

Development of Medium- to Long-Range Hydrologic Forecasting  
System for Ganges-Brahmaputra-Meghna River Basins

# Improvement Plan for Developing an Integrated Dissemination System in Bangladesh



# 1. Introduction

Early warning system is critical in disaster risk reduction and management and climate change adaptation because it could decrease lots of damages that could be included from various disasters. Early warning system is to monitor, forecast and predict natural hazardous events. In addition, it has to assess the risk of the event and deliver appropriate information to people residing in the prone areas to make them take proper actions<sup>1</sup>. Due to its increasing importance, it has been selected as one of the seven priorities in the Sendai Framework for Disaster Risk Reduction 2015–2030 by the United Nations Office for Disaster Risk Reduction (UNDRR). These days, as an effort to make the dissemination of warnings to the community more effective, the importance of digitalization and mobile technologies have increased<sup>2</sup>.

Community centred early warning system can be described of four major components<sup>3</sup>: understanding the risk of the disaster; monitoring, analysing, and forecasting the risk and impact; disseminating and communicating the alerts and warnings to the community populations; and capacities of local communities to take proper actions to the warnings. Effective early warnings could be delivered when all these four components are sufficient. Risk knowledge refers to collect the data systemically and analysis of the risk with mapping the flood risks. Risk analysis includes identification of exposures toward the flood risk and vulnerability such as assets and populations that are to be affected by the flood. The monitoring and forecasting is to observe and detect the hazards of the flood and provide the forecasts and warnings using the hydrological models with observed data. Warning Dissemination is to deliver adequate information and early warning messages to the populations that are under the risk. These warning messages should include information such as actions that have to be taken. The warnings should also be delivered in timely manner in order to give time to take those actions. Preparedness and Response Capabilities refers to create and implement both national and local level response plans to minimize the impacts of the flood and navigate the government to take proper and effective measures.

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<sup>1</sup> United Nations Office for Disaster Risk Reduction. (n.d.). “Early Warning System”

<sup>2</sup> UNDP. (2019). Five approaches to build functional Early Warning Systems.

<sup>3</sup> United Nations Office for Disaster Risk Reduction and World Meteorological Organization (2023). Global Status of Multi-Hazard Early Warning Systems

Bangladesh, one of the countries with the highest vulnerability to the climate change induced natural disasters, have put lots of efforts to develop their early warning systems and dissemination systems toward the general publics in all the regions. From this report, current status of Bangladesh's early warning and dissemination system would be analysed based on the comparison with other countries' cases and literature reviews. After the analysis, the improvement plans would be provided to be suggested to the stakeholders and policy makers.

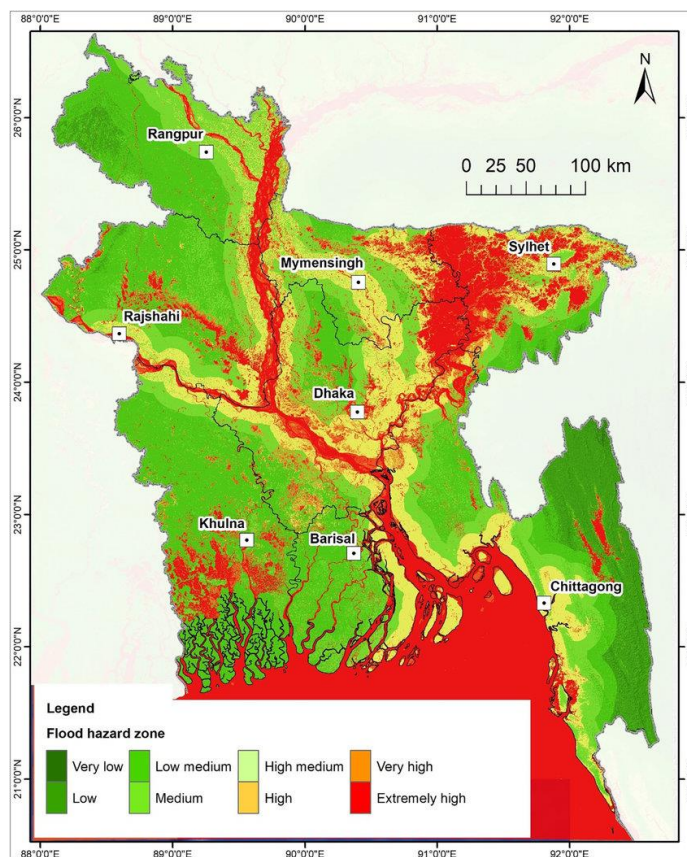


Figure 1 Flood Hazard Map of Bangladesh (Uddin & Matin, 2021)<sup>4</sup>

<sup>4</sup> Uddin & Matin. (2021). Potential flood hazard zonation and flood shelter suitability mapping for disaster risk mitigation in Bangladesh using geospatial technology

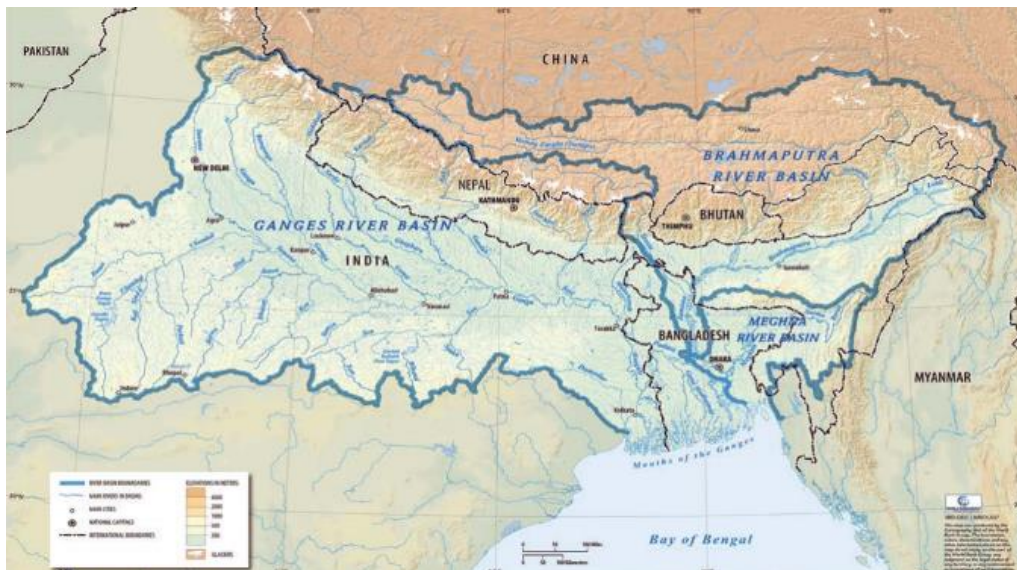
## 2. Integrated Dissemination System of Bangladesh

### 1) General Characteristics of Bangladesh

Bangladesh has a tropical monsoon climate, and it makes the country with high variability in annual rainfall, temperature, and humidity. Historically, the average temperature of Bangladesh is approximately 26°C, with annual variations ranging from 15°C to 34°C. The winter in Bangladesh is somewhat mild summer is hot and humid. Geographically, it is located on the northern coast of the Bay of Bengal, where numerous rivers traverse, which makes the country highly vulnerable to a variety of climate events, including monsoons, cyclones, and floods. During the monsoon season, which runs from June to October, approximately 80% of the annual rainfall falls into the landscape. Even though this rainfall is crucial for agriculture, but also often causes widespread flooding which affect more than half of its landscape under the risk of inundation. During the dry season of November to April, the precipitation and the temperature are low with occasional mild to moderate cold. This climate supports abundant biodiversity and fertile land, but it also poses important challenges, especially in terms of water management, agriculture, and disaster preparedness. Bangladesh's vulnerability to climate-induced risks, such as extreme flood and cyclones, highlights the importance of effective flood forecasting and warning systems to mitigate its impact on communities and agriculture. Flood risks in Bangladesh are increasing along with worsening vulnerability to natural disasters, and poverty, environmental destruction, population growth, rapid urbanization, weak governance, and climate change are fuelling these dangerous trends.

The Ganges-Brahmaputra-Megna (GBM) River Basin is one of the most important river systems in the world, covering regions spanning several countries, including India, Nepal, Bhutan, Bangladesh, and eventually joins and flows into the Bay of Bengal, where it plays a critical role in the region's livelihoods, agriculture, and economy, supporting a population of hundreds of millions of people. In addition, the river basin experiences the same monsoon climate as other regions, and precipitation patterns are essential for the region's economy, but the climate and the heavy precipitation also could be a risk factor that can cause massive annual floods, resulting in loss of life and damage to infrastructure, housing, and crops. The management of the GBM River Basin involves complex cross-border water governance issues, given the number of countries through which the river flows and

the diverse needs and priorities of these countries. Cooperation between countries, which is essential for socioeconomic development and environmental sustainability



**Figure 2. The Ganges-Brahmaputra-Meghna River Basins (World Bank, 2017)**

in the region, is critical for sustainable water resource management, flood control, and ensuring the ecological health of river systems

## **2) Development of the Bangladesh Flood Prediction and Warning System**

The Bangladesh Water Development Board (BWDB) has been taking both structural and non-structural measures at the forefront of flood management for last decades. Through the Flood Forecasting and Warning Center (FFWC), established in 1972, Bangladesh has been providing various hydrological services, including flood forecasting which is also one of the important roles they play. The systems have been developed over time.

In the early stages of flood forecasting (1972-1988), the initial forecast was carried out by tracking real-time data at 11 gauge points. Simple methods such as inter-gauge correlations and Muskingham-Cunge were used at this stage. Since 1981, with the support of the World Meteorological Organization (WMO) and the United Nations Development Program (UNDP), operations and hydrological databases have been simplified. As a result, flood forecasting for the floods occurred in 1987 and 1988 was developed to be quite accurate. Following these catastrophic floods, the development of numerical model-based forecasts had been driven, and the Danish

Hydrographic Laboratory (DHI) collaborated with the WMO to develop national models. Several models were used in subsequent years such as MIKE 11 modelling (1989-1991) and 48-hour deterministic forecasts (1991-1995). As the number of real-time forecast sessions increased, the flood forecasting model was further upgraded under the Bangladesh Flood Action Plan (1995-1999), improving the accuracy of the forecasting model and adding Geographic Information System (GIS) modules to the model. When this flood forecasting system showed effective results in a severe flood occurred in 1998, expansion plan of forecasting system was driven for the better actions. In addition, this flood event led to the needs of longer lead times, regional forecasts, and better community support. FFWC has improved accuracy and lead times for the flood forecasting, expanded its reach to all flood-prone areas, and supported to strengthen community-level information distribution and build sustainable institutions. As a result, data from the European Center for Medium-Term Forecasts were used in 2004 to extend the deterministic forecast to the 3-day forecast and the probabilistic forecast to the 10-day forecast (mid-term).

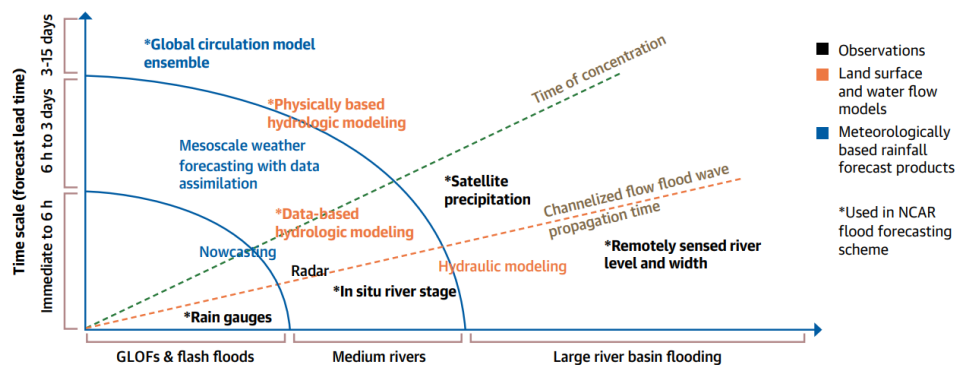
The concept of the model emerged in the second phase of the 2012 Integrated Disaster Management Program. The key to this approach is to utilize the development of numerical weather modelling and ensemble prediction and Flood Forecasting and Warning Center (FFWC) used a Weather Research Forecast (WRF) model to predict precipitation. The model itself used quantitative precipitation to generate deterministic flood forecasts with an extended lead time from 3 days to 5 days.

Flood warning in Bangladesh is disseminated by the Bangladesh Flood Forecasting and Warning Center (FFWC) and the warning messages are spread through various channels such as phone, SMS, and internet. The FFWC website provides daily updates on flood forecasts, and an interactive voice response system has also been developed, allowing anyone to receive short messages about current flood information by calling 1090, giving immediate access to critical data. However, there still need to be improvement on early warning systems to ensure the safety of the populations in the community. In particular, the current flood forecast does not provide a regional flood-based flood forecast, so there is a limit to the forecast for a specific region. In addition, the flood maps provided by the Meteorological Administration are based on existing Digital Elevation Models (DEMs), requiring updated high-resolution DEMs to be included to increase the accuracy of the flood maps. While 10-day flood forecasts help with immediate preparedness, long-term

forecasts play an important role in agricultural planning and resource management. With the development of numerical modelling, access to seasonal weather forecasts has been increasing, and it is necessary to apply these long-term forecasts to effectively manage water resources.

### 3) Ganges-Bramaputra-Megna (GBM) River Basin

Flood forecasting in the GBM basin requires consideration of the different types of flood that may occur in the region such as sudden flood which have relatively small scale, but short-lived, and large scale flood that lasts for the longer period over a wider area. Different tools are used depending on the type of flood as follows<sup>5</sup>.



**Figure 3. Forecasting Tools and Methods for Different Types of Floods (World Bank, 2017; modified from Hopson et al., 2015)**

Although each country belonging to the GBM has different flood forecasting and monitoring methods and requirements, various cooperation between countries is being promoted to strengthen flood management<sup>6</sup>.

The end-to-end early warning system would help local residents at risk of flooding by reducing losses from flooding. The core components of end-to-end flood forecasting and early warning systems are instructed below:

- Risk assessment: Identify and map the location of physical assets with people vulnerable to flood impacts

<sup>5</sup> World Bank Climate Change Knowledge Portal. (accessed 2023). <https://climateknowledgeportal.worldbank.org/country/bangladesh/climate-data-historical>

<sup>6</sup> Priya et al. (2017). Flood Risk Assessment and Forecasting for the Ganges-Brahmaputra-Meghna River Basins. © World Bank, Washington, DC. <http://hdl.handle.net/10986/28574>

- Real-time monitoring: Continuously monitor rainfall and water levels to collect and distribute data
- Flood forecasting: Predict future water levels with potential flood coverage and duration using weather forecasts and monitoring data  
Warning: Analyse flood forecasting to identify possible impacts and generate alerts
- Radio and communication: Broadcast accurate, authoritative, and specific advice to help individuals make informed decisions
- Preparedness and Response: Community Support to Reduce Flood Damage and Promote Recovery Efforts
- System Assessment: Review the effectiveness of the flood forecast & warning system, integrate stakeholder feedback, learn from successful strategy identification and experience, suggest improvements

Understanding the risk of the flood is critical to managing and adapting to flood risk<sup>7</sup>. Making wise decisions to reduce flood damage requires a clear understanding of who and what is at risk. Risk assessment is conducted by using various tools to estimate how a flood can affect valuable assets such as people, buildings, roads, and crops. This information can help prioritize targeted measures such as flood mitigation measures and early warning systems.

Recently, the Ganges River basin has received a comprehensive flood risk assessment for the first time in the region. The decision was made because the Ganges River basin has a history of devastating floods that have caused enormous economic losses and human casualties, and its data availability is relatively high compared to other areas. The assessment is made with a series of maps and tables showing the different areas and assets at risk of river flooding. Detecting and predicting flood risk is at the heart of an early warning system designed to protect people. Using these tools together, we can draw a full picture of the flood risk across the Ganges River basin, which will help us estimate the magnitude of the damage caused by the flooding.

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<sup>7</sup> NASA (2015). Bangladesh to use SERVIR satellite-based flood forecasting, warning system. Climate Change: Vital Signs of the Planet. <https://climate.nasa.gov/news/2251/bangladesh-to-use-servir-satellite-based-flood-forecasting-warning-system/>

In 2015, the Bangladeshi government released a newly developed flood forecasting and warning system by SERVIR. The system, which uses data from the Jason-2 satellite, has succeeded in increasing the lead time for flood alerts, helping to protect lives and property. The Bangladesh Water Resources Development Board plans to expand the use of the system to other parts of Bangladesh (NASA, 2015).

#### **4) Flood Forecasting in Bangladesh**

In 1972, Flood Forecasting and Warning Service (FFWS) of Bangladesh was established under Bangladesh Water Development Board (BWDB) as a permanent entity<sup>8</sup>. When the country suffered from the flood during 1987 and 1988, the importance of forecasting and delivering warning messages through hydro-informatics and geo-informatics technologies increased. After the severe impact of flood in 1998, the project called 'Consolidation and Strengthening of Flood Forecasting and Warning Services' was raised with the support of Danish International Development Agency to improve the forecasting capacity of the FFWS and Flood Forecasting and Warning Centre (FFWC).

In the beginning of the century, FFWC and Bangladesh Disaster preparedness Centre (BDPC) implemented 'People Oriented Flood Warning Dissemination Procedure' with the assistance of Danish International Development Agency. Through this project, telephone and fax were selected as the major disseminating media source for flood early warning to the district and upazila (sub-district) level. For disseminating the message to the union and village level, police of the village and Ansar Village Defence Party manually delivered the warning message to community members. After cell phones became prevalent among the populations, text message became the major disseminating medium for the flood early warning under 'Community Flood Information System (CFIS)' project which was implemented by River Technology Institute (RTI), Center for Environmental and Geographic Information Services (CEGIS) and BDPC with the assistance of United States Agency for International Development (USAID). In addition, with the collaboration with

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<sup>8</sup> Flood Forecasting and Warning Centre (FFWC). (2016). Annual Flood Report 2016. <http://www.ffwc.gov.bd/images/annual16.pdf>

Teletalk, a state-run mobile operator in Bangladesh, the government of Bangladesh disseminated flood early warning to the flood prone region in Shirajganj district.

During 2013-2014, for the intention of improving the dissemination mechanism of FFWC, they developed their website under the 'Comprehensive Disaster Management Program II'.

Regardless of efforts to improve the flood forecasting capacity of the institutions, the way of warning dissemination to the end users still needs to be improved. According to the study which analysed the response of populations in flood-prone regions by FFWC and CSFFWS, the current status of the warning communication and dissemination is insufficient. For instance, the current lead time for the dissemination is 60 hours and it is not enough to take adequate actions. In addition, the dissemination has been prepared using the technical terms to the national level, not for the community level. For instance, Hosen (2019) interviewed key informants and early warnings were understandable only for the several groups of stakeholders on flood. Also, due to the lack of coordination among related organizations, warning messages were not properly or timely delivered to the community members in the floor-prone areas. To improve this system, community members should participate and give feedback regarding the system.

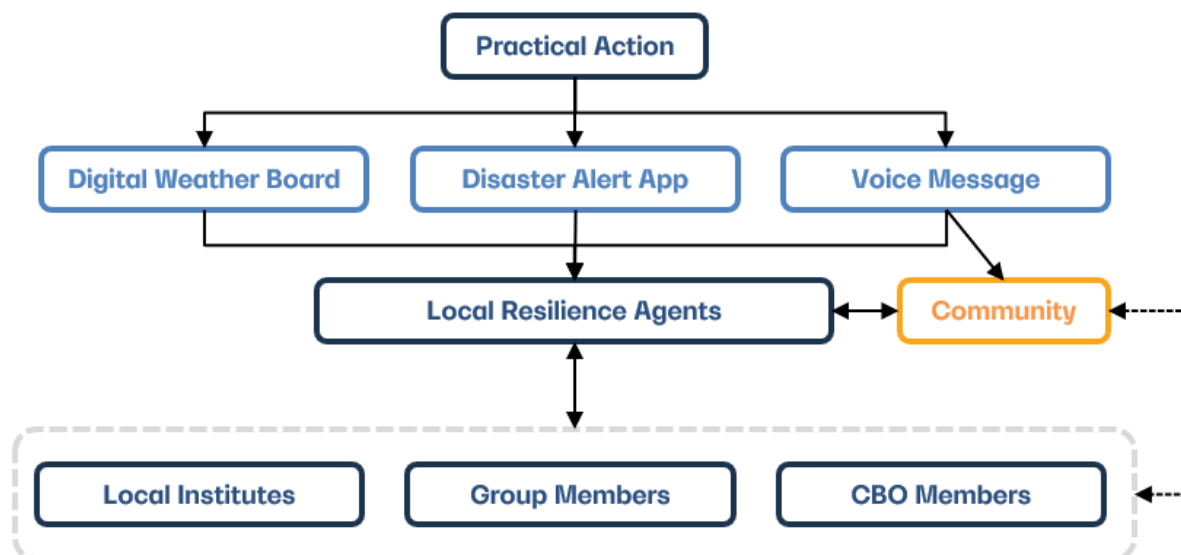


Figure 4 Dissemination of Flood Warning in Bangladesh (Practical Action, 2022)<sup>9</sup>

<sup>9</sup> Practical Action (2022) Practical Action's Approach to Localized Flood Early

### **3. Global Integrated Dissemination System**

#### **1) Integrated Dissemination System in South Korea**

The average annual temperature in Korea has risen by about 1.8 degrees over the past 106 years (1912-2017), and the polarization of precipitation has intensified. In the second half of the 21st century (2071-2100), the amount of annual precipitation on the Korean Peninsula is expected to increase by 5.5 to 13.1% compared to 1981-2010.

In order to effectively respond to changes in climate change, economic and social conditions, the government establishes the first Master Plan for National Water Management (2021-2030) according to the needs of a new water management plan to establish a sustainable water management system. This is the top-level water-related national plan that encompasses water management plans for each field, and is established by the Minister of Environment every 10 years based on Article 27 of the Water Management Act, and changed every 5 years in consideration of changes in conditions, etc. In addition, a basic national water management plan should be established after deliberation by the National Water Management Committee. The plan includes 14 contents such as the basic goals and direction of the national water management policy, matters related to the mitigation and prevention of disasters caused by flood and drought, and measures to respond to the vulnerability of water management due to climate change.

Regarding the establishment of a water disaster safety system among the basic national water management plans, the government aims to minimize damage to the people even if there is a drought & flood that has not been experienced until 2030. It presents strategies such as strengthening infrastructure flood safety and expanding investment in prevention, establishing an extreme flood response system to climate change, and upgrading the flood forecast system. The strategy to strengthen infrastructure flood safety and expand investment in prevention was divided into dams, rivers, and reservoirs to prepare tasks, and includes improving dam management regulations reflecting improvements in each flood response step, improving operation manuals for each dam, and establishing a simulation system and AI-based decision-making support system that visualizes the flood transmission process. It also proposes to significantly expand support for flood warnings in rivers,

expand rainfall radars, and strengthen functions dedicated to flood forecasting as detailed tasks of the strategy to advance the flood forecast system, and to accurately and quickly deliver information on flood occurrence to expected areas<sup>10</sup>.

The Korean government started the flood risk map production project in 2001 and has been providing flood risk maps produced through the Flood Risk Map Information System since 2021<sup>11</sup>. The flood risk map is a map showing the extent and depth of flooding in the surrounding areas of the river under the assumption that extreme conditions such as the collapse of the embankment and the overflow of the embankment occur due to flooding exceeding the design frequency of the river control. It is also basic information for flood preparation that can be used to produce disaster maps by local governments, provide basic data on flood-related insurance, and establish measures to prevent flooding. There are two types of flood risk maps: an urban flood map that shows the expected area of flooding caused by river inundation, the range of damage, and the expected depth of flooding; and a river inundation map that shows the extent of flooding and the depth of flooding under conditions assuming capacity excess and failure of excellent exhaust facilities such as rainwater pumping stations and rainwater reservoirs

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10 Ministry of Environment of South Korea(2022), Master Plan for National Water Management (2021~2030)

11 Flood Risk Map Information System(<https://floodmap.go.kr/public/publicIntro.do>)

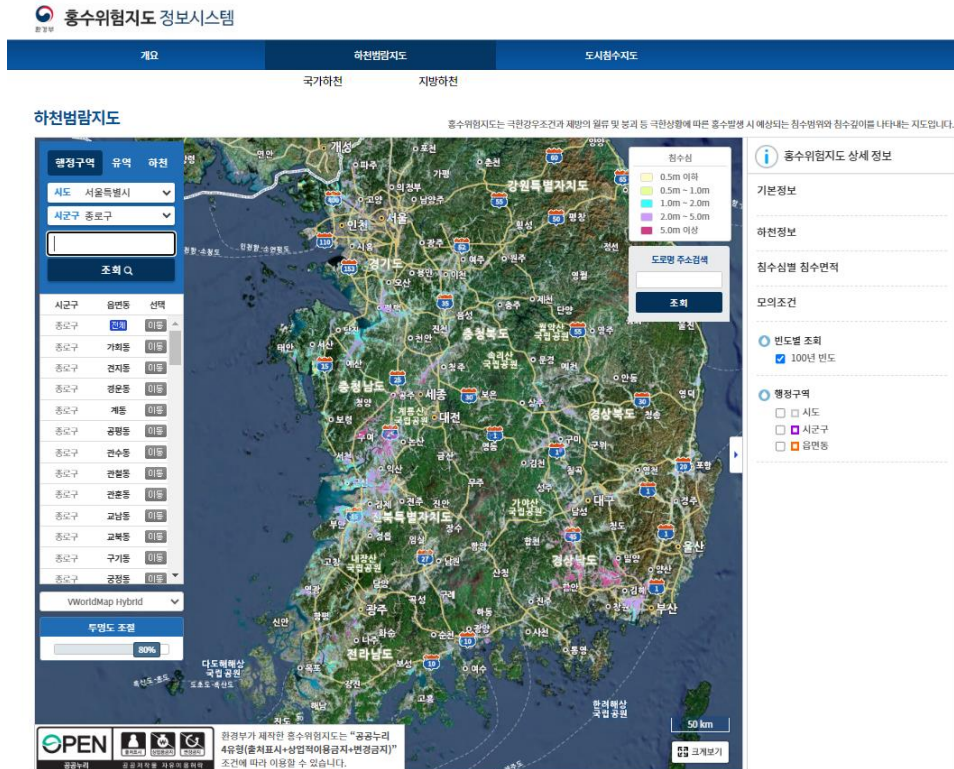


Figure 5 The Image of River Inundation Map (Flood Risk Map Information System)

The Ministry of Environment is pushing to expand the number of flood warning points from 75 to 223 from May 2024, and operate a flood forecasting system using artificial intelligence (AI) based on big data to quickly analyze whether the flood has occurred at the flood warning points. The artificial intelligence flood forecasting system is a system that automatically analyzes flood levels every 10 minutes using artificial intelligence, verifies them using physical models, and issues special reports when dangerous conditions are expected<sup>12</sup>. Starting in May, the Ministry of Environment plans to provide customized flood information to residents near the flood warning point by sending safety information about their location and areas of concern about flooding to residents near the flood warning point, and guiding vehicle drivers entering the area to navigation starting in July. In addition, the Han River Basin Management Committee suggested the establishment of a digital twin-based AI flood forecasting system and a deep-sea rainwater tunnel through the 1st Hangang River Basin Management Comprehensive Plan (2021-2030). Due to the increase in the frequency of torrential rain and the expansion of impermeable areas due to

12 Han River Basin Management Committee (2024) The First Master Plan for Han River Basin Water Management (2021-2030)

urbanization, the problem of flooding low-lying areas due to temporary surge in rainwater flowing along the surface is frequent, and the government wants to secure enough golden time with rainfall & river water monitoring using AI techniques and river inundation & urban flooding forecasting that integrates sewage flow measurements.

Since 2023, the Korea Meteorological Administration has operated a 'Cell Broadcasting Services (CBS) of the Korea Meteorological Administration heavy rain emergency disaster text' in the metropolitan area<sup>13</sup>. This is a type of disaster text broadcast that is sent under the Disaster Text Broadcasting and Operation Regulations, and it is a new system to induce immediate safety measures by sending disaster text messages immediately after dangerous weather occurs. The Korea Meteorological Administration's heavy rain emergency disaster text is sent directly to the public when rain with accumulated precipitation of 50mm per hour and accumulated precipitation of 90mm per hour is observed, and when very strong rain with accumulated precipitation of 72mm per hour is observed to secure time to prevent damage. The disaster text is subdivided into units of Eup, Myeon, and Dong and there is a difference in that it warns only people in the area where dangerous situations have occurred. From May 2024, an expanded pilot operation will be conducted in Gwangju, and Jeonnam area.

## **2) Integrated Dissemination System in Japan**

Japan is one of the countries in East Asia and due to its location and its East Asian Monsoon climate, the country has been facing frequent typhoons annually is highly vulnerable to the flood<sup>14</sup>. When these disasters occur, the national and local governments collect and share the related information and take emergency actions to rescue impacted populations.

From the Meiji era, metrological observations have been undertaken and after the Typhoon Muroto in 1934 set the foundation of meteorological services for flood forecasting. Flood Control Act was established and developed throughout the history to cover more rivers in the country and implement plans for preparing and responding disasters.

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<sup>13</sup> Korea Meteorological Administration (2024)

<sup>14</sup> UNDRR (2023) Predicting and managing flood risks from extreme rain events in Japan

The main stakeholders of flood warning implementation are the Japan Meteorological Agency (JMA), Ministry of Land, Infrastructure, Transport and Tourism (MLIT), prefectural government, and municipalities. When the flood is expected, JMA informs the MLIT and populations using media. When the warnings are issued, it is delivered to prefectural government, then to the municipal offices by radio and fax. Depend on the level of the events, proper actions are taken and if required, evacuation information is issued.

Municipalities are in charge of managing the historical disaster data and collecting disaster information. Even though it is their responsibility to assess the vulnerability and exposure to the hazards, if the level of capacity of the municipality is not sufficient to do so, they could request to prefectural government for the supports<sup>15</sup>. When the level of hazard such as water levels and expected inundation areas is assessed from the municipality, they disseminate the information and the messages to the residents.



**Figure 6 Flood Hazard Map in Kurihashi town, Japan (Sugiura, n.d.)**

When hazardous weather events are expected, the Emergency Warnings, Warnings, Advisories and Bulletins are issued by Japan Meteorological Agency (JMA) to mitigate the negative impacts of these events<sup>16</sup>. Local Meteorological Offices (LMOs) delivers the messages to their respective prefectures and emergency warnings are created when the level of the events are expected to be meet the

<sup>15</sup> Cao et al., (2024) Current status and challenges in operating flood early warning systems at the local level in Japan

<sup>16</sup> Japan Meteorological Administration (n.d.) Forecast Services

relevant criteria. When these messages are issued, the advisory plan and actions are followed. For the bulletins, it could be also issued by Regional Headquarters (RHs) of JMA or JMA Headquarters depends on the severity of the events.

For disseminating the warnings to the publics, a telephone auto-answering service is the main service that is utilized by JMA. They are also directly connected with both central and local governments and media. Recently, JMA has introduced Information Network for Disaster Prevention (INDiP) which is the high-speed communications network. It enables the connection between individual LMOs/RHs with JMA Headquarters that it would enable more rapid dissemination of both text and graphic information and warnings. For the maritime users, the information is delivered via JMA radio facsimile broadcast (JMH) service operated by JMA and fishery radio communications.

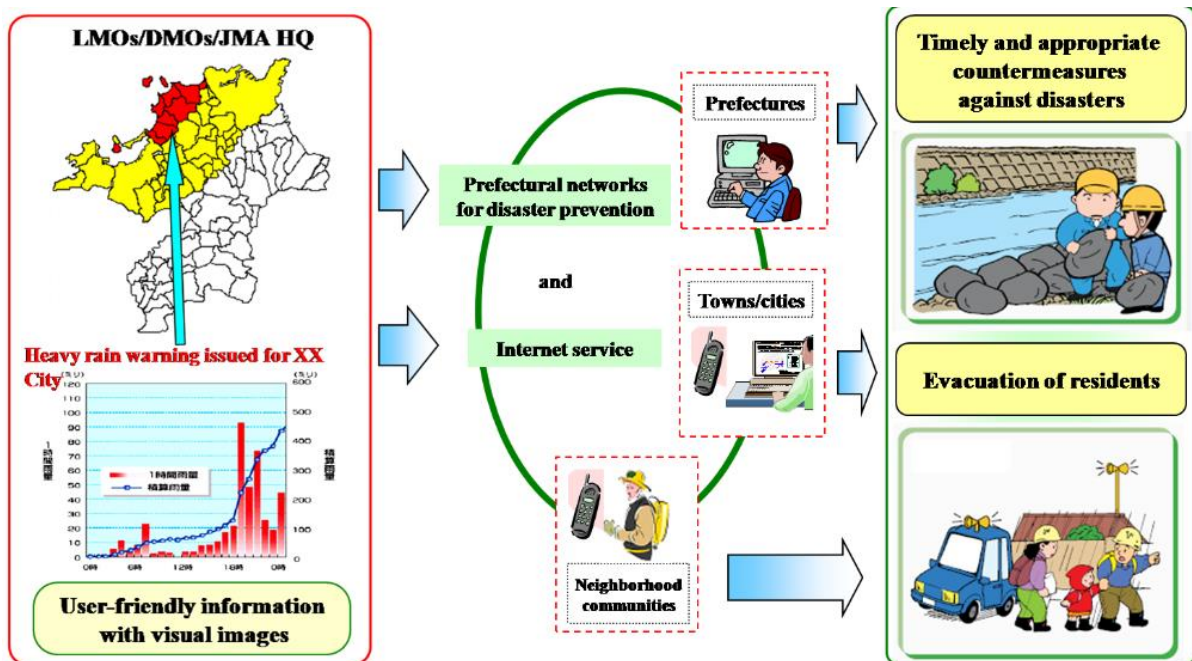


Figure 7 Warning Dissemination Flow in Japan (JMA, n.d.)

### 3) Integrated Dissemination System in The Philippines

The Philippines is among the most natural disaster-prone countries in the world which is ranked above top 10 every year (European Commission, 2022)<sup>17</sup>. The major natural disasters are floods, droughts, typhoons, landslides, earthquakes and volcanic eruptions and the location and the topography of the country put the country in danger. In addition, due to the climate change, the hydrological patterns have been changing and the number and the severity of extreme weather events also have increased (GSMA, 2022a).

Natural disasters have damaged economically and physically, and they even increased the fatality. In order to prepare for these natural disasters, the Philippines have developed early warning systems and have introduced Mobile and digital technologies. For instance, thanks to the early warning systems, even though the intensity of the Typhoon was similar, the loss of life decreased from 6,300 in 2013 Typhoon Haiyan to 400 in Typhoon Rai in 2021(GSMA, 2022b)<sup>18</sup>.

When the severe events are detected by the monitoring agencies of the country, the related information is delivered to the National Disaster Risk Reduction and Management Council (NDRRMC), the main policymaking body. Emergency Operations Centres that are run 24 hours, produce alerts and deliver warnings messages to mobiles and TV through mobile network operators (MNO). In addition, with the support of Google, the warnings could be automatically appeared in Google public alerts.

In Philippines, the mobile network operators are crucial in disseminating and communicating early warnings. These organizations should provide mobile disaster alerts to the populations without any charge based on the Republic Act No. 10639. MNO Globe assumes that around 70% of the populations could be approached with their cell broadcasts and the information for the remaining 30% could be delivered by SMS.

Early warnings are disseminated to the populations and subnational Disaster Risk Reduce and Management (DRRM) councils assess the disaster risks to prepare and support implementations for the further actions. The early warning system in localized level is operated independently from the national level system. Interior and

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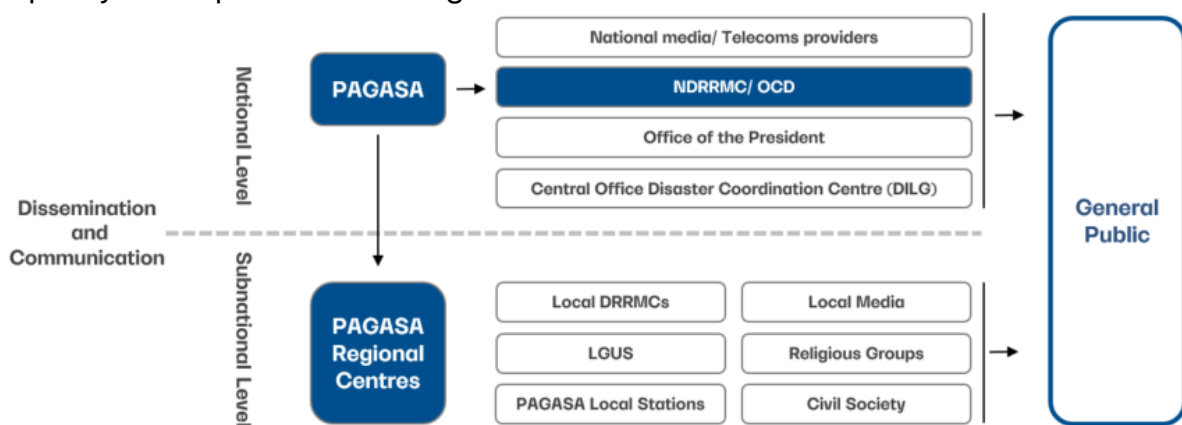
<sup>17</sup> European Commission. (2022). "Country Risk Profile: Philippines". Disaster Risk Management Knowledge Centre

<sup>18</sup> GSMA. (2022). Typhoon Rai Response: The role of the mobile industry

Local Government (DILG) developed guidelines that could support local governments to prepare and adapt to the disaster in timely manner. In addition, private stakeholders such as mobile network operators and community-based organizations are assisting governments to disseminate information and assist community members.

The government of the Philippines operates emergency warning broadcast systems (EWBS) in the Department of Information, Communication and Technology (DICT) to deliver emergency announcements and up-to-date information from the NDRRMC<sup>19</sup>. Cell broadcast, social media, and broadcast via TV and radio supports information, education and communication (IEC) of disaster risk reduction.

As such, even though the country has been putting lots of efforts on advancing the early warning systems to deliver proper warnings to people, there are still delays of warnings from the government and SMS are prone to the congestion. In addition, considering the affordability and usability of the devices, there needs to be an additional technology to transfer the warnings for those who are still not connected. For example, warning dissemination in local level is done through local government through local DRRM councils in both digital (SMS and social media) and non-digital channels (emergency vehicles with megaphones, batingaw (community bell) and church bells). In the rural areas of the country, TV White Space technology are potential technologies that could be utilized in the place where ICT infrastructure or mobile network coverage is still deficient<sup>20</sup>. In addition, the government is trying to enhance the international supports to improve the infrastructure and build the capacity to adopt new technologies in the local communities.



**Figure 8 Key stakeholders in the Philippines’ EWS ecosystem (GSM Association, 2022)**

<sup>19</sup> DICT. (2019). Early Warning Broadcast System (EWBS) Standard Operating Procedures (SOP)

<sup>20</sup> NOMINET. (5 November 2015). “What is TV White Space?”

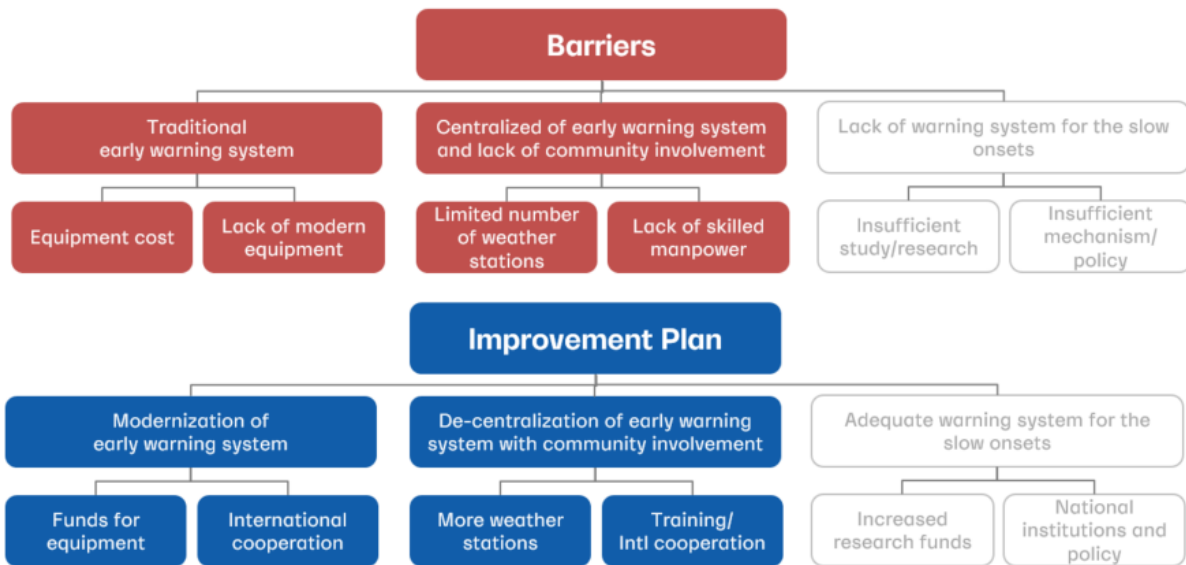
## **4.Improvement Plan of Integrated Dissemination System**

### **1) Barrier analysis**

The barriers that hinder the development of the integrated dissemination system are divided into two categories: financial and non-financial<sup>21</sup>. The financial barrier could be defined as the investment and fundings that are required for modernizing the current systems that could improve the waning dissemination. Non-financial barriers could be divided into capacity, organizational/behavioural and policy/law. Lack of skilled expertise, capacity, and technological information would be capacity barriers. In addition, the lead time it takes for the local community members to receive the warnings need to be shortened that forecasting and analyzing the events and dissemination capacity need to be improved. The organizational/behavioural barriers could be slow adaptation to the modernized warning system of local residents, lack of collaborations among related organizations, and less participation of local participants. In addition, some messages that have been sent to the general publics were not understandable for not educated. Top-down and centralized process was discussed as the barrier in policy and law.

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<sup>21</sup> Government of the People's Republic of Bangladesh (2012) Technology Needs Assessment and Technology Action Plans for Climate Change Adaptation



**Figure 9 Barriers and Improvement Plan in Bangladesh Warning System (Source from Government of the People’s Republic of Bangladesh)**

## 2) Improvement Measures

Improvement measures could also be divided into three categories: technology, dissemination, and international supports.

**(Technology)** Technology measures include fostering technological developments through partnerships with various organizations both in nationally and internationally. In addition, checking and developing the technological capacities for the technical experts are required. In order to do so, capacity building programs and seminars need to be held regularly for the technical experts and stakeholders. The technological areas that need to be addressed are forecasting, analyzing, utilizing and disseminating the related information. This would also decrease the lead time. For the maintenance purpose, regular monitoring of operation of facilities and deployed technologies are required.

**(Dissemination)** Regarding the dissemination measures, as mentioned in other countries cases, the warning messages could be delivered to publics from the Meteorological administrations by themselves directly. It could diminish the time it takes for the general publics to receive the warning messages. In addition, communication system among related organizations also needs to be developed. Promoting the participation of local communities are required for the better actions

on the dissemination. For the better inclusion of local communities and deal with the social barriers, public technology demonstrations are required to make people experience the new technologies and improve the awareness. Last but not least, policies and acts are required to promote smoother transfer of the technologies and warnings. For instance, easier wordings need to be used to make sure all the community members understand the messages regardless of their level of education.

**(International Support)** Increasing investment and funding to the disaster risk reduction area is required. If the barriers are difficult to be addressed by the national authorities by themselves, preparing proposals from international funding sources could be supportive to deliver funding and technological assistance

## 5. Conclusion

Due to its location and its topography, Bangladesh is one of the most flood-vulnerable countries in the world. To address these issues, the country has developed its warning and dissemination systems throughout the history. Bangladesh Water Development Board is in charge of managing the flood and the Flood Forecasting and Warning Center (FFWC) provides flood forecasting. However, the warning and dissemination system still need to be developed because the current lead time is too long to take the timely and proper actions and warning messages are not understandable for not educated.

To address the barriers of the country, the country's current status on the system was analyzed based on the literature review and case studies on three countries, South Korea, Japan, and the Philippines which are countries adjacent to the ocean and suffers from the flood every year were conducted and compared between the system of Bangladesh. Main barriers were insufficient funding and investment to the hydrometeorological field, lack of skilled experts, and it has led to longer lead time for the residents to receive the warning messages.

In order to improve these discussed barriers, technologies and infrastructures need to be improved with capacity building programs. In addition, regarding the dissemination itself, to diminish the lead time, the warnings could be sent from the Meteorological Administration directly with the messages that are understandable for everyone. Political supports would be required to make changes in this field. Lastly, international funding and technical assistances could help the country to demolish the barriers that are not easy to tackle with their own resources.