MEMBER REPORT

ESCAP/WMO Typhoon Committee

11th Integrated Workshop

Philippines

Cebu City, Philippines

24 – 28 October 2016

CONTENTS

I. Overview of tropical cyclones which have affected/impacted Member's area in 2015

1. Meteorological Assessment (highlighting forecasting issues/impacts)

There were only ten tropical cyclones affected, enter or developed in the Philippines Area of Responsibility, a very low number compared to the previous years, from January up to October: Tropical Depression (Ambo) in June, Typhoon Nepartak (1601) in July and Severe Tropical Storm (STS) Nida (1604) also in July and August, Typhoon Lionrock (1610) in August, STS Namtheun (1612), Typhoon Merante (1614) and Typhoon Malakas (1615) in September, Typhoon Sarika (1621) and T

- Tropical Depression with local name Ambo was first spotted as a Low Pressure Area east of Bicol Region then developed into a Tropical Depression morning of 26 June 2016. It made landfall in Aurora morning of 27 June 2016 after which it weakened into a Low Pressure Area (LPA).

- Nepartak was already a typhoon when it entered the Philippine Area of Responsibility (PAR) in the morning of 5 July 2016. Although it did not make a landfall but the outer spiral of Nepartak affected Batanes and Babuyan group of Islands. Tropical Cyclone Warning Signals (TCWS) were hoisted over the said areas and Gale Warning for Shipping were also issued over the seaboards of Luzon and Eastern Visayas due to strong to gale force southwesterly winds.

- Nida formed as a LPA embedded in the ITCZ inside PAR morning of 29 July 2016. It intensified into a STS before making a landfall in province of Cagayan afternoon of 30 July 2016. TCWS's were raised over the provinces of Northern and Eastern Luzon and Gale Warnings for shipping were also issued in areas where there were no TCWS but were affected by the surge of the Southwest wind flow. Pre-emptive evacuation was done in the landslide and flood prone areas and no casualty reported.

- Lionrock was already a typhoon when it enter in the northeastern border of PAR in the late morning of August 24, with maximum winds of 130 kph with gust of 160 kph. It then moved slowly in a south southwest direction. It remain almost quasi-stationary for almost 36 hours and then move northeast slowly in the morning of August 26 as it intensified at 160 kph with gust of 195 kph. It started to accelerate in the evening of the same day and exited PAR in the evening of August 27.

- Namtheun (Enteng) started as a LPA embedded in the monsoon trough and developed into a TD inside PAR in the early morning of September 1. It intensified into a TS in the late morning of the same day as it move northeast at 19 kph. Namtheun intensified into a STS in the evening of the same day as it exited PAR.

- Merante (Ferdie) was already a STS when it entered eastern border of PAR in the morning of Sept. 11 and continues to gain strength and became a Typhoon as it moved in a WNW direction towards extreme Northern Luzon. It made landfall over Itbayat, Batanes and the eyewall passed over Basco, Batanes in the early morning (1:50 Am) of 14 September with sustained winds of 220 kph with gust of 260 kph. It exited PAR in the afternoon of the same day.

- Malakas (Gener) was also a STS when it entered PAR at midnight of 13 September as it moved West Northwest at 20 kph in the general direction of Batanes – Taiwan Area. Malakas intensified into a typhoon and directly affected Batanes group of islands by the outer spiral of the system as it moved NNW then northward towards the eastern seaboard of Taiwan. It exited in the northern boundary of PAR in the afternoon of 17 September.

- Megi (Helen) enter PAR as an STS in the afternoon of 24 September and moved WNW at 24 kph in the general direction of Batanes – Taiwan area. It intensified into a typhoon as it moved closer to Taiwan. It made landfall over Taiw an in the afternoon of 27 September and exit PAR in the evening of the same day. TCWS # 2was raised over Batanes group and TCWS # 1 over Babuyan group of islands and Northern Cagayan. No damage reported.

- Sakira (Karen) developed into a TD inside PAR and intensified into a TS and intensified further into a typhoon in the evening of 14 Oct 2016. It made landfall in Baler, Aurora in the morning of 16 Oct. 2016 with center winds/gust of 150/210 kph. Sakira crossed Central Luzon and exit landmass in Pangasinan. Pre-emptive evacuation wasdone in the landslide and flood prone areas and no casualty reported.

Station Name	Pressure (mslp)	Max. Sustained winds (10 min.)	Peak Gust	24 Hr. Rainfall
Baler. Aurora	957.4	35 mps	52 mps	148.0 mm
Casiguran, Aurora	993.5	22 mps	36 mps	195.9 mm

- Haima (Lawin) was already a typhoon when it entered PAR and continues to gain strength and became a super typhoon. It made landfall southern Cagayan in the evening of October 19 and crossed northern Luzon and was over West Phil. Sea in the morning of October 20.

Figure 1 Tracks of tropical cyclones that affected Philippines from 1 January up to the present.

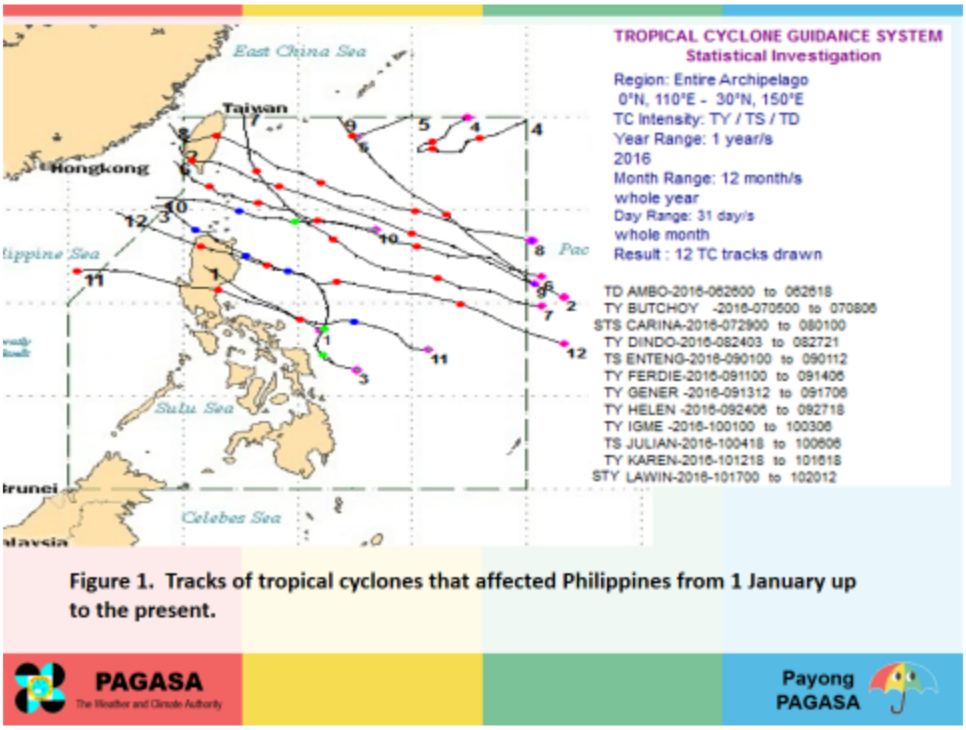


Figure 1. Tracks of tropical cyclones that affected Philippines from 1 January up to the present.

Table 1: Tropical Cyclone Classification being used by PAGSA (as of 06 May 2015)

CATEGORY	INTENSITY	
	Kilometer per hour (kph)	Nautical miles per hour [knots] (kt)
1. Tropical Depression (TD)	61 or less	33 or less
2. Tropical Storm (TS)	62-88	34-47
3. Severe Tropical Storm (STS)	89-117	48-63
4. Typhoon (TY)	118-220	64-100
5. Super Typhoon (STY)	More then 220	More than 120

Table 2: Tropical Cyclone Warning Signals (TCWS) (as of 18 May 2015)

PSWS	LEAD TIME (Hrs)	WINDS (KPH)	IMPACT OF THE WIND

#1	36	30 – 60	No damage to very light damage
#2	24	61 – 120	Light to moderate damage
#3	18	121 – 170	Moderate to heavy damage
#4	12	171 – 220	Heavy to very heavy damage
#5	12 or <	More than 220	Very heavy to widespread damage

PAGASA has adopted a new Tropical Cyclone Classification that includes Severe Tropical Storm and Super Typhoon Category that is used for domestic warnings and bulletins. Aside from the TC classification, PAGASA also modified the Tropical Cyclone Warning Signals (previously named Public Storm Warning Signals {PSWS}) from PSWS 1 to 4, to TCWS 1 to 5. This is due to the recommendations from higher authorities and other stakeholders after the disaster brought by Yolanda.

PAGASA extended its tropical cyclone forecast track from three days to five days starting from 2015 typhoon season. This was due to the request of the Department of Interior and Local Government (DILG) to have five days forecast track for the preparations of every local government units to be affected for the coming of the weather disturbance. They said that three days is not enough for the preparations.

2. Hydrological Assessment (highlighting water-related issues/impact)

Typhoon Sakira and Super Typhoon Haima brough moderate to heavy rainfall in Central and Northern Luzon that caused floodings and landslides in several provinces.

Nepartak (Butchoy),Nida (Carina) brought more than 100 mm of rainfall in 24 hours in many areas of Luzon and Eastern Visayas during their passage except for the TD which recorded below 100 mm of rainfall.

For Typhoon Lionrock and STS Namtheun, they don’t have direct effect to the country but Lionrock enhanced the southwest monsoon and brought moderate to occasionally heavy rains in some provinces of western Luzon. Namtheun on the other hand has no significant rainfall recorded.

PAGASA issued Flood Bulletins for telemetered river basin and Flood Advisories for non-telemetered river basin in Luzon and some regions

in Visayas during the passage of three tropical cyclones.

Table 3: 24 hour Rainfall during the passage of TD (Ambo)

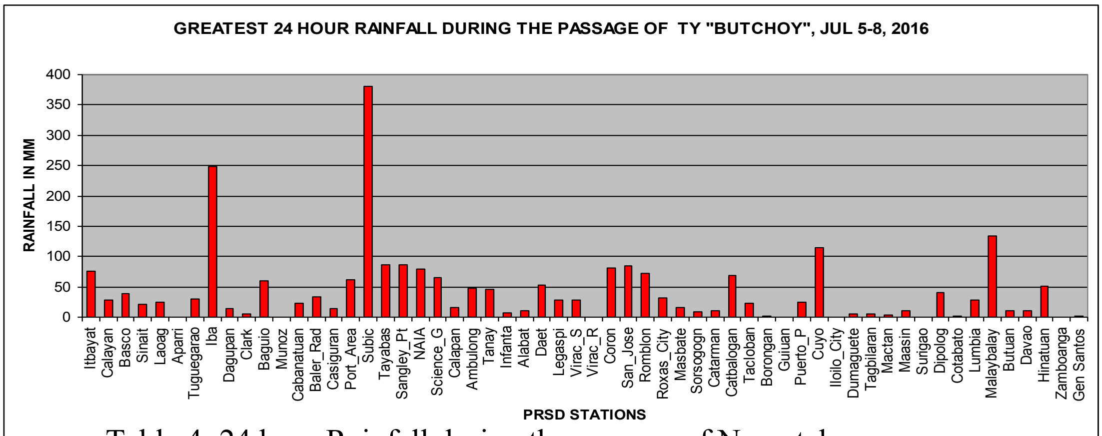
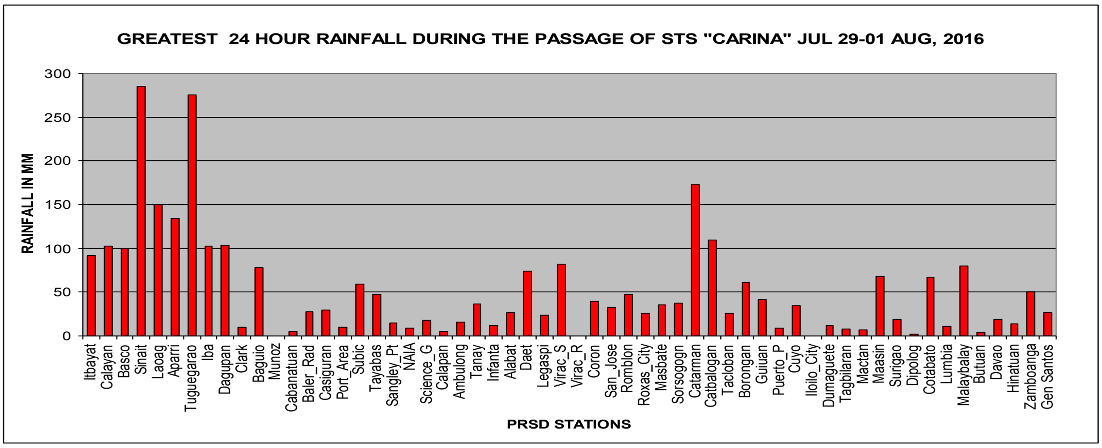
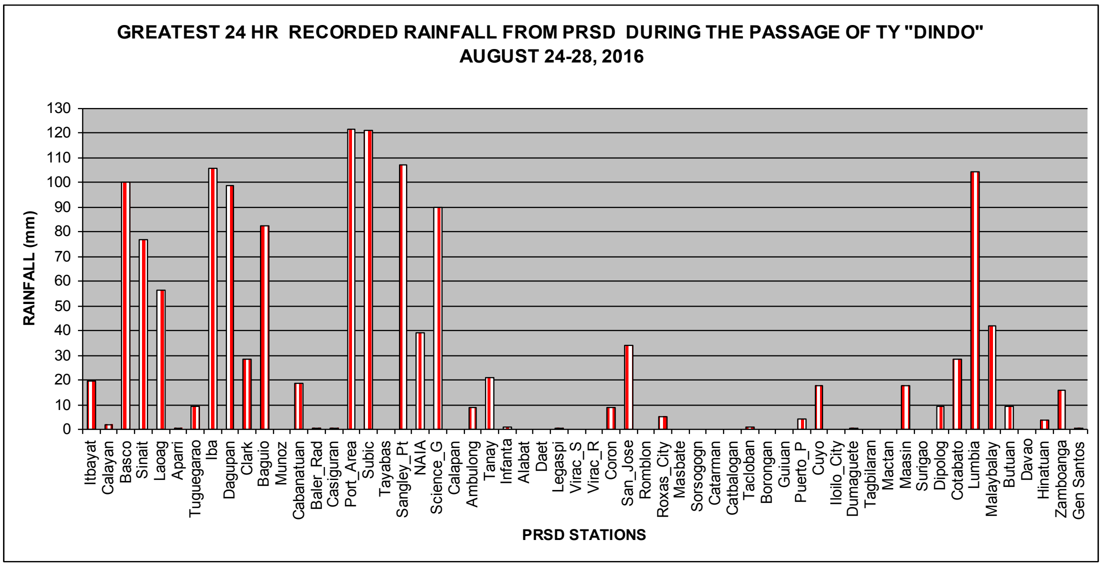


Table 4: 24 hour Rainfall during the passage of Nepartak



Nepartak brought more than 300 mm of rainfall over Subic Bay, Zambales and more than 200 over Iba, Zambales for 24 hours during its passage.

Table 5: 24 hour Rainfall during the passage of Nida



Nida on the other hand, brought more than 250 mm of rainfall for 24 hours over Sinait, Ilocos Norte and Tuguegarao, Cagayan during its landfall and passage on Northern Luzon.

Typhoon Lionrock brought more than 100 mm of rainfall in 24 hours in some areas of western Luzon that caused flashfloods.

3. Socio-Economic Assessment (highlighting socio-economic and DRR issues/impacts)

The three TC's did not cause significant damage in the Philippines.

There were flooding and landslides during the passage of Nida. Some roads were not passable in many places in Northern Luzon due to flooding and landslides. A total of 163 families were pre-emtively evacuated in the provinces of Cagayan and Isabela and in the province of Samar before the landfall and due to heavy rains brought about by Nida (source-NDRRMC)

4. Regional Cooperation Assessment (highlighting regional

cooperation successes and challenges)

PAGASA is one of the training center of WMO in the region, conducted Meteorologist Training Course (MTC) with four foreigners attended the training. They were Gary Vite from Tonga, Levu Antfalo from Vanuatu, Iosefo Sidney Cauravouvinaka from Fiji and Samit Prasaad from Fiji. The training lasted for one (1) year which started last October 2015 up to September 2016.

Figure 2. Meteorologist Training Course (MTC), PAGASA RTC, Quezon City, Philippines

With the help of JICA, Satellite experts from Japan Meteorological Agency (JMA) conducted training on Himawari -8/9 Satellite Analysis Using Sataid and were attended by eight (8) Forecasters from Weather Division of PAGASA. This training helps and enhanced the forecaster knowledge in satellite image analysis.

TC Members' Report
Summary of Progress in KRAs

Title of item (1):

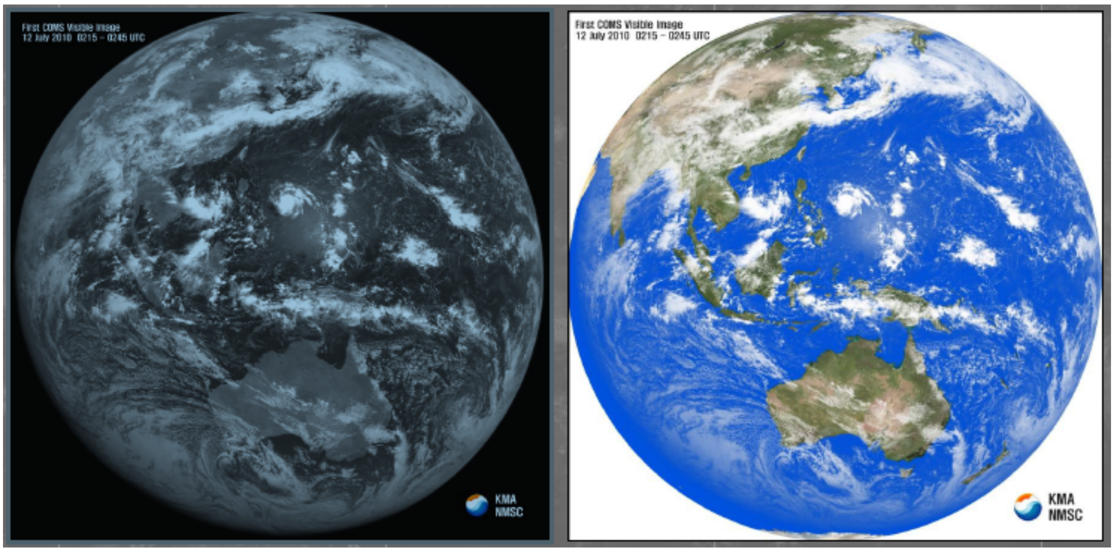
Radar and Satellite Observations of Tropical Cyclones

Main text:

A new C-band Doppler Radar was installed Baguio City and started operation last July 2016. The radar would be used for monitoring tropical cyclones when the TC is over inland in Northern and Central Luzon and over offshore west of Luzon. This radar will also be used in rainfall warning and monitoring by the Northern Luzon PAGASA Regional Services Division.

PAGASA also acquired additional mobile radar which will be used as back-up for land based radar if one is not working and will also be used for cloud seeding operations.

PAGASA has received a Receiving System of COMS satellite, a donation from KOICA. It was installed last February 2016 and located at 36,000 kms above the equator at a longitude of 128.2°E. The satellite can generate 16 types of analysis data (products) and will be available every 15 minutes. This information is very useful in locating and identifying the different disturbances especially tropical cyclones.



Global Visible Images

Fig. 4. Visible Image

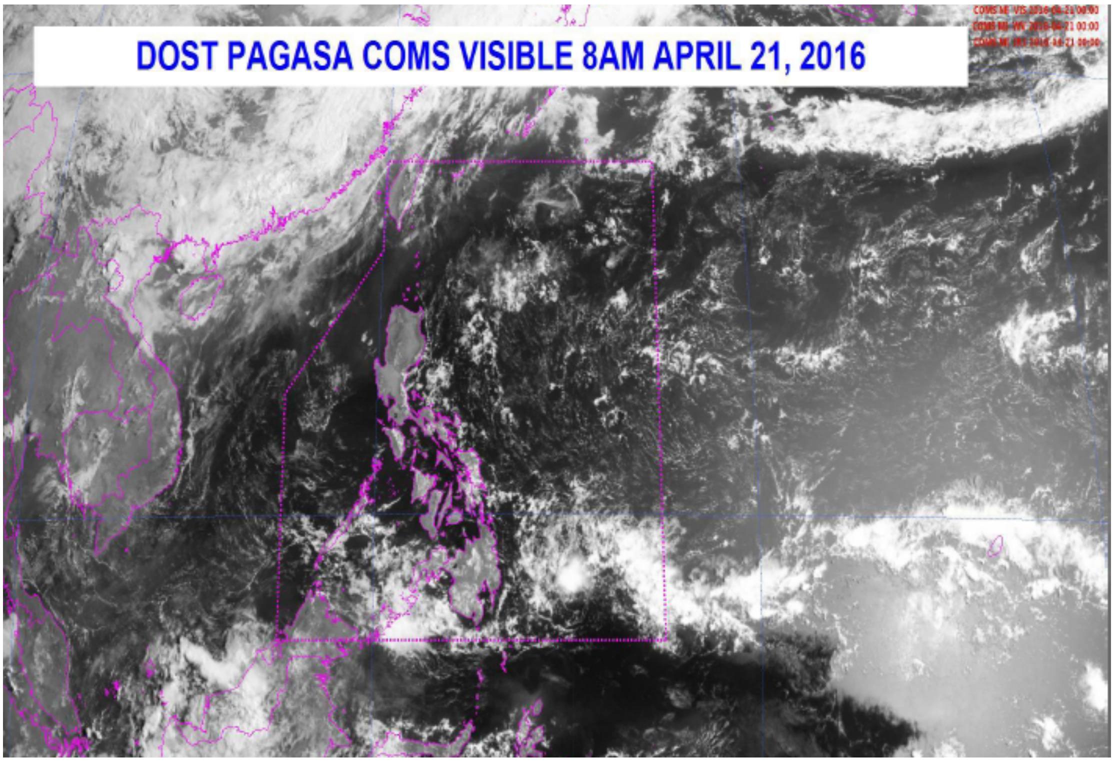
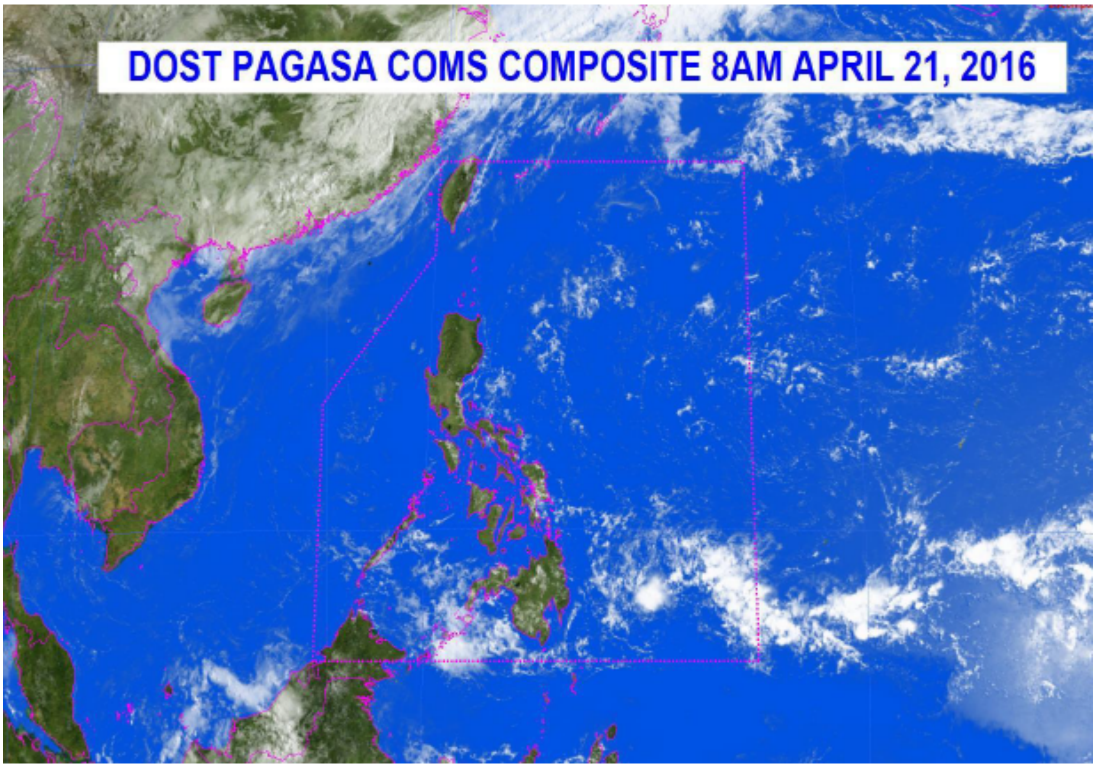


Fig. 5. Composite Image



Identified opportunities/challenges, if any, for further development or collaboration:

A study or training on how to determine tornado and hailstorm formation within the severe thunderstorm cells by using satellite. Last August, we experienced tornado occurrences in Manila and Bulacan areas. As of now, it is still a challenge for us to identify this kind of disturbance because it is only now that we have radar data on this kind of events.

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Summary Table of relevant KRAs and components:

KRA =	1	2	3	4	5	6	7
Meteorology						✓	
Hydrology						✓	
DRR						✓	
Training and research						✓	
Resource mobilization or regional collaboration							

TC Members' Report

Summary of Progress in KRAs

Title of item (2):

5-day Tropical Cyclone Forecast Tracks

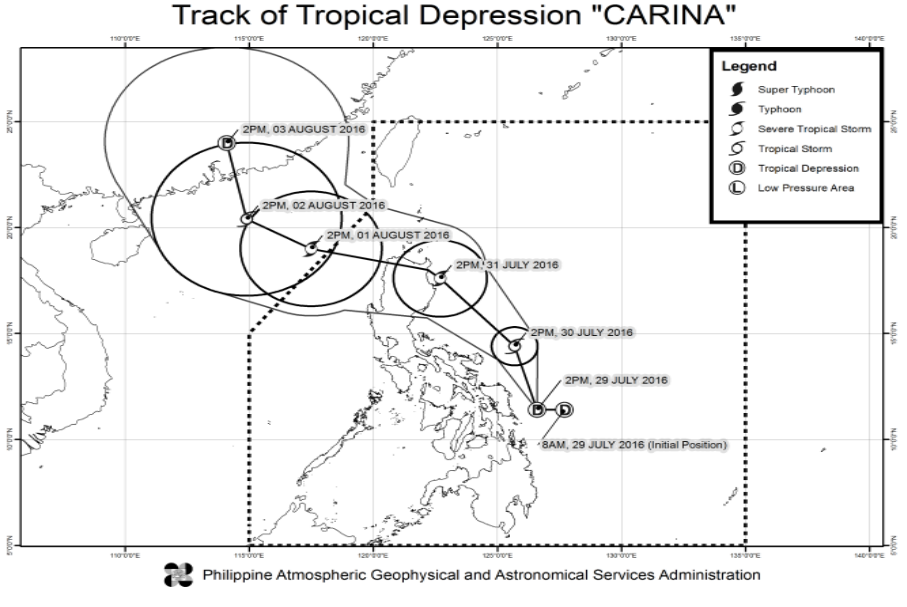
Main text:

PAGASA extended its tropical cyclone forecast track from three days to five days which started last year, 2015 typhoon season. This was due to the request of the Department of Interior and Local Government (DILG) to have five days forecast track especially for landfalling TC, for the preparations of every local government units to be affected by the TC. They said that three days is not enough for all the preparations that they have to undertake like the pre-positioning of relief goods, medicine and equipment in anticipation of relief, rescue and clearing operations. This includes the human resources needed in the different operations that local government units will undertake.

In the improvement of Tropical Cyclone Warning services, PAGASA will issue 3-hourly Severe Weather Bulletin from the 6-hourly issuance. This is done if TC is expected to make landfall or pass very close to the landmass of the Philippines within the next 24 hours or 500 km away. The 3-hourly issuance will be implemented until 6 hours after the TC has stepped out of the landmass or when the distance is 500 kms or more from the coast and is moving farther away from the country.

In the Accuracy of the forecast track from 24 up 72 hours, there was a great improvement in 2015 compared to 2014. The 24 hour forecast error in 2015 is 94 kms compared to 141 kms in 2014. There is a 30% improvement in the accuracy of the forecast track., In the 48 hour forecast track error in 2015 is 157 kms compared to 220 kms in 2014 and the improvement is 28 %. In the 72 hour forecast track error last year was 188 kms compared to 298 kms in 2014 and the improvement is 37%.

FIG. 6. Forecst track of STS Nida



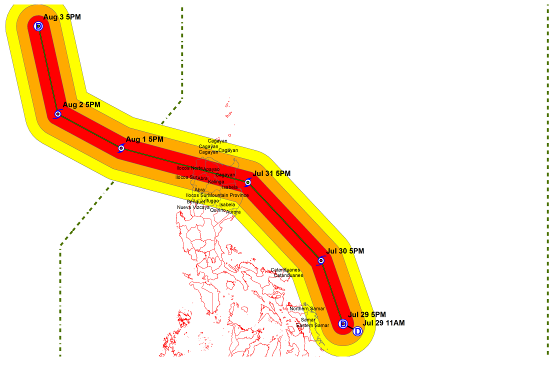


Fig. 7: Severe Tropical Storm "NIDA" (CARINA)

Five (5) days tropical cyclone track forecast with different critical levels

FORECAST TRACK ERROR (in km)

Year : 2016					
	TC Name	FORECAST ERROR (KM)			INTENSITY
		24 hr	48 hr	72 hr	
1	AMBO				Tropical Depression
2	NEPARTAK (BUTCHOY)	114.67	192.34	357.85	Typhoon
3	NIDA (CARINA)	76.20			Severe Tropical Storm
4	LIONROCK (DINDO)	86.15	146.43	154.21	Typhoon
5	NAMTHEUM (ENTENG)				Tropical Depression
6	MIRANTE (FERDIE)	66.50	80.97	106.80	Typhoon
7	MALAKAS (GENER)	83.63	180.90	314.44	Typhoon
8	MAGI (HELEN)	68.86	148.17	142.12	Typhoon
9	CHABA (IGME)	68.37			Typhoon
	AVERAGE	80.63	149.76	215.08	
	Target	100	200	300	

Table 6. Average track error in 2016

Table 7. 3-Days Average TC Tracks

Summary

TC Name	INTENSITY	FORECAST ERROR (KM)					
		24 hr		48 hr		72 hr	
			filtered		filtered		filtered
Amang	Severe Tropical Storm	96.13	96.13	182.13	182.13	257.69	257.69
Betty	Tropical Storm	104.90					
Chedeng	Typhoon	96.84	105.52	151.85	163.82	113.87	
Dodong	Typhoon	94.59	94.59	114.50	114.50	129.79	129.79
Egay	Severe Tropical Storm	150.97	141.99	271.55	257.30	391.30	334.03
Falcon	Typhoon	61.64	61.64	101.26	101.26		
Goring	Typhoon	86.33	86.33				
Hanna	Typhoon	52.26	52.26	89.98	89.98	101.10	101.10
Ineng	Typhoon	79.56	79.56	123.43	123.43	156.79	156.79
Jenny	Typhoon	93.30	93.30	124.28	124.28	198.55	198.55
Kabayan	Severe Tropical Storm	100.39	67.15				
Lando	Typhoon	90.45	88.01	122.40	130.05	146.69	144.31
Marilyn	Typhoon	162.81	162.81	299.39	299.39		
Nona	Typhoon	103.98	93.79	183.61	144.91	223.22	188.47
Onyok	Tropical Depression	105.20		221.23			
	Average	98.62	94.08	165.47	157.37	191.00	188.84

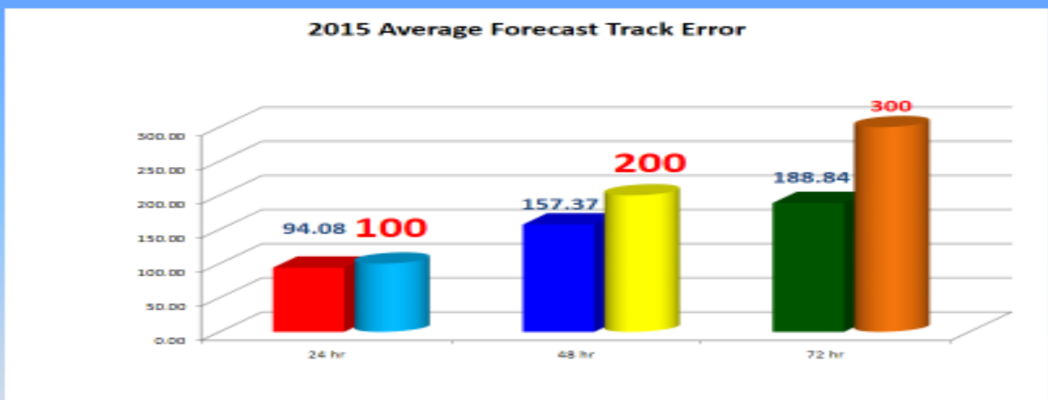


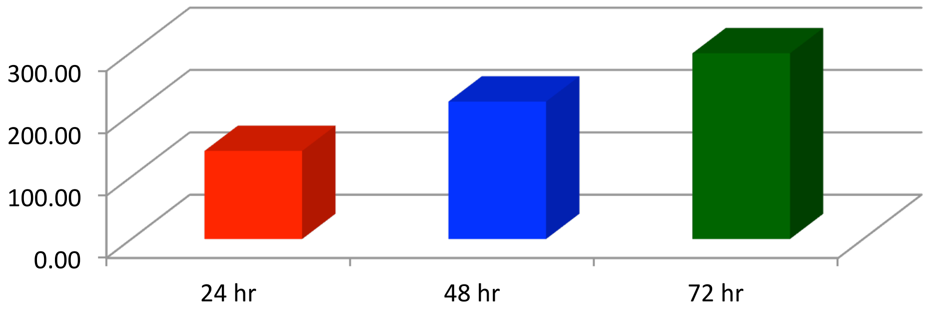
Figure 8. Average error of PAGASA track forecasts for 2016

Table 8. 3-Days Average TC Tracks Error (2014)

Year 2014

TC Name		FORECAST ERROR (KM)			INTENSITY
		24 hr	48 hr	72 hr	
1	AGATON	186.37	313.69		
2	BASYANG	232.99	572.63		
3	CALOY	184.29			
4	DOMENG	105.79	246.46	549.48	
5	ESTER	306.79			
6	FLORITA	87.42	164.95		
7	GLENDA	128.90	186.54	347.17	
8	HENRY	134.37	209.46	230.71	
9	INDAY	251.15	334.15		
10	JOSE	77.15	93.53	131.36	
11	KARDING				
12	LUIS	140.06	244.94	438.05	
13	MARIO	153.33	348.12	601.47	
14	NENENG				
15	OMPONG	58.64	137.02	196.59	
16	PAENG	84.82	83.74	182.45	
17	QUEENIE	82.47	108.83		
18	RUBY	78.97	115.70	176.38	
19	SENIANG	110.54	149.05	126.43	
20					
21					
AVERAGE		**141.41**	**220.59**	**298.01**	
Target		100	200	300	

Fig. 9. 2014 Average Forecast Track Error



TYPHOON TRACK ERROR COMPARISON

HOURS	2014 (AVERAGE)	2015(AVERAGE)	% (IMPROVEMENT)
24	141	97	31%
48	220	157	28%
72	298	188	37%

HOURS	2015 (AVERAGE)	2016(AVERAGE)	% (IMPROVEMENT)
24	94	80	15%
48	157	149	5%
72	188	215	-14%

Table 9. Comparison or error and improvement in percent

PAGASA
The Weather and Climate Authority

Payong PAGASA

Identified opportunities/challenges, if any, for further development or collaboration:

To find out a very good method to estimate of the forward speed (kph) of TC because this will greatly affect the exact time of landfall.

Summary Table of relevant KRAs and components:

KRA =	1	2	3	4	5	6	7
Meteorology	✓	✓		✓	✓	✓	
Hydrology							
DRR							
Training and research							
Resource mobilization or regional collaboration							

TC Members' Report

Summary of Progress in KRAs

Title of item (5):

Information and Educational campaign to Strengthen the Readiness and Resilience of Communities to Typhoon-related Disasters

Main text:

PAGASA continued to participate in regular exercises and drills on tropical cyclone disaster prevention and preparedness with relevant government departments and organizations. Information and Education Campaign (IEC) is also continuing activities of the agency especially to the tri-media, local government units (LGU's) and other agencies involve in disaster preparedness, relief and rescue activities.

PAGASA is a member of a core group called Pre-Disaster Risk Analysis (PDRA) wherein whenever there is a TC outside PAR and expected to enter PAR in the next 24 hours, PAGASA will suggest to the National Disaster Risk Reduction Management Council (NDRRMC) that PDRA will convene. In the meeting of the group, PAGASA will give a current and the forecast scenario as to the effect of the TC to any part of the country. Usually, this kind of advance meeting is done if the TC is landfalling or will pass very close to the landmass, so that early preparations can be made from the national level down to the barangay level. Every day PAGASA will give an update on the typhoon track and other relevant information until when it will made landfall.

Fig. 10. PDRA Meeting during the occurrence of Typhoon Nepartak

Last PDRA meeting with Usec. Alexander Pama

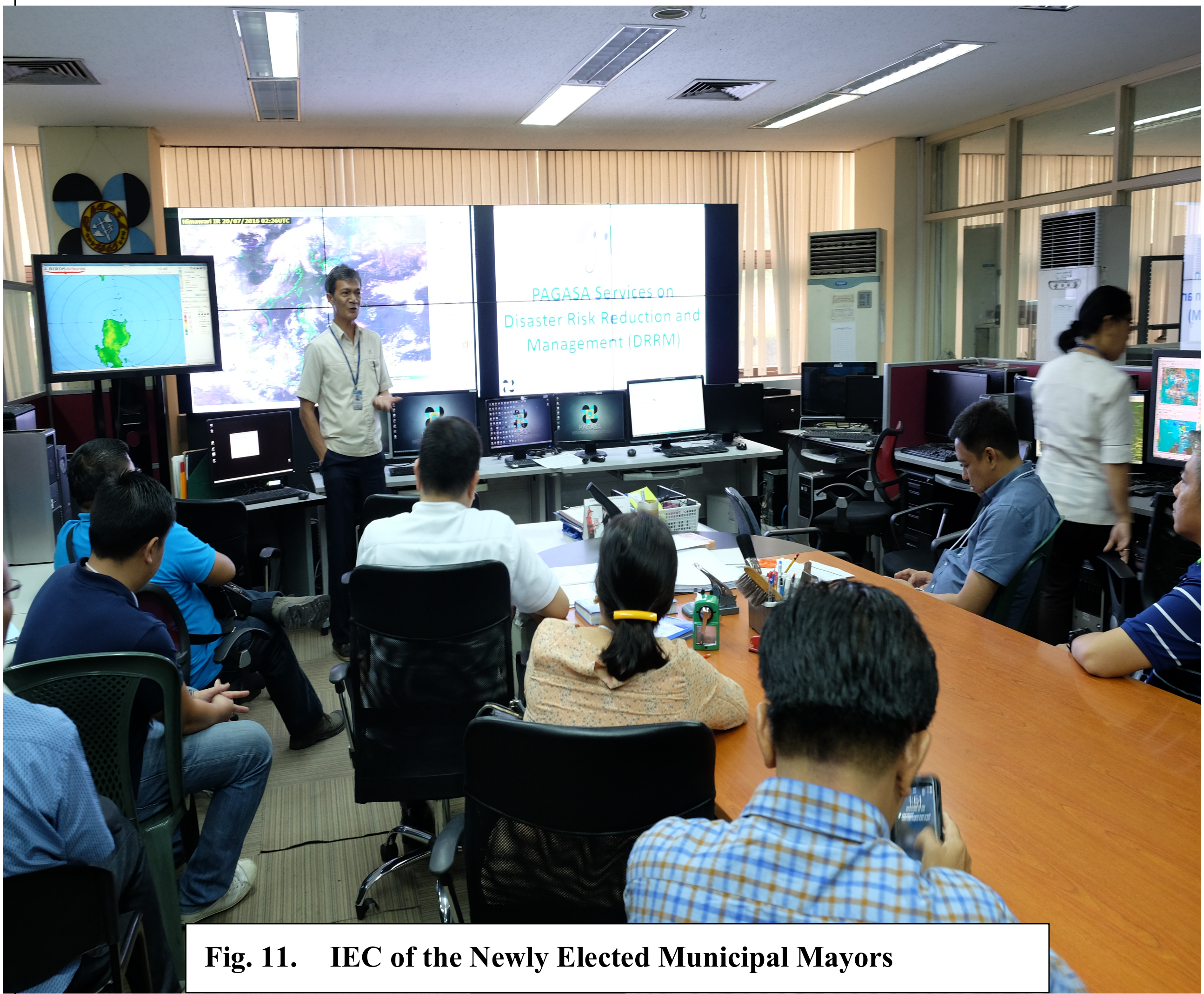


Fig. 11. IEC of the Newly Elected Municipal Mayors

Figure 12. Flood Drill in Barangay Poblacion1-A, Imus City,

GMMA READY Project on Community-Based Flood Early Warning System (CBFEWS) for the Province Cavite, Barangay Poblacion 1-A, City of Imus, Province of Cavite
10 June 2015

Preparations for the Flood Drill

Preparation for the flood drill

This is a warning instrument (siren) used to warn people during calamities.

The barangay captain announces the start of flood drill

The evacuee carry their belongings and animals to the evacuation center.

Residents rushed to the nearest evacuation center. No pick up points but there are leaders for each sitio to guide them.

Priority are the PWDs, elderlies & children. Father of the house were left behind to take care of their belongings and to follow if necessary

Rescuing the injured, casualties by the help of health workers and CDRRMO Rescue Unit

Assessment and evaluation. Each agency and LGUs are required to report their findings and gave solution to the problems.

The organizing committee – PAGASA, OCD, LGUs from CDRRMO and Brgy. Poblacion A-1, Imus City

Identified opportunities/challenges, if any, for further development or collaboration:

PAGASA will Continue to do IEC to the different stakeholders in view of future needs and explore opportunities to collaborate with communication and social expert on warning communication strategies and public education aspects of Disaster Risk Reduction.

Summary Table of relevant KRAs and components [please tick boxes, can be more than one, as appropriate]:

KRA =	1	2	3	4	5	6	7
Meteorology	✓	✓		✓	✓		
Hydrology							
DRR		✓		✓	✓		
Training and research							
Resource mobilization or regional collaboration							

TC Members' Report
Summary of Progress in KRAs

Title of item (6):

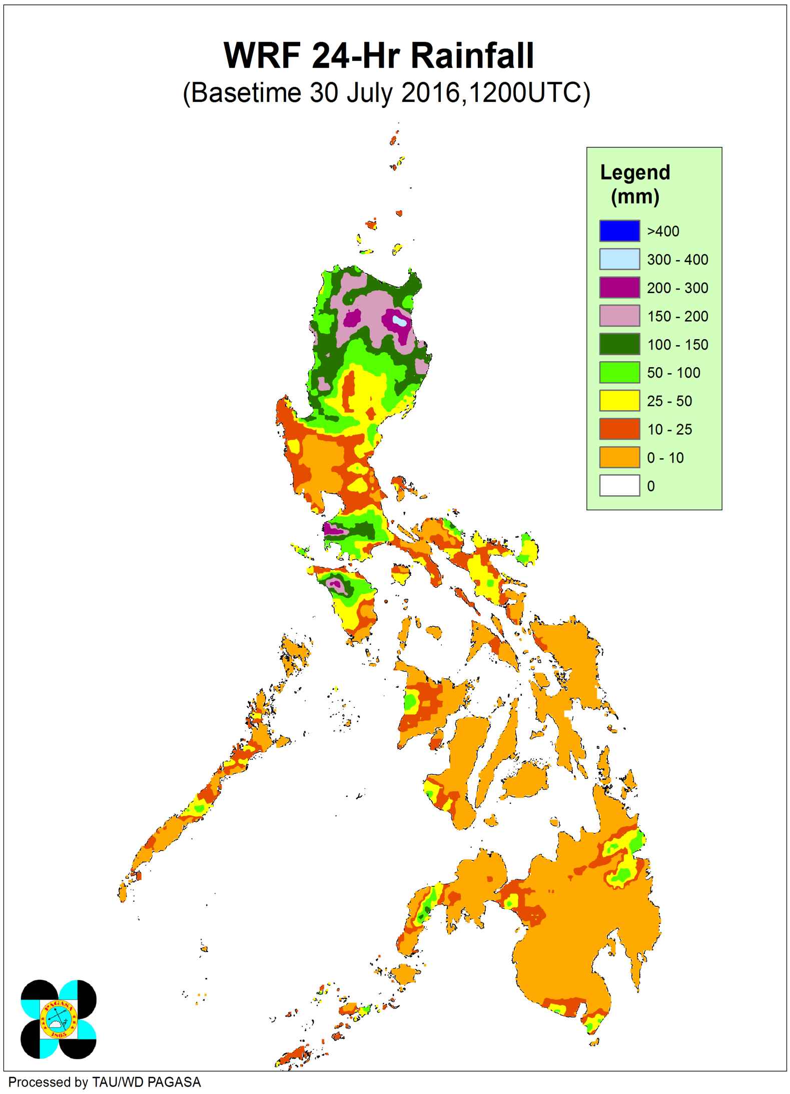
GIS- Based Forecast Rainfall Map up to the Barangay Level

Main text

PAGASA make a post-processing of global model such as the Global Spectral Model (GSM) of the Japan Meteorological Agency (JMA) and operates a mesoscale numerical weather prediction model such as the Weather Research and Forecasting Model (WRF) designed for both atmospheric research and operational forecasting needs. PAGASA uses the Integrated High Performance Computing System (IHPC) with architecture facilitating parallel computation and system extensibility which processed WRF that two dynamical cores and uses data assimilation system. The model serves a wide range of meteorological applications across scales from tens of meters to thousands of kilometers. We use this model to extract rainfall amount and intensity to determine if it will cause flooding in the area.

The current requirement of disaster managers and the general public on heavy rainfall forecasts is, "Area specific and time bound". To address this, the PAGASA, thru the advancement in technology and emergence of mapping software, employed the use of the Geographical Information System (GIS) to overlay numerical model rainfall forecast at the barangay boundary level. This GIS mapping started on 01 August 2016 during the occurrence of southwest monsoon or Habagat. To come up with a detailed rainfall map, PAGASA is overlaying the rainfall forecast from the Global Spectral Model (GSM) at 0.25 degree (27.75 km) horizontal resolution and the Weather Research and Forecasting (WRF) model at 12 km horizontal resolution then apply a krigging method to interpolate the areal distribution. Hence, there are two kinds of forecast rainfall maps: the bigger resolution GSM map which is conservative and the finer resolution WRF map which is often exaggerated. All numerical models have its capabilities and limitations; and uncertainty of forecast increases with forecast period or time lag. These are being considered in the analysis done by Weather Forecasters and are being explained to the end-users. Further improvement and verification will be undertaken to ensure the efficiency of the newly developed information system.

Fig. 13. 24-Hr Rainfall (GIS Map)



Identified opportunities/challenges, if any, for further development or collaboration:

Upcoming development efforts would focus on assimilation of remote-sensing observations and fine-tuning of physical processes with a view to further improving model performance in rainfall forecasting and TC movements.

Summary Table of relevant KRAs and components:

KRA =	1	2	3	4	5	6	7
Meteorology	✓	✓				✓	
Hydrology							
DRR							
Training and research						✓	
Resource mobilization or regional collaboration							

Summary of Progress in KRAs

Title of item (8):
Continual Capacity Building Through Various Trainings

Main text:

Enhancing and updating the knowledge of PAGASA personnel due to the fast advancement of technology, trainings and workshops were done in the different fields and subjects. This was in collaboration with experts from the different institutions and academe.

Figure 14. Simulation and Testing Activity of the "CAP on a MAP: Improving Institutional Responsiveness to Coastal Hazards through Multi-Agency Situational

Figure 15. National Symposium on "Cloud Seeding Operations & Mitigation Measures for Climate Variability"

Figure 16. Meteorologist Technicians Training Course
To produce qualified Meteorological Technicians, who will be tasked to observe weather parameters to be used in weather analysis and forecasting.

Summary Table of relevant KRAs and components:

KRA =	1	2	3	4	5	6	7
Meteorology						✓	
Hydrology							
DRR					✓		
Training and research							
Resource mobilization or regional collaboration							

TC Members' Report
Summary of Progress in KRAs

Title of item (9):
Heavy Rainfall Warning and Thunderstorm Warning (Nowcasting)

Main text:

Flooding or flashfloods is a common disaster during the southwest monsoon season or during the occurrence of thunderstorms especially in Metro Manila area. In order to warn the public of the impending threat of flooding due to heavy rainfall and thunderstorms, PAGASA develop this kind of warning system.

The objectives of this is to develop an end-to-end rainfall warning decision support tool designed to alert the concerned communities and decision-makers about the occurrence of heavy rainfall event caused by local convective and synoptic weather systems. To provide easy to interpret information that allows individuals and communities to protect their lives and properties.

For any early warning system to succeed, several components are necessary:

} Technology to detect and monitor the hazard;
} Communication systems to alert the public;
} Local leaders trained to make the right decisions;
} A public that is educated to react appropriately to warnings; and
} Response protocols — such as evacuation plans — prepared and rehearsed well in advance of the threat.

All these elements must work well, both individually and in harmony.
Failure in any one of these elements can mean failure of the whole early warning system.

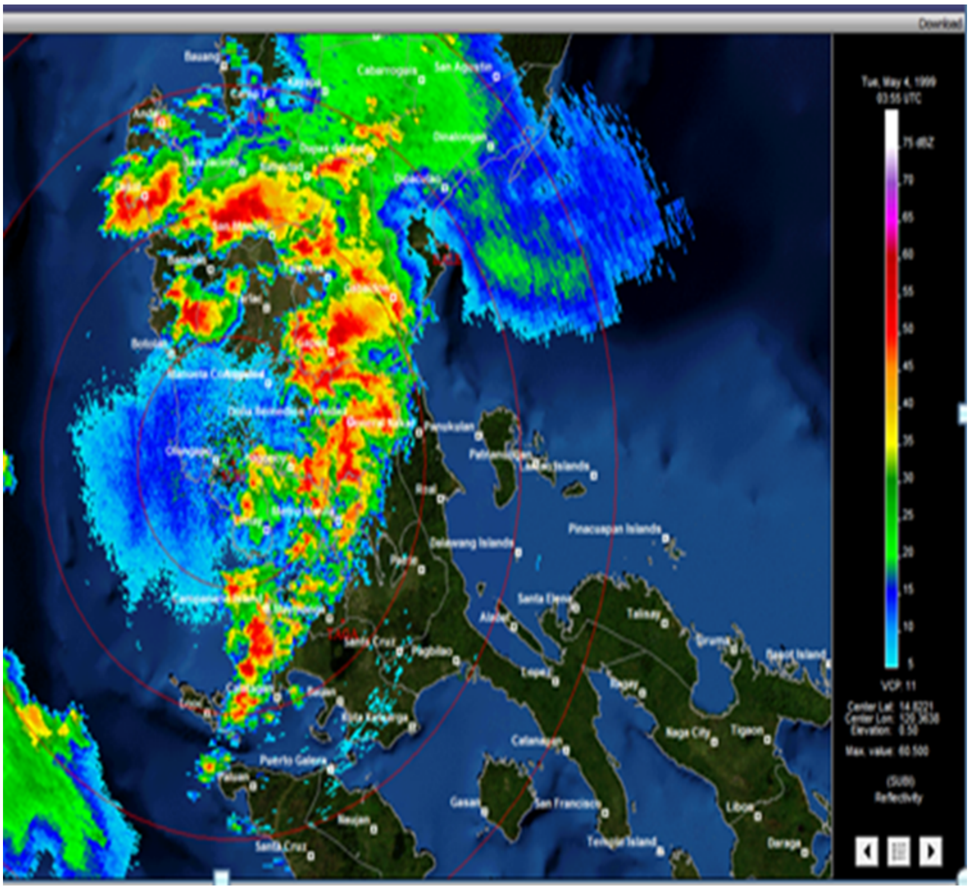


Fig. 17. Radar image show location of rain with different colors used to depict RR intensity. Each color corresponds to a certain degree of intensity, the brighter the colors are, the more intense the precipitation

Fig. 18. Upper Air Observation

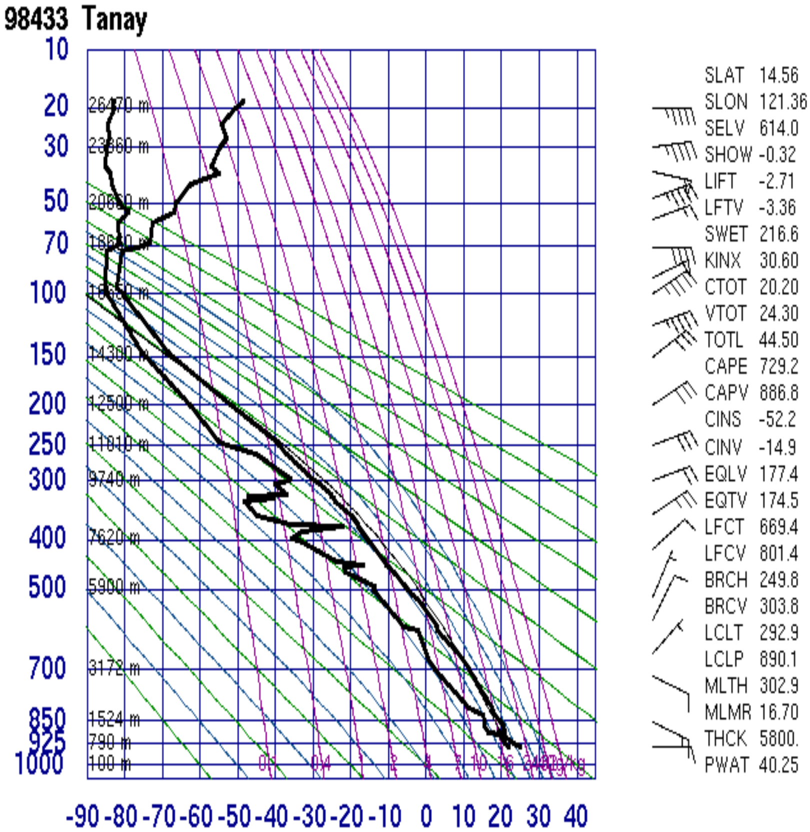
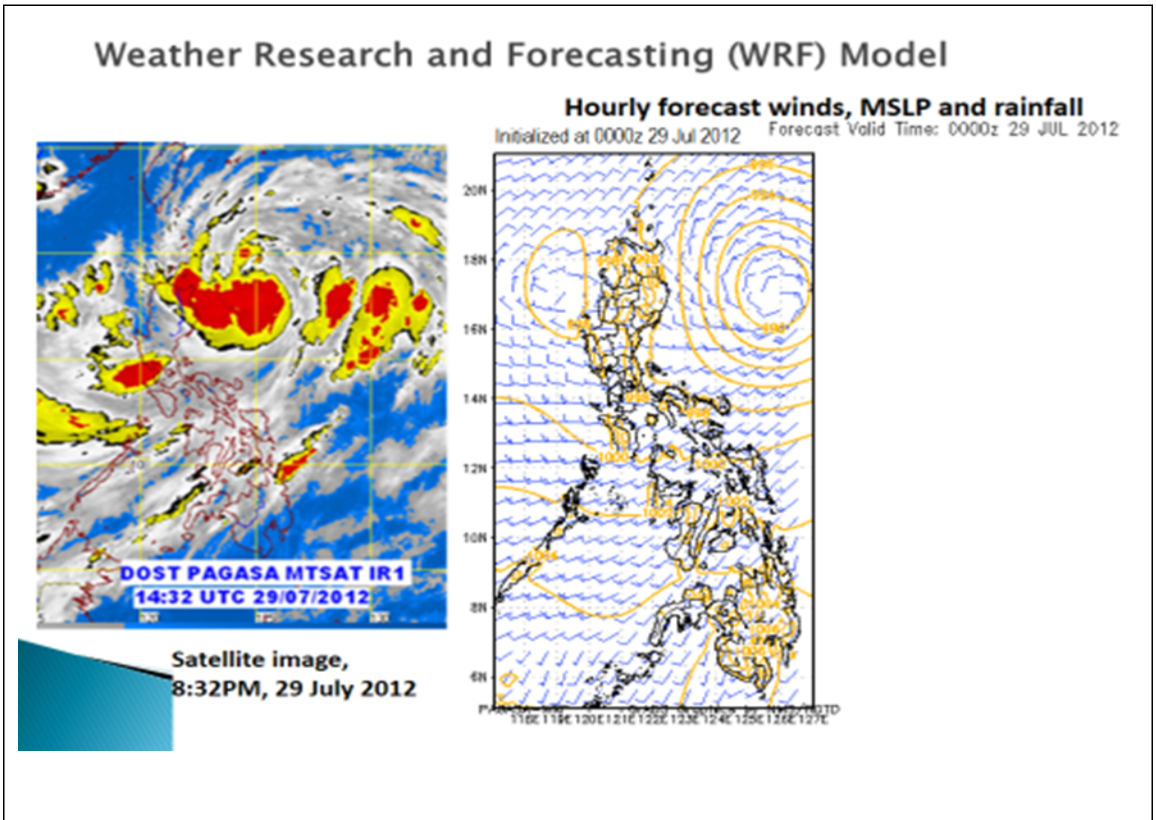


Fig. 19. Satellite and WRF Model



Identified opportunities/challenges, if any, for further development or collaboration:

We find it difficult to detect tornado and hailstorm during the occurrence of Severe Thunderstorms and it is only now that we have a radar data from those events. The research division is trying to determine the different indices and signatures from the images. We are seeking the help of the expert for the early detection of this events.

Summary Table of relevant KRAs and components:

KRA =	1	2	3	4	5	6	7
Meteorology						✓	✓
Hydrology						✓	✓
DRR							
Training and research							✓
Resource mobilization or regional collaboration							

HYDROMET REPORT

Typhoon Committee - Hydrology Report

Roy A. Badilla[1]

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Hydrometeorology Division
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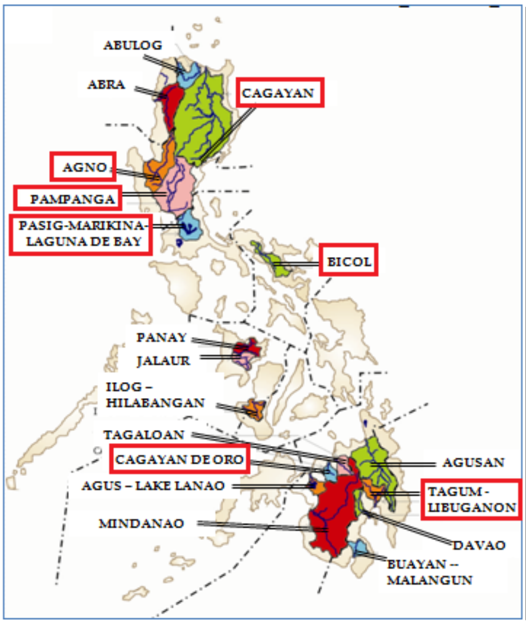
INTRODUCTION:

The Philippines obtains its water supply from different sources. These includes: rainfall, surface water resources, i.e. rivers, lakes and reservoirs and ground water resources. It has eighteen (18) major river basins (figure 1) and 421 principal river basins as defined by the National Water Resources Board (NWRB).PAGASA being mandated to monitor the meteorological and hydrological conditions of the country's river systems through Hydrometeorology Division (HMD) in collaboration with Regional Services Divisions, provide hydrological or flood information and warnings. To help prevent or mitigate the disastrous effects of flooding is one of main undertaking of HMD's Flood Forecasting and Warning System (FFWS). At present PAGASA-HMD is monitoring the country's 18 major river basins mentioned and among these, seven (7) aretelemetered equipped with complete hydrological network for monitoring. In addition, the agency is collaborating with other national institution involved in the implementation of flood warning and mitigation for Dam operations. At present, six (6) major dams in Luzon are being monitored by PAGASA namely, Magat, Ambuklao, Binga, SanRoque, Pantabangan and Angat Dams (figure 2).



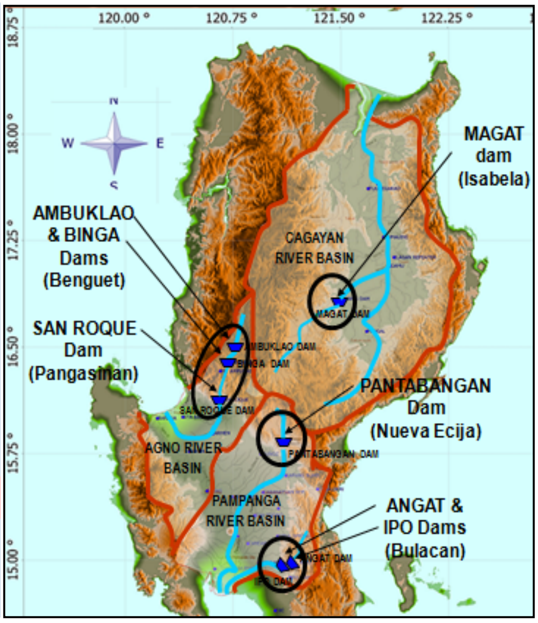


Figure 1: 18 Major River Basins **Figure 2**: Major Dams in Luzon

HYDROLOGICAL ASSESSMENT:

1. FFWS Activities during the Passage of Typhoon Nona and Tropical Depression Onyok
2. FFWS Activities during the Passage of Tropical Cyclones in 2016
3. FFWS Activities during August 2016 SouthWest Monsoon (Habagat)
4. FFWS Activities during El Niño (Dam Status)

1. FFWS Activities during the Passage of Typhoon Nona (Melor)

Typhoon Nona with international name Melor (Figure 3) was strong tropical cyclone that struck the Philippines in December 2015. It began developing on December 7 and entered the Philippines Area of Responsibility (PAR) on

December 11. On December 13, it became a typhoon and made its first landfall on Northern Samar then in Sorsogon, Burias Island, Romblon and Oriental Mindoro before weakening into tropical storm. It turned southward on entering South China Sea before weakening into a tropical depression and dissipating.

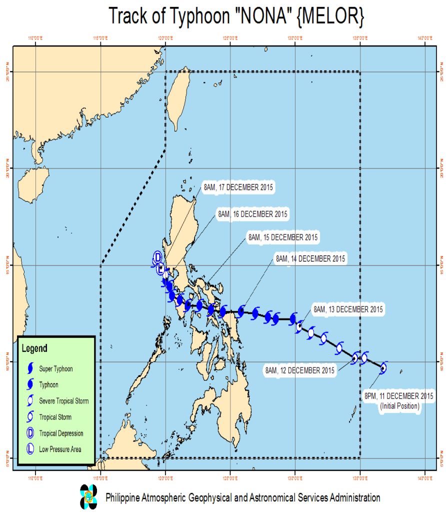


Figure 3: Track of Typhoon Nona (Melor)

General Flood Advisories were issued to Regions 3, 4A-B, 5, 6, 7 and 8 (Table 1). These advisories were initially released even before the passage of typhoon. In Cagayan river basin, moderate to intense rainfall were observed and then a Flood Bulletin was issued on December 15, 2016 at 5PM while Pampanga River Basin Flood Forecasting and Warning Center issued its 1st General Flood Advisory for Upper Pampanga targeting Nueva Ecija and Bulacan on December 16.

Table 1: General Flood Advisories Issued

GENERAL FLOOD ADVISORY	
REGION	NO. ISSUED
CAR	**17**
I	**17**
II	**3**
III	**3**
IVA	**4**
IVB	**4**

V	**5**
VI	**4**
VII	**4**
VIII	**4**
X	**4**
XI	**4**
XIII	**3**

Also on December 16, PAGASA commenced the preparatory phase of flood warning operation for Angat Dam intended for Norzagaray, Angat, San Rafael, Bustos, Baliuag, Pulilan, Plaridel, Hagonoy and Calumpit. Later that day, preparatory phase for Binga and San Roque Dams were also commenced at 12:25 and 6:30 PM, respectively. Commencement of preparatory phase of flood warning for dam operation is usually done when a definitely large amount of rainfall is expected to fall or cascade in the river basin due to an approaching weather system such as tropical cyclone. It is also done when large amount of rainfall is observed and NIA or NPC has announced a dam release. Afterwhich, a Flood Warning Phase of the Flood Warning Operation will follow. Activities here includes disseminating flood bulletin by broadcasting warning message in warning stations directly affected by the dam discharge**.**On December 17 at 7:15 in the morning, Angat Dam released their dam discharge warning operation since the water level has already reached 213.05m while the actual discharge was stared at 9:00 am (WL=213.11). Discharge operation was terminated at 5:00AM on December 18, 2016 however a new commencement of preparatory phase of flood warning operation was then issued again on December 19 at 7:30 in the morning since the water level has again increased. Actual dam discharge happened at 6:00 PM of the same day and was terminated on December 24.

During the passage of the typhoon, not only Angat Dam has operated its spillways. Ambuklao, Binga, San Roque, Magat and Ipo Dams were also on their spilling operations (see Table 2).

Table 2: List of Dam under operation during Typhoon Nona

DAM IN SPILLING OPERATION	
DAM	DATE
Angat	**17-18 & 19-24 December**
San Roque	**16-22 December**
Ambuklao	**17 December**
Binga	**17 December**
Ipo	**17-18 December**
Magat	**17 21-24 December**

2. FFWS Activities during the Passage of Tropical Cyclones in 2016

A. Tropical Depression Ambo

Tropical Depression Ambo had developed over the Philippine Sea on June 26, at 555 km east of Manila thenmade landfall on Luzon also on the same day. It quickly dissipated to a Low Pressure Area on the following as it left the PAR (Figure 4)

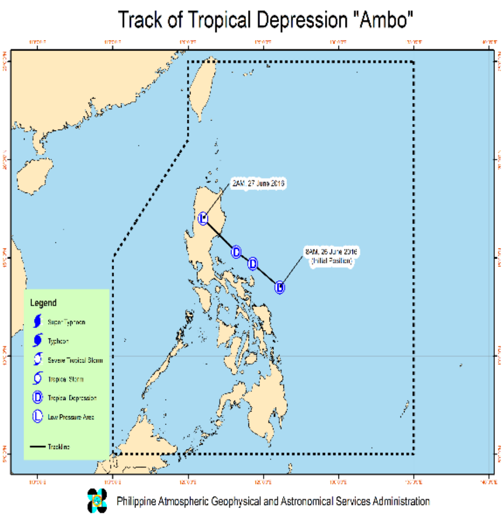


Figure 4: Track of TD Ambo

B. Typhoon Butchoy (Nepartak)

On July 2, a Low Pressure Area (LPA) over Marianas Island has developed into a Tropical Depression (TD) and was namedNepartak. It entered the Philippine Area of Responsibility (PAR) on July 5, and was named Butchoy with a maximum sustained winds of 120 kph near the center and gustiness of up to 150 kph moving Northwest at 30 kph. At that time it has already intensified into a Typhoon and further intensified while affecting Batanes group of island. TY Buchoy slowed down on July 7 to 20 kph and moved West Northwest towards Taiwan raising the warning signal to number 2 to Calayan and Batanes Group of Islands. It also enhanced the Southwest Monsoon (Habagat) which brought moderate to occasionally heavy rains over the Provinces of Zambales, Bataan, Cavite, Batangas, Mindor and Northern Palawan. The following are the General Flood Advisory issued during the passage of TY Buchoy.

Table 3: GFA Issued during TY Butchoy

GENERAL FLOOD ADVISORY	
REGION	NO. ISSUED
CAR	6
1	7
2	2
3	7
4A	7
4B	14
5	8
6	8
7	4
8	6
10	4
13	4
ARMM	1

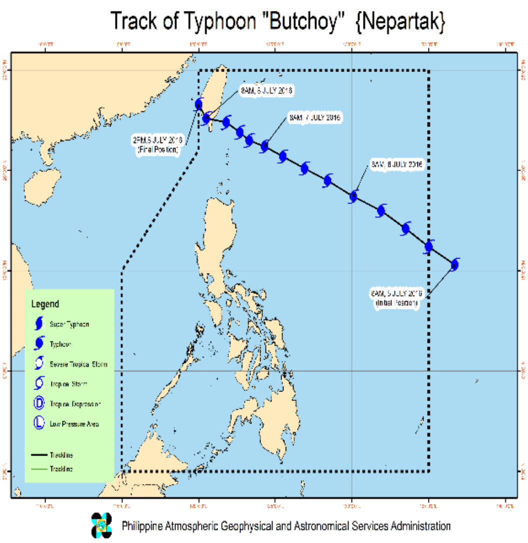


Figure 5 Track of TY Buchoy

C. Severe Tropical Storm Carina (Nida) 29 July to 01 August

On July 29, a Low Presure Area east of Borongan City, Eastern Samar has developed into Tropical Depression and was named Carina. It brought moderate to heavy rainfall within 30km diameter and affected Bicol region, Eastern Visayas and CARAGA as it moved 45kph Northwest at 11 kph. It has intensified into a tropical storm while moving in the direction of Northern Luzon on July 30, further intensified and affected Cagayan Area. It traversed Balintang

Channel before it left PAR on August 1. Some provinces were alerted against moderate to heavy rains thus general flood advisories were issued.

Table 4: GFA Issued during STS Carina

GENERAL FLOOD ADVISORY	
REGION	NO. ISSUED
CAR	**5**
1	**5**
2	**5**
3	**4**
4A	**6**
4B	**8**
5	**7**
6	**8**
7	**6**
8	**6**
10	**7**
11	**1**
12	**2**
13	**6**
ARMM	**7**

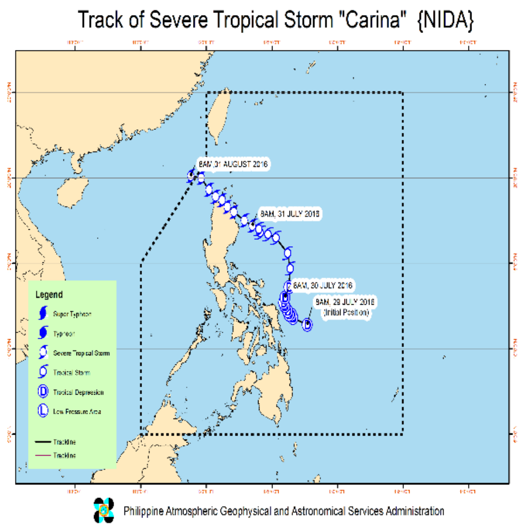


Figure 6 Track of STS Carina

D. Typhoon Dindo (Lionrock) 24-27 August

On August 24, a typhoon with international name "Lionrock" entered the PAR wand was named Dindo. It was first located at 1200km East Northeast of Itbayat, batanes with maximum sustained winds of up to 130kph and gustiness of up to 160kph slowly moving south southwest. It brought moderate to heavy rainfall within its 400 km diameter.It slightly weakened then accelerated while moving east northeast and re-intensified before it exited on August 27. It brought moderate to heavy rains and affected most part of Luzon.

Table 5: GFA Issued during TY Dindo

GENERAL FLOOD ADVISORY	
REGION	NO. ISSUED
CAR	**17**
1	**17**
2	**3**
3	**18**
4A	**7**
4B	**10**
6	**9**
NCR	**7**

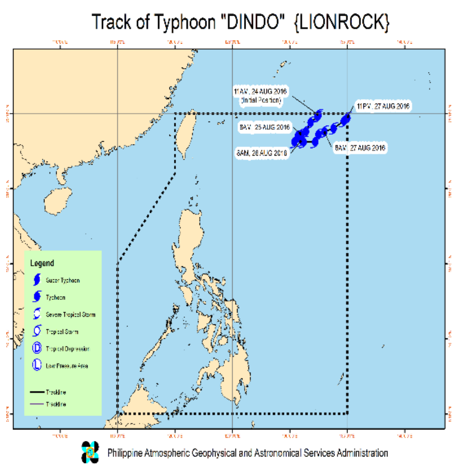
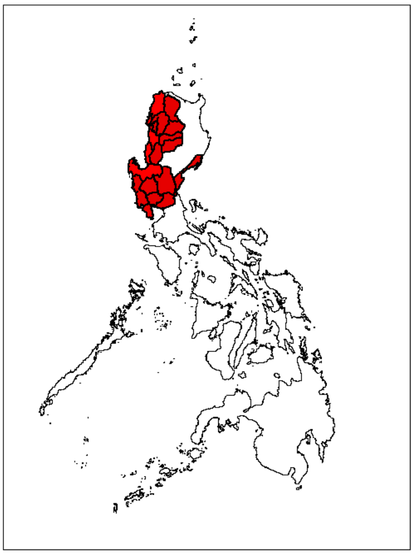


Figure 7: Track of TY Dindo

E. Severe Tropical Storm Enteng (Namtheum)) September

STS Enteng was a short lived typhoon which entered and exited PAR in one day, 01 September. The rains it brought affected mostlythe western section of Northern Luzon Figure 7.



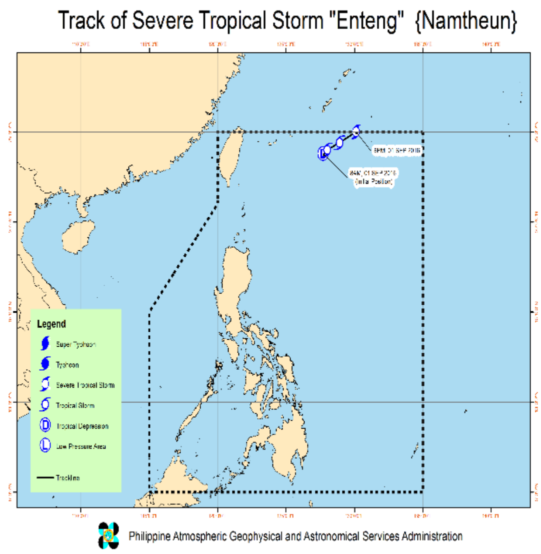


Figure 8: Regions where GFA were issued **Figure 9**: Track of STS Enteng

F. Typhoon Ferdie (Meranti) 11-14 September

Typhoon Ferdie entered the PAR on September 11. It was first located at 1145km East of Casiguran, Aurora having a maximum sustained winds of 140 kph and gustiness of up to 140kph moving 22 kph. It intensified as it continued to move west northwest direction. It made landfall over Itbayat, Batanes carrying moderate to heavy rains. With its strength and location, tropical cyclone warning signal (TCWS) 4 was raised in Batanes Group of Islands, 3 in Babuyan Group of Islands, 2 in Ilocos Norte, Apayao and Northern Cagayan and 1 for the rest of Cagayan, Isabela, Abra, Kalinga and Northern Ilocos Sur. Ferdieexeited PAR on the 14th of September at around 12:30 and all the TCWS were lowered. There were at least 5 flood advisories issued to each of the affected regions.

Table 6: GFA issued during TY Ferdie

GENERAL FLOOD ADVISORY	
REGION	NO. ISSUED
CAR	**5**
1	**5**
2	**5**
3	**5**
4B	**6**
5	**5**
6	**6**

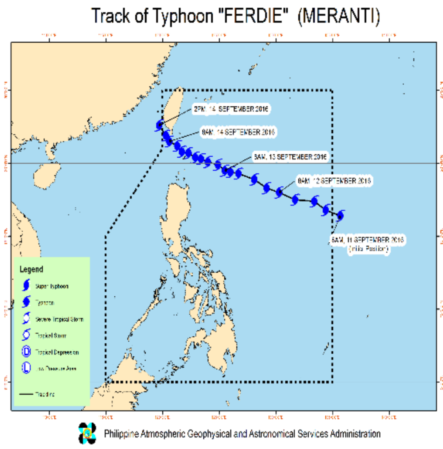


Figure 10: Track of TY Ferdie

3. FFWS Activities during August 2016 Southwest Monsoon (Habagat)

The SouthwestMonsoon or locally known as Habagat has been disturbing the country since 08 August 2016. On August 9-10, the LPA located at Aparri, Cagayan enhanced the this system which brought moderate to heavy rains over Metero Manila, Ilocos Region, CALABARZON, MIMAROPA and the Provinces of Benguet, Zambales and Bataan. This SW monsoon continued to bring light to heavy rains with thunderstorms over Luzon and Western Visayas on August 12-14. Meanwhile the presence of another LPA located at east of Baler, Aurora again enhanced the Habagat which brought monsoon rains over Luzon on August 15-16. On August 17, the Southwest Monsoon affected the western section of Northern and Central Luzon which brought light to moderate rains while thunderstorm affected the region of Cordillera, Cagayan Valley and the provinces of Zambales and Bataan as the LPA exited PAR. Habagat has weakened on August 18 which brought light to moderate rains over Luzon, Visayas and the Regions of Northern Mindanao and CARAGA. During this time, Metro Manila and the rest of the country only experienced isolated rainshowers and some thunderstorms.

Meanwhile on August 21, another LPA spotted at East Northeast of Catanduanes again enhanced the Southwest Monsson which affected Southern Luzon and Visayas. The enhanced SW monsoon brought heavy rains over the region of MIMAROPA, Bicol, Western Vizayas and Negros Island until the following days.

During this event, general flood advisories (Table 7) were issued to the affected regions while monitored major river basins issued flood bulletin to warn the people living in the low lying areas on the possible rise of rivers. Even major dams in Luzon (Table 8) had operated their spillways in order to prevent further effects or flooding.

Table 7: GFA issued during Habagat

GENERAL FLOOD ADVISORY	
REGION	NO. ISSUED
CAR	14
I	14
II	8
III	23
IVA	19
IVB	21
V	

Table 8: List of Dams in Operation

DAM in SPILLING OPERATION	
DAM	DATE
IPO	13-17 August
AMBUKLAO	19-25 August
BINGA	16-25 August

4. **FFWS Activities during El Niño (*Dam Status*)**

PAGASA had started issuing El Nino advisories beginning April of 2015 due to detection of a weak El Nino in the tropical Pacific Ocean recorded in the last quarter of 2014. It was that time when warmer than average Sea Surface Temperature Anomaly (SSTA) of at least 0.5^0C were observed. The event was further confirmed when the results of global climate models suggested that El Nino condition would continue until the mid of 2015 with chances of strengthening toward the end of the year.

During this event it was observed that several areas of the country were affected by dry spell while others were affected by drought. Dry spell is characterized by three (3) consecutive months of below normal rainfall condition whereas drought is described as having three (3) consecutive months of way below normal rainfall condition. In addition, slightly warmer than average air temperatures were also experienced in the country. Since there were lesser rains, the most affected sector in the country is the agriculture due to lesser water supply from irrigation. Most of the irrigation water for instance in Luzon come from dams and during El Nino episode, the Major Dams being monitored by PAGASA showed significant drop in their water level.

A. Angat Dam

Angat Dam is a found in Norzagaray, Bulacan which main purpose is to provide water for domestic use (90% Metro Manila), power generation and irrigation. At the time of El Nino, the reservoir water level has dropped below its operation critical level of 180m starting latter part of May 2015 up to August of the same year.

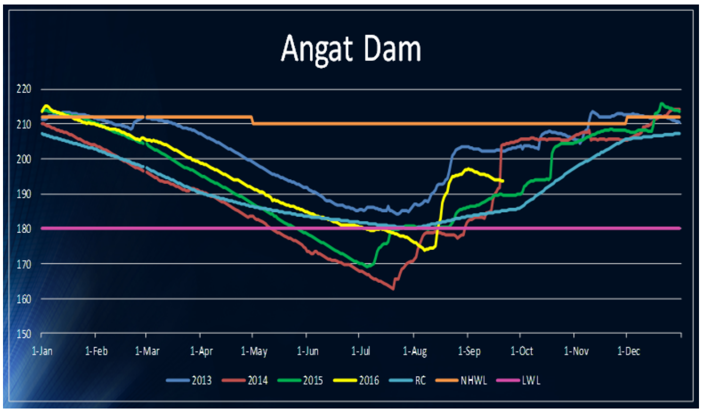


Figure 11 Reservoir Water Level Trend of Angat Dam 2013-2016

B. Pantabangan Dam

Pantabangan Dam is one of the largest dams in Southeast Asia located in Pantabangan, Nueva Ecija. It is a multi-purpose dam which major function is to supply water for irrigation and for power generation. Though its water level had not reached the critical point, it was recorded that its reservoir water level was below the rules curve throughout the year and it was at its lowest for the past four years during El Nino. Almost the same trend in 2014 but occurred earlier in May.

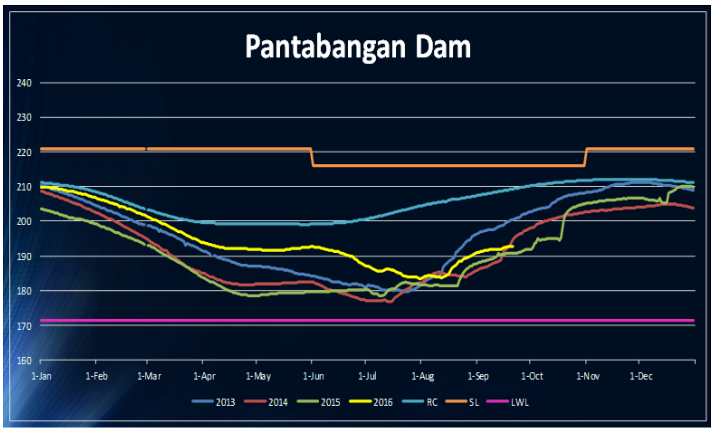


Figure 12 Reservoir Water Level Trend of Pantabangan Dam 2013-2016

C. Magat Dam

Magat Dam is a large rock-fill dam located in Ramon, Isabela. It is situatedalong Magat River, a major tributary of Cagayan River. It is amulti-purpose dam which is used primarily for irrigating about 85, 000 hectares of agricultural lands in Luzon, flood control and power generation through the Magat Hydroelectric Power Plant. In 2015, the reservoir water level of the dam dropped twice its rule curve. That happened in the months of April and August. During such event, the priority purpose of the dam is focused on irrigation.

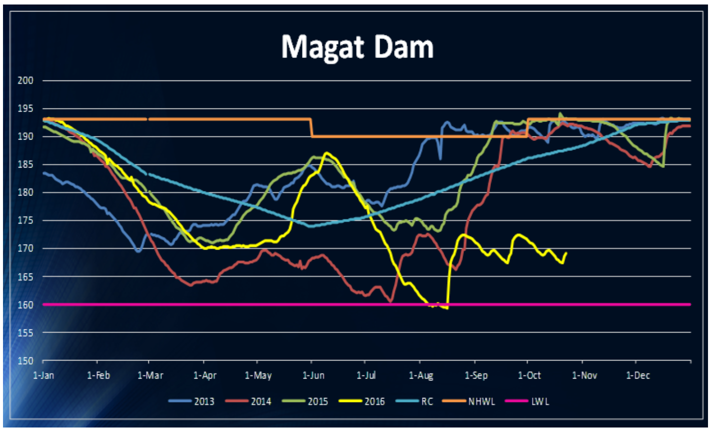


Figure 13 Reservoir Water Level Trend of Magat Dam 2013-2016

D. Ambuklao-Binga-San Roque Dams

This cascading dams are located within the Agno River Basin. Both Ambuklao and Binga dams are found in Benguet and they part of hydroelectric facility in the province. The water being released by Ambuklao once it reaches the Normal High Water Level (NHWL) is catched by Binga Dam while the water freed by Binga is passed to San Roque Dam.

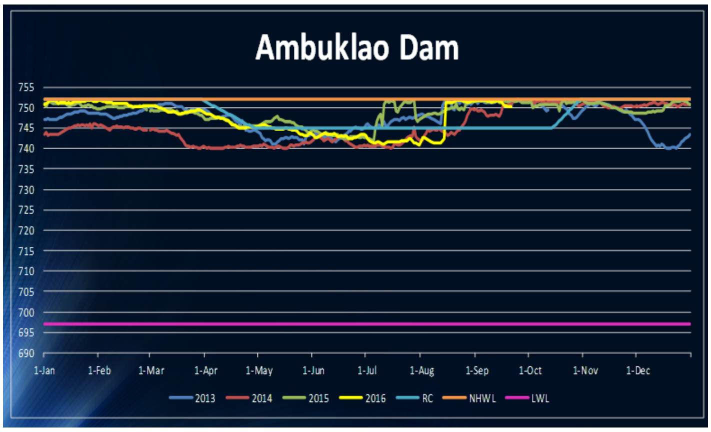


Figure 14: Reservoir Water Level Trend of Ambuklao Dam 2013-2016

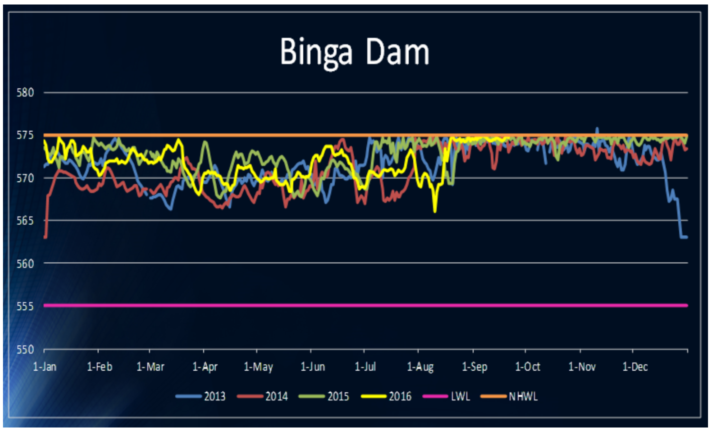


Figure 15: Reservoir Water Level Trend of**Binga** Dam 2013-2016

The reservoir water elevations of the first two dams follow the same annual trend wherein their level is located between the NHWL and the Low Water Level (LWL).

On the other hand, San Roque Dam is a dam operated under San Roque Multipurpose Project and the largest dam in the Philippines found in San Manuel, Pangasinan. A gated spillway protects the dam from overtopping and during wet season, the water run-off is stored for later release through water turbines to generate power and irrigate farms. There is no significant change on the annual trend of reservoir water level of this dam during El Nino. Like in all other years, it was descending from January up to July and recovers during wet season up to the later part of the year.

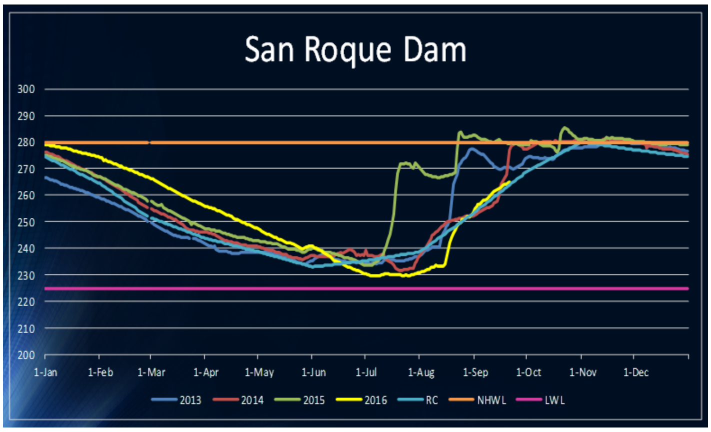


Figure 16: Reservoir Water Level Trend of San Roque Dam 2013-2016

PROGRESS IN KEY AREAS (Project Status)

1. **Establishment of Flood Forecasting and Warning System /Center for Major River Basins**

One of the priority projects of the past Philippine administration is the establishment of Flood Forecasting and Warning System (FFWS) in each of the major river basin in the Philippines. It was conceptualized due to the series of devastations brought by flooding whenever Tropical Cyclones would pass the Philippine Area of Responsibility. There are 18 major river basins in the Philippines and only five (5) of which have their own monitoring center for forecasting flood. As mentioned in the previous section they are all found in Luzon namely Pampanga, Agno, Bicol and Cagayan River Basins. All of them are also being monitored by PAGASA aside from the monitoring systems found in their vicinity.

As of the moment, there are 13 more river basins for which the construction of the river centers and installation of monitoring equipment are still on-going. The table below shows the status of the said project

Table 9: Status of FFWC/FFWS

River Basin	River Center	Monitoring System
Abra (Luzon)	Completed	On-going installation
Abulog (Luzon)	60%	-
Agusan (Mindanao)	85%	-
Agus (Mindanao)	(Construction not started yet)	-
Buayan- Malungon (Mindanao)	50%	On-process (documents)
Cagayan de Oro (Mindanao)	(Construction not started yet)	Completed
Davao (Mindanao)	Completed	On-process (documents)
Ilog-Hilabangan (Visayas)	50%	On-going installation
Jalaur (Visayas)	Co-Located with Iloilo RADAR	On-process (documents)
Panay (Visayas)	(Construction not started yet)	On-going installation

Mindanao (Mindanao)	(Construction not started yet)	-
Tagum-Libuganon (Mindanao)	Completed	Completed
Tagoloan (Mindanao)	(Construction not started yet)	On-process (documents)

2. Deployment of Early Warning System in Disaster ProneAreas

This project also known as **DEWS** project is a joint effort of Department of Science and Technology- Advanced Science and Technology Institute, PAGASA and Regional Offices. It aims at deploying 1,000 hydrometeorological devices and warning stations to improve local weather and flood monitoring capabilities for the 65 principal river basins and remaining ungauged major river basins in the Philippines. At present, hydrographic survey training for 16 DOST regional offices were already conducted and the surveys were already done in 9 regions. In addition, a total of 536 Automatic Rain Gauge (ARG) units were calibrated. Installation of the warning post to some regions were already done and Information, Education and Communication campaign was already conducted in Samar and Leyte provinces. Below (Figure 17) is the Beta version of website developed by ASTI for the said project

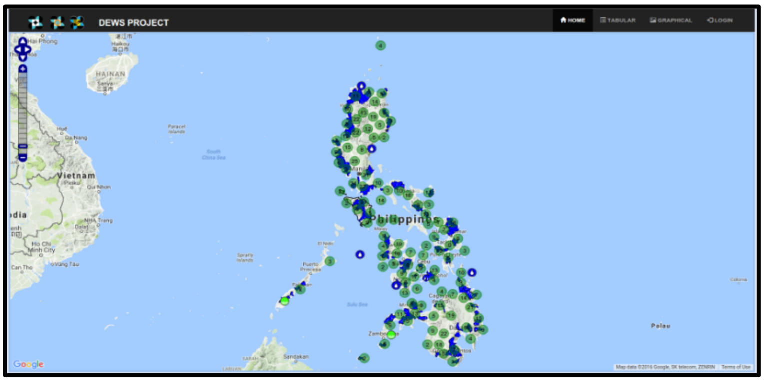


Figure 17: Beta version of website developed by ASTI for DEWS Project

3. Flash Flood Alert System (FFAS) and Automatic Rainfall Warning System (ARWS)

TheFlashFlood Alert System (FFAS) and Automatic Rainfall Warning System (ARWS)were developed and funded by the National Disaster Management Institute(NDMI) Korea. The alert monitoring system user interface (Figure 18) were installed at PAGASA Central Office, Mindanao PRSD at Cagayan De Oro and at the

CDRRMO. In this system, the data are coming from hydrological network installed at the downstream of Cagayan de Oro River Basin. It was made operational last January 2016.

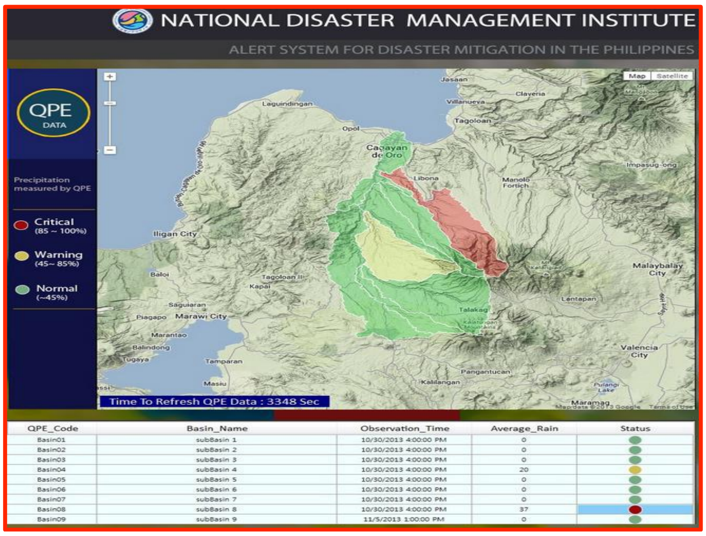


Figure 18: Graphical User Interface of NDMI Project

4. **Greater Metro Manila Area-Ready Project**

The GMMA-Ready project is project funded by the United Nation Development Program. The project has 5 components namely, Community Based Flood Early Warning System (CBFEWS), Flood Hazard and Mapping, Vulnerability and Assessment, CBEWS Storm Surge and the Geomorphic Impact Modelling. Most of these components were completed. One of the components, which is very much in accordance with function of PAGASA-FFWS is the establishment of CBFEWS in Greater Metro Manila. In this project, CBFEWS was established to the river basins in Bulacan, Rizal, Laguna and Cavite (Figure 19). Local gauging instruments for the communitywereinstalled. In this system, the trained community personnel or volunteers will be the ones to do the observation either manually or operate automatically and transmit the hydrological data to the Disaster Operation office for warning purposes.

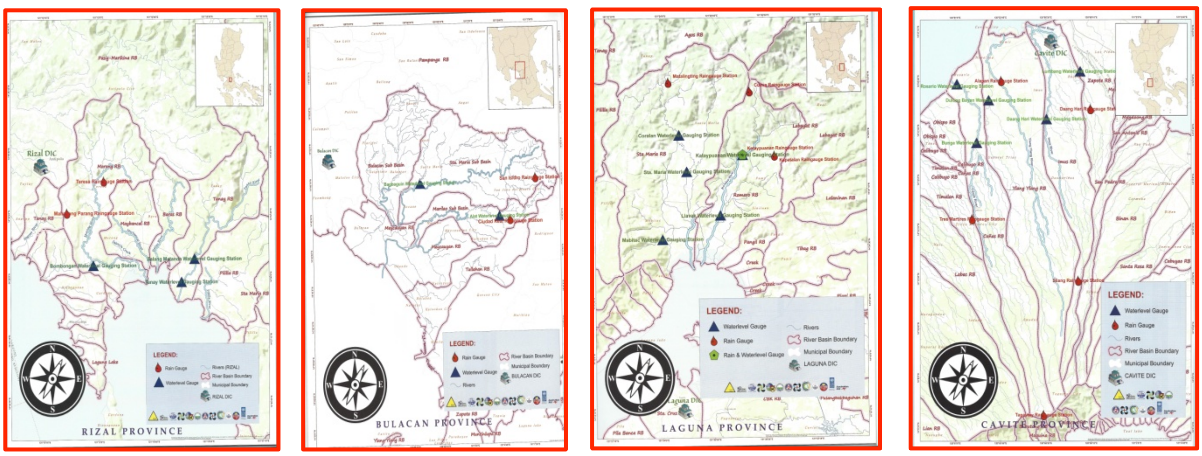


Figure 19CBFEWS Hydrological network established in Rizal, Bulacan, Laguna and Cavite.

Japan Non-Project Grant Aid

The Japan Non-Project Grant Aid (NPGA) through Japan International Cooperations System (JICS) provides Flood Forecasting and Warning System instruments for Davao, Tagoloan and Buayan-Malungon River Basins. The Government of the Philippines will provide the infrastrature to house these equipment. At present, the instruments were all delivered to Davao Synoptic Station and the installation care of local contractor is now on bidding process.

Figure 20NPGA Target Hydrological network in Davao, Buayan Malungon and Tagoloan River Basins

5. Regional Integrated Multi-Hazard Early Warning System (RIMES)

RIMES in partnership with the Government of India is implementing the project Development and Implementation of User-Relevant End-to-End Hydrological Forecast Generation and Application System for Disaster Mitigation in the Philippines. PAGASA as project partner will ensure the smooth implementation of the project and responsible for the identification of sites for the monitoring equipment. At present, the equipment are being shipped to the project site and the installation will soon follow.

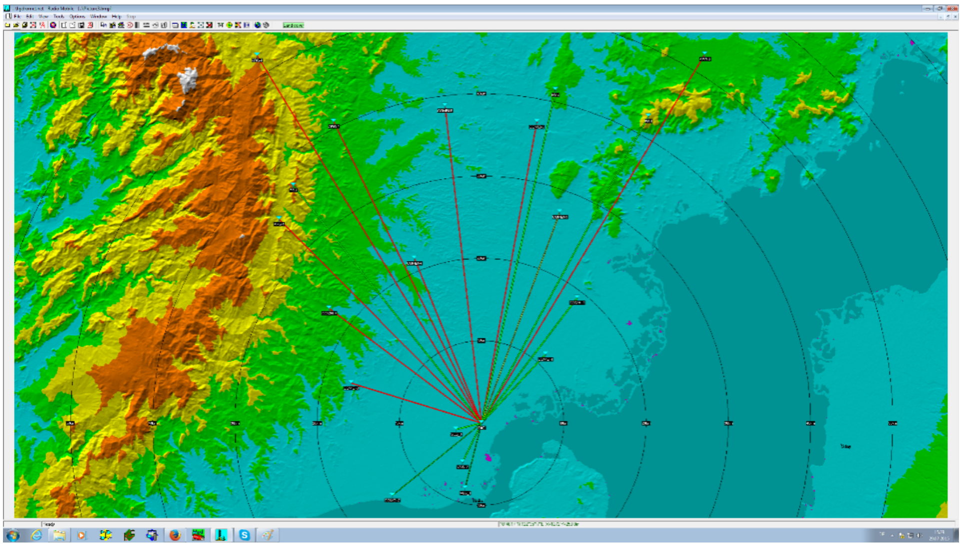


Figure 21: Proposed sites of hydrometeorological instruments to be installed