



POLISI PEMBANGUNAN HIJAU JOHOR

Guidelines

**Flood Early Warning System
Climate Change (Flood Mitigation) Johor**

Guidelines

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Flood Early Warning System Climate Change (Flood Mitigation) Johor



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List of Abbreviations

UNDRR	United Nations Office for Disaster Risk Reduction
APM	Civil Defence Force
CAP	Common Alerting Protocol
GIS	Geographic Information System
JKPB	Disaster Management Committee
JPS	Department of Irrigation and Drainage
JS-SEZ	Johor-Singapore Special Economic Zone
NADMA	National Disaster Management Agency
NaFFWS	National Flood Forecasting and Warning System
UN	United Nations Organization
PBT	Local Authority
POI	Point of Interest
PPS	Temporary Evacuation Centers
PPT	Permanent Evacuation Centers
PRABN	National Flood Forecasting and Warning Program
SMS	Short Message Service
SUK	State Secretary
WMO	United Nations-World Meteorological Organization

1.0

Purpose

This guideline is designed to provide guidance on the types of Flood Early Warning System and the basic methods required to develop an effective early warning system. It also outlines the key components necessary to ensure a community-based early warning system can be fully established.

This guideline covers three (3) types of Flood Early Warning System technologies:

- i. Basic Technology
- ii. Intermediate Technology
- iii. Advanced Technology



2.0

Introduction to Early Warning System

2.1 Definition of Early Warning System

According to United Nation Organization (UN), United Nations Office for Disaster Risk Reduction (UNDRR), an early warning system is an integrated system that includes hazard monitoring, forecasting, disaster risk assessment, communication, activities and processes preparedness. This system aims to enable individuals, communities, governments, organizations, and other stakeholders to take timely action to reduce disaster risks before hazardous events occur.



2.2 Existing Systems in Malaysia

The Department of Irrigation and Drainage (JPS) Malaysia has developed two main systems for flood early warning: the National Flood Forecasting and Warning Program (PRABN) and the National Flood Forecasting and Warning System (NaFFWS). These forecasting programs and early warning systems provide flood predictions up to seven days in advance, with warnings issued 48 hours before a flood occurs. The system utilizes weather forecast data, water levels, and hydrology, focusing on major river basins including Sungai Kelantan, Terengganu, and Pahang as well as 38 major river basins in Malaysia. NaFFWS integrates real-time data from rainfall stations, rain radar, and hydrological models to predict flood-prone areas.

However, a localized system is highly necessary to complement the existing systems developed by JPS and to obtain more accurate flood forecasts for early warning lead time regarding river overflow at specific Points of Interest (POI). This will help ensure more precise and consistent warnings. A more localized system also focuses on smaller river basins, operates at a lower cost, and is more manageable by local authorities for maintenance and implementation.

2.3 Types of Flood Early Warning Systems

The types of Flood Early Warning Systems are categorized based on the level of technology used, namely:

Technologically Basic

Technologically Intermediate

Technologically Advanced

Details on the types of Flood Early Warning Systems are provided in Table 1

Table 1: Types of Technology in the Flood Early Warning System

Technologically Basic	Technologically Intermediate	Technologically Advanced
• Basic method used. • Observations are made using water level data from upstream catchment areas to predict floods. • Does not involve expert services or a flood forecasting center. • Example: Residents in upstream river areas visually monitor water levels and alert downstream communities if there is a sudden rise in water levels	• Limited technical resources are available for a systematic approach to flood forecasting. • Warnings are issued based on the past experience of flood forecasting experts and real-time observations. • Example: Using medium-scale water level and weather monitoring stations to manually monitor both upstream and downstream river conditions, and provide forecasts supported by local experts.	• Involves a sophisticated and systematic approach with adequate technical resources. • Forecasts are made based on hydrological and hydraulic models, as well as telemetric observation systems. • Example: The warning system is supported by complex rainfall and river flow prediction models, with automatic data monitoring from telemetric stations, weather radars, or satellites. Warnings are sent via mobile applications, SMS, and other communication systems.

2.4 Components of Early Warning System

These guidelines focus on **three (3) main components**, namely:

Component 1:

Observation and Forecasting



This component involves flood hazard observation and the provision of early warning services. The main functions of this component include:

- Accurate observation of early warning system parameters.
- Strong scientific foundation for analysis and forecasting.
- Generation of precise warnings delivered at the appropriate time.

Component 2:

Preparedness and Response



This component focuses on the development of response plans by authorities and communities. The main functions of this component include:

- A response plan that is continuously updated and tested.
- Encompassing local capacity and knowledge.
- Community preparedness and response actions to warnings.

Component 3:

Dissemination and Communication



This component focuses on risk communication and the dissemination of early warnings. The main functions of this component include:

- Warnings reach all at-risk communities.
- Community understanding of risks and warnings.
- Clear and useful warning information.

3.0

Functions of Flood Early Warning System

According to the 2023-2027 Executive Action Plan by the United Nations-World Meteorological Organization (WMO), the functions and objectives of the early warning system are as follows:

- Climate change has led to more frequent and extreme weather events. These results in widespread negative impacts, including environmental damage and economic losses for humans.
- Flood early warnings are essential for providing timely information to the public about flood hazards or disasters. This information enables authorities, communities, and individuals to take proactive measures and act early to minimize the impact of flood risks.
- Flood early warnings should also be people-centered, prioritizing those most vulnerable to hazards. Warnings must be timely and delivered in a manner that facilitates quick and effective action.
- Flood early warnings should also promote information sharing and cross-sector collaboration among relevant stakeholders.



The functions of the Flood Early Warning System are summarized in Figure 1.

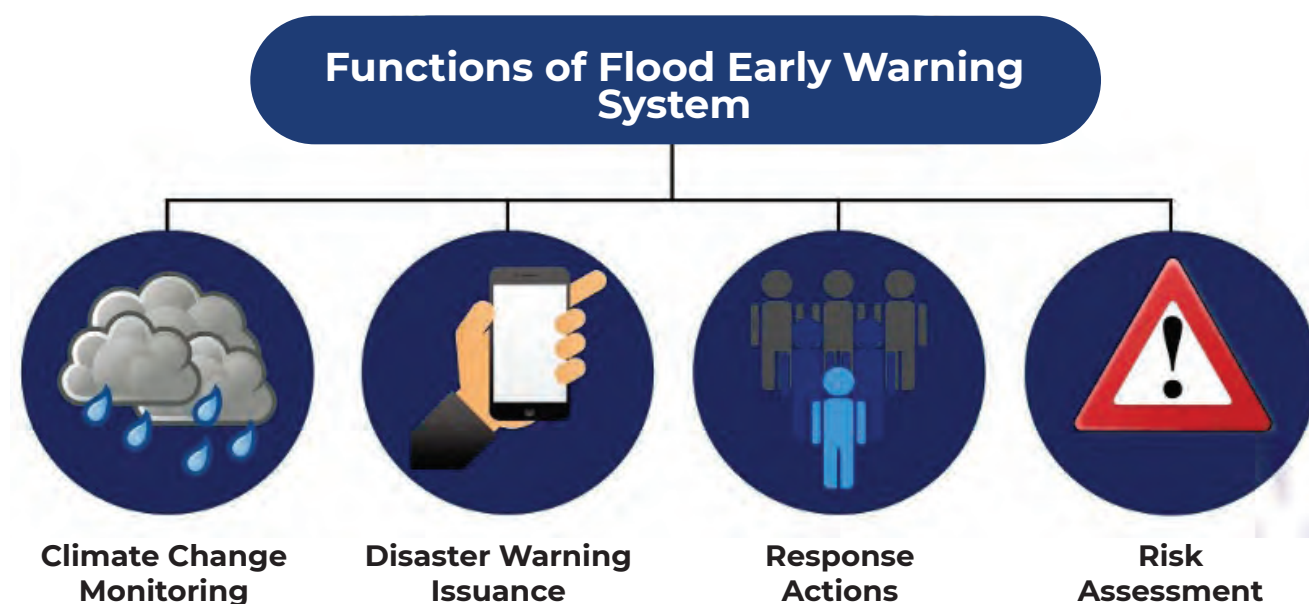


Figure 1: Functions of the Flood Early Warning System

4.0 Guidelines for Flood Early Warning System

According to UNDRR and WMO, flood monitoring and warning services must be based on scientifically sound principles. Based on the components of the early warning system, the key aspects required in the development of a Flood Early Warning System are shown in Figure 2.

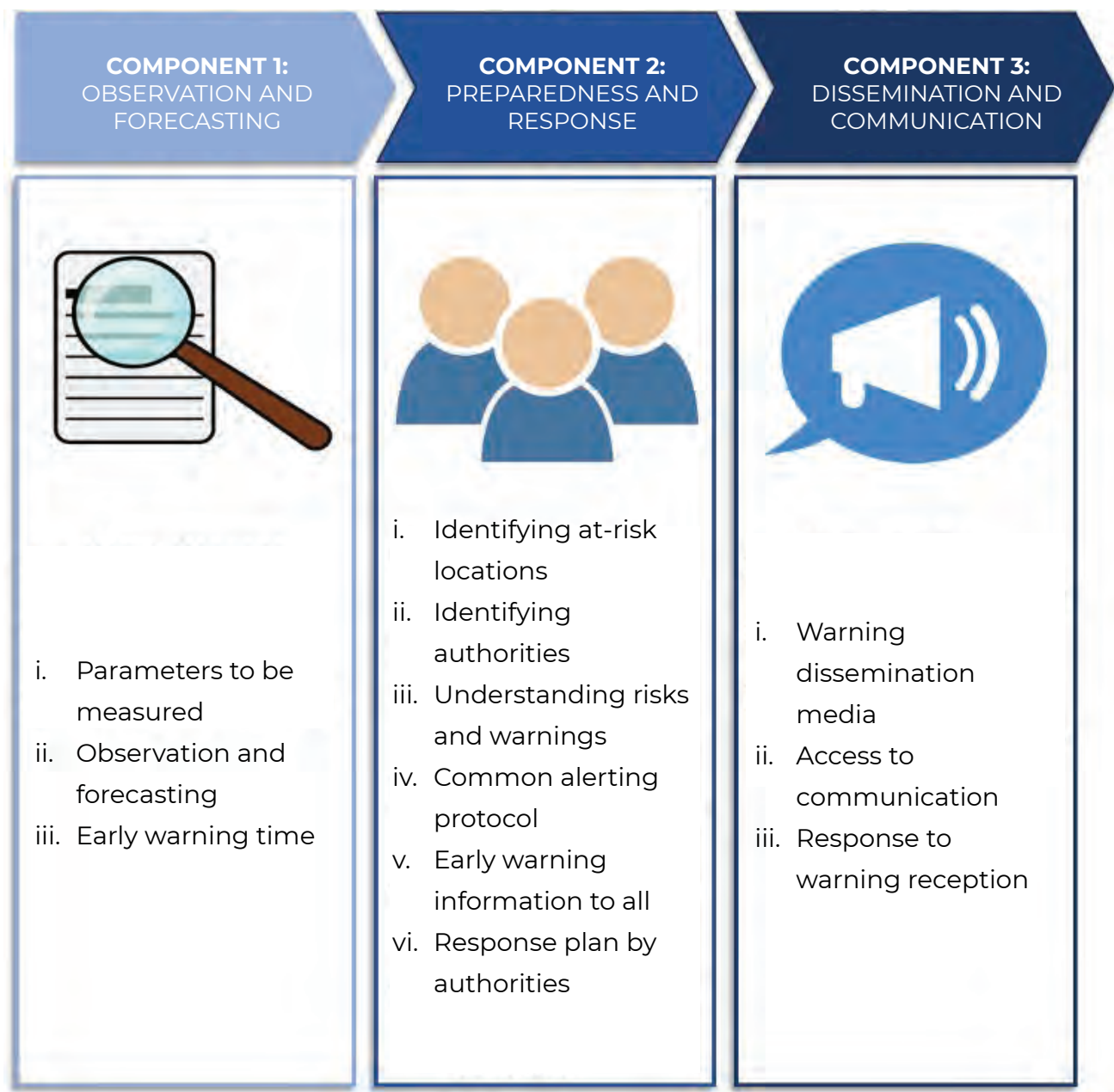


Figure 2: Guidelines for Flood Early Warning System

4.1

Component 1: Observation and Forecasting

Parameters to be Measured

Technologically Advanced	• Rainfall intensity. • River water levels. • Within catchment areas and river drainage networks. • Data is stored and managed using a telemetry system.
Technologically Basic or Intermediate	• Water level data at upstream and downstream of the river. • Drainage system network.
Data Observation Methods	• On-site (ground) observations. • Remote sensing data, considering bias correction.



Monitoring and Forecasting

- The main drivers of the flood forecasting system include hydrological, hydraulic, or hydrodynamic modeling.
- Hydrological modeling uses hydrometeorological data to determine the river peak flow rate in the catchment and the duration of the peak flow.
- Hydraulic or hydrodynamic modeling predicts the peak flow rate and simulates the threshold water level of rivers during a flood event.
- By using geo-referenced river water levels or Geographic Information System (GIS) applications, flood depth maps can be generated to predict flood locations.
- In addition to real-time observations of meteorological parameters, such as rainfall data and upstream river water levels in catchment areas, meteorological forecast data from the Meteorological Department is also used for flood forecasting modeling.

Early Warning Time

- Warning time that is too short for authorities to respond poses a major threat to communities. Therefore, the warning time must be sufficient to allow for effective action.
- In hydrological modeling, the warning time can be estimated by calculating travel time of peak flow from upstream observation location to the warning location.
- However, the warning time may be short depending on the characteristics of the catchment area and drainage system, especially in small areas prone to flash floods.
- Longer warning time is crucial to ensure that the authorities can implement response actions effectively.

4.2 Component 2: Preparedness and Response

Identifying at-risk Locations

- The initial step in flood preparedness is identifying high-risk areas.
- This includes hazard mapping based on historical data, hydrological analysis, and flood simulations.
- Risk mapping should cover hazard zones, exposure elements, and vulnerability factors.
- It also involves identifying critical areas such as residential zones, key infrastructure (hospitals, police stations, schools), and economic sectors (plantations, industrial areas) that are at risk.
- Understanding these risks help in developing targeted action plans and allocating resources more effectively during disasters.

Identifying Authorities

- Authorities responsible for flood response must be clearly identified to ensure each entity understands its roles and responsibilities.
- These include meteorological agencies, local authorities, disaster management bodies, emergency response teams (police, fire department), and healthcare services.
- Clear role assignment ensures efficient communication and coordinated response, preventing confusion during emergencies.
- According to National Disaster Management Agency (NADMA) Directive No. 1, the national disaster management policy and mechanism outline the structure of the Disaster Management Committee (JKPB), as shown in Table 2. The members of this committee consist of various agencies.
- At the district level, the District Officer chairs the JKPB and has the authority to issue response directives.

Table 2: Disaster Management Committee (JKPB) Based on NADMA Directive No. 1

	FEDERAL	STATE	DISTRICT
Chairman	YAB Prime Minister or a Minister appointed by the YAB Prime Minister	State Secretary (SUK)/ Senior Officer appointed by the State Government	District Officer
Secretariat	National Disaster Management Agency (NADMA)	State Civil Defense Force (APM)	District Civil Defense Force (APM)
Role	Formulating policies, developing strategies, issuing directives, and action plans, as well as setting the direction for national disaster management and making improvements from time to time, along with other responsibilities as outlined in the scope of duties under NADMA Directive No.1.	Implementing policies, strategies, directives, action plans, and directions in managing disasters at the state level (assistance to affected districts such as financial aid, assets, and human resources), along with other responsibilities as outlined in the scope of duties under NADMA Directive No.1.	Implementing policies, strategies, directives, action plans, and directions in managing disasters at the district level (coordinating actions, assets, and ensuring adequate human resources, as well as ensuring accurate communication is relayed to the media), along with other responsibilities as outlined in the scope of duties under NADMA Directive No.1.

Understanding Risks and Warning

- The public and authorities must have a clear understanding of the flood risks in their areas and the types of warnings issued. An example of a river water level warning issued by the JPS can be found in Figure 3 on the website <https://publicinfobanjir.water.gov.my/>.
- This includes understanding the meaning and levels of warnings (such as alert, warning, danger), the potential impacts of flooding, and the actions that need to be taken at each warning stage.
- Continuous education and training are essential to ensure that this understanding remains up-to-date and is comprehended by all levels of society.

WATER LEVEL THRESHOLD



Figure 3: River water level warnings by the Department of Irrigation and Drainage (JPS) Malaysia

Common Alerting Protocol

- The Common Alerting Protocol (CAP) is a standard for delivering consistent and uniform warning messages (Figure 4).
- CAP is used to deliver alerts to various parties through multiple channels such as radio, TV, social media, and SMS alert systems.
- This protocol ensures that the information conveyed is accurate, consistent, and easily understood by all parties.
- It also helps prevent any confusion or the spread of inaccurate information, which could hinder rescue efforts.

- It works by entering important information into a standardized form, allowing the authorities to ensure that the warning reaches the public through various media channels with consistent information.
- Key information to be included in the CAP emergency warning:
 1. What is the emergency?
 2. Where is the affected area?
 3. How urgently should people act?
 4. How severe is the impact of this emergency?
 5. What is the experts' confidence level or information accuracy level?
 6. What should the public do?

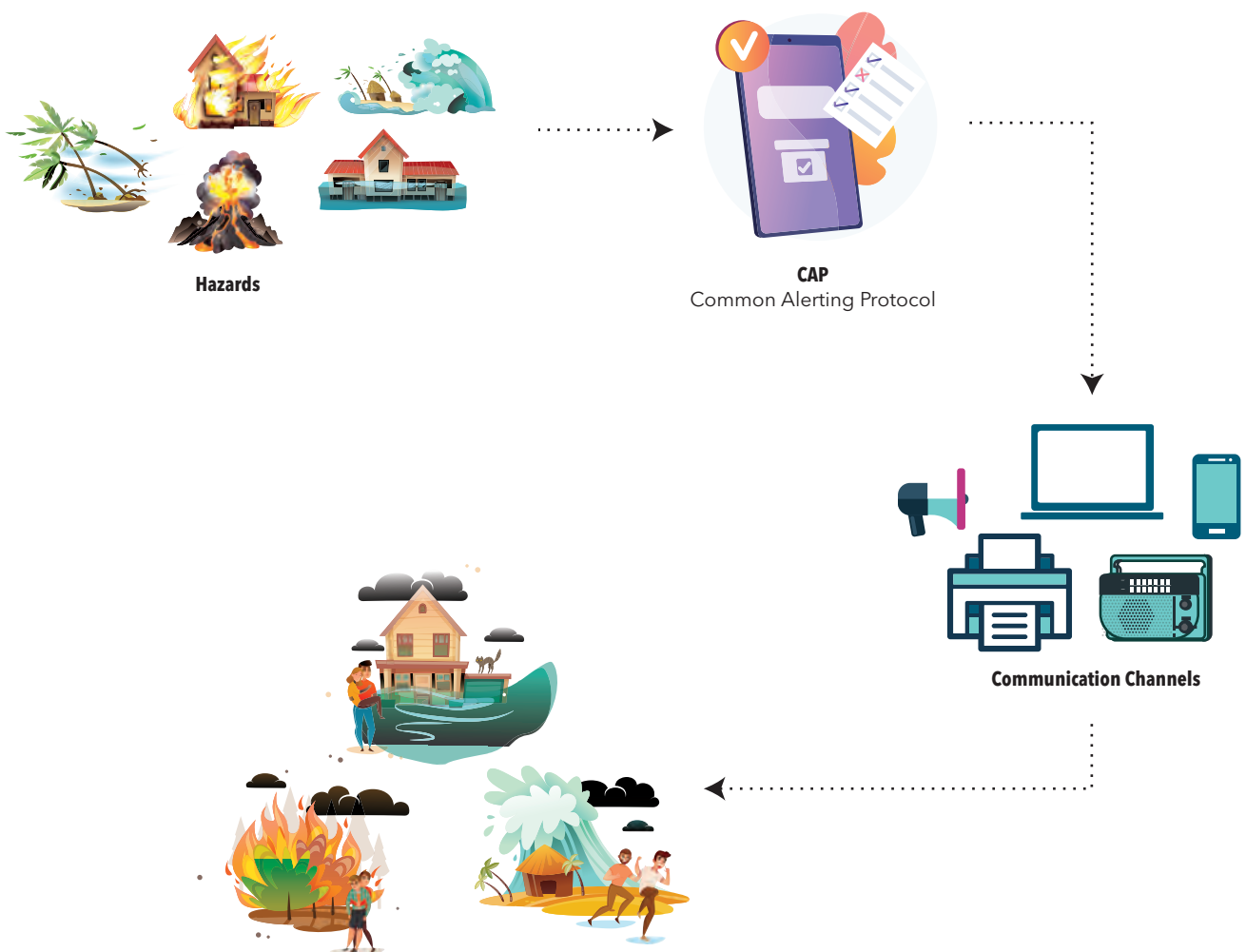


Figure 4: CAP Infographic by UNDRR

Early warning information to everyone

- Early warning systems must ensure that information is disseminated to all populations in risk areas, regardless of geographical location or access to technology.
- This includes using various channels such as warning sirens, electronic signage, smartphone applications, as well as short message service (SMS).
- Ensure that this information is conveyed in multiple languages and formats that are easy to understand, including people with disabilities.
- The effectiveness of information delivery is key in ensuring that every individual receives timely and accurate information and can respond promptly.



Action Plan by The Authorities

- The authorities must have a clear and detailed action plan when a warning is issued. This includes coordinating rescue operations, evacuations, protection, and the management of temporary evacuation centers
- Regular training must be conducted to ensure the readiness and efficiency of all parties involved in real situations.
- Cooperation between agencies, sufficient resources, and clear communication are critical in ensuring a swift and effective response.
- A comprehensive and organized disaster evacuation map is crucial in ensuring that rescue operations and the evacuation of residents to safe locations can be carried out smoothly without any disruptions or additional disasters. The evacuation map should be created with consideration of the entry and exit routes for rescue and evacuation to the Temporary Evacuation Centers (PPS).
- A safety or integrity analysis of the evacuation center locations must also be carried out to ensure that the PPS or Permanent Evacuation Centers (PPT) are protected from disaster risks, taking into account the probability of critical flooding occurring.

4.3 Component 3: Dissemination and Communication

Media for Disseminating Warnings

- Effective dissemination of warnings involves an operational telecommunications system that sends flood warning alerts from the flood warning center to local authorities and to communities who are at risk.
- The media for disseminating warnings include targeted SMS notifications to the public at high risk, TV, radio, websites, sirens, loudspeakers, social media, disaster volunteers, and flood risk management authorities.

Access to Communication

- The dissemination and communication of warnings must take into account the accessibility of communication for the at-risk public.
- An amateur radio system in areas without telecommunications coverage needs to be developed. This system should include well-maintained and prepared amateur radio users and equipment.

Response to Warning Reception

- The reception and response of the community to early warnings are crucial in ensuring the effectiveness of the early warning system.
- Methods to achieve a good response to warning reception include building local capacity by disaster management authorities, which involves:
 1. Systematic training and education
 2. Disaster preparedness plans
 3. Community awareness programs that focus on warning responses.
- The formation of volunteer groups led by the community is essential in supporting efforts to evacuate the high-risk public.
- Conducting public awareness campaigns such as training, seminars, TV and radio advertisements, as well as posters to deliver messages about preparedness and response to warnings.
- Conducting Mock Drills at locations with an operational Flood Early Warning System to test awareness of community evacuation procedures.

5.0

Framework of the Flood Early Warning System in Johor

5.1 Workflow of the Flood Early Warning System

- The Flood Early Warning System framework for the state of Johor should include processes as shown in Figure 5.
- Hydrological observations and monitoring, such as rainfall intensity and river water levels, are the primary data required, depending on the level of technology used in the system.
- Once the observation data is obtained, information processing will take place. If water level threshold values are detected, a flood warning forecast will be issued and displayed at the Flood Early Warning System Monitoring Center.
- A potential flood warning will be issued at the monitoring location and river responsibility center at the Local Authority (PBT) or district level and reported to the state level, as shown in Figure 6.
- Warnings and disaster response actions must be verified and issued by the district officer in accordance with NADMA Directive No. 1. Potential flood warnings will be disseminated through pre-planned channels and follow the existing CAP.
- Authorities, response teams, and communities must act according to the Action Plan once the warning has been disseminated.



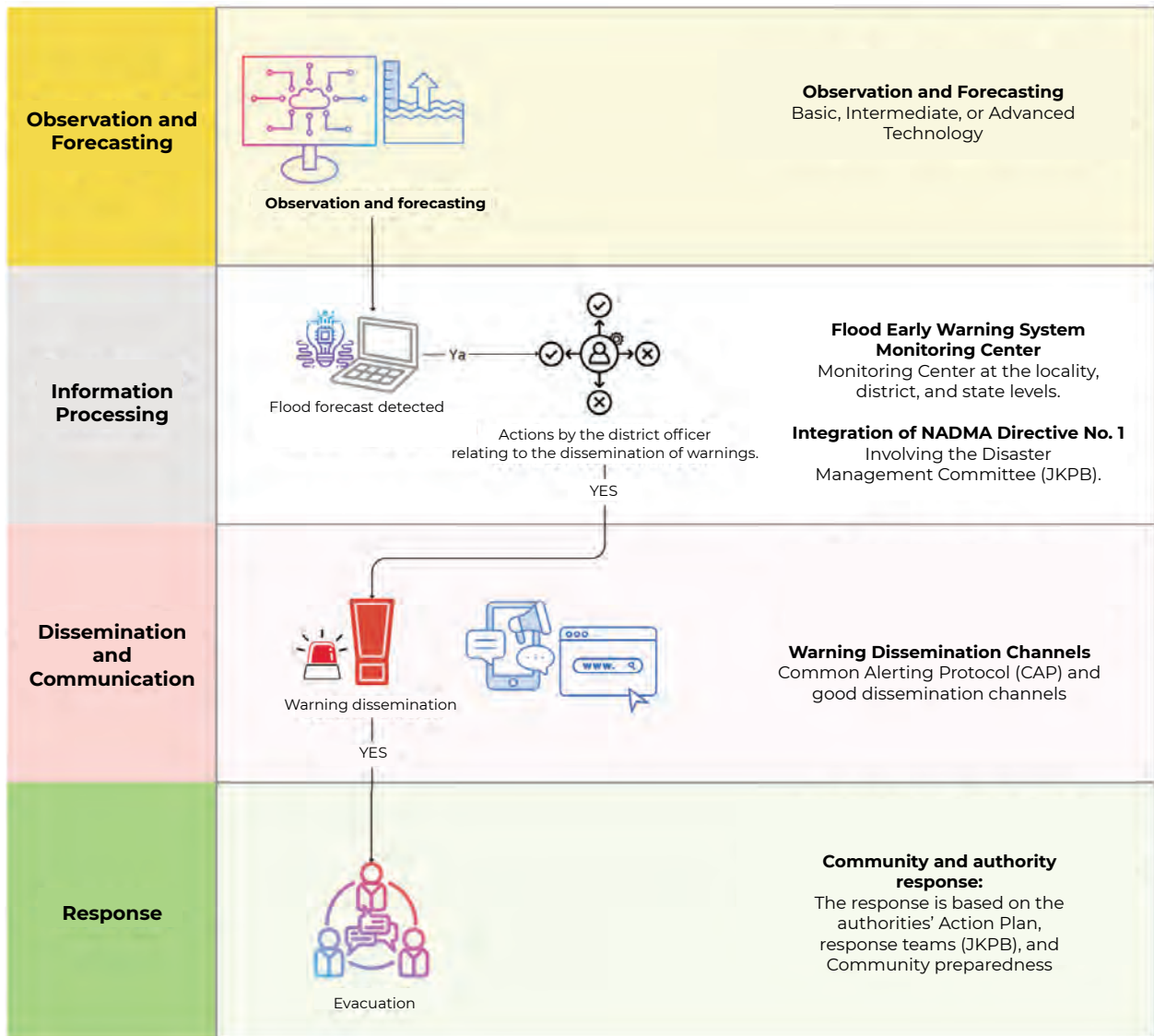


Figure 5: Flowchart of the Flood Early Warning System process

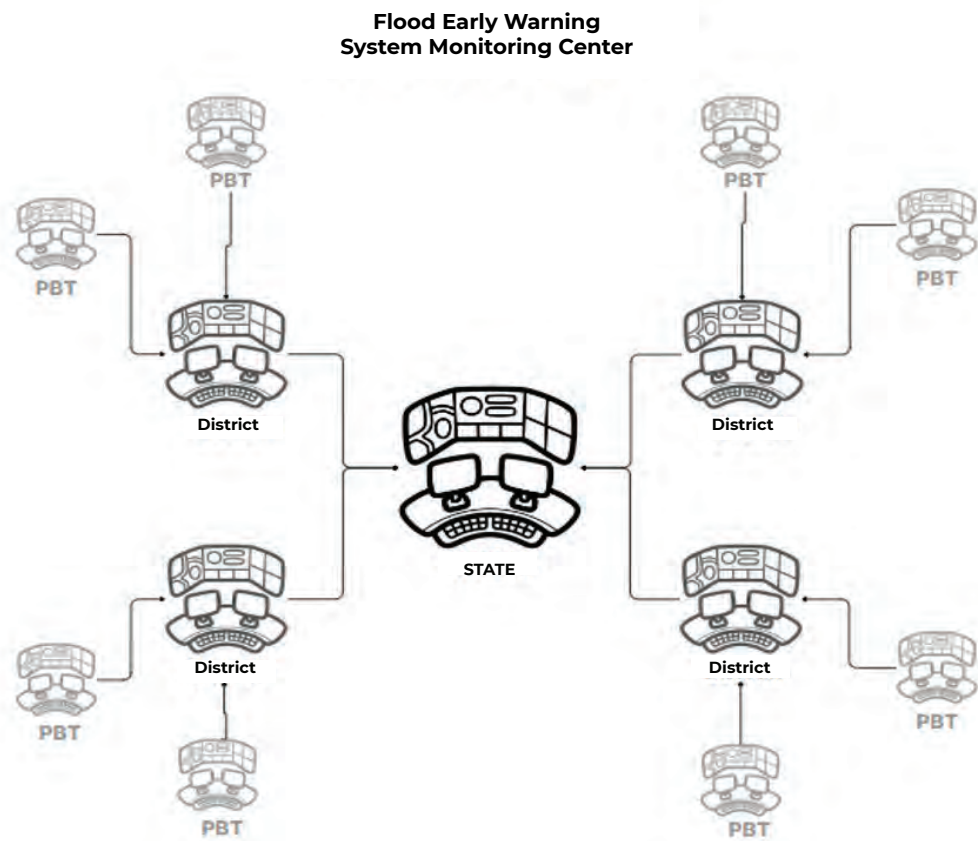


Figure 6: Layered Structure of the Flood Early Warning System Monitoring Center

5.2 Location Criteria for the Flood Early Warning System in Johor

The location criteria for the Flood Early Warning System requirements are as shown in Table 3 below.

Table 3: Location Criteria for Flood Early Warning System Requirements

Criteria	Details
1. High Flood Exposure Areas	• Locations with a history of frequent flooding or experiencing major floods. • Areas prone to flash floods due to rapid rainwater flow to low-lying areas or weak drainage systems.
2. Population Density and Social Impact	• Locations with a high population density should be prioritized as the impact of floods on lives and property is greater. • Areas with critical infrastructure such as schools, hospitals, and roads, or major business centers that, if affected, could lead to significant social and economic impacts.
3. Availability of Meteorological and Hydrological Data	• Areas with existing weather and hydrology stations. Locations that already have the infrastructure for collecting meteorological and hydrological data ease the implementation of the system. • Existing data centers or monitoring systems. Locations near data centers or central monitoring systems will enhance the functionality of the existing facilities.
4. Community Readiness and Risk Awareness	• Communities with low levels of awareness and vulnerability need special attention because they are more exposed to flood risks. The provision and installation of an efficient and easy-to-understand flood warning system is crucial not only for ensuring their safety but also for enhancing the community's preparedness and awareness of disaster risks. • Active and proactive community involvement in flood risk management facilitates integration of the warning system, making disaster prevention and response measures more effective.
5. Economic Loss Potential	• Locations with economic significance, such as industrial zones, commercial centers, or major business hubs, should be considered, as flooding in these areas can lead to significant economic losses. Areas like the Johor Special Economic Zone (JS-SEZ) should be prioritised. • Agricultural areas that rely on irrigation systems and are frequently affected by Floods.

5.3 Equipment and Data Requirements for the Flood Early Warning System

The equipment criteria and data requirements for the Flood Early Warning System are as shown in Table 4. The installation of monitoring equipment must be carried out within the drainage system and river basin at warning locations.

Table 4: Equipment Criteria and data requirements for the Flood Early Warning System

Technology	Equipment	Data	Details	Location	Mechanism
Basic	River water level measuring instruments.	River water level (m)	Based on Hydrological Procedure No. 25 of the Department of Irrigation and Drainage (JPS), the installation of the Standard Stick Gauge is as follows: • 2-meter-length • Spacing at 0.01-meter intervals	Upstream	• Notification of observations by residents upstream to those downstream, particularly to residents in locations with flood water level warnings: • The danger level can be determined based on the experience of local residents or the authorities in the area.
Intermediate	River water level measuring instruments.	River water level (mm)	Based on Hydrological Procedure No. 3 JPS, the installation and use of the Event Water Level Recorder include: Measurement Interval: • 15 minutes or less (taking into account the lead time required and the travel time of water from upstream to downstream for water level forecasting). Type of Water Level Observation Instruments: • Analog or Digital Water Level Recorders. • Automatic observation to data loggers for data recording.	Upstream and downstream	• Installation of water level observation instruments at the upstream and downstream sections of the river: • The downstream section is a critical location for flood water level warnings. - Installation at the upstream section allows for water level forecasting downstream using the early warning system at the Flood Forecasting Center or based on threshold levels set by experts.

Advanced	Water level and rainfall intensity level measuring instruments.	River water level (mm)	Based on Hydrology Procedure No. 3 JPS, the installation and use of the Event Water Level Recorder. Measurement interval: 15 minutes or less (taking into account the lead time required and the travel time of water from upstream to downstream for water level forecasting) Types of water level observation instruments: - Analog or Digital Water Level Recorders - Automatic Observation to Data Logger.	Upstream and downstream	- The system encompasses a telemetry system and the processing of rainfall and water level data from upstream using hydrological and hydraulic models at the Flood Early Warning Forecasting Center. - Rainfall forecast data from Malaysian Meteorology Department can serve as part of the input for flood modeling. - The system also includes the dissemination of warnings via mobile applications, SMS, and communication systems.
		Rainfall intensity (mm)	The type of rainfall observation instruments used can be referred to Hydrology Procedure No. 32 JPS, the Hydrological Standard for Rainfall Station Instrumentation, or a better observation equipment. Measurement interval: 5 to 15 minutes. Types of rainfall intensity observation instruments: - Tipping bucket (minimum 0.5 mm) - Weighing gauge - Radar	In the river basin area of warning location	

