Landscape Risk Assessment

MINDANAO RIVER BASIN

2025

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Note: Part of the report used Generative AI to synthesize the narrative.

I. EXECUTIVE SUMMARY

This report presents the findings of the "Mindanao River Basin – Landscape Risk Assessment" project, undertaken to comprehensively assess the vulnerability of the basin to climate change and natural hazards, and to inform the development of sustainable development strategies. The project, initiated in September 2024, has yielded critical insights into the escalating environmental challenges facing this vital ecosystem.

Increased Flood Risk Due to Environmental Degradation

The project noted a significant rise in the frequency and severity of flooding in the basin, strongly linked to environmental degradation. Studies show a direct correlation between deforestation rates and flood magnitudes, particularly in upper watersheds (Hurtado-Pidal et al., 2022). Protecting existing forests and reforesting upper watershed areas, like those in Upper Pulangi and most of the Mindanao River Basin (MRB) headwaters, is crucial for flood risk mitigation and forest conservation.

Compounding this issue, decadal primary forest loss, unsustainable agricultural practices like slash-and-burn, and rapid urbanization have severely impacted the basin. Urbanization increases impervious surfaces, reduces water infiltration, and encroaches on floodplains, worsening flood impacts. Current reforestation efforts are limited by insufficient awareness, poor community engagement, and a lack of sustainable management.

Deteriorating Water Quality

Deteriorating water quality within the Pulangi River system is evident, with increasing fish kills, declining aquatic biodiversity, and elevated turbidity levels. This is attributed to factors such as agricultural runoff, industrial discharges, and increased sediment loads resulting from soil erosion. The pressures from these contribute to heavy algal blooms resulting in high turbidity and anoxic conditions in the deeper parts of the waterbody due to the decay of detritus which leads to fish kills (Bhagowati & Ahamad, 2019).

Emergence of New Landslide-Prone Areas

The project has identified the emergence of new landslide-prone areas within the basin, underscoring the dynamic and evolving nature of its geomorphological processes. This concerning trend is primarily a result of agricultural practices that contribute to significant soil erosion. When forests are cleared for farming, especially on slopes, the soil loses the binding strength provided by tree roots. The loosened soil, combined with altered drainage patterns due to land use changes, creates unstable conditions, leading to the formation of these new landslide-prone zones. This highlights a critical need to re-evaluate land management and agricultural techniques in the basin to mitigate future risks.

II.
KEY ACCOMPLISHMENTS

Data Collection

- Collated secondary data on climate projections (temperature, precipitation) for the period of the past 10 years from repu table sources.
- Compiled historical records of flooding events from the 1970s to 2023 and land slide events within the basin.
- Compiled elevation data, shapefiles, raw data, and satellite observations.

Field Work

- Conducted a Transect Walk for Upstream MRB in San Vicente, Dangcagan, Bukidnon, to observe and document local land use practices, infrastructure, and potential vulnerabilities.
- Conducted a Transect Walk for Midstream MRB in Pagalungan and Downstream MRB in Cotabato City.

Data Analysis and Mapping

- Identified critical watersheds within the basin based on population density, lan cover, and historical hazard events i.e. flood and landslide.
- Developed GIS maps depicting historical hazard zones, vulnerable communities, and infrastructure distribution.
- Developed a soil erosion map of the Mindanao River Basin.
- Conducted a preliminary inventory of critical infrastructure within the basin.
- Conducted a preliminary inventory of rain gauges and water levels.

Dissemination

- Presented preliminary project findings and outputs workshops, seminars, and technical reports to relevant stakeholders.

Strengthen Collaboration

- Foster stronger collaboration between government agencies (including the National Power Corporation), local communities, and academic institutions to ensure effective communication, coordination, and response during emergencies.

III. BACKGROUND OF THE MINDANAO RIVER BASIN

The Mindanao River Basin (MRB), the second largest river system in the Philippines, encompasses a substantial land area of 2,085,491 hectares and represents a vital ecological and socio-economic lifeline for the island of Mindanao.

Spanning five administrative regions and nine provinces, this basin is characterized by a network of waterways, alongside the Ambal-Simuay and Ala Rivers, and several lakes. Agriculture constitutes the dominant land use within the MRB, occupying 52% of its total area, thereby underscoring the indispensable role of forest ecosystems in maintaining the basin's ecological integrity and long-term viability.

Administratively, the basin's influence is broad, encompassing nine provinces, 11 cities, 163 municipalities, and 3,891 barangays. The Province of North Cotabato constitutes the largest single portion of the basin, accounting for 29.34% of its total area. Demographic data from May 2010 estimated the basin's population at 6,424,431, resulting to a population density of 3.067 individuals per hectare. Subsequent data from the Philippine Statistics Authority in 2016 indicated a population increase to 7,163,052 by 2015, highlighting the region's ongoing demographic expansion and developmental trajectory.

The basin faces various environmental challenges, including heightened susceptibility to flooding, increased siltation and sedimentation rates, deforestation within its watershed areas, riverbank erosion, and water contamination from domestic and agricultural effluents. The Mindanao River Basin Management Council (MRBMC) was established to address these multifaceted issues.

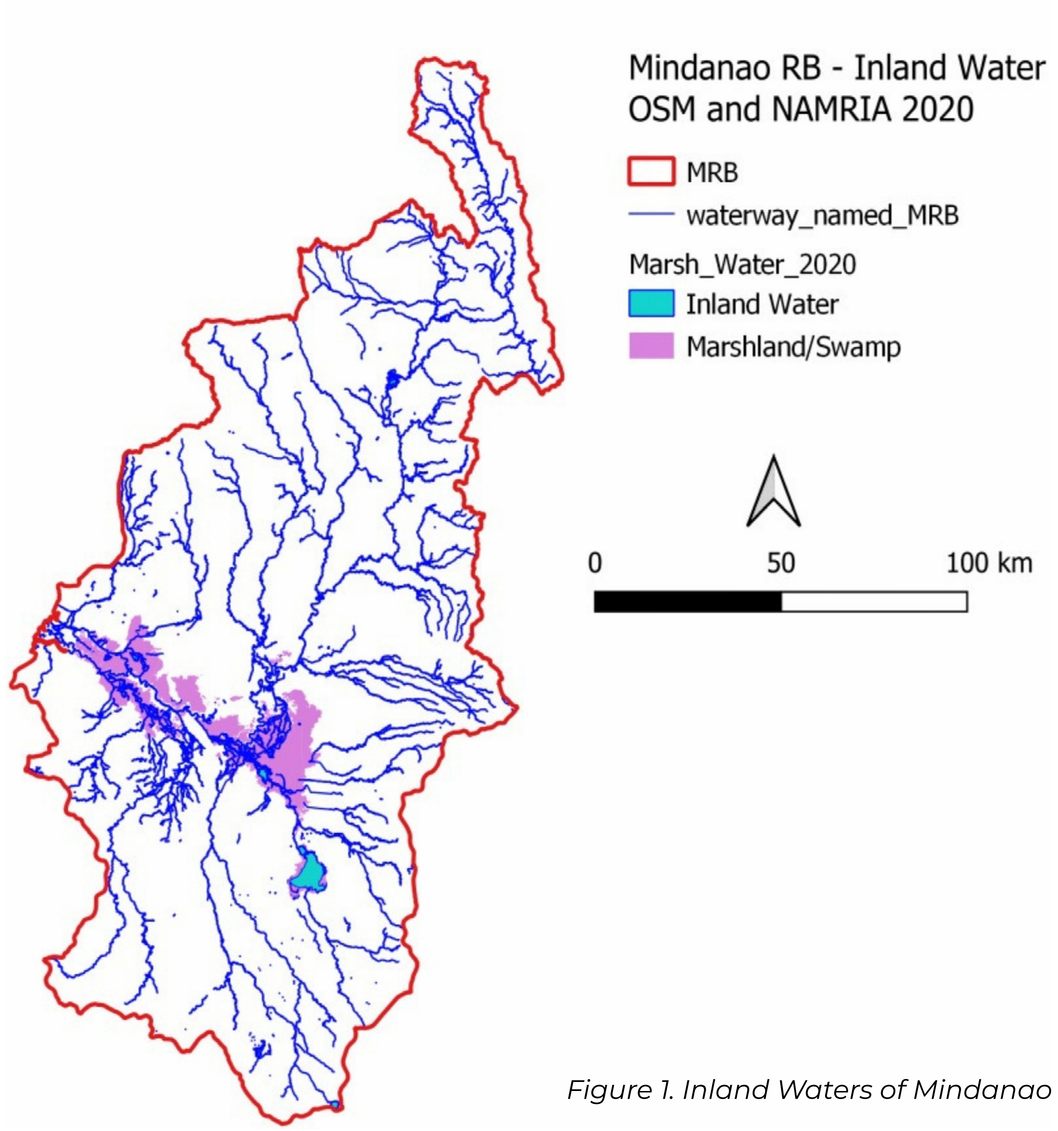


Figure 1. Inland Waters of Mindanao River Basin

IV. FRAMEWORK AND OBJECTIVES OF THE LANDSCAPE RISK ASSESSMENT

The MRB-Landscape Risk Assessment follows this framework with the corresponding areas to be assessed:

Risk Knowledge: involves deeply understanding potential threats by identifying hazards (specific dangers and their characteristics), determining exposure (what elements are susceptible to these dangers), and assessing vulnerability (the susceptibility of exposed elements to harm, considering inherent weaknesses and coping capacity).

Response Capability: builds the capacity to react effectively to hazards by developing clear plans (actionable strategies for response, evacuation, and recovery), through regular Practice (drills, simulations, and training to ensure proficiency and coordination), and by allocating necessary resources (personnel, equipment, funding, and supplies).

Monitoring and Warning: ensures continuous vigilance and timely threat communication through observation (systematic data collection on hazards and vulnerabilities), analysis (interpreting data to predict events and assess impact), and defining clear triggers (conditions that initiate warnings or response protocols).

Dissemination and Communication: focuses on ensuring risk information and warnings prompt appropriate action by ensuring access (information availability through multiple channels), fostering understanding (clear, concise, and comprehensible messaging), and facilitating action (encouraging appropriate responses and empowering communities).

This assessment has the following objectives:

1. **Data Inventory and Analysis**:
To compile and analyze historical and current data on rainfall, river levels, flow rates, land use changes, and disaster impacts to understand flood dynamics and inform the development of an Early Warning System (EWS) and policy recommendations.

2. **Monitoring and Communication Enhancement**: To assess existing weather monitoring equipment and communication channels to improve data gathering, forecasting, and warning dissemination for basin-wide anticipatory action and rapid response.

3. **Evaluation of Preparedness and Response**: To evaluate local communities' and governments' disaster risk reduction initiatives and response capacities, providing actionable recommendations to enhance resilience and establish coordinated rapid response protocols for flooding events.

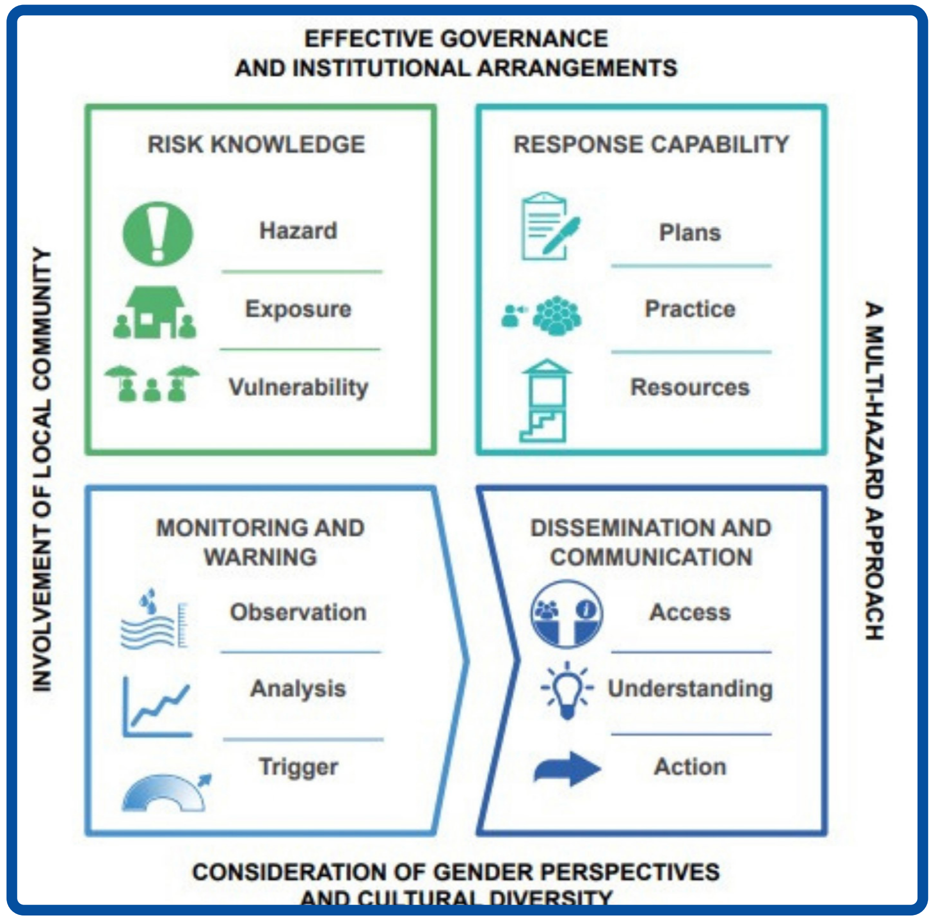


Figure 2. Mindanao River Basin-Landscape Risk Assessment Framework

V. RISK KNOWLEDGE

A. Hazard Profile and Trends

A significant portion of the Mindanao River Basin lies at higher elevations, ranging from 250 to 500 meters and above 1000 meters, which serve as the primary sources of water runoff. These higher elevations contribute to the flood susceptibility of the lower-lying areas, which constitute a smaller percentage (approximately 14%) of the total basin area. As water from the elevated parts of the MRB flows downwards, it converges towards the lower levels situated between the province of North Cotabato and the Bangsamoro Autonomous Region in Muslim Mindanao (BARMM), which is the project's area of interest.

As illustrated in **Figure 3: Elevation Map of Mindanao River Basin**, the basin's topography clearly shows these distinct elevation zones. Notably, the central area of the MRB between these provinces has a very low average elevation of only 5 to 10 meters above sea level and is located a considerable distance of 100 kilometers from the sea. This results in a flat terrain with an insufficient gradient for rapid drainage. This low elevation and flat terrain are problematic because water tends to accumulate in the basin's center and drains sluggishly, substantially increasing flood susceptibility during periods of heavy rainfall.

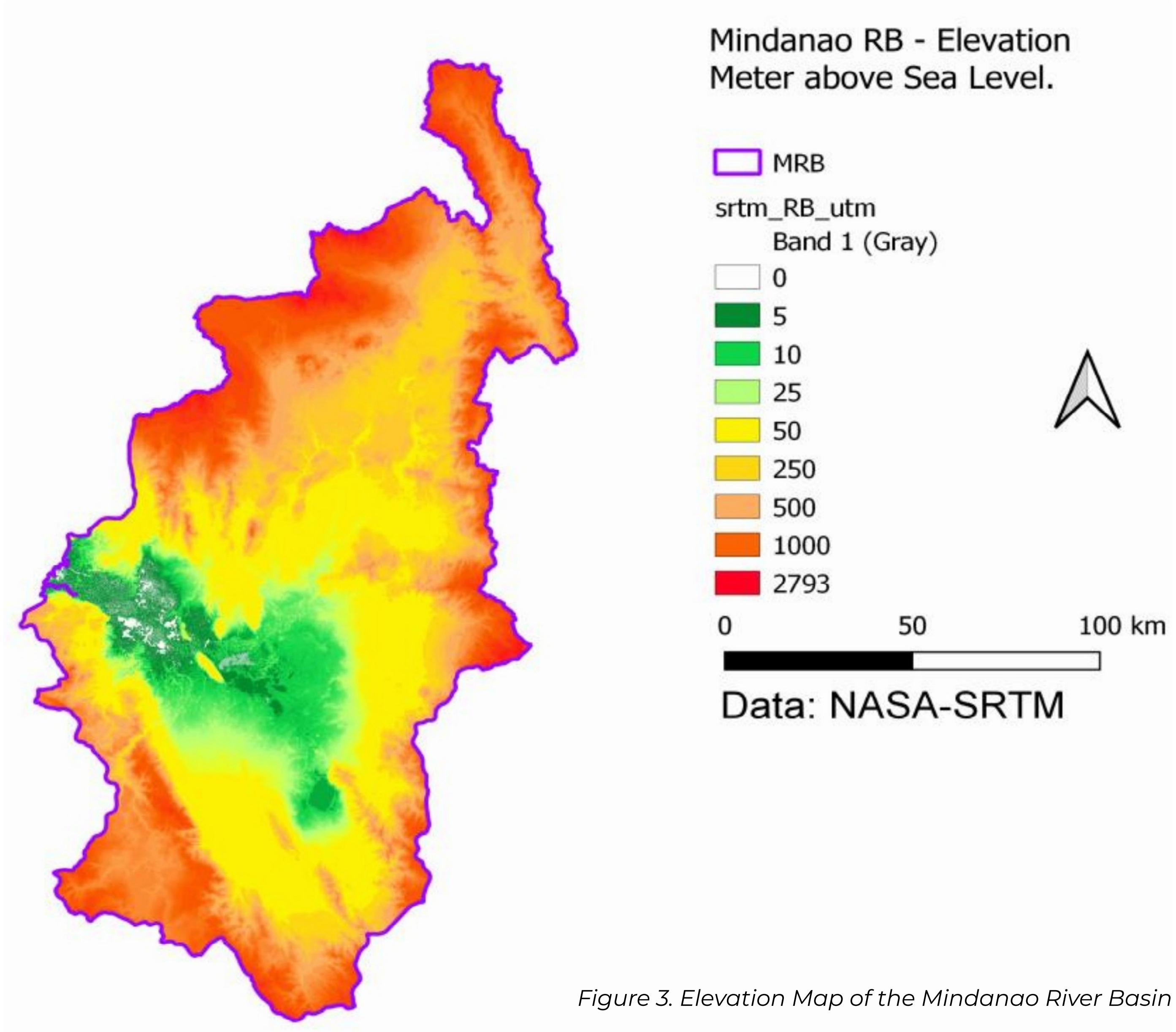


Figure 3. Elevation Map of the Mindanao River Basin

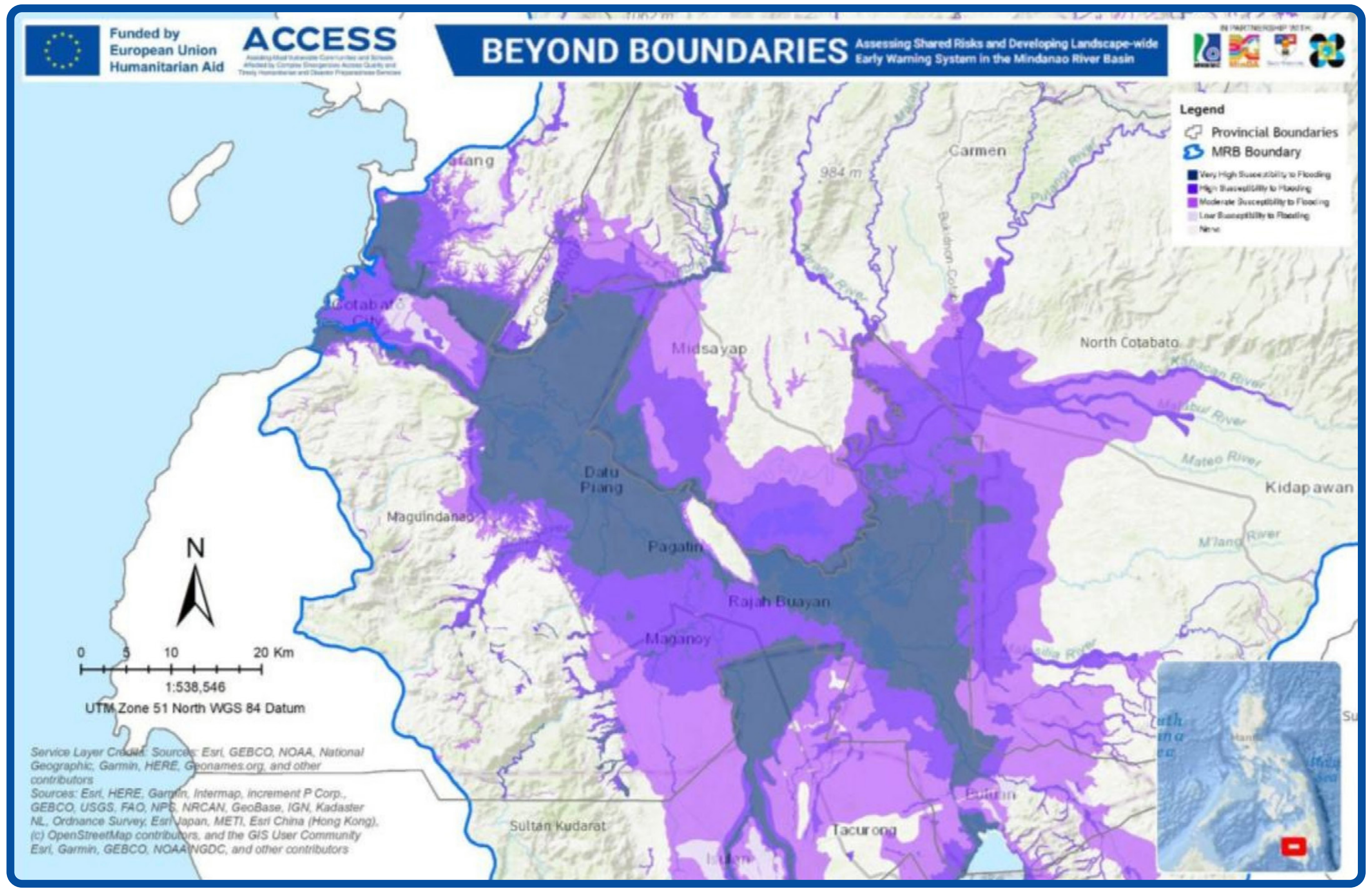


Figure 4. Flood Susceptibility Map of Downstream MRB

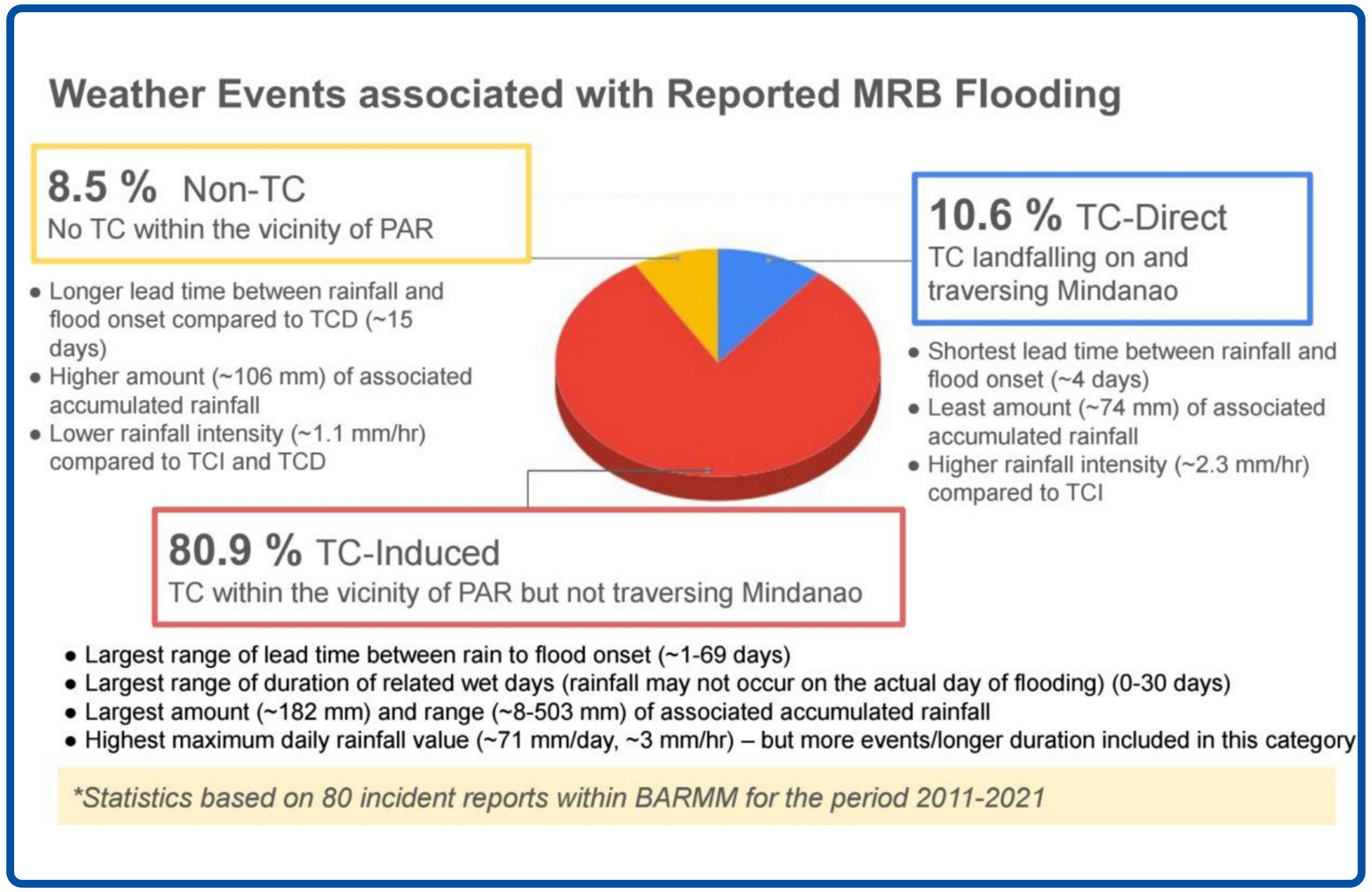


Figure 5. Weather Events Associated with MRB Flooding, Dr Francia Avila-Manila Observatory

Figure 4: Flood Susceptibility Map of Downstream MRB shows that areas along the Rio Grande de Mindanao where Cotabato City and municipalities under the BARMM lie, have very high to high susceptibility for flooding. A recent rainfall observation from the GPM Satellite (2024) confirms that flood-prone zones in Cotabato experienced significant rainfall between 50mm to 270mm/day from June to August 2024. Averages for three months showed 9–13mm/day, enough to keep lowland areas consistently submerged. Satellite-based water anomaly mapping further revealed floodwater retention lasting up to 8 months in some areas. A case study of Pagalungan identifies it as a persistent marshland where residents live in stilt houses, illustrating that even minor flood events can linger for days (e.g., August 24-29 flood).

Beyond flooding, the MRB is also susceptible to landslides, particularly in areas with steep slopes. These events are often triggered by intense rainfall and manifest as large cracks in the ground and displacement of vegetation, such as coconut trees. Field surveys have observed visible instances of soil displacement even without seismic activity, indicating that local hydrological conditions and land characteristics play a significant role. (Detailed drivers of landslide vulnerability, including land-use change, soil characteristics, and underground water sources, are discussed in the "Drivers of Risk" section.)

Analysis of the past 24 years of rainfall in the MRB reveals frequent extreme rainfall events, notably between December and February, with significant total rainfall over extended periods, including recent events from 2015 to 2024. **Figure 5** shows an **excerpt of Dr Francia Avila's report on weather events associated with MRB flooding**. Based on the report, historical flood events in the MRB between 2011 and 2021 show that over 80% were linked to tropical cyclones within the Philippine area, even without direct hits, and were associated with very heavy daily rainfall. Direct hits from tropical cyclones, though less frequent (around 10%), also caused flooding with intense rainfall and rapid onset. Over a 39-year period, Mindanao has experienced 11 major typhoons. These trends, coupled with projected increases in rainfall intensity, directly elevate the risk of flooding, especially in low-lying areas, and are compounded by the potential for increased runoff from upstream land-use changes, which will be discussed in the succeeding sections of the report.

B. Socio-Economic Vulnerability

The Bangsamoro Autonomous Region in Muslim Mindanao (BARMM) faces significant socio-economic challenges that substantially increase its vulnerability to landscape risks. With a poverty incidence of 39.4% among families in 2021, nearly four out of ten families have incomes below the poverty threshold, severely limiting their capacity for disaster preparedness, access to post-disaster healthcare, and effective recovery. This socio-economic fragility is critically compounded by the region's historical and ongoing conflicts. The intersection of natural hazards with conflict creates a devastating cycle: *conflicts disrupt economic activities and displace communities, pushing them into more precarious, hazard-prone areas (e.g., riverbanks or unstable slopes) and weakening essential governance structures*. This directly undermines development and resilience-building efforts, leaving already vulnerable populations even more exposed to the impacts of floods, droughts, and other natural disasters.

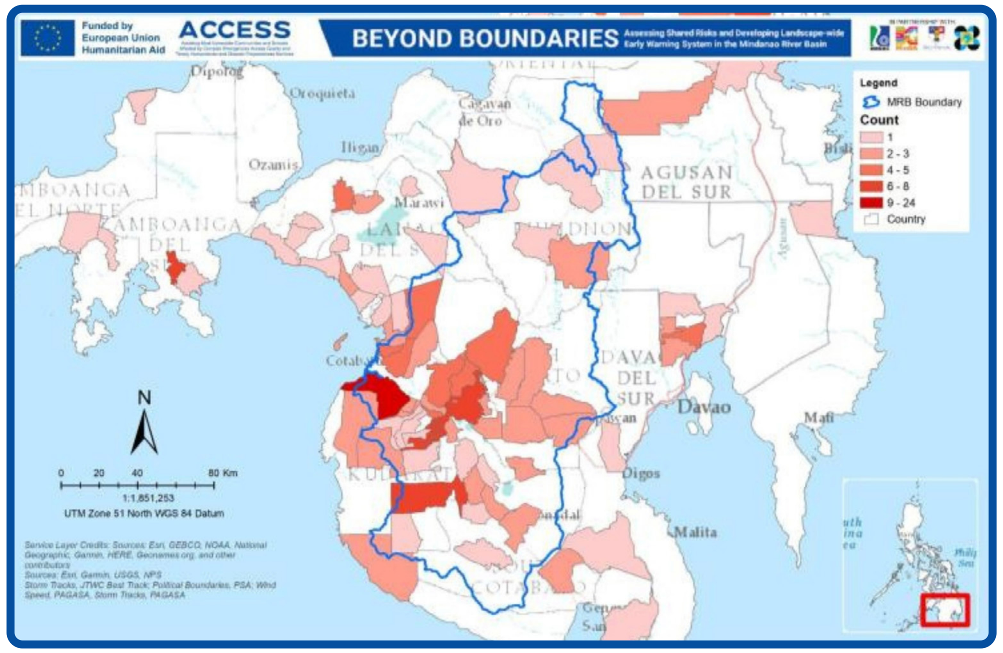


Figure 6. Conflict Incident Count

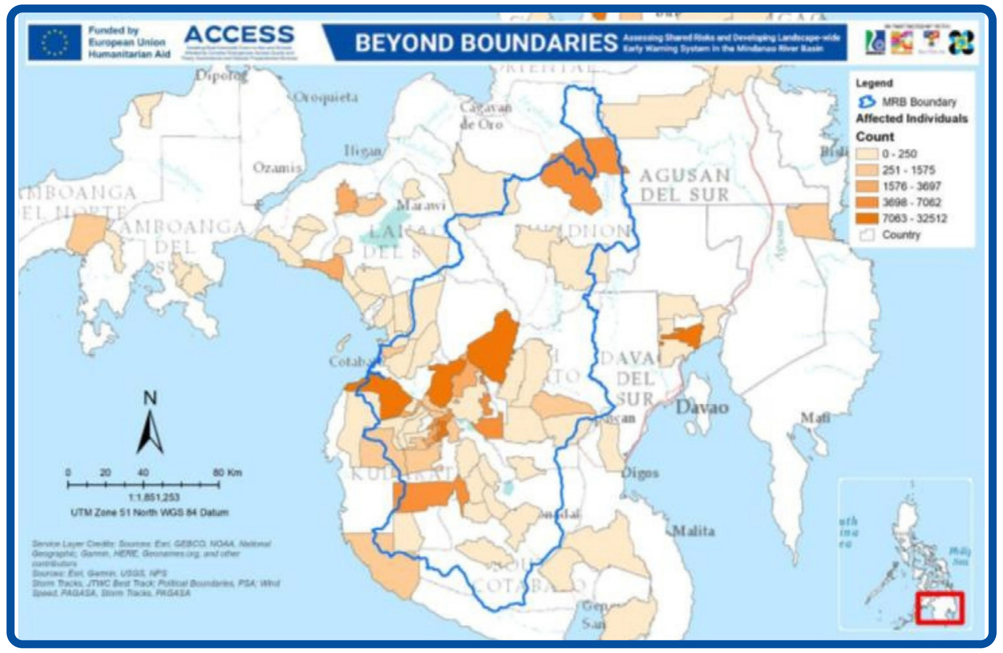


Figure 7. Affected Individual Count

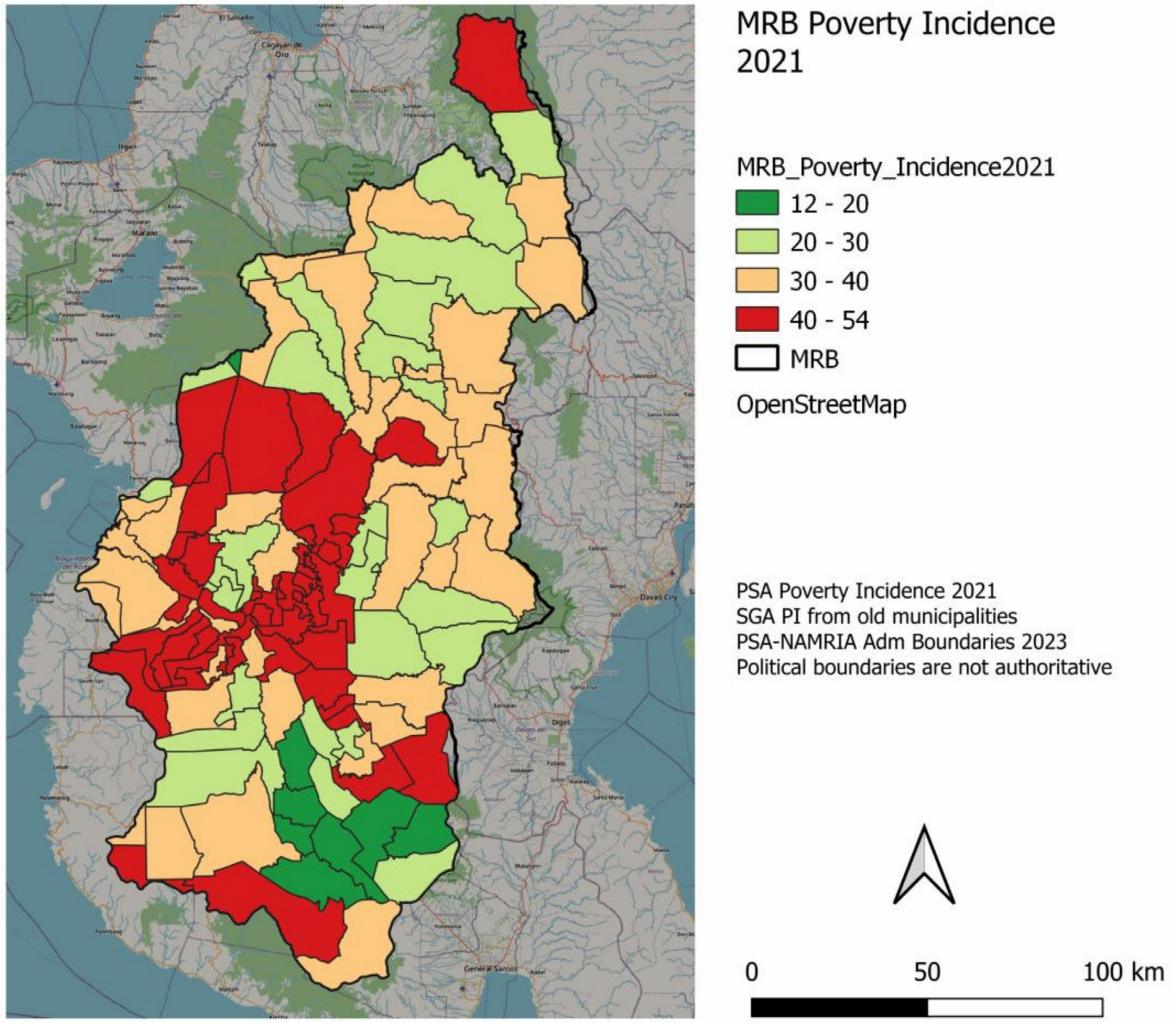


Figure 8. MRB Poverty Incidence in 2021

Figure 8 above shows the **Poverty Incidence of areas in the MRB** where localities in South Cotabato and the BARMM have the highest poverty incidence at 40-54%. This is evident as many communities in BARMM rely on agriculture and fishing, livelihoods highly susceptible to climate change impacts such as droughts, floods, and altered rainfall patterns. In conversations among locals, it has been observed that there is a shift to fishing in areas often affected by flooding, with growing concerns of contaminated sediments ingested by fish, which causes mutations among the catch. Furthermore, existing social inequalities marginalize certain groups, including Indigenous communities and internally displaced persons, limiting their access to crucial resources. The coastal municipalities within BARMM illustrate this complex situation, where poverty intersects with high exposure to floods. Communities in areas like Pagalungan have developed forms of "toxic resiliency," normalizing persistent flooding and repurposing homes with mini-dikes and elevated school walkways, yet often without long-term structural solutions or official support.

Institutional challenges also heighten vulnerability. The transition from ARMM to BARMM saw critical gaps in disaster reporting, coordination, and clarity on land use policies. There is currently no central disaster database for the MRB, despite decades of reports, leading to fragmented information. Overlaps and coordination gaps between BARMM, SGAs, and neighboring LGUs (Regions 9, 10, and 13) result in fragmented policy, delayed responses, and underreported impacts (e.g., almost no BARMM data for 2011–2020). This highlights a fragile institutional memory, where response protocols can vanish with leadership changes, emphasizing that "the cost of waiting is higher than the cost of preparing."

C. Drivers of Risk: Land-Use-Land-Cover Change and Climate Trends

Land Use and Land Cover (LULC) changes significantly impact the soil integrity and hydrological response of the Mindanao River Basin. The Revised Universal Soil Loss Equation (RUSLE) framework highlights how factors like rainfall erosivity, soil erodibility, slope, cover management, and support practices determine average annual soil loss. High erosion-prone areas include deforested slopes converted to agriculture (corn, rubber, banana), where loss of vegetative cover, poor land use planning, and shallow-rooted crops exacerbate soil erosion. Areas in Bukidnon, characterized by clay loam soil, are particularly prone to swelling and landslides during extreme rain.

A substantial 50% of the MRB exhibits high to severe soil vulnerability (50-200+ tons/ha/year), with an additional 18% classified as very severe to extreme (over 200 tons/ha/year). This widespread vulnerability, characterized by steeper slopes and less stable land cover, leads to significant soil erosion. The increased mobilization and transport of sediment into the MRB's river network directly contribute to flooding by reducing the water-carrying capacity of river channels (aggradation), thereby increasing the likelihood and severity of inundation in lowland areas. This effect is compounded during periods of high rainfall, including the historically frequent extreme events and projected increases in rainfall intensity.

The 2020 LULC analysis is seen in **Figure 9. The Land Use and Land Cover Map of the MRB** reveals a basin predominantly covered by annual crops (41%), followed by perennial crops (18%) and brush/shrubs (14%). Forest cover, including open and closed forests, is limited to a relatively small 12%. This distribution has critical implications for soil integrity. Forest ecosystems offer the most effective natural protection against erosion, while the extensive cultivation of annual crops leaves soil more exposed, especially during critical agricultural cycles, leading to higher soil loss.

On the other hand, climate change further contributes to extreme weather events like droughts and floods, influenced by rising temperatures. While upland areas tend to be cooler with higher precipitation, lowland areas in Cotabato and BARMM are warmer. January to March are typically dry, and May to October are wet, with July experiencing the most significant rainfall. Projections indicate relatively minor shifts in average rainfall patterns for the MRB, with a tendency towards drier dry seasons and wetter wet seasons, and small changes in indices measuring rainfall extremes.

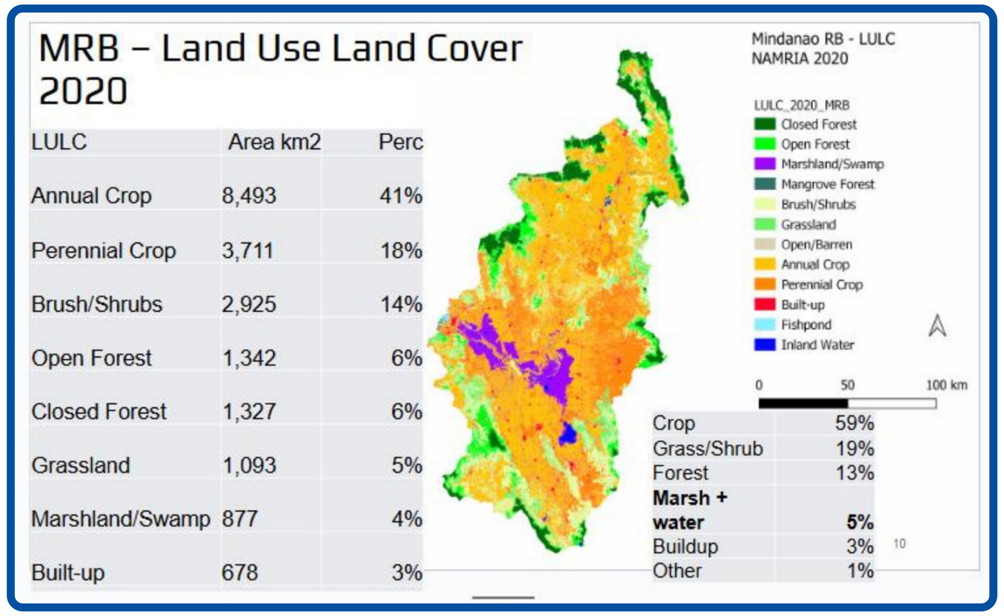


Figure 9. Land Use and Land Cover Map

However, a 2011 PAGASA study projects a notable increase (up to fivefold for most provinces) in very extreme daily rainfall events (150 mm or more) during 2006-2035 compared to 1971-2000, though this increase is expected to moderate later. A clear upward trend in regional temperatures is projected for 2021-2050, with estimates indicating an increase of +0.8 □ to +1.2 □, suggesting the disappearance of cold nights and normalization of warm spells. Furthermore, existing infrastructure challenges, such as outflow blockages and drainage dilemmas, exacerbate these risks. Channels and dikes often offer asymmetric protection by being built on only one side of rivers, and cut-off channels intended for water diversion have failed due to poor drainage or hyacinth clogging. The construction of the Tunggol Bridge unintentionally widened waterway sections, slowing downflows and leading to persistent inundation.

In the EWS workshop, the link between environmental degradation and the increasing frequency and severity of hazards was discussed. Specifically, the following Environmental Drivers of Risk namely: Decadal Primary Forest Loss, Unsustainable Agricultural Practices, and Urbanization.

1. **Decadal Primary Forest Loss**: Extensive deforestation within the basin has significantly reduced forest cover, leading to increased soil erosion, reduced water infiltration, and amplified surface runoff. This finding is supported by studies such as François et al. (2024), which documented the significant decline in forest cover across the country and its implications for hydrological processes as well as the use of forests as a nature-based solution for conserving and managing natural resources, including water, soil, and air. Figure 10. Forest Loss as recorded by ESSC, shows how old forest has gradually declined since the 1900s up until the late 1980 while as seen in Figure 9, there is a minimal amount of forest cover along the area of study in South Cotabato and the BARRM.

2. **Unsustainable Agricultural Practices**: Unsustainable agricultural practices, such as slash-and-burn techniques and the use of agrochemicals, contribute to soil erosion, nutrient depletion, and water pollution. This is corroborated by reports from the transect walk and the anecdotal narrative of the residents in San Vicente, which have documented the negative impacts of unsustainable agricultural practices on soil health and water quality in various parts of the Philippines. A synthesis report of the transect walks conducted will be discussed in detail in the next sections.

3. **Urbanization**: Rapid urbanization within the basin has led to increased impervious surfaces, reduced infiltration rates, and the encroachment of development into floodplains, exacerbating flood risks

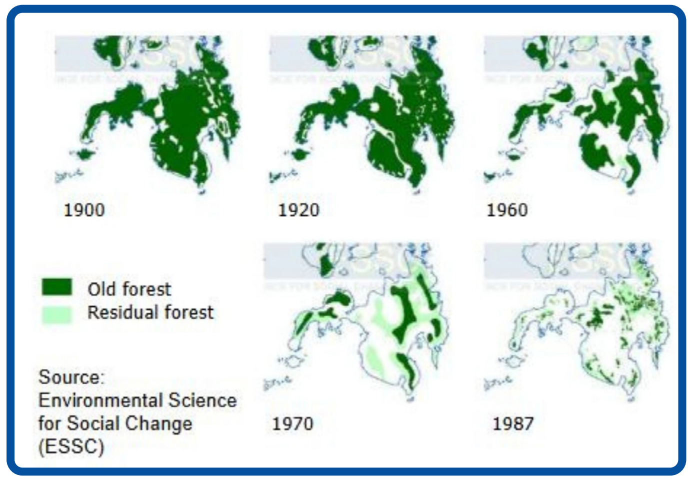


Figure 10. Forest Loss as recorded by ESSC (Environmental Science for Social Change)

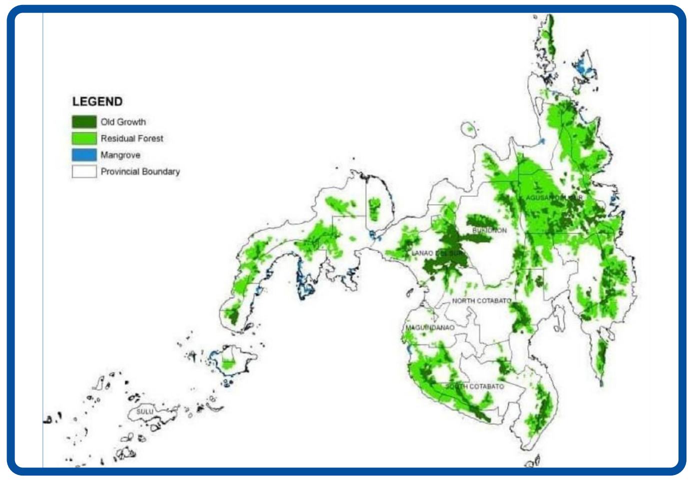


Figure 11. Forest Loss in Mindanao, Source (ESSC)

VI. MONITORING AND FORECASTING

This section evaluates the current systems and practices for monitoring climate and hazards within the Mindanao River Basin and assesses the capabilities for forecasting future events. It also identifies critical gaps and proposes recommendations for enhancing these functions. Within this framework, effective monitoring and forecasting rely heavily on three interconnected components: observation, analysis, and trigger. Observation involves collecting raw data, analyzing this data into actionable information, and triggers are the mechanisms by which warnings and actions are initiated based on these analyses

A. Current Monitoring Capabilities and Observations

The Mindanao River Basin (MRB) utilizes a network of strategically located monitoring stations to gather crucial hydrological and meteorological data, which is particularly relevant to downstream areas prone to flooding. This network comprises various types of instruments, each serving a distinct purpose in understanding the basin's water dynamics and potential flood risks.

Rain gauges (RG) are deployed across the basin to measure the amount of rainfall, providing essential information on precipitation inputs. **Water Level Stations (WS)** are positioned along rivers and tributaries to track the height of the water surface, offering direct insights into water levels and potential for overflow. Complementing these are **Automatic Weather Stations (AWS)**, which provide a more comprehensive suite of meteorological data, including rainfall, temperature, wind speed, and other parameters influencing the basin's hydrological conditions. The precise geographical coordinates (latitude and longitude) of each station are recorded, enabling accurate spatial mapping and analysis of the collected data. These stations are often managed or identified under systems like Phil-Sensors, indicated by specific naming conventions and codes, and are located within various provinces and municipalities across the MRB, including Cotabato, Bukidnon, and Maguindanao.

Table 1 below shows the status of **Early Warning Systems (EWS) across Regions 10, 12, 13, and the Bangsamoro Autonomous Region in Muslim Mindanao (BARMM)**. The data indicates that less than half of the EWS in Regions 10 and 12 are operational. In the BARMM, only 14% (8 out of 46 EWS) are operational. Region 13 has only one EWS installed, which is currently operational.

Region	Operational	Non-Operational	Percentage of Operational EWS
10	22	23	48.89%
12	70	109	39.11%
13	1	0	100.00%
BARMM	8	46	14.81%
TOTAL	**101**	**279**	**36.20%**

Table 1. Status of Philsensor's Early Warning System

B. Challenges in Data Management and Early Warning Systems

Despite the existing monitoring infrastructure, the functionality of Early Warning Systems (EWS) within the MRB presents a mixed picture, as observed in the data provided by PhilSensors.

This mixed functionality highlights significant challenges. A critical absence is a central disaster database for the MRB, leading to fragmented information and underreported impacts, particularly evident in the limited BARMM data between 2011–2020 following the transition from ARMM. Governance gaps further complicate matters, with overlaps and coordination challenges among BARMM, national agencies (SGAs), and neighboring LGUs in Regions 9, 10, and 13, resulting in fragmented policy, delayed responses, and reduced effectiveness of early warning systems. Institutional memory is fragile; response protocols and lessons learned often vanish when LGU leadership changes. At the community level, "toxic resiliency" normalizes flooding without long-term solutions. Insights from the April 2024 Davao workshop confirmed weaknesses such as coordination gaps, overlapping roles during disaster response, and a lack of sustainable follow-through from planning to action, echoing a local official's sentiment: "You train us, but in the next flood, we still have no power to act."

C. Recommendations for Enhanced Monitoring and Forecasting

1. **Complete Data Collection and Assessment**: Obtain missing information, particularly coordinates, for all stations. Conduct a thorough assessment of the condition and utilization status of all stations to ascertain their functionality.

2. **Prioritize Rehabilitation and Repair**: Essential rehabilitation and repair of non-functional stations are needed, including the installation of necessary equipment in those lacking it, and ensuring proper calibration.

3. **Comprehensive Training and Capacity-Building**: Implement comprehensive training and capacity-building programs for personnel responsible for operating and maintaining the EWS equipment, focusing on data interpretation and utilization for effective early warning dissemination.

4. **Improve Data Access and Management**: Vital improvements in data access and management are needed through clear and efficient protocols and systems. Efforts should be directed towards standardizing operation and data collection methods across the MRB regions and integrating data from diverse sources to achieve a holistic understanding of hydrological and meteorological conditions.

5. **Community Engagement**: Pursue community engagement to incorporate indigenous and local weather forecasting practices, which can enhance the accuracy and effectiveness of early warnings.

6. **Sustainable Funding and Maintenance**: Securing sustainable funding and developing a regular maintenance schedule are critical for the long-term operation and reliability of the EWS infrastructure.

7. **Centralized Data Platform**: Recommend the development of an open-access, SQL-like platform capable of tracking rainfall, damage, infrastructure, and household impacts, updated by both national agencies and LGUs.

8. **Improved Inter-Agency Coordination**: Suggest clarifying roles and fostering better coordination among BARMM, SGAs, and neighboring LGUs to ensure a unified and efficient approach to disaster monitoring and response.

9. **Strengthened Follow-Through Mechanisms**: Emphasize the need for sustainable follow-through mechanisms that ensure planning translates into concrete, long-term actions on the ground.

10. **Barangay-level Empowerment**: Advocate for empowering barangay-level entities, ensuring they have the necessary resources, authority, and sustained support to act effectively during disasters.

11. **Enhanced Communication and Clarity**: Stress the community's demand for clear communication and coordinated efforts, beyond just technical climate models. Highlight that "resilience starts with listening" to local insights.

12. **Proactive Preparedness**: Reinforce the guiding principle: "The cost of waiting is higher than the cost of preparing," advocating for proactive investments in monitoring and forecasting infrastructure and systems.

13. **Integration of Dam Releases**: Real-time data on dam discharges from the Pulangi Hydro Electric Power Plant must be integrated into the EWS. This information is critical for accurate flood forecasting and timely warning dissemination to downstream communities.

VII. RESPONSE CAPABILITY

This section assesses the existing mechanisms, strengths, and critical challenges related to disaster response and recovery within the Mindanao River Basin, evaluating the effectiveness of immediate actions and long-term support systems. Within the overarching MRB-Landscape Risk Assessment Framework, effective response capability is fundamentally built upon robust plans, consistent practice, and adequate resources. These elements are crucial for ensuring that the region can effectively react to hazards, provide emergency services, and initiate recovery efforts.

A. Institutional Framework for Disaster Response

The MRBMC's line of authority and communication is structured to facilitate clear decision-making and coordination. The MRB Council is the main decision-making body, comprising the executive heads of member institutions, with its Chairperson elected by the council members. Communication flows downward from the MRB Council through the Program Management Office (PMO), which acts as the secretariat, managing day-to-day operations, coordination, and policy implementation. The PMO further coordinates with technical working groups (TWGs), committees, and stakeholder organizations to carry out specific functions and projects. The MRBMC also maintains formal linkages with regional bodies such as the Regional Development Councils, Bangsamoro Economic Development Council, and Local Development Councils, ensuring alignment of plans and policies. Relationships with Protected Area Management Boards (PAMBs) are also established for biodiversity and conservation efforts. Overall, authority resides with the MRB Council for high-level policy direction, while the PMO and TWGs serve as the operational and technical links to stakeholders and implementing agencies, ensuring effective communication and coordination across all levels. This organizational structure is visually represented in **Figure 12. MRBMC Organization Structure**. The emergency protocols used within this framework are detailed in **Figure 13. Emergency Protocols used in MRBMC**.

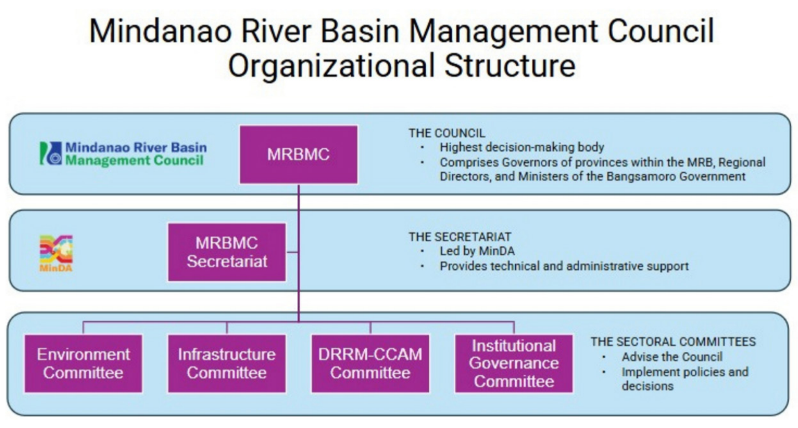


Figure 12. MRBMC Organization Structure

SIMPLIFIED EMERGENCY PREPAREDNESS AND RESPONSE (EPR) PROTOCOLS	
STANDBY No to Very Low Risk	❑ Send warnings and advisories ❑ Monitor the situation ❑ Anticipate augmentation
ALPHA Low Risk	❑ Send warnings and advisories ❑ Cascade preparedness directives ❑ Anticipate augmentation ❑ Release Situational Report
BRAVO Medium Risk	❑ Send warnings and advisories ❑ Cascade preparedness directives ❑ Preemptively evacuate ❑ Activate EOC to Blue Alert ❑ Activate selected Response Clusters ❑ Preposition Resources ❑ Provide advance augmentation ❑ Release Situational Report
CHARLIE High Risk	❑ Send warnings and advisories ❑ Cascade preparedness directives ❑ Recommend for work/class suspension ❑ Preemptively (or forcibly) evacuate ❑ Activate EOC to Red Alert ❑ Activate majority of Response Clusters ❑ Preposition Resources ❑ Pre-deploy teams in strategic areas ❑ Authorize advance assistance for families ❑ Provide advance augmentation ❑ Release Situational Report

Figure 13. Emergency Protocols used in MRBMC

Complementing the MRBMC, the Bangsamoro Autonomous Region in Muslim Mindanao (BARMM) has recently released its own Disaster Risk Reduction and Management (DRRM) Plan, featuring a distinct organizational structure. The BARMM Chief Minister serves as the Chairperson of the **Bangsamoro DRRM Council (BDRRMC)**, establishing the highest level of authority for DRRM within the BARMM government. The BDRRMC is supported by several Vice Chairpersons, each responsible for a specific pillar of DRRM:

- **Vice Chairperson for Disaster Prevention and Mitigation:** Focuses on communication and authority related to proactive measures to reduce risks before disasters occur.

- **Vice Chairperson for Disaster Preparedness**: Handles communication and authority concerning readiness measures, ensuring communities and agencies are prepared to respond effectively.

- **Vice Chairperson for Disaster Response and Early Recovery**: Manages communication and authority during and immediately after a disaster event, focusing on immediate needs and initial steps towards recovery.

- **Vice Chairperson for Disaster Rehabilitation and Recovery**: Oversees communication and authority for longer-term efforts aimed at restoring and improving the lives and livelihoods of affected communities.

The **Bangsamoro DRRM Council Head of Secretariat and Implementing Arm** plays a crucial role in operationalizing the council's decisions and managing information flow, serving as a central point for communication, coordination, and the implementation of DRRM programs and activities. This structure is illustrated in **Figure 14. BDRRMC Structure**.

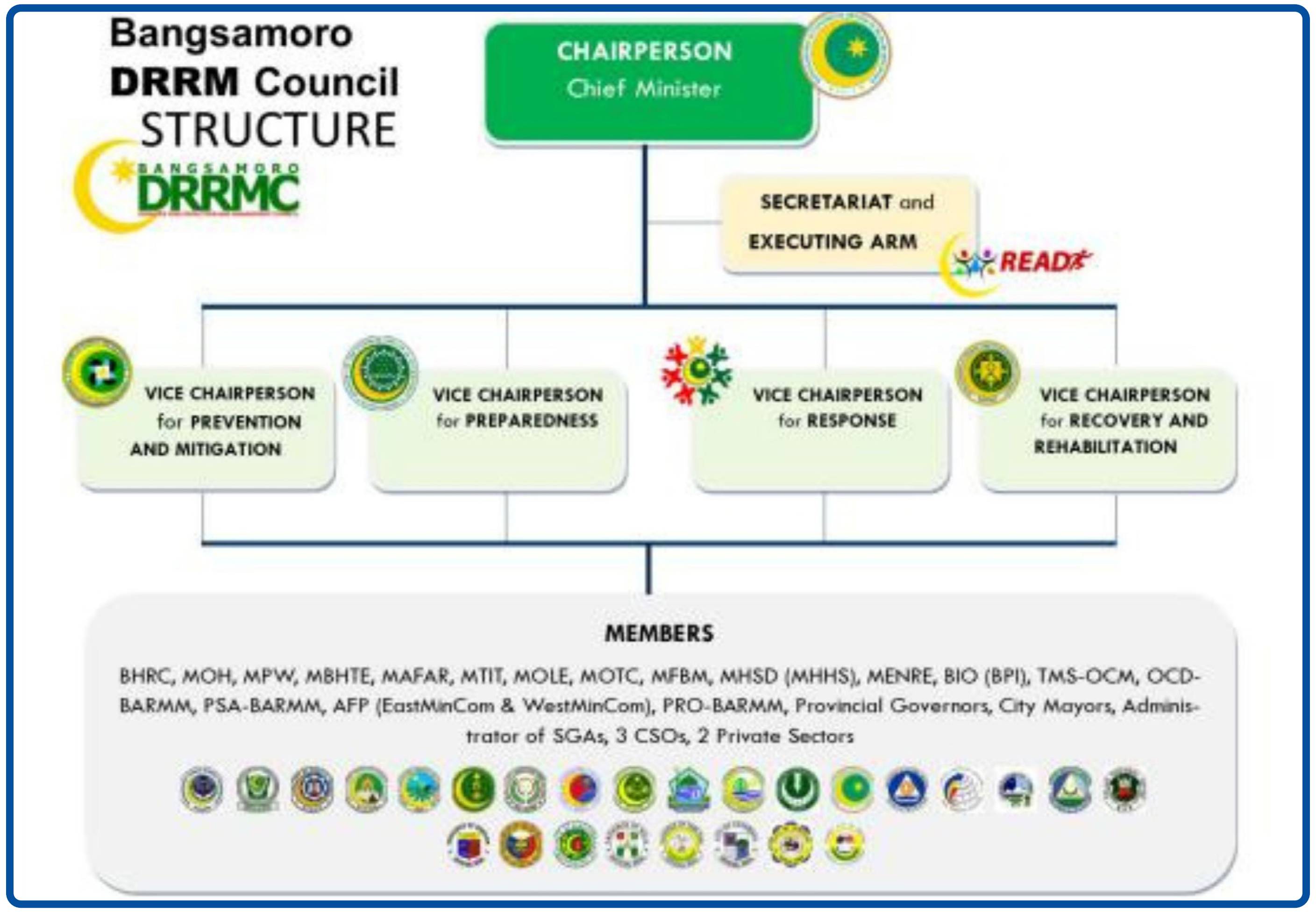


Figure 14. BDRRMC Structure

B. Existing Response Mechanisms and Local Adaptation

The Mindanao River Basin (MRB) exhibits a blend of formal preparedness activities and informal community-driven adaptations in response to recurring hazards. Formal mechanisms include early warning drills conducted at various levels, indicating an established, albeit sometimes limited, system for preparedness and training.

At the community level, particularly in frequently flooded areas like Pagalungan, residents have developed self-initiated adaptations such as constructing stilt houses, building mini-dikes, and elevating school walkways to cope with persistent inundation. While these local adaptations demonstrate remarkable ingenuity and resilience, they often represent survival tactics in the absence of consistent, long-term structural solutions or official government support. The engagement of barangays and the high level of local awareness regarding hazards are notable strengths that contribute significantly to the initial, immediate response efforts carried out by communities themselves.

C. Challenges in Disaster Response Coordination and Implementation

Despite these existing mechanisms, the MRB faces significant systemic weaknesses that hinder effective and timely disaster response, particularly concerning the adequacy of plans, consistency of practice, and availability of resources. Critical coordination gaps and overlapping roles among various government entities, including the Bangsamoro Autonomous Region in Muslim Mindanao (BARMM), national agencies (SGAs), and neighboring Local Government Units (LGUs) in Regions 9, 10, and 13, lead directly to fragmented policy, delayed responses, and inefficient resource deployment. A major impediment is the pervasive lack of sustainable follow-through, where initial planning and training often fail to translate into consistent or sustained action on the ground, leaving communities vulnerable during subsequent events. This highlights deficiencies in both plans and practice.

Compounding these issues is a fragile institutional memory, evidenced by response protocols and lessons learned frequently vanishing when LGU leadership changes, resulting in inconsistent and less effective responses over time. This indicates a lack of resilient plans and continuous practice. The sentiment from local officials underscores a critical gap in empowering local communities with the necessary authority, resources, and decision-making capacity for effective immediate response. Furthermore, the mixed functionality of Early Warning Systems (EWS), including non-functional stations, a lack of user orientation, data access problems, and incomplete installations, directly impairs the ability to trigger and implement timely and effective disaster responses, reflecting deficiencies in resources and practice. Finally, the absence of a central disaster database significantly impedes efficient post-disaster assessment, monitoring of recovery efforts, and learning from past responses, thereby limiting the refinement of future plans.

D. Recommendations for Strengthening Response Capabilities

To enhance the effectiveness, efficiency, and sustainability of disaster response and recovery efforts in the MRB, ensuring robust plans, consistent practice, and adequate resources, several key recommendations are vital:

1. **EWS Rehabilitation and Operationalization**: Prioritize the rehabilitation and repair of non-functional EWS stations, ensuring complete installation and proper calibration to enable timely and accurate warnings that facilitate immediate response. This directly impacts the resources and practice for effective triggering.

2. **Comprehensive Training for Response Personnel**: Implement comprehensive training and capacity-building programs for all personnel involved in disaster response, focusing on practical skills for emergency operations, data interpretation for rapid decision-making, and effective early warning dissemination to communities. This enhances practice.

3. **Improve Data Access and Management for Response**: Establish clear and efficient protocols for data access and management that support rapid assessment of damages, needs, and recovery progress post-disaster. This includes standardizing operational and data collection methods across regions. This strengthens plans and supports data-driven practice.

4. **Strengthened Inter-Agency Coordination**: Urgently clarify roles and foster robust coordination mechanisms among BARMM, national agencies, and LGUs to ensure a unified, coherent, and swift response during emergencies. This is critical for well-executed plans and collaborative practice.

5. **Empowerment of Local Communities**: Advocate for genuinely empowering barangay-level entities with the necessary resources, training, and decision-making authority to initiate and manage immediate response actions effectively. Reinforce that “resilience starts with listening” to local needs and capacities, integrating local knowledge into plans and practice.

6. **Development of Resilient Protocols**: Establish clear, robust, and consistently applied response protocols that are institutionalized and not subject to disruption by changes in leadership. This ensures sustained plans.

7. **Sustainable Funding and Maintenance for Response Infrastructure**: Secure sustainable funding and develop regular maintenance schedules for all response-related infrastructure, including EWS, communication systems, and evacuation facilities. This addresses the critical need for resources and consistent practice.

8. **Holistic Data for Response and Recovery**: Develop an open-access, SQL-like platform capable of tracking not only hazards but also damage, infrastructure impacts, and household status, which is vital for effective post-disaster response and recovery planning and long-term recovery efforts. This supports comprehensive plans and informed practice.

9. **Proactive Preparedness**: Reinforce the guiding principle: “The cost of waiting is higher than the cost of preparing,” advocating for proactive investments in response infrastructure and systems. This emphasizes the importance of forward-looking plans and allocation of resources.

10. **Protocols and Standard Operating Procedures (SOPs)**: Clearly defined protocols and SOPs for EWS activation, communication, and response should be developed and regularly reviewed. These protocols should explicitly address the potential impacts of dam releases on downstream communities.

11. **Drills and Scenario-Based Planning**: Regular drills and scenario-based planning exercises, specifically incorporating scenarios involving dam releases, can help communities practice their response to different types of emergencies, identify potential bottlenecks, and improve coordination among stakeholders.

VIII. DISSEMINATION AND COMMUNICATION

This section examines the existing channels and practices for disseminating critical information related to risk assessment, early warnings, and disaster management within the Mindanao River Basin. It identifies challenges in ensuring clear, timely, and actionable communication to all stakeholders, particularly local communities, and proposes recommendations for improvement. Effective dissemination and communication are crucial for enabling access, fostering understanding, and ultimately driving action in response to hazards.

A. Existing Communication Channels and Practices

Communication and dissemination efforts within the Mindanao River Basin are structured through formal institutional frameworks, a combination of vertical and horizontal channels, and supported by a range of communication technologies.

Vertical Communication

The flow of communication for warnings and directives operates within a hierarchical structure. At higher risk levels, designated as ALPHA, BRAVO, and CHARLIE, warnings and advisories are disseminated, and preparedness directives are cascaded down through various levels. This originates from national or regional agencies like PAGASA for typhoon warnings, and extends through governmental tiers to reach communities. This top-down approach is also evident in the BARMM DRRM Council, where the Chief Minister's leadership establishes a clear line of authority for DRRM communication. Vice Chairpersons oversee specific phases like Prevention, Preparedness, Response, and Recovery, thus channeling information from the council to local units. The activation of the Emergency Operations Center (EOC) at different alert levels (Blue and Red) further illustrates this vertical escalation of communication and the deployment of response mechanisms from central authorities to operational teams and the public. Actions such as preemptive evacuations, recommendations for work or class suspensions, and the prepositioning or pre-deployment of resources are all triggered by these higher warning levels.

Horizontal Communication

The Emergency Preparedness and Response (EPR) protocols also mention the activation of selected or a majority of Response Clusters at higher warning levels (BRAVO, CHARLIE). This signifies coordination among different agencies and organizations (e.g., health, rescue, relief) at the same level to ensure a unified and effective response. The need to "Anticipate augmentation" at lower levels (STANDBY, ALPHA) implies resource sharing among neighboring local government units or agencies to prepare for potential escalation. The "Community Local Observation Chart (CLOC)" involves community-level observations related to various sectors where there is a sharing mechanism within communities, potentially feeding into the formal warning systems.ed regularly to proactively educate the public about flood risks, warning signs, and emergency response procedures, aiming to improve public understanding of risks and appropriate actions.

Overall, warning communication in the Philippines and the Mindanao River Basin utilizes a combination of vertical channels for disseminating alerts and directives from higher authorities down to communities, alongside horizontal coordination mechanisms among various agencies, sectors, and local government units at the same level to ensure a comprehensive and effective response. The BARMM DRRM Council's structure and the EPR protocols highlight these interconnected communication pathways.

Existing Government Communication hannels: A diverse set of channels is currently employed by government entities to disseminate warnings and information.

- Public Address Systems: Utilized for broadcasting advisories (e.g., from PAGASA, NPC) directly to communities, effective in reaching a large number of people in specific geographic areas, especially where other forms of communication are limited.

- Mobile Alert Systems: Leverage mobile phone technology for alerts and warnings, with "recuenda" suggesting a reminder or notification system. This includes SMS-based alerts or notifications via dedicated mobile applications.

- Traditional Media: Newspapers provide detailed information, while television and radio offer real-time updates and warnings, remaining crucial for reaching a broad audience during emergencies.

- Public Information Campaigns: Conducted regularly to proactively educate the public about flood risks, warning signs, and emergency response procedures, aiming to improve public understanding of risks and appropriate actions.

- Social Media: Platforms like Facebook and Messenger are used for quickly sharing updates, warnings, and advisories, and facilitating communication among communities and response agencies.

- Email-blast: Used to send warnings and information to relevant stakeholders, including government agencies, organizations, and potentially registered individuals or communities.

- SMS: Short Message Service (SMS) or text messaging serves as a reliable and accessible channel for disseminating urgent warnings, even on basic mobile phones.

B. Challenges and Gaps in Dissemination and Communication

Despite these structures, significant challenges impede effective dissemination and communication, primarily stemming from systemic gaps in achieving widespread access, fostering clear understanding, and enabling informed action. A key issue is the fragmentation of governance, where overlapping roles and coordination gaps among BARMM, national agencies (SGAs), and various regional LGUs lead to inconsistent or unclear communication of policies, warnings, and response protocols. This directly addresses the community's demand for "communication, coordination, and clarity," which is currently lacking.

Furthermore, the persistent "lack of sustainable follow-through" and fragile institutional memory (where response protocols vanish with leadership changes) result in communication breakdowns or the loss of established communication procedures over time, impacting both access and understanding. The absence of a central disaster database severely hinders efficient, standardized information sharing among agencies and with the public, delaying the timely dissemination of crucial updates and thus limiting access. While communities adapt to recurring floods, the lack of long-term solutions or effective action despite warnings implies a failure in actionable communication or the empowerment of communities to take effective action based on information received. Additionally, challenges with Early Warning Systems (EWS) functionality, including non-functional stations, data access problems, and inadequate user orientation directly impede the reliable and timely dissemination of warnings to affected populations, thereby restricting access and hindering action.

C. Recommendations for Enhanced Dissemination and Communication

To significantly improve the effectiveness, clarity, and reach of dissemination and communication efforts in the MRB, ensuring robust access, fostering clear understanding, and enabling informed action, the following recommendations are crucial:

1. **Develop Clear, Standardized Communication Protocols**: Establish comprehensive, easy-to-understand communication protocols and channels for all levels of disaster management, from national to barangay. These protocols should define roles, responsibilities, and triggers for information dissemination, enhancing access and understanding.

2. **Establish a Centralized Open-Access Data Platform**: Implement an open-access, SQL-like data platform to serve as a single source of truth for real-time and historical data on hazards, damages, and interventions. This will facilitate timely and consistent information sharing among all stakeholders and with the public, significantly improving access to critical information.

3. **Foster Two-Way Communication Channels**: Prioritize and actively cultivate two-way communication channels, especially with local communities. This ensures that authorities "listen" to local insights, traditional knowledge, and feedback, fostering trust and relevance in disseminated information and improving understanding. "Resilience starts with listening."

4. **Build Capacity for Effective Communication**: Implement targeted capacity-building programs for DRRM personnel at all levels, focusing on developing effective communication skills, including clarity, conciseness, cultural appropriateness, and the use of diverse media formats to reach various audiences. This directly enhances the ability to achieve understanding.

5. **Integrate Indigenous and Local Knowledge**: Incorporate indigenous and local weather forecasting practices and traditional knowledge into official communication strategies. This enhances the credibility and understanding of early warnings within communities.

6. **Ensure Consistent Communication of Protocols**: Develop and institutionalize communication procedures for response protocols and plans that are resilient to changes in leadership, ensuring continuity and consistency in messaging. This maintains access and understanding of critical procedures.

7. **Empower Action through Communication**: Shift communication strategies beyond mere warning to actively empowering communities to act. This involves clearly communicating what actions need to be taken, who is responsible, and what resources are available, directly addressing the "no power to act" sentiment and driving action.

8. **Leverage EWS Functionality**: Ensure the full functionality of EWS to guarantee that warnings can be disseminated accurately and on time, forming the backbone of effective communication and enabling timely action.

9. **Clarity and Simplicity**: EWS messages must be clear, concise, and easily understood by all members of the community, regardless of their level of education or literacy. Technical jargon should be avoided and messages should be translated into local languages.

10. **Timeliness**: Timely dissemination of warnings is crucial. Sufficient lead time is essential to allow communities to prepare, evacuate, and take necessary precautions, especially considering the potential for rapid water level changes due to dam releases.

11. **Cultural Sensitivity**: Communication strategies must be culturally appropriate, taking into account local customs, languages, and social norms.

12. **Accessibility**: EWS messages should reach all members of the community, including vulnerable populations such as the elderly, children, people with disabilities, and those with limited access to information.

IX. PRECIPITATION PATTERNS AND HIGHLIGHTS ON THE TRANSECT WALK – UPSTREAM, MIDSTREAM, AND DOWNSTREAM

The transect walks and data analysis conducted in the Mindanao River Basin (MRB) reveal critical insights into the evolving flood and landslide risks and the dynamic interplay between environmental changes and community vulnerability, particularly in Bukidnon (upstream), Cotabato City (downstream), and various midstream areas within BARMM.

A. Upstream MRB

In the upstream stretch, particularly in Dangcagan, Bukidnon, and extending towards the Pulangi IV dam, precipitation data shows a consistent pattern of rainfall, punctuated by significant extreme events. An extreme daily rainfall of approximately 100 mm was observed in early February 2024. While there was a minimal precipitation period from late February through early June, rainfall became more regular between June and September, averaging around 15 mm/day and featuring four pronounced peaks of about 40 mm/day that coincided with the Cotabato City flood. This highlights that even moderate but sustained rainfall in upstream Bukidnon can contribute significantly to downstream flooding, emphasizing the interconnectedness of the basin's hydrology.

The transect walk in Dangcagan provided valuable insights into the local landscape and the interplay of historical land use changes, hazard events, and current vulnerabilities, specifically concerning landslides. Local residents recounted a past where the area was predominantly covered by a diverse forest, teeming with valuable timber species. However, historical land tenure issues and competing claims, including DENR stewardship contracts (from 2002 for 20 years) and Indigenous Peoples' (IPs) assertion of ancestral domain rights and pursuit of Community-Based Forest Management (CBFM) arrangements, have significantly influenced land use patterns and forest cover changes.

The walk also facilitated the validation of historical landslide events through direct observation and discussions with local residents. In **Figure 15** below, observed landslide scars were cross-referenced with geohazard maps from the Mines and Geosciences Bureau (MGB) and the University of the Philippines National Institute of Geological Sciences (UP NOAH), providing valuable ground-truth data and improving the accuracy of existing hazard assessments. Through these observations and discussions, several key landslide triggers were identified:

- **Increased Direct Run-off**: Deforestation has significantly increased surface runoff, leading to soil erosion and heightened susceptibility to landslides.
- **Land Use Change**: The conversion of forested areas for agriculture and urban development has altered the natural hydrological balance, consequently increasing the risk of landslides.
- **Extreme Rainfall Events**: Intense and more frequent rainfall events, exacerbated by climate change, have become significant triggers for landslides, particularly in areas with soft soils such as Kidapawan Clay

Figure 15. Transect Walk Photos and Satellite Data of Dancagan, Bukidnon (Upstream MRB)

B. Midstream MRB

The midstream section of the MRB largely mirrors the upstream precipitation patterns, with a maximum daily rainfall of approximately 90 mm. A pronounced dry spell from late February through mid-April 2024 was observed, suggesting an earlier onset of the rainy season here compared to upstream. Precipitation remained consistent from May to late November, with sporadic spikes between June and early September 2024, and an increase in December 2024 with a maximum extreme event of 70 mm/day in the southern midstream.

Crucially, the midstream area, particularly around the Rio Grande's confluence with the cut-off channel leading to the Liguasan Marsh, shows significant land-use changes that have altered the basin's natural flood regulation capacity. Satellite images from 1995, 2020, and 2024, as seen in **Figures 16-18**, illustrate the disappearance of natural oxbow lakes that once served as vital floodwater storage during high flows. These areas have been converted to agricultural land, and former wetland forests have been cleared, reducing the landscape's ability to retain excess water.

By 2024, the majority of the river's flow has shifted into the cut-off channel, while the main Rio Grande channel has noticeably declined in discharge due to increased sediment loads. This redistribution of flow, coupled with active riverbank erosion, indicates a severely compromised natural flood attenuation system.

The transect walk in Pagalungan Elementary School, as seen in **Figure 19**, further highlighted the direct human impact of these changes. The school's isolation during floods due to lack of a bridge and the inundation of its flooring disrupt learning and pose safety risks. The community's reliance on SMS for communication and bangkas for transportation during floods points to a need for improved communication and evacuation strategies. Observations from elders regarding continued rising water levels due to sedimentation underscore the urgency for mitigation measures. The lack of current mitigation efforts and forced relocation of residents highlight a critical need for proactive flood management in these midstream areas.

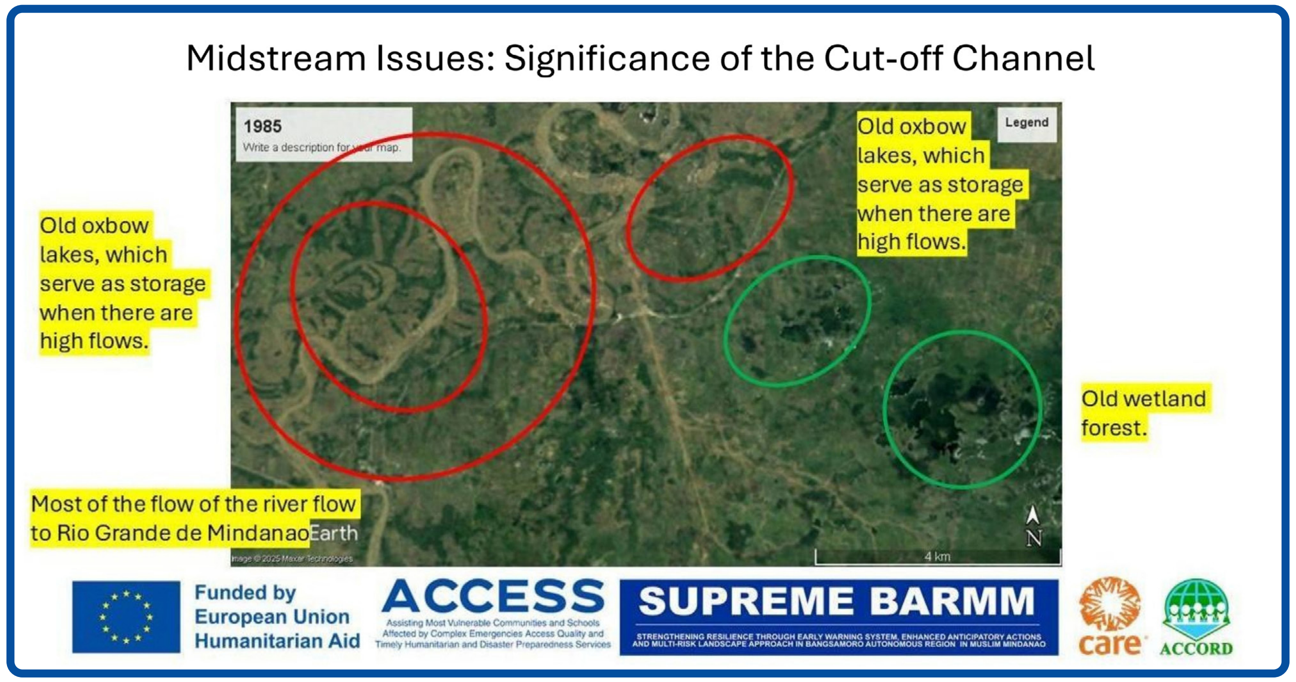


Figure 16. 1995 Satellite Image of Midstream MRB

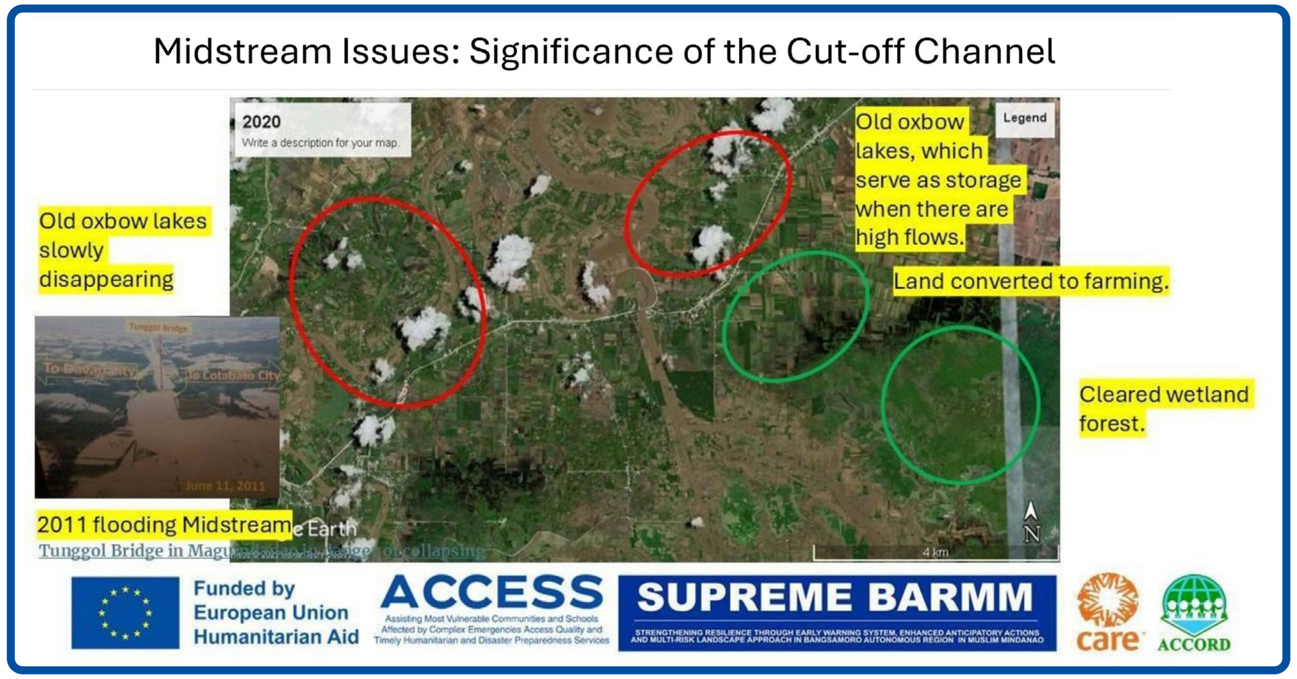


Figure 17. 2020 Satellite Image of Midstream MRB

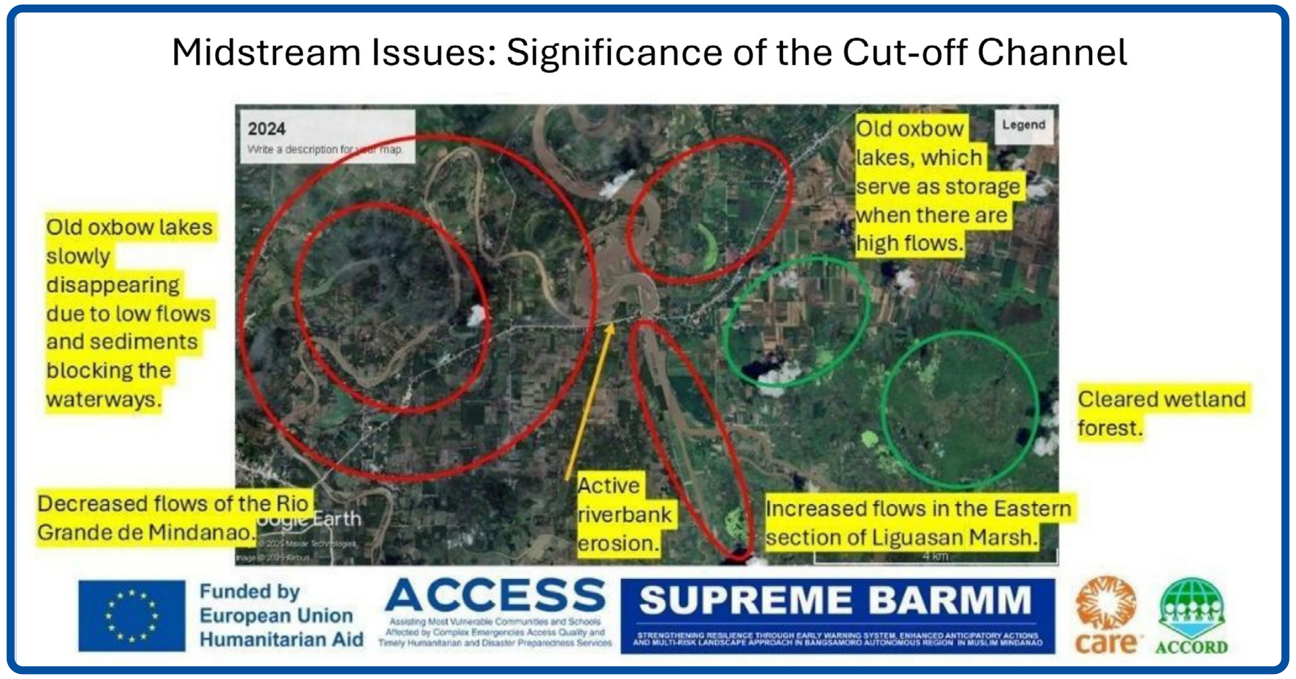


Figure 18. 2024 Satellite Image of Midstream MRB

Figure 19. Transect Walk Photos of Pagalungan (Midstream MRB)

C. Downstream MRB

Cotabato City, located downstream, generally experiences similar precipitation trends but with more regular rainfall and fewer extended dry intervals in its southern reach. The analysis of weekly, time-averaged precipitation maps from June to August 2024 reveals a clear seasonal escalation that culminated in the catastrophic August flood event. June began with moderate, isolated rainfall, followed by a localized downpour in July. August, however, saw progressively larger extremes, including an intense 140.3 mm/day storm during Typhoon Wukong's landfall in the second week, and a record 271.8 mm/day event in the third week. This progression underscores how the basin's temporal and spatial precipitation patterns, partly driven by tropical cyclones, converged to produce severe flooding in Cotabato City.

Meanwhile, the downstream confluence of the Rio Grande de Mindanao and the Matampay River has been dramatically reshaped over the past two decades.

Figure 20 shows the 2004 satellite image of Matampay River in Cotabato City where a tight cluster of homes sits perilously close to the very tip of the river junction—mere meters from the point where the two channels meet—and is almost entirely encircled by water. Figure 21 shows that by 2010, that settlement's footprint has visibly retracted, indicating that successive flood events likely compelled residents to abandon or relocate structures away from the most inundation-prone land.

Between 2014 and 2024, as seen in Figures **21-23**, the confluence of the Rio Grande de Mindanao and the Matampay River has been reshaped by both natural and engineered forces. By 2024, the small settlement that once clung to the very tip of the junction has vanished—its soil banks rendered unstable by ongoing erosion. Meanwhile, reduced flow in the main channel (diverted increasingly into the cut-off channel) has given rise to several newly exposed islets. Furthermore, authorities have constructed flood-protection embankments around the intersection; these structures have confined high-flow inundations and spared buildings, though they have left stretches of other communities exposed. The CDRMMO also reports that the original islet settlement also experienced an incidence of fire.

The decade-long sequence of satellite images and field reports underscores how dynamic fluvial processes and human responses have reshaped the Rio Grande–Matampay junction and its riparian communities.

Figure 20. 2004 Satellite Image of Matampay River, Cotabato City

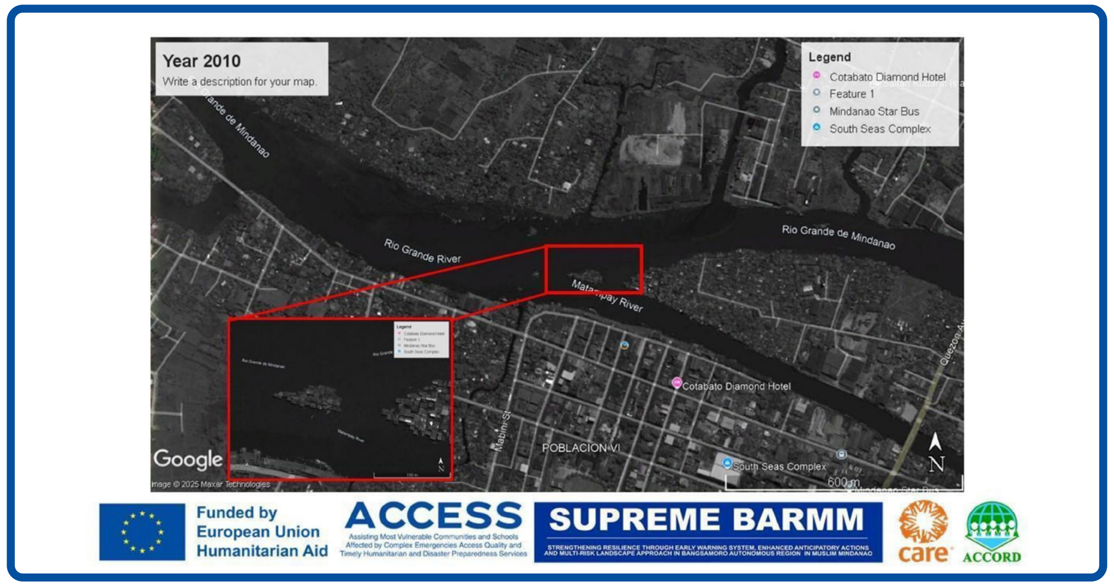


Figure 21. 2010 Satellite Image of Matampay River, Cotabato City

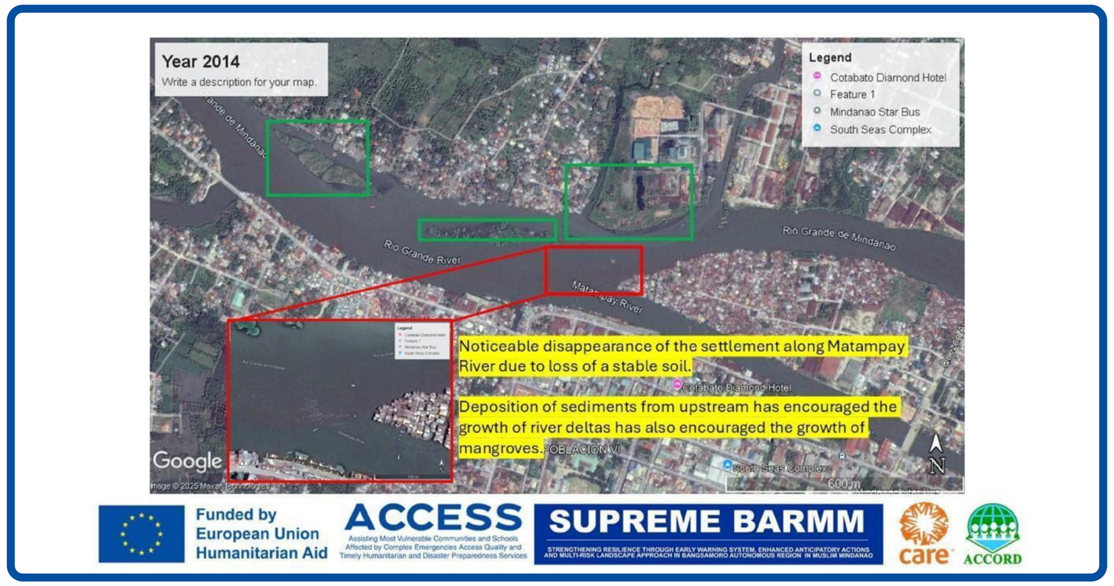


Figure 22. 2014 Satellite Image of Matampay River, Cotabato City

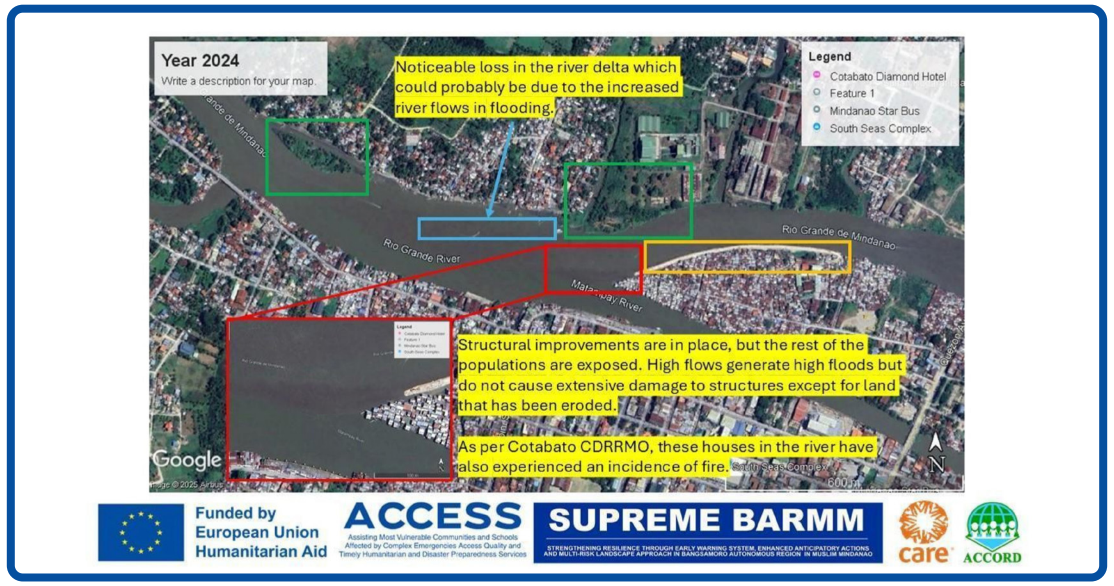


Figure 23. 2024 Satellite Image of Matampay River, Cotabato City

The transect walk, as seen in **Figure 24**, revealed that Poblacion, located along the riverbank, is vulnerable to flooding due to its geographical location and environmental factors. Mitigation efforts, such as the construction of path walks, as seen in **Figure 25**, have improved accessibility and reduced garbage disposal into the river. However, the barangay lacks a formal EWS and relies on retroactive responses based on visual water level cues. The 2011 flood, caused by water hyacinth blockage, highlighted the severity of the flood risk. The reliance on the high school as the evacuation center, despite national guidelines, indicates a lack of alternative options. The long flood subsidence periods and absence of city-led relocation efforts exacerbate the vulnerability of the residents, particularly the high number of illegal settlers along the river.

Figure 24. Transect walk at Poblacion, Cotabato City (Downstream MRB)

Figure 25. Transect walk at Poblacion, Cotabato City (Downstream MRB)

D. Implications for the MRB and Areas of Interest

The data and observations from the transect walks highlight several critical implications for the Mindanao River Basin:

1. **Increased Flood Vulnerability**: The extensive land-use changes in the midstream, particularly the conversion of natural flood-retention areas (oxbow lakes and wetland forests) into farmland, have severely diminished the basin's capacity to naturally attenuate floodwaters. This means that even similar rainfall events are likely to result in more severe and prolonged flooding in downstream areas like Cotabato City and other BARMM communities.

2. **Heightened Landslide Risk**: In upstream areas like Dangcagan, deforestation and land-use changes for agriculture and urban development have significantly increased surface runoff and soil erosion, making these areas highly susceptible to landslides, particularly during extreme rainfall events. This introduces a significant additional hazard beyond just flooding.

3. **Hydrological Shift and Erosion**: The observed shift of the majority of the Rio Grande's flow into the cut-off channel, coupled with increased sediment loads and active riverbank erosion, indicates a significant and potentially irreversible alteration of the river's hydrology. This shift impacts navigation, water quality, and the stability of riparian communities.

4. **Compounded Hazards**: Communities, especially in the downstream areas like Cotabato City, face compounded hazards, as seen with the islet settlement being lost to both erosion and fire. This underscores the need for multi-hazard risk assessments and integrated disaster risk reduction strategies.

5. **Limitations of Current Interventions**: While efforts like flood-protection embankments and early warning systems are in place, their effectiveness is often limited. Structural defenses can confine floodwaters, but they may not eliminate the risk, and the lack of upstream EWS connection creates significant blind spots in warning dissemination.

6. **Need for Integrated and Proactive Management**: The findings underscore an urgent need for comprehensive flood and landslide management plans that address not only downstream impacts but also upstream land-use practices (like reforestation and sustainable agriculture) and midstream hydrological changes. This includes prioritizing infrastructure development (like bridges in Pagalungan), implementing nature-based solutions for flood retention, strengthening EWS connections (both within and between upstream/downstream areas), and establishing robust early warning and evacuation strategies that empower communities to act. Sustainable practices, like preventing overfishing and destructive fishing methods, and addressing sedimentation, are also critical for long-term basin health and disaster mitigation.

X. EWS WORKSHOP FINDINGS: SIGNIFICANT FINDINGS AND SYNTHESIS

This section presents the significant findings from the project, corroborating escalating environmental challenges in the Mindanao River Basin, and synthesizes key takeaways from the Early Warning Systems (EWS) Workshop.

A. Significant Findings

1. **Increasing Flood Frequency and Severity**
   a. Anecdotal evidence from local communities aligns with data from the National Disaster Risk Reduction and Management Council (NDRRMC) situational reports, confirming an increasing frequency and severity of flooding events.
   b. This corroborates academic research, such as studies by Hurtado-Pidal et al. (2022) in Ecological Engineering, which demonstrate a direct correlation between deforestation rates and flood magnitudes in watersheds.

2. **Emergence of New Landslide-Prone Areas**
   a. The project identified the emergence of new landslide-prone areas within the basin, indicating a shifting landscape of risk. These areas were previously unrecorded in existing hazard maps, highlighting the dynamic nature of geomorphological processes. This emphasizes the need for continuous monitoring and updating of hazard maps.

3. **Deteriorating Water Quality**
   a. Evidence of worsening water quality within the Pulangi River system was observed, including:

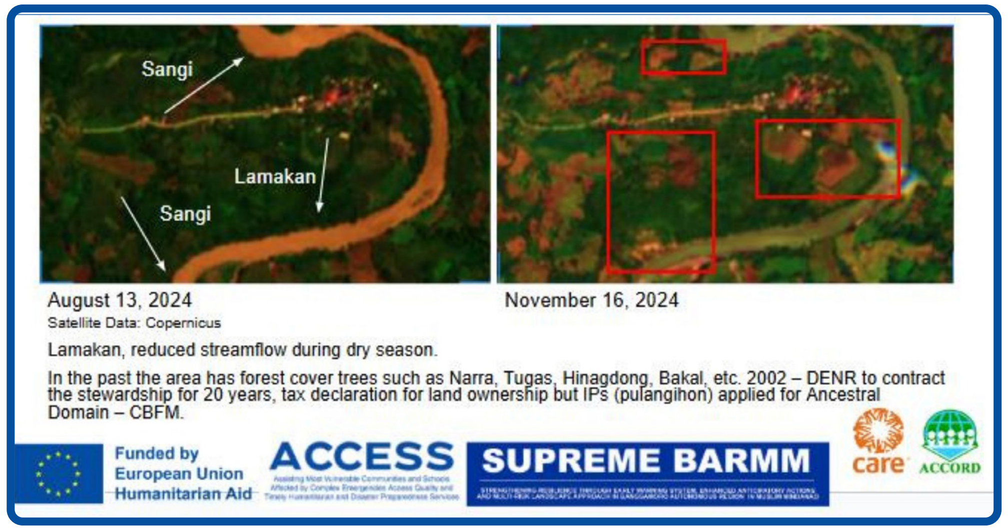


Figure 26. Satellite images of landslides before and after the event.

i. **Fish kills**: Increasing incidence, indicative of declining water quality and potential pollution from agricultural runoff and industrial discharges. This aligns with studies on water quality degradation in Philippine rivers (e.g., Walag, Canencia, and Fiedler, 2018).
ii. **Loss of Biodiversity**: Decline in aquatic biodiversity, including fish species, due to habitat degradation and water pollution. This is consistent with findings from studies such as Muthoka et al. (2023), which identified main threats to aquatic biodiversity and potential management strategies.
iii. **Increased Turbidity**: Elevated turbidity levels in the Pulangi River, suggesting increased sediment loads due to erosion and land degradation within the watershed. This is supported by studies on soil erosion and sediment transport in Philippine watersheds (e.g., Salino et al., 2024).

B. Synthesis of EWS Workshop

The workshop on Early Warning Systems (EWS) for the Mindanao River Basin highlighted the critical importance of effective communication and community engagement in disaster preparedness. A particular emphasis was placed on the vital need to integrate the Pulangi Hydro Electric Power Plant dam discharges into the warning systems of communities located along the Pulangi River and Rio Grande de Mindanao. This synthesis underscores that even with advanced monitoring, the success of an EWS hinges on clear, actionable communication and active community participation.

XI. PHOTO DOCUMENTATION OF TRANSECT WALK ACTIVITIES

Transect walk to the flood-prone area near the river

Brgy. San Vicente, Dangcagan, Bukidnon

Transect Walk near Pulangi River; Observing Flood-prone Banks

Dangcagan, Bukidnon

Participants of the Mindanao River Basin Transect Walk

Pulangi IV Hydroelectric Powerplant

Participants of the Mindanao River Basin Transect Walk Workshop

Luxe Hotel, Cagayan de Oro City

Transect Walk

Brgy. San Vicente, Dangcagan, Bukidnon

Transect Walk on landslide hazard

Brgy. San Vicente, Dangcagan, Bukidnon

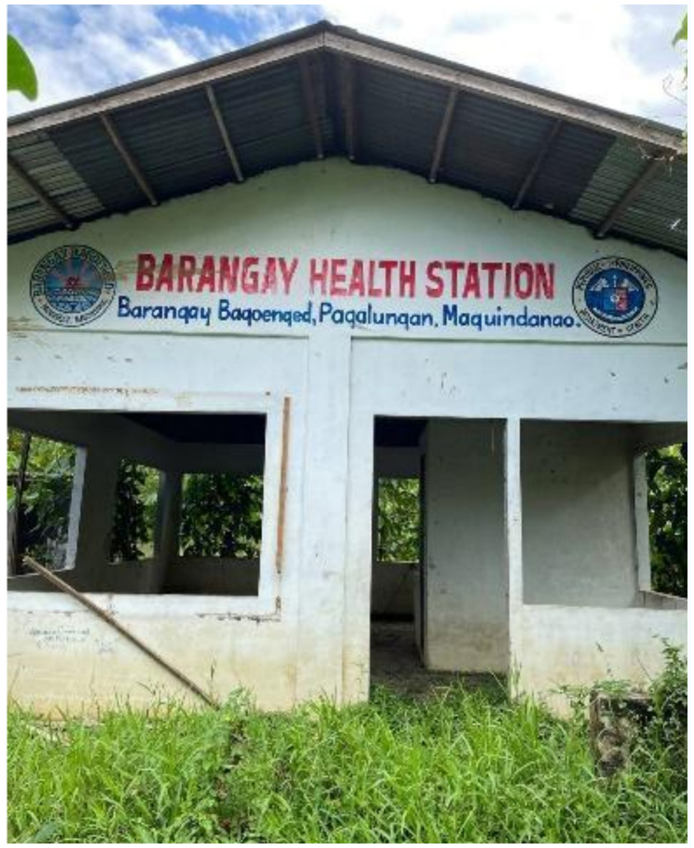
Visit to PAGASA Regional Office

Region X

Visit to the National Power Corporation

Pulangi IV Hydropowerplant

Pagalungan, Manguidanao del Norte



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