. Dissemination and Communication

- Develop and use fail-proof communication system that are cost effective and easy to maintain.
- Use multiple trusted channels to release early-warning information and messages in accessible formats.
- Identify, promote and strengthen community-based early warning system in hard to reach areas.
- Invest more in local dissemination channels and means of communication for last mile connectivity.

4. Response Capacity

- For effective and timely response to early warning, actively engage at-risk communities, especially at the grassroots levels, and expand city-level EWS.
- Develop community-based response mechanism and provide adequate training and equipment support.
- Strengthen capacity of, and partnerships between, national, state/provincial and local emergency response teams and departments (police, fire, hospital, etc.), volunteers and civil society.

Additional preparedness and response priorities:

- Establish dedicated financing for local preparedness, maintenance of warning systems, early action, and building community resilience capacity.
- Develop practical indicators to assess warning reach, comprehension, early action taken, and reduced losses, including lessons from near-miss events.
- Use SADR and similar platforms as mechanisms for regional knowledge exchange, reflection, and policy influence.

Duryog Nivaran (DN) is a dynamic research, training, and advocacy network dedicated to strengthening disaster risk reduction and disaster risk mitigation (DRM) across South Asia. Our mission is to enrich the understanding of stakeholders by disseminating research findings, sharing valuable information, and exchanging insights on critical issues in disaster management within the region. Our vision is rooted in transforming perspectives on disasters and vulnerability, advocating for proactive disaster mitigation strategies across South Asian countries.

At the heart of DN's mission is the promotion of an alternative perspective on disasters, emphasizing that affected communities are active partners in their own resilience and sustainable development. This approach underscores our belief that by addressing underlying vulnerabilities and building resilience, communities can better withstand and recover from disasters.

Registered in Sri Lanka, DN is governed by a steering committee and operates with a collaborative structure with members, both individuals and organizations, across Bangladesh, India, Nepal, Pakistan, Maldives and Sri Lanka.

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