Impact-Based Forecasting and Warning System in the Philippines (IBFWS): A Forecasting Paradigm

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Abstract

In the recent years, the occurrence of high-impact weather events has become more frequent and severe. Despite accurate and reliable warning information, significant impacts have still been recorded. This leads us to question, "why do good forecast result in a poor response"? Conventionally, warning centers primarily provides warnings based on meteorological thresholds and information are quite technical and general which do not necessarily provide specific guidance for impending weather conditions. Hence, the development of Impact-Based Forecasting and Warning System (IBFWS) attempts to translate hazard information into potential impacts thus shifting information from what the weather will be to what the weather will do. The new forecasting paradigm attempts to make information actionable, trigger anticipatory action and enable humanitarian intervention. IBFWS effectively supports disaster managers and local responders undertaking proper and appropriate response actions during significant weather events. The system integrates risk information (hazard, exposure and vulnerability) such that impacts are estimated in terms of number of affected population and damage to infrastructure and agriculture, among others. The system utilizes a color-coded (green, yellow, orange, red) warning based on the risk matrix which contains information on the likelihood of potential impacts or risk levels and clear advice on what to do. Despite the promising benefit of IBFWS, findings from test cases suggest the need to further refine impact tables and tailor-fit the system to improve local-based early warning services and for effective local disaster risk reduction and management (DRRM).

Introduction

Despite the advent of technology which leads to increasing accuracy of weather forecasting over time, significant losses are still being recorded during severe and high-impact weather events. For instance, during Typhoon Yolanda (international name "Haiyan") which struck the country particularly in the Visayas regions in November 2013. Accurate warnings were issued by the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) for heavy rains and severe winds as well as possible height of storm surges. However, despite the accuracies of forecast and warning information, the National Disaster Risk Reduction and Management Council (NDRRMC) still reported 6,201 deaths, 28, 626 injured and 1,785 were still missing. Were the warnings not enough or impacts were not properly considered which resulted to poor response? Had there been better knowledge of the risks, particularly of the storm surge, it is likely that more extensive evacuations from exposed areas could have been taken place sooner. Hence, the World Meteorological Organization (WMO) said that it is no longer enough to provide just an accurate weather forecast and warning information, people are now demanding information about what to do to ensure their safety and protect their property.

There are two basic issues in early warning system that have been identified: (1) Difficulties in accessing or understanding alerts, and (2) Lack of understanding on what actions to take once the alert is received. Impact-based forecasting attempts to address these issues to ensure that early warning information would trigger immediate and appropriate response. IBFWS attempts to

narrow the gaps between early warning information and user's expectations and communicating easy-to-understand warning in plain, simple language to propel appropriate early action and/or effective response.

Impact-based Forecasting Warning System (IBFWS) Model

The process of IBFWS (Fig. 1) requires four (4) main components namely, (1) forecasting weather and climate extremes, (2) weather translation to hazards, (3) impact estimation, and (4) early actions and early response.

The weather and climate extreme represents science-based analysis of an impending high-impact weather events, for instance the presence of tropical cyclones which provides analysis of its characteristics in terms of track, size and intensity. These are evidently supported by various state-of-the-science technologies and numerical weather prediction (NWP) models to investigate its behavior and its potential impacts. The primary hazards from extreme events include severe wind and heavy rainfall shall be investigated to include their potential to generate other cascading hazards such as storm surge, floods and flash floods and rain-induced landslides, among others. Information on hazards shall be translated into their corresponding impacts through a risk-based approach to determine the probability and magnitude of harm on human beings, their properties and livelihoods because of their exposure and vulnerability to a hazard. A combination of information on hazard, exposure and vulnerability will determine the level of risk, quantify them and eventually estimate the impacts in terms of the number of populations to be affected, buildings and infrastructures, disruption to various sectors including agriculture, health, transportation and communication, among others. Estimating impacts is vital to approximate socio-economic losses.

Finally, once the level of risk is determined and potential impact are estimated, appropriate response mechanism will be undertaken by the local government units, disaster management authorities and decision makers during the impending threat of a high-impact weather event. Early actions and/or early response will be conducted to include possible pre-emptive of forced evacuation, early harvesting, structural reinforcements and emergency release of funds, among others.

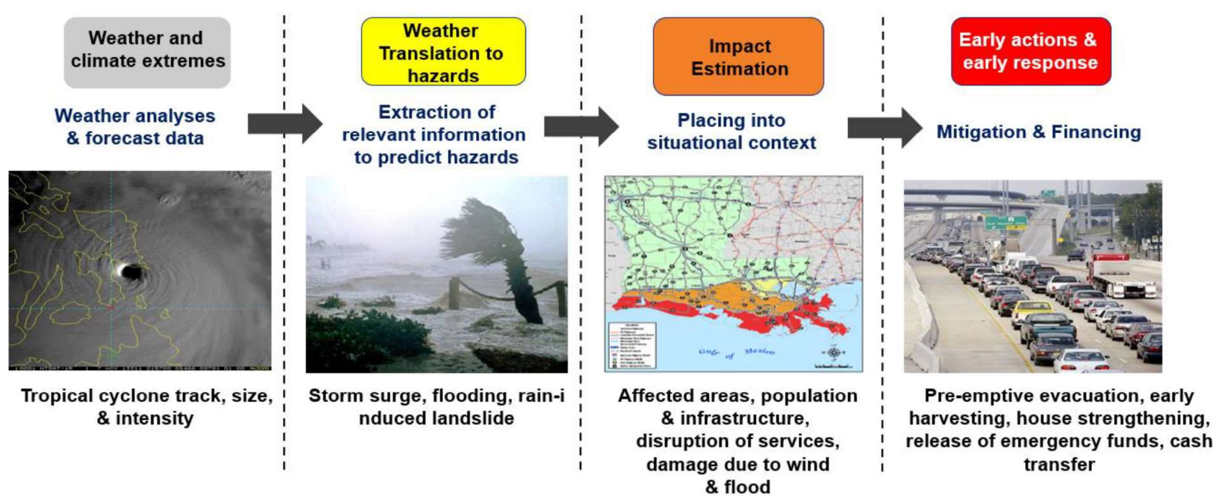


Fig. 1: The IBF system model. The decision-making process entails science-based approach to identify hazards and estimate impacts to trigger early and/or anticipatory actions (Source: WMO,2015).

The Paradigm Shift: From what the weather will be to what the weather will do

In the Philippines, the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) is responsible to provide forecasts and warnings on hydrometeorological and climatological events. These forecasts are usually statements of the expected evolution of sensible meteorological variables such as wind, temperature, humidity and precipitation, among others, which are commonly provided in a deterministic way. Further, the level of risks in the warning information is not properly considered, and so the potential impacts which, in turn, does not trigger effective and appropriate response by the local decision makers and disaster managers.

Further, the evolution of probabilistic information has grown substantially through the development of ensemble prediction systems. In probabilistic information, forecast uncertainties are considered in order to manage user's expectations.

Through IBFWS, warnings are tailored towards the end-users through information of impacts rather than technical meteorological thresholds. Fig. 2 presents the paradigm shift from conventional forecasting to impact-based forecasting which conveys information on impacts of the hazards to individuals of specific communities.

Fig. 2. IBF transitions from conventional forecasting (left) to forecasting impacts (right) – the paradigm shift from what the weather will be to what the weather will do.

On the other hand, one must understand that a meteorological event poses cascading hazards known as the "Hazard Domino Effect" (Fig. 3). In order to establish reliable estimate on the impacts, the source must be identified as well as its associated hazards. For instance, a tropical cyclone brings strong wind and heavy rainfall as the primary hazards. These hazards induce secondary hazards. Strong wind generates storm surge while heavy rainfall results to floods/flashfloods and rain-induced landslides. These hazards, coupled with information on exposure and vulnerabilities would provide tertiary hazards which are associated with impacts.

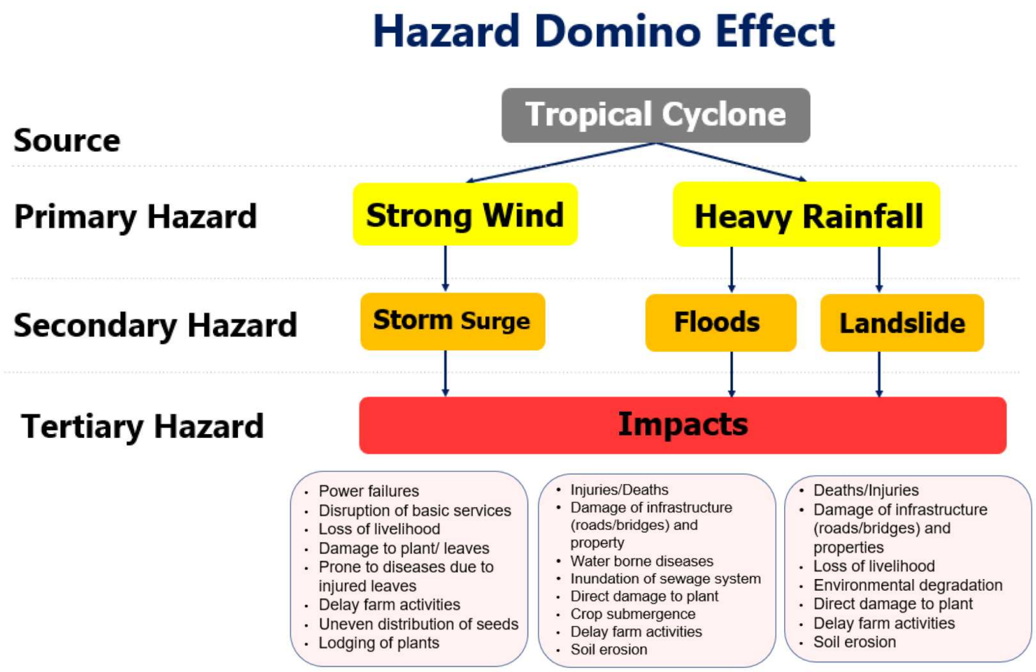


Fig. 3. The Hazard Domino Effect.

The 6Ps of IBFWS Development

There are six (6) components of IBFWS development in the country known as “6Ps” – People, Partnership, Probability of Loss, Platform, Phenomenon, and Publicize (Fig. 4). The people represent the forecasters, researchers, and local stakeholders composed of disaster managers and decision makers who are key players in the development of the IBF system. The partnership defines the linkage and collaboration to ensure proper direction and common understanding on IBF. Partners work together and contribute each other’s expertise to realize shared objectives and ensure that the project will offer great impacts to the public. Through partnership, agreements are established to ensure commitment to support related activities such as data gathering, development of impact tables, response matrices, standard operating procedures, conduct of pilot testing and validations, among others.

On the other hand, probability of loss refers to estimation of impacts or losses during high-impact weather events through risk assessment with combined information on hazard, exposure and vulnerability to determine socio-economic losses. This information will provide better understanding on the potential impacts that may occur on a specific area including number of populations to be affected, buildings and infrastructures, among others. The platform is a visualization tool used to support decision when generating forecast and warning on IBF. The tool is a convenient platform for forecasters to visualize risks and potential impacts given the hazard information derived from probabilistic forecast and other numerical model information. Warnings are provided through a color-coded contour maps showing areas expected to experience certain degree of impacts based on a color-coded warning from yellow, orange and red. This provides easy-to-understand warning information to ensure appropriate response mechanisms conducted by local responders and decision makers during high-impact weather events.

Moreover, the phenomenon pertains to severe and high-impact weather event. In-depth and thorough analysis of weather system through state-of-the-art technologies such as highly sophisticated numerical models producing both deterministic and probabilistic information, upper air sounding, satellite, and doppler weather radars among others are utilized to aid substantial scientific information about the hazard and the predictability of high-impact weather. Lastly, publicize pertains to information dissemination through maximum utilization of all communication channels to ensure that warning information reach the last mile. This includes utilization of social media platforms, radio, and television to disseminate warning information including proper communication of forecast uncertainty.

All these components should work hand-in-hand to ensure successful implementation of Impact-Based Forecast and Warning System. Failure of one component will disable the whole system causing IBFW system to function at insignificant level.

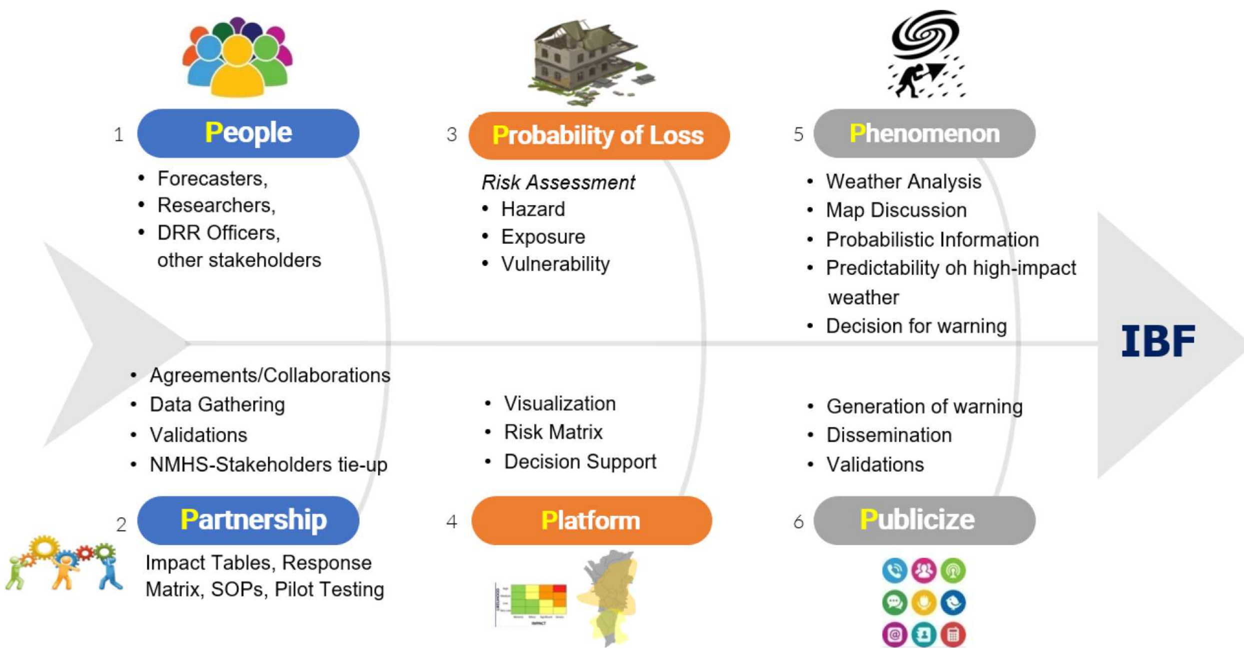


Fig. 4. Components of IBFW system – 6Ps.

Disaster Risk Assessment

Risk is the product and union of hazard, exposure and vulnerability (Fig. 5). Risk assessment process analyzes potential hazards and evaluates existing conditions of exposure and vulnerability that could harm people, properties and livelihoods, among others. The assessment includes the analyzes of an impending hazard, for instance strong wind and heavy rainfall associated with tropical cyclones, its characteristics in terms of location, intensity and timing as well as the potential to generate high-impact. The analysis of exposure and vulnerability information is essential in risk analysis including the physical, social, health, environment and economic aspects.

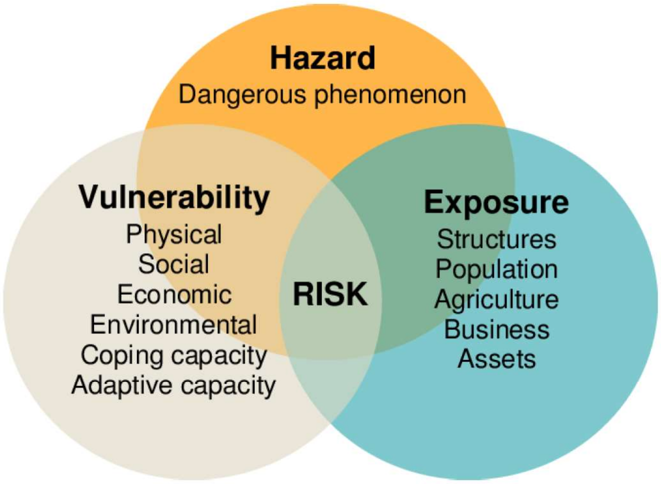


Fig. 5: Conceptual framework for disaster risk assessment.

In the IBFWS process, risk assessment plays a critical role to substantiate analysis on the areas with certain degree or level of risk. As earlier described about the risk, Fig. 6 presents the determination of risk based on the information of hazard, exposure and vulnerability. The figure describes the severe wind risk based on hazard information established exposures and the vulnerability information associated with the type of buildings and/or structure that will be damaged based on the impending risk.

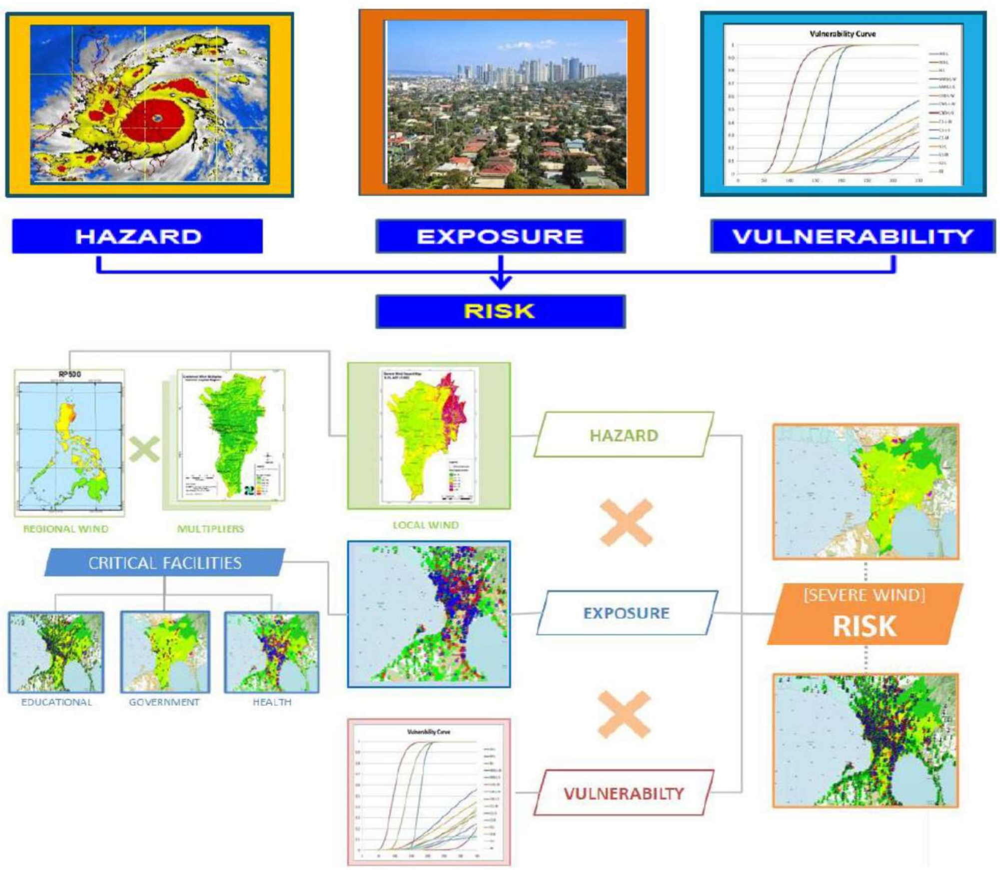


Fig. 6. Severe wind risk assessment for Metro Manila.

Further, detailed representation of risk is presented in Fig. 7. The figure depicts that weather hazards combined with exposure information such as population, infrastructure, land use and topography as well as vulnerability information will aid better visualization of the areas at risk, for instance during heavy rainfall which leads to flooding. Exposure and vulnerability information are essential to support the decision of the forecasters especially when a specific hazard is expected to affect in urban communities with dense population, in which weakly built structures are at risk.

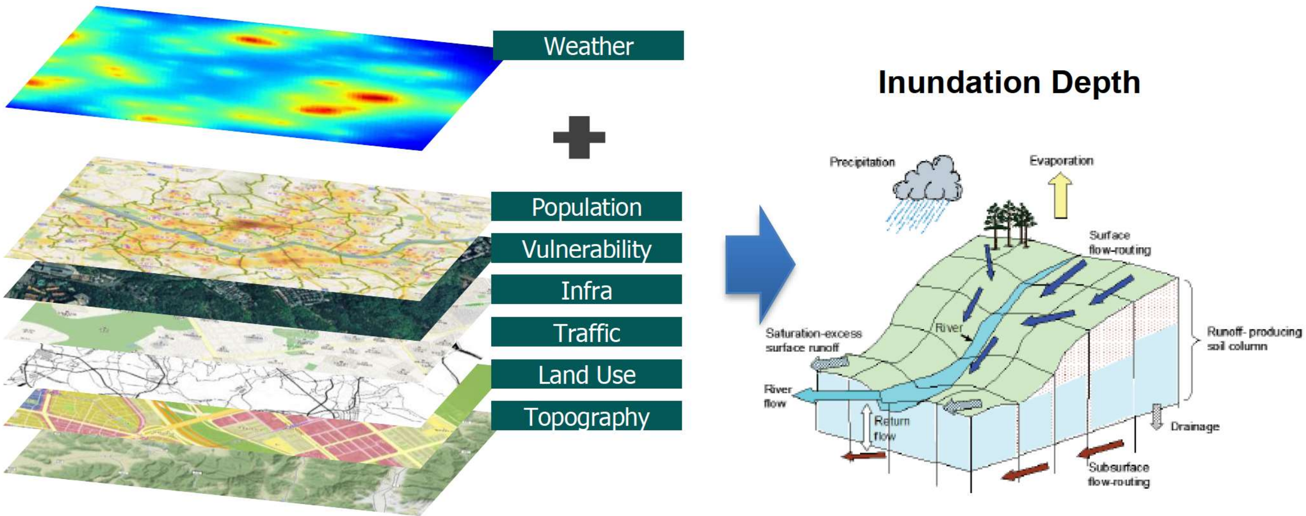


Fig. 7. Representation of risk based on combined information of hazard, exposure and vulnerability.

IBF Visualization Tool

To support forecaster's decision when issuing IBF warning, a visualization tool was developed which provides a one-stop-shop information needed by the forecasters. The tool is designed to integrate all information necessary in the Impact-Based forecast and warning process. The features of the tool include hazard information derived from the analysis of various meteorological products through numerical weather prediction models that produce both deterministic and probabilistic information. Other features are exposure information such as number of populations, structures, location of critical facilities like hospitals, schools, public offices, churches, and fire stations, among others. The tool can also be accessed by stakeholders who can view IBF Warning products and provide feedbacks through the platform. The tool is subject to continuous improvement to incorporate more exposure data from the Philippine Statistics Authority (PSA) and other agencies. Fig. 8 presents several features of the visualization tool that support in the IBFWS decision-making process.

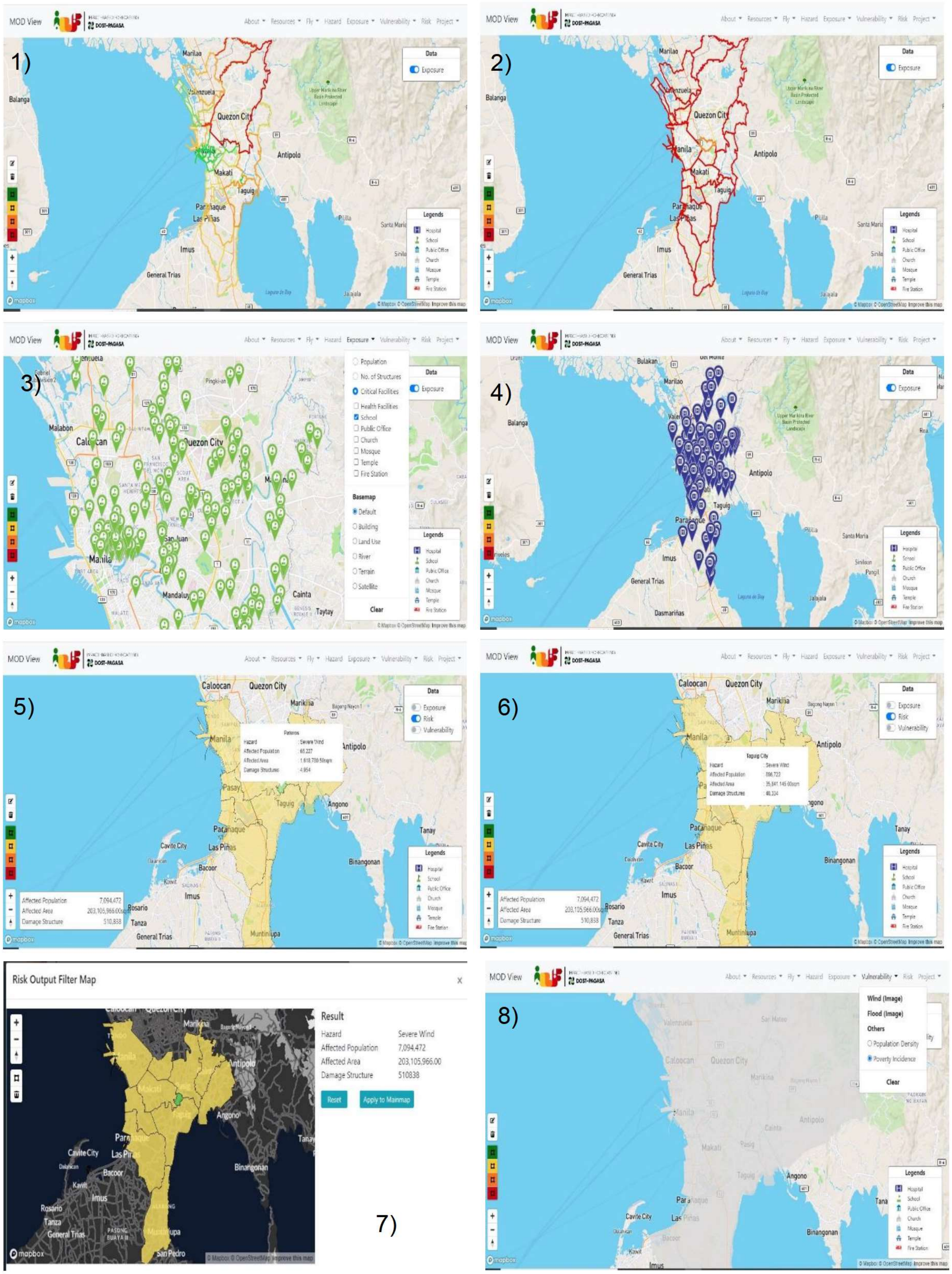


Fig. 8. Some features of the IBFWS visualization tool – (a) total number of populations, (2) total number of structures, (3) critical facility - schools, (4) critical facility – health office, (5) risk output – risk data, (6) risk output – yellow risk data, (7) risk output calculation, and (8) vulnerability – poverty incidenc

Risk Matrix: Operational Approach

IBFWS requires partnership and collaboration between the National Meteorological and Hydrological Service (NMHS) and the disaster management authorities. In the Philippines, PAGASA works closely with the local government units (LGUs) through the local disaster risk reduction and management officers (LDRRMOs). Both the science agency (PAGASA) and the stakeholders identify how the likelihood of an impending hazard and the degree of severity of impacts can be considered in tandem to create a risk matrix. The risk matrix (Fig. 9) presents the likelihood of potential impacts to happen. The strength of the forecasters to predict the hazard in terms of timing, location and intensity, is vital to investigate the likelihood of the hazard that could result in adverse impacts. Based on the impact table, the most appropriate impact level can be identified. The potential impacts can be provided by local stakeholders who are knowledgeable on the local features of their respective areas such as topography, flood prone areas, and other vulnerable sectors and/or communities. The figure presents the suggested operational application of the IBFWS concept, combining impact information with likelihood to identify the risk level from 1 to 10. Unlike traditional threshold-based weather warning, the approach as illustrated by the risk matrix provides a (1) consistent means for the early expression of potential impacts in advance of an impending hydrometeorological event, and (2) means to progressively express changing expectations of risk as a function of varying exposure, vulnerability and likelihood of hydrometeorological hazard.

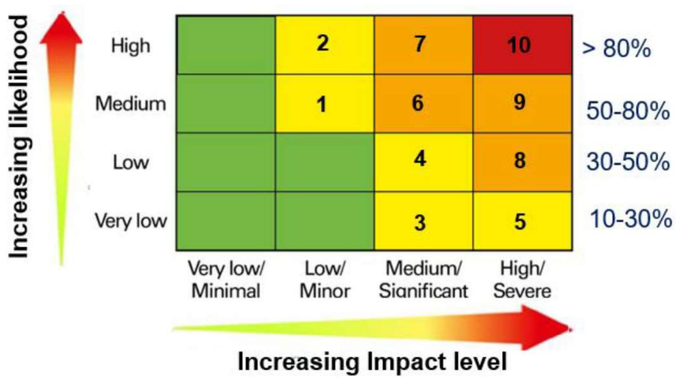


Fig. 9. Risk Matrix

Case Study: Typhoon Odette

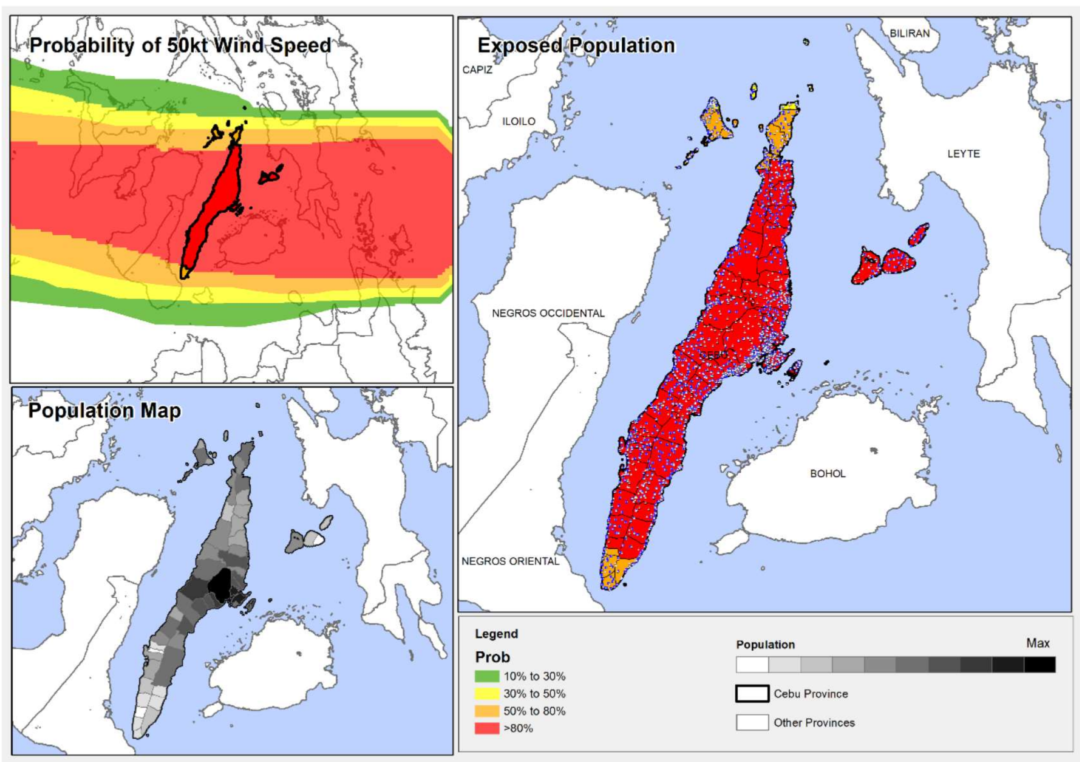
Typhoon Odette (international name "Rai") was the 15th tropical cyclone that hit the country in December 2021. It was one of the powerful and catastrophic tropical cyclones in 2021. It entered the Philippine Area of Responsibility (PAR) on 14 December 2021, rapidly intensified and reached typhoon category. Typhoon Odette made 9 landfalls as it traversed the Philippine landmass from 16 – 17 December 2022 leaving which killed more than 400 individuals and left many people homeless. The National Disaster Risk Reduction and Management Council (NDRRMC) recorded 29.73 billion Pesos and 17.74 billion Pesos damage to infrastructure and agriculture, respectively.

Severe Wind

Tropical Cyclone Odette rapidly intensified into typhoon category on 15 December 2022, one day before it made landfall at Siargao Island, Surigao Del Norte on 1:30PM, 16 December 2021. It maintained under typhoon category as it traversed many islands in Northern Mindanano and Central Visayas. The typhoon recorded the highest peak of maximum sustained winds of 175 kph near the center and gustiness of up to 205 kph.

Based on probabilistic information (Fig. 10), the entire province was expected to experience 50 knot (~95 kph) wind speed with more than 80% likelihood of happening while the southern- and northernmost tip of the province has 50-80% chance of ~95 kph wind speed to occur. The figure also provides an estimate of the number of exposed populations for the said threshold of varied chances to happen. In areas covered by more than 80% chance of receiving ~95 kph, more than 4.6 million populations are at-risk with 90% of exposure while roughly about 450,000 individuals are exposed in the southern and northernmost tip of the province with only 50-80% of receiving ~95 kph wind speed with 9% of exposure.

More than 2,000 critical facilities are exposed to severe wind of the same threshold with more than 80% chance of occurring while only 237 are at risk to areas where the same wind speed has only 50-80% likelihood of happening.



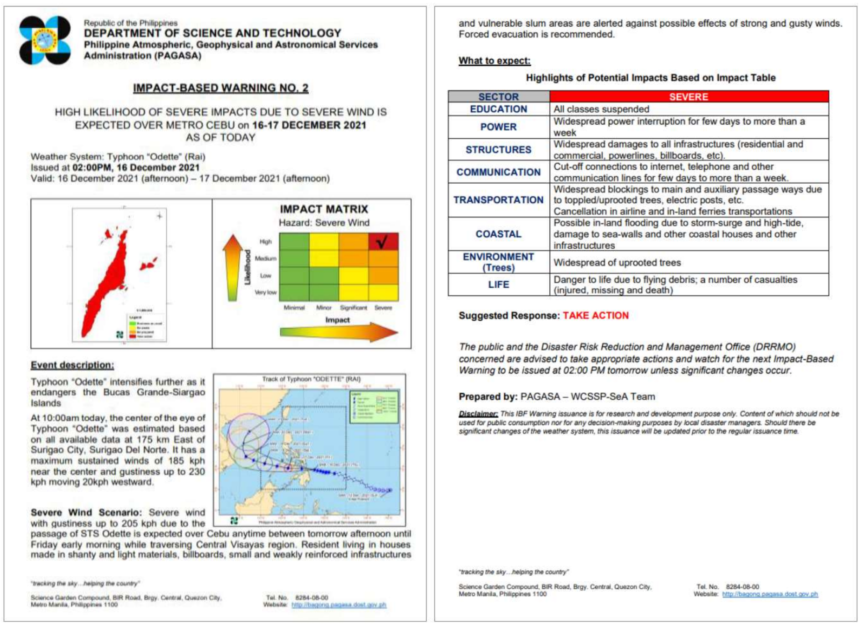
Probability of 50kt Wind Speed	Exposed Population	Total Cebu population	Percentage of Exposure
>80%	4,632,474	5,158,755	90%
50 to 80%	449,771		9%
30 to 50%	76,510		1%
10 to 30%	-		0%

Probability of 50kt Wind Speed	Exposed Critical Facilities	*breakdown Schools	Health
>80%	2,037	1,057	980
50 to 80%	237	108	129
30 to 50%	51	30	21
10 to 30%	3	3	-

Fig. 10. Estimate of exposed population and exposed critical facilities to strong wind (~95 kph) of varied probability of happening.

Because of the looming threat of strong winds posed by Typhoon Odette, Impact-Based warnings for severe wind were also issued in the Province of Cebu. At 2:00PM, December 15 2021, IBF Warning No. 1 was raised for the province with Orange warning or high likelihood of significant impacts. Location of the center of the tropical cyclone Odette was roughly at 550 km. east of Hinatuan, Surigao Del Sur packing up maximum sustained winds of 120kp near the center and gustiness of up to 150 kph moving westward at 20 kph. During IBF Warning No. 1, Metro Cebu was placed under Tropical Cyclone Wind Signal No. 1 with 39 – 61 kph of wind to affect the province with 36 hours. Models showed persistence on the likelihood of hazard (severe wind) to affect in the province of Cebu.

At 2:00PM, 16 December 2021, IBF Warning No. 2 was issued placing the Province under Red Warning or high likelihood of severe impacts due to severe wind (Fig. 11). The location of Typhoon Odette was nearly 150 km east of Surigao City, Surigao Del Norte with maximum sustained winds of 185 kph near the center and gustiness of up to 230 kph.


Republic of the Philippines
DEPARTMENT OF SCIENCE AND TECHNOLOGY
Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA)

IMPACT-BASED WARNING NO. 2

HIGH LIKELIHOOD OF SEVERE IMPACTS DUE TO SEVERE WIND IS EXPECTED OVER METRO CEBU on **16-17 DECEMBER 2021**
AS OF TODAY

Weather System: Typhoon "Odette" (Rai)
Issued at **02:00PM, 16 December 2021**
Valid: 16 December 2021 (afternoon) – 17 December 2021 (afternoon)

Event description:

Typhoon "Odette" intensifies further as it endangers the Bucas Grande-Siargao Islands

At 10:00am today, the center of the eye of Typhoon "Odette" was estimated based on all available data at 175 km East of Surigao City, Surigao Del Norte. It has a maximum sustained winds of 185 kph near the center and gustiness up to 230 kph moving 20kph westward.

Severe Wind Scenario: Severe wind with gustiness up to 205 kph due to the passage of STS Odette is expected over Cebu anytime between tomorrow afternoon until Friday early morning while traversing Central Visayas region. Resident living in houses made in shanty and light materials, billboards, small and weakly reinforced infrastructures and vulnerable slum areas are alerted against possible effects of strong and gusty winds. Forced evacuation is recommended.

What to expect:

Highlights of Potential Impacts Based on Impact Table

SECTOR	SEVERE
EDUCATION	All classes suspended
POWER	Widespread power interruption for few days to more than a week
STRUCTURES	Widespread damages to all infrastructures (residential and commercial, powerlines, billboards, etc).
COMMUNICATION	Cut-off connections to internet, telephone and other communication lines for few days to more than a week.
TRANSPORTATION	Widespread blockings to main and auxiliary passage ways due to toppled/uprooted trees, electric posts, etc. Cancellation in airline and in-land ferries transportations
COASTAL	Possible in-land flooding due to storm-surge and high-tide, damage to sea-walls and other coastal houses and other infrastructures
ENVIRONMENT (Trees)	Widespread of uprooted trees
LIFE	Danger to life due to flying debris; a number of casualties (injured, missing and death)

Suggested Response: **TAKE ACTION**

The public and the Disaster Risk Reduction and Management Office (DRRMO) concerned are advised to take appropriate actions and watch for the next Impact-Based Warning to be issued at 02:00 PM tomorrow unless significant changes occur.

Prepared by: PAGASA – WCSSP-SeA Team

Disclaimer: *This IBF Warning issuance is for research and development purpose only. Content of which should not be used for public consumption nor for any decision-making purposes by local disaster managers. Should there be significant changes of the weather system, this issuance will be updated prior to the regular issuance time.*

"tracking the sky…helping the country"

Science Garden Compound, BIR Road, Brgy. Central, Quezon City, Metro Manila, Philippines 1100
Tel. No. 8284-08-00
Website: http://bagong.pagasa.dost.gov.ph

Fig. 11: Impact-Based Warning No. 2 for Severe Wind (Red Warning) issued at 2:00PM, 16 December 2022

Impacts of severe wind

The aftermath of Typhoon Odette left widespread and massive damages in the province of Cebu that are associated with strong wind. Fig. 12 shows some of the impacts of severe wind in many parts of the province particularly those located within the immediate vicinity of the typhoon's track. In the figure, it could be observed that strong winds inflicted damages in many areas which includes building damages, uprooted trees, toppled down powerlines, and vessel brought onshore. IBF Warning No. 2 indicates potential impacts particularly on education, power, structures, communication, and transportation sectors among others. These sectors indeed were the ones severely affected during the passage of typhoon Odette in the province of Cebu indicative that IBF warnings fairly captured the potential impacts.

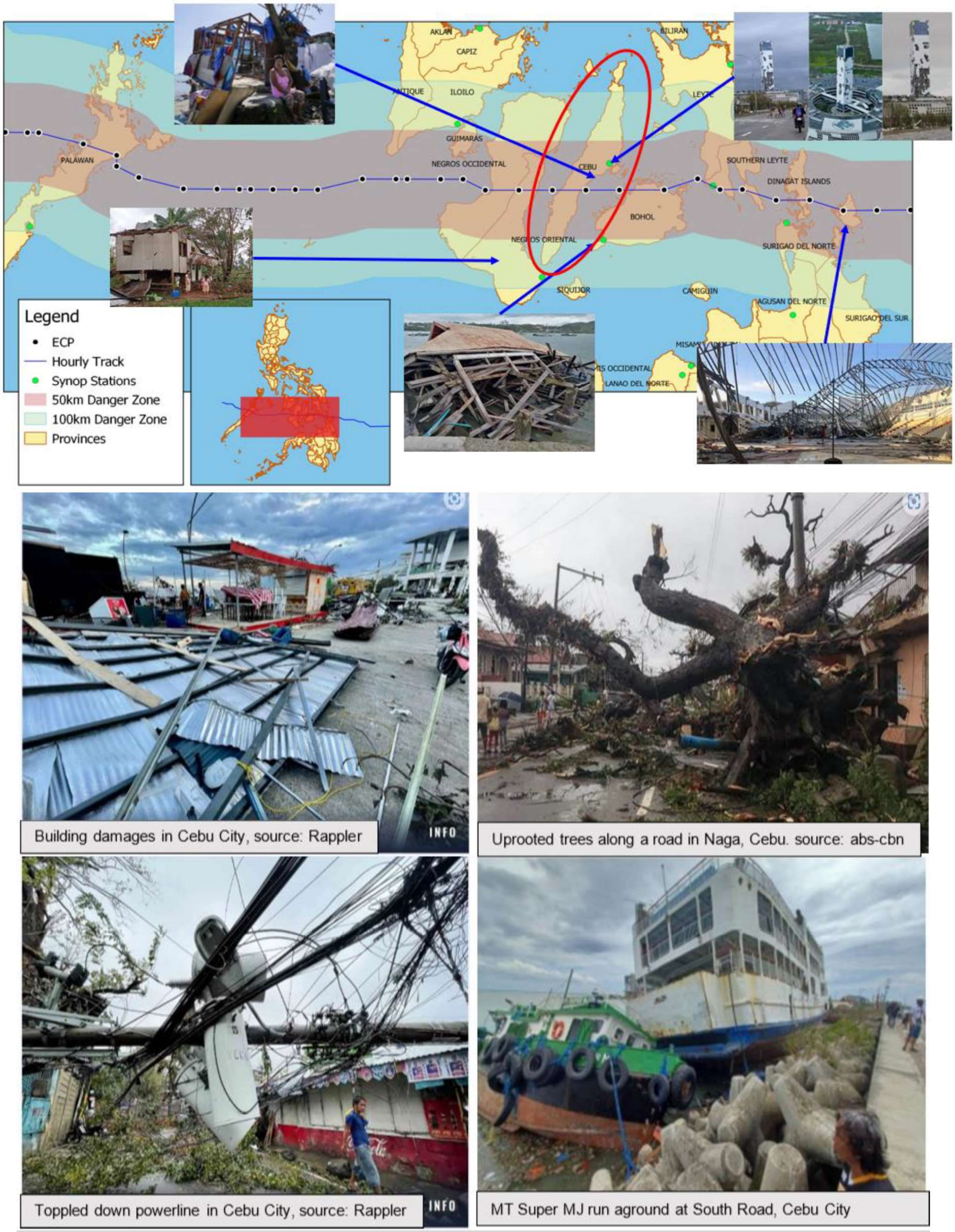


Fig. 12. Impacts of severe in some areas in the province of Cebu.

Heavy Rainfall

Probabilistic information (Fig. 13) reveals the likelihood of 16mm/3hr rainfall to affect the province of Cebu (Fig. 10). The entire province would be experiencing the aforementioned rainfall amount with more than 80% chance of happening. Meanwhile, the northernmost tip of the province has 50 – 80% chance of experience same amount of rainfall.

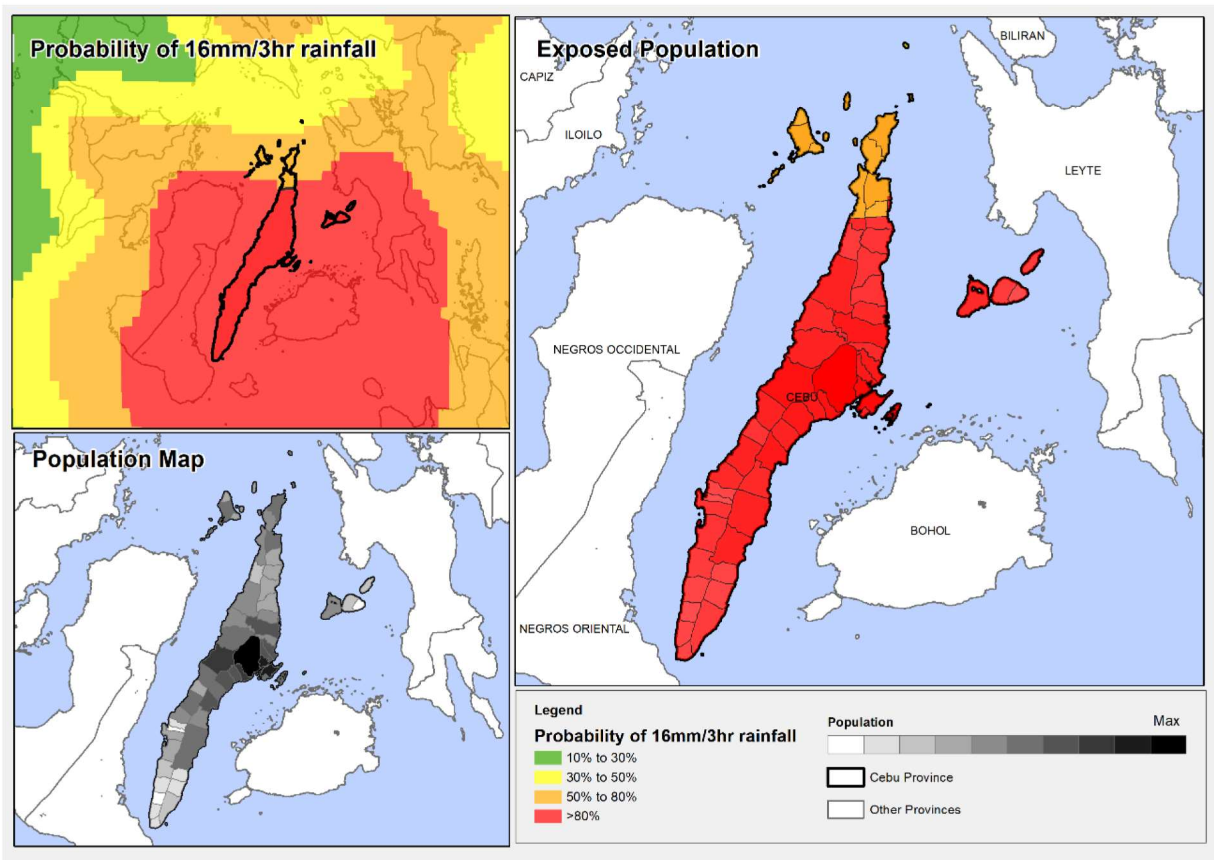


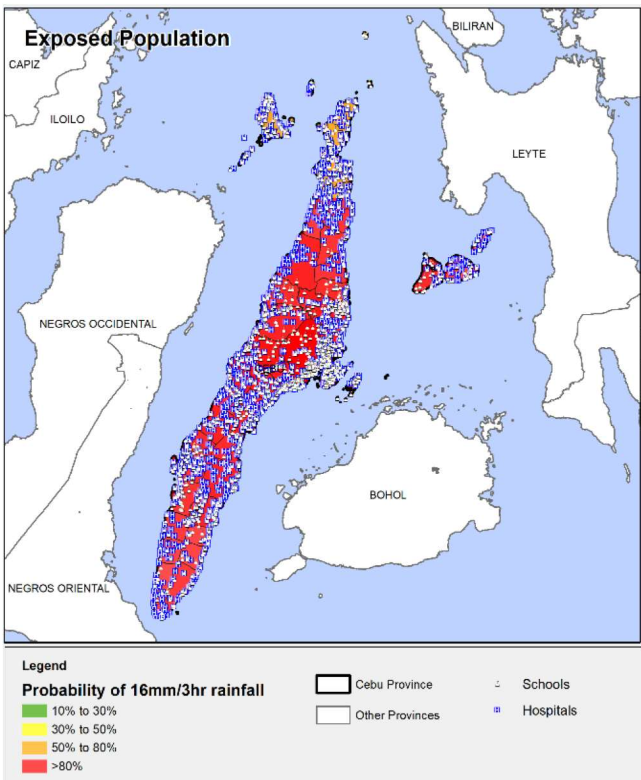
Fig. 13: Probability of 16mm/3hr rainfall during the passage of Typhoon Odette

The exposed number of population as well as the exposed critical facilities covered by different likelihoods (%) of 16mm/3hr rainfall were also estimated (Fig. 14). In the figure, it is noted that 96% of the population would be affected in areas covered by more than 80% chance of 16mm/3hr rainfall. Only 3% and 2% of the population are exposed for the 16mm/3hr rainfall with 50-80% and 30-50% chance of happening, respectively.

Moreover, exposed critical facilities reach to about 2,000 in the areas where 16mm/3hr rainfall has 80% chance of occurring. More than 300 critical facilities are exposed to areas with 50-80% likelihood of such rainfall amount to happen. Only 2% of the critical facility are exposed to areas with only 30-50% chance for a 16mm/3hr rainfall to occur.

The figures provide an estimate of the impacts in terms of the number of exposed populations as well as the exposed critical facilities in the at-risk areas. The approach gives a visualization on the potential impacts in areas where hazard (heavy rainfall) is expected to affect.

Given the condition above, at 2:00PM, 15 December 2021, because of the proximity of Typhoon Odette to the Province of Cebu and the severity of potential impacts that it may cause, IBF warning No. 2 for heavy rainfall was elevated from yellow (IBF Warning No. 1) to Red or high likelihood of severe impacts. This means that severe impacts associated with heavy rainfall has high chance of happening within the forecast period. Similarly, the same level of warning (red) was issued the following day, 2:00PM, 16 December 2021 (Fig. 12) due to the imminent threat of severe flooding and landslides associated with heavy rainfall caused by typhoon Odette. As indicated in the red warning for heavy rainfall, some potential impacts include suspension of all levels of classes, serious traffic congestions, widespread flooding, major damages to residential houses built with light materials, water contamination, power outages, disruption to communication, water-borne diseases, damage to agricultural productions, and a number of casualties, among others.



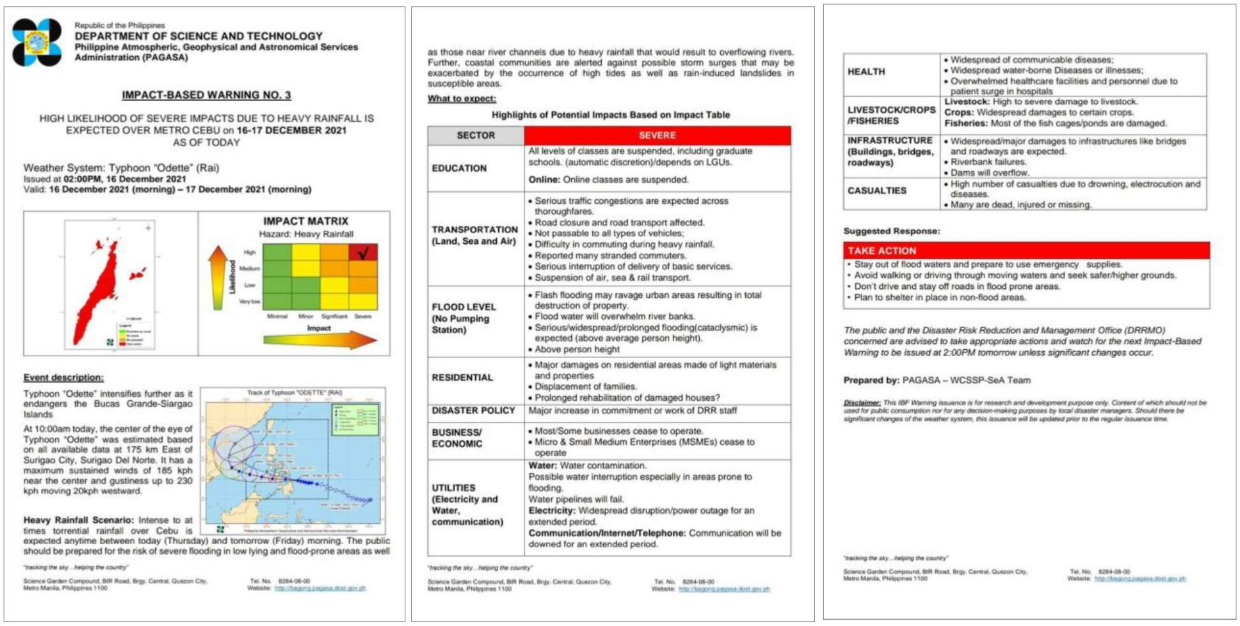
Probability of 16mm/3hr rainfall	Exposed Population	Total Cebu Population	Percentage of Exposure
>80%	4,929,138	5,158,755	96%
50% to 80%	136,115		3%
30% to 50%	93,502		2%

Probability of 16mm/3hr rainfall	Total Exposed Critical Facilities
>80%	1,999
50% to 80%	326
30% to 50%	3

Fig. 14: Percentage of exposed population and number of exposed critical facilities that may be affected per level (%) of likelihood of occurrence of 16mm/3hr rainfall over the Province of Cebu

Given the conditions above, IBF Warning No. 1 for heavy rainfall (Yellow Warning/Very Low Likelihood of Severe Impacts) was raised over Cebu province at 2:00PM, 14 December 2021, valid for 24 hours. At 2:00PM the following day, IBF Warning No. 2 was raised to Red Warning (High likelihood of severe impacts) due to the impending threat of heavy rainfall which was expected to directly hit the Province of Cebu where dense populations several vulnerable sectors were at risk.

At 2:00PM, 16 December 2021, the Red Warning was maintained in IBF Warning No. 3 (Fig. 15) indicating several sectors that would experience severe impacts particularly education, transportation and communication, infrastructure, health and agriculture, among others.



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IMPACT-BASED WARNING NO. 3

HIGH LIKELIHOOD OF SEVERE IMPACTS DUE TO HEAVY RAINFALL IS EXPECTED OVER METRO CEBU on **16-17 DECEMBER 2021**
AS OF TODAY

Weather System: Typhoon "Odette" (Rai)
Issued at **02:00PM, 16 December 2021**
Valid: **16 December 2021 (morning) – 17 December 2021 (morning)**

Event description:

Typhoon "Odette" intensifies further as it endangers the Bucas Grande-Siargao Islands

At 10:00am today, the center of the eye of Typhoon "Odette" was estimated based on all available data at 175 km East of Surigao City, Surigao Del Norte. It has a maximum sustained winds of 185 kph near the center and gustiness up to 230 kph moving 20kph westward.

Heavy Rainfall Scenario: Intense to at times torrential rainfall over Cebu is expected anytime between today (Thursday) and tomorrow (Friday) morning. The public should be prepared for the risk of severe flooding in low lying and flood-prone areas as well as those near river channels due to heavy rainfall that would result to overflowing rivers. Further, coastal communities are alerted against possible storm surges that may be exacerbated by the occurrence of high tides as well as rain-induced landslides in susceptible areas.

What to expect:

Highlights of Potential Impacts Based on Impact Table

SECTOR	SEVERE
EDUCATION	All levels of classes are suspended, including graduate schools. (automatic discretion)/depends on LGUs. **Online:** Online classes are suspended.
TRANSPORTATION (Land, Sea and Air)	• Serious traffic congestions are expected across thoroughfares. • Road closure and road transport affected. • Not passable to all types of vehicles; • Difficulty in commuting during heavy rainfall. • Reported many stranded commuters. • Serious interruption of delivery of basic services. • Suspension of air, sea & rail transport.
FLOOD LEVEL (No Pumping Station)	• Flash flooding may ravage urban areas resulting in total destruction of property. • Flood water will overwhelm river banks. • Serious/widespread/prolonged flooding(cataclysmic) is expected (above average person height). • Above person height
RESIDENTIAL	• Major damages on residential areas made of light materials and properties • Displacement of families. • Prolonged rehabilitation of damaged houses?
DISASTER POLICY	Major increase in commitment or work of DRR staff
BUSINESS/ ECONOMIC	• Most/Some businesses cease to operate. • Micro & Small Medium Enterprises (MSMEs) cease to operate
UTILITIES (Electricity and Water, communication)	**Water:** Water contamination. Possible water interruption especially in areas prone to flooding. Water pipelines will fail. **Electricity:** Widespread disruption/power outage for an extended period. **Communication/Internet/Telephone:** Communication will be downed for an extended period.
HEALTH	• Widespread of communicable diseases; • Widespread water-borne Diseases or illnesses; • Overwhelmed healthcare facilities and personnel due to patient surge in hospitals
LIVESTOCK/CROPS /FISHERIES	**Livestock:** High to severe damage to livestock. **Crops:** Widespread damages to certain crops. **Fisheries:** Most of the fish cages/ponds are damaged.
INFRASTRUCTURE (Buildings, bridges, roadways)	• Widespread/major damages to infrastructures like bridges and roadways are expected. • Riverbank failures. • Dams will overflow.
CASUALTIES	• High number of casualties due to drowning, electrocution and diseases. • Many are dead, injured or missing.

Suggested Response:

TAKE ACTION
- Stay out of flood waters and prepare to use emergency supplies.
- Avoid walking or driving through moving waters and seek safer/higher grounds.
- Don't drive and stay off roads in flood prone areas.
- Plan to shelter in place in non-flood areas.

The public and the Disaster Risk Reduction and Management Office (DRRMO) concerned are advised to take appropriate actions and watch for the next Impact-Based Warning to be issued at 2:00PM tomorrow unless significant changes occur.

Prepared by: PAGASA – WCSSP-SeA Team

Disclaimer: *This IBF Warning issuance is for research and development purpose only. Content of which should not be used for public consumption nor for any decision-making purposes by local disaster managers. Should there be significant changes of the weather system, this issuance will be updated prior to the regular issuance time.*

"tracking the sky…helping the country"

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Fig. 15: Impact-Based Warning No. 3 for Heavy Rainfall (Red Warning) issued at 2:00PM, 16 December 2022

Impacts of Heavy Rainfall

Situational Report No. 15 for Typhoon Odette issued by the National Disaster Risk Reduction and Management Council (NDRRMC) on 28 December 2021 reported a total of 220 deaths, 562 injured and 32 missing individuals in Region 7 which includes the Province of Cebu while 60 roads and 5 bridges were reported unpassable due to damages largely brought by severe flooding. Fig. 16 shows some of impacts of heavy rainfall which causes severe flooding in many parts of Metro Cebu. The province of Cebu received enormous amount of rainfall on December 16 – 17, 2022 which brought massive flooding in many areas in the province.

Fig. 16. The pictures above (photo from Ms. Michelle Oporto) streets of Osmeňa, Fuente, Ayala and most parts of Cebu City were submerged by floodwaters. Most roads were completely unpassable because of floodwaters. The pictures below (snipped from video from Kackie Fernandez from Cebu) was the Willy Wonka's Chocolate factory in Cebu which was also flooded.

Discussions and Recommendations

Progressing from general weather forecast and warning to impact-based forecast and warning services may require complex efforts, however, these challenges may be addressed when there is partnership and collaboration between early warning agency and critical stakeholders. Successful impact-based forecasting requires strong partnership in order to develop better risk assessments, improved monitoring, early warning and enhanced overall response to hazards and disasters. Considering impact-based warning heavily relies on risk-based approach, each partner should play a critical role in order to establish a comprehensive risk information. This includes development of exposure data and vulnerability information. This information is taken from various partners and institutions whose mandate are geared towards statistics, mapping and disaster risk reduction and management. Working closely together, information provider and users collectively provide an integrated, authoritative, unified voice that everyone could resonate with, and in turn could take effective action.

Current effort on IBFWS in the country shows promising partnership between PAGASA and several stakeholders however more efforts should be put to validate warning issuances and calibrate the IBF system. This can only be done when participation of the local government units in IBFWS undertakings is in full swing.

On the other hand, some noteworthy recommendations in the implementation of IBFWS are as follows:

- Regular consultations with partners and stakeholders should be done to develop GIS-based relevant data required for risk assessment to identify areas of highest risk and to refine impact tables, standard operating procedures (SOP), and discuss progress and address challenges to improve the IBFW system;
- More capacity building activities should be undertaken for forecasters and stakeholders on IBFWS.
- Forecast uncertainty should be well communicated in order to management information user's expectations;
- More cases should be undertaken in order to calibrate the system.
- Establish legal agreements between PAGASA and critical partners to ensure their commitment
- Development of site-specific thresholds for severe wind and heavy rainfall to localize information of potential impacts.

References

WMO Guidelines on Multi-hazard Impact-based Forecast and Warning Services, WMO No. 1150, 2015 Publication

https://ndrrmc.gov.ph/attachments/article/1329/FINAL_REPORT_re_Effects_of_Typhoon_YOLANDA_HAIYAN_06-09NOV2013.pdf

https://ndrrmc.gov.ph/attachments/article/4174/SitRep_No_15_for_Typhoon_ODETTE_2021.pdf

https://www.rappler.com/nation/typhoon-odette-cebu-queen-city-in-ruins

https://www.rappler.com/nation/cebu-city-give-aid-families-of-killed-typhoon-odette/

https://news.abs-cbn.com/news/12/17/21/1-dead-thousands-flee-in-ph-due-to-typhoon-odette

https://www.pna.gov.ph/articles/1163057