MEMBER REPORT
Philippines

ESCAP/WMO Typhoon Committee
12th Integrated Workshop
Jeju, Republic of Korea
30 October – 3 November 2017

CONTENTS

I. Overview of tropical cyclones which have affected/impacted Member's area in 2017

Meteorological Assessment (highlighting forecasting issues/impacts)

In 2017 only 14 tropical cyclones entered and developed inside the Philippine Area of Responsibility (PAR), four (6) were Tropical Depression, five (6) Tropical Storm (TS), one (1) Severe Tropical Storm (STS) and one (2) typhoon. From the 13 tropical cyclones shown in Figure 1, only four (5) made landfall and these were TD (Auring) and TD (Crising) that weakened into a Low Pressure Area (LPA) after making a landfall, TS Doksuri, STS Hato (1713) and TS Pakhar (1714) and TS Doksuri. Some of the TC's does not affect the Philippines like TD (Bising) and TD (Dante), TD (Isang), TD (Nando), and Typ Talim.

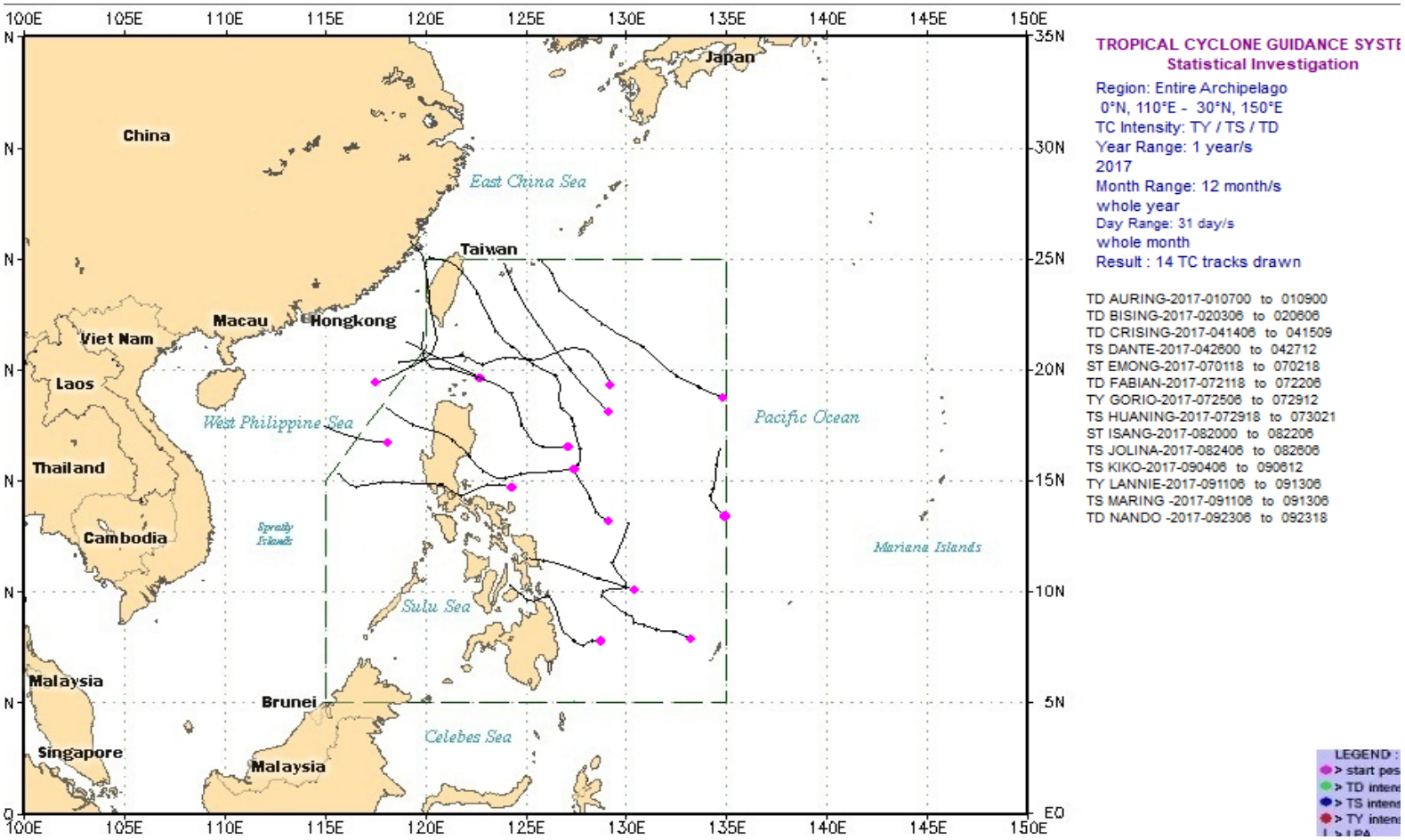
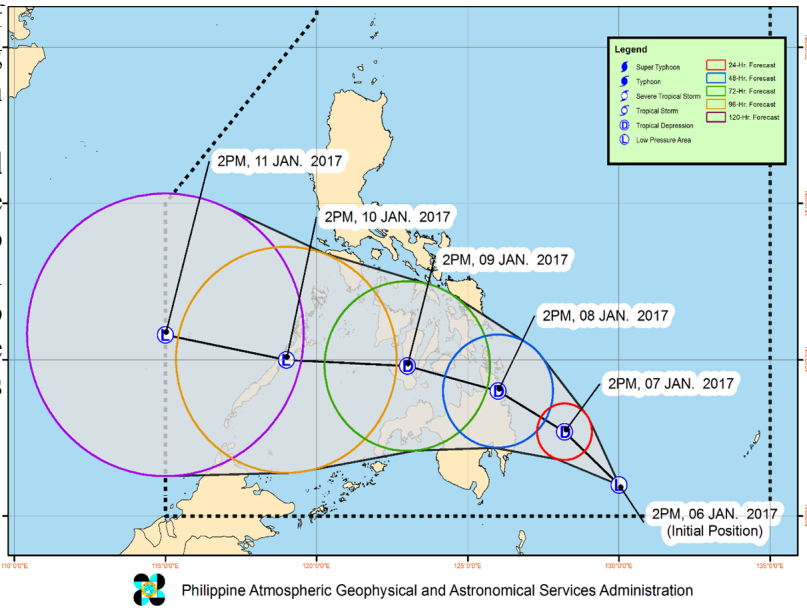


Figure 1. Tracks of Tropical cyclones that entered and developed inside the PAR in 2017

1. TROPICAL DEPRESSION (TD) AURING

"AURING" has developed inside the Philippine Area of Responsibility (PAR), East of Mindanao in the morning of Jan 07. It then moved northwest and made landfall in Surigao Del Norte in the afternoon of Jan 08. **"AURING"** has slightly weakened then traversed the Mindanao and Bohol Sea before it became a Low Pressure Area in the vicinity of Mactan, Cebu in the morning of Jan 09. It also enhanced the Northeast Monsoon and based on the initial reported observations from the PRSD, moderate to occasionally heavy rains and thunderstorms were observed over Mindanao, Central and Eastern Visayas including Bicol Region.



Weather Advisory Issued - 3

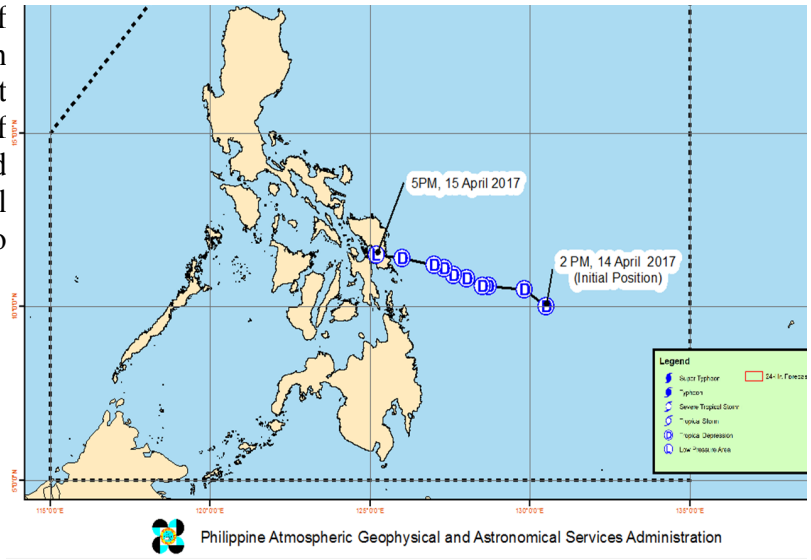
Tropical Cyclone Warning for Shipping – 9

Severe Weather Bulletin Issued – 15

No damage reported

2. TD CRISING

"CRISING" also developed inside the Philippine Area of Responsibility (PAR), East of Mindanao in the afternoon of April 14. It continued moving in a West Northwest direction closer to Eastern Visayas. In the afternoon of April 15, it made landfall over Eastern Samar and weakened into a Low Pressure Area (LPA). The rainfall observations from the PRSD Stations were moderate to occasionally heavy.



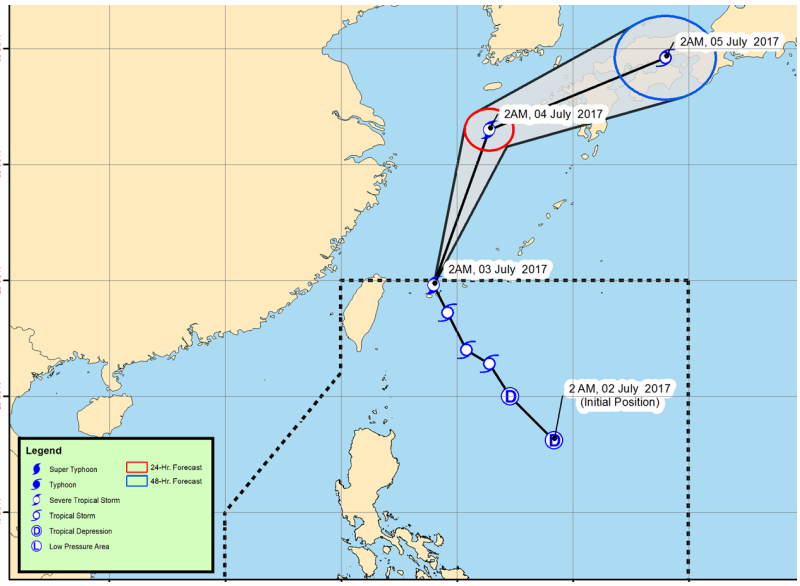
Weather Advisory issued – 4 (LPA)
Tropical Cyclone Warning for shipping issue – 6
Severe Weather Bulletin issued – 6
No damage reported

3. STS NANMADOL (1703)

MAX. SUSTAINED WINDS - 90 KPH

GUST-115 KPH

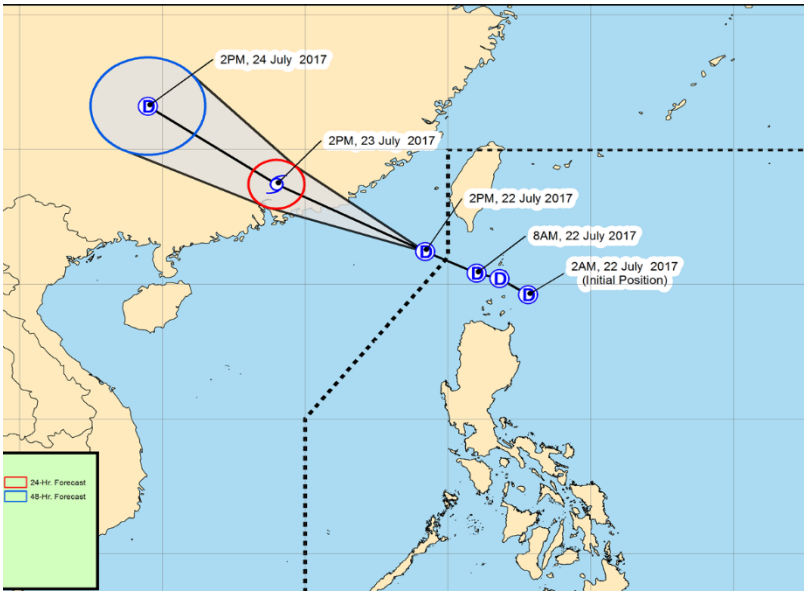
"Nanmadol"(Emong) became a Low Pressure Area (LPA) inside the Philippine Area of Responsibility (PAR) and developed into a Tropical Depression in the early morning of July 02 East of Luzon. It then moved North Northwest prior to recurvature. Nanmadol intensified into a Tropical Storm then into a Severe Tropical Storm before it exit the Northern border of the PAR in the morning of July 03. It slightly enhanced the Southwest Monsoon.



Tropical Cyclone Warning for shipping issue – 5
Severe Weather Bulletin Issued (Alert) - 4

4. TD FABIAN

"Fabian" has developed into a Tropical Depression in the early morning of July 22, East of Extreme Northern Luzon. It moved West Northwest passing very close to Batanes Group of islands. Fabian has maintained its strength as it left the Western border of the PAR in the afternoon of July 22nd.

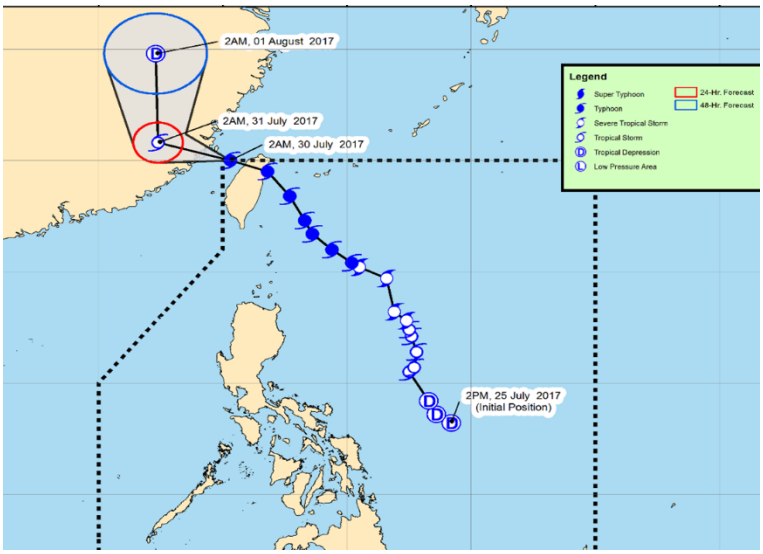


Tropical Cyclone Warning for shipping issue – 3
Severe Weather Bulletin Issued (Alert) - 4
No damage reported

5. TYPHOON NESAT (1709) MAX. SUSTAINED WINDS - 150 KPH

GUST-180 KPH

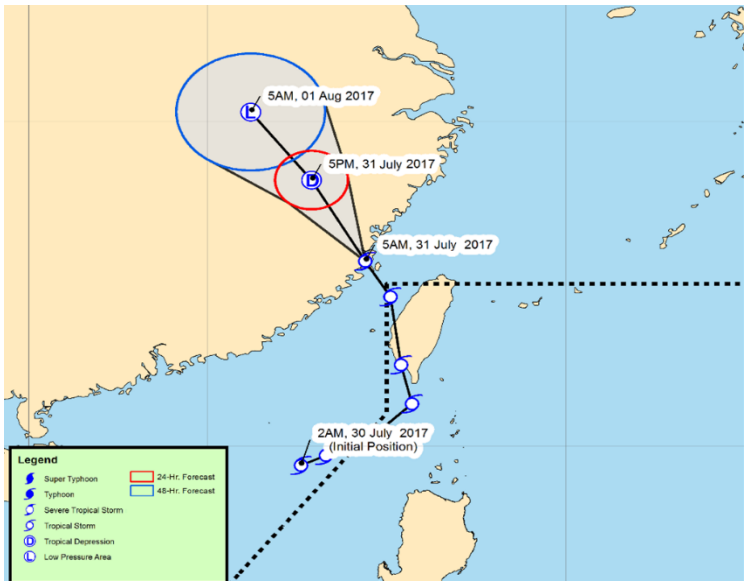
"Nesat" (Gorio) has developed into a Tropical Depression in the afternoon of July 25th East of Bicol. It moved North Northwest slowly and gained strength while over the Philippine Sea. **"Nesat"** has continued to intensify reaching typhoon intensity as it maintained a poleward direction leaving the Northwestern border of the PAR in the early morning of July 30. **TY "Nesat"** enhanced the Southwest Monsoon that brought moderate to occasionally heavy rains and thunderstorms over the Western section of Luzon and Visayas.



Weather Advisory Issued – 3
Tropical Cyclone Warning for shipping issue – 19
Severe Weather Bulletin Issued (Alert) - 16

6. TS HAITANG (1710)
MAX. SUSTAINED WINDS - 85 KPH
GUST-120 KPH

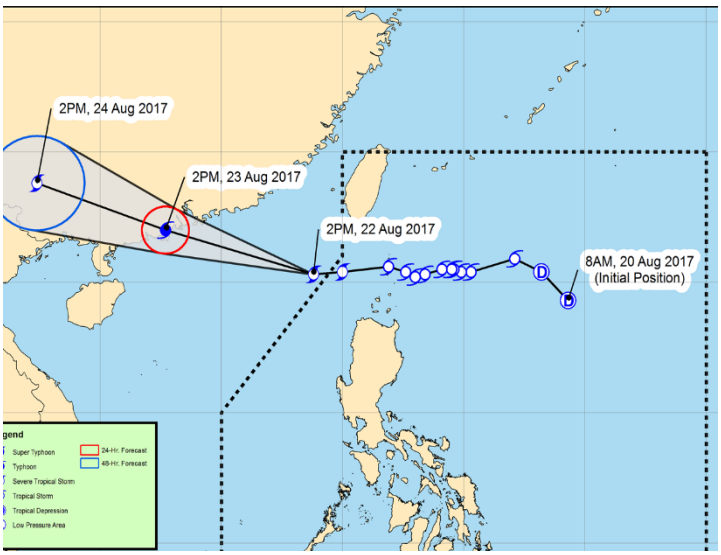
"Haitang" (Huaning) as Tropical Storm from the West Philippine Sea has entered the Northwestern border of the PAR in the early morning of July 30th. It was moving Northeast then to North and crossed Southwestern Taiwan. Haitang has maintained its poleward direction leaving the Northern border of the PAR in the early morning of July 31. TS Haitang enhanced the Southwest Monsoon that brought moderate to heavy rains and thunderstorms in Luzon especially over the Western section.



Tropical Cyclone Warning for shipping issue – 6
Severe Weather Bulletin Issued – 6

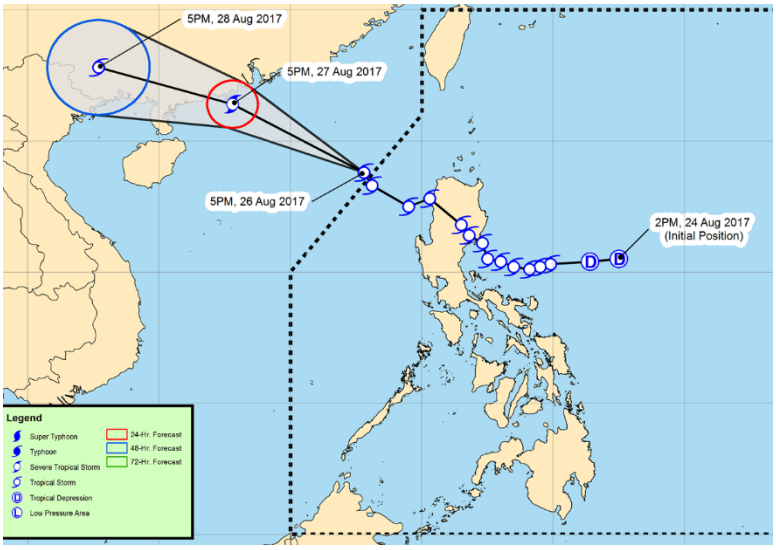
7. STS HATO (1713)
MAX. SUSTAINED WINDS - 110 KPH
GUST-137 KPH

"Hato"(Isang) has developed into a Tropical Depression (TD) inside the PAR, East of Batanes in the morning of Aug 20. It gained strength as it moved in a Westward direction towards Batanes group of islands. It maintained the Westward direction and passed much closed to Batanes and exited the Western border of the PAR in the afternoon of Aug 22. Hato enhanced the Southwest Monsoon that brought moderate to heavy rains and thunderstorms in Luzon especially over the Western section.



Weather Advisory Issued – 10
Tropical Cyclone Warning for shipping issue – 10
Severe Weather Bulletin Issued (Alert) – 14

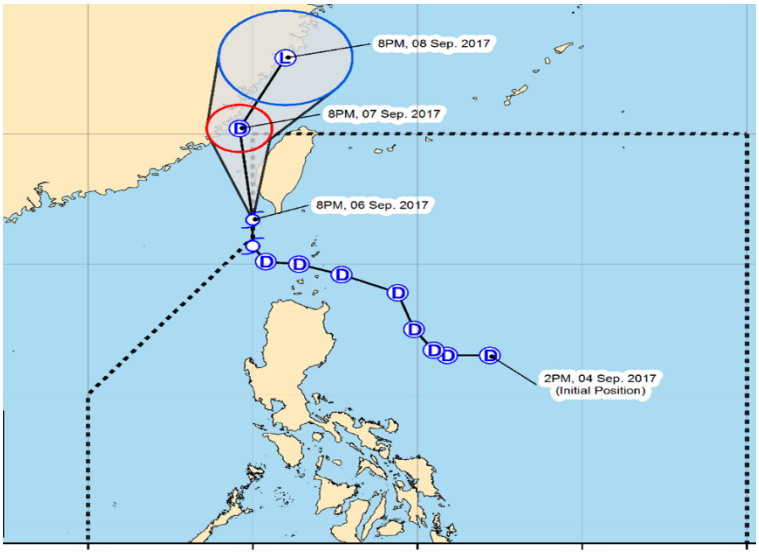
8. TS PAKHAR (1714)
MAX. SUSTAINED WINDS - 80 KPH
GUST-105 KPH



"Pakhar" (Jolina) developed into a Tropical Depression (TD) inside the PAR, 540 kms East of Casiguran, Aurora in the afternoon of Aug 24. It gained strength as it continued moving closer to Northern Luzon area. Pakhar made landfall in Casiguran, Aurora then traverse the rugged terrain of Northern Luzon out into the West Philippine Sea. It exited in the Western border of the PAR in the evening of Aug 26. It also enhanced the Southwest Monsoon that brought moderate to heavy rains and thunderstorms in Luzon and some parts in Visayas.

Tropical Cyclone Warning for Shipping issued – 9
Severe Weather Bulletin issued – 15

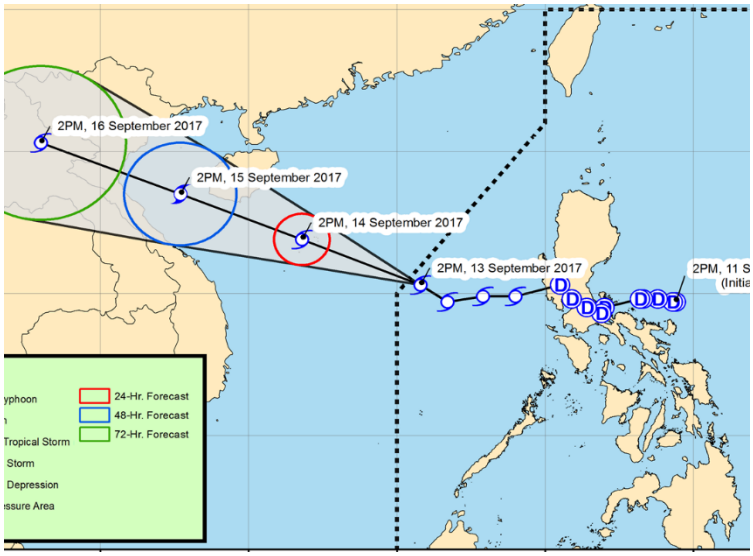
9. TS GUCHOL (1717)
MAX. SUSTAINED WINDS - 65 KPH
GUST-80 KPH



"Guchol"(Kiko) has developed into a Tropical Depression (TD) inside the PAR, East Northeast of Baler in the afternoon of Sep 4. It maintained its strength as it continued moving closer to Extreme Northern Luzon. Guchol has moved West Northwest to West then traversed the Balintang Channel out into the West Philippine Sea. It attained storm intensity as it left the Northwestern border of the PAR in the evening of Sep 6. Guchol did not enhanced the Soutwest Monsoon and moderate to heavy rainfall was only concentrated to the areas directly affected.

Weather Advisory Issued – 1
Tropical Cyclone Warning for shipping issue – 10
Severe Weather Bulletin Issued (Alert) – 9

10. TS DOKSURI (1719)
MAX. SUSTAINED WINDS - 85 KPH
GUST-105 KPH

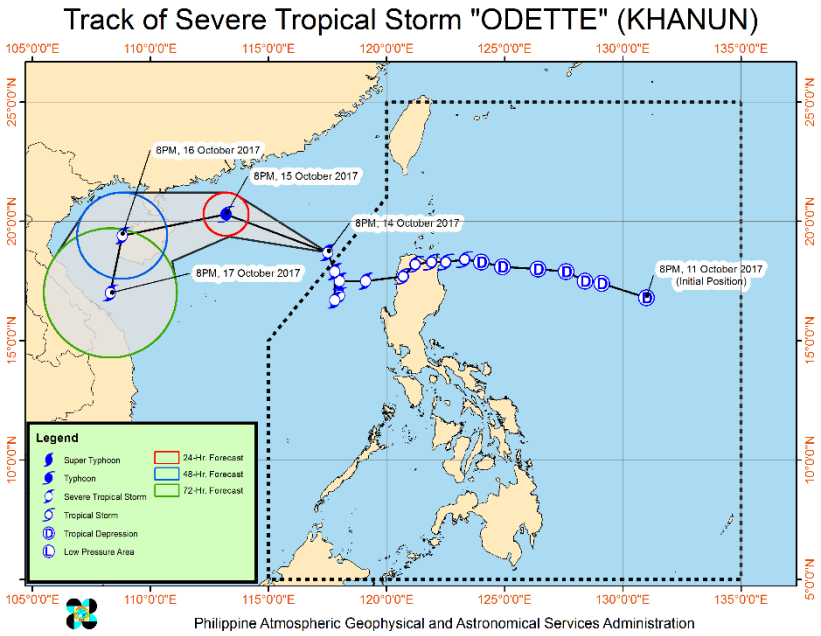


"Doksuri" has developed into a Tropical Depression(TD) inside the PAR, 300 kms East of Infanta, Quezon, in the afternoon of Sep 11. It then moved West Northwest towards Quezon - Aurora Area. It made landfall in Mauban, Quezon in the morning of Sept. 12, then traversed the Provinces of Laguna, Rizal, Quezon City, Bulacan, Pampanga and exited the landmass in Zambales. Maring intensified into a Storm while over the West Philippine Sea, before exited the PAR in the afternoon of Sept. 13. Although it was only a TD when it traversed the landmass of Luzon, it brought heavy rainfall that caused flooding in several Cities in Metro Manila and Provinces in Southern Luzon.

Severe Weather Bulletin Issued – 14
Tropical Cyclone Warning for shipping issue - 9

11. STS KHANUN (1720)
MAX. SUSTAINED WINDS - 90 KPH
GUST-105 KPH

"Khanun" developed into a Tropical Depression(TD) inside the PAR, 925 kms East of Tuguegarao City, in the evening of Oct. 11. It then moved West Northwest towards Cagayan Province. It intensified into a storm before landfall in Northern Cagayan in the early morning of Oct. 13. Khanun traversed the landmass of extreme Northern Luzon in the morning of the same day. It again intensified into a STS after exiting the landmass and remained almost stationary for 12 hours. Khanun exited the PAR in the afternoon of Oct. 14.



Severe Weather Bulletin Issued – 18

Tropical Cyclone Warning for shipping issue - 13

Issuance of Severe Weather Bulletin

NEW CHANGES:

- When a tropical cyclone is predicted to **make landfall or pass close to the coastline in 24 hrs**, SWB will be issued **every 3 hours instead of every 6 hours** until the TC has no effect over the coast and landmass.

- Information on TC occurrence over the NW Pacific Ocean will be provided even if it is still outside from the Phil. Area of Responsibility. (PAR)

- **Hourly update** on the TC position is given once a TC Warning Signal is raised over an area.

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

- Of the 15 tropical cyclones that impacted Philippines, only TD Auring caused severe damages to properties and agriculture due to flooding and landslides. There were 32 casualties caused by drowning and buried due to landslides.

- PAGASA issued Flood Bulletins for telemetered River Basin and Flood Advisories for Non-Telemetered River Basin in Luzon and some regions in Visayas and Mindanao during the passage of these tropical cyclones.

Figure 2: Flooding associated with TD Maring

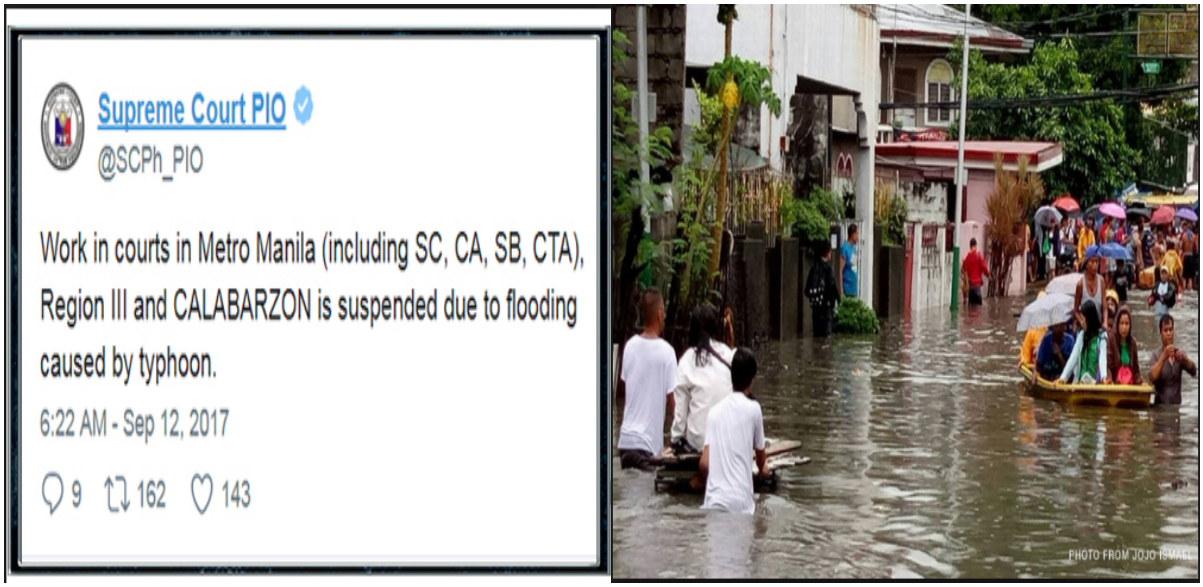
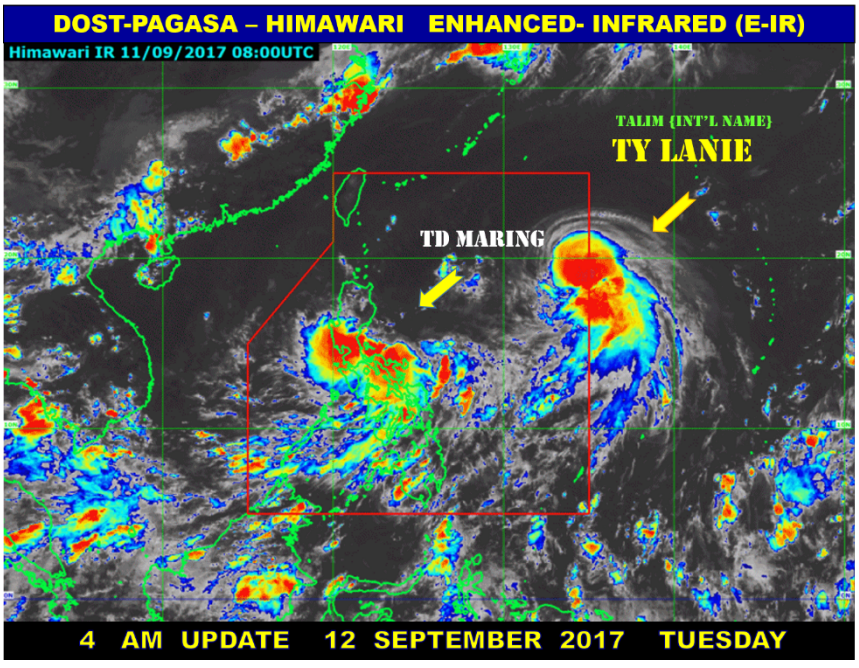


Figure 3: Flooding associated with TD Maring

Sep 11,2017		Sep 12,2017		Sep 13,2017	
ALABAT	537.5	PORT AREA	98.7	BALER RADAR	101.0
AMBULONG	273.7	SUBIC BAY	96.5	CATBALOGAN	78.0
TAYABAS	201.4	TANAY	85.0	SANGLEY POINT	56.0
INFANTA	189.2	TAYABAS	81.5	CABANATUAN	39.0
DAET	160.8	SANGLEY POIN	70.8	SAN JOSE	23.6

Table 1. Showing the 24 hour rainfall recorded over Metro Manila and other Provinces in Southern Luzon.



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

- Of the 14 tropical cyclones that impacted Philippines, only TD Maring caused severe damages to properties and agriculture due to flooding and landslides. There were 32 casualties caused by drowning and landslides.

A total of **697,263 families / 3,110,165 persons** were affected in **2,154** barangays of **160** municipalities, **37** cities and **19** provinces of Regions I, III, IV-A, IV-B, CAR, and NCR:

Regions	Affected Areas				Affected Population	
	Province	City	Muns	Brgys	Families	Persons
NCR	-	16	1	221	49,924	234,884

Aside from the widespread flooding monitored in various areas in Luzon, **25 other incidents** were reported in Regions III, IV-A, IV-B, and CAR: **6** landslides, **9** drowning, **6** collapsed structures, **1** vehicular accident and **3** other incidents:

INCIDENTS	REGION	PROVINCE / CITY / MUNICIPALITY
LANDSLIDE (6)	III (4)	Between Porac and Clark, Pampanga, Lubao, Pampanga Porac, Pampanga Olongapo City, Zambales
	IV-A (2)	Trece Martirez, Cavite (2)
DROWNING (9)	IV-A (9)	Sariaya, Quezon Kawit, Cavite Bacoor City, Cavite (2) Imus City, Cavite (3) Noveleta, Cavite Morong River, Rizal
COLLAPSED STRUCTURES (6)	III (1)	Olongapo City, Zambales
	IV-A (5)	Tanza, Cavite Trece Martirez, Cavite (3) Binangonan, Rizal
VEHICULAR ACCIDENT (1)	IV-B (1)	Sta. Cruz, Occidental Mindoro

Damages to Properties (Tab G)

PhP1,645,105,326.54 worth of damages to agriculture and infrastructures were incurred in Regions I, III, IV-A, IV-B, and CAR. Of this, damages to infrastructures amounted to **PhP860,630,279.73** while damages to agriculture amounted to **PhP784,475,046.81:**

Regions	Agriculture (Crops, HVCC, livestocks, fisheries, agricultural equipment, etc.)	Infrastructure (roads, bridges & other structures)	TOTAL
I	210,514,167.59	27,000,000.00	**237,514,167.59**
II	343,057,403.98	259,275,000.00	**602,332,403.98**
IV-A	166,798,307.35	204,178,664.15	**370,976,971.50**
IV-B	35,497,814.00	69,542,000.00	**105,039,814.00**
CAR	28,607,353.89	300,634,615.58	**329,241,969.47**
TOTAL	**784,475,046.81**	**860,630,279.73**	**1,645,105,326.54**

Table 2. Showing the Incidents and Damage to properties in different Regions

Casualties (Tab C)

There were thirty-two (32) persons reported dead, three (3) are still missing, and three (3) were injured:

Region	Dead	Injured	Missing
NCR	1	-	-
I	4	-	-
III	12	-	1
IV-A	14	2	-
CAR	1	28	2
TOTAL	32	30	3

Affected Population (Tab D)

A total of 697,263 families / 3,110,165 persons were affected in 2,154 barangays of 160 municipalities, 37 cities and 19 provinces of Regions I, III, IV-A, IV-B, CAR, and NCR:

Regions	Affected Areas				Affected Population	
	Province	City	Muns	Brgys	Families	Persons
NCR	-	16	1	221	49,924	234,884

Damages to Properties (Tab G)

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TOTAL	784,475,046.81	860,630,279.73	1,645,105,326.54

Table 3. Showing number of casualties and the affected population. Source: NDRRMC

4. Regional Cooperation Assesment (highlighting regional cooperation successes and challenges)

PAGASA and KOICA have collaborated in the automation of Flood Early Warning System for Disaster Mitigation in Greater Metro Manila. The issuance of Flood Warning in the Urban and River Flooding will now be easy and fast as well as the warning sounding of siren along the river banks if the water reach critical level. This is the 3rd Early Warning Project of Koica in the Philippines.

This project will greatly benefit people living near river banks and creeks because they will be warn immediately about the impending threat of river flooding and can evacuate to safer areas.

Fig. 4. Kick-off meeting in the automation of Early Warning System

TC Members' Report

Summary of Progress in KRAs

Title of item (1):

Radar, High Frequency Doppler Radar (Coastal Radar) and Satellite Observations of Tropical Cyclones

A new C-band and S-band Doppler Radar installation were ongoing in Busuanga, Zamboanga, Daet, Camarines Norte, Baler, Aurora, Agno, Pangasinan and in Bohol. These Radars will be operational late this year or early next year. The radars would be used in monitoring tropical cyclones when the TC is over inland in any part of the country and over offshore as long as it is within the range. These radars will also cover the blind areas of the existing radars. This will also be used in rainfall monitoring and warning by the PAGASA Regional Services Division throughout the country.

PAGASA also acquired additional one mobile radar (total - 3) 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 and by the Storm Chaser Group.

There is a planned to upgrade the satellite from China (FY2E) this coming October and hopefully this will be operational before the year end. This satellite will help in determining the location of a TC and to identify the weather system affecting the country and can also be used as back-up.

PAGASA has installed High Frequency Doppler Radar (Coastal Radar) along the nautical highway that connect the three main islands, Luzon, Visayas and Mindanao where many Ferry Boats and small Sea Vessels are plying. These Coastal Radars are used to monitor the wind speed and direction, wave height and ocean current. This can also be used to monitor and track weaker TC's.

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

An enhancement training on Satellite and Radar images analysis especially on tornado and hailstorm formation within the severe thunderstorm cells. It is still a problem to us to forecast this kind of weather phenomena.

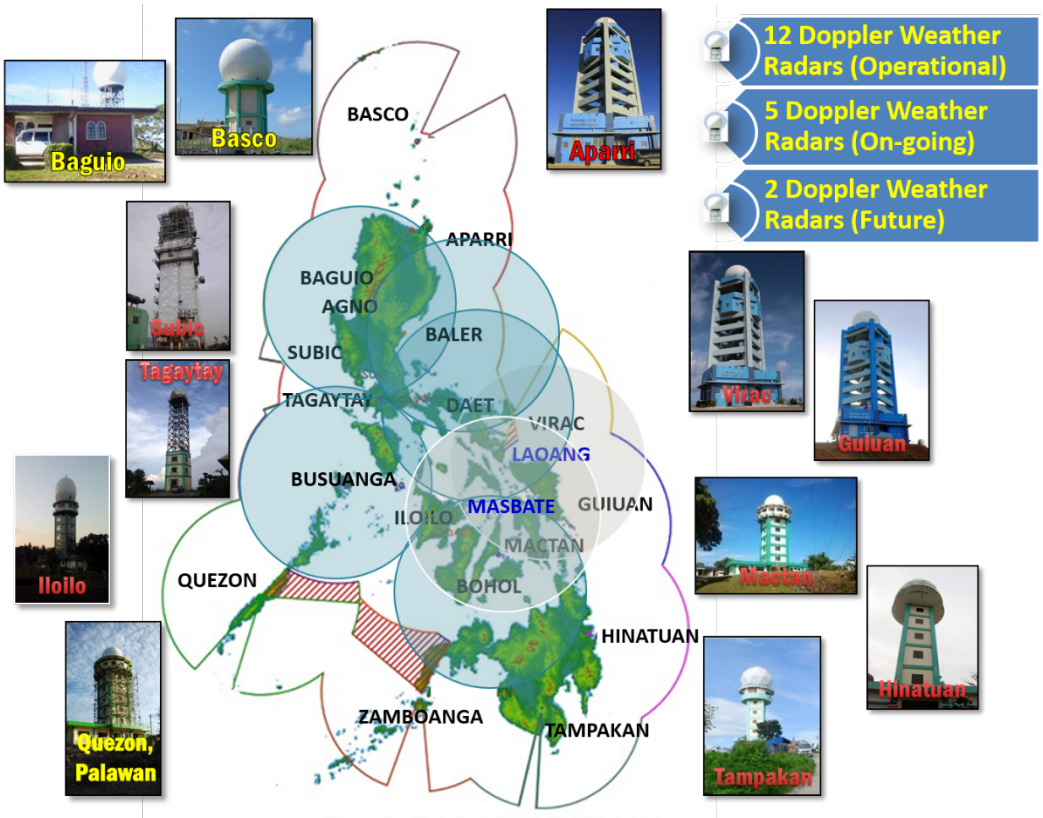


Fig. 5. RADAR STATIONS

One Additional Mobile X-band Radar (total-3)

Radar Data Analysis

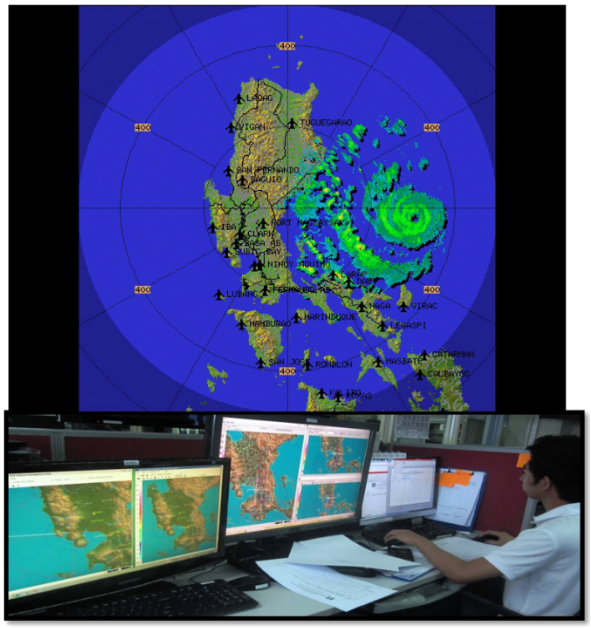
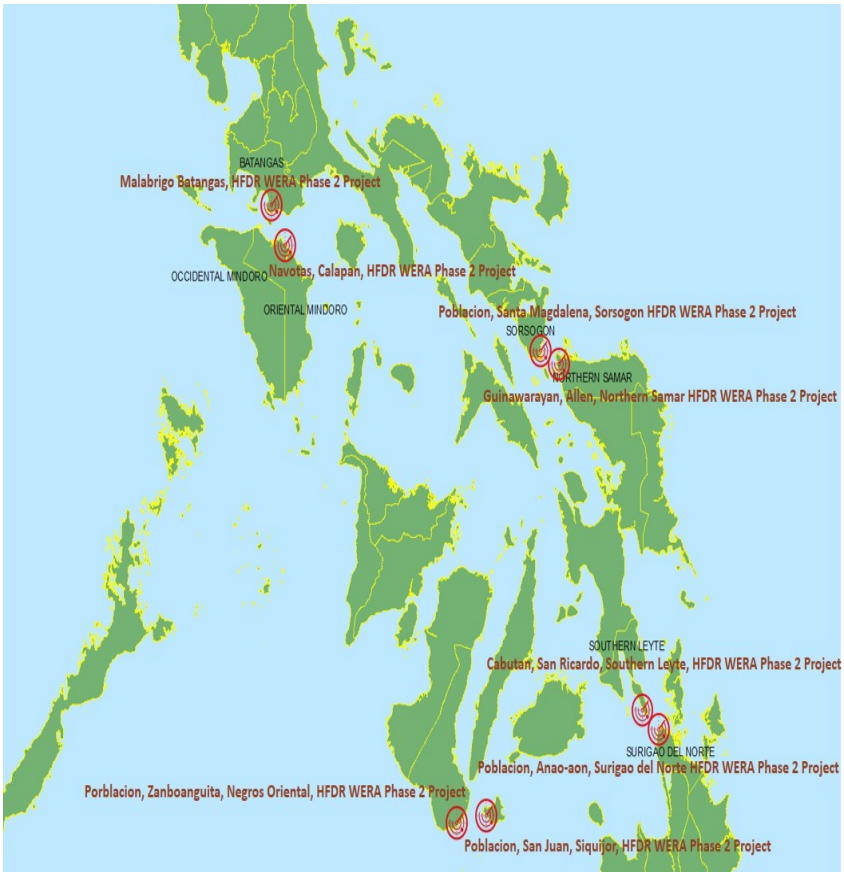


Fig. 6. Mobile Radars



Place	Freq	Date installed	Status
Luzon			
Malabrigo, Lobo, Batangas	26 Mhz	April 2017	Working but weak internet signal
Brgy. Navotas, Calapan, Oriental Mindoro	26 Mhz	April 2017	Working but weak internet signal
Sta. Magdalena, Sorsogon	26M hz		To be installed by October
Guinarawayan, Allen, Northern Samar	26M Hz		To be installed by October
Visayas			
Poblacion, San Juan, Siquijor	16M Hz	On going	
Poblacion, Zamboangita, Negros Oriental	16M hz	On going	
Visayas/Mindanao			
Cabutan, San Ricardo, Southern Leyte	26 MHz	August 2017	Working
Poblacion, Anao-aon, Surigao del Norte	13M Hz	August 2017	Working

Figure 7. Location of the installed HFDR

Update of the Project High Frequency Doppler Radar (Coastal Radars) WERA

Present status

Installed projects:
Area: Luzon

1. Malabrigo, Lobo, Batangas
2. Calapan, Oriental Mindoro

Area Mindanao/Visayas

1. San Francisco, Surigao
2. San Ricardo, Southern Leyte

On going
Area: Visayas

1. San Juan, Siquijor
2. Zamboanguita, Negros Oriental

Area Southern Luzon

1. Sta. Magdalena, Sorsogon
2. Allen, Northern, Samar

Problems/Challenges
Most of the problem is the communication of Globe or Smart. The signal is very weak that it cannot sustain the transmission of data. The possible solution to this problem is putting a high gain antenna for the cellular mobile phone. Training on Coastal Radar is also needed to capacitate our Marine Forecasters.

Title of item (2):
New Changes in the issuance of Severe Weather Bulletin (SWB)

- PAGASA has some changes in the issuance of SWB, when a tropical cyclone is predicted to make landfall or pass close to the coastline in 24 hrs, SWB will be issued every 3 hours instead of every 6 hours, until the TC has no effect over the coast and landmass.

- We also include information on the possible raising of Tropical Cyclone Warning Signal #1 of Provinces where there are Ports, because when TCWS #1 is raised, there will be no movement of all kinds sea vessels regardless of tonnage and size. This will also avoid or minimize the number of stranded passengers at the Ports.

- Information on TC occurrence and location over the North Western Pacific Ocean will be provided even if it is still outside from the Phil. Area of Responsibility (PAR).

- Hourly update on the TC position is given once a TC Warning Signal is raised over an area.

Title of item (3):
Information and Educational Campaign to Strengthen the Readiness and Resilience of Communities to Typhoon-related Disasters

- PAGASA conducted regular exercises and drills every year on tropical cyclone disaster prevention and preparedness with relevant government departments and organizations. Information and Educational Campaign (IEC) is also a 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.
- Every occurrence or formation of a TC inside or outside PAR, PAGASA will continue to give the current and the forecast scenario as to the effect of the TC to any part of the country, as member of a core group called Pre-Disaster Risk Analysis (PDRA). 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 it will made landfall.

Figure 13. Workshop on PAGASA Warning products/information for DRRMOs of Metro Manila Cities & Selected Cities & Municipalities (Aug. 16, 2017)
WMO/PAGASA Regional Training Center
2/F, PAGASA Central Office, Agham Rd., Diliman, Q. C.

Figure 14. Media Seminar- Workshop for National Capital Region (NCR)
June 23 – 25, 2017, Vista Venice Resorts, Morong Bataan.

Figure 8. Pre-Disaster Risk Analysis (PDRA) Meeting whenever there is a Weather Disturbance that will affect the Philippines

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.

Title of item (4): Installation of Cray High Performance Computing in PAGASA Forecast

- Cray XC40
- **Peak Performance**
  - ***Intel Xeon E5-2698 V3 (Haswell)***
    - 2.3 GHz, 16 Cores
    - 16 64-bit FU (Function Units) in each core, 16 FP (Floating Points) per CP (Clock Period), all in double precision
  - ***Each socket yields***
    - 2.3 * 16 * 16 = 588.8 GFLOPS (Floating Points Operation Per Second, Double Precision)
  - ***Each compute nodes yields 1,177.6 GFLOPS or 1.1776 TFLOPS***
  - ***340 compute nodes yield 400.4 TFLOPS***
- **The machine will cater to UKMO's UM, WRF, COSMO and Regional Climate Model (RegCm)**

For the UKMO UM:
Phase 1 system

- The key priority is the installation on operational component, which is a 4.4km deterministic model domain comprising 600*800 points with 70 levels

- A **real-time research** component will also be installed, which is a 1.5 km deterministic model nested inside the 4.4 km model, with a 333 m deterministic model nested inside the 1.5 km model. The domains for the 1.5 km and 333 m models are labelled D2 and D3 in the below figure, respectively.
- The aim of the 333 m model is to allow scientists and forecasters within PAGASA and the Met Office to understand the value of extremely detailed, short-range forecast information over the most populous area of the Philippines. It is emphasized that this model is at the cutting-edge of NWP with the UM and is therefore highly experimental (to a lesser degree this is also true of the 1.5 km model).

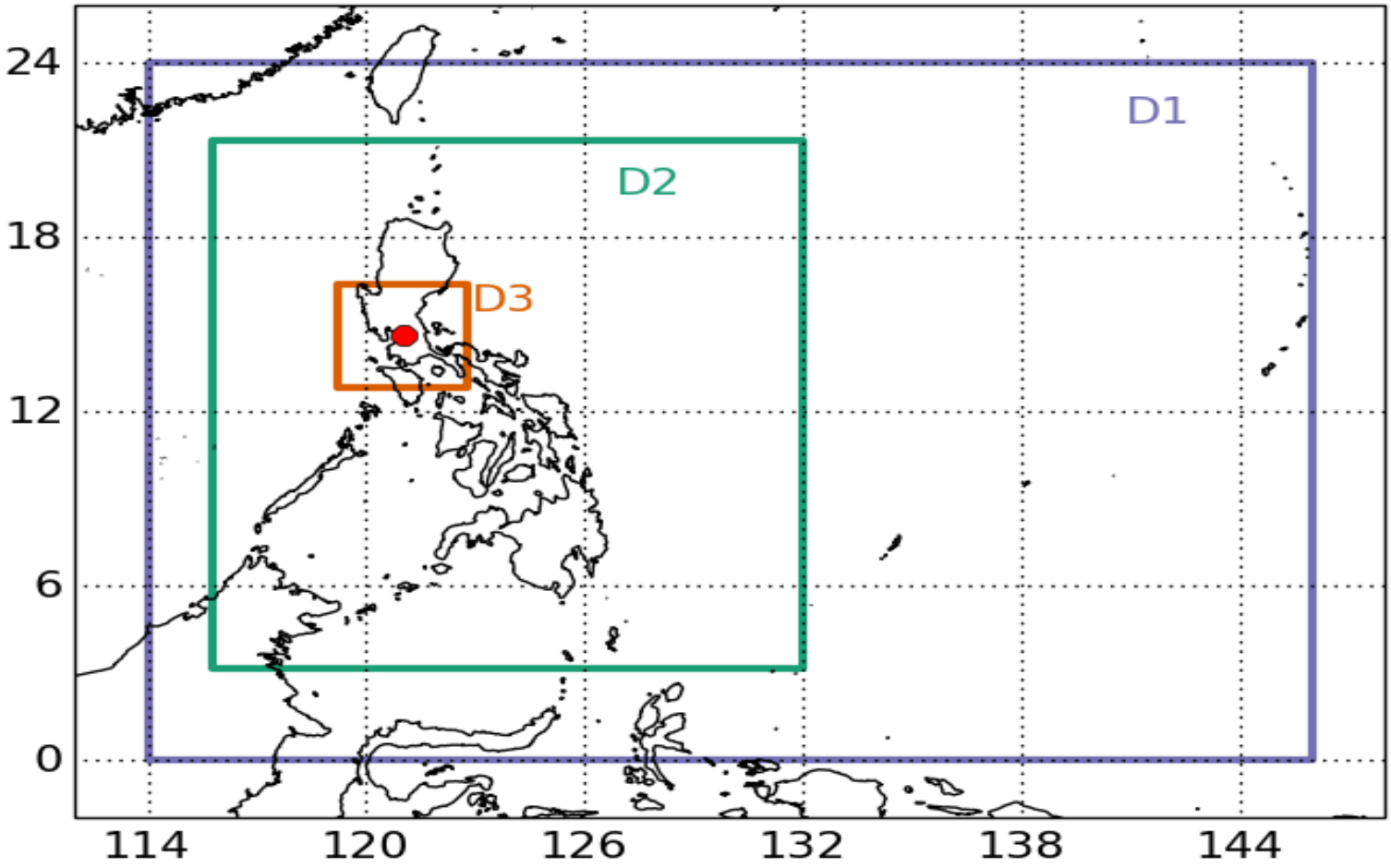


Figure 9. Map indicating the 3 domain area

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 improve model performance in rainfall forecasting, TC intensity and movement.

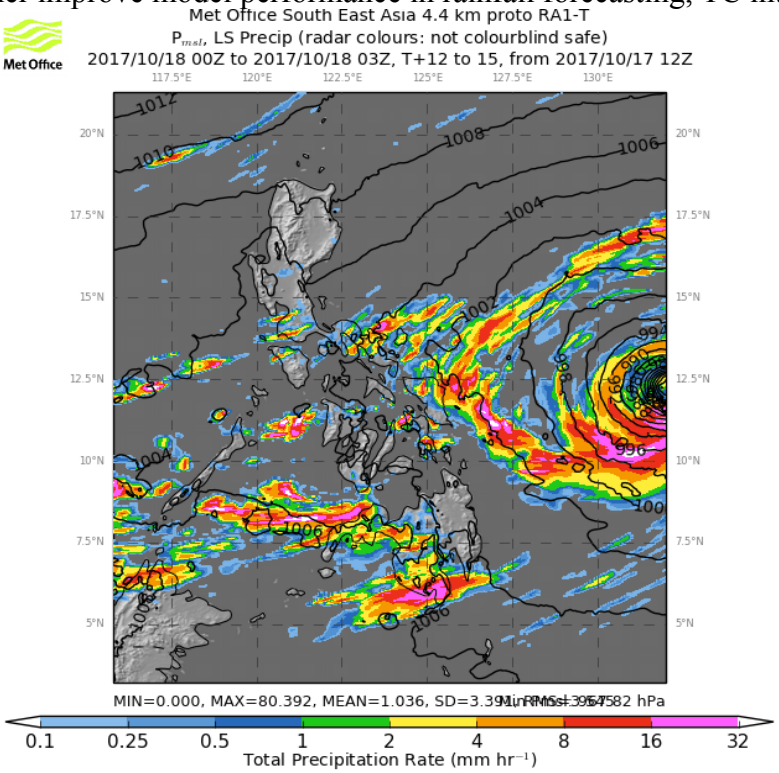


Figure 10. Sample of the High Resolution UK-UM

Title of item (5):
Continual Capacity Building through Various Trainings

- 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.
- PAGASA also conducted regular workshops to the Municipal, Provincial and City Disaster Risk Reduction Officers to capacitate and enhanced their knowledge of the information that we issued during the occurrence of inclement weather and how to used our website to find the information that will help them decide especially in the cancellation of classes and work.
- We also conduct regular trainings and workshops for the Quad Media so that they will be familiar with the warnings we issue and the meteorological terminology that we used.

Figure 12. Meteorological Technicians Training Course (MTTC)
(April 4-Sept. 14, 2017)
WMO/PAGASA Regional Training Center
2/F, PAGASA Central Office, Agham Rd., Diliman, Q. C.

Typhoon Committee - Hydrology Report

Roy A. Badilla[1]
Socrates F. Paat, Jr.[1]
[1]*Philippine Atmospheric, Geophysical and Astronomical Services Administration*
Hydro-Meteorology Division
Diliman, Quezon City Philippines

A. INTRODUCTION:

The Philippines obtains its water supply from different sources. These include 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 the 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 the main undertakings of HMD's Flood Forecasting and Warning System (FFWS). At present PAGASA-HMD is monitoring the country's 18 major river basins mentioned above and among these, seven (7) are telemetered and equipped with complete hydrological facilities for monitoring. In addition, the agency is collaborating with other national institutions 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, San Roque, Pantabangan and Angat Dams (Figure 2).

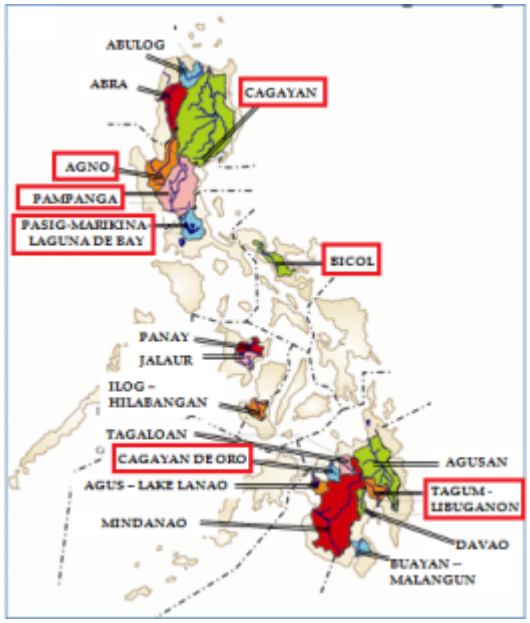


Figure 1: 18 Major River Basins

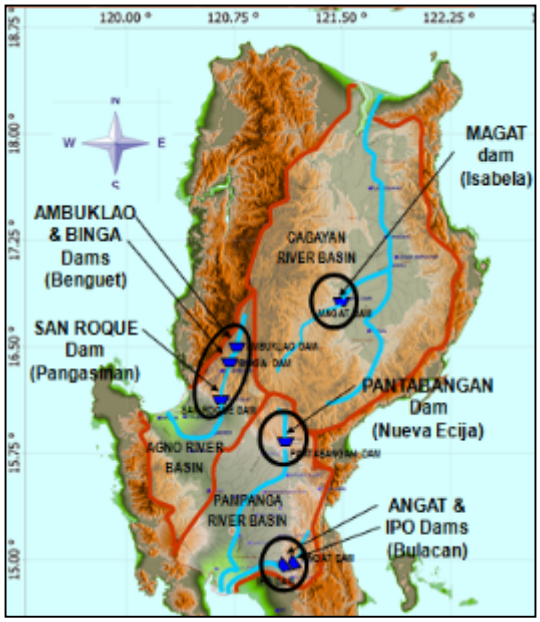


Figure 2: Major Dams in Luzon

B. HYDROLOGICAL ASSESSMENT:

1. FFWS Activities during the Passage of Tropical Cyclones in 2017
2. FFWS Dam monitoring Activities

1. FFWS Activities during the Passage of Tropical Cyclones that affected Telemetered River Basins

The current year 2017 may be considered a "normal year" for the country as far as occurrence of tropical cyclones (TCs) is concerned. As of October, 16 TCs have been recorded, four TCs short of the average which is 20 per year. Of these 16 TCs, six (6) have directly or indirectly affected the river basins and Flood Forecasting and Warning Centers (FFWCs) reacted accordingly.

Table below summarizes the issuances of hydrological warnings issued by PAGASA due to the occurrences of tropical cyclones. These TCs are discussed briefly thereafter.

Table 1. Summary of Issuances of Flood Bulletins and General Flood Advisories in Telemetered River Basins

PABC RIVER CENTERS	TD BISING 3-6 FEB 2017		TD GORIO 25-30 JUL 2017		TD JOLINA 24-26 AUG 2017		TD KIKO 4-6 SEP 2017		TY LANNIE 11-13 SEP 2017		TD MARING 11-13 SEP 2017	
	Issuances	Final Advisory	Issuances	Final Advisory	Issuances	Final Advisory	Issuances	Final Advisory	Issuances	Final Advisory	Issuances	Final Advisory
PAMPANGA GEN FLOOD ADV.			3		1				2	1	3	1
PAMPANGA FLOOD BULLETIN					2							
AGNO GEN FLOOD ADV.			1		3							
AGNO FLOOD BULLETIN			3	1								
BICOL GEN FLOOD ADV.									1		1	
BICOL FLOOD BULLETIN					4				2	1	2	1
CAGAYAN GEN FLOOD ADV.					1		1					
CAGAYAN FLOOD BULLETIN	3	1			3		1	1				
	3	1	7	1	14	0	2	1	5	2	6	2
TOTAL	4		8		14		3		7		8	

a. TC Bising

"BISING" developed inside the Philippine Area of Responsibility (PAR), East of Mindanao in the afternoon of February 3. It continued moving in a West-Northwest direction closer to Eastern Mindanao. In the night of February 5, while about 470km east-northeast of Hinatuan, Surigao del Sur, it changed direction from north-northwest to north-northeast. It hovered in that part of the Pacific Ocean and weakened into a Low Pressure Area (LPA) in the afternoon of February 6.

A day before TC Bising developed into a LPA in the eastern part of Mindanao, moderate to heavy rains were observed in the eastern part of northern Luzon particularly in the Cagayan river basin (CRB). The said river basin is quite far from the location of Bising hence these were not directly related. Nonetheless, floodings were reported in the CRB rendering some roads and bridges impassable.

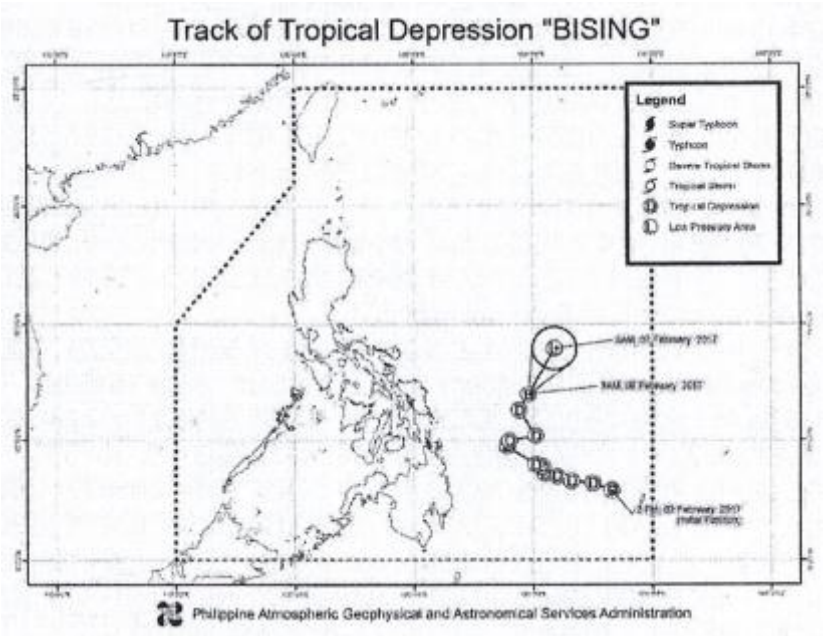


Figure 3: Track of TC Bising

b. Typhoon NESAT

"Nesat" (Gorio) developed into a Tropical Depression in the afternoon of July 25th east of Bicol. It moved North-Northwest slowly and gained strength while over the Philippine Sea. **"Nesat"** continued to intensify reaching typhoon intensity as it maintained a poleward direction leaving the Northwestern border of the PAR in the early morning of July 30. **TY "Nesat"** enhanced the Southwest Monsoon that brought moderate to occasionally heavy rains and thunderstorms over the Western section of Luzon and Visayas.

c. **TS PAKHAR**

"Pakhar" (Jolina) developed into a Tropical Depression (TD) inside the PAR, 540 kms East of Casiguran, Aurora in the afternoon of Aug 24. It gained strength as it continued moving closer to Northern Luzon area. Pakhar made landfall in Casiguran, Aurora then traversed the rugged terrain of Northern Luzon out into the West Philippine Sea. It exited in the Western border of the PAR in the evening of Aug 26. It also enhanced the Southwest Monsoon that brought moderate to heavy rains and thunderstorms in Luzon and some parts in Visayas.

d. TS GUCHOL

"Guchol"(Kiko) has developed into a Tropical Depression (TD) inside the PAR, East Northeast of Baler in the afternoon of Sep 4. It maintained its strength as it continued moving closer to Extreme Northern Luzon. Guchol moved West Northwest to West then traversed the Balintang Channel out into the West Philippine Sea. It attained storm intensity as it left the Northwestern border of the PAR in the evening of Sep 6. Guchol did not enhance the Southwest Monsoon and moderate to heavy rainfall was only concentrated on the areas directly affected.

e. Typhoon TALIM

Typhoon Talim (Lannie) entered the eastern border of the PAR in the afternoon of September 11. It threatened the extreme northern part of Luzon because of its strong gustiness of 145pkh and moderate to heavy rains. It further intensified in the next two days while in the eastern side of Ryukyu Island before exiting the PAR in the afternoon of September 13.

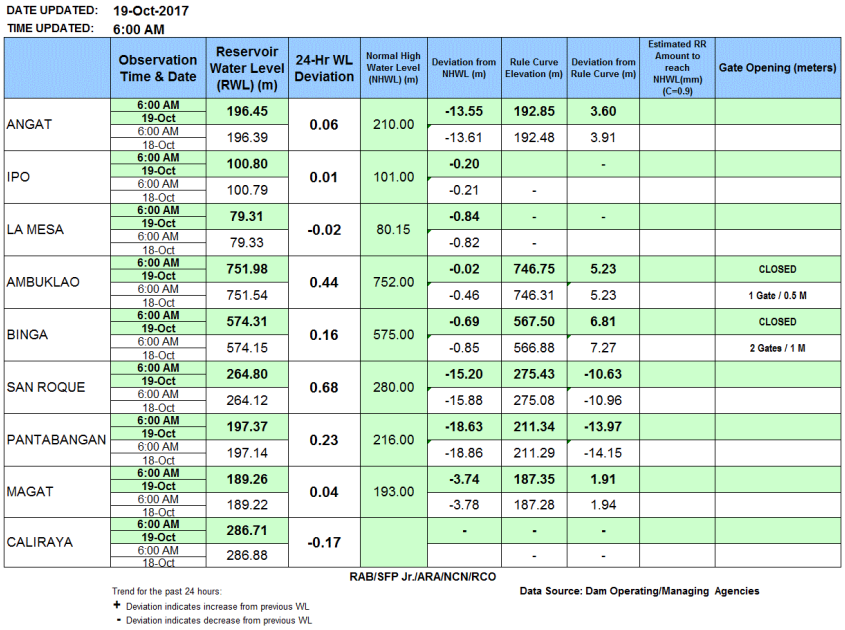
f. **Typhoon MARING**

When Typhoon Lannie entered the PAR on September 11, an LPA east of Southern Luzon developed into a Tropical Depression and was named Maring. Maring later brought moderate to heavy rains over the regions of Bicol, Mimaropa, Calabarzon, Metro Manila and Central Luzon. In the evening of September 12, it made landfall over Mauban, Quezon. With its moderate to heavy rains, numerous floods and landslides were reported in the provinces of Quezon, Rizal, Laguna, Cavite, Bulacan and Metro Manila. At about noontime, it was over Rizal-Metro Manila area moving west-northwest at 15 kph. It exited the land mass of Luzon during late night on the same day via Zambales going towards West Philippine Sea (WPS).

Maring intensified while over the WPS moving slightly faster at 18 kph and by late afternoon of September 13, it was already outside the PAR.

2. FFWS Dam Monitoring Activities

PAGASA monitors the major dams round the clock, be it high or low flow conditions. At present, nine (9) of the major dams in Luzon Island are telemetered. During normal condition, PAGASA uploads the status of the dams in its official website after gathering the 6:00 AM water level. Figure 7 shows a sample of uploaded images.



DATE UPDATED: 19-Oct-2017
TIME UPDATED: 6:00 AM

	Observation Time & Date	Reservoir Water Level (RWL) (m)	24-Hr WL Deviation	Normal High Water Level (NHWL) (m)	Deviation from NHWL (m)	Rule Curve Elevation (m)	Deviation from Rule Curve (m)	Estimated RR Amount to reach NHWL(mm) (C=0.9)	Gate Opening (meters)
ANGAT	6:00 AM 19-Oct	196.45	0.06	210.00	-13.55	192.85	3.60		
	6:00 AM 18-Oct	196.39			-13.61	192.48	3.91		
IPO	6:00 AM 19-Oct	100.80	0.01	101.00	-0.20		-		
	6:00 AM 18-Oct	100.79			-0.21	-			
LA MESA	6:00 AM 19-Oct	79.31	-0.02	80.15	-0.84	-	-		
	6:00 AM 18-Oct	79.33			-0.82	-			
AMBUKLAO	6:00 AM 19-Oct	751.98	0.44	752.00	-0.02	746.75	5.23		CLOSED
	6:00 AM 18-Oct	751.54			-0.46	746.31	5.23		1 Gate / 0.5 M
BINGA	6:00 AM 19-Oct	574.31	0.16	575.00	-0.69	567.50	6.81		CLOSED
	6:00 AM 18-Oct	574.15			-0.85	566.88	7.27		2 Gates / 1 M
SAN ROQUE	6:00 AM 19-Oct	264.80	0.68	280.00	-15.20	275.43	-10.63		
	6:00 AM 18-Oct	264.12			-15.88	275.08	-10.96		
PANTABANGAN	6:00 AM 19-Oct	197.37	0.23	216.00	-18.63	211.34	-13.97		
	6:00 AM 18-Oct	197.14			-18.86	211.29	-14.15		
MAGAT	6:00 AM 19-Oct	189.26	0.04	193.00	-3.74	187.35	1.91		
	6:00 AM 18-Oct	189.22			-3.78	187.28	1.94		
CALIRAYA	6:00 AM 19-Oct	286.71	-0.17		-	-	-		
	6:00 AM 18-Oct	286.88				-	-		

RAB/SFP Jr./ARA/NCN/RCO

Trend for the past 24 hours:
+ Deviation indicates increase from previous WL
- Deviation indicates decrease from previous WL

Data Source: Dam Operating/Managing Agencies

Figure 9. Sample image indicating Status of Major Dams

Table below shows the current year's summary of instances of dam operations wherein actual dam gate openings were conducted. This is part of the Flood Forecasting and Warning System for Dam Operation (FFWSDO), a major activity of PAGASA, in collaboration with agencies related to disaster and risk management.

Table 3. Instances of Flood Forecasting and Warning System for Dam Operations

	NAME OF DAM	DAM OPERATIONS CONDUCTED			
1	ANGAT	-	-	-	-
2	AMBUKLAO	Jul 28- Aug 7	Aug 25 - Aug 28	Aug 30 - Sep 7	Oct 17 - Oct 18
3	BINGA		Aug 25 - Aug 29	Aug 30 - Sep 10	Oct 14 - Oct 18
4	SAN ROQUE	-	-	-	-
5	PANTABANGAN	-	-	-	-
6	MAGAT	Dec 29 2016 - Jan 04 2017	Feb 2 - Feb 6	May 28 - Jun 2	Aug 25 - Aug 28

Following are pertinent information of the dams monitored by PAGASA. These dams, which are mostly multi-purpose, are either owned by the National Power Corporation (NPC), National Irrigation Administration (NIA) or Metropolitan Waterworks and Sewerage System (MWSS), corporations or agencies that are government-owned except for NPC which is partly privatized.

a. Angat Dam

Angat Dam is a located in Norzagaray, Bulacan. Its main purpose is to provide water for domestic use (90% Metro Manila), power generation and irrigation. During the El Nino Episode of 2015, the reservoir water level dropped below its operation critical level of 180m starting on the latter part of May up to August of the same year. In 2017, the dam water level was generally normal with no dam spill due to flood control (as of October), as shown in the Figure below.

Note: 2017 water level trend is shown thick black line.

Figure 10 Reservoir Water Level Trend of Angat Dam 2005-2017

b. Pantabangan Dam

Pantabangan Dam, located in Pantabangan, Nueva Ecija is one of the largest dams in Southeast Asia. It is a multi-purpose dam which major function is to supply water for irrigation and for power generation. Records show that its water level did not reach the critical point. Also, during the 2015 El Nino, water level was below the rule curve throughout the year and it was at its lowest for the past four years during El Nino. It was almost the same trend in 2014 but occurred earlier in May. Years 2016 and 2017, almost have the same trend which is still way below the rule curve and normal high water level.

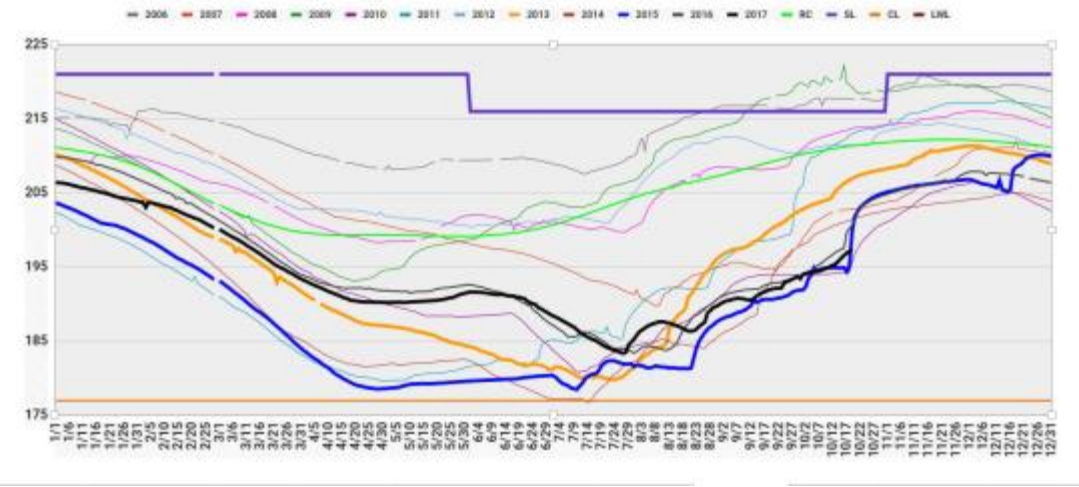


Figure 11. Reservoir Water Level Trend of Pantabangan Dam 2006-2017

c. Magat Dam

Magat Dam is a large rock-fill dam located in Ramon, Isabela. It is situated along Magat River, a major tributary of the Cagayan River (the largest river in the country). It is a multi-purpose dam which is used primarily to irrigate 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 events, the priority purpose of the dam was focused on irrigation.

In 2017, Magat dam conducted four (4) spilling operations, the first being a carry-over of the previous year (09 December, 2016 – 04 January 2017). These water releases were all properly coordinated with and minimal losses were incurred with no casualties.

Figure 12 Reservoir Water Level Trend of Magat Dam 2006-2017

d. Ambuklao-Binga-San Roque Dams

These 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 caught by Binga Dam while the water freed by Binga passes to San Roque Dam.

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 previous years, there is a descending trend from January to July and recovers during wet season towards the later part of the year.

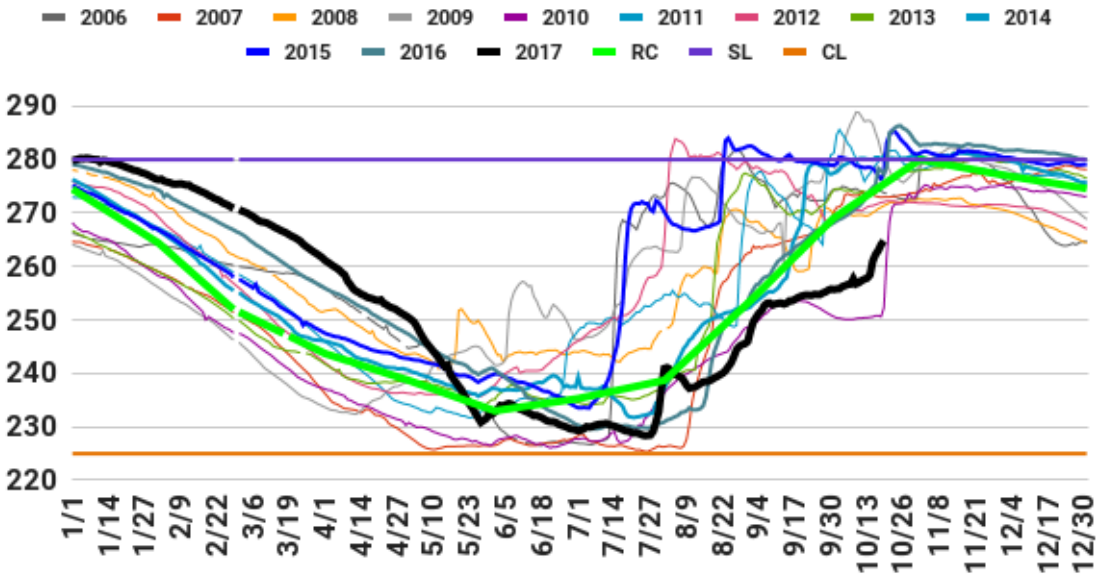


Figure 13: Reservoir Water Level Trend of San Roque Dam 2006-2017

C. PROGRESS IN KEY AREAS (Project Status)

1. Establishment of Flood Forecasting and Warning Systems for Major River Basins

One of the priority projects of the Philippine government is the establishment of a Flood Forecasting and Warning System (FFWSs) in Major River Basins in the Philippines. This 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) have their own monitoring center for forecasting flood. As mentioned in the previous section, they are all found in Luzon namely Pampanga, Agno, Bicol, Cagayan and Pasig-Marikina River Basins. All of them are being monitored by PAGASA aside from the monitoring systems found in their vicinity.

At present, there are 13 other river basins wherein construction of the river centers and installation of hydrological monitoring facilities are in different phases of implementation. They are either on-going construction, bidding phase, site survey and so on. The table below shows the status of the said project.

Table 4: Status of the Implementation of the Flood Forecasting and Warning Centers (FFWCs) and Hydrological Monitoring Network Facilities (HMFs) Projects

River Basin	FFWCs	HMFs
Abra (Luzon)	Completed	On-going installation
Abulog (Luzon)	Completed	-
Agusan (Mindanao)	Completed	Bidding Phase
Agus (Mindanao)	Contract Awarded	-
Buayan- Malungon (Mindanao)	Completed	Contract Awarded
Cagayan de Oro (Mindanao)	Bidding Phase	Completed
Davao (Mindanao)	Completed	Contract Awarded
Ilog-Hilabangan (Visayas)	Completed	On-going installation
Jalaur (Visayas)	Completed (Co-Located with Iloilo RADAR)	Testing Phase
Panay (Visayas)	10.00% (on-going)	Testing Phase
Mindanao (Mindanao)	Contract Awarded	Bidding Phase
Tagum-Libuganon (Mindanao)	Completed	Completed
Tagoloan (Mindanao)	Bidding Phase	Contract Awarded

2. Deployment of Early Warning System in Disaster Prone Areas

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 posts to some regions were already done and Information, Education and Communication (IEC) campaigns were already conducted in target provinces and cities namely, Samar, Leyte, Bataan, Cagayan, Kalinga, Agusan del Sur, Sarangani and Davao City. Below (Figure 17) is the Beta version of website developed by ASTI for the said project.

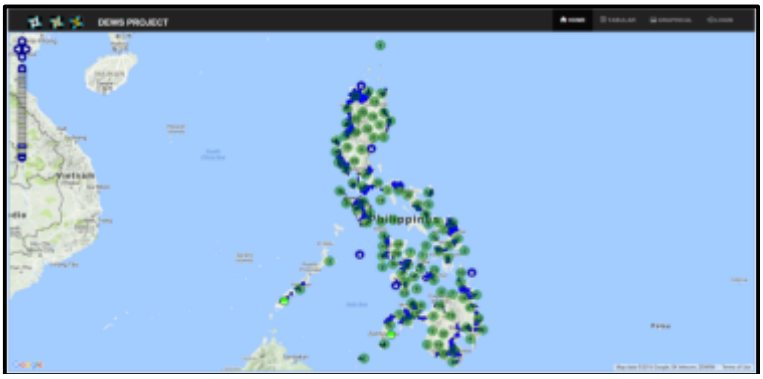


Figure 14: Beta version of website developed by ASTI for the DEWS Project

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

The Flash Flood 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.

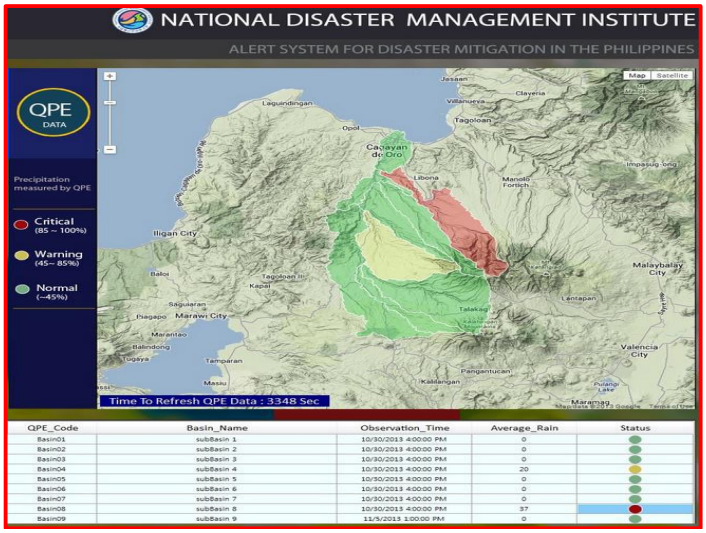


Figure 15: Graphical User Interface of NDMI Project

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 community were installed. 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.

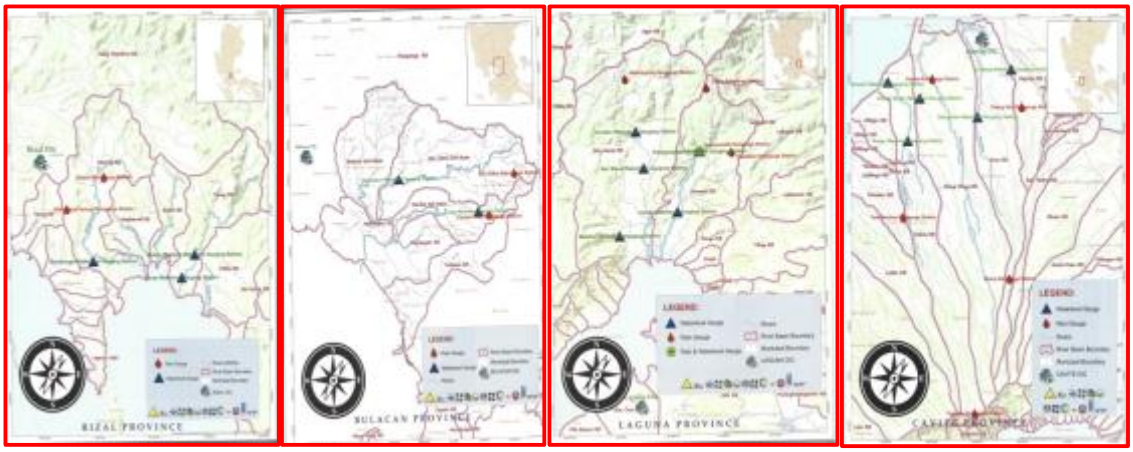


Figure 16. CBFEWS Hydrological network established in Rizal, Bulacan, Laguna and Cavite

5. 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 17. NPGA Target Hydrological network in Davao, Buayan Malungon and Tagoloan River Basins

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

RIMES (with headquarters based in Bangkok, Thailand) in partnership with the Government of India implemented the project Development and Implementation of User-Relevant End-to-End Hydrological Forecast Generation and Application System for Disaster Mitigation in the Philippines. Jalaur River Basin, one of the 18 major river of the country was the target area of the said project. PAGASA as project partner ensured the smooth implementation of the project and responsible for the identification of sites for the monitoring equipment.

In August this year, RIMES representative were in the country for the final activities of the project.