Multi Hazard Early Warning System Capacities and Needs Assessment in Southeast Asia: Myanmar and Viet Nam

01st July 2022

Multi-Hazard Early Warning System Assessment in Myanmar and Viet Nam

Final Report

Acknowledgements

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This assessment was conducted by five members team with experience in areas of meteorology, hydrology, disaster risk management, hazard risk assessment, early warning system design/development and climate risk management. The key findings of this assessment will be shared and reviewed by the key stakeholders and their valuable inputs will be incorporated in this draft final report.

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Executive Summary

South East Asia (SEA) region is prone to various hydro-meteorological hazards including floods, droughts and cyclones. These hazards are becoming more and more intricate, complex and multi-faceted. South East Asian countries like Myanmar and Vietnam are extremely vulnerable due to their unique geo-climatic locations in Bay of Bengal and South China Sea.

National Meteorological and Hydrological Services (NMHS) in these countries are mandated and accountable to provide short- and long-range weather forecast as well as early warning to institutions and communities. Recognizing the fact that the frequency and severity of hydro-meteorological hazards is on the rise in changing climatic conditions, capacities of national meteorological and hydrological services will not suffice. Due to unpredictability and increasing frequency of extreme weather events clearly require significant improvement in the capacities for weather monitoring and forecast and early warning in near future.

Although, early warning system exist in these countries, it requires timely upgradation and modernization of instruments as well as technology. In this paper, an attempt is made to assess and highlight existing capacities of national meteorological and hydrological services and national disaster management organisations and their future needs. Capacities and needs of national and sub-national level agencies were assessed through key informant interviews, focus group discussions and shared learning dialogues.

The early warning system assessment was conducted in Myanmar and Vietnam using early warning system assessment matrix, which was developed based on four pillars for early warning system suggested by World Meteorological Organization (WMO), including i.) disaster risk knowledge, ii.) detection, monitoring and forecasting of the hazards and possible consequences, iii.) warning dissemination and communication and iv.) preparedness and response capability and few cross-cutting issues such as gender, governance etc.

Contents

1. Introduction

A systematic approach towards managing risk through a well-established early warning system can minimize loss of lives and adverse economic impact. EWS backed with effective institutional capacities and arrangements can predict hazards in a timely and effective manner, thereby enhancing capacities of decision makers and empowering communities at risk. Acceptance of the Sendai Framework for Disaster Risk Reduction (SFDRR) 2015-2030 at the Third United Nations World Conference in Sendai, Japan, on March 18, 2015 has led to a paradigm shift in disaster risk management from a post-disaster response to a comprehensive and strategic approach in disaster risk management encompassing preparedness and prevention strategies[1]. The SFDRR is the outcome of stakeholder consultations initiated in March 2012 and inter-governmental negotiations from July 2014 to March 2015, supported by the United Nations Office for Disaster Risk Reduction at the request of the United Nations General Assembly.

The SFDRR is the successor global framework of the Hyogo Framework for Action (HFA) 2005-2015 which was aimed to building the resilience of nations and communities to disasters. The HFA was conceived to give further impetus to the global work under the International Framework for Action for the International Decade for Natural Disaster Reduction of 1989, and the Yokohama Strategy for a Safer World: Guidelines for Natural Disaster Prevention, Preparedness and Mitigation and its Plan of Action, adopted in 1994 and the International Strategy for Disaster Reduction of 1999.

The **target 'G'** of the SFDRR stresses the substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to people by 2030. At a national level there is a growing reliance upon EWS as more people and assets are being exposed to the hazards. This calls for functional EWS (most effective for events that take time to normally develop, such as tropical cyclone) or Alert Systems (most effective for events that start immediately, such as earthquake) that have applicability for most hazards. Advancements in observation and monitoring, mathematical modelling, computing capabilities, communication technology and conduct of scientific risk assessment have allowed technical and disaster management agencies to timely disseminate accurate warnings and move people and assets from the harm's way. Warning dissemination and staging response actions are as important as accurate forecasting and determining potential impact. Any weak link in the elements of EWS (even in case of previous well performing system) will result in under-performance or its failure. Hence assessment of EWS is important. The assessment of the effectiveness of system can be done during the event, post-event or during the lean period. This assessment of EWS for Myanmar and Vietnam is done during the lean period. While it is important to have technical competence around a range of elements (forecasting, prediction, impact assessment), discussions with stakeholders emphasize that EWS is more organizational and institutional process which works to reduce loss. The assessment investigates into the condition of EWS governance, requirements of EWS users, core services provided by technical

[1] Sendai Framework for Disaster Risk Reduction (SFDRR) 2015-2030,
Assessed Online at: https://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf

and disaster management agencies, coordination mechanism between technical and disaster management agencies and finally on issues centered around service delivery and feedback.

The purpose of this assessment and report is to measure the existing capacities and future needs of the NMHS, National Disaster Management Organisations (NDMO) and other technical agencies involved in design and implementation of early warning systems for hydro-meteorological hazards in Myanmar and Vietnam. The study aims to assess the existing early warning systems, through;

- Review of the technical design/structure and efficacy of existing early warning system, assessment of early warning agencies, communications networks, protocols for issue of warning, and transmission to the people, assessment of how the residents of the city access the information and how they act upon it.
- Review of the technologies involved in the early warning system network design, technical specifications, up-time performance standards, connectivity and integration with all the important facilities and installations, emergency services, and the disaster management system in the city.
- Review of the mode of collecting information related to hazard events, monitoring, and transmitting it to other agencies, particularly by the provincial government and township/city administration.
- Review of the mode and reach of the warning especially last mile connectivity and dissemination plan through mass media, print and audio-visual.
- Review the messages disseminated through the EWS: on timeliness, appropriateness, accuracy, and simplicity parameters.
- Review of the service support for maintaining the EWS on a regular basis and ensuring hundred percent uptime.

This report also reviews the institutional mechanism and the decision making across the components for EWS. This report considers the use of early warning systems assessment matrix (tool for assessment given in **Annex 2**) to assess the level of development and present the findings for Myanmar and Vietnam. Specifically, it focuses on the hydro-meteorological hazard warning system, their current status, and capabilities and supporting disaster risk reduction.

1.1 Asia-Pacific Regional Risk-scape

In recent years hazards of different category and origin have caused significant loss of lives and economic damages. The damages are showing a growing trend, and increase in climate variability and climate change can tip of many existing mechanisms of managing risk. A closer look into the nature of the hazard events clearly indicates the role of the technical agencies (national/sub-national) and the disaster management agencies (at the national/ sub-national/township/city) in early warning as critical. The increasing factor of risk in today's society underlines the need for enhanced cooperation from a wide spectrum of stakeholders in effective risk reduction and emergency response. Hydrological and meteorological (or "hydro-met") hazards are accountable for 90% of total disaster losses worldwide (World Bank, 2017[2]). Asia and the Pacific region is exposed to range of hydro-met hazards including droughts, floods, cyclones, storm surge and sea level rise clustered around many hotspots in the region and pose direct and indirect threats to lives and livelihoods by damaging and destroying infrastructure, assets, and land.

The extent of disaster risk can be represented in the Asia and the Pacific regional 'risk-scape' shows in **Figure (1)**.

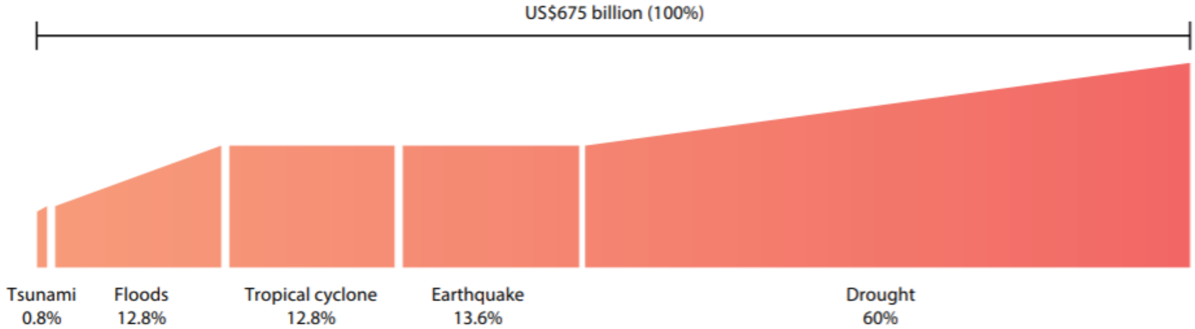

Fig. (1): Asia-Pacific Regional Risk-scape (Average Annual Losses)
Source: Asia-Pacific Disaster Report 2019, UNESCAP[3]

Multi-hazard average annual loss for the region is $675 billion, of which $405 billion, or 60 percent, is drought-related agricultural losses[4] and in total more than 80 percent are from all hydro-met hazards such as floods and cyclone. The inclusion of slow-onset hazards (such as drought) has, for the first time, shown the full extent of disaster risk in the region. Future scenarios of hydro-met hazards in many parts of South-East Asia may become even more frequent and intense if actions are not taken now to build resilience, according to the joint study by the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) and the Association of Southeast Asian Nations (ASEAN). Hydro-met hazards, especially droughts can also be particularly damaging in countries where many people mostly rely on agriculture for primary employment (61% in Lao PDR, 41% in Vietnam, 31% in Indonesia, 27% in Cambodia and 26% in the Philippines).[5]

Owing to 'unprecedented' climate change, frequency and severity of hydro-meteorological hazards is on the rise in many South East Asian countries, and risk is increasing with the time. Disaster risk, fueled by extreme weather events reached beyond coping capacities of many countries and provinces in South East Asia such as Myanmar and Vietnam. The South East Asia region faces a daunting spectrum of natural hazards. Indeed, many countries reached at a

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[2] World Bank (2019), 'Seminar on Hydromet Projects at the World Bank: Opportunities for Collaboration. Assessed Online at: https://www.worldbank.org/en/events/2019/04/03/drmhubtokyo-seminar-on-hydromet-projects-at-the-world-bank-opportunities-for-collaboration
[3] UNESCAP (2019), Asia Pacific Disaster Report 2019, Assessed Online at: https://www.unescap.org/publications/asia-pacific-disaster-report-2019
[4] UNESCAP (2019), Asia Pacific Disaster Report 2019, Assessed Online at: https://www.unescap.org/publications/asia-pacific-disaster-report-2019
[5] UNESCAP (2019), Asia Pacific Disaster Report 2019, Assessed Online at: https://www.unescap.org/publications/ready-dry-years-building-resilience-drought-south-east-asia

tipping point beyond which disaster risk, fueled by extreme weather events, exceeds their capacity to respond. **Figure (2)** shows hydro-meteorological hazards in South East Asia.

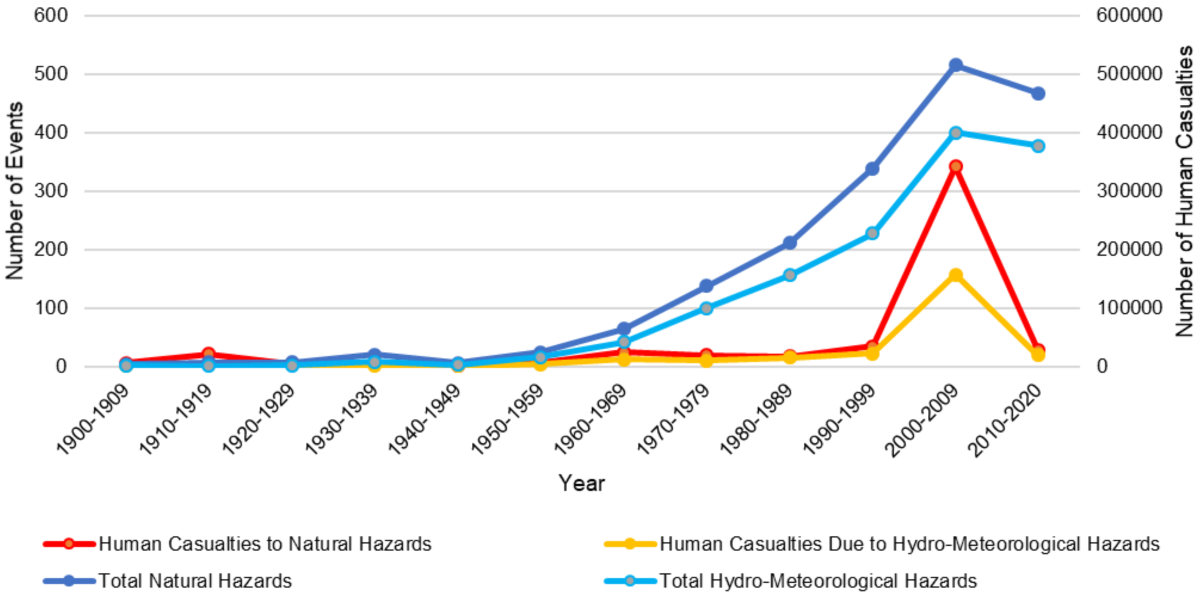

Fig. (2): Hydro-Meteorological Hazards in South East Asia

Source: EM-DAT[6]

1.2 Hydro-Meteorological Hazards in Myanmar

The Republic of the Union of Myanmar is prone to a wide range of disasters caused by various natural and human-made hazards. The already high level of disaster risk is further compounded by climate change and variability, environmental degradation, and haphazard development. Myanmar have not yet fully recovered from the crippling damage and losses from Cyclone Nargis in 2008 that reached 11.7 trillion Myanmar Kyats. Cyclone Nargis affected 2.4 million people and left almost 140,000 people dead in its wake. Since the Cyclone Nargis catastrophe, Myanmar has accelerated programs meant to reduce and manage disaster risk. The Myanmar Action Plan on Disaster Risk Reduction or MAPDRR, which is aligned with the Sendai Framework for Disaster Risk Reduction (SFDRR) and the ASEAN Agreement on Disaster Management and Emergency Response (AADMER), prioritizes seven components. This Risk Assessment Roadmap therefore is a manifestation of this component and a contribution to the implementation of MAPDRR. **Figure (3)** represents hydro-meteorological hazards in Myanmar.

[6] EM-DAT: The Emergency Events Database - Universite catholique de Louvain (UCL) - CRED, D. Guha-Sapir - www.emdat.be, Brussels, Belgium

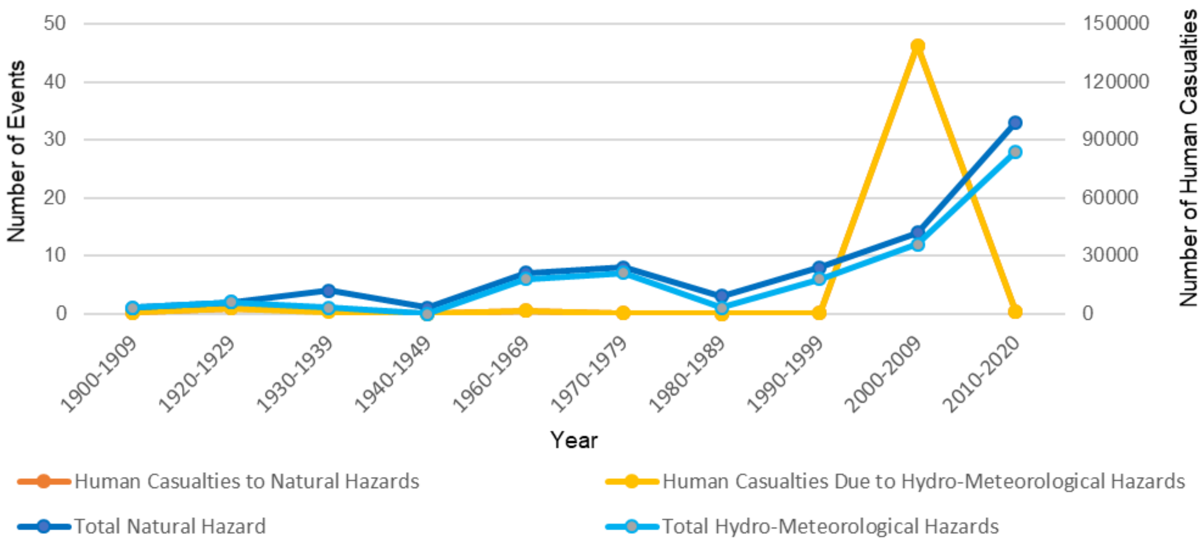

Fig. (3): Hydro-Meteorological Hazards in Myanmar

Source: EM-DAT[7]

1.3 Hydro-Meteorological Hazard in Vietnam

Located in the tropical monsoon area in south East Asia, Vietnam is one of the most hazard-prone countries in the Asia Pacific Region. Because of its topography, Vietnam is susceptible to typhoons, floods, droughts, sea water intrusion, landslides, forest fires and occasional earthquakes of which typhoons and floods are the most frequent and most devastating hazards. The storm season lasts from May to December with storms hitting the northern part of the country in May through June and moving gradually south from July to December. Given the massive concentration of its population along the coastline and in the low-lying deltas, disasters take a heavy toll in lost lives and damaged livelihoods. The growth of economic activity and development into marginally suitable areas such as floodplains, costal swamps, drainage channels or other natural buffers only adds to the vulnerability of the population. **Figure (4)** represents comparison between all-natural hazards and hydro-meteorological hazards in Vietnam.

[7] EM-DAT: The Emergency Events Database - Universite catholique de Louvain (UCL) - CRED, D. Guha-Sapir - www.emdat.be, Brussels, Belgium

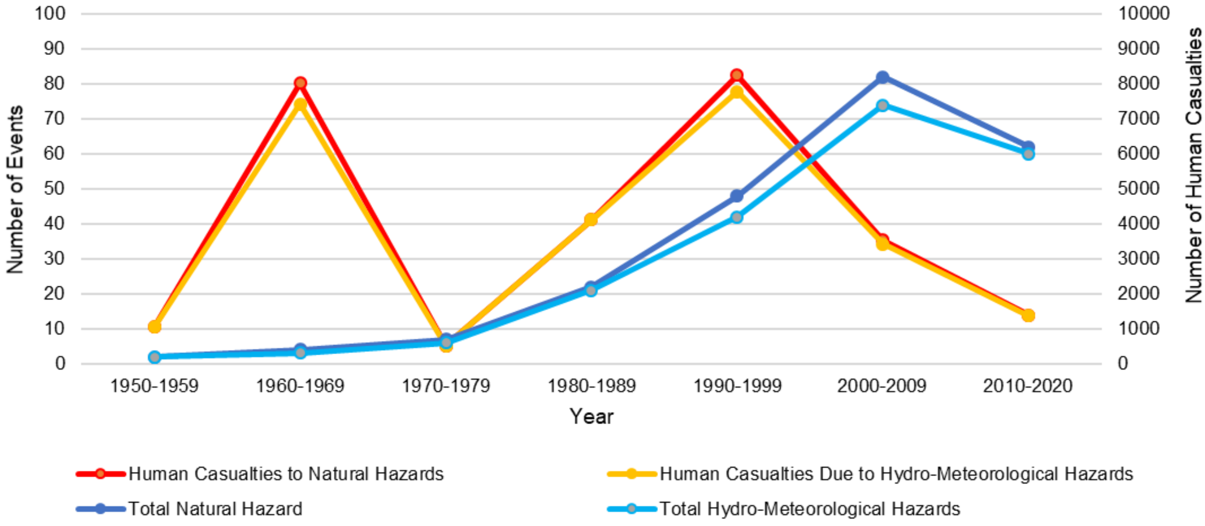

Fig. (4): Hydro-Meteorological Hazards in Vietnam
Source: EM-DAT[8]

2. Early Warning System

Early warning in the usual context means some form of, either written or verbal indication of, an impending natural hazard event. Early warning in the disaster context implies the means by which a potential danger is detected or forecast and an alert issued. In this report, the following definition has been taken into consideration: 'The provision of timely and effective information, through identifying institutions, that allows individuals exposed to the hazard to take action to avoid or reduce their risk and prepare for an effective response'. (ISDR 2004[9]). Early warning is a major element of disaster risk reduction. It can prevent loss of life and reduce the economic and material impacts of hazardous events including disasters. To be effective, early warning systems need to actively involve the people and communities at risk from a range of hazards, facilitate public education and awareness of risks, disseminate messages and warnings efficiently and ensure that there is a constant state of preparedness and that early action is enabled. According to the United Nations International Strategy for Disaster Reduction (UNDRR), an early warning system is the set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by hazards to take necessary preparedness measures and act appropriately with sufficient time to reduce the possibility of harm or losses (UNDRR 2009[10]). This definition encompasses the range of factors necessary to achieve timely warnings for effective response. A people-centered early warning system necessarily comprises four key elements: risk knowledge; monitoring and warning services; dissemination and communications; and response capability (UNDRR, 2009; Phaiju et al., 2010[11]).

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[8] EM-DAT: The Emergency Events Database - Universite catholique de Louvain (UCL) - CRED, D. Gu ha-Sapir - www.emdat.be, Brussels, Belgium

[9] UNISDR (2004), 'Terminology: Basic terms of disaster risk reduction', Assessed Online at: https://www.unisdr.org/2004/wcdr-dialogue/terminology.htm

[10] UNDRR (2009), 'Terminology on Disaster Risk Reduction'. Assessed Online at: http://www.unisdr.org/files/7817_UNISDRTerminologyEnglish.pdf

[11] Phaiju, A., Bej, D., Pokharel, S. & Dons, U. (2010). Establishing Community Based Early Warning System: Practitioner's Handbook, 2010. Lalitpur, Nepal. Mercy Corps and Practical Action.

The thematic key pillars / components of early warning systems are presented in **Figure (5)** (WMO, 2017[12]**).** In addition to the key pillars, governance has also been assessed as a cross cutting component to support each pillar for have an effective and people-centric early warning system.

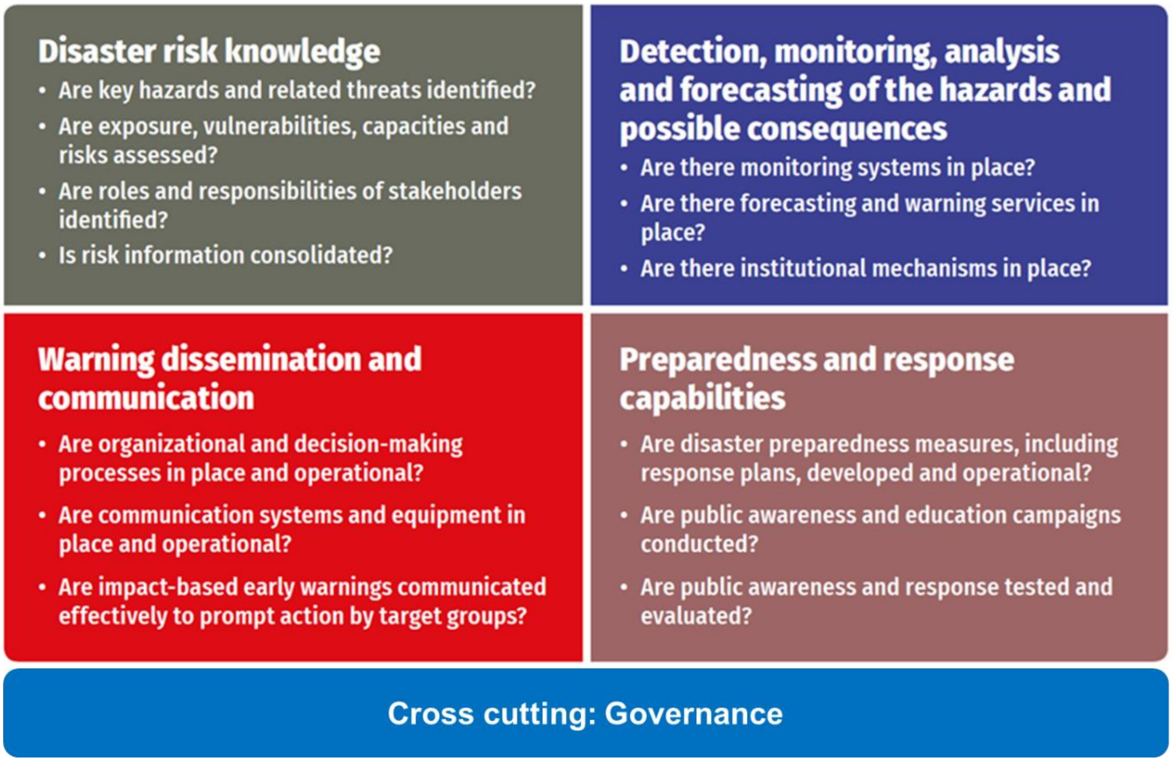


Fig. (5): Key Pillars of Early Warning Systems
Source: Modified after WMO (2017)[13]

Pillar I: Disaster risk knowledge

Risks arise from the combination of hazards, exposure of people and assets to the hazards and their vulnerabilities and coping capacities at a particular location. Assessments of these risks require systematic collection and analysis of data and should consider the dynamics and compounding impacts of hazards coupled with vulnerabilities resulting from unplanned urbanization, changes in rural land use, environmental degradation and climate change. The level of risk can change depending on the actual impacts and consequences of hazards. Therefore, the risk assessment must include an assessment of the community's coping and adaptive capacities. It is also important to gauge the perception of the level of risk faced by those who are vulnerable. Studies of human interaction and reactions to warnings can also provide insights to improve the performance of early warning systems. Risk assessments should be used to identify the location of vulnerable groups, critical infrastructure and assets, to design evacuation strategies including evacuation routes and safe areas, and to expand warning messages to include possible impacts. For example, maps based on risk assessments

[12] WMO (2017), Multi-hazard Early Warning Systems: A Checklist. Accessed Online at; https://public.wmo.int/en/resources/world-meteorological-day/wmd-2018/multi-hazard
[13] WMO (2017), Multi-hazard Early Warning Systems: A Checklist. Accessed Online at; https://public.wmo.int/en/resources/world-meteorological-day/wmd-2018/multi-hazard

help to motivate people, prioritize needs and interventions and guide preparations for disaster risk management measures, including prevention, preparedness and response.

Pillar-II: Detection, monitoring, analysis and forecasting of the hazards and possible consequences

Warning services lie at the core of an early warning system. There must be a sound scientific basis to the system and reliable technology for (i) monitoring and detecting hazards in real time or near real time; and (ii) providing forecasts and warnings 24 hours a day, 365 days a year. It must also be monitored and staffed by qualified people. Continuous monitoring of hazard parameters and their precursors (when available for a particular hazard) is essential to generate accurate warnings in a timely fashion that allow sufficient time for the affected community or communities to enact their disaster management plans appropriate for that hazard. The systems used for detection and monitoring, which could be automated, should allow for strict quality control of the data under international standards when these are available. Warning services should have a multi-hazard perspective (e.g. heavy rainfall may not only trigger flooding but also landslides, the warning for which may come from a separate authority) and be coordinated whenever possible to gain the benefit of shared institutional, procedural and communication networks and capacities. Data, forecasts and warnings should be archived in a standardized way to support post-event analysis and improvements of the system over time.

Pillar III: Warning dissemination and communications

Dissemination and communication systems (including the development of last-mile connectivity) ensuring people and communities receive warnings in advance of impending hazard events, and facilitating national and regional coordination and information exchange. Warnings must reach those at risk. Clear messages containing simple, useful and usable information are critical to enable proper preparedness and response by organizations and communities that will help safeguard lives and livelihoods. Trust is a big part of effective risk communication. If the information source cannot be trusted, those at risk may not respond proactively to the warnings – and it takes a long time to establish trust. Regional, national and local communication systems must be pre-identified and appropriate authoritative voices established. The use of multiple communication channels is necessary to ensure as many people as possible are warned, to avoid failure of any one channel, and to reinforce the warning message. There are numerous standards and protocols used by alerting authorities to transmit warnings. The Common Alerting Protocol is an international standard format for emergency alerting and public warning, developed by the International Telecommunication Union and promoted by a number of agencies. It is designed for “all-hazards”, that is, hazards related to weather events, earthquakes, tsunamis, volcanoes, public health, power outages, and many other emergencies.

Pillar IV: Preparedness and response capabilities

Institutions and people enabled to act early and respond to a warning through enhanced risk education. It is essential that people understand their risks, respect the national warning service and know how to react to the warning messages. Education and preparedness programmes play a key role. It is also essential that disaster management plans include evacuation strategies that are well practiced and tested. People should be well informed on options for safe behaviour to reduce risks and protect their health, know available evacuation routes and safe areas and know how best to avoid damage to and loss of property.

Figure (6) represents schematic of a multi-hazard early warning system.

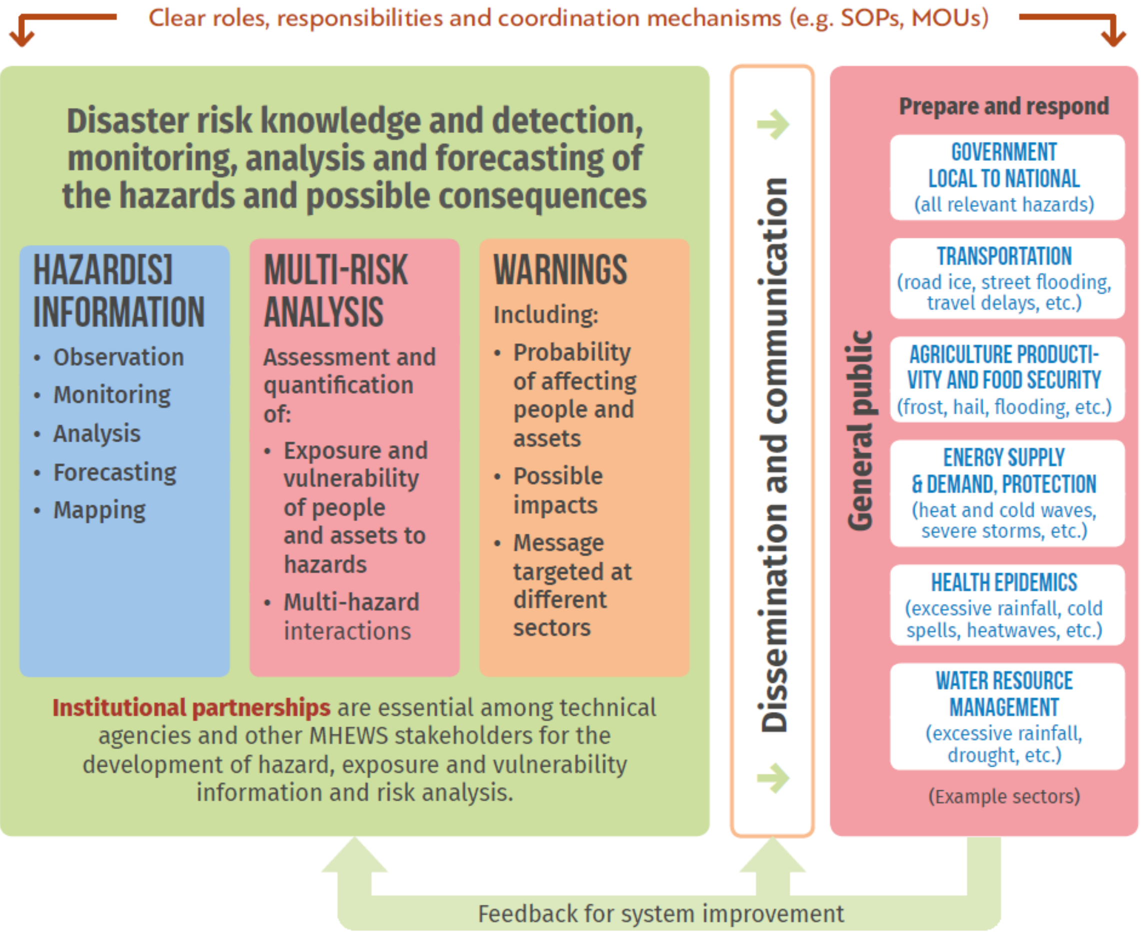


Fig. (6): Schematic of a Multi Hazard Early Warning System

Source: UNISDR, 2017[14]

These four components need to be coordinated across many agencies at national to local levels for the system to work. Failure in one component or lack of coordination across them could lead to the failure of the whole system. The issuance of warnings is a national responsibility; thus, roles and responsibilities of various public and private sector stakeholders for implementation of EWS should be clarified and reflected in the national to local regulatory frameworks, planning, budgetary, coordination, and operational mechanisms.

Over the last decade, South East Asia has incorporated disaster-reduction policies in its regional, national, social and economic development plans to establish effective preparedness measures and improve the response capacities. The value of timely and effective warnings in averting losses and protecting resources/development assets becomes apparent. Countries like Myanmar and Vietnam are exposed to greater risk due to severe exposure of elements at risk. Some of the recent events show the rising trend in the number of people being affected by

[14] WMO (2017), Multi-hazard Early Warning Systems: A Checklist. Assessed Online at; https://public.wmo.int/en/resources/world-meteorological-day/wmd-2018/multi-hazard

disasters, especially in these counties. Warning represents an added value and function in the overall disaster risk management/disaster risk reduction framework. There are three main abilities that constitute the basis of early warning system.

- The first is technical capability to identify a potential risk or the likelihood of occurrence of a hazardous phenomenon, which threatens a vulnerable population.
- The second ability is that of identifying accurately the vulnerability of a population to whom a warning has to be directed,
- The third ability, which requires considerable social and cultural awareness, is the communication of information to specific recipients about the threat in sufficient time and with sufficient clarity so that they can act to avert negative consequences.

Warning systems are only as good as their weakest link. They can, and frequently do, fail in both developing and developed countries for a range of reasons. There are significant decision points for the scientific/technical agencies and the disaster management agencies. These decision points coincide with the phases of the disaster management/emergency management decision stages (say, for hydro-meteorological event with sufficient lead time). A range of factors influence the hazard event phase and the emergency phase. They include:

- Lack of standardized EWS framework, which is understood by both technical and disaster management agencies.
- Non-availability of warning information products and services at different temporal and spatial scales, and provision of same information content for various sectors/stakeholders.
- Warning message not being aligned in terms of societal impacts, risk assessment not being undertaken and potential impact assessment being based on either individual understanding or on past experience and being non-scientific.
- Lack of systemization steps for emergency response based on event severity.
- Warning content unable to facilitate appropriate and timely decision actions at least to those people who are most immediately at risk or are under the influence of the hazard.

An effective early warning system connect technical agencies that generate warning information with disaster management/emergency management institutions and finally with communities/people at risk.

3. Assessment Methodology

A systematic process was adopted by the ADPC team to assess the EWS capacities and needs, particularly with respect to the systems for hydro-meteorological hazards in Myanmar and Vietnam. ADPC team first developed an early warning system assessment methodology and questionnaire. In house testing of questionnaire was done before mobilizing to field missions in Myanmar and Vietnam. The methodology developed for this assessment draw upon international and national best practices and guidelines of World Meteorological Organization (WMO), especially for multi hazard early warning. The assessment was done at national and sub-national level with a well-structured questionnaire allowing responders to provide ranks on the functions of existing early warning systems under four pillars of early warning including risk knowledge, monitoring & warning services, dissemination & communications and response capabilities and cross cutting theme including governance.

The assessment conducted based on Key Informant Interview (KII) and Focus Group Discussions (FGD) at national and sub-national level with key relevant institutions such as NMHS and NDMO. This questionnaire-based assessment, with guiding questions for each pillar and their indicators / sub-indicators, has been conducted to capture actual ground situation / status of early warning systems. As mentioned above, it was necessary to conduct this assessment through KII and FGD at various hierarchy to understand the actual situation of the system.

After successful completion of the assessment in field, weightage was given to all indicators, results were analyzed and represented using spider diagrams to visualize the status of early warning system in each country at various pillars. A combined assessment report has been prepared for both the countries with descriptions / narratives.

First, assessment team shortlisted total 19 indicators related to early warning system from literature review and linked them with four pillars. As mentioned above, later in this assessment weightage were given to all representative indicators of four pillars using Delphi method.

For any early warning system to be effectively functioning, flow of information from national to local level is important. The capacities and needs were assessed through a scoring system ranging from 0-5. The scores are based on the people's perceptions and opinions on early warning systems at the national, provincial, district and the commune levels. The brief description of the scoring system is given below **Table (1).**

Score	Levels	Scale Definition
0	None	No information on early warning or No role in early warning
1	Very Low	Rarely receives or send early warning messages
2	Low	Flow of early warning information is unclear (sometimes it is received and sometimes does not reach the intended audience)
3	Medium	Flow of early warning information is clear
4	High	Quick flow of early warning information to intended audience
5	Very High	Effective warning system with SOP

Table (1): Scoring System with the Scale Definitions

Source: Modified after Dutta et al. (2015)[15]

4. Results and Discussions

4.1 Myanmar

Early warning system capacities and need assessment in Myanmar was conducted in two phases at national, sub-national, and local level agencies including DMH, DDM, YCDC and

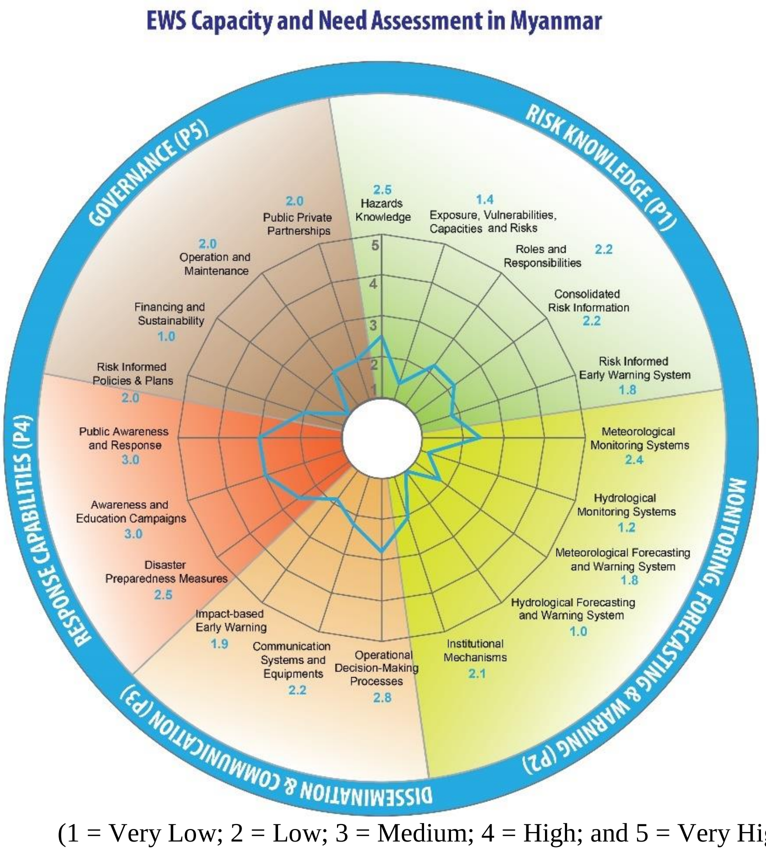
[15] Rishiraj Dutta, Senaka Basnayake, Atiq Kainan Ahmed (2015), 'Assessing Gaps and Strengthening Early Warning System to Manage Disasters in Cambodia'. Assessed Online at: https://pdfs.semanticscholar.org/d98a/e6bcc548ad3ad7168a821ddf5d16d0b0daf4.pdf?_ga=2.34486690.261640564.1580605444-984619652.1580605444

Dala Township Committee in Myanamr. **Figure (7)** represents multi-hazard early warning system assessment in Myanmar.

Pillar I: Disaster Risk Knowledge

Disaster risk knowledge is one of the four pillars of EWSs, which is applicable across all the hierarchies from national, sub-national to local and community level in varying scales. In Myanmar, EWS assessment was conducted with key national level, sub-national to local level actors and key findings and points of discussion are given in below narratives. In Myanmar, national level governmental agencies (such as DDM) carried out various multi-hazard risk assessments including hazard mappings mostly through joint efforts of government departments and international organizations such as WB, ADB and UN and some INGOs. Post Cyclone Nargis (2008), many international agencies conducted hazard assessment in Myanmar. A detailed list is given in **Annex 3**.

Recently, YCDC carried out flood hazard assessments for Yangon and its neighborhood (including Dala) with support from international agencies such as JICA and Dutch Embassy. These initiatives provided technical information on various hazards including floods, storm surge and products and outputs will be highly useful for risk informed planning and development in Yangon and Dala township. However, these initiatives mostly driven by the interests of the parties involved or by the availability of financial and technical resources and undertaken for certain purposes. **Figure (7)** represents the multi-hazard early warning system assessment in Myanmar.



(1 = Very Low; 2 = Low; 3 = Medium; 4 = High; and 5 = Very High)

Fig. (7): Multi-hazard Early Warning System Assessment in Myanmar

Currently, DMH is implementing Ayeyarwady Integrated River Basin Management (AIRBM) Project with financial support from the Word Bank (US$100 million). The objective of the AIRBM Project is to help Myanmar develop the institutions and tools needed to enable informed decision making in the management of Myanmar's water resources and to implement integrated river basin management of the Ayeyarwady Basin. The AIRBM Project includes three components: i) Water Resources Management Institutions, Decision Support System, and Capacity Building; ii) Hydro-Meteorological Observation and Information Systems Modernization; and iii) Navigation Enhancement of the Ayeyarwady.

Disaster risk knowledge at DMH is only based on historical events, and at very basic level. DMH haven't conducted any hazard risk assessment studies, however share data and information for such initiative's in Myanmar. In current scenario, there is a requirement of regular capacity building on understanding of various aspects of hazard risk in Myanmar. This is also well reflected in the spider diagram presented in **Figure (7).** However, DDM and YCDC has good understanding on this pillar, especially at sub-national level. As per discussions with the YCDC, they have conducted local level hazard assessment as well as risk assessment in selected areas of Yangon and its vicinity. They also conducted awareness raising activities in selected areas. Under URCE project, ADPC is closely working with national and sub-national governmental agencies to take up this forward to scale up and scale out to Dala.

Pillar-II: Detection, monitoring, analysis and forecasting of the hazards and possible consequences

Detection, monitoring, analysis and forecasting of the hazards and possible consequences is second pillars of EWS, as it helps to detect and provide likelihood of any phenomena. The mandate related to this pillar is generally lies with national hydro-meteorological services (NHMSs) of countries. In case of Myanmar, Department of Meteorology and Hydrology (DMH) is mandated National Meteorology and Hydrology Service (NHMS) in Myanmar to provide hydro-meteorological early warning to higher authorities, line departments, provincial and local government, disaster management agencies, media, international NGOs, national NGOs, and public.

The Spider diagram (**Figure 6)** shows current status of monitoring and forecasting hydro-meteorological hazards in Myanmar, which is at moderate level. As per the discussions with national level organizations in Myanmar, it is evident that monitoring and forecasting is mainly done by DMH. It appears that DMH observation network to monitor and detect impending hydro-meteorological events are in upgradation phase, and many international agencies (such as MetNo) are closely working with DMH to enhance its forecasting capacities, techniques and tools, which are being used currently. Therefore, DMH join hands with international agencies to upgrade current forecasting system hydro-meteorological hazards with is at moderate level. ADPC is closely working with DMH in Nay Pyi Taw and Yangon to build their forecasting capacities. In 2017, DMH enhanced its capacity by establishing three weather radar stations in

Yangon, Mandalay, and Kyaukphyu (a major town in Rakhine State in western Myanmar) as well as 30 automatic weather observation stations across the country[16].

Pillar III: Warning Dissemination and Communications

Warning dissemination and communications of early warning is the third important pillar of overall EWS. In most cases, this component become weak, especially at sub-national and local level. DMH under administrative control of the Ministry of Transport performs its duties of routine observation and analysis of meteorological phenomena, and disseminate weather forecast and warning for the general public. DMH also provides meteorological and hydrological information for shipping and aviation as well as agricultural and environment activities. These tasks and services are performed on real-time basis and continuously for 24 hours. DMH provides warnings and advisories to the people in danger area through governmental organization and mass media, whenever abnormal to severe weather condition may occur in the area. This information is also provided to neighbouring countries through Global Telecommunication System of World Meteorological Organization (WMO). Through those works, DMH has been contributing and assisting to development of socio-economic activities in the Union of Myanmar and also in neighbouring countries.

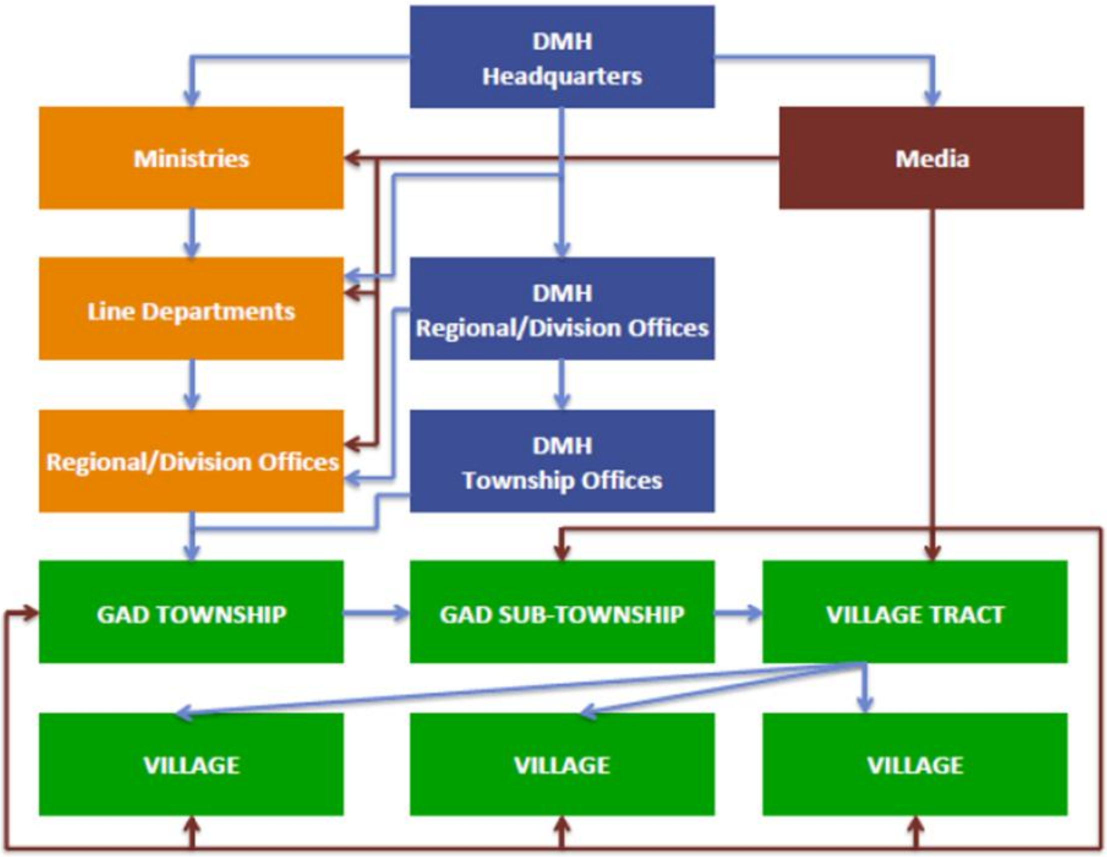


Fig. (8): Warning Dissemination and Communications in Myanmar
Source: DMH, 2019

DMH disseminates all weather forecasts and warning information to higher Authorities, Local Authorities, Non-Governmental Organizations (NGOs), Government agencies such as,

[16] Department of Meteorology and Hydrology, Assessed Online at: https://www.moezala.gov.mm/

Ministry of Transport and Communications (MOTC), Ministry of Social Welfare Relief and Resettlement (MSWRR), Department of Disaster Management (DDM) (former name Relief and Resettlement Department - RRD), Ministry of Agriculture(MOA), Ministry of Health (MOH), Department of Water and Irrigation (DWIR) Office of Government- President and relevant Meteorological offices in different provinces. DMH published meteorological articles about current weather events, significant weather and updated information of meteorological conditions were published in state Newspapers, Ministry of Transport's Journal and other private Journals. DMH established a link with Myanmar Radio, MRTV, FM radios broadcasting about early warning and advisories while Tropical Cyclone approaching Myanmar Coastal areas. Latest position, expected weather, suggested actions were informed to general public effectively. DMH owned weather studio for effective communication with clear, understandable weather information and DMH official website www.dmh.gov.mm, Facebook and automatic weather answering phones fulfil early warning system with updated warning and news. As per the above description warning dissemination and communications of early warnings in Myanmar is moderate level. DHM and NEOC contributions to this assessment is substantially high compared to other national organizations, whom we have interviewed.

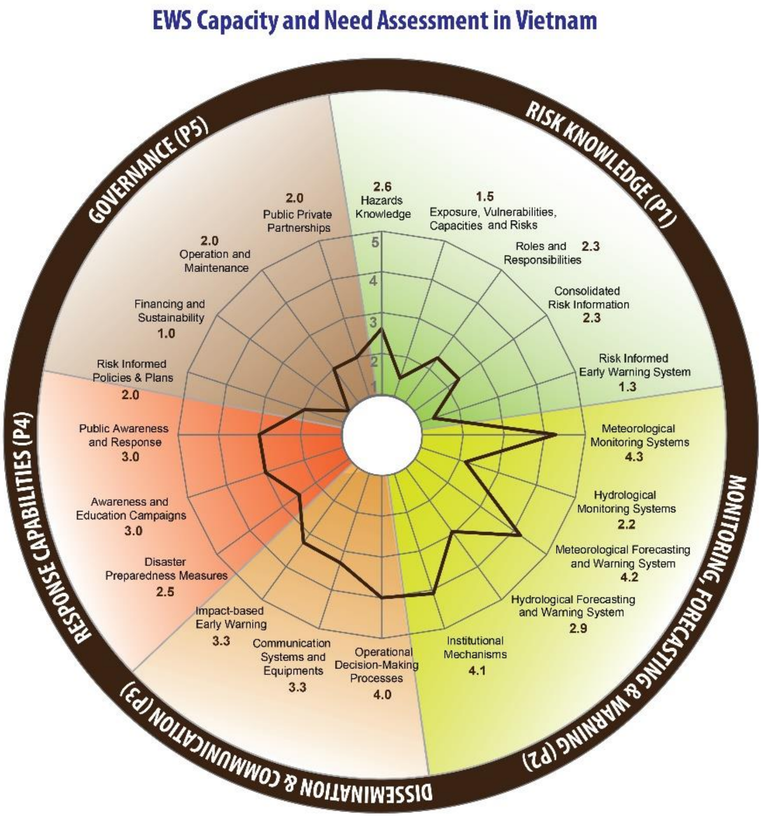
Pillar IV: Preparedness and Response Capabilities

Preparedness and response capabilities is the forth pillar of EWS which is also applicable across all the levels similar to disaster risk knowledge but, it is important, especially at local and community level. Preparedness and response capabilities is generally improved through local and community level engagement in early warning activities. Awareness raising is one of them, in addition to conducting table-top simulations with local level authorities and drills and simulation exercise with communities. DDM are involved in improving response capabilities of sub-national and local level agencies and communities and therefore they contributed heavily to this pillar.

Overall preparedness and response capabilities of the local governments and communities in Yangon seems low to medium due to the fact that some initiatives are taken up with the involvement of national and sub-national government. Preparedness and response capabilities activities seems quite weak in Dala as per discussion. Dala township committee is involved in raising awareness of local vulnerable communities with the assistance of NGO.

4.2 Vietnam

EWS capacity and need assessment in Vietnam was conducted between 18th to 22nd November 2020 with VNMHA in Hanoi and Ho Chi Minh (HCM) City. **Figure (9)** represents multi-hazard early warning system assessment results in Vietnam. Pillar wise discussion on early warning system assessment is described in following sections.



(1 = Very Low; 2 = Low; 3 = Medium; 4 = High; and 5 = Very High)

Fig. (9): Multi-hazard Early Warning System Assessment in Vietnam

Pillar I: Disaster Risk Knowledge

Disaster risk knowledge is the first pillar of overall EWS assessment. EWS assessment in Vietnam covered discussions only with VNMHA and the inputs from VNDMA and other relevant government agencies in future will value add to the overall EWS assessment. At national and regional level, VNMHA is well aware from various hydro-meteorological hazards in Vietnam and its vicinity such as floods, cyclone, drought etc. As per information furnished by VNMHA, they haven’t conducted any hazard risk and vulnerability assessment in Vietnam. However, multi hazard risk and vulnerability assessment have been conducted in Vietnam under several programmes and projects supported by international organisations at different level. A detailed list of various risk assessment is presented in **Annex 4.**

Pillar-II: Detection, monitoring, analysis and forecasting of the hazards and possible consequences

VNMHA is mandated agency for detection, monitoring, analysis and forecasting of the hydro-meteorological hazards in Vietnam. As per regulation on Law of natural disaster prevention and preparedness (approved in 2013); Law of hydro-meteorological (approved in 2015), VNMHA (MONRE) is responsible to provide the hydro-meteorological, marine forecasts and warning to promote the natural disaster prevention and preparedness, social-economic development, national security and defence. VNMHA is the government organisation under Ministry of Natural Resources and Environment (MONRE), has the functions to assist the Minister in managing, exploiting the national hydro-meteorological station networks (including meteorological and hydrological basic investigations, forecasts, documentation), carrying out observations on air and water environment to serve disaster prevention and preparedness, socio-economic development, to ensure security and defence in over the country.

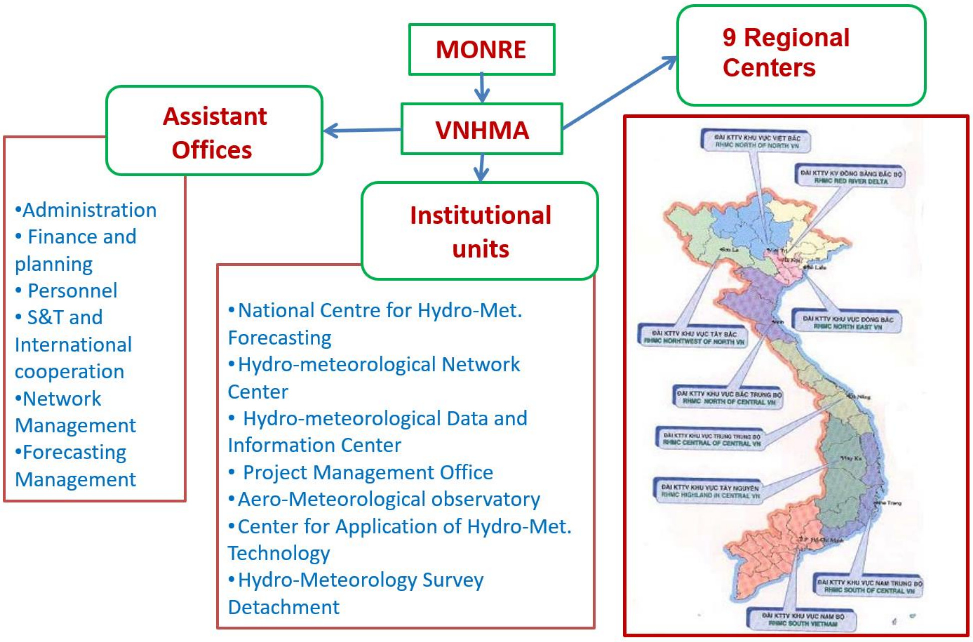


Fig. (9): Hazard Monitoring and Forecasting in Vietnam

Source: WMO, 2019[17]

Figure (10) represents hazard monitoring and forecasting mechanism in Vietnam. The VNMHA of Vietnam administers offices including[18]:

- National Center of Hydro-Meteorological Forecasting (NCHMF),
- 9 regional hydro-meteorological centers,
- 54 provincial hydro-meteorological forecasting centers and observation station networks.

National Centre for Hydro-Meteorological Forecasting (NCHMF) is functional unit of VNMHA with authority to issue forecasting/warning information for weather, climate, hydrology, water resource, marine weather (i.e. hydro-meteorology) and provide hydro-meteorology services.

VNMHA have regional/national level detection/monitoring system for cyclones, heavy rainfall, droughts, etc. (inclusive satellite, NWP, etc.). However, VNMHA need more data on hydrological information in the transboundary area to forecast hydrological forecast. Currently, VNMHA manages infrastructure at national level including 200 manually stations, 272 hydrologic manual stations, 1,000 automatic rain gauges stations and will increase within 5 years including islands, 21 marine stations. VNMHA manages various regional/city level

[17] WMO (2019), Online Assessed At: https://www.wmo.int/pages/prog/amp/pwsp/SWFDP-VientianeLao-PWSWeek2.html

[18] Joint Meeting of RA II WIGOS Project and RA V TT-SU Jakarta, Indonesia / 11 October 2018 BMKG Headquarter https://www.jma.go.jp/jma/jma-eng/satellite/ra2wigosproject/documents/joint_meeting_program_presentation/CountryReport/Vietnam.pdf

station including for Nam Dinh 2 Met stations and 3 hydrology (Water level and discharge) stations and for My Tho 1 Met station and 12 hydrology (Water level not discharge).

VNMHA recently completed project to establish data center hub to archive/store data at national level. VNMHA have established model for riverine flood forecast in Vietnam, however model for urban flood forecast need to be set-up. VNMHA need technical assistance for urban flood modelling in Nam Dinh and My Tho and open for various suggestions and collaboration. VNMHA does not have SOPs and currently using WMO guidelines. VNMHA have technical regulation for flood forecasting depend on the term of the forecast and each term has different regulations.

Pillar III: Warning Dissemination and Communications

VNMHA is responsible for warning dissemination and communications in Vietnam. VNMHA uses various methods to transmit the hydro-meteorological forecasts and warning, via: official letter; email; telephone; video conferencing; telegram for marine activities; Fax; TV Interview; SMS. **Figure (10)** represents the warning dissemination and communications mechanism in Vietnam.

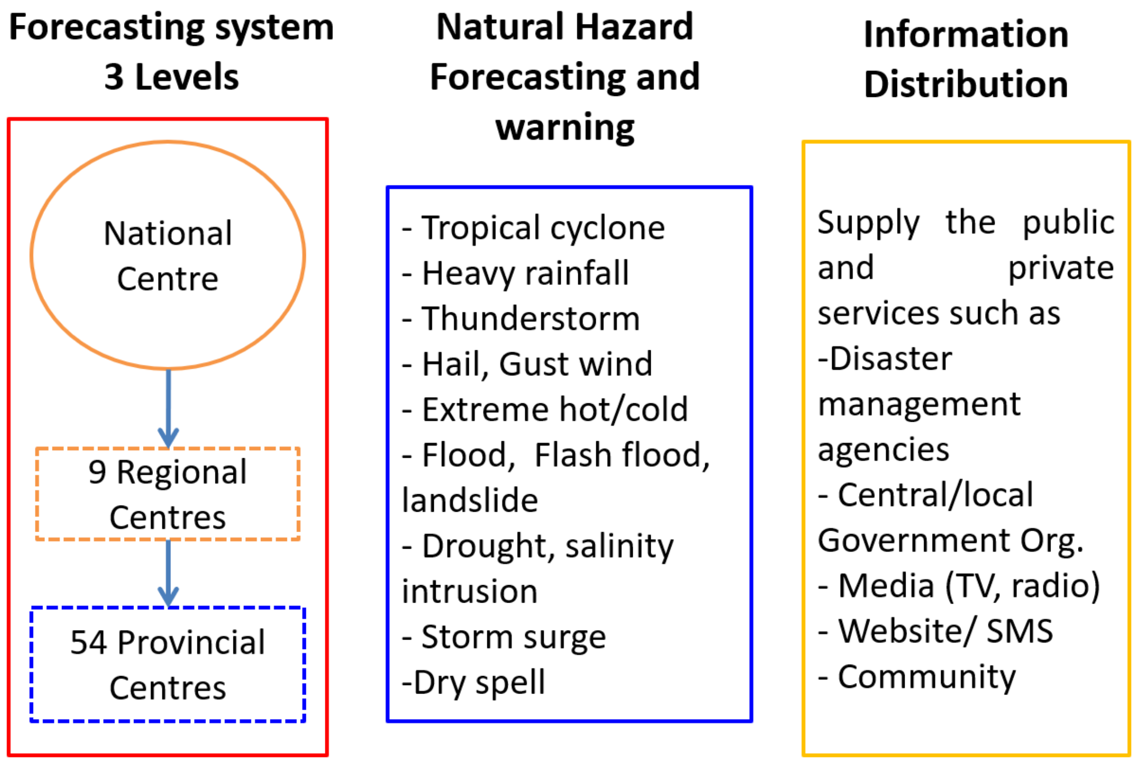


Fig. (10): Warning Dissemination and Communications in Vietnam
Source: WMO, 2019[19]

Pillar IV: Preparedness and Response Capabilities

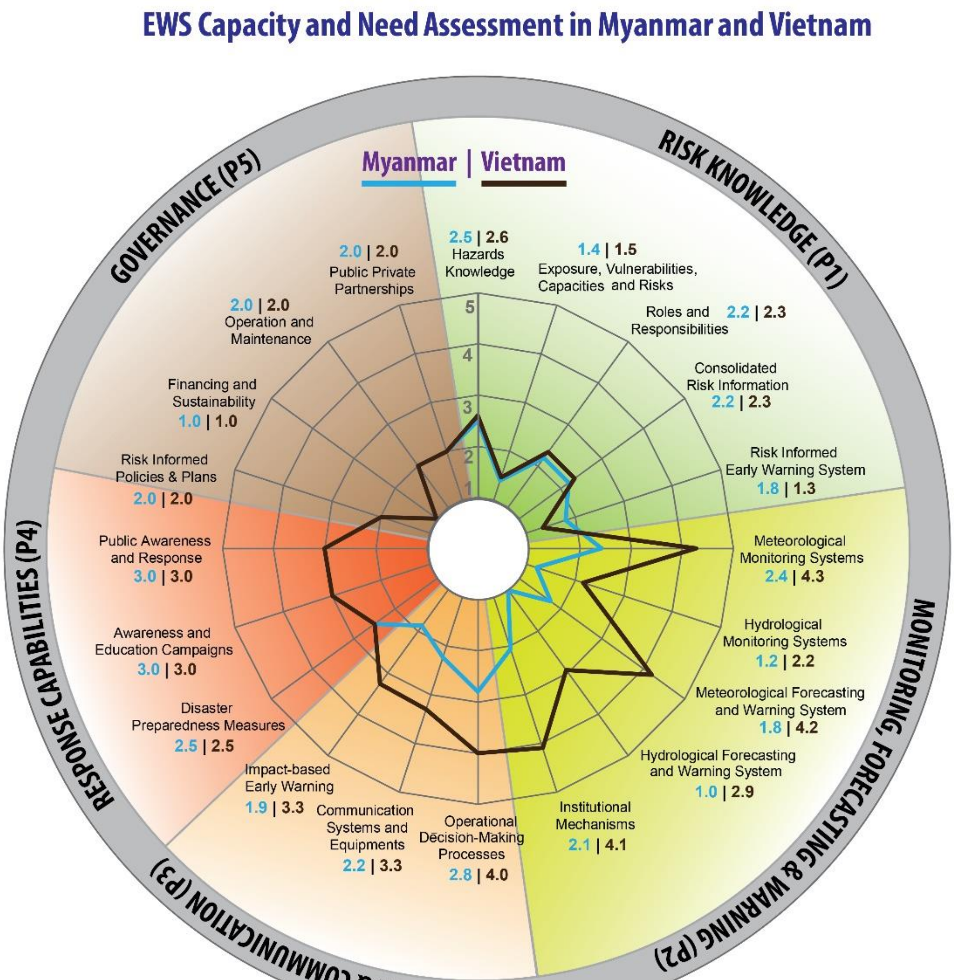
Vietnam National Disaster Management Authority (VNDMA) is responsible agency for preparedness and response during pre and post disasters situations in Vietnam. VNDMA was

[19] WMO (2019), Online Assessed At: https://www.wmo.int/pages/prog/amp/pwsp/SWFDP-VientianeLao-PWSWeek2.html

established under Minister of Agriculture and Rural Development (MARD). VNMDA act immediately after receiving information from VNMHA and make necessary decisions to evacuate people from hazard prone areas. There will be more value addition to this pillar in Vietnam after having discussion with VNDMA.

4.3 Comparative Assessment of EWS of Myanmar and Vietnam

The overall results of early warning system assessment in both the countries showed that the status of early warning system requires further strengthening below national level, which is also evident from **Figure (11)**. Both the countries are using earth observation (EO) data and in-situ data for meteorological and hydrological monitoring and forecast. **Figure (11)** represents comparative assessment of multi-hazard early warning system in Myanmar and Vietnam.



(1 = Very Low; 2 = Low; 3 = Medium; 4 = High; and 5 = Very High)

Fig. (11): Multi-hazard Early Warning System Assessment in Myanmar and Vietnam

In Myanmar, DMH is responsible for all tasks related to meteorology and hydrology fields including routine observation and analysis of meteorological phenomena, and providing weather and climate information for the general public. These are the most important works for mitigation and prevention of natural disasters. DMH also provides meteorological and hydrological information for shipping and aviation as well as agricultural and environment activities. These tasks and services are performed as real-time and continuously for 24 hours every day. DMH also provide severe weather warning and advisories to the people in danger area through governmental organization and mass media.

DMH collects and analysis of the different Numerical Weather Prediction (NWP) model outputs from global and regional centres (GFS, NCEP, JMA, BMD, RIMES, KMA, ECMWF and etc.) to be useful in enhancing the weather forecasting and monitoring system. DMH also operationally run the WRF model with horizontal resolution of 30km with (25) Eta - levels in the vertical and the integration is carried up to 72 hours forecast. DMH has applied Diana Tool (ECMWF model) and its overlay with satellite image (HIMAWARI-8) to use for improving of the short-range and medium range weather forecasting. DMH receive meteorological satellite data directly from HIMAWARI-8 satellite and FY-2D & FY-2E (CMAcast receiving system). Near real time other Satellite images (INSAT, KALPANA-1, and NOAA) receive from internet. DMH have 3 nos. of Weather Radars and 110 nos. of AWS and 20 nos. of ASOS. DMH analysis synoptic chart, upper air chart, satellite images and other information source through internet for severe weather warning and tropical cyclone monitoring. DMH also using warnings and advisory from RSMC, New Delhi, JTWC and TMD. DMH use Ocean forecast (INCOIS) on SWFDP-BoB website for the Sea Route forecast for Myanmar waters. DMH access Global/Regional Numerical Weather Prediction (NWP) products of IMD, NCEP and ECMWF on SWFDP-BoB website. These forecast products are a good reference to use operational severe weather forecasting and warning information for Early Warning System. Not only operational forecasters but also decision makers at DMH are aware of this website and used the products in day-to-day forecast.

In Vietnam, VNMHA is responsible for meteorological and hydrological monitoring and forecast. VNMHA is well equipped with advanced systems and technology, which supports the overall national early warning systems. VNMHA collects satellite sensor data (geostationary data) from JMA–Himawari8/9 satellite sensor and it is gathered from two data sources: (a) directly from satellite receiving station (HimawariCast Rx system which established in 2015 and relocated to new VMMA building in 2017) and (b) via internet (HimawariCloud, Wis–JMA portal and CEReS Chiba University-Japan). The satellite data is received in two main formats: (a) binary z-file type of SATAID-JMA software and (b) the Himawari Standard Data (HSD) format. The main software for exploring satellite data is SATAID software from JMA. The raw data of Himawari is also converted to other format (netcdf, binary) for further applications. Other satellite data types are from NOAA system including (a) sea surface wind - ASCAT from NOAA (via internet) and (b) radiances from NOAA sounders (ATOVS) in various format (via internet).

5. Recommendations

Although the assessment provided a valuable insight about existing early warning system in Myanmar and Vietnam. However, some key recommendation will limitations should be highlighted and acknowledged.

There is a limited number of surface observations instruments in Myanmar and Vietnam, especially at township/city level, which resulted in limited detection capacity of surface events (high winds, heavy rain, etc.). There is a need for installations of modern surface observations instruments in study cities (Dala, My Tho and Nam Dinh) and also to integrate it with the overall systems that are available at national and sub-national level.

A long-term observation strategy needs to be developed to improve the monitoring network to provide reliable observations in real-time and also people's awareness and knowledge related to weather forecasts, warning role. The quality of forecasts, warnings also need to be enhanced and more precise. Awareness programme should aim at strengthening the level of preparedness. The programmes should be contextualized and scenario-based.

There is requirement of trained human resources and trainings of existing staff on regular intervals at all level from national to local level. Capacity building at local level on EWS (technical and management) is crucial for system development and implementation. The township committee and city authority should earmark funds for training so as to assist the process of strengthening the emergency operation center, communities at risk, media, emergency responders and key stakeholders.

Simple and easy to use visualization tools should be made available by technical and disaster management agencies to the citizens. This will ensure participation and effective decision-making. Also need for a simplified technical language in forecast and warning.

Warning products should clearly indicate threats to the population/stakeholders. Efforts have to be made by the technical and disaster management agencies to tailor the warning that allows not only understanding the potential event but also determining the potent impact. The warning at the city level should highlight societal impacts and not be broad-based. Stakeholders should be able to distinguish between low impact and high impact events. At the city level, there has to be minimum ambiguity in information when shared with the general public. Communities at risk should be able to perceive risk and react appropriately.

Development of early warning system (monitoring, impact forecasting, warning formulation) has to be hazard specific. Early warning system development should take into consideration predominant hazards and more frequent/less frequent events (but with a potential for severe damage).

Warning mechanism should keep focus on communities at risk. A generic city-level warning may not be appropriate, given the diversity of the geo-climatic conditions in both the countries. In addition, customized local level warnings need to be provided to hotspot locations.

There is a need to create discussion platform for deliberation and discussion between technical agencies (NMHS and NDMO), other key departments at national and sub-national level. In addition, there is a need to create an appropriate framework with due legal process to ensure that roles and responsibilities of the agencies are defined and executed. There is a requirement of functional early warning system with clear SOPs that determine response. Standardization of departmental plans and terminology ensures effective response actions. SOPs have to be evaluated and modified through conduct of drills. Township and city level agencies should develop hazard analysis, vulnerability assessment and risk assessment (on GIS platform). Climate variability and climate change should be an integral part of the risk assessment.

To strengthen disaster preparedness and emergency response, it is important to ensure that emergency response actions are guided through scientific and observed data. The local level EOC should establish and harmonize flow of information from all agencies and determine potential impact locations within the city.

6. Summary

EWS assessment report provides insights to issues that need to be addressed for an operational early warning system in Myanmar and Vietnam. The results of early warning system assessment provide an understanding on current technical capacities, issues and future needs to improve existing early warning system, as well as for design and implementation of upcoming early warning system in both the countries. It was envisaged that these countries need to tailor solutions for public safety, and early warning system should be designed and developed considering various extreme events and hazard scenarios. It is important to keep these systems people-centric and subsequently build risk knowledge among the stakeholders for success of an early warning system system. Early warning system assessment matrix developed for this assessment can be used as a tool for further review in both the countries. A robust early warning system audit mechanism can also be rolled in the future to measure system efficiency.

Based on the early warning system assessment conducted in Myanmar and Vietnam in Southeast Asia, the study summarized that both the countries have early warning systems in place at national level and NMHS are equipped with latest technology and instruments such as radar systems. However, the systems do have few bottlenecks and barriers that needs to be addressed at sub-national and city/township/local level. It is important at this stage to note that existing early warning system in both countries at sub-national and local level needs upgradation and enhancement to meet the larger objective of reducing fatalities and protecting infrastructure/assets from future events. It was recognized during assessment that an operational early warning system has the potential of minimizing loss and contributing to sustainable development and building resilience. While technology is available for establishing the robust communication system for early warning system, it is the institutional foundation and the networking arrangements which have to be deep rooted for meeting the desired objectives of the system. All the key elements of the system have to be functional and it is important to review them annually by targeting for different scenarios and measuring performance.

The assessment identifies that the critical bottlenecks and barriers exists when it comes to coordination, resource availability, dissemination and communications of early warning information from national to local level which also forms the last mile connectivity of an effective early warning system. These bottlenecks and barriers are been well highlighted from the early warning system assessment results.

The assessment further summarized that more awareness generation and capacity building programmes need to organize both at sub-national and local levels are needed that should include testing of existing guidelines, SOP's, conduct drills and simulations for specific hazards and introduction of more innovative approach for community awareness. These should then result in strengthening the existing systems by making it more effective, robust and reliable. Steps at the national level should also include periodic review of early warning systems and their feasibility to update and upgrade. Adequate allocation of resources (budget and human) is an important area to achieve for further strengthening of the systems as well as improving the linkages in communication networks from national to local levels to make it more reliable and effective so that timely information reaches the vulnerable sections at a much faster pace. It is also been expected that countries involve more experts in getting their technical advice and build their institutional capacities towards achieving the skills and knowledge of understanding and using early warning systems effectively so that it reaches the right kind of people at the right time.

Annex 1: Snaps of EWS Assessment in Myanmar and Vietnam:

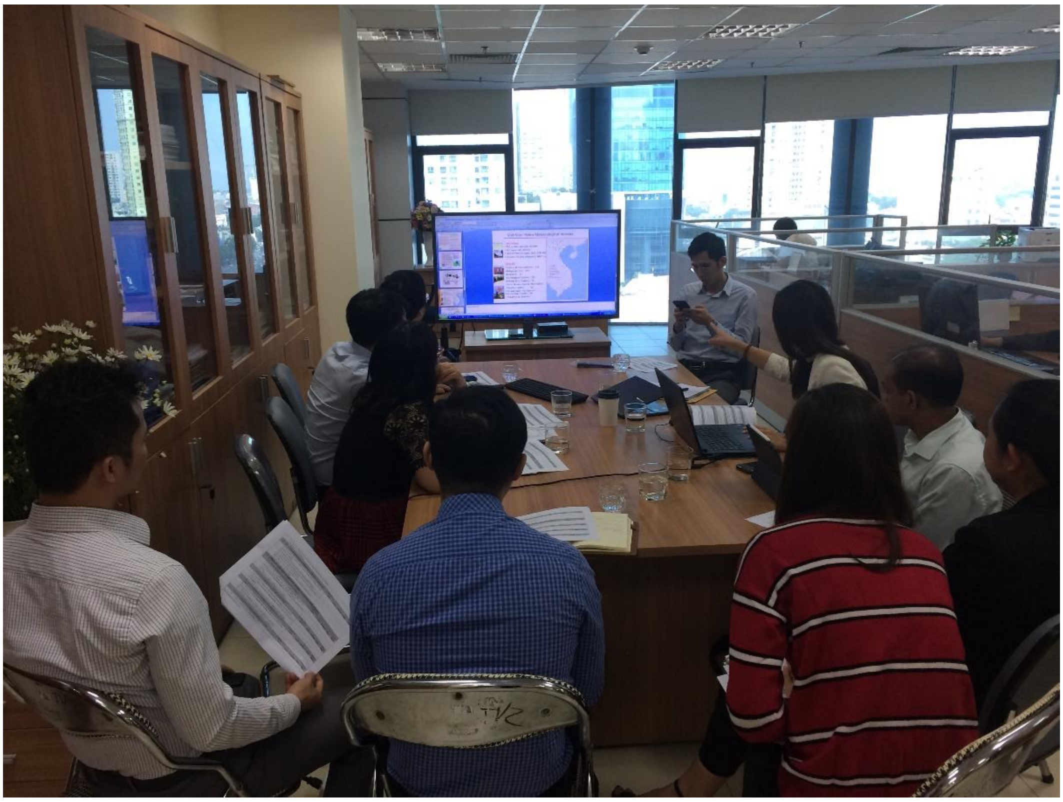
EWS Capacity and Need Assessment with Department of Meteorology and Hydrology (DMH), Nay Pyi Taw (Myanmar) on 16th to 17th October 2019

EWS Capacity and Need Assessment with Meteorology Officials from DMH, Nay Pyi Taw (Myanmar) on 16th to 17th October 2019

EWS Capacity and Need Assessment with Hydrology Officials DMH, Nay Pyi Taw (Myanmar) 16th to 17th October 2019

EWS Capacity and Need Assessment with DMH Regional Office, Yangon (Myanmar) 16th t0 17th October 2019

EWS Capacity and Need Assessment with VNMHA Officials, Hanoi (Vietnam) 18th to 22nd November 2019



EWS Capacity and Need Assessment with VNMHA Officials, Hanoi (Vietnam) 18th to 22nd November 2019

EWS Capacity and Need Assessment with Northern Regional Center of VNMHA, Hanoi (Vietnam) 18th to 22nd November 2019

EWS Capacity and Need Assessment with Southern Regional Center of VNMHA, Ho Chi Minh City (Vietnam) 18th to 22nd November 2019

EWS Capacity and Need Assessment with Southern Regional Center of VNMHA, Ho Chi Minh City (Vietnam) 18th to 22nd November 2019

EWS Capacity and Need Assessment with Southern Regional Center of VNMHA, Ho Chi Minh City (Vietnam) 18th to 22nd November 2019

Annex 2: Multi Hazard Early Warning System Assessment Format

Multi Hazard Early Warning System Assessment						
Sr. No.	**Pillar 1: Disaster Risk Knowledge:**					
A	**A. Are key hazards and related threats identified?**	**1 (None/Very Low)**	**2 (Low)**	**3 (Medium)**	**4 (High)**	**5 (Very High)**
	A1. What type of natural hazards (Hydro-met and Geological) occurred in your region/city?					
	A2. Are there any hotspots identified in your region/city?					
	A3. How historical information archived (collected, collated and stored) in your region/city?					
	A4. Is there any natural hazard assessment conducted and mapping done in your region/city?					
B	**B. Are exposure, vulnerabilities, capacities and risks assessed?**	**1 (None/Very Low)**	**2 (Low)**	**3 (Medium)**	**4 (High)**	**5 (Very High)**
	B1. What are the key elements at risk and critical infrastructure (exposure) in your region/city?					
	B2. Is there any vulnerability assessment conducted in your region/city?					
	B3. Is there any risk assessment conducted in your region/city?					
C	**C. Are roles and responsibilities of stakeholders identified?**	**1 (None/Very Low)**	**2 (Low)**	**3 (Medium)**	**4 (High)**	**5 (Very High)**
	C1. Who is responsible to conduct hazard, vulnerability and risk assessment in your region/city?					
	C2. Who is responsible to disseminate risk information to different stakeholders in your region/city?					
	C3. Are you aware about any legislations, policy, plans for risk assessment in your region/city?					
D	**D. Is risk information consolidated?**	**1 (None/Very Low)**	**2 (Low)**	**3 (Medium)**	**4 (High)**	**5 (Very High)**
	D1. How and which form the risk assessment and knowledge is stored in your region/city?					
	D2. Is there any plan to update the risk assessment with new data sets in your region/city?					
	D3. How cross-cutting issues such as gender, disability and					

	governance used in risk assessment?					
	D4. How risk information used in key sectors such as urban planning, infrastructural development in your region/city?					
E	**E. Is risk information properly incorporated into the early warning system?**	**1 (None/Very Low)**	**2 (Low)**	**3 (Medium)**	**4 (High)**	**5 (Very High)**
	E1. Is risk assessment and knowledge is incorporated in early warning system and evacuations planning?					
	E2. Are safe shelters identified based on risk assessment and knowledge?					
	E3. Are key sectors (urban planning) are using this information in their day-to-day activities or policy & plans in your region/city?					
	E4. Is there any cross-cutting issues such as gender, disability and governance incorporated in early warning system					
	Pillar-II: Detection, monitoring, analysis and forecasting of the hazards and possible consequences					
	A1. Are there any meteorological monitoring systems in place?	**1 (None/Very Low)**	**2 (Low)**	**3 (Medium)**	**4 (High)**	**5 (Very High)**
	A1.1. Do you have any regional/national level **detection/monitoring** system for cyclones, heavy rainfall, droughts, etc. (Inc. Satellite, NWP, etc.)?					
	A1.2. What kind of weather **observation** network is available in the national level and the city?					
	A1.3. What kind of **data archiving** system is available?					
	A2. Are there any hydrological monitoring systems in place?	**1 (None/Very Low)**	**2 (Low)**	**3 (Medium)**	**4 (High)**	**5 (Very High)**
	A2.1. Are there riverine/urban flood **detection/monitoring** systems available?					
	A2.2. Are measurement parameters **data available** in real time/near-real time and how is the **quality**?					
	A2.3. Are the riverine/urban flood modelling well **calibrated and validated**?					

	B1. Are there meteorological/climatological forecasting and warning services in place?	**1 (None/Very Low)**	**2 (Low)**	**3 (Medium)**	**4 (High)**	**5 (Very High)**
	B1.1. What kind of specific **forecasts and warnings** produced in nationally and for targeting the city?					
	B1.2. What kind of techniques (weather) used for information generation?					
	B1.2. What kind of techniques (climate) used for information generation?					
	B2. Are there hydrological forecasting and warning services in place?	**1 (None/Very Low)**	**2 (Low)**	**3 (Medium)**	**4 (High)**	**5 (Very High)**
	B2.1. Are there riverine/urban flood **forecasting** available?					
	B2.2. Are there riverine/urban flood **warning** services available?					
	B2.3. What are the **improvements** further required?					
	C1. Are there institutional mechanisms (meteorological and hydrological) in place?	**1 (None/Very Low)**	**2 (Low)**	**3 (Medium)**	**4 (High)**	**5 (Very High)**
	C1.1. Do you have your own **SOPs** for forecast and warning generation?					
	C1.2. Any (meteorological/hydrological) **Act** currently in place?					
	C1.3. Do you have any **MOU** signed with national, regional agencies/city development authorities and **cross-border** information sharing?					
	Pillar-III: Warning Dissemination and Communications					
	A. Are organizational and decision-making processes in place and operational?	**1 (None/Very Low)**	**2 (Low)**	**3 (Medium)**	**4 (High)**	**5 (Very High)**
	A1. What are the **Organizational/Institutional arrangements** for dissemination and communications; what roles they play in EW dissemination and communications?					
	A2. Are there any **Standard Operating Procedures (SOPs)** for early warning information dissemination, function, and decision making established?					

	B. Are communication systems and equipment in place and operational?	**1 (None/Very Low)**	**2 (Low)**	**3 (Medium)**	**4 (High)**	**5 (Very High)**
	B1. What are the regular **channels/modes** used in existing EW dissemination system?					
	B2. What are the **equipment's** in practice for EW dissemination (E.g. radio, tv, website, MHEWC, VHF radio, megaphone)					
	B3. Is there any **Emergency Operations Center (EOC)** in place at target city/regional level?					
	C. Are impact-based early warnings communicated effectively to prompt action by target groups?	**1 (None/Very Low)**	**2 (Low)**	**3 (Medium)**	**4 (High)**	**5 (Very High)**
	C1. Do the **EW information reach from source to end user (end to end) promptly? What is the time lag** for reaching the EW information to last-mile urban habitats?					
	C2. What is the **process of validation and feedback** on warning					
	C3. What is the **process of interpretation** of warning and risk information at various levels (eg authorities, local gov., citizens etc)?					
	C4. Does/how EW information triggers **Evacuations** at urban areas, what are the process and issues;					
	C5. Do the **Social Inclusion** issues in the warning information (PWDs) considered effectively?					
	Pillar-4: Preparedness and Response Capabilities					
	A. Are disaster preparedness measures, including response plans, developed and operational?	**1 (None/Very Low)**	**2 (Low)**	**3 (Medium)**	**4 (High)**	**5 (Very High)**
	A1. Is there any disaster management plan existing for the target area? At what level and how functional is that?					
	A2. Is there any integration of EW and multi-hazard risk information in the disaster management plan?					
	B. Are public awareness and education campaigns conducted?	**1 (None/Very Low)**	**2 (Low)**	**3 (Medium)**	**4 (High)**	**5 (Very High)**

	B1. Are there any **public awareness campaigns or educational programs** for the target communities existing?					
	B2. Is there adequate **training on EW** provided to the authorities and practitioners in the target urban areas?					
	C. Is public awareness and response tested and evaluated?	**1 (None/Very Low)**	**2 (Low)**	**3 (Medium)**	**4 (High)**	**5 (Very High)**
	C1. Are there any **EW simulations and drills** carried out to test EW and evacuations in the target urban area? **How often** such EW simulations-drills are conducted?					
	C2. What is the status of **integration of EW and risk information into the Urban CBDRM** process?					
	Pillar-5: Governance of EWS					
	A. Are there EWS and Risk information are mainstreamed into the national level policy, strategies and development plans and global commitments?	**1 (None/Very Low)**	**2 (Low)**	**3 (Medium)**	**4 (High)**	**5 (Very High)**
	A1. Has EWS and Risk information been integrated to specific national level policies, strategies and development plans?					
	B. Are there EWS related financing and sustainability included and provisioned into the national budget and financing?	**1 (None/Very Low)**	**2 (Low)**	**3 (Medium)**	**4 (High)**	**5 (Very High)**
	B1. What is the financing for EWS in the country?					
	C. On what level the 'Operation and Maintenance of the EWSs are provisioned and incorporated?	**1 (None/Very Low)**	**2 (Low)**	**3 (Medium)**	**4 (High)**	**5 (Very High)**
	C1. What are the operation and maintenance measures taken on a regular basis?					
	D. What level the 'Public Private Partnerships' are adopted for EWSs?	**1 (None/Very Low)**	**2 (Low)**	**3 (Medium)**	**4 (High)**	**5 (Very High)**
	D1. What type of PPPs are existing?					

Annex 3: Multi Hazard Risk Assessment Studies in Myanmar

List of Multi Hazard Risk Assessment Studies in Myanmar			
Sr. No.	**Name of Study**	**Year**	**Organisation**
1	Seismic hazard assessment of Yangon City	2015	MGS, MEC and UN-Habitat
2	Earthquake risk assessment of Pyay City	2015	MGS, MES, MEC and UN-Habitat
3	Multi-hazard assessment as a country report for natural disasters	2015	AHA Center and JICA
4	Earthquake risk assessment of Bago, Taungoo and Sagaing City	2013	MGS, MES, MEC and UN-Habitat
5	Earthquake Risk Assessment of Mandalay	2012	ADPC/DMH/ MEC
6	Multi Hazard Risk Assessment of Rakhine State of Myanmar	2011	UNDP/ADPC/ MES
7	Multi Hazard Risk Assessment of Nargis-affected Area, January	2011	UNDP/ TARU/ INRM/ MSR
8	Hazard Profiling of Myanmar	2009	ADPC
9	Deterministic and Probabilistic Seismic Zoning Map of Myanmar	2008 2012	Myanmar Earthquake Committee
10	Flood Hazard Mapping of Lower Chindwin River Basin	2005	DOH India
11	Flood Risk Assessment for Hpa-An City, ongoing,	2019	DMH, RRD, DUHD, UNDP and UN-Habitat
12	Flood Risk Assessment- Yangon, Mawalamyine and Mandalay -	-	DMH and ADB
13	Flood Risk Assessment of Bago River Basin	2015	University of Tokyo
14	Seismic Risk Assessment of Yangon City	-	-

Annex 4: Multi Hazard Risk Assessment Studies in Vietnam

List of Multi Hazard Risk Assessment Studies in Vietnam			
1.	Development of Coastal Multi-Hazard Mapping, Vulnerability & Risk Assessments and Investment Framework for Coastal Interventions Coastal Communities in Vietnam	2018	ICEM
2.	Multi-hazard assessment as a country report for natural disasters	2015	AHA Center and JICA
3.	EO Support to Multi-Hazard Vulnerability Assessment in Ho Chi Minh (Vietnam) and Yogyakarta (Indonesia)	2011	ESA
4.	Synthesis Report on Ten ASEAN Countries Disaster Risks Assessment	2010	UNISDR/World Bank
5.	Key Indicators for Asia and the Pacific 2012 43rd edition	2012	ADB ASEAN (10 countries)
6	Progress Report on Flood Hazard Mapping in Asian Countries ICHARM Publication No.16, ISSN 0386-5878/ Technical Note of PWRI No. 4164	2010	UNESCO (ICHARM)/PERI
7	A Primer: Integrated Flood Risk Management in Asia 2	2005	Asian Disaster Preparedness Center (ADPC)/UNICEF
8	Climate Change Vulnerability Mapping for Southeast Asia	2009	Economy and Environment Program for Southeast Asia (EEPSEA)
9	Reducing Vulnerability and Exposure to Disasters the Asia-Pacific Disaster Report 2012	2012	ESCAP/UNISDR
10	Advancing Disaster Risk Financing and Insurance in ASEAN Countries: Framework and Options for Implementation, Volume2: Appendix 1	2011	GFDRR/World Bank
11	Flood Risk Management in the Border Zone between Cambodia and Vietnam	2009	The Mekong River Commission Secretariat
12	Program for Hydro-Meteorological Disaster Mitigation in Secondary Cities in Asia (PROMISE) 2005 to 2010	2011	Asian Disaster Preparedness Center (ADPC)
13	Flood Hazard and Risk Assessment of Hoang Long River Basin, Vietnam	2010	Water Resources University, Nakhon Pathom Rajabhat University (MIKE by DHI conference)

List of Multi Hazard Risk Assessment Studies in Vietnam			
14	Flood Vulnerability Assessment of Downstream Area in Thach Han River Basin, Quang Tri Province	2010	Hanoi University of Science, Cietnam National University
15	Global assessment report on disaster risk reduction (2009) Risk and poverty in a changing climate	2009	United Nations International Strategy for Disaster Reduction Secretariat (UNISDR)
16	VIETNAM: Natural Hazard Risks	2011	United Nations Office for the Coordination of Humanitarian Affairs Regional Office for Asia and the Pacific (OCHA-ROAP)
17	From Disaster to Reconstruction: A Report on ADB's Response to the Asian Tsunami	2005	Asian Development Bank
18	Holocene Eruption and Selected Volcanoes in Asia-Pacific	2011	United Nations Office for the Coordination of Humanitarian Affairs, Regional Office for Asia Pacific (OCHA -ROAP)
19	Overview of Early Warning in Cambodia, Indonesia, Lao PDR, Philippines and Vietnam	2002	Asian Disaster Preparedness Center
20	The Economics of Climate Change in Southeast Asia: A Regional Review	2009	UNESCO (ICHARM)/PERI
21	Weathering the Storm: Options for Disaster Risk Financing in Vietnam	2011	World Bank
22	Natural Disaster Hotspots: A Global Risk Analysis	2005	World Bank
23	Disaster risk management programs for priority countries - 2nd edition	2011	UNISDR (united nations office for disaster risk reduction)
24	Completion Report of Emergency Rehabilitation of Calamity Damage Project in Vietnam	2009	ADB
25	Geo-Information Technology for Hazard Risk Assessment - Vietnam	2009	ADB
26	Project for Building Disaster Resilient Societies in Central Region in Vietnam	2009	JICA
27	Climate Change Vulnerability Mapping for Southeast Asia	2009	Economy and Environment Program for Southeast Asia (EEPSEA)