COUNTRY ASSESSMENT REPORT FOR THE PHILIPPINES

Strengthening of Hydrometeorological Services in Southeast Asia

ISDR THE WORLD BANK WMO PAGASA GFDRR Global Facility for Disaster Reduction and Recovery

ACKNOWLEDGMENTS

This Country Assessment Report for the Philippines is part of a study that aimed to strengthen the hydro-meteorological services in Southeast Asia. The production was a collaborative effort of the World Bank, the United Nations Office for Disaster Risk Reduction (UNISDR), the National Hydrological and Meteorological Services (NHMS) and the World Meteorological Organization (WMO) with financial support from the Global Facility for Disaster Reduction and Recovery (GFDRR).

The study investigated the capacity of the NHMS of five ASEAN Member States, namely Lao PDR, Cambodia, Indonesia, the Philippines and Viet Nam - to respond to the increasing demands for improved meteorological and hydrological information by various socio-economic sectors. Taking a regional approach, it recommended investment plans to improve the NHMS with the ultimate goal for reducing losses due to natural hazard-induced disasters, sustainable economic growth and abilities of the countries to respond to climate change.

The Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) supported the country assessment and coordinated the participation of various departments, including the National Irrigation Administration, National Grid Corporation of the Philippines (NGCP), the Department of Agriculture, the Forest and Environment Management Bureaus, the National Water Resources Board and private sector, among others.

The Disaster Risk Reduction Division of the WMO provided technical inputs and facilitated peer review of the draft reports, which have resulted in significant quality improvements.

A national consultation was organized by PAGASA to review the final draft report. The PAGASA, National Grid Corporation of the Philippines and Japan International Cooperation Agency (JICA) provided comments for improving the report. WMO presented opportunities for regional cooperation at the national consultation.

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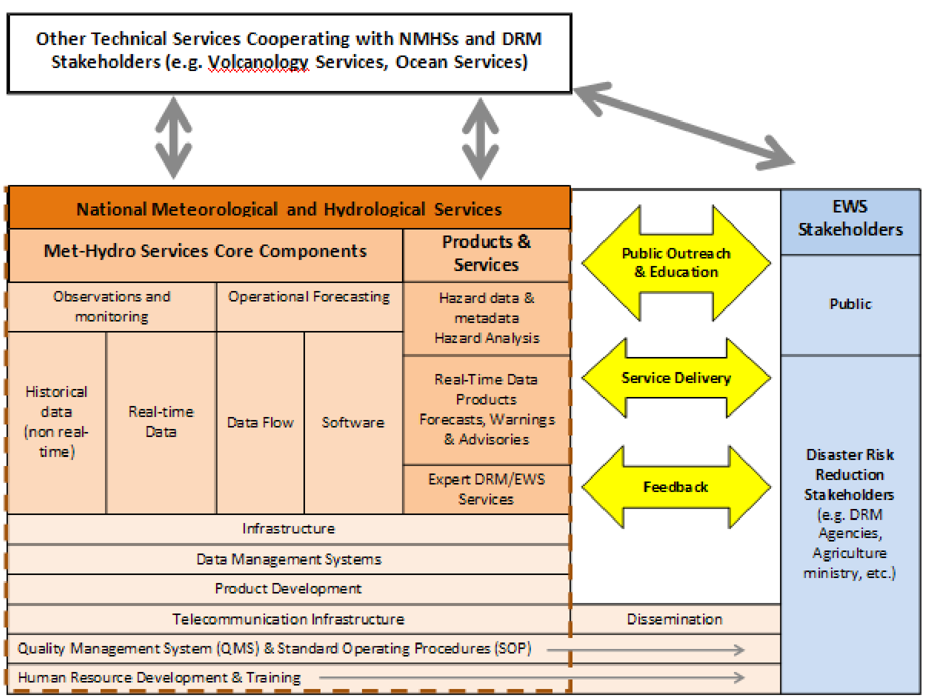
ACRONYMS

AADMER	ASEAN Agreement on Disaster Man agement and Emergency Response
ADB	Asian Development Bank
ADPC	Asian Disaster Preparedness Centre
ACIAR	Australian Center for International Agricultural Research
AFP	Armed Forces of the Philippines
APCC	APEC Climate Center
APCN	Asia Pacific Climate Network
ASEAN	Association of South East Asian Nations
AusAID	Australian Agency for International Development
BCA	Benefit-Cost Analysis
CBFEWS	Community based flood early warning system
CCA	Climate change adaptation
CCC	Climate Change Commission
CLIMPS	Climate Information, Monitoring and Prediction Section
COST	ASEAN Committee on Science and Technology
CSCAND	Collective Strengthening of Community Awareness to Natural Disasters
DEWMS	Drought Early Warning and Monitoring System
DOST	Department of Science and Technology
DRR	Disaster Risk Reduction
DRRM	Disaster risk reduction and management
DWD	"Deutscher Wetterdienst" (German national meteorological service)
ECMWF	European Center for Medium Range Weather Forecasting
EWS	Early Warning System
GDP	Gross Domestic Product
GFDRR	Global Facility for Disaster Reduction and Recovery
GTS	Global Telecommunication System
HFA	Hyogo Framework for Action 2005-2015
ICAO	International Civil Aviation Organization
ICTP	International Center for Theoretical Physics
IOC	International Oceanographic Commission
IPCC	Intergovernmental Panel on Climate Change
ITAP	Typhoon Action Plan
IWRM	Integrated Water Resources Management
JICA	Japan International Cooperation Agency
LGU	Local Government Unit
NCCAP	National Climate Change Action Plan
NDRRMC	National Disaster Risk Reduction and Management Council
NDRRMP	National Disaster Risk Reduction Management Plan
NGCP	National Grid Corporation of the Philippines
NMHS	National Meteorology and Hydrology Services
NOAH	National Operational Assessment of Hazards
NSCCC	National Steering Committee on Climate Change
NWP	Numerical Weather Prediction
OCD	Office of Civil Defense
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Services Administration
PDP	Philippine Development Plan 2011-2016
PDRF	Philippine Disaster Reconstruction Foundation
PHIVOLCS	Philippine Institute of Volcanology and Seismology
PCIC	Philippine Crop Insurance Corporation
RIMES	Regional Integrated Multi-Hazard Early Warning System for Africa and Asia
RWS	Rainfall Warning System
SNPRC	Special National Public Reconstruction Commission
UNFCCC	United Nations Framework Convention on Climate Change
UNDP	United Nations Development Programme
UNESCAP	United Nations Economic-Social Commission for Asia Pacific
UNESCO	United Nations Education, Science and Culture Organization
USAID	United States Agency for International Development
USTDA	U.S. Trade and Development Agency
WB	The World Bank
WIS	WMO Information System
WMO	World Meteorological Organization

The role of hydro-meteorological services

All human activities are affected by weather and climate.The various socio-economic sectors in the Philippines are beginning to appreciate the value of hydrometeorological services due to the serious impacts of recent weather and climate events on their activities and business operations. The frequent occurrence and increasing severity of extreme weather and climate events in the country are seen as indications of a changing climate. As climate change progresses with time, the impacts will exacerbate and will affect all sectors in unprecedented ways, particularly in areas where water is a limited resource. On the other hand, tropical cyclones can bring extreme rainfall resulting to catastrophic flooding. The attendant weather and climate extremes resulting to floods and droughts can considerably decrease agricultural productivity. Accelerated sea level rise due to global warming will expose more people to the risk of coastal flooding and also increase exposure to vector-borne infectious diseases that threaten human health. Moreover, tourism which is an important source of income in many countries will experience severe disruption due to sea level rise and frequent occurrence of extreme weather and climate events associated with climate change.

As the impacts of climate change continue to accelerate due to global anthropogenic climate change, the National Meteorological and Hydrological Services (NMHSs) will be faced with the increasing challenges and demands of providing more accurate, timely and useful forecasts, products and information. The core aspects of support that NMHSs provide to disaster risk reduction (DRR) agencies and early warning system (EWS) stakeholders are shown in Figure 1.



Source: Golnaraghi, mgolnaraghi@wmo.int

Figure 1. Schematic of linkages of Meteorological Services with EWS stakeholders

To achieve or address such demand, it is necessary and urgent to put in place or to enhance the very basic requirements for an NMHS to function effectively according to the capacity of NMHS, as follows:

1) adequate networks to monitor hydrometeorological parameters; 2) a robust communication system for data transmission,dissemination of forecasts and sharing of information; 3) high speed computing system for data assimilation and numerical weather prediction; 4) adequately trained human resource and 5) a more interactive approach with users of weather and climate information. The trans-boundary nature of weather-causing phenomena would require collaboration among NMHSs in the region. Hence, there is now an urgent need to enhance regional cooperation and data sharing which is currently being undertaken by the World Meteorological Organization (WMO) through its WMO Information System (WIS).

Assessment of hydrometeorological services in the Philippines

The recent occurrences of floods associated with tropical cyclones, flash floods and the droughts caused by the El Niño phenomenon have greatly improved the visibility of the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), the Philippine NMHS. It is also one of the main goals of the agency to educate the media and conduct more frequent press briefings during the occurrence of tropical cyclones in the Philippines.

Although the last few decades were marked by widespread disasters in the Philippines that are mostly caused by hydrometeorological hazards, the much needed support for upgrading the services of PAGASA came piecemeal. It was only in 2004 after the occurrence of a series of tropical cyclones resulting to massive floods and landslides that awareness in the highest level of government was heightened; this triggered a paradigm shift in disaster management from relief and response to preparedness and mitigation in the Philippines. It also brought to the forefront the value of a robust early warning system in support of Disaster Risk Reduction (DRR), thus paving the way to provide for the modernization of the hydrometeorological observing facilities of PAGASA. To further strengthen the country's preparedness against meteorological and climate related hazards, the agency made a commitment in line with the "Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities Against Disasters" (HFA), with the expected outcome of "the substantial reduction of disaster losses, in lives as well as the social, economic and environmental assets of communities and countries."

Currently, the need for accurate and more frequent updates on severe weather bulletins for tropical cyclones is being addressed by PAGASA through its automation program. In addition, short-term rainfall forecast for flash flood prone areas is also sought by emergency managers for timely evacuation of threatened communities. This will be addressed upon the completion of the radar program being implemented by PAGASA. This will also benefit the other socio-economic sectors such as aviation, land transport, construction, and industry. Moreover, the provision of tailor made forecast for individual sectors has already started in the agricultural sector with the provision of farm weather forecasts, climate outlooks, and related services.

There were two important developments that unfolded from the series of disasters in the Philippines over the past decade. First, there is a realization in all sectors of the importance of meteorological and hydrological services; and second, the need to share data and other information to other NMHSs in the region. A positive outcome of the 2004 events in the municipalities of Real, Infanta and Nakar, Quezon province (referred to as REINA) was the establishment of a mechanism for public-private partnership in the reconstruction of devastated communities with the issuance of an executive order by the Office of the President.

With the upgrading of some PAGASA's facilities, the needs of the different sectors for more accurate, timely and effective forecasts can be partly addressed and will redound to increasing the value of the agency's forecast products. The PAGASA is also making efforts to commercialize some of its specialized products to private companies and other organizations in the private sector, such as aviation, shipping, and others.

National setup for production of hydrometeorological services in the Philippines

The PAGASA is the duly mandated agency to provide weather, climate, agro-meteorological, and hydrological services in the Philippines for public safety and in support of economic development. It also disseminates official time service as well as provides basic astronomical services in the country.

PAGASA operates and maintains about 98% of all hydrometeorological observation networks in the country. These are used for hydrometeorological monitoring, forecasting, and warning. The rest are operated by other government agencies and private organizations. It also has the longest historical record of hydrometeorological observations in the country. However, there are many years of data that were recorded during the pre-war era that need to be rescued and these can be used in climate related assessments and studies. In addition, it is also beneficial if hydrometeorological data from other government agencies and private organizations can also be accessed.

The operation centres for weather, climate, and hydrology are within the PAGASA Headquarters premises while the aviation meteorological service offices are located in major airports in the country.

All official forecasts, warnings, advisories, outlooks, and press releases on severe weather and extreme events such as tropical cyclones, floods, droughts/ dry spell, and El Niño/La Niña are issued by the headquarters.

As the NMHS provider in the Philippines, PAGASA has a major role in DRR efforts in the country, contributing to efficient conduct of activities and optimal production in various socio-economic sectors. Capacity development of PAGASA will benefit the country especially in the context of emerging needs of vital socio-economic sectors due to climate change and environmental stress. PAGASA's updated strategic plan addresses its capacity development needs in line with the WMO Regional Association V (RA V) Strategic Plan 2012-2015 which involves production of accurate, timely and reliable forecasts and warnings; improvement of delivery of weather, climate, water and related information and services; provision of scientific and technical support to decision makers such as climate change projection, and others. The agency also has adopted the PAGASA Onwards 2020 (Long-term Plan) and the R&D – Operations and Services Framework. The Investment Portfolio is regularly updated. All proposed programs are in consonance with the National Science and Technology Plan (NSTP).

State of affairs of the PAGASA

The PAGASA considers its workforce as its most important resource. The agency has a pool of technical and administrative support personnel. It is also hiring young and qualified new graduates to enhance its ageing work force and implements a regular training program to address the continuous migration of experienced forecasters to private companies abroad which provide much higher salaries and benefits. As of December 2011, the PAGASA has a total of 873 staff, with 193 in the administrative support group, 82 engaged in research and development (R&D), 584 involved in operations and services, and 11 engaged in the education and training program. There are 11 holders of PhD, 50 of MSc, four (4) of Diploma in Meteorology, one (1) of Diploma in Space Science and 16 have taken up some postgraduate units.

The Rationalization Program of PAGASA was approved in October 2008 and is currently being implemented to bring PAGASA's services to the countryside through the establishment of five (5) Regional Service Divisions.

Its budget allocation from the government has increased several times over the last few years for the upgrading of its facilities and equipment in order to meet the growing needs of the different sectors for accurate and reliable forecasting and early warning services. Currently, the PAGASA is implementing a modernization program which includes the establishment of 14 Doppler radars, more than 150 automatic weather stations (AWS), 100 automatic rain gauges (ARG), two (2) Aviation Weather Observing Systems (AWOS), two (2) marine meteorological buoys, one (1) wind profiler, six (6) upper air stations, and forecast automation.

The salient features of PAGASA's modernization are :

- Development of a three (3)-year modernization plan;
- Acquisition of additional needed state-of-the-art equipment and instruments, machines, computers and other facilities to improve capabilities in providing timely and reliable forecasting warning services, and information for agriculture, transportation and other industries across the country;
- Manpower training and human resources development;
- Strengthening of Regional Weather Services Centers at strategic areas in the country;
- Cultivation of greater awareness by the public of the weather system through educational projects and programs.

PAGASA personnel who are engaged in operational activities render uninterrupted services on 24/7/365 basis. The Weather and Flood Forecasting Center (WFFC) and the PAGASA Central Office which are both located in Quezon City were established in 1990 and 2002, respectively and provide suitable workplace for the PAGASA staff to carry out their mandated tasks. The WFFC also serves as the venue for press conferences during the occurrence of tropical cyclones in the country. A second building at the Central Office is also proposed for the Tropical Cyclone Research Center of PAGASA. Field stations are likewise proposed to be upgraded.

The PAGASA actively participates in a number of international and regional collaborative undertakings which benefits its technical personnel in terms of knowledge sharing and capacity building. The PAGASA is a designated WMO Regional Training Center for South Pacific and is also a member of the Typhoon Committee. It has undertaken collaborative activities and projects with various UN organizations such as WMO, International Civic Aviation Organization (ICAO), UNESCO, UNDP, and UNESCAP. It has also established linkages with UNEP, Intergovernmental Panel on Climate Change (IPCC), Asia Pacific Climate Network (APCN), International Center for Theoretical Physics (ICTP), International Oceanographic Commission (IOC), ASEAN Committee on Science and Technology (COST), APEC Climate Center (APCC), and the Regional Integrated Multi-Hazard Early Warning System (RIMES), among others. The Agency has also signed Memorandum of Understanding (MOU) for sharing of data and information and the conduct of collaborative research and training of technical personnel with the Korea Meteorological Administration (KMA), Department of Hydrology, Meteorology and Climate Change (DHMCC) of Vietnam, and the Department of Meteorology and Hydrology of Mongolia. PAGASA also has an on-going collaboration with the Japan Agency for Marine Science and Technology (JAMSTEC) and with "Deutscher Wetterdienst" (DWD), Germany's national meteorological service. It has also made linkages in a number of universities abroad for the post graduate studies of its personnel.

The production and dissemination of hydrometeorological forecasting and warning services is generally fair since most of the observations are still done manually and data integration and processing still need to be undertaken. On-line hydrometeorological observations are mostly in Luzon Island and very limited in the Visayas and Mindanao. The quality of information is also fair due to limited automatic editing and production system. The PAGASA still does not issue quantitative short-term forecasts or nowcasts[1] due to lack of appropriate equipment and inadequate skill of its technical personnel in this field.

With these gaps in consideration, the PAGASA's vision is to achieve the following:

- Play a leading role in hydrometeorological early warning system;
- Provide public access to quality meteorological, climatological, hydrological, and astronomical products;
- Play a strong advocacy role on climate change and the need for adaptation strategies
- Attain excellence in tropical cyclone forecasting in the ASEAN region
- Be a strong and dynamic organization with inspired and dedicated workforce
- Have well-managed resources.

The realization of PAGASA's vision is supported by the national government, the private sector, and various foreign donors who have provided grants to upgrade the facilities of PAGASA. Among the foreign organizations that have provided funding support to PAGASA are the Japan International Cooperation Agency (JICA), Korea International Cooperation Agency (KOICA), Taiwan Economic Cooperation Office (TECO), the Australian Agency for International Development (AusAID), United Nations Development Programme (UNDP), Spanish Government, World Bank, United States Trade and Development Agency (USTDA), Norwegian Agency for Development Cooperation (Norad), Asian Disaster Preparedness Center (ADPC), Australian Center for International Agricultural Research (ACIAR), GeoScience Australia (GA), Australian Bureau of Meteorology (BoM), and the United States Agency for International Development (USAID).

In addition, there is a need to source out funding for the implementation of the outcome of the feasibility study on the improvement of hydrometeorological telecommunication system funded by the U.S. Trade and Development Agency (USTDA).

Project proposal to strengthen the PAGASA

It is fully recognized that for DRR to be successful, there is a need for close coordination among the different government agencies and private organizations involved, as well as the active participation of the public, apart from improved capabilities of NMHSs in the provision of forecast of warning services. Production of accurate and reliable forecasts and warnings and related information would need an integrated system as shown below. Each part will require a certain level of investment and human expertise in order to achieve the desired outcome.

[1]Nowcasting is comprised of a detailed description of the current weather along with forecasts obtained by extrapolation for a period of 0 to 6 hours ahead. Nowcasting is a power tool in warning the public of hazardous, high-impact weather including tropical cyclones, thunderstorms and tornados. The public is warned of the possibility of flash floods, lightning strikes and destructive winds.

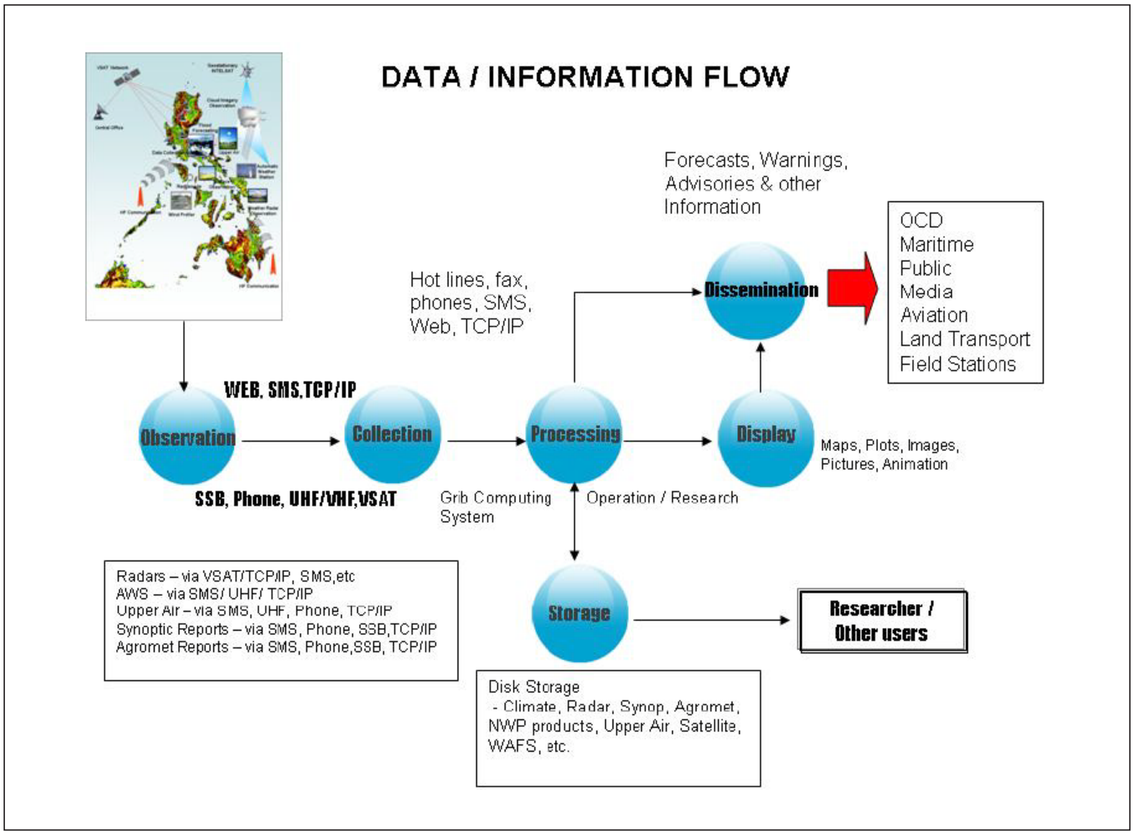


Figure 3. PAGASA data/information flow diagram (Source: Engineering Technical Services Division, PAGASA).

Under this setup, it is important that the forecaster's workstation should include visualization and editing tools and should have easy access to all data and products for use as guidance in the formulation of forecasts and warnings. With the planned forecast automation, more forecast products can be generated to suit the specific needs of the various end users.

Investment plan

The proposed project to improve PAGASA's services for the benefit of the various socio-economic sectors in the country (such as disaster risk reduction and management, agriculture, water resources, energy, health, transportation, tourism, etc.) takes into consideration the agency's on-going modernization program funded by the national government, including grants from foreign donors in the past five years. The proposal has also considered the various needs of disaster risk management and other major sectors. In addition, the higher cost-benefit ratio of sharing weather and climate data and information in the region warrants the improvement of observing networks and forecasting systems from a regional perspective. The large increase in operational cost of PAGASA as a result of its modernization will be reflected in the investment plan as a consequential cost to be funded by the national government in order to ensure sustainability of the entire system. In columns A and B in the table below, the distribution of costs of the five-year project for strengthening PAGASA is shown considering a stand-alone system and with regional cooperation system, respectively.

Item	Cost (US$)	
	A – Stand-alone	B – Regional cooperation
International cooperation of experts	100,000	30,000
Telecommunication system		
- Hardware + software	14,800,000	14,800,000
- Annual operation		
Data management		
- Hardware including storage and installation	300,000	300,000
- Consultation and training	50,000	50,000
- Annual maintenance		
Meteorological observation network		
- Automatic rainfall stations	1,005,000	1,005,000
- Communication costs		
Hydrological observation network		
- Telemetered hydrological stations	6,160,000	6,160,000
Maritime observation network		
- Marine buoys	1,200,000	1,200,000
- Data communication + maintenance		
Remote sensing network		
- Lightning detection	100,000	100,000
Forecasting and production tools		
- Visualization system	300,000	300,000
- Training	100,000	100,000
Training	300,000	200,000
Research and development	310,000	310,000
- Impacts of climate change		
- Socio economic impacts		
- National seminar on socio-economic benefits		
- End-user seminar		
Project management		
- Consultant	250,000	125,000
- Local project coordinator	100,000	50,000
Total	25,075,000	24,730,000

The modernization of PAGASA covers the on-going projects on flood forecasting, radar, wind profiler, marine buoy, AWOS, AWS, High speed PC cluster computing system, the acquisition of other necessary equipment, upgrading of telecommunication system, and specialized training of personnel in hydro-meteorology and related fields. The last is considered a critical component of the modernization programme. It also involves strengthening of cooperation among NMHSs in Southeast Asia for data sharing, exchange of related information, and research collaboration.

Socio-economic value of weather forecasts and other hydrometeorological services in the Philippines

Vital to the continuous and effective operation of an NMHS for the provision of forecasts and warnings and other relevant services to the various socio-economic sectors in the country is sustained funding support from the national government, foreign donors, and the private sector.

After the great flood in Metro Manila resulting from Tropical Storm Ketsana on 26 September 2009, the government created the Special National Public Reconstruction Commission (SNPRC) as government's counterpart to the newly established Philippine Disaster Reconstruction Foundation (PDRF), a private sector led reconstruction entity. The SNPRC and PDRF spearheaded the signing of a Memorandum of Agreement (MOA) between the PAGASA and the three major private telecommunication companies (TelCos) in the Philippines (SMART, GLOBE and SUNCELLULAR) for the co-location of the observation equipment of PAGASA in the cellular transmission sites of the TelCos.

SNPRC and PDRF have ceased to exist however cooperation between PAGASA and private telecommunication companies continues. This significant partnership is a major breakthrough since the inititive addresses a major need of PAGASA, i.e. acquiring secure monitoring and observation sites.

For a 20% reduction in damages, the total discounted socio-economic benefits of PAGASA improvements from 2010 to 2029 are calculated to be US$173.70 million.

The total cost of PAGASA improvements for a stand-alone system is US$32.70 million over a five-year period. A system based on regional cooperation costs is less at US$27.14 million. The small diffeence is because the equipment to be installed in the Philippines cannot cover the other countries in the region due to its distance. However, the observed data from the Philippines will be shared to other NMHSs which will provide critical information on tropical cyclones in the western North Pacific and South China Sea that threatens to affect the other countries. The cost benefit (C/B) ratios are as follows:

Option	Total Costs (Million US$)	Discounted Benefits (Million US$)	Cost/benefit Ratio (C/B)
Stand alone	32.70	173.70	1:6.3
With regional cooperation	27.14	173.70	1:6.4

In summary, the following are the main findings of the computations:

- The discounted values of the benefits due to the improvements in the NMHS of the Philippines, based only on the decrease in damages due to the improvements, are immense and more than enough to pay for the cost of improvements;
- The C/B ratios based on the costs of NMHS improvements and the discounted values of the benefits from the improvements are inferior to the 1:7 ratio set by the WMO;
- The C/B ratio for the system with regional integration being better than that for the stand alone system implies that the regional integration system is more desirable; and
- The C/B ratios would improve further if the indirect benefits of the NMHS improvements and the benefits beyond 2029 are included in the computation of benefits.

Environmental impacts of enhancement of the observation network

Only the relay towers (with 30 meter typical height) for the communication link of telemetered flood forecasting and warning system may cause obstruction and would require permits especially from the local aviation authority prior to its construction. Other than that, the tower poses no adverse impact to the environment.

Financing of the proposed project

The PAGASA is currently implementing a number of projects to improve its observation network with funding from the national government and foreign donors as part of its modernization program.

The proposed project which complements the PAGASA modernization plan will seek the support of foreign donors. In the implementation of foreign assisted projects, the national government provides counterpart funds and technical personnel to assist in project implementation. The Philippine' government has funded the establishment of nine (9) new Doppler radars and other observing equipment that are expected to be operational in 2016. The government is also expected to allocate funds as consequential expenses for the operation and maintenance of new equipment to be procured under this project in support of regional cooperation in Southeast Asia.

THE PHILIPPINES IN A NUTSHELL

1

1.1 General description

The Philippines is an archipelagic Southeast Asian country located on the Pacific Rim. It was a Spanish colony from the first half of the 16th century. Revolutionists declared a republic in 1898 but it was immediately thwarted by Americans as a result of the Treaty of Paris which ended the Spanish-American War. In 1935, the Philippines became a self-governing commonwealth. The islands fell under Japanese occupation during World War II. American and Filipino forces fought together during the war years to regain control. Following the end of the war, the Republic of the Philippines attained its independence on 4 July 1946.

http://www.learnnc.org/lp/media/uploads/2008/08/philippines_rel93.jpg

Figure 1.1 Location map of the Philippines

The Philippines was under a dictatorship during the rule of Ferdinand Marcos which ended in 1986 when the "people power" movement forced him into exile and installed Corazon Aquino as president. Fidel Ramos was later elected president in 1992 followed by Joseph Estrada in 1998. In 2001 Estrada was driven out by another "people power" movement which installed Gloria Macapagal-Arroyo as president. Benigno Aquino III replaced Macapagal-Arroyo after her second term as President in 2010.

The Philippines is a republic with three separate and sovereign and yet interdependent branches: the executive headed by an elected President; the legislative, with laws promulgated by a two-tier Congress composed of elected senators and congressmen (or representatives) of political districts; and judicial, with the Supreme Court as the highest judicial body.

Geography and Land Use

- Location: Southeast Asia, archipelago between the Philippine Sea and the South China Sea, east of Viet Nam
- Total area: 300,000 km2; land area: 298,170 km2; water area: 1,830 km2
- Coastline: 36,289 km
- Maritime claims: territorial sea-irregular polygon extending up to 100 nm from coastline as de fined by 1898 treaty; since late 1970s has also claimed polygonal-shaped area in South China Sea up to 285 nm in breadth
- exclusive economic zone: 200 nm
- continental shelf: to depth of exploitation
- Land use: arable land: 19%; permanent crops: 16.67%; other: 64.33% (2005); Irrigated land: 15,500 km2 (2003)
- Total renewable water resources: 479 km3 (1999)
- Freshwater withdrawal (domestic/industral/agricultural): total: 28.52 km3/yr (17%/9%/74%); per capita: 343 m3/yr (2000)

Natural hazards :

- Along the typhoon belt, usually affected by 20 tropical cyclones every year with 9 making land fall with associated strong winds and heavy rains causing floods and landslides; it is also affected by earthquakes, tsunamis, volcanic eruption and its associated hazards.

Environment- current issues :

- Uncontrolled deforestation including in water shed areas; soil erosion; air and water pollution in especially in major urban centers; coral reef degradation; increasing pollution of coastal mangrove swamps that are important fish breeding grounds.

People

- Population: 97,976,603 (July 2009 est.)
- Life expectancy at birth, total population : 71.09 years
- Ethnic groups: Tagalog 28.1%, Cebuano 13.1%, Ilocano 9%, Bisaya/Binisaya 7.6%, Hiligaynon Ilonggo 7.5%, Bicol 6%, Waray 3.4%, other 25.3% (2000 census)
- Languages: Filipino (official; based on Tagalog) and English (official); eight major dialects - Tagalog, Cebuano, Ilocano, Hiligaynon or Ilonggo, Bicolano, Waray, Pampango, and Pangasinan
- Literacy: 93.4% (Note: defined as population of 15 years and over that can read and write. Source: UNDP, 2011)

Government

- Government type: Republic
- Capital: Manila
- Administrative divisions: 80 provinces and 120 chartered cities

Transnational issues

The Philippines claims sovereignty over Scarborough Reef (also claimed by China together with Taiwan) and over certain parts of the Spratly Islands, known locally as the Kalayaan (Freedom) Islands, also claimed by China, Malaysia, Taiwan, and Viet Nam; the 2002 "Declaration on the Conduct of Parties in the South China Sea," has eased tensions in the Spratly Islands but falls short of a legally binding "code of conduct" desired by several of the disputants. In March 2005, the national oil companies of China, the Philippines, and Viet Nam signed a joint accord to conduct marine seismic activities in the Spratly Islands; Philippines retains a dormant claim to Malaysia's Sabah State in northern Borneo based on the Sultanate of Sulu's granting the Philippines Government power of attorney to pursue a sovereignty claim on his behalf

1.2 Economic overview

The Philippines GDP grew barely by one percent in 2009 but the economy weathered the 2008-09 global recession better than its regional peers due to minimal exposure to securities issued by troubled global financial institutions; lower dependence on exports; relatively resilient domestic consumption, supported by large remittances from four-to five-million overseas Filipino workers; and a growing business process outsourcing industry. Economic growth in the Philippines has averaged 4.5 percent per year since 2001. Despite this growth, poverty worsened because of a high population growth rate and inequitable distribution of income. Macapagal-Arroyo averted a fiscal crisis by pushing for new revenue measures and, until recently, tightening expenditures to address the government's yawning budget deficit and to reduce high debt and debt service ratios. However, the government abandoned its 2008 balanced-budget goal in order to help the economy weather the global financial and economic storm.

The key economic indicators of the Philippines for the period 2000-2008 are presented below. It is noticeable among others and in particular that the GDP growth and GDP per capita growth performance of the country have significantly decreased in 2008 which was directly attributable to the prevailing global financial crisis that commenced in that year.

Gross Domestic Product

- GDP (purchasing power parity): US$324.9 billion (2009 est.)
- GDP (official exchange rate): US$160.6 billion (2009 est.)
- GDP - growth: 0.9% (2009 est.)
- GDP - per capita (PPP): US$3,300 (2009 est.)
- GDP - composition by sector
  # agriculture: 14.9%; industry: 29.9%; services: 55.2% (2009 est.)

Budget : revenues: US$23.29 billion; expenditures: US$29.23 billion (2009 est.)

Labor market

- Labor force: 37.89 million (2009 est.)
- Labor force - by occupation
  agriculture: 34%; industry: 15%; services: 51% (2009 est.)
- Unemployment rate: 7.5% (2009 est.)
- Population below poverty line: 32.9% (2006 est.)
- Agriculture - products: sugarcane, coconuts, rice, corn, bananas, cassavas, pineapples, mangoes; pork, eggs, beef; fish
- Industries: electronics assembly, garments, footwear, pharmaceuticals, chemicals, wood products, food processing, petroleum refining, fishing
- Industrial production growth rate: -2% (2009 est.)

Energy

- Electricity: production: 56.57 billion kWh (2007 est.); consumption: 48.96 billion kWh; (2007 est.); exports: 0 kWh (2008 est.); imports: 0 kWh (2008 est.)
- Oil: production: 25,120 bbl/day (2008); consumption: 313,000 bbl/day (2008 est.); exports: 36,720 bbl/day (2007 est.); imports: 342,200 bbl/day (2007 est.); proved reserves: 138.5 million bbl (1 January 2009 est.)
- Natural gas: production: 2.94 billion m3 (2008 est.); consumption: 2.94 billion m3; 2008 est.); exports: 0 m3 (2008 est.); imports: 0 m3 (2008 est.; proved reserves: 98.54 billion m3 (1 January 2009 est.)
- Pipelines: oil 107 km; refined products 112 km (2009)

Exports and imports

- Exports - commodities: semiconductors and electronic products, transport equipment, garments, copper products, petroleum products, coconut oil, fruits
- Exports – partners: US 17.6%, Japan 16.2%, Netherlands 9.8%, Hong Kong 8.6%, China 7.7%, Germany 6.5%, Singapore 6.2%, South Korea 4.8% (2009 est.)
- Imports – commodities: electronic products, mineral fuels, machinery and transport equipment, iron and steel, textile fabrics, grains, chemicals, plastic

- Imports – partners: Japan 12.5%, US 12%, China 8.8%, Singapore 8.7%, South Korea 7.9%, Taiwan 7.1%, Thailand 5.7% (2009 est.)
- Natural resources: timber, petroleum, nickel, cobalt, silver, gold, salt, copper

Reserve, Debt, Aid

- Reserves of foreign exchange and gold: US$44.2 billion (31 December 2009 est.)
- Debt - external: US$53.14 billion (30 September 2009 est.)

Communications

- Telephones - main lines in use: 3.905 million (2008)
- Telephones - mobile cellular: 68.102 million (2008)
- Radio broadcast stations: AM 383, FM 659, shortwave 4 (2008)
- Television broadcast stations: 297 (plus 873 CATV networks) (2008)
- Internet hosts: 283,607 (2009)

Transportation

- Airports - with paved runways
  - Total: 85
  - Over 3,047 m: 4
  - 2,438 to 3,047 m: 8
  - 1,524 to 2,437 m: 28
  - 914 to 1,523 m: 35
  - Under 914 m: 10 (2009)
- Airports - with unpaved runways
  - Total: 169
  - 1,524 to 2,437 m: 4
  - 914 to 1,523 m: 66
  - Under 914 m: 99 (2009)
- Heliports: 2 (2009)
- Roadways: 897 km
  - Paved: 21,677 km; unpaved: 180,233 km (2008)
- Waterways: 3,219 km (limited to vessels with draft less than 1.5 m) (2008)
- Merchant marine: total – 391
  - By type: bulk carrier 75, cargo 125, carrier 16, chemical tanker 17, container 6, liquefied gas 5, passenger 6, passenger/cargo 68, petroleum tanker 36, refrigerated cargo 15, roll on/roll off 11, vehicle carrier 11
  - Foreign-owned: 161 (Bermuda 34, China 4, Greece 4, Hong Kong 1, Japan 81, Malaysia 1, Netherlands 23, Norway 10, Singapore 1, Taiwan 1, UAE 1)
  - Registered in other countries: 11 (Comoros 1, Cyprus 1, Hong Kong 1, Indonesia 1, Panama 7) (2008)

1.3 Climate

The climate of the Philippines is tropical monsoon dominated by a rainy season, dry season and a relatively cool season that dominates in December to February. The southwest (summer) monsoon brings heavy rains to most parts of the archipelago from May to September, whereas the northeast (winter) monsoon brings cooler and drier air from December to February with moderate to heavy rains in the eastern part of the country. Manila and most of the lowland areas are hot, sunny and dusty from March to April. However, temperatures rarely rise above 37°C (99°F) in Manila. The highest temperature recorded in the Philippines was 42.2 °C in Tuguegarao in Cagayan Valley on 29 April 1912 and on 11 May 1969. The absolute minimum temperature of 3.0 °C was recorded in January of 1903 in the mountain city of Baguio.

Annual average rainfall ranges from as much as 5,000 mm (200 in.) in the mountainous east coast section of the country to less than 1,000 mm (39 in.) in some of the sheltered valleys. Monsoon rains, although hard and drenching, are not normally associated with high winds and waves. But the Philippines sit astride the typhoon belt, and the country suffers an annual onslaught of dangerous tropical cyclones from July through December. An average of 19 to 20 tropical cyclones fall under the Philippine Area of Responsibility (PAR). Tropical cyclones are especially hazardous for northern and eastern Luzon and eastern Visayas, but highly urbanized Metro Manila gets devastated periodically as well. Based on the modified Coronas classification, the climate of the Philippines is divided into four (4) categories based on the rainfall distribution shown in Figure 1.2.

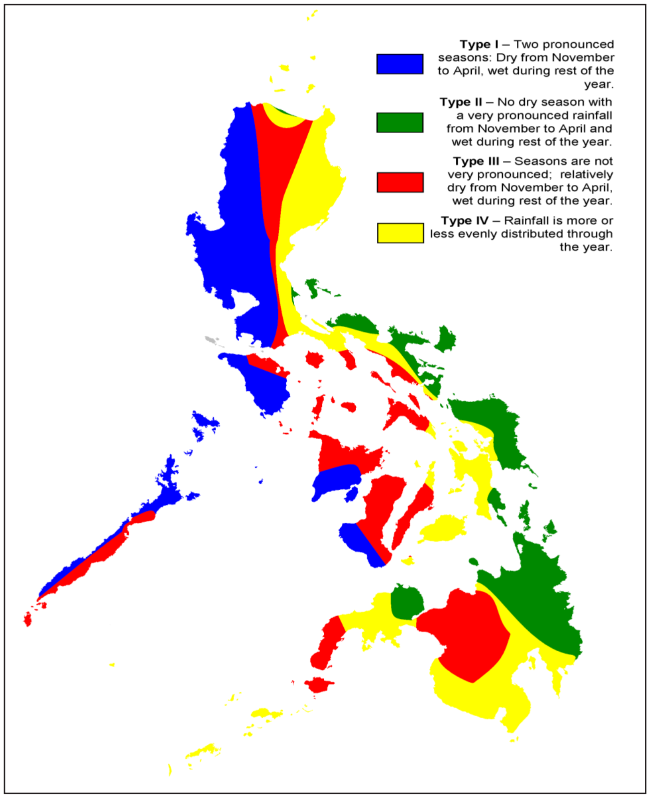


Figure 1.2 Climate of the Philippines based on Modified Coronas classification
(Source: Climatological and Agro-meteorological Division, PAGASA).

1.4 Disaster Risk Profile

The proneness of the Philippine archipelago to natural hazards is defined by its location and attributes. It is located along the typhoon belt in the western North Pacific Basin where about 33 percent of tropical cyclones originate. On the average, 5 to 7 tropical cycles are destructive (Table 1.1). It is also affected by other severe weather systems such as the monsoons and the inter-tropical convergence zone, among others. These weather systems oftentimes produce heavy rainfall that trigger floods and rain induced landslides. The country is also situated in the Pacific Ring of Fire where two major plates (Philippine Sea and Eurasian) meet. This explains the occurrence of earthquake and tsunamis as well as the existence of around 300 volcanoes of which 22 are classified as active.

The heavy rains associated with a series of four (4) tropical cyclones in November 2004 and early December 2004 triggered flash floods and massive landslides in the provinces of Quezon, Aurora, and Nueva Ecija. The reported casualties including missing persons reached more than 1,700 persons with about 3 million people directly affected while the estimated damages to agriculture, properties, and infrastructures including the dam at General Nakar amounted to about US$260million.

From September until early December 2006, a series of four (4) typhoons battered Luzon and Visayas islands, a record breaking event in the history of tropical cyclone occurrences in the Philippines. Typhoon Xangsane hit Metro Manila, Typhoon Parma affected Northern Luzon provinces, Typhoon Durian devastated the province of Albay and Camarines Sur, and Typhoon Utor battered Tacloban City, the capital of Leyte province. The total estimated damages from the four typhoons amounted to US$286.96 million, or almost 94% of the total damages for 2006 estimated to be US$306.52 million.

On 21 June 2008, Typhoon Fengshen brought untold suffering and devastation to millions of Filipinos nationwide. Its onslaught affected 4.7 million persons with 557 casualties, 826 injured and 87 missing. It also caused one of the worst sea disasters in the country with the sinking of a major passenger ferry carrying toxic chemicals. Total damages to private properties, infrastructure and agriculture amounted to US$293.48 million.

On 26 September 2009, Tropical Storm Ketsana brought torrential rains equivalent to one month rainfall in just 6 hours on the Philippine capital of Manila causing extensive flooding. It affected 4.9 million persons with 464 casualties, and damage to infrastructure and property amounted to US$234 million.

The manifestations of a changing climate are already evident in the Philippines. There have been marked changes in the frequency and intensity of extreme events as well as changes in the climate pattern. Communities at risk have become more vulnerable that existing coping mechanisms no longer suffice. As global climate change escalates, the risk of floods, droughts and severe tropical cyclones increases. One of the lessons learned in the flooding in Metro Manila and adjacent provinces is that flooding in the metropolis is now conditional, i.e. flood impacts depend on land use, urbanization, and climate variability and change (Nilo and Espinueva, 2009).

Hydrometeorological related hazards cost the Government an average of PhP15 billion (US$326.09 million) per year in direct damages, or more than 0.5% of the national GDP, and indirect and secondary impacts would increase this cost (Rabonza, 2006).

Table 1.1. Disastrous tropical cyclones in terms of damage

Year	Name	Areas affected	Damages in million US$
1990	Mike	Central Visayas	235.86
1995	Angela	Southern Luzon	202.17
1993	Flo	Central Luzon	190.22
2006	Xangsane	Luzon	143.70
1988	Ruby	Southern Luzon	122.61
2006	Durian	Southern Luzon	118.48
1984	Ike	Northeastern Mindanao/Visayas	82.80
2001	Utor	Luzon	78.04
1991	Ruth	Northern Luzon	75.43
2001	Nanang	Visayas	70.65
2003	Imbudo	Luzon	70.22
1995	Sybil	Visayas	60.87
1988	Skip	Visayas	59.78
2004	Mindulle	Southern Luzon	53.26
2006	Chanchu	North & South Luzon	52.83
2008	Fengshen	Visayas and Luzon	293.48
2009	Ketsana	Luzon	241.30
2009	Parma	Luzon	426.74

Source: Office of Civil Defense.

1.5 Institutional and Planning Context (Governance)

There are nineteen executive departments of the Philippine government. The heads of these departments are referred to as the Cabinet of the Philippines.

The Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) is the key government institution that renders national hydrometeorological services (NHMS). It is one of the eight (8) service institutes under the Department of Science and Technology (DOST). Together with another DOST service institute, the Philippine Institute for Volcanology and Seismology (PHIVOLCS), PAGASA acts as warning agencies and an active S&T partner in disaster risk reduction (DRR). The DOST is also a member of the Advisory Board of the Climate Change Commission which is chaired by the President. One of the functions of the Board is to assist the Commission in the formulation of climate adaptation and mitigation policies and to give advice on matters related to the mandate of the agencies.

The Philippine Development Plan 2011-2016 (PDP) is the national development roadmap of the country. It aims for an economic growth of seven to eight per cent per year for at least six years, and achieving or surpassing the Millennium Development Goals. The PDP has identified disaster risk reduction and management (DRRM) and climate change adaptation (CCA) as major cross-cutting concerns.

National policy promotes mainstreaming the integrated concerns of DRR and CCA into national and local decision making and planning processes. This is reflected in the legal framework for climate change adaptation in Republic Act No. 9729 of 2010 (Climate Change Act) and disaster risk reduction in Republic Act No. 10121 (Disaster Risk Reduction and Management Act of 2011). Both laws require local government units to adopt plans: the Local Climate Change Action Plan (LCCAP) and Local Disaster Risk Reduction and Management Plan (LDRRMP), respectively.

Philippines adopted the National Disaster Risk Reduction Management Plan (NDRRMP) in 2011. The NDRRPMP identified the PDPs approaches to DRRM as follows:

- Mainstream DRRM and CCA into existing policies (i.e. land-use, building code, General Appropriations Act or GAA), plans and programs (i.e. researches, school curricula)
- Reduce vulnerability through continued and sustained assessments especially in high-risk areas
- Integrate DRRM and CCA in all educational levels and in specialized technical training and research programs
- Raise public awareness of DRR and mitigating the impacts of disasters through the formulation and implementation of a communication plan for DRR and CCA
- Increase resilience of communities through the development of climate change-sensitive technologies and systems and the provision of support services to the most vulnerable communities
- Strengthen the capacity of communities to respond effectively to climate and other natural and human-induced hazards and disasters
- Institutionalize DRRM and CCA in various sectors and increase local government and community participation in DRRM and CCA activities
- Push for the practice and use of Integrated Water Resources Management (IWRM) and prioritize the construction of flood management structures in highly vulnerable areas, while applying DRRM and CCA strategies in the planning and design of flood management structures
- Intensify the development and utilization of renewable energy and environment-friendly alternative energy resources/technologies.

Another plan that shall have repercussions on the service provided by NHMS is the National Climate Change Action Plan (NCCAP) which outlines the agenda for climate change adaptation and mitigation for 2011 to 2038. NCCAP counts Ecosystem and Environmental Stability and Human Security as strategic priorites; both directly interphase with DRRM. NCCAP recognizes that "DRRM and CCA approaches and programmes need to converge especially since climate and weather-related hazards can lead to large-scale disasters if processes and communities are not prepared and risks are not reduced." The two institutions, National Disaster Risk Reduction and Management Council (NDRRMC) and the Climate Change

Commission (described in sections 1.5.2 and 1.5.3, respectively have entered into a Memorandum of Understanding to "harmonize and coordinate the planning, development and implementation requirements of LCCAPs and LDRRMPs by local government units.

1.5.1 Science and technology

PAGASA, as a warning agency, operates and maintains a system of monitoring for weather, hydrological phenomena and weather variability. As one of the eight (8) service institutes under the Department of Science and Technology (DOST), it renders also science and technology related services dealing with risk identification, hazard mapping, hazards monitoring, early warning and preparedness. It is a scientific and technical institution that promotes disaster and hazard information; it operates and maintains a system of monitoring for weather, hydrological phenomena, and climate variability. According to the DOST website, PAGASA is "mandated to provide protection against natural calamities and utilize scientific knowledge as an effective instrument to insure the safety, well-being and economic security of all the people, and for promotion of national progress."

Over the last two or three years, its hazard mitigation work has spanned the broad spread of disaster risk reduction activities as a partner in the Collective Strengthening of Community Awareness for Natural Disasters (CSCAND) Technical Working Group. The group comprised of the Mines and Geosciences Bureau (MGB), National Mapping and Information Resources Authority (NAMRIA), Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), and the Office of Civil Defense (OCD) under the Department of National Defense, is mandated to improve our understanding of natural hazard risks in the country.

Due to the perennial damage caused by hydro-meteorological hazards, the government put high priority on flood forecasting and issuance of warnings at least six (6) hours before occurrence of a flooding event. Thus, the DOST put in place the National Operational Assessment of Hazards (NOAH) which integrates disaster-related projects of the DOST. NOAH includes 3D digital terrain mapping, sensors and warning systems development, installation and upgrading Doppler radars, flood modelling, geohazards mapping, tsunami monitoring and information and communication systems. It is done in collaboration with the academe (such as the National Institute of Geological Sciences (NIGS) and the College of Engineering at the University of the Philippines. Measuring devices are being installed at observation stations in the Cagayan, Iligan, Agno and Bicol river basins.

1.5.2 Disaster risk reduction and management (DRRM)

The legal framework for dealing with disaster in the country is Republic Act 10121, which was passed in May 2010. This marked a significant change from the old law that existed since 1978, Presidential Decree No. 1566 (Strengthening the Philippine Disaster Control, Capability and Establishing the National Program of Community Disaster Prevention). For a long time, the latter no longer reflected the social realities of the time and defaults on the developmental context of disasters and climate change.

RA 10121 acknowledges the need to "adopt a disaster risk reduction and management approach that is holistic, comprehensive, integrated, and proactive in lessening the socio-economic and environmental impacts of disasters including climate change, and promote the involvement and participation of all sectors and all stakeholders concerned, at all levels, especially the local community."

In terms of institutional arrangements, the council structure from the old law was retained. The council was renamed National Disaster Risk Reduction and Management Council (NDRRMC). The DOST was a member of the previous council (called National Disaster Management Council). In the present law, the DOST secretary is designated at the Vice Chairperson for disaster prevention and mitigation of the NDRRMC. PAGASA and PHIVOLCS being the most relevant service institutes of DOST, are, by default, regular attendees of the council meeting. All departments are part of the NDRRMC, which is chaired by the Secretary of the Department of National Defense

The Philippines like most countries in the world adopted the Hyogo Framework for Action 2005-2015 (HFA) in January 2005. The Philippine government then formally shifted the focus from disaster response to disaster preparedness and mitigation. In the past years, however, the country experienced major disasters that propelled the relevant institutions to adopt measures that in effect reflected this shift.

The REINA project was a response to the typhoon that left considerable damage to agriculture and settlements in the municipalities of Real, Infanta, Nakar in Quezon province, which is located in the eastern seaboard facing the Pacific Ocean. In the disaster rehabilitation project, PAGASA was part of team consisting of the CSCAND agencies. It required substantial scientific input into early warning, disaster preparedness and mitigation. REINA project became the starting point of a new approach not only recovery but also in the approach towards hazards, i.e., reducing disaster risks and vulnerability.

Due to the success of the project, the READY project was conceived to provide the necessary support to the provinces which are most at risk. Funded by the Australian Agency for International Development (AusAID) and administered by the United Nations Development Programme (UNDP), again the same government agencies teamed.

Multi-hazard identification and disaster risk assessment, community disaster preparedness (Community-based Early Warning System,CBEWS), information,education and communication) are components of the READY Project. (Note: READY stands for Hazards Mapping and Assessment for Effective Community-Based Disaster Risk Management) The READY project aims to provide immediate, reliable information to the communities at risk, on the various geological and hydro-meteorological hazards in their respective localities. PAGASA dealt with two of nine hazards, namely flood/flash flood and storm surge.

Being a warning agency for hydrometeorological hazards, PAGASA needs to incorporate information, education and communication into its work. To cite, the law entreats the establishment of early warning systems (EWS) which it defines as "the set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss." As a NMHS, PAGASA faces huge challenges especially as the impacts of climate change are increasingly being experienced in different parts of the country.

1.5.3 Climate Change

In accordance with R.A. 9729, the Climate Change Commission (CCC) was established. As part of the DOST and CCC Advisory Board Member, PAGASA is expected to perform its role in the formulation of climate adaptation and mitigation policies. The major part it has played is the generation of climate change scenarios.

In the preparation of the National Communication to the United Nations Framework Convention on Climate Change (UNFCCC), PAGASA contributes information on climate change such as climate projections in the Philippines based on research findings. (Note: The Initial Communication was submitted in 1999, while the Second National Communication was submitted in 2011) PAGASA is expected to play a more important role in this area of expertise.

The climate projections generated using PRECIS, a model based on Hadley Centre's regional climate modelling system, were a useful aid in the preparation of the National Communication also The scenarios are "characteristics of plausible future climates" (PAGASA, ADAPTAYO and MDGF, 2011; Climate Change in the Philippines).   The projections are also used for national and local planning purposes.

SOCIO-ECONOMIC BENEFITS OF HYDROMETEOROLOGICAL SERVICES

2

The increasing frequency of occurrence and severity of hydrometeorological events in the country, especially tropical cyclones, could result to higher human casualties and damages that can significantly slow down economic development.

The assessment of the benefits of hydrometeorological services, in the context of economic cost-benefit analysis (BCA or CBA) can be a helpful tool in evaluating the benefits of upgrading NMHS facilities. CBA can also be used as reference in identifying the investment areas (e.g. monitoring, modelling, research, etc.) where funding support can be provided.

2.1 Weather and climate-dependent economic sectors

Of the weather and climate-dependent economic sectors of the Philippines, manufacturing and agriculture have been the most dominant contributors to the national economy. In 2007, these sectors respectively contributed 23.2% and 14.0% to the gross domestic product (Table 2.1). In totality the weather and climate-dependent economic sectors contributed 61% to the GDP in the same year.

Table 2.1 Main economic sectors and weather dependent sectors in national economy, Philippines (% of GDP at 1985 constant prices excluding taxes, i.e. % of gross value added, GVA).

Sector	2000	2001	2002	2003	2004	2005	2006	2007
Agriculture, hunting and related service activities	15.8	16.1	16.0	15.6	15.3	14.7	14.3	14.0
Forestry, logging and related service activities	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Fishing	3.8	4.0	4.0	4.1	4.2	4.3	4.3	4.3
Land transport; transport via pipelines, water transport; air transport; Supporting and auxiliary transport activities; activities of travel agencies	4.2	4.2	4.1	4.1	4.1	3.9	3.8	3.8
Post and telecommunications	2.8	3.3	3.7	4.0	4.3	4.7	4.9	5.0
Mining and quarrying	1.1	1.0	1.5	1.6	1.6	1.7	1.5	1.7
Manufacturing	24.4	24.7	24.4	24.3	24.1	24.2	24.0	23.2
Electricity, gas and water supply	3.3	3.3	3.3	3.2	3.2	3.1	3.1	3.1
Construction	6.6	5.0	4.6	4.3	4.2	3.8	3.9	4.5
Hotels and restaurants	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Total	63.6	63.0	63.0	62.7	62.5	61.7	61.3	61.0

Source: United Nations Statistics Division.
Retrieved from http://data.un.org/Data.aspx?d=SNA&f=group_code%3a202

2.2 Methodology for computing socio-economic benefits

The methodology employed for computing the potential socio-economic benefits of planned improvements in the NMHS done here is driven by the availability of secondary data. Benefits are defined as avoided or reduced costs from damage. The use of secondary data is necessitated by the limited time and resources available for this work. The secondary data were collected from institutional sources. These secondary data were enhanced by informed assumptions provided by institutional key informants. It should be emphasized that the accuracy of the computations done here is dependent on the accuracy of the secondary data on the socio-economic damages caused by weather and climate-related natural disasters from the institutional sources.

In chronological order, the specific steps followed in the measurement of the economic and social impacts of weather and climate-related disasters and the potential benefits from planned NMHS improvement for the Philippines are the following:

- Identification of the different kinds of potential direct economic and social damages resulting from weather and climate-related disasters and their affected economic and social sectors;
- Determination of the different kinds of potential economic and social damages that have already been quantified by the institutional and related data sources;
- Collection of the quantified data of economic and social damages;
- Measurement, based on certain assumptions, of the increase/reduction in the value of economic and social damages as a result of the planned improvements in their NMHS; and
- Measurement of the total economic and social benefits due to planned improvements in the NMHS.

The weather and climate-related disasters and their potential direct impacts on the affected economic and social sectors are presented below (Table 2.2). In addition to the potential direct impacts of weather and climate-related disasters, there are potential indirect impacts on the other sectors that have backward and forward linkages to the mainly affected sectors. For instance, disruptions in agriculture may impact the other sectors of the economy through increases in the prices of agricultural goods and services in the market.

An examination of the secondary data available, however, showed that the data and information needed for computing the value of the indirect impacts of weather and climate-related disasters are not available. Thus, the computation done here consider only the direct socio-economic impacts of weather and climate related disasters as generated from the institutional data sources.

Based on reduction of damages as a result of the planned improvement in the NMHS, the costs of the NMHS improvements are taken in a succeeding section of this report. Based on the cost and benefit figures, the cost/benefit (C/B) ratios are computed and compared with the ratio set by the WMO.

2.3 Results and analysis

Natural hazard-induced disasters

The data on total number of disasters, number of deaths, number of persons who were rendered homeless, number of persons who were injured and total number of persons affected by natural hazard-induced disasters in the Philippines for the period 1990-2009 are presented in Table 2.3. For the 1990 to 2009 period, the country had 226 such disasters causing death of more than 20,000 people and injury to more than 16,000 persons. The disasters also affected more than 82 million individuals and rendered more than 2.4 million persons homeless.

Total socio-economic damages

The value of direct socio-economic damages caused by weather and climate-related disasters in the Philippines for the 1990-2009 period and the estimated damages for the 2010-2029 period are presented in Table 2.4. The annual estimated socio-economic damages for 2010-2029 were computed as the average of the annual actual damages for the 1990-2009 period adjusted to inflation. The average annual actual socio-economic damages for the 1990-2009 period was at US$232 million and in the absence of 2010 data is reflected as the annual estimated damages for that year.

Table 2.2 Potential direct impacts of weather and climate-related disasters on different economic and social sectors in the Philippines.

Economic/Social sector		Potential Direct Impacts
Economic Sectors	Agriculture	Lost income, disruption in operations, damaged irrigation, dams and other agricultural infrastructure and facilities, soil erosion, land degradation, fertility depletion, alteration of fruiting and harvesting dates; resurgence of pests, diseases in rice, scale insects in fruits, and invasive weeds, etc.
	Transportation & Communication	Lost income, disruption in operations, damaged transportation and communication infrastructure and facilities, etc.
	Energy	Lost income, disruption in operations, damaged energy infrastructure and facilities, etc.
	Tourism	Lost income, disruption in operations, damaged tourism infrastructure and facilities, tarnished image as a tourist destination, etc.
Social Sectors	Human Settlements	Lost and impaired human lives and property, reduction in land and property values in affected areas, etc.
	Health	Lost income due to death or injury, disruption in operations, psychic costs due to death or injury, cost of rehabilitation, etc.
	Education	Lost income, disruption in operations, opportunity costs of cancellation of classes, rehabilitation costs of damaged schools and related property, etc.
	Water	Diminished water access and water availability, management and control cost of water pollution, etc.

The reduction in damages (Table 2.5) is assumed to start in 2012, a year after the start of the project, and increases up to 2016. A reduction in the economic damages of 2% annually from 2012 to 2015 and 10% thereafter is further assumed meaning that the effects of the improvement gradually occur in equal increments until it reaches maximum effect by 2016 and onwards. While there are no available previous researches which indicate the right percentage of damage reduction in damages which should be assumed, the 10% reduction in damages used here is based on informed opinion of key informants and technical people and considered a conservative estimate. From 2010-2029, the estimated reduction in damages or the socio-economic benefits amount to US$705.20 million and the annual average reduction is US$35.26 million.

Table 2.5 also presents the discounted or net present value of the estimated reductions in the economic damages, or the socio-economic benefits, due to improvements of the NMHS of the Philippines. The social discount rate used in 12 percent which is within the 10 to 12 percent used by the Asian Development Bank (ADB) for public projects (Zhuang et al. 2007). The results show that the total discounted socio-economic benefits from 2010 to 2029 are US$173.70 million while the annual average benefits are US$8.690 million. These discounted figures are way lower than the undiscounted figures shown in the same table.

In the case of costs, there are two options for improvements in NMHS considered. The first, the stand-alone option, is the case where the improvements are separate investments of the country while the second, the regional cooperation option, means that the improvements are done as part of an integrated regional system. Because of the efficiency effects of integration, the costs of the latter are lower than the former. The undiscounted capital costs, which will all be spent at the start of the project for the stand-alone option, is US$24.95 million while that for the regional cooperation option is US$24.85 million. The discounted and undiscounted operating and maintenance costs for the two options are provided in Tables 2.6.

Table 2.3 Selected statistics related to weather and climate-related disasters in the Philippines, 1990 to 2009

Year	Number of disasters that occurred	Number of persons who died	Number of persons homeless	Number of persons injured	Total affected
1990	9	913	1,110,020	1,288	7,286,601
1991	9	6,153	75,073	3,109	1,572,688
1992	7	180	9,267	91	2,100,126
1993	10	592	249,122	570	3,929,411
1994	17	337	371,802	192	2,876,643
1995	13	1,725	116,000	2,447	3,405,997
1996	5	83	96,000	21	133,636
1997	4	67	-	5	471,770
1998	6	604	-	866	9,923,299
1999	16	364	9,781	177	3,492,351
2000	10	736	125,250	393	6,355,912
2001	9	630	100,000	480	3,541,737
2002	12	395	3,000	178	3,416,147
2003	10	350	83,203	75	687,749
2004	12	1,918	8,700	1,321	3,262,978
2005	4	39	-	-	213,057
2006	19	2,984	-	2,703	8,568,968
2007	15	129	-	24	2,009,056
2008	20	959	54,645	1,015	8,459,896
2009	19	1,116	100	690	10,490,198
Total	226	20,274	2,411,963	15,645	82,198,220

Source of data: EM-DAT: The OFDA/CRED International Disaster Database. Retrieved from http://www.emdat.be/advanced-search

Note: In this table and the succeeding ones, the weather and climate-related natural disasters specifically include drought, extreme temperature, flood, mass movement wet, storm and wildfire.

Table 2.4 Actual and estimated economic value of damages due to weather and climate-related natural disasters in the Philippines, 1990-2009 (million US dollars)			
Actual Damages		Estimated Damages	
Year	Value	Year	Value
1990	453	2010	232
1991	276	2011	244
1992	74	2012	258
1993	337	2013	272
1994	169	2014	287
1995	1,018	2015	303
1996	42	2016	319
1997	8	2017	337
1998	235	2018	355
1999	80	2019	375
2000	88	2020	396
2001	11	2021	417
2002	26	2022	440
2003	42	2023	464
2004	139	2024	490
2005	3	2025	517
2006	347	2026	545
2007	17	2027	575
2008	481	2028	607
2009	544	2029	640

Source of data: For 1990-2009, the data were taken from EM-DAT: The OFDA/CRED International Disaster Database

Note: The figures for 2010-2029 estimated annual damages were computed as the average annual actual damages for 1990-2009 multiplied by the average annual inflation rate for the period.

Table 2.5 Estimated 10% reduction in the socio-economic damages, or the socio-economic benefits due to improvements in NMHS in the Philippines, 2010-2029 (million US dollars)		
Year	Undiscounted Value	Discounted Value
2010	0.00	0.00
2011	0.00	0.00
2012	5.16	3.67
2013	10.88	6.91
2014	17.22	9.77
2015	24.24	12.28
2016	31.90	14.43
2017	33.70	13.61
2018	35.50	12.80
2019	37.50	12.07
2020	39.60	11.38
2021	41.70	10.70
2022	44.00	10.08
2023	46.40	9.49
2024	49.00	8.95
2025	51.70	8.43
2026	54.50	7.94
2027	57.50	7.48
2028	60.70	7.05
2029	64.00	6.63
Total	705.20	173.70
Average	35.26	8.69

Source of data: Table 2.4.

Table 2.7 presents the options that can be taken for the NMHS improvements, discounted total costs of the improvements, discounted total benefits from the improvements, discounted net benefits from the improvements and the C/B ratio. The total costs of the NMHS improvements are the capital costs which are assumed to be spent at the beginning of the project and therefore not discounted and the discounted O&M costs. Again, the undiscounted capital costs are US$24.95 million for the stand-alone option and US$24.85 million for the regional cooperation option. The discounted O&M costs of US$2.73 million for the stand-alone option and the US$2.27 million for the regional cooperation option are taken from Table 2.6. The discounted total benefits are taken from Table 2.5. The discounted net benefits and C/B ratio are as defined earlier.

Table 2.6 Undiscounted and discounted operating and maintenance costs of improvements in NMHS in the Philippines, 2010-2029 (million US dollars)				
Year	Undiscounted O&M Costs		Discounted O&M Costs	
	Stand Alone	With Regional Cooperation	Stand Alone	With Regional Cooperation
2010	0.00	0.00	0.00	0.00
2011	0.00	0.00	0.00	0.00
2012	0.30	0.25	0.21	0.18
2013	0.32	0.27	0.20	0.17
2014	0.35	0.29	0.20	0.16
2015	0.37	0.31	0.19	0.16
2016	0.40	0.33	0.18	0.15
2017	0.43	0.35	0.17	0.14
2018	0.46	0.38	0.16	0.14
2019	0.49	0.41	0.16	0.13
2020	0.53	0.44	0.15	0.13
2021	0.57	0.47	0.15	0.12
2022	0.61	0.50	0.14	0.12
2023	0.65	0.54	0.13	0.11
2024	0.70	0.58	0.13	0.11
2025	0.75	0.62	0.12	0.10
2026	0.80	0.67	0.12	0.10
2027	0.86	0.72	0.11	0.09
2028	0.93	0.77	0.11	0.09
2029	0.99	0.82	0.10	0.09
Total	10.49	8.70	2.73	2.27
Average	0.52	0.44	0.14	0.11

Note: O&M costs start in year 2012. In that year, O&M costs are estimated at one percent of the capital costs and then increases yearly at the rate of inflation. Note: The O&M costs are discounted using the social discount rate. The O&M costs are discounted using the social discount rate.

For the stand-alone system, the undiscounted plus discounted total cost of NMHS improvements is US$32.70 million while the discounted total benefits due to NMHS improvements is US$173.70 million when a 10% decrease in damages is considered as benefits. Therefore, the discounted net benefits are US$141.00 million while the C/B ratio is 1:5.31. The C/B ratio, however, is lower than the 1:7 ratio set by WMO.

For a system based on regional cooperation, the total cost of NMHS improvement is US$27.14 million which is lower than the cost of a stand-alone system. Again, the discounted total benefits due to the NMHS improvements are US$173.70 million when a 10% decrease in damages is considered as benefits. Therefore, the discounted net benefits are US$146.56 million and the C/B ratio is 1:6.40 which is not as favorable as the 1:7 ratio recommended by WMO.

Table 2.7 Options, costs, discounted total benefits, discounted net benefits and cost-benefit ratios for improvements in NMHS in the Philippines, 2010-2029				
Option	Total Costs (Million US$)	Discounted Total Benefits (Million US$)	Discounted Net Benefits (Million US$)	Cost/benefit Ratio (C/B)
Stand-Alone	2.70	173.70	146.00	1:6.3
Regional Cooperation	27.14	173.70	146.56	1:6.40

It is noted that the mentioned C/B ratios generated above for both of the systems considered are similar but inferior to the C/B ratios computed by other studies on benefits of meteorological and hydrological services. These derived C/B ratios are also higher than the WMO minimum ratio of 1:7 (Hautala et al., Tammelin 2007, Leviakangas et al. 2007).

Table 2.8 Annual statistics of disasters that occurred and persons affected in the Philippines from 1990-2009					
Year	Number of disasters	Persons affected	Persons rendered homeless	Missing persons	Persons who died
1990	9	7,286,601	1,110,020	1,288	913
1991	9	1,572,688	75,073	3,109	6,153
1992	7	2,100,126	9,267	91	180
1993	10	3,929,411	249,122	570	592
1994	17	2,876,643	371,802	192	337
1995	13	3,405,997	116,000	2,447	1,725
1996	5	133,636	96,000	21	83
1997	4	471,770	-	5	67
1998	6	9,923,299	-	866	604
1999	16	3,492,351	9,781	177	364
2000	10	6,355,912	125,250	393	736
2001	9	3,541,737	100,000	480	630
2002	12	3,416,147	3,000	178	395
2003	10	687,749	83,203	75	350
2004	12	3,262,978	8,700	1,321	1,918
2005	4	213,057	-	-	39
2006	19	8,568,968	-	2,703	2,984
2007	15	2,009,056	-	24	129
2008	20	8,459,896	54,645	1,015	959
2009	19	10,490,198	100	690	1,116
Total	226	82,198,220	2,411,963	15,645	20,274

Source of data: EM-DAT: The OFDA/CRED International.

Sectoral economic damages

By economic sector, some anecdotal secondary data are available indicating the physical and economic damages caused by weather and climate-related disasters. From 1990 to 2009, the total value of economic damages due to these disasters was largest in agriculture, followed by infrastructure and private/ commercial (Table 2.9). Agriculture damages were approximately nine times bigger than infrastructure damages and about 500 times larger than private/commercial damages.

For the agriculture sector specifically in the 2004 to 2008 period, the crops subsector had the largest economic damages due to weather and climate-related disasters followed by fisheries and livestock (Table 2.9).Within the agriculture sector, agricultural facilities and irrigation had the same values of damages except in 2008 when the former had a relatively higher value than the latter.

Table 2.9 Estimated values of economic damages on property due to weather and climate-related natural disasters in the Philippines, 1990-2009 (in million US dollars).

Year	Infrastructure	Agriculture	Private/ Commercial	Total
1990	55	496	51	602
1991	48	181	7	236
1992	97	269	2	368
1993	239	523	20	782
1994	42	78	14	134
1995	140	504	9	653
1996	3,400	6,088	1,131	10,619
1997	23	47	2	72
1998	120	471	34	625
1999	56	62	24	142
2000	127	67	13	207
2001	69,868	58,153	7	128,028
2002	13	21	2	36
2003	28	54	4	86
2004	76	163	3	242
2005	10	41	2	53
2006	189	215	2	406
2007	28	62	2	92
2008	185	331	0.2	516
2009	21	11	3	35
Total	74,765	67,837	1,332	143,934

Sources of data: National Disaster Coordinating Council, Office of Civil Defense, Philippines; NSCB (2010, 2009)

Note: in this table, weather and climate-related disasters include typhoons, storm surges, drought/dry spells, monsoon rains, continuous rains, flooding, landslides/soil erosion, tornado, and strong winds.

In the transportation sector, for the 1990 to 2009 period, vehicular transportation had the largest total number of accidents and the largest number of dead and injured persons due to accidents followed by sea transportation and air transportation (Table 2.10). On the other hand, sea mishaps had the largest number of person missing followed by vehicular accidents and air mishaps. These data, however, is for damages in transportation and do not reflect those can be attributed specifically to natural hazard-induced disasters, much less weather and climate-related.

Table 2.10 Estimated values of economic damages due to natural disasters in the agriculture sector of the Philippines, 2004-2008 (in thousand US dollars)

Sub-sector	2004	2005	2006	2007	2008
Crops	87,203	80,247	184,665	109,240	222,919
Fisheries	34,007	111	21,060	1,922	70,866
Livestock	784	8	4,352	63	4,952
Sub Total	121,994	80,366	210,076	111,225	298,737
Agricultural facilities	11,351	-	25,086	105	41,932
Irrigation	11,351		25,086	105	38,172
Sub Total	22,703	-	50,172	211	80,104
Total	144,696	80,366	260,248	111,436	378,840

Source of data: Management Information Division, Department of Agriculture, Philippines

There are few available secondary data on the physical and economic damages caused by weather and climate-related disasters in the energy sector in the Philippines. It was estimated that in 2006, a major typhoon, Xangsane caused infrastructure damages worth US$18 million and un-served energy of US$214 million (Table 2.11). In the same year, another major typhoon, Durian, resulted to economic damages in un-served energy of US$11 million.

As shown earlier in Table 2.2, weather and climate-related disasters are also likely to have significant impact on other economic sectors of a country such as tourism. These impacts, however, have not been quantified physically and economically based on available sources.

Table 2.11 Number of and physical damages due to accidents in the Transport sector of the Philippines, 1990-2009.				
	Sea mishaps	Air mishaps	Vehicular accidents	Total
No. of Incidents	229	61	388	678
Dead	1114	365	1505	2984
Injured	1091	82	3479	4652
Missing	1554	4	42	1600
Affected	3759	451	5026	9236

Source: National Disaster Coordinating Council (NDCC), Office of Civil Defense (OCD)

2.4 Summary of findings

In retrospect, following are the main findings based on the computations done for the Philippines:

- The discounted total and net benefits due to the improvements in the NMHS of Philippines, based even only on the decrease in damages due to the improvements, are immense and more than enough to pay for the cost of improvements;
- The C/B ratios based on the actual costs of NMHS improvements and the discounted values of the total benefits from the improvements are inferior to the 1:7 ratio set by the WMO;
- The C/B ratio for the system with regional integration is better than the ratio for the stand-alone system which implies that being more efficient the former system is also more desirable; and
- The C/B ratios would improve further if the indirect benefits of the NMHS improvements, productivity gains in the economy and the benefits beyond 2029 are included in the computation of benefits.

In the future, a re-computation may be in order if and when the secondary data are revised and these are made available to users.

3 USER NEEDS ASSESSMENT OF HYDROMETEOROLOGICAL SERVICES AND INFORMATION

Dramatic political, social and economic changes in many parts of the world have taken place in the last decade, resulting in political and economic realignments and groupings that are expected to affect, or have already affected fiscal and monetary priorities among leading western nations vis-à-vis the Asian countries, including the Philippines, such that a change in the magnitude of investment flow from traditional sources may likewise be expected. Quite significantly, while these changes occur, there is a growing concern on adapting to the impacts of climate change

To enable the different socio-economic sectors to assess the hydrometeorological services information provided by PAGASA, a consultation meeting and workshop were conducted in 2010. These were attended by various sector representatives from agriculture, water resources, environment, energy, health, transport, tourism, construction, insurance, and disaster reduction.

3.1 Agriculture

Agriculture is one of the major economic sectors in the country and accorded high priority in terms of budgetary support from the government. To optimize productivity, agro-meteorological service is required in its day-to-day activities like scheduling of farming operations such as irrigation, spraying, and harvesting. Livestock production is also affected by weather and climate. The utilization of atmospheric and geophysical information in crop and livestock production, however, has not yet been fully utilized in the country. Agro-meteorological services are designed to help minimize the adverse effects of extreme climate events to agricultural operations while taking full advantage of favorable weather conditions at the different stages of crop growth in order to increase yield.

Farm weather services in terms of seasonal forecasts, farm weather forecasts and advisories are now provided by PAGASA to the agriculture sector and disseminated to the farmers. There is also an increasing demand for climate forecast as input in agricultural planning for climate sensitive crops such as rice and corn during the occurrence of extreme climate events. Since rice and corn are the staple food, the application of climate forecasts for agriculture should cover all agricultural areas in the country. In addition, agro-meteorological research stations are established in state colleges and universities to study crop calendaring, plant pest and disease control, among others.

The Philippine government has also implemented a range of risk management programs for farmers and other agricultural stakeholders to address concerns on low productivity and seasonal climate variability (Reyes et al, 2009). Formal surveys and focus group discussions with rice and corn farmers were conducted in major areas in coming up with a list of mitigation tools. Results show that the preferred development interventions most acceptable to farmers are: better climate information, accessible credit, crop insurance and special assistance programs (Reyes et al, 2009). Historical data from PAGASA's Climate Data Section are utilized by agencies like the National Irrigation Administration (NIA) for its project studies.

The said study also indicates that only El Niño/ La Niña Advisory and Tropical Cyclone Warning effectively reach a majority of the farming populace from among the list of climate information products from PAGASA. Ninety four percent of the farmers in the selected sites were aware of ENSO forecasts, while 85% received tropical cyclone warnings (Table 3.1). The rest of the information products got a low awareness rating ranging from 19% to as low as 2%. Usefulness and reliability ratings were acceptable with only a few expressing extreme discontent on the products. Based on the figures, much has yet to be done to properly disseminate climatic information, improve its accuracy, and package the products in more appropriate ways.

Table 3.1 Awareness on, usefulness and reliability of PAGASA's climate information products

Product	Awareness %	Usefulness* %					Reliability** %			
		1	2	3	4	5	1	2	3	4
Monthly weather situation & outlook	19	1	4	4	8	4	2	6	6	6
Annual seasonal climate forecast	19	1	5	7	2	2	1	4	8	5
El Niñ0/ La Niña	94	11	16	38	16	13	9	26	24	18
Tropical cyclone warning	85	5	14	32	16	14	6	22	27	18
10-day advisory	7	-	1	5	-	1	-	2	2	1
Farm weather forecast	5	-	1	1	-	2	-	1	-	2
Phil. Agroclimatic Review and Outlook	2	-	-	-	-	2	-	-	-	2
Press release on significant events	2	-	-	1	-	1	-	1	-	1
Phil. Agri-weather Forecast	4	-	-	2	-	1	-	1	1	1
Climate impact assessment bulletin for agriculture	4	-	-	2	-	1	-	1	1	1

** Usefulness rating: 1-not useful, 2-somewhat useful, 3-useful, 4-highly useful, 5-vital*

*** Reliability rating: 1-unreliable, 2-somewhat reliable, 3-reliable, 4-excellent*

Source: Reyes et. al., 2006.

It should be noted that PAGASA does not provide advisories to farmers directly. Instead, PAGASA provides advisories to provincial and municipal agricultural officers, who are then responsible to disseminate the information to farmers.

Filipino farmers are mostly risk-averse by nature and more than 90% of smallholder agricultural workers cannot afford a failed season of cropping. Seasonal climate forecasts (SCFs) can be applied as mitigating measures to soften the blow of climatic deviations.There is a wide spectrum of technologies or approaches to mitigate the effects of drought and flooding and among these is crop insurance. Crop insurance can serve as an intervention that provides assurance that the farmer would at least breakeven during the cropping season. Measures need to be explored to bridge seasonal climate forecasts with the adoption of agricultural risk management tools like crop insurance.

The articulated needs of the agriculture sector are:

- 10-day inflow forecast as a basis for the allocation of irrigation diversion requirement
- Lead time of at least 6-months of climate forecast/outlook for planning of program areas.

3.2 Environmental protection and forest management

For the environment and forest management, data series of meteorological parameters and stability class indices are required to set air quality standards that will facilitate the formulation of environment standard. More rain gauges should be installed in watershed and forest areas to enhance forest management.

3.2.1 Regional Pollution

Rapid industrial growth and the corresponding concentration of pollution in urban and industrial areas pose real challenges to policy makers. Air and water pollution are the most visible signs of the degradation of the ecosystem. Consequences of unregulated industrial activities have the potential to create high concentrations of air and water pollutants that can be carried across national boundaries. This is made possible not only due to the dispersion and transport capabilities of the atmosphere but also because of the photochemical transformations and interactions most of which have yet to be investigated exhaustively.

3.2.2 Accidental release/spill of hazardous substances

Immediate and long-term effects of accidental release or spill of hazardous substances to the atmosphere and water bodies serve as grim reminders of the real dangers it poses to human survival and ecological balance. The Chernobyl nuclear meltdown, the Alaska oil spill and just recently, the MT Solar 1 oil spill in the country are classic examples. On August 11, 2006, MT Solar 1 owned by Sunshine Maritime Development Corporation sank in rough seas 15 miles off the southern tip of Guimaras Island. At its location, the depth of the water is between 600 to 700 meters below sea level.

At the national level, the increasing probability of tanker collisions in the archipelago's narrow straits because of the expected additional oil discoveries in the industrial zones brings the real danger that economic progress entails. Amidst this backdrop, meteorologists, climatologists and hydrologists can provide assistance in the preparation of contingency plans at national and local levels that can be readily implemented in times of emergency.

The needs are:

- Air quality standards setting through formula tion of environment standard
- Real time data (raw data) - annual data in hourly basis of wind speed and wind direction
- Stability class indices
- Technical support for calibrating meteorological sensors and other instrument
- Climate change monitoring
- Inclusion of CO2 monitoring vs. atmospheric temperature
- Forest management
- Installation of rain gauge instruments for water-shed and forest areas for measurement of rainfall data.

3.3 Water resources

Water greatly influences people's lives. Lack of it causes droughts and too much of it results to floods. In between these extremes lies the important task of meteorological and hydrological services in the prudent and effective utilization and management of the country's water resources in cooperation with other agencies. In the 2001 study of the Asian Disaster Preparedness Center (ADPC) on extreme climate events, the water resources of major reservoirs in the country were found to be highly vulnerable to the El Niño and La Niña phenomena. As a result of the study, the PAGASA and ADPC are now implementing a project that will provide inflow forecasts for the water resources management of Angat dam.

Water resource development projects involving construction of dams, artesian wells, water and sewerage treatment plants are designed on the basis of knowledge of the local climate. Their effective operation relies on up-to-date information on temperature, humidity and rainfall. To ensure the continuous and sufficient supply of water for farming, industry and households, it is vital to maintain close links between PAGASA and the authorities that manage water resources projects. As the population increases, a policy on water resources management must be in place. The concerned government agencies may have to seek guidance from PAGASA in the assessment of water resources for which climate is the driving force.

The needs are:

a. For efficient operation of dams/reservoirs
   - Quantitative precipitation forecasts within the catchment/drainage areas of dams
   - Localized flood forecasts with a map showing the level and extent of inundation
   - Upgrading/strengthening of flood forecasting systems for dam operation
   - Improvement/construction of flood control structure downstream of dams

b. For simulation of water allocations of reservoirs:
   - Rainfall, evapo-transpiration, inflow/outflow data
   - Wind speed/direction forecast for cloud seeding activities

c. Water Availability Assessment
   - Historical rainfall data (daily and monthly)
   - Installation of more automatic weather stations.

3.4 Energy production and distribution

Energy planners will need the guidance of weather and hydrology experts more and more in the next decade. This fact has become apparent in the light of the growing concern about increasing levels of greenhouse gases in the atmosphere with its effects on future climate. Concerns on global warming and climate change elicited a renewed interest in hydro-electric power and other alternative energy sources such as wind, solar, thermal, and others.

Another important consideration is the transmission and consumption of electricity. The transmission as well as the use of electricity for cooling/air conditioning requirement strongly depends on weather conditions, especially temperature. The PAGASA can assist in operational planning to meet the expected demand for electricity through provision of weather information. Utilization of technical information is also important for proper scheduling of production and distribution of energy for various uses.

Moreover, real time weather forecast, possible areas where lightning may strike, the track of a typhoon and the location of strong winds within a typhoon and the forecast maximum temperature comprise crucial information in the operation of nationwide transmission network of power. With the country experiencing an average of 20 tropical cyclones per year, the National Grid Corporation of the Philippines (NGCP), the sole operator of the electric power grid in the country finds merit in having a pro-active plan to respond to any crisis or emergency situation arising from typhoons, heavy rains, and flash floods. In November 2009, the NGCP forged a partnership with the PAGASA to advance its Integrated Typhoon Action Plan (ITAP) to establish policies dealing with major weather disturbances and ensure that all NGCP units crucial in the management of such emergency and power restoration activities are familiar with the procedures and their roles in the event of a crisis, arising from hydrometeorological related disasters.

Within the ITAP is the Storm Tracking and Response System (STaRS) project for the acquisition of current and historical typhoon/ weather data for use in the STaRS program as an offshoot to the enormous damage in the transmission towers of the NGCP during Typhoons Xangsane and Durian in 2006. To enhance NGCP's monitoring capability of lightning occurrences and real time weather, NGCP is planning to put up about 50 automatic weather stations, share the data and collaborate with PAGASA's researches.

The needs are:

- Accurate real-time weather forecasts and information
- Forecasts of track and maximum winds in a tropical cyclone
- Flood forecasts and extent and level of inundation
- Hourly temperature forecast
- Advisories on areas likely to be affected by lightning
- Data/information and advisories on sunspot and solar flares
- Collaborative studies with PAGASA to address the above needs such as mitigating impact on electrical transmission.

3.5 Transport

3.5.1 Land

Much of total transport needs for bulk goods and passengers are borne by land transportation. Time and again, however, this mode has been subject to difficult conditions caused by adverse weather. Highway engineers will surely appreciate the advice of experts on risks related to rain-induced landslides and flood-susceptible roadways in order to optimize transport flow. Provision of information concerning potential rainfall events of varying return periods based on risk assessment including flood hazard or better yet, flood risk maps must be communicated to motorists and commuters to help them avoid low-lying and flood-prone areas. It shall be noted that the Land Transportation Office (LTO) developed an "Emergency Response Team" mini handbook, as preparedness measure for different hazards.

The needs are:

- Customization of flood forecasts that shows the impacts of rain and floods which will be the basis in issuing weather advisory to commuters in strategic areas
- Accurate short-term and quantitative rainfall forecasts.

3.5.2 Maritime

The Philippines is archipelagic and endowed with rich marine and coastal ecosystems that provide food and livelihood to communities. Sea navigation and fishing are major sources of income of the country. Among the most productive fishing grounds in the country is the Guimaras Strait. Fishing vessels and oil tankers ply this route with such regularity. What happened on 11 August 2006 when an oil tanker carrying more than 2 million liters of industrial fuel or bunker oil capsized in Panay Gulf due to strong winds and high waves resulted in one of the worst damage ever recorded to the sea environment. The accident once again underscored the importance of weather forecasts and climatological data in sea navigation. With appropriate shipping bulletins and warnings, sea navigators can route ships to avoid severe weather, thus reducing risk of injury and damage. Maps of prevailing wind direction during the SW and NE monsoon seasons, climatology of ocean currents and weather patterns along the Philippine Area of Responsibility as well as the frequency of isolines of gale force winds in major sea routes and map of extreme winds should be made available to seafarers.

3.5.3 Aviation

PAGASA's aviation meteorological services play an important role in national development. Air transportation is resorted to when other modes of transportation cannot meet the requirements of various users in terms of convenience, transport time, and safety. More and more people take air transport such that the potential for greater loss of life from aircraft disaster has also increased. The aviation industry needs accurate weather information to help ensure safe, regular, and economical flight operation.

In October 2009, the PAGASA through its Aviation Meteorological Service Section (AMSS) of the Weather Division located at the Ninoy Aquino

International Airport (NAIA) was subjected to audit by the International Civil Aviation Organization (ICAO), along with the Civil Aviation Authority of the Philippines (CAAP). As a result of the audit, the PAGASA applied for ISO certification specifically for its aviation services. With the assistance of the Metals Industry Research and Development Council (MIRDC) of the DOST and the Development Academy of the Philippines (DAP), PAGASA staff members were trained on Quality Management System (QMS) requirements, understanding and implementing ISO 9001:2008 and Quality Management Representative (QMR) skills development. Currently, Procedures Manual and Operations Manual for the Documentation Audit were partially completed in preparation for the ISO Certification of PAGASA's Aviation Meteorology Services in 2012.

A concern is the accuracy and reliability of weather forecasts issued by PAGASA upon which the aviation sector relies completely.

The needs are:

- Terminal Forecast at least three (3) hours before landing
- Calibration of weather instruments installed in 85 airports in the country.

3.6 Construction sector

Construction works are mostly done outdoors hence exposed to the prevailing weather. Construction engineers avail of weather and climate information in order to avoid or reduce the cost of delays caused by inclement weather and to maximize construction activities during extended periods of fine weather. Climatological and hydrological data are also valuable to architects and engineers in the design of buildings and other structures.

The needs are:

- Rainfall intensity duration frequency analysis
- Depth-Area-Duration analysis
- Seasonal outlook.

3.7 Land use and planning

Land use planning also requires hydrometeorological information in order to ensure that areas that are prone to weather related hazards are not developed for human settlement or residential purposes and are adequately protected.

The needs are:

- Long -term synoptic and hydrological data
- Vulnerability and hazard maps
- Risk assessment (flooding, landslides, storm surges, strong winds, etc.)

3.8 Recreation and Tourism

As recreation and tourism as one economic sector is becoming increasingly important, weather forecasts are not only used by visiting tourists to schedule their activities but also by the tourism industry to ensure the safety of tourists and to promote specific tourists destinations. Tourists use air, maritime or land transport in going to their destinations in the country. These modes of transport are vulnerable to severe weather events.

The needs are:

- Weather outlook for planning purposes
- Information about severe weather and localize forecast
- Accurate weather forecasts for tourist resorts
- Short-term forecasts for three (3) to ten (10) days, monthly and seasonal forecasts.

3.9 Health

On health concerns, weather can also be an important and contributing factor in the outbreak and spread of diseases. Changes in temperature can increase the incidence of colds and flu. Exposure to intense sunlight and high temperatures during the dry season can cause heat stroke and skin illnesses, while the onset of rains can result in the outbreak of dengue fever, typhoid fever, water-borne and other communicable diseases. Hence, the PAGASA can provide weather and climate information that can assist public health authorities in planning to address these concerns.

The needs are:

- Improved forecast on temperature, rainfall and air quality
- Accurate forecast on flooded areas
- Studies that will serve as basis to produce tailor-made forecasts.

3.10 Insurance

Another stakeholder of hydrometeorological services is the insurance sector. Based on the Philippine Crop Insurance Corporation (PCIC) data, the two top causes of loss claims for rice and corn crops up until year 2000 were typhoons/floods and droughts (Reyes, et al, 2009). Statistics show that typhoons and floods were the major causes of production damage for rice, while drought was the number one cause of loss for corn. From 1981 to 2007, claims on rice insurance from typhoon/flooding amounted to PhP1.050 billion. The combined rice and corn crop insurance claims attributed to damages from typhoons/floods and droughts amounted to PhP1.7 billion which corresponds to 66% of the total indemnity paid by the PCIC for all insured commodities covering all causes since the start of its operation. This figure alone effectively describes the impact of seasonal climate variability on crop insurance operations and agricultural productivity as a whole.

The losses related to Typhoon Ondoy (Ketsana) in September 2009 that reached PhP11 billion is seen as one of the largest payouts in the recent history of the local insurance industry. Claims for damage to property amounted to PhP10 billion while claims for damage to automobiles reached PhP1 billion according to the Philippine Insurers and Reinsurers Association (PIRA), (Insurance Philippines, July-December 2009). A positive consequence of the catastrophe was a change in viewing insurance as an expense to an investment. As the impact of climate change is likely to cause more frequent and more severe tropical cyclones and floods in the future, insurance will become increasingly an option to cushion the impacts of natural disasters. As a result, insurance companies are requiring more reliable weather advisories and climate outlooks.

The needs are:

- Vulnerability, hazard and risk maps on floods, storm surges, typhoon (strong winds and rains), El Niño/La Niña
- Accurate weather advisories and climate outlooks
- Historical data for risk assessment
- Studies on impacts of climate change/climate variability as they affect insurance/risk transfer mechanisms.

3.11 Disaster Reduction

Following the Fourth Assessment Report of the International Panel on Climate Change (IPCC), all international fora and meetings underscored the link between adaptation and DRR policies. Since climate change and disaster risk management entities have similar aims and benefits, climate change adaptation policies and measures must build on and expand existing DRR efforts in a similar manner that DRR approaches must account for the impact of climate change (Venton and La Trobe, 2008). The Hyogo Framework of Action (HFA) 2005-2015 provides guidance to facilitate a comprehensive, system-wide risk-reducing approach to weather and climate related hazards.

Effective disaster reduction depends not only on the capacities of NMHSs in providing forecasting and early warning services, but also the level of preparedness, specifically coordination among concerned government agencies, private organizations, and the media, as well as involvement of the public (Figure 3.1).

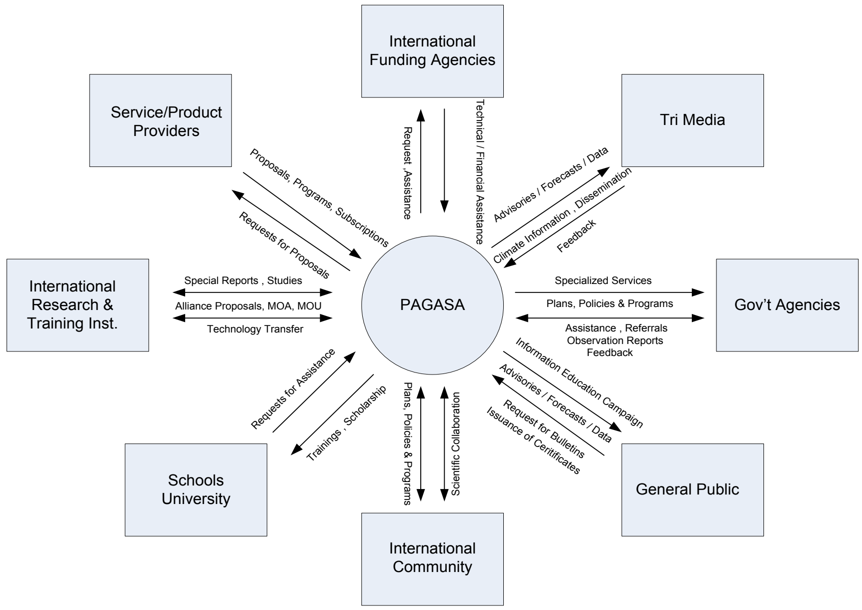


Figure 3.1 PAGASA and its environment

The ASEAN Agreement on Disaster Management and Emergency Response (AADMER) is a regional legally-binding agreement that obliges the ASEAN Member States together to promote regional cooperation and collaboration in reducing disaster losses and intensifying emergency response to disasters in the region. AADMER was signed by ten ASEAN Member States in 2009. The agreement contains provisions on disaster risk reduction, monitoring and early warning, prevention and mitigation, preparedness and response, rehabilitation, technical cooperation and research, mechanisms for coordination and establishment of an ASEAN Coordination Center for Humanitarian Assistance on disaster management (AHA Center). On 14 September 2009, the Philippines ratified the AADMER. The AADMER entered into force on 24 December 2009.

After several years of review in Congress, the Disaster Risk Reduction and Management Act of 2009 was finally passed into law on May 31, 2010. Among the major provisions of the law are:

- Adoption of a DRR framework (a shift in focus from disaster response to preparedness and mitigation);
- Development of a National Disaster Risk Reduction and Management Plan (NDRRMP);
- Mainstreaming of DRR and CCA in development and planning processes, peace processes and conflict resolution approaches;
- Ensuring that DRR and CCA measures are gender responsive, sensitive to indigenous knowledge systems and respectful of human rights
- Establishment of permanent disaster risk management offices in all local government units (LGUs) in the country;
- Enhancement / building the capacity of the Office of Civil Defense (OCD) at all levels; Inclusion of more representatives in the new National Disaster Risk Reduction Management Council (NDRRMC); and
- Renaming the calamity fund as the Local DRRM Fund (LDRRMF) which will allow for the usage of the fund for DRR purposes. At least 5% of the estimated revenue from regular sources which shall be set aside by the local council (previously 5% maximum) and 30% of the 5% shall be allocated as Quick Response Fund or stand-by for relief and recovery programs.

As one of the warning agencies under the new NDRRMC, the PAGASA is also actively involved in pre-disaster activities and community preparedness and planning, and in disaster response activities. The severe weather warning issued by the agency triggers the activation of national action plans to reduce the impacts of severe weather phenomena such as typhoons and the resulting floods and landslides. In coordination with the OCD and other disaster management organizations, PAGASA personnel also serve as resource persons in seminars and workshops given to members of the DRRMCs on disaster risk reduction measures.

In order to achieve a high level of awareness of the population, the PAGASA adopted an aggressive and sustained public awareness program on natural hazards such as typhoons, floods, landslides, and extreme climate events like El Niño and La Niña. This involves utilizing advances in information communication technology (ICT) in the production of information materials in an attractive and easily understood format for the media, general public, decision makers, and development partners. Production of radio and TV plugs, multi-media presentations and conduct of lectures for community disaster preparedness and planning are some of the additional activities of the agency. The information materials are designed to provide the public a clear understanding of the various hydro-meteorological hazards and how to prepare in order to prevent or minimize its adverse effects.

The needs of the disaster reduction sector are:

- Upscaling of community –based early warning system
- Enhancing Information, Education and Communication (IEC) program
- Multi-hazard mapping
- Accurate forecasts and warnings
- Weather and climate information in all time scales
- Real time radar images
- Accurate quantitative rainfall forecasts
- Site specific weather forecasts
- Dispersion modelling for oil spill, etc.
- More frequent tropical cyclone warnings (at least three hourly)
- Improved forecasts on extreme events (floods and droughts).

3.12 Military

The Armed Forces of the Philippines (AFP) also conduct disaster relief operations in various communities during disasters. In 2007, the AFP Disaster Response Task Force (AFPDRTF) conducted 262 search and rescue operations, 145 relief operations, 97 rehabilitation/clearing operations, 93 transport operations and 27 aerial reconnaissance operations. Several air and naval resources as well as 9,655 AFP personnel, were used for these operations. A total of 78,203 persons were evacuated, rescued or transported during the occurrence of destructive typhoons.

To carry out the priority programs of the military would require weather and climate information for operation and planning. The specific needs of the military include:

- Specific weather forecast including winds at different altitudes
- Information and forecast on cloud height
- Upper air observations
- Doppler radar data/images (horizontal and vertical cross sections)
- On-line connection to some hydrometeorological observations.

3.13 Climate change

The PAGASA has generated climate projections for the Philippines using the PRECIS model which is a PC-based regional climate modelling system developed at the Met Office Hadley Centre for Climate Prediction and Research in UK. Model runs result in projection of future changes in temperature and precipitation over the Philippines. The scenarios were developed simulating the baseline climate during the period 1971-2000 for two time-slices centered on 2020 (2006-2038) and 2050 (2039–2065). Initially, A1B emissions scenario of the IPCC was used.

Results of projection show an increasing trend in annual rainfall over most parts of Luzon and Visayas between the range of 2% to 17 % by 2020 and 1% to 16 % by 2050 (Hilario, et al, 2009). On the other hand there is a general reduction in regional annual average rainfall in Mindanao by about 0.5% to 11 % by 2020 and 2% to 11% in 2050. There are large differences in seasonal rainfall. Seasonal temporal rainfall variation projections are depicted in Figure 3.2.

There will be a likely increase by 0.9 ºC to 1.1 ºC by 2020 and from 2 ºC to 2.2 ºC by 2050 for minimum temperature and an average mean minimum rise in minimum temperature for the whole country of about 2ºC by 2050. The southern part of the Philippines (Regions 9,10,11,12, CARAGA and ARMM) will be warmer compared to other parts of the country. The highest seasonal increase is 1.8 ºC to 2.4 ºC during MAM, JJA and SON. Minimum temperature is expected to rise in Region 9 by as much as 2.6 ºC during JJA. Projected changes in seasonal mean temperature are shown in Figure 3.3. Hilario, et al further noted that the quantitative estimates have large associated uncertainty. These scenarios will be able to provide indicative figures that are useful inputs for long-term planning by the various sectors in the country.

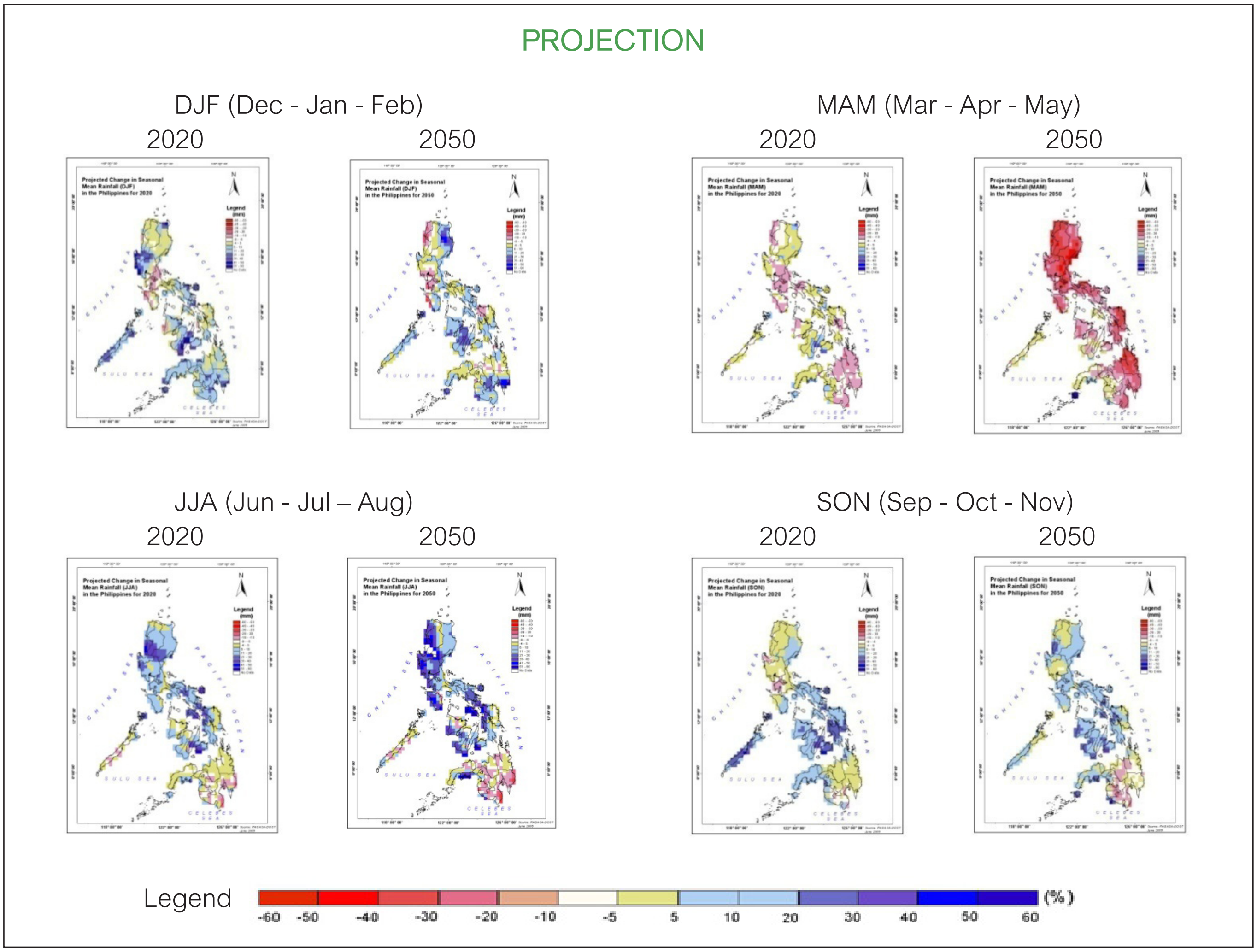


Figure 3.2 Projected changes in seasonal mean rainfall (%) (Source: Climatological and Agro-meteorological Division (CAD), PAGASA).

Some of the major conclusions are as follows:

- Model simulations under A1B emissions scenario indicate a marked increase in temperature in 2020 and 2050. The simulation results were able to detect the variation of temperature in the different regions the country.
- Widespread warming is projected in all parts of the country, but there are substantial spatial differences in the projected rainfall changes.
- A major bias involving underestimation of temperature is evident in all the project sites.
- The pattern correlation is significant for temperature indicating that there is coherence in the spatial pattern between the two data sets.
- It is likely that the drier seasons of DJF and MAM will become drier and the wetter season of JJA and SON becoming greater and wetter with time.
- Reduction in rainfall in most areas of Mindanao is seen for all seasons by 2050.
- A much active and stronger southwest monsoon season is projected as seen in significant increases in rainfall in JJA becoming greater with time.

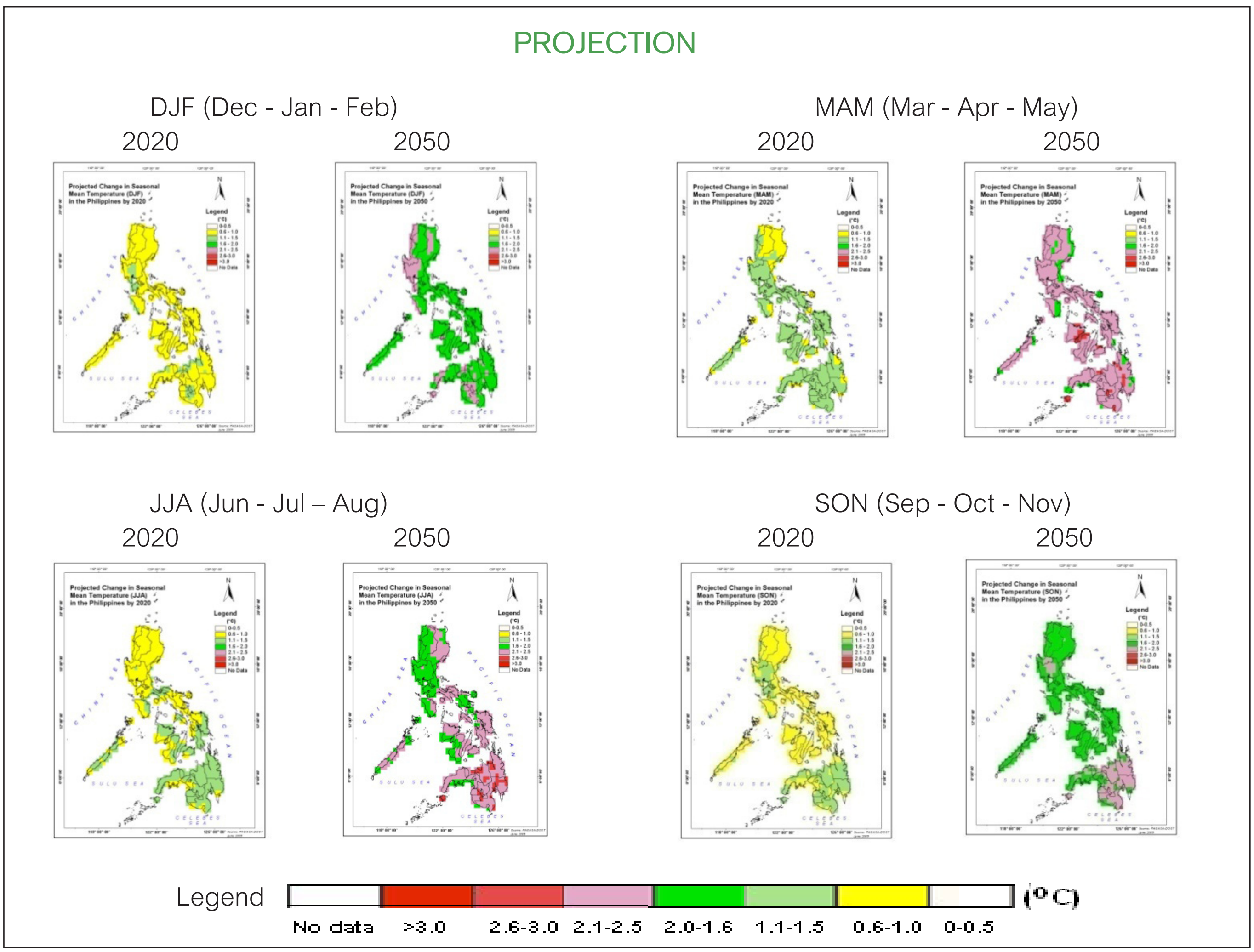


Figure 3.3 Projected changes in seasonal mean temperature (oC) (Source: PAGASA, 2011. Climate Change in the Philippines)

3.14 Media

Philippine media is very active in covering and broadcasting weather events. In the past decades, the media has been critical of PAGASA, however, with the series of in-house media seminars and workshops conducted since 2003 up to the present, the media has become an ally and partner of PAGASA in properly disseminating forecasts and warnings in a timely manner and in the promotion of important issues like climate change, disaster risk reduction, importance of hydrometeorological services to the various socio-economic sectors and its role in national development. During the passage of typhoons, the media are mainstays in the PAGASA premises to cover press briefings and conferences that are conducted four (4) times a day. To maintain the one voice policy, the PAGASA has designated spokespersons in various issues such as weather and tropical cyclone information, hydrology and flood information, and climate related information.

Needs:

- Audience-centered ways and means to help media communicate forecasts
- Continuation of IEC programs for media (including meteorological processes and hydrological processes).

4 THE NATIONAL METEOROLOGICAL AND HYDROLOGICAL SERVICES IN THE PHILIPPINES IN A NUTSHELL

4.1 Historical overview and Legal basis

The PAGASA is the National Meteorological and Hydrological Service (NMHS) institution in the Philippines. It is mandated to provide weather, flood, climate and astronomical products and services to promote the people's safety and well-being, and contribute to national development.

Weather forecasting started as a private undertaking of the Jesuits in 1865, known then as Observatorio del Ateneo Municipal. It was transformed into a government undertaking in 1884 through a Decree by the King of Spain and became Observatorio Meteorologico de Manila. During the American regime, it became known as the Weather Bureau pursuant to Act No. 131 by the Philippine Commission in 1901. It finally became PAGASA in 1972 by the issuance of Presidential Decree No. 78, a span of over 140 years of service to the Filipinos. The PAGASA has advanced its services not only in weather forecasting but also in other allied fields to address the needs of the country. By mid-70s, flood forecasting and typhoon moderation were included as a major functions. By the mid-80s, the PAGASA was attached to the Department of Science & Technology (DOST).

Emerging scientific and technological capabilities in weather, flood and climate predictions are matched by increasing national needs for improved warnings and forecasts and a more integrated focus in these three scientific disciplines without losing sight of its astronomical services. PAGASA is now in the process of implementing its automation program which will considerably enhance its products and services that will provide users with information tailored for their specific needs.

4.2. Office location

The PAGASA central office is situated on a 75,000 square meter lot within the national government center in Quezon City. The Central Office is a 4-storey building which was constructed in 2000. Less than a kilometre from the Central Office is the Weather and Flood Forecasting Center (WFFC), a 2-storey building within a 40,000 square meter lot. Built in 1990, the latter houses the two major operational divisions of PAGASA, namely the Weather and Hydrometeorology Divisions. The two buildings are quite modern and meet the requirements of a standard NMHS office. However, there is a need to upgrade the facilities of the field stations and some of its infrastructures to be at par with other NMHSs in the region.

4.3 Organizational structure

The Agency has continuously undergone institutional restructuring to keep up with the trends in technology in order to enhance its services and address the needs of the public. In October 2008, the PAGASA was reorganized through Executive Order (EO) 128 consisting of five (5) technical divisions shown in Figure 4.1 with the following functions:

- Maintain a nationwide network pertaining to observation and forecasting of weather and other climatological conditions affecting national safety, welfare and economy;
- Undertake activities relative to observation, collection, assessment and processing of at mospheric and allied data for the benefit of

agriculture, commerce and industry;
- Engage in studies of geophysical and astronomical phenomena essential to the safety and welfare of the people;
- Undertake researches on the structure, development and motion of typhoons and formulate measures for their moderation; and
- Maintain effective linkages with scientific organizations here and abroad, and promote exchange of scientific information and cooperation among personnel engaged in atmospheric and astronomical studies.

The five (5) technical divisions are composed of several sections as follows:

a) Weather Division (WD)
   - Weather Forecasting Section (WFS)
   - Techniques Development and Satellite Section (TDSS)
   - Meteorological Telecommunication Section (MTS)
   - Marine Meteorological Section (MMS)
   - Aviation Meteorology Section (AMS)

b) Hydro-Meteorology Division (HMD)
   - Flood Forecasting and Warning Section
   - Hydrometeorological Data Application Section
   - Hydrometeorological Telecommunication Section

c) Climatology and Agrometeorology Division (CAD)
   - Climate Data Section (CDS)
   - Climate Impact Assessment Section (CIAS)
   - Climate Monitoring and Prediction Section (CLIMPS)
   - Farm Weather Forecasting Section (FWFS)

d) Research & Development and Training Division (RDTD)
   - Numerical Modelling Section (NMS)
   - Hydrometeorology and Tropical Meteorology Research and Development Section (HTMRDS)
   - Climate and Agrometeorology R&D Section (CARDS)
   - Training and Public Information Section (TPIS)
   - Astronomy and Space Science Section (ASSS)

e) Engineering and Technical Services Division (ETSD)
   - Meteorological Guides and Standards Section (MGSS)
   - Infrastructure Section (IS)
   - Meteorological Equipment and Instrument Section (MEIS)

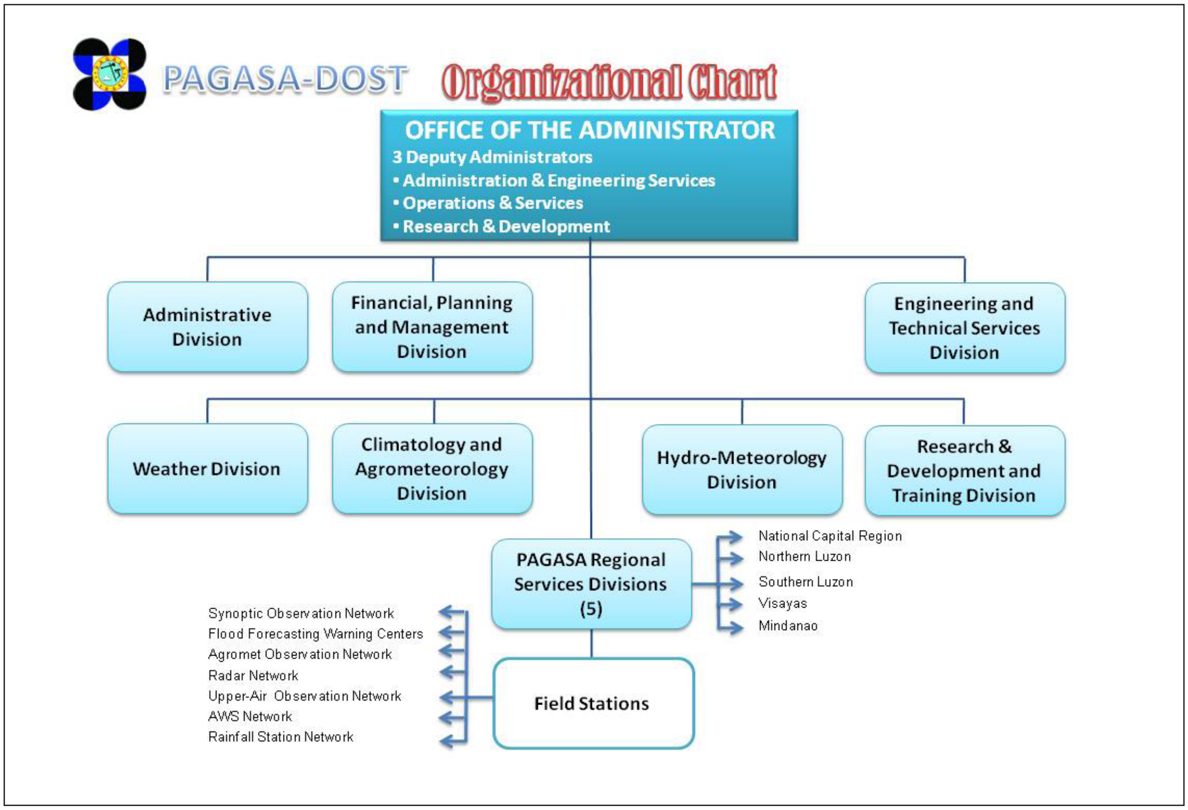


Figure 4.1 Organizational structure of PAGASA
(Source: PAGASA, as approved by the Department of Budget and Management)

In line with the efforts of the national government to serve its citizenry down to the community level, the Rationalization Program includes the establishment of five (5) PAGASA Regional Service Divisions (PRSDs) to decentralize PAGASA's services. The PRSDs provides regional and local forecasting services that facilitate the timely delivery of services and increase the visibility of PAGASA in the provinces and far-flung areas that are highly vulnerable to hydrometeorological hazards. The five PAGASA Regional Service Centers are:

a) Northern Luzon Regional Service Division in Tuguegarao, Cagayan
b) Southern Luzon Regional Service Division in Legazpi, Albay
c) Visayas Regional Service Division in Mactan Island, Cebu
d) Mindanao Regional Service Division in El Salvador, Misamis Oriental
e) National Capital Regional Service Division in Quezon City, Metro Manila.

The Regional Service Divisions are headed by Weather Services Chiefs.

4.4 Mission and vision

PAGASA's mission is to provide weather, flood, climate and astronomical services and products to promote the people's safety and well-being in order to contribute to national development. The agency's vision is related to the PAGASA Strategic Plan 2008-2012: Working together for a safer nation to provide the best weather, flood and climate information for the Philippines in order to:

- reduce weather- and water-related fatalities and damage to properties;
- generate and deliver information that can be trusted when needed;
- infuse proven advances in S&T;

- work with stakeholders to make the weather, flood and climate endeavour more effective;
- measure, report and evaluate performance; and
- enhance research collaboration with international scientific communities.

4.5 Annual report

The PAGASA regularly prepares an annual report at the beginning of each year in preparation for the yearly budget deliberation by the Philippine Congress. A copy of the report is available upon request.

4.6 Financial resources

The PAGASA maintains a wide range of monitoring stations that entails considerable maintenance costs. Its annual operating budget covers personal services (PS), maintenance and other operation expenses (MOOE) and capital outlay (CO). The fiscal budget from 2000 to 2010 is shown in the Table 4.1.

Table 4.1 Annual budget of PAGASA

Year	Personnel services (PS)	Maintenance & other operating expenses (MOOE)	Capital outlay (CO)	Total	Other Releases
2000	207,722,000	134,136,000	10,050,000	351,908,000	
2001	229,188,000	117,008,000	500,000	346,696,000	
2002	230,582,000	103,468,000	56,000,000	390,050,000	
2003	247,255,000	87,555,000	-	334,810,000	
2004	236,603,000	87,555,000	-	324,158,000	25,900,000
2005	235,280,000	87,555,000	-	322,835,000	110,000,000
2006	230,801,000	87,555,000	-	318,356,000	39,144,000
2007	241,216,000	*108,755,000	209,000,000	558,971,000	279,000,000
2008	242,703,000	*215,339,000	88,852,000	546,894,000	535,760,000
2009	261,450,000	168,531,000	337,500,000	767,481,000	400,000
2010	229,081,000	*385,146,000	169,358,000	783,585,000	
2011	238,478,000.00	378,285,000.00	200,361,000.00	817,124,000.00	

**Foreign Assisted Projects included*

Budget releases from 2003 to 2006 were at a minimum and this was spent for the payment of basic operating expenses, with very limited budget for maintenance of monitoring facilities and equipment. After a four-year moratorium, there was a surge in the budget for CO and MOOE for infrastructure projects that include foreign-assisted projects. The disaster that occurred in 2004 served as a wake up call and paved for the prioritization of a phased modernization of PAGASA equipment and facilities. From 2007 up to the present, PAGASA has been a beneficiary of several grant projects from various foreign donors. “Other releases” refer to allocation apart from the approved budget during the fiscal year through the Government Appropriations Act (GAA); these releases for special or emergency purposes that are approved through a special allotment release order (SARO) with corresponding Notice of Case Allocation (NCA).

4.7 Human resources

Over the past 147 years since the weather service was established in the country, the progress of the agency was achieved in parallel with the professional growth and development of its human resource. The PAGASA has a pool of 887 (as of 2008) personnel broken down by Science and Technology (S&T) functions: 78 administrative, 198 research and development, 603 S&T service delivery and eight are engaged in Science Technology Education and Training Program. The work force of PAGASA is considered a critical resource considering that meteorology and hydrology are specialized fields; expertise in these fields is only available in the agency. The PAGASA has a pool of technically trained personnel in specialized fields from weather observation, operation and maintenance, weather forecasting, research and training development, information technology, and administrative management (Table 4.2).

The average age of PAGASA's personnel is 49 years, however young technical personnel are being recruited and trained further to uplift its work force. This is one of the top priorities of the Agency. Moreover, the PAGASA is continuously losing its forecasters to private organizations offering lucrative salaries abroad. Continuous training of young recruits to become forecasters has to be sustained by the agency. To address this problem, the Agency has supported six post graduate scholars under the PAGASA Scholarship Program in 2011.

Table 4.2 Distribution of PAGASA personnel according to educational levels

Level of Education	Total No. of personnel
PhD graduate	11
MS graduate	50
Diploma graduate	5
Postgraduate	1
BS graduate	434
BS Undergraduate	378

Under the DOST-Science Education Institute (SEI) scholarship program, 16 PAGASA personnel are pursuing MS degrees in atmospheric science at the Ateneo de Manila University.

4.8 Training Programmes

To keep pace with the advancement in meteorology and related disciplines, the agency regularly undertakes several in-house training courses to improve the capabilities of its personnel. Some of the training courses that are conducted by the agency for its staff and for some participants from other NMHSs are as follows:

Regular Courses include the Meteorologist Training Course (MTC) and the Meteorological Technician's Training Course (MTTC). Courses that are offered on ad hoc basis are Agrometeorology, Hydrology, Flood Forecasting, Agrometeorology, Weather Forecasting, Climatology, Radar Operation and Applications, Marine Meteorology, Operation and Maintenance of Hydrometeorological Equipment and Facilities, and Computer Literacy Training.

4.9 Visibility of PAGASA

As the country's provider of hydrometeorological forecasts and information and owing to the frequent occurrence of hydrometeorological events that are weather and climate related, the PAGASA enjoys high visibility in public. With the series of disasters and tragedies in recent years and with the increasing impacts of climate change in the country, the national government, private sector, academe and the general public now recognize the critical role of PAGASA in disaster risk reduction and sustainable economic development. Although the Agency does not have its own broadcast media facility, practically all TV, radio and print media consistently cover the Agency's activities. Requests for lectures and media interviews on hydrometeorological hazards, the impacts of climate change and the Philippine climatic trends have soared to the extent that PAGASA is now having difficulty in attending to these requests.

As soon as a tropical cyclone threatens the Philippines,TV stations would set up their mobile broadcast facilities at the Weather and Flood Forecasting Center to get round the clock updates on weather and flood forecasts through press briefings held four times a day as well as interviews with forecasters.

4.10 International membership and networking

The PAGASA is the WMO-designated Regional Meteorological Training Center for South Pacific and is a member of the UNESCAP-WMO Typhoon Committee, International Civil Aviation Organization (ICAO) and the WMO and has established affiliations with international organizations such as the United Nations Environment Program (UNEP), United Nations Development Program (UNDP) as well as the Intergovernmental Panel on Climate Change (IPCC). It also has linkages with the Asia Pacific Climate Network (APCN), International Center for Theoretical Physics (ICTP), International Oceanographic Commission (IOC), ASEAN Committee on Science and Technology (COST), the Asia Pacific Climate Center (APCC), and Regional Integrated Multi-Hazard Early Warning System (RIMES), among others.

The PAGASA is also engaged in a number of projects funded by international organizations such as the Japan International Cooperation Agency (JICA), the Korea International Cooperation Agency (KOICA), the Taiwan Economic Cooperation Office (TECO), UNDP, the United States Trade and Development Agency (USTDA), the Norwegian Agency for Development Cooperation (Norad), the Australian Center of International Agricultural Research (ACIAR), GeoScience Australia (GA), Bureau of Meteorology (BoM), and the Australian Agency for International Development (AusAID), the United States International Agency for International Development (USAID) and the Asian Disaster Preparedness Center (ADPC).

The Agency has signed Memorandum of Understanding (MOU) for sharing of data and information and the conduct of collaborative research and training with the Korea Meteorological Administration (KMA), the Ministry of Natural Resources and Environment (MoNRE) of Viet Nam, and Japan Agency for Marine Science and Technology (JAMSTEC).

4.11 Cooperation with other providers of hydrometeorological services in the Philippines

Weather enthusiasts that provide tropical cyclone forecasts and warnings in the web should serve as a challenge for PAGASA to enhance its linkages and improve its services.

For hydrological services, cooperation among government agencies, specifically in flood forecasting and warning for dam operation (FFWSDO) is well in place. The PAGASA chairs the Joint Operation and Management Committee (JOMC) of the FFWSDO. The JOMC oversees the judicious operation of the reservoirs during flood season. The member agencies that manage the operation of the major reservoirs include the National Irrigation Administration (NIA), National Power Corporation (NPC), and Metropolitan Waterworks and Sewerage System (MWSS). Other members which act as monitoring agencies include the Office of Civil Defense (OCD), Department Public Works and Highways (DPWH), National Water Resources Board (NWRB), and Metro Manila Development Authority (MMDA). NWRB reviews and approves protocols such as flood operation rules of dams.

In response to recent major flood disasters, the updating of protocols has been done. According to the revised protocol, chief executives of local government unit are issued warning four (4) hours before opening the spillway of a dam. JICA supports a technical cooperation project for FFWSDO with PAGASA/HMD; O&M of equipment has been identified as one of its crucial components, even as the observation network is being expanded.

In the case of Metro Manila, a flood forecasting and warning system called Effective Flood Control Operation System (EFCOS), mainly works at the downstream of the Pasig-Marikina river basin. Developed by the DPWH and consequently transferred to MMDA for its operation, EFCOS is designed to connect also with PAGASA in Science Garden. Cooperation to run such a system in a very important highly urbanized area as Metro Manila entails adequate technical support and budget from PAGASA.

CURRENT SERVICES OF NMHS

5

As the NMHS institution in the Philippines, the PAGASA provides the following products and services to meet the demands of the different economic sectors (Table 5.1).

Table 5.1 PAGASA's major products and services

Services	Products	Issuance
1. Weather Forecast and Tropical Cyclone Warning	Public weather forecasts	2x a day
	Severe weather bulletins	4x a day
	Shipping forecasts	2x a day
	Tropical cyclone warning for shipping	2x a day
	Gale warning information	2x a day
	Airways and terminal forecasts	
	METAR	2x a day
	TAFOR	2x a day
	Special forecast for Mayon Volcano	2x a day
	Forecast for selected Philippine cities/municipalities	2x a day
	Information on the onset of monsoon	1x a year
	Information on the termination of monsoon	1x a year
2. Flood Forecasting & Warning Services	Flood bulletins for monitored river basins	2x a day
	Flood bulletins for monitored dams	4x a day
	Flood warning information – for dams	Every 3-6 hrs
	General flood advisories –non-telemetered river basins	2x a day
	Hydrological forecasts – during non flood watch	1x a day
	Flood situationer for Metro Manila	2-4x a day
	Establishment of Community-based Flood EWS	Per request
	Public information drives for monitored dams	1x a year
3. Climatological & Farm Weather Services	Daily farm weather forecast & advisories	1x a day
	10-day regional agroclimatic weather & advisories	1x a day
	10-day Philippine Agroclimatic Review & Outlook	1x a month
	Monthly Weather Situation and Outlook	1x a month
	El Niño/La Niña advisory	1x a month
	Annual seasonal forecasts	1x a year
	Philippine Agroclimatic Review and Outlook	1x a month
	Press release on significant events	As need arises
	Philippine agri-weather forecast	1x a month
	Climate impact Assessment Bulletin for Agriculture	1x a month
4. Astronomical Services	Philippine Standard Time	1x a week
	Stargazing/telescoping sessions, lectures and shows	As need arises
	Seminar for science teachers on basic astronomy	1x a year
	Planetarium tour in selected areas in Luzon	As need arises

Note: METAR – Meteorological Aerodrome Report; TAFOR- Terminal Area Forecast.

5.1 Weather services

The provision of timely, accurate and reliable weather forecasts, advisories and warnings is a continuing challenge to NMHS in the Philippines. Forecasts of extreme weather condition are crucial to mitigate impacts on life and property.

Formulation of weather and typhoon forecasts and warnings utilizes satellite and radar information, observed data from all available observation stations such as ship reports, upper air and synoptic stations as well as from automatic weather stations, and output of numerical weather prediction models (NWPs) available to PAGASA that includes Mesoscale Model MM5, Global System for Mobile Telecommunication (GSM), ETA model (the old version of Weather Research and Forecasting or WRF model), and High Resolution Model (HRM).

In addition, advanced weather surveillance radars which are capable of providing information on rainfall intensity, wind speed, and other relevant parameters will enable PAGASA to expand its operational services to include nowcasting and localized forecasting at the community level.

Table 5.2 Types of forecast issued by PAGASA

Type of forecast	Validity/lead time	Frequency	Availability on website
Nowcasts	0	0	No
Very short	24 hours	2x a day	Yes
Short range	72 hours	Daily	Yes
Mid-range	7 to 10 days	Daily	Yes
Long range	30 days ahead	1x a month	Yes
Seasonal	Next 3 months	1x a month	Yes

5.1.1 Processing and visualization tools

Visual tools depicting the outputs of numerical models in the form of isobaric streamline or rainfall charts are useful in the formulation of forecasts. The PAGASA is currently using the GRADS software and GIS for the visualization of NWP outputs as well as its forecast products that are made available to various end-users. All forecasts are disseminated to the concerned government agencies and the other sectors as well as the media through fax, SMS, Tweeter and e-mail as well as posted in the PAGASA website.

5.1.2 Accuracy of forecasts

Tropical cyclone track forecasts including monthly and seasonal rainfall forecasts are verified regularly using statistical methods. At present, no verification is done for the daily weather forecasts and other forecasts issued by PAGASA.

5.1.3 Users of weather, flood and climate information and forecasts

The increasing frequency of extreme weather and climate events has heightened the awareness of the general public. The key sectors of the economy, the government and the media are demanding more frequent, accurate and reliable forecasts.

At present, PAGASA's forecasts and services provided to the general public are free of charge. However, plans for commercialization of some PAGASA products are underway. The demand for tailor made forecast has increased and with this development, the PAGASA is taking the challenge to improve its analysis, visualization and production tools to cater to the needs of individual sectors such as water resources and agriculture. But an important prerequisite to achieve this is the upgrading of its telecommunication facilities and forecast automation which the PAGASA seeks to realize in the next three (3) years.

5.1.4 Needs for weather forecasts and real-time meteorological data

The geographical location of the Philippine makes its real-time weather information critical to neighbouring countries, especially during the typhoon season. As soon as a tropical disturbance has developed in the Pacific and threatens to cross the Philippines, all the neighbouring areas such as Japan, Viet Nam, Cambodia, Thailand, China, Korea and Lao PDR start to closely monitor the weather disturbance and assess its possibility of affecting their respective countries. In view of this, enhancing the observing network of PAGASA and sharing all observed data will greatly benefit other countries in the region.

5.2 Early warning system

The PAGASA's weather and hydrological services fulfil the requirements for a 24/7/365 on-line service pending completion and operationalization of all Doppler radars and automation program. "Nowcasts" services are being developed as the said program progresses.

At present, round the clock monitoring of hydrological events is limited to the four (4) major river basins which are equipped with automatic monitoring facilities. There are eighteen (18) major river basins and 421 principal river basins in the Philippines which are highly vulnerable to floods in the event of heavy thunderstorms and other severe weather phenomena and would require telemetered flood forecasting and warning system. Moreover, the current flood bulletins are textual and too technical for the end users and there is a demand for more understandable forecasts showing the limits of inundation and the infrastructures at risk. This will require the utilization of GIS and exposure data for the decision makers to appreciate the forecast.

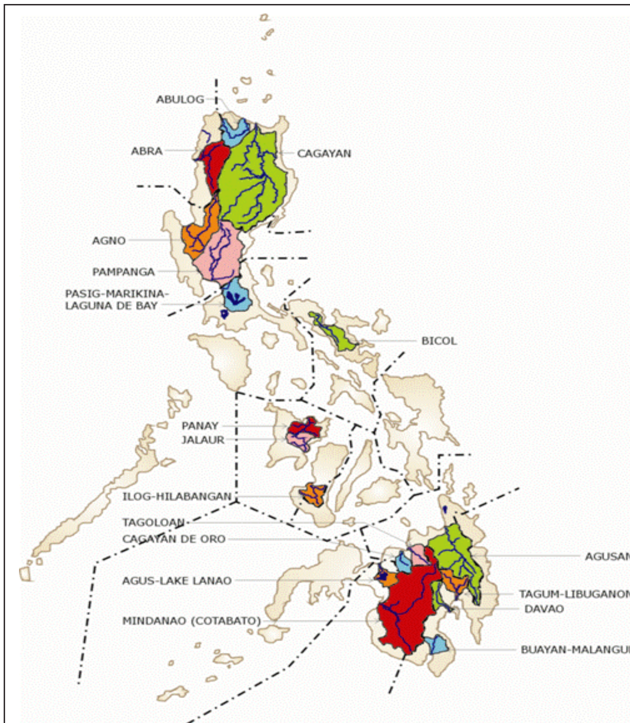


Figure 5.1 Major river basins in the Philippines
(Source: Hydrometeorological Division, PAGASA).

For weather forecasts, the existing monitoring network and telecommunication system limit the issuance of tropical cyclone updates to six-hourly despite the demand for more frequent issuance of bulletins. Information on the location of extreme wind intensities in a typhoon will also be very useful for the energy and other socio-economic sectors.

The PAGASA's existing telemetered Flood Forecasting and Warning System (FFWS) in the Pampanga, Agno, Bicol and Cagayan river basins should be expanded to cover other ungauged major river basins (Figure 5.1) in the country that includes the following :

1) Luzon Island: National Capital Region River Basin, Abra River Basin, Abulug River Basin
2) The Visasyas: Panay River Basin, Ilog-Hilabangan River Basin
3) Mindanao Island: Agusan River Basin, Buayan-Malungan River Basin, Davao and Cagayan de Oro River Basin, Mindanao (Cotabato) River Basin, Tagaloan River Basin, Tagum-Libuganon River Basin

In addition, DOST is implementing the nationally-budgeted National Operational Assessment of Hazards (NOAH) project which focuses on establishment of EWS in the country's major and principal river basins.

Currently, PAGASA is conducting a study to establish a Rainfall Warning System (RWS) for Metro Manila. The RWS is an end-to-end rainfall warning decision support tool designed to alert concerned communities and the decision-makers about the occurrence of heavy rainfall event that may cause flooding or aggravate existing flooding. This study is conceived to serve the needs of decision-makers and other stakeholders and provide easy-to-interpret information that allows individuals and communities to protect their lives and properties. Early warning information empowers people to take action when a disaster is about to happen. The information provided by EWS enables authorities and institutions at various levels to take appropriate actions, and immediately and effectively respond for any eventualities.

The early warning process consists of the following:

- Monitoring and warning development
- Dissemination/communication of warnings
- Response protocol; and
- Warning verification/validation.

The rainfall information will come from in-situ rain gauges, radar-derived rainfall measurements, satellite estimates and other related data. The RWS will use color-coded warning levels corresponding to the amount of rainfall. When the system is finalized, PAGASA will launch a massive information drive to educate the public and the LGUs on the different warning levels.

5.3 Climatological and agrometeorological services

The agency operates and maintains a climatological data bank where various types of field weather observational data are stored and archived. These data and related information are very essential for climate impact assessment, crop-weather relationship studies, and climate analysis. Climatological data also serve the information needs of development planners and decision makers in both private and government sectors.

The PAGASA started issuing climate outlooks during the 1986-1987 El Niño when it established the Drought Early Warning and Monitoring System (DEWMS) in 1986. The DEWMS evolved to become the National ENSO Early Warning and Monitoring System (NEEWMS) to further enhance the monitoring and assessment of the extreme climate events i.e. El, Niño and La Niña. In 1997, the NEEWMS was re-organized into the Climate Information, Monitoring and Prediction Section (CLIMPS), the Philippine version of the WMO CLIMPS project, adopting a new approach for the provision of climatological services, which integrated past, present and future climate information. The CLIMPS has the following operational activities:

- Continuous monitoring and analyses of the climate affecting the Philippines;
- Collection, application and interpretation of various global indicators influencing the Philippine climatic condition;
- Development/validation of indices and methodologies to predict, monitor and assess potential impacts of climatic fluctuations for socio-economic benefit;
- Provision of advisories, updates and outlooks, especially in relation to ENSO and its impacts in the Philippines; and
- Information and Education Campaign.

One of the activities of the CLIMPS is the conduct of a regular Climate Outlook Forum which aims to: 1) develop an understanding of extreme weather and climate events (El Niño, La Niña, tropical cyclones, etc.) and how they impact on the different sectors; 2) increase awareness on available PAGASA services for the different sectors and on the use of climatic data and information for various activities; and 3) validate climate information with the view of making them more user friendly.

To address the needs for long-lead information related to ENSO and seasonal climate variability, the PAGASA regularly issues seasonal climate forecasts (SCF). These forecasts help farmers and decision makers by guiding them to be prepared to deal with fluctuations in the seasonal climate and income losses. SCF applies probabilistic approach in projecting climatic deviations within the season. PAGASA is guided by outlooks released by international climate centers such as the National Center for Environmental Prediction/Climate Prediction Center (NCEP/CPC) of National Oceanic and Atmospheric Administration (NOAA), International Research Institute (IRI) for Climate and Society, APEC Climate Center (APCC), and the Australian Bureau of Meteorology (BoM) for forecasts.

In addition, statistical models are currently being used by PAGASA in seasonal rainfall forecasting, such as Climate Predictability Tools (CPT) and CPT is a forecasting tool developed by IRI while Rainman statistical software has been developed by the Australian Center for International Agricultural Research (ACIAR) that uses ENSO and ENSO phase indicators.

Maps comparing the expected monthly/seasonal condition as a percentage of normal and as deviation from normal are used in presenting the forecast. To disseminate the SCF and other climate information and to promote discussion, quarterly forums are conducted by PAGASA attended by institutional partners and key stakeholders. During ENSO events, the forum is held on a monthly basis. Among those who regularly attend the forum are representatives from various economic sectors, representatives of interagency committees involved in water resource management, agriculture and disaster management, and other end-users. The Climate Forum is a regular activity that began in March 2003.

Farmers get most climate related information from television and radio programs. Regular press releases are also made by the agency especially during extreme climate events. Local agricultural technicians also help disseminate appropriate advisories. All products of the Climatology and Agrometeorology Division are published in the PAGASA website (Figure 5.2).

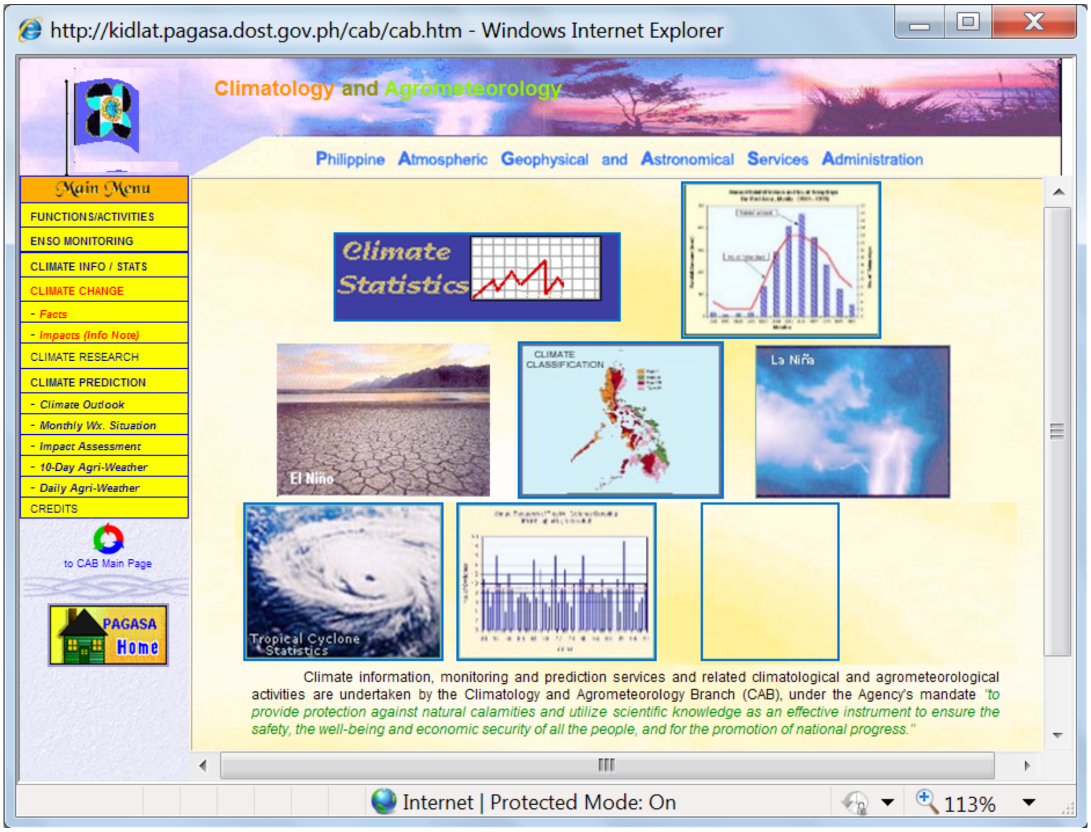


Figure 5.2 Website of the PAGASA's Climatology and Agrometeorology Division.

5.4 Hydrological services

The rainfall and water level of monitored rivers, lakes and reservoirs are measured by automatic water level gauge which are programmed to transmit observed data every hour to the field centers and consequently to the central flood forecasting center. Transmitted real-time data are stored in the computer for processing and displayed through computer monitors. Each station is equipped with a data logger and stored data are retrieved during the quarterly inspection.

The river discharge is computed using a rating equation relating water level and flow of the river. The rating equation or rating table is established by conducting hydrographic surveys such as discharge measurements and cross-sectioning of the river channel every quarter or during low, medium and high flows. The rating curve defines the relationship between the water level and the discharge or runoff. Discharge measurements are carried out using the current meter or by slope-area method. Real-time data are utilized for flood forecasting and warning services.

In 1973, the pilot flood forecasting and warning system (FFWS) was established in the Pampanga river basin. Because of its effectiveness in mitigating the impacts of floods, similar systems were put up in the Agno, Bicol and Cagayan (ABC) river basins in 1983. The unprecedented release of flood waters in one of the major reservoirs in Luzon facilitated the establishment of the FFWS in the major reservoirs of Angat and Pantabangan in 1986 and in 1992 for Binga/Ambuklao and Magat dams. The issuance of flood bulletins is limited to the telemetered river basins of Pampanga, Agno, Bicol and Cagayan and in the target areas of the four (4) telemetered major reservoirs (Figure 5.3). The daily status of monitored reservoirs is displayed on the PAGASA website (Figure 5.4). The PAGASA also acts as a monitoring agency in the Effective Flood Control Operation System (EFCOS) of the Pasig-Marikina-Laguna Lake basin that encompasses the urban catchment of Metro Manila. In a KOICA-assisted project, the FFWS is being enhanced in Metro Manila.

With the prevalence of flooding in ungauged river basins, PAGASA initiated the establishment of community based flood early warning system (CBFEWS). In 2004, the people-centered methodology for CBFEWS was developed and introduced in pilot areas using a river basin approach. The CBFEWS highlights the participation of the community and local government units in the observation, transmission, and analysis of observed data including the issuance and dissemination of flood advisories to flood prone communities. This strategy is developed to address the issues and complexity of factors surrounding the forecasting of floods which would require cooperative and multidisciplinary effort among meteorologists, hydrologists, town planners and civil defense authorities. At present, the areas that are covered by CBFEWS include the two (2) major river basins of Jalaur and Agus-Lake Lanao.

Flood bulletins are disseminated to the public through the OCD, other concerned government agencies, private institutions and the media. To make predictions as accurate as possible, the PAGASA needs to undertake flood forecasting based on quantitative precipitation forecasts (QPFs) taking advantage of weather radar and satellite data. This is an issue that is frequently raised by the national government and the public after every occurrence of a flood disaster.

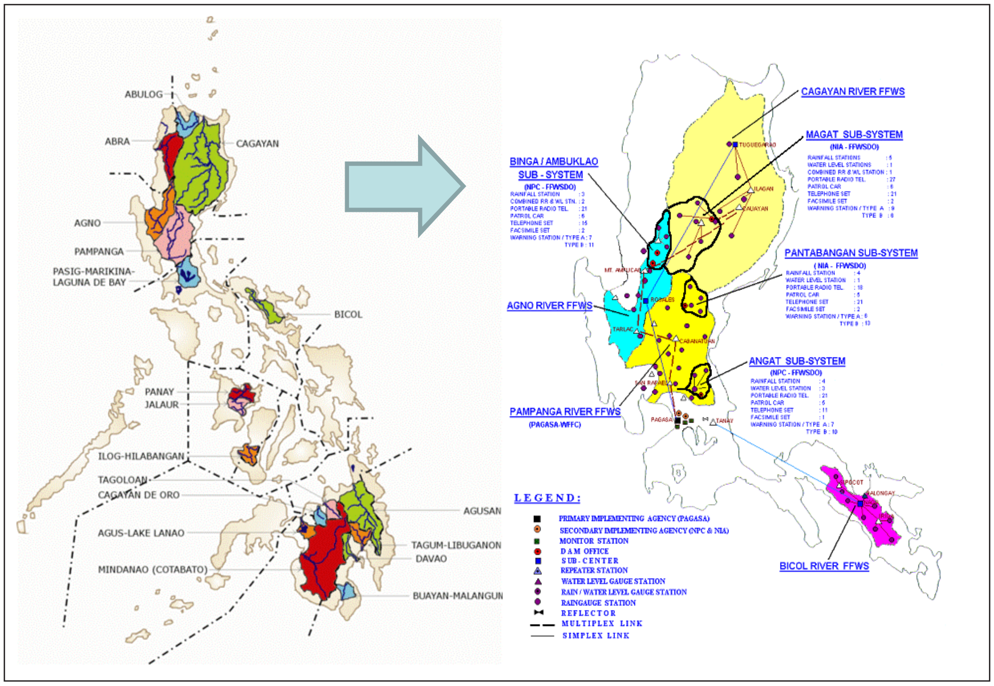
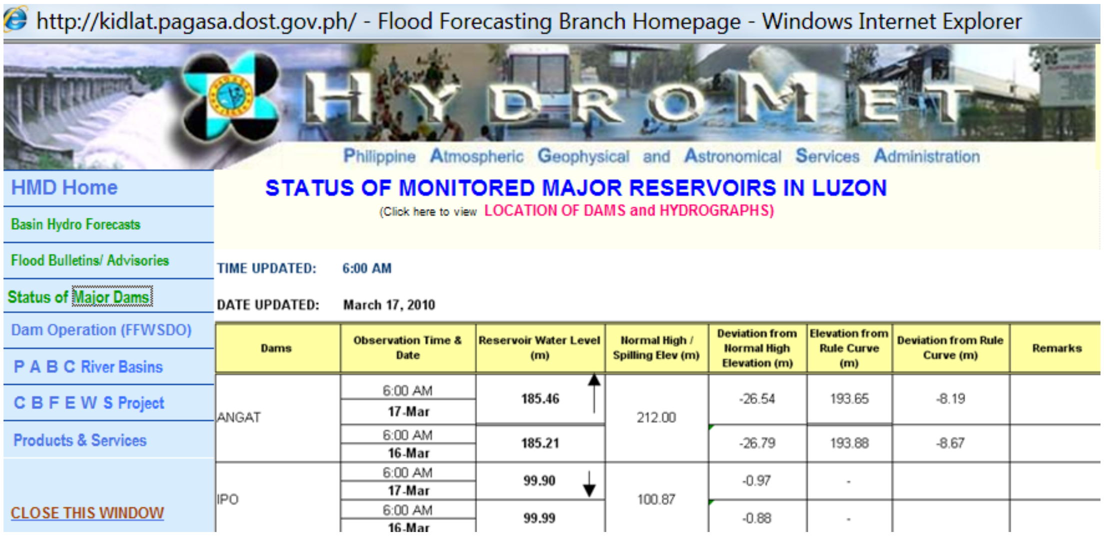


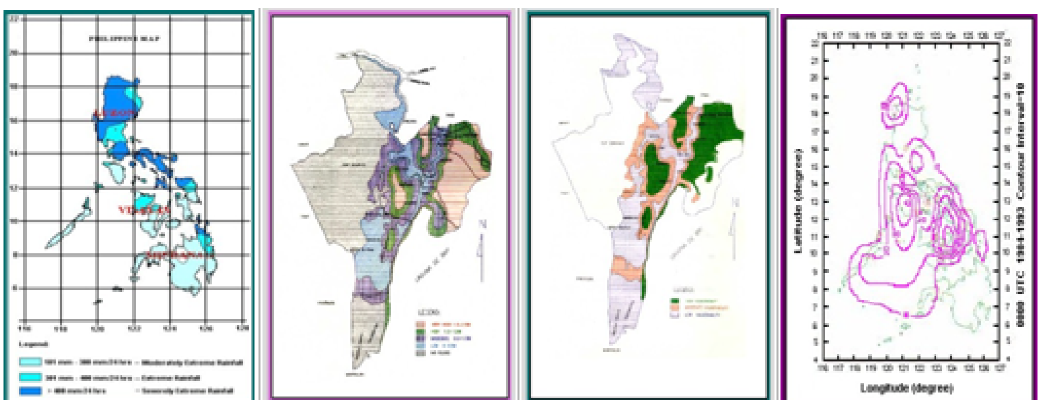
Figure 5.3 Location of major river basins (left) and basins equipped with telemetered flood early warning systems (right) (Source: Hydrometeorological Division, PAGASA).



Dams	Observation Time & Date	Reservoir Water Level (m)	Normal High / Spilling Elev (m)	Deviation from Normal High Elevation (m)	Elevation from Rule Curve (m)	Deviation from Rule Curve (m)	Remarks
ANGAT	6:00 AM 17-Mar	185.46	212.00	-26.54	193.65	-8.19	
	6:00 AM 16-Mar	185.21		-26.79	193.88	-8.67	
IPO	6:00 AM 17-Mar	99.90	100.87	-0.97	-		
	6:00 AM 16-Mar	99.99		-0.88	-		

Figure 5.4 Example of daily status of monitored reservoirs on the PAGASA webpage.

Other hydrological services include products from statistical analyses of hydrometeorological data such as rainfall intensity duration frequency (RIDF), probable maximum precipitation (PMP), depth-area-duration (DAD) curves. The services provided currently meet quite well the demands concerning statistics and analyses. At present, the HMD is developing tools for the issuance of 10-day inflow or runoff forecasts for irrigation water allocation.



Annual Extreme Rainfall Analysis (1961-1998) | Flood Hazard Map of Taguig, Metro Manila | Flood Vulenrability Map of Taguig, Metro Manila | Thunderstorm Frequency in the Philippines during the SW Monsoon

Figure 5.5 Hazard and vulnerability maps

In addition, 1:10,000 flood hazard maps for key selected cities and municipalities as well as vulnerability maps are available. The flood hazard mapping program in PAGASA is a continuous activity. Peer reviewed maps are provided to the LGUs as a tool to update their comprehensive land use plans. The 1:50,000 flood hazard maps for the whole country are also available. Sample hazard maps published in the web are shown in Figure 5.5.

Other agencies who are involved in dam operation activities such as the NIA, NPC and MWSS also maintain hydrological network. The data derived from these networks are shared with PAGASA and other agencies such as the OCD and DPWH.

5.5 Marine services

The Marine Meteorology Section was recently created under the Rationalization Program of PAGASA. It is currently issuing meteorological forecast for shipping twice a day, tropical cyclone warning for shipping four times a day during the occurrence of a tropical cyclone, and gale warning twice a day during surges of the monsoons and other extreme events. These forecasts are posted in the PAGASA website as well as disseminated to the following agencies through fax and e-mail:

- Philippine Coast Guard (PCG)
- Philippine Ports Authority (PPA)
- Maritime Industry Authority (MARINA), the regulatory body for maritime navigation
- Philippine Navy
- Shipping companies
- Operators of fishing vessels.

5.6 Environmental services

5.6.1 Water quality

Water quality and ground water monitoring are not the responsibility of PAGASA. However, since the quality of surface and ground water, including the dispersion of water borne pollutants, are related to weather and climate, there appears a need for PAGASA to establish collaboration with concerned agencies.

5.6.2 Air quality

Air quality monitoring is also not the responsibility of PAGASA; however, PAGASA issues haze advisory for aviation, health and other sectors. For the conduct of dispersion modelling studies on the assessment of atmospheric chemical and physical composition change, the PAGASA needs to coordinate with the Environmental Management Bureau (EMB) under the Department of Environment and Natural Resources (DENR). There has been a suggestion from EMB that WRF might be included in environmental impact assessments wherein different scenarios are used for air pollution transport modelling. EMB also needs data from PAGASA's weather forecasting.

5.7 R&D based Expert Services

The research units of PAGASA conduct various researches in the fields of meteorology, hydrology, climatology, oceanography, astronomy and allied fields. A number of research works by PAGASA's professional staff are published in recognized journals. Among the studies completed between 2004 and 2010 are:

- A probable correlation between the 500-Mb vorticity advection and large scale precipitation
- Relationships among meteorological parameters observed on board R/V Researcher and R/V Albacora
- One dimensional numerical model for storm surge prediction
- Storm surge numerical model for Manila Bay
- A study of earthquake swarm in Siquijor area
- Health risk map related to tropical cyclone oc currence in Metro Manila
- Extreme wind hazard mapping in the Philippines
- Analysis of the relationship between the position of major wing discontinuity and the position of areas of rainfall over the Philippines
- Maximum rainfall values over Luzon for duration of one and two days and return period from 2 to 50 years
- A study on the effectiveness of four mathematical models on the development of sweet corn (H801) and the daily variations of solar radiation and air temperature
- Air pollution modelling in Metropolitan Manila

area using Gaussian distribution
- Storm surge potentials of selected Philippine coastal basins
- Seismicity of the Philippines and the expectations of maximum earthquake motions
- A study of tropical cyclones originating from the South China Sea
- Quantitative rainfall forecasting
- Flood hazard mapping and vulnerability analysis of the coastal towns of Bataan along Manila Bay area
- Socio-economic influence on human response to tropical cyclone warning
- Verification of 1994-1998 tropical cyclone forecasts of PAGASA
- Analyses of vorticity, omega and 850 hPa wing of the FLM 12
- Theoretical study of radial distribution of rainfall in a matured tropical cyclone
- Thunderstorm hazard in the Philippines
- The revised analogue method of forecasting tropical cyclone movement
- Tropical cyclone rainfall estimation using satellite observations and rainfall compositing
- Forecasting rainfall of tropical cyclones affecting Metro Manila
- The development and application of the direct model output statistics (DMOS)
- Epidemiological study for Metro Manila using climatic variability
- Hazard mapping of thunderstorm over Visayas
- Southwest monsoon surge associated with tropical cyclone
- Tropical cyclone winds, warnings and damages
- Flood vulnerability analysis of Taguig, Metro Manila
- Flood hazard mapping of Taguig, Metro Manila
- Tropical cyclone wind profiles
- Tropical cyclone rainfall nomogram for the Pinatubo Area.

The Quick Response Team of PAGASA

Organized under the R&D units of the agency is a quick response team called the Special Tropical Cyclone Reconnaissance, Information Dissemination and Damage Evaluation (STRIDE) team. It is a mobile group, whose foremost mission is to undertake reconnaissance survey and assessment before, during and after the passage of tropical cyclones in the Philippines. The team also coordinates with LGUs for disaster preparedness in areas threatened by an approaching storm. It performs actual investigation of the characteristics of landfalling tropical cyclones. It undertakes damage assessment after the passage of a tropical cyclone. It also conducts surveys and interviews to assess community response to warnings issued by PAGASA in the affected areas. The team is composed of technical staff with expertise in tropical cyclones, hydrology, and damage assessment.

5.8 Information services

The Public Information Unit of the agency organizes lectures for students, public information drives, and seminar-workshops for media practitioners. It also produces brochures, radio and television plugs and other information materials in hydro-meteorology. Abstracts of completed studies are also posted in the PAGASA website.

5.9 Library services

In addition to books and other hardbound reference materials, computer-based materials and information in CD-ROM and other media and downloads from the internet are available to library users. Along this line, the PAGASA has linked up with Science Network (SciNET), a computer science library network capable of accessing local and international libraries. In the next few years, the PAGASA will acquire additional library facilities for use in its in-house training activities and for research purposes.

5.10 Training services

The PAGASA addresses training needs of both its personnel and those of other national meteorological and hydrological services. Having been designated as one of the Regional Training Center (RTC) in the Southwest Pacific, the PAGASA routinely accepts foreign participants to its various training programs as part of its commitment to international cooperation. The PAGASA needs to continue updating its training facilities as well as developing its training staff in order to improve the quality of its training programs. It also develops administrative competencies of the workforce through in-house and external training courses.

5.11 Internet

The PAGASA maintains a website on which are posted its products and information on its various activities (Figure 5.6.). The website serves as medium to disseminate forecasts and warnings through e-mail and social networking (e.g., Facebook, Twitter). It remains a powerful channel for the dissemination of its products and services. The existing site and its internet link were upgraded recently to address comments and inputs from various sectors.

During the occurrence of past tropical cyclones, many people have complained about the difficulty in accessing the PAGASA website. This is due to congestion since thousands of people log on to get weather updates. The PAGASA website (www.pagasa.dost.gov.ph) contains information on the following: real-time weather, tropical cyclone warning, flood forecasts, climate information, astronomy updates, hilippine Standard Time, hourly satellite imagery updates, etc.

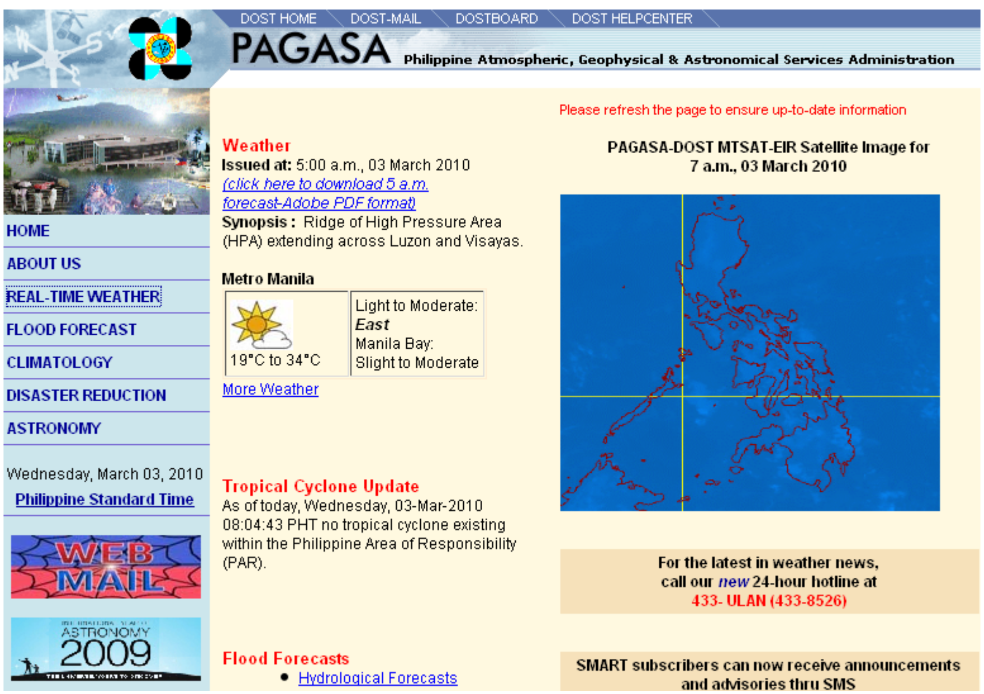


Figure 5.6 PAGASA website.

The PAGASA website also contains definitions of weather forecast terminologies including those pertaining to cloud description, precipitation, wind description, and sea condition.

5.12 Other agencies providing hydrometeorological services

Although, the PAGASA has embarked on a number of partnerships with some organizations in order to expand its observing network and for data sharing, it undertakes a wide range of activities much on its own. Collaboration with sectors is still non-existent. For instance, there is potentially an opportunity for the agency to expand its observing network by collaborating with some airline and mining companies which have their own meteorological monitoring facilities.

PAGASA'S NETWORK OF OBSERVING STATIONS

6

6.1 Surface network

To carry out its mandate the PAGASA is equipped with observing network and communication system for data gathering and transmission to the forecasting center. Its facilities are a combination of old and state-of-the-art hardware as shown in Table 6.1.

6.1.1 Synoptic stations

There are a total of 58 synoptic stations in the Philippines with a density of one (1) station per 5,172 square kilometres. This is in accordance with the WMO standard of one station for every 10,000 square kilometres. In mountainous areas, however, there are only very few stations; thus the WMO standard is not met.

Table 6.1 Observation network of PAGASA.

Type of facility	Existing	On-going/ proposed	Remarks
Synoptic stations	58		Manual
Climate Station	90		Manual
Upper air stations	6		Laoag, Tanay, Legazpi, Cebu, Davao and
Puerto Princesa			
Aviation weather observation stations (AWOS)			Ninoy Aquino International Airport
Automatic Weather Stations (AWS)	153	150	Transmission of data thru SMS
Wind profiler	1	0	Science Garden in Quezon City
Agromet stations	24		Conventional
Marine bouy	2	2	
Visual storm stations	0	0	
Ozone monitoring station	1	0	Baguio City
Major/principal river basins equipped with telemetered gauging stations	8	0	Pampanga, Agno, Bicol, Cagayan, Pasig-Marikina, Agus-Lake Lanao, Jalaur and Aurora river basins Total hydrometeorological stations: 85, i.e. 47 water level and 38 rainfall stations

6.1.2 Climatological stations

The PAGASA has a total of 90 climatological stations that are all manually operated. Currently, some of the manually operated stations are being replaced by automatic weather station (AWS). A total of 153 AWSs acquired through funding support from KOICA, TECO, Spanish Government through Millennium Development Goals Achievement Fund (MDG-F), MWSS, and DOST-Grants-In-Aid (GIA) programme.

6.1.3 Marine observations

The PAGASA has recently installed two marine meteorological buoys in central Philippines along the shipping route where navigation traffic is frequent. The National Mapping and Resource Information Agency (NAMRIA), the Bureau of Coast Guard and Geodetic Survey (BCGS) and the Philippine Ports Authority (PPA) also maintain meteorological equipment for maritime purposes and tidal gauges. However, the observed data from these agencies are not yet shared with PAGASA.

6.1.4 Hydrological stations

The country has 18 major river basins and only eight (8) of these are equipped with hydrological monitoring and flood forecasting and warning system. In addition, watersheds of major reservoirs are also equipped with telemetered rainfall and water level gauges which are utilized for flood forecasting and warning system for dam operation. These facilities are maintained by the dam managers such as NPC, NIA and MWSS. The data from these networks are shared with PAGASA.

The Bureau of Standards under the Department of Public Works and Highways (DPWH) also maintains a network of annual water level stations all over the country which are utilized in the infrastructure activities such as building of bridges, etc.

6.1.5 Agro-meteorological observations

There are a total of 28 agro-meteorological stations that are mostly located in state colleges and universities; these stations are jointly maintained by PAGASA and state colleges and universities. Other agencies such as the Bureau of Soil and Water Management (BSWM), the Department of Agriculture and NIA also maintain rainfall stations for their use. These data are not yet shared with PAGASA.

6.1.6 Ozone observations

Currently, the Philippines has one (1) ozone monitoring station located in Baguio City under PAGASA.

6.2 Remote sensing observations

6.2.1 Upper air observations

Upper air observations are essential inputs in numerical weather prediction models since they provide a vertical profile of the atmosphere. Direct in-situ measurements of air temperature, humidity and pressure with height are measured with balloon-borne instrument platform with radio transmitting capabilities called radiosonde, typically to altitudes of approximately 30 km. These data are crucial in the forecast for severe weather and for aviation route forecasts.

Currently, the Philippines is equipped with six (6) upper air stations strategically located to represent the entire country. The main concern in operating these stations is the high cost of radiosonde transmitters. These instruments are imported and its annual budgetary requirement amounts to approximately US$220,000.

6.2.2 Radars

A weather surveillance radar (WSR) is useful in locating precipitation and estimate its intensity and in determining the center of tropical cyclones. In addition to this capability, state-of-the-art Doppler radars are capable of estimating radial velocity which can be used to determine the wind strength of tropical cyclones as well as to analyse its structure.

Currently, PAGASA has seven (7) operational Doppler radars. Seven (7) more new Doppler radars are being installed, two (2) will be operational in 2012, one (1) in 2013, one (1) in 2014 and another three (3) in 2016. A total of 14 Doppler radars are programmed to be operational in 2016 (Figure 6.1). However, there is also a need to install additional automatic weather stations for the calibration of these radars. One of the new Doppler radars is a part of the three (3) which are provided under the grant from the Government of Japan through the Japan International Cooperation Agency (JICA). The radars provided by Japan are different from the current radars. Technical experts emphasize that rainfall data should be calibrated accurately and transferred to PAGASA/HMD as quickly as possible to enhance usefulness for flood forecasting and warning operations.

6.2.3 Lightning observation

There is one (1) lightning observation equipment in the country which has been installed in collaboration with the University of the Philippines. With the increasing frequency of lightning occurrence that caused more fatalities and damages in the country, the PAGASA should come up with a plan to install more lightning observation stations in the country.

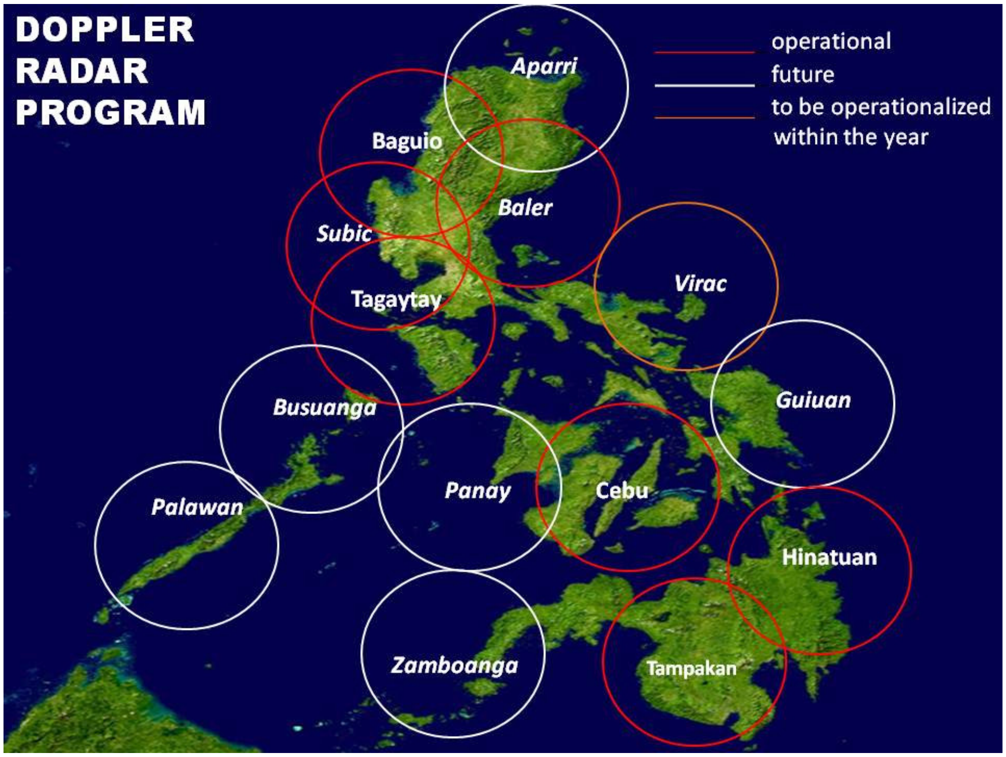


Figure 6.1 Doppler radar network showing existing and under implementation (Source: Engineering Technical Services Division, PAGASA).

6.2.4 Satellite observation

Weather forecasters routinely use satellite imageries in synoptic analysis, and in weather monitoring and forecasting. With the help of satellite imageries, forecasters are also able to detect the development of tropical cyclones, as well as locate and estimate its wind intensity.

There are two types of weather satellites, the geostationary and polar-orbiting satellites. At present, the PAGASA has ground receiving system for the MTSAT, CMACast, NOAA, and MODIS satellites.

The PAGASA has also requested KOICA to acquire the COMS (Communication Ocean and Meteorological Satellite) receiving and analysis system. It has submitted a proposal for a two-year grant project for the receipt and analysis of images from COMS. A series of training activities on COMS for PAGASA has been conducted by KOICA.

MAINTENANCE, CALIBRATION & MANUFACTURING OF MONITORING FACILITIES

7

7.1 Meteorological observations

The PAGASA Meteorological Instruments Laboratory is located at Science Garden in Quezon City. PAGASA is responsible for the certification, verification, and standardization of calibration of meteorological instruments and the fabrication of some weather instruments. PAGASA is also designated as the Regional Instrument Center (RIC) of the WMO for Southwest Pacific. As a RIC, PAGASA assists members of the region in calibrating their national meteorological standards and related environmental monitoring instruments. It also provides technical maintenance support to the nationwide PAGASA observing network and to other government agencies and non-government organizations for the repair and calibration of their meteorological instruments. The laboratory includes a wind tunnel used for the calibration of wind measuring equipments such as anemometers; a barometer calibration chamber to calibrate mercurial and aneroid types including microbarographs; and two thermometer chambers and mercury filling devices. Defective hygrometers are also repaired and adjusted in the facility. The standard (8”) rain gage and thermometer shelters are locally fabricated while sunshine cards are mass-produced for the solar radiation network of PAGASA and the Department of Agriculture (DA).

The Philippine Navy and many shipping agencies rely on PAGASA for the repair, adjustment, and calibration of ship meteorological instruments and equipment including ship radars. A Memorandum of Understanding between the PAGASA and the Civil Aviation Association of the Philippines (CAAP) gives PAGASA the responsibility to undertake on-site periodic check and/or calibrate meteorological instruments in the eighty five (85) airport stations in the country provided that a letter of request from the latter from the latter is received at least two weeks before the calibration is done.

Currently, there are private companies and government institutions that develop meteorological instruments such as rain gauges and automatic weather stations. The Advanced Science and Technology Institute (ASTI) under the Department of Science and Technology is producing rain gauges and AWS which are now being installed all over the Philippines. Among the thrusts of the DOST is the enhancement of PAGASA’s observation network through the installation of instruments fabricated by ASTI. In addition to PAGASA’s network, a total of 153 AWSs and 75 ARGs have been installed nationwide.

Private companies such as SMART Telecommunication in coordination with the Ateneo de Davao University are fabricated AWS and automatic water level sensors. Staff and students from the Ateneo de Davao University attended a one (1) week hands-on training in PAGASA for the calibration of the said instruments. The fabricated equipment have been piloted in the community based flood early warning system in the Davao river basin through collaboration among SMART, Ateneo de Davao, PAGASA and the local government of Davao City.

The maintenance of the ASTI-developed equipment is the responsibility of PAGASA. With the increasing number of its monitoring instruments, the PAGASA should ensure that it has the capacity in terms of skilled staff and protocol to calibrate and maintain the new equipment. With this development, the PAGASA's network is now composed of different brands of AWS (locally fabricated and imported sensors). Calibration of the sensors and ensuring accuracy of measurements from the various observation stations are important tasks as PAGASA also verifies whether the instruments conform to standards. Thus, the integration of data from all instruments for analysis poses a big challenge for PAGASA.

7.2 Hydrological observations

Telemetered hydrological stations are maintained by the Hydrometeorological Telecommunication Section of PAGASA. The PAGASA telecom engineers have a Maintenance and Operating Manual which stipulates the frequency of maintenance that includes both regular and emergency maintenance.

Most of the hydrological stations have been in place since the early 1980s. While some are still operational, others have deteriorated and exceeded their lifespan. Among the four (4) monitored river basins, the Pampanga and Agno FFWSs have been upgraded in 2009 and 2011, respectively, while the upgrading of Cagayan and Bicol FFWSs are scheduled to be completed by 2012.

The upgrading of the Pampanga, Agno and Bicol FFWSs is under a grant from the Government of Japan while the improvement of the FFWS facilities of Cagayan river basin is funded by the Government of Norway through Norad. In addition, the PAGASA is currently implementing the technical cooperation project under JICA to strengthen existing facilities of monitored dams in Luzon.

The ASTI is also developing ultrasonic water level sensors to improve the hydrologic network of major river basins in the country. However, for most river basins, the pressure type water level sensor is more appropriate for rivers in the Philippines.

The National Hydraulic Research Center (NHRC) of the University of the Philippines has the laboratory for the calibration of hydrologic equipment.

NUMERICAL WEATHER PREDICTION (NWP)

8

The PAGASA uses several tools to predict weather, calibrates them and compares the results in order to produce accurate and precise predictions. Some of these are free software while others are given as grants or purchased.

8.1 Operational models

Weather forecasters utilize numerical weather prediction (NWP) products to guide them in preparing routine daily weather forecasts and issuing warnings during the occurrence of tropical cyclones in the country. Observational data from upper stations, radars, weather satellites as well as surface weather observations are used as input to numerical models. The models run by PAGASA are described in Table 8.1.

Table 8.1 Description of Numerical Weather Prediction models

Model	Developer	Resolution	Remarks
Eta	Yugoslavian 1970s and was upgraded in the early 1980s; undergone further developments at NCEP in 1990.	28-km resolution centered at 11oN latitude and 125oE longitude	It uses the output of the Japanese Global Spectral Model (GSM) for the models' initial atmospheric conditions.
Storm Surge Model	Japan Meteorological Agency (JMA)	Based on the shallow water equations and computes storm surges due to wind setup and inverted barometer effect	Covers 36 stations in Luzon, Visayas and Mindanao
VAG (wave model)	METEOFRANCE	104-1350E, 2 - 240N, 125x89 grids spaced at 0.250 (Wave forecasts) for 72 hours (Output)	Winds from the Global Spectral Model are used to drive (input) the Philippine waters and obtain the wind-generated waves
WRF	Weather Research and Forecasting Network		
Global Spectral Model (GSM)	Japan Meteorological Agency (JMA)		

The PAGASA also access other models through the internet such as the Global Forecast System from NOAA, the Navy Operational Global Atmospheric Prediction System (NOGAPS) of Fleet Numerical Meteorology and Oceanography Center (FNMOC), and the Tropical Extended Limited Area Prediction System (TXLAPS) from the Australian Bureau of Meteorology. A tropical cyclone forecasting software called TC Module system has been installed by the Australian Bureau of Meteorology at PAGASA as well.

PAGASA uses the Regional Integrated Multi-hazard Early Warning System (RIMES) regularly for numerical weather prediction forecasts (Figure 8.1).

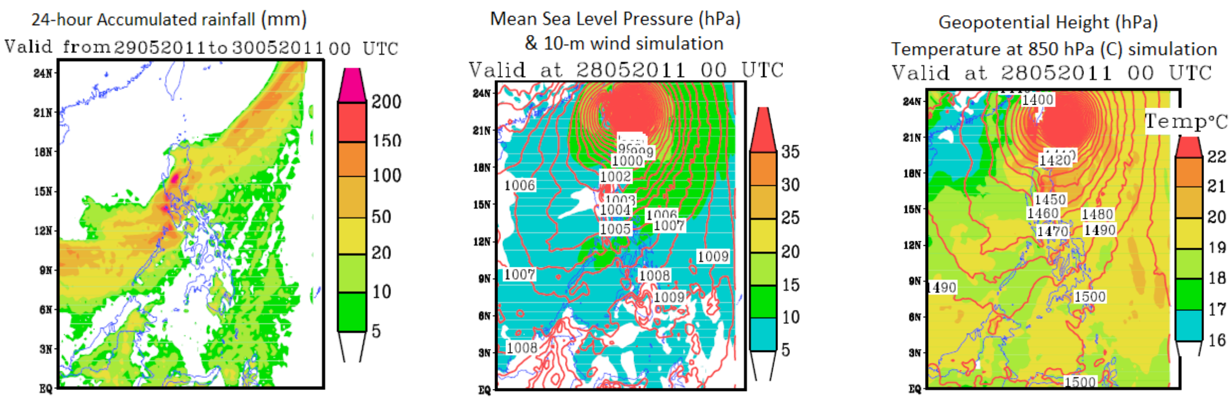
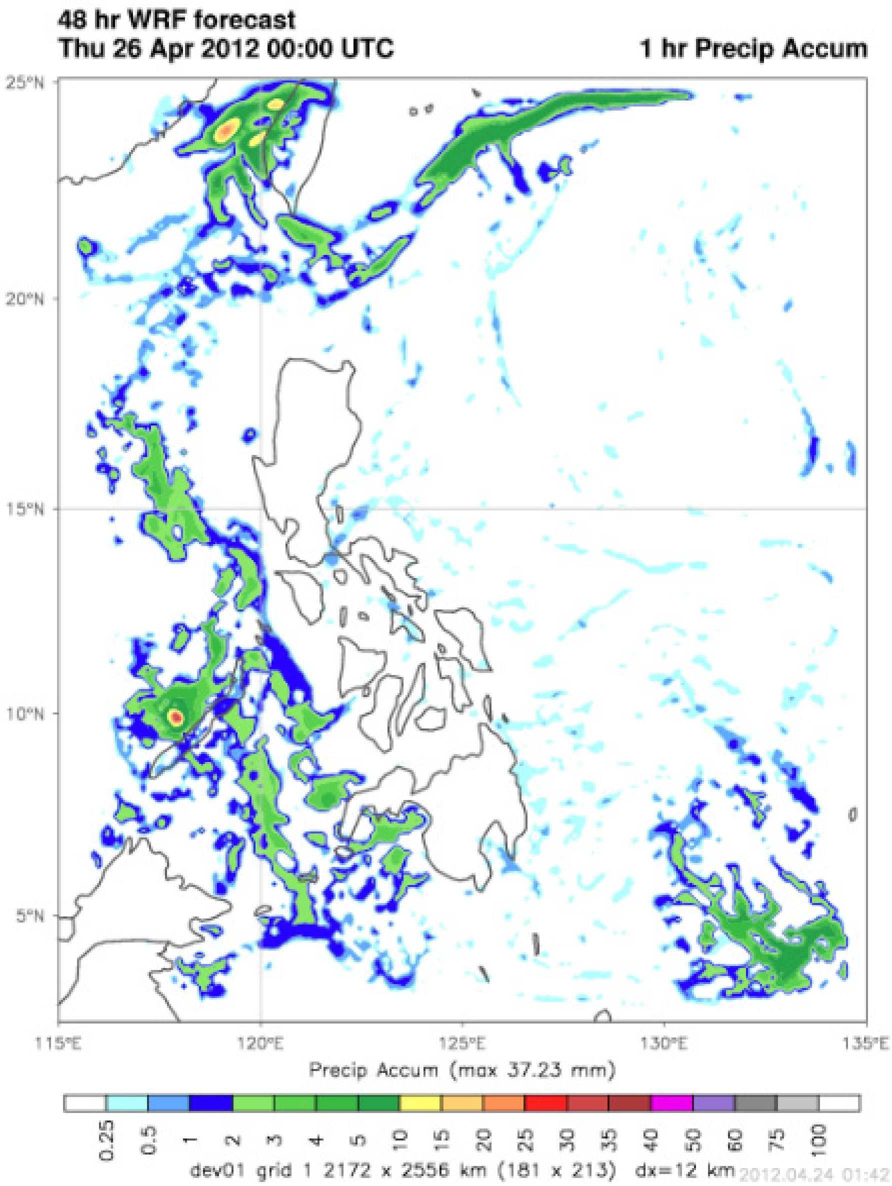


Figure 8.1 Sample outputs of RIMES (Source: Hydrometeorological Division, PAGASA).

In January 2011, the PAGASA completed the acquisition and installation of the integrated high power computing system (iHPC) by the Weather Decision Technologies (based in the US) designed to integrate all the data derive from ground and remote observation platforms such as, AWS, upper air observations, radar, satellite, marine bouys, AWOS, wind profiler, etc. Based on the available data, it is now producing valuable forecasts and information to improve the operational activities of PAGASA. Imbedded in the iHPC is the numerical weather prediction model: Weather Research and Forecasting (WRF) (Figure 8.2).

8.2 Verification of NWPs

The NWPs run by PAGASA often perform differently on a daily basis and even during the occurrence of tropical cyclones. In terms of tropical cyclone track forecasting, the forecast tracks would have 24-hr deviations of about 200 to 300 km in the case of weak storms. The numerical models perform better when a cyclone reaches typhoon intensity.



8.2 A WRF output of the iHPC (Source: Hydrometeorological Division, PAGASA).

9 INFORMATION COMMUNICATION TECHNOLOGY (ICT)

9.1 Communication facilities

For a three year period, the PAGASA operated a meteorological telecommunication system that employs the microwave technology, with multiplex capability for transmission/reception of data and for use in sending fax messages as well as for telephone calls. However, the frequency of the telecommunication backbone system was within the bandwidth of cellular mobile telecommunication system (CMTS) which caused serious interference in its signal and rendered the system ineffective. With the increasing number of automatic weather stations and other observing facilities, the PAGASA needs to upgrade its existing telecommunication facilities to meet its requirements for data transmission and dissemination of forecasts and warnings. Currently, the PAGASA is implementing a project on the installation of VSAT facilities in strategic areas in the country for the transmission of radar imageries. In synoptic and automatic weather stations, Global System for Mobile Telecommunication (GSM)/General Packet Radio System (GPRS) is utilized for data transmission.

Table 9.1. Communication facilities for transmission, reception and exchange of data and products

	RD	RI	SD	SI	RW	SW
Telephone	/	/	/	/	/	/
Mobile Phone			/	/		
GSM-GPRS			/			
Telefax				/	/	/
Dedicated Leased Lines			/			
UHF radio transceiver						
High frequency/Single side band radio	/		/			
HF Radio E-mail						
Aeronautical Fixed						
Telecommunication Network	/	/	/	/	/	
Very Small Aperture Terminal			/			
Data Collection Platforms used to transmit data from AWSs			/			
Global Telecommunication System (WMO-GTS)	/		/			
Meteosat Second Generation Satellite system	/	/				
Other satellite system	/	/				
Internet	/	/	/	/	/	/
E-mail	/		/			
Post/mail						
Print media				/	/	/
TV –national				/	/	/
TV-commercial				/	/	/
Radio				/	/	/
Local radio				/	/	/
Amateur radio						
Bulletins				/	/	/
Telegraph						

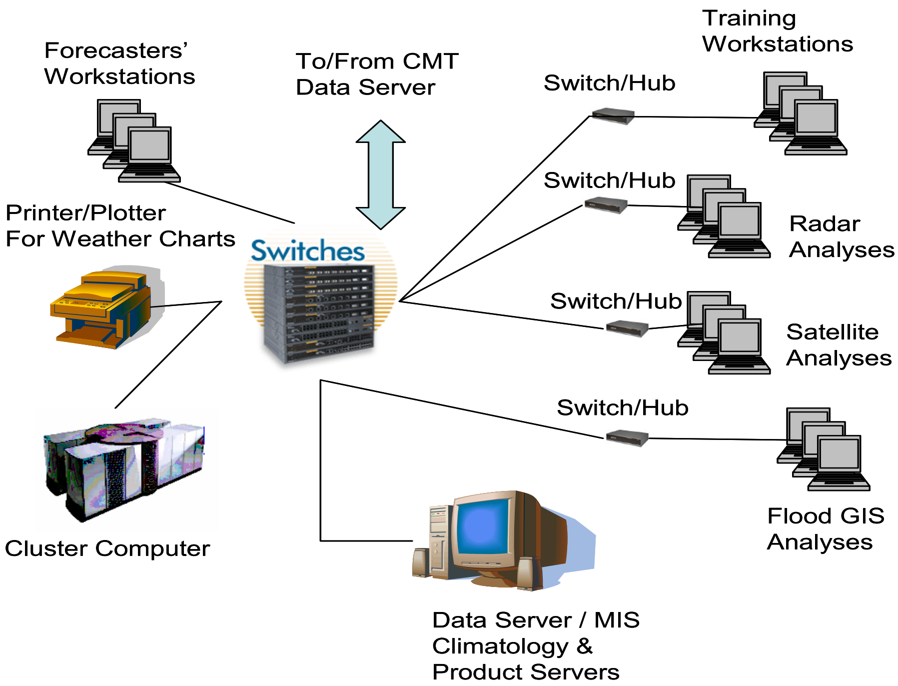
GPRS is a Mobile Data Service available to users of GSM and IS-136 mobile phones. GSM/GPRS data transfer is typically charged between 150-300 bytes of transferred data, while data communication via traditional circuit switching is billed per minute of connection time, independent of whether the user has actually transferred data or has been in an idle state. GPRS can be utilized for services such as wireless access point (WAP) access, short messaging system (SMS) and multi-messaging system (MMS), and also for internet communication services such as e-mail and web access.

9.2 IT infrastructure

One of the IT acquisitions of the agency is the PAGASA Interactive Climate and Weather Information Network (PICWIN) which is capable of processing observed data to generate products. To address the problem of interference, the PAGASA adapted the use of short messaging (SMS) technology. Weather observation data can now be promptly transmitted to the Central Forecasting Center for timely processing, analysis and forecast formulation (Figure 9.1) using SMS. However, SMS cannot be used for voluminous data.

In addition, forecasts and warnings are disseminated to the end-users through the SMS. The system also provides an internet-based service that allows the field stations and end-users to obtain forecasts, warnings and other information directly from the PAGASA website in near real-time.

Networking infrastructure: LAN and internet access, routers, firewalls, switches (10/100/1000)
Connections to Internet: 2 x 4 Mbps, 2 ISP (Primary and back-up) – data from field stations can be coursed through the internet



9.1 PICWIN project (Source: PAGASA Investment Portfolio).

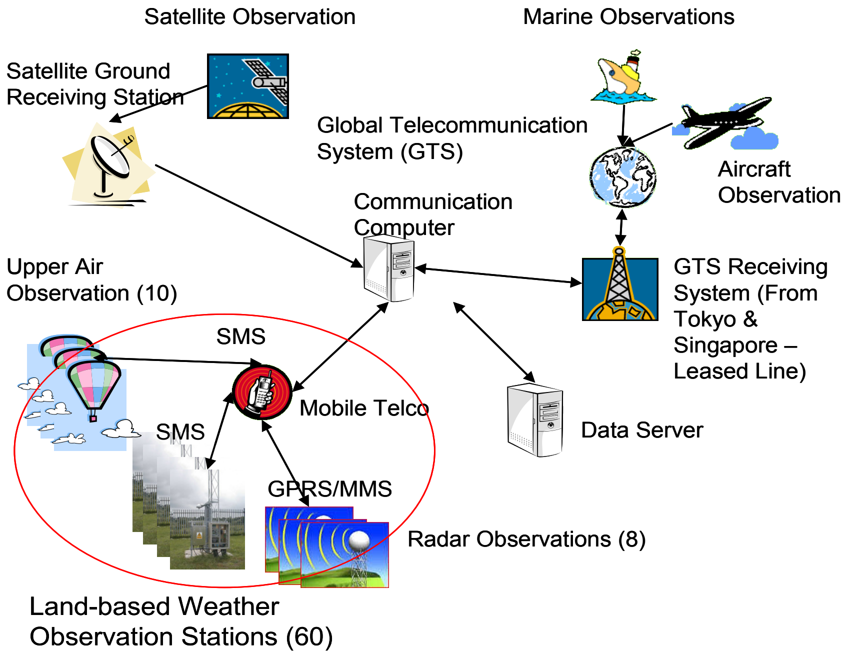


Figure 9.2 Cellular based Meteorological Telecommunication of PICWIN (Source: Hydrometeorological Division, PAGASA).

The PAGASA internet services

The PAGASA internet is a leased line service with a connection speed of 4Mbps. A backup ISP with the same bandwidth is also available. It caters to the downloading of NWP models as well as other web services for the operations center and the Central Office (see Figure 9.3). PAGASA operates its own mail server using Apache. The anti-virus security for the gateway is protected by Astaro and Kaspersky for workstations; PAGASA renews the contract services on a yearly basis.

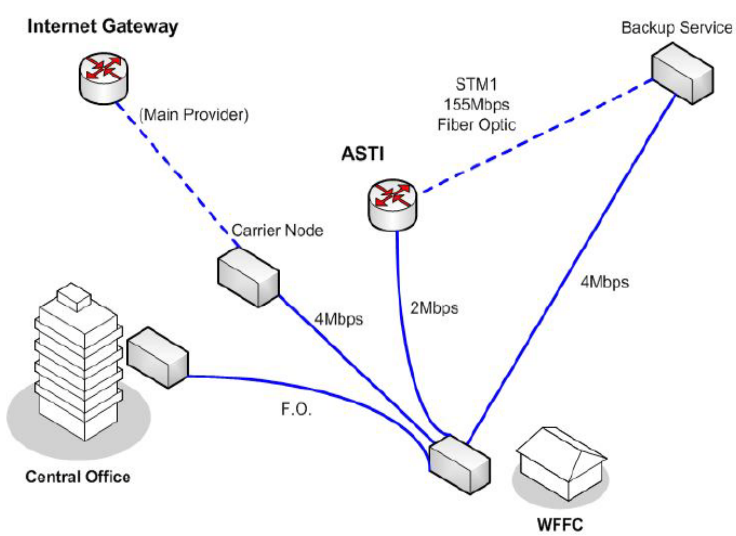


Figure 9.3 PAGASA ISP Network (Source: PAGASA).

The PAGASA webmail is configured in a 64-bit server which is running on Debian Linux as operating system, powered by Qmail/Vpopmail, as back end and Squirrelmail as front end with virus/spam scanner on incoming mails, run by SpamAssasin & ClamAv. All software used are open-source.

In 2010, the PAGASA upgraded its website and migrated from 1.0 Joomla! to Joomla! 1.5 (ASTI's e DOST Project) with additional extensions (Joomla! 1.5). Also, the agency established the PAGASA Web-based Intranet Services starting in 2010. A new PAGASA website was launched in January 2012.

9.3 Data management

9.3.1 Database and archives

The PAGASA has an inventory of archived data in paper format at the Climate Data Section (CDS). For climate data management system, the CDS still uses Clicom 3.0 program to input hourly and 3-hourly data on stand-alone desktop computers. Dbase and Fortran programs are used to input and process daily synoptic data. The inventory of digitized climatic data is shown in Table 9.2.

Table 9.2 Inventory of Archived Data in paper form at CDS

Data forms	Period	Number of forms
Synoptic Data a) 1001 Forms b) 1201 Forms	1951-2007 1951-2007	1,251,408 36,092
Agromet Data a) 8007A Forms b) 8008 Forms	From start to present Start usually in the 70s	8,754 8,754
Climate/Rain data a) 1051	From start to present * Most of the stations start usually in the 70s	25,308
Historical Records	1901 to 1934	Some books were lost.

The Philippine data found in the ASEAN Compendium include daily and monthly data from synoptic (58), agromet (24) and climate/rain (157) stations for the following weather elements: rainfall, maximum temperature, minimum temperature, dry bulb temperature and wet bulb temperature, from 1951 to 2000. The Rainman Version 4.1 includes an updated monthly rainfall data up to 2004 in the ASEAN Compendium.

Table 9.3 Inventory of digitized climatic data

Database	Period digitized	No. of stations	Data format
Daily • Synoptic Data • Agromet Data • Climat/Rain data	1951- present From start to present From start to present	63 stations 33 stations 227 stations	ASCII, DBASE III
Monthly • Synoptic Data • Agromet Data • Climat/Rain Data	Pre-war to 1940, 1951- present From start to present From start to Present	63 stations 31 stns w/pre war 33 stations 227 stations	ASCII, DBASE III
3-Hourly	1985-2004 *ending year varies	26 stations (336 years)	ASCII, CLICOM
3-hourly data from card	1951 - 1980	45 stations	ASCII

Hydrological data (rainfall and water level) from telemetered major river basins monitored by PAGASA are archived in Fortran program in ASCII format starting from 1973 to 2010; the rest are still in paper form. Digitization of the data forms are in progress. Products from the hydrometeorological data include rainfall intensity duration frequency (RIDF), probable maximum precipitation (PMP), depth area duration (DAD) maps and probable maximum flood (PMF). Streamflow data in principal and major rivers in the country are with the Bureau of Research and Standards and the National Water Resources Board (NWRB). As far as hydrological data is concerned, there are several agencies that keep and maintain the database. Apart from PAGASA, BRS, and NWRB, hydrological data are also archived by the NIA, NPC, MWSS, MMDA (for the Pasig-Marikina-Laguna Lake basin), Flood Control and Sabo Engineering Center (FCSEC), Local Water Utilities Administration (LWUA) and local government units.

Two marine buoys have been installed - one in Bantayan Island in Madridejos, Cebu City in 2009 and another in Burias Island in Masbate in 2010. A wind profiler was installed in Quezon City in 2011. By 2016, there will be 14 Doppler radars installed in the Philippines.

9.3.2 Quality monitoring of collected data

The Meteorological Guides and Standards Section of PAGASA conduct quality control of meteorological data manually. It has yet to develop a real-time quality control system for data from AWS as well as manned stations.

For hydrological data, the River Forecast Centers of major river basins in PAGASA conduct the initial quality control data. The telemetered hydrological data from the River Forecast Centers are forwarded to the Hydrometeorological Data Application Section (HMDAS) of the Hydrometeorology Division who is responsible for the final quality control and analysis of the observed data.

9.4 IT Personnel

Currently, the PAGASA has seven (7) IT personnel as follows: Network and internet administrator: 1; Web and ftp portal management: 3; Web content and information system management: 3 The IT staff members possess programming skills use C, C++, Perl, php, and script programming. It shall be noted through that no official IT plantilla positions are in place. However, the seven personnel mentioned above have been designated as such in response to the agency's needs.

9.5 Need to improve communication system and data management

The enhancement of its observing facilities and increase in the amount of data from ground observations such as from automatic weather stations, synoptic, climate/rain, agromet and hydrometeorological stations including remote sensing data from satellites and weather radars requires a robust communication system. A robust communication system (including internet connection) on data exchange shall play a vital role in the existing set-up of PAGASA; the communication system should be enhanced and consequently maintained well. With the archipelagic nature of the Philippines and its high exposure to hydrometeorological hazards it also needs a redundant communication system to serve as backup. The single side band radios that are installed in all observing stations in the country are sufficient to serve as backup.

A Feasibility Study on the Upgrading of Meteorological and Hydrological Communication System by the United Stated Trade and Development Agency (USTDA) is still on-going. The next step after the completion of the feasibility study is to secure approval, endorsement and funding support for the implementation of the project.

On data management, there is a need to establish the operational protocol for data archiving and database management. A Database Management System (DBMS) or Information System (IS) for all the observational networks (AWS, rain gauges, radar, satellite, marine buoy, upper air and other related data) is a priority. This entails high cost, needing funds and resources.

There is also an urgent need to undertake data rescue program which will cover the following activities:

a. Digitization of pre-World War II daily values of the three (3) priority weather elements (Tmax, Tmin & Rainfall) for 15 synoptic stations;
b. Backup of all digitized long-term datasets of synoptic and agromet stations copied in CDs and other mediums and the corresponding metadata for these stations; and
c. Digital imaging of Spanish era data from the Manila Observatory.

At present there are only three (3) database management staff members in PAGASA who are appropriately training. There is therefore a need to train additional staff on database management.

PAGASA is currently working with the Advanced Science and Technology Institute (ASTI-DOST) to improve communications system and data management in PAGASA.

10 NATIONAL AND INTERNATIONAL COOPERATION AND DATA SHARING

With its geographical location, all real-time meteorological data from the Philippines are very valuable to neighbouring countries especially during tropical cyclone occurrences. As soon as a tropical cyclone forms in the western North Pacific all neighbouring areas such as Viet Nam, China, Cambodia, Thailand, Lao PDR, Japan and South Korea need more data from the Philippines to enable them to closely monitor the development of the disturbance and analyse any potential threat to their area. In view of this, improving the observing network of PAGASA will greatly benefit the Philippines as well as the nearby countries

The PAGASA has already completed the implementation of WMO Information System (WIS) part A which is the migration to Table-Driven Code Format (TDCF). The bandwidth of its Global Telecommunication System (GTS) link has also been upgraded to 64 kbps. The establishment of IP connectivity with PAGASA's Regional Services Division and active radar stations is also ongoing.

10.1 National

Sharing of hydrometeorological data and information with institutions, utility providers and the academe for use in research, agricultural applications, and environment monitoring is undertaken through internet portal, ftp servers, and IP connectivity.

Near real-time local hydrometeorological data is also shared to interested local users. Just recently, the PAGASA signed a Memorandum of Agreement with the National Grid Corporation of the Philippines (NGCP), a private power transmission company, for the implementation of a project entitled Storm Tracking and Response System (STaRS) which involves sharing of weather data and forecast information. This initiative came as an offshoot of the enormous damage in the transmission towers of the NGCP in 2006 during the passage of Typhoons Milenyo (Xangsane) and Reming (Durian). Under this agreement the PAGASA will provide real-time weather data and information to NGCP such as:

- Hourly tropical cyclone update
- Hourly weather data from synoptic, agromet, Doppler radar, and AWS;
- Hourly update of weather satellite images;
- NWP output every 8-hours;
- Rainfall and water level of monitored dams and rivers; and
- Information on solar flares and magnetic storms.

The agency prepares various reports that cater to the needs of the different sectors of society which are also shared to the end-users. It has also come up with a comprehensive Information System Strategic Plan (ISSP) which was submitted to the Commission on Information and Communication Technology for approval.

Strategy for data collection and dissemination

Data collection from field stations particularly for synoptic message is through Short Message Sending (SMS) or by HF/SSB radiophone. An automated program through a laptop terminal sends the information to a central collection at the NMHS and processed by the Weather Division. The PAGASA still operates its HF/SSB radiophone network for data collection as well as dissemination of warnings and advisories. The system is very effective especially

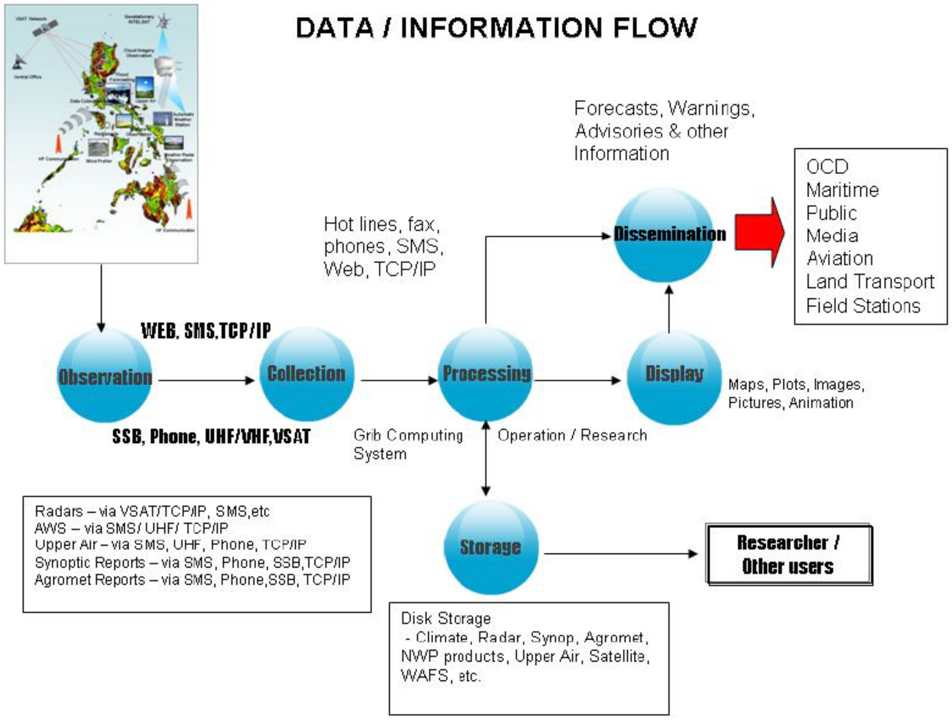


Figure 10.1 PAGASA's data/information flow

(Source: Engineering Technical Services Division, PAGASA).

in times of calamity or during the absence of local communication services such as the internet and SMS.

During map discussions or in the event of an inclement weather, video conference is employed for the Central Forecasting Office in Quezon City to communicate with the PAGASA Regional Service Centers and vice versa.

Using the internet, the PAGASA is also developing a local information system. Regional Service Divisions have access to hydrometeorological data and information needed in the provision of localized forecasting services. Internet services available at field stations varies from dial-up service, DSL connections (384-512kbps), portable SHDSL modem 64 kbps service, and 2-4Mbps leased line connections.

10.2 International

International data exchange is done through the GTS where weather data from 27 synoptic stations and two (2) upper air stations are transmitted to Regional Telecommunication Hub (RTH) Tokyo on a real-time basis (Figure 10.2). With its recently improved observing network the PAGASA should endeavor to share more data from its radars and new upper stations to other NMHSs, especially in the region. Sharing more data will improve the initialization of numerical models and consequently improve its forecast performance.

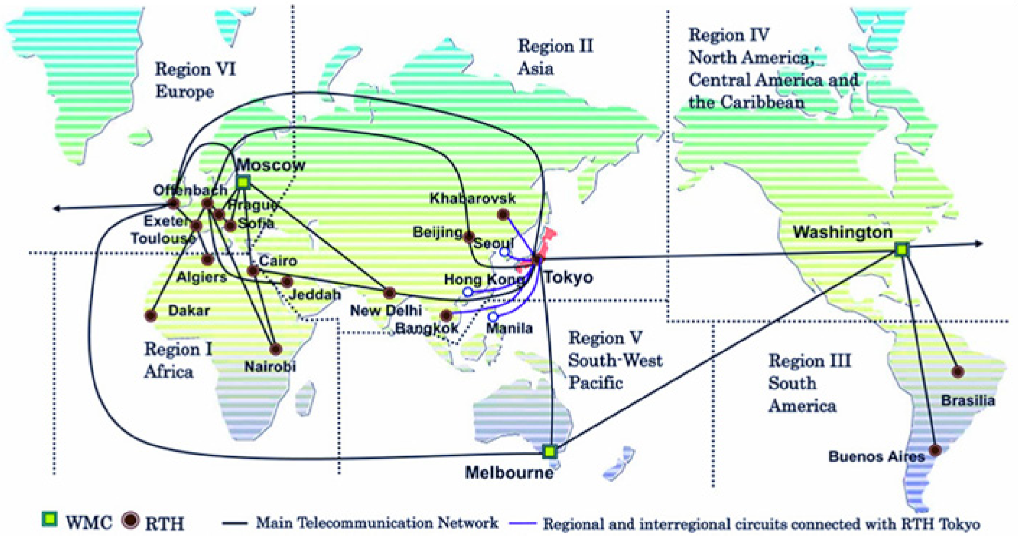


Figure 10.2 Schematic overview of Global Telecommunication System

(Source: http://www.jma.go.jp/jma/jma-eng/jma-center/rth/RTH_Tokyo.html)

One of the major accomplishments of PAGASA in its international commitment is the implementation of WMO World Information System (WIS) Part A which focused on the improvements of the GTS for time-critical and operation-critical data, including its extension to meet operational requirements of WMO Programmes in addition to the World Weather Watch (including improved management of services). A PAGASA staff was trained on WIS by the Japan Meteorological Agency (JMA) in March 2010. The PAGASA is now compliant with WIS.

Further, the Philippines has migrated from traditional alphanumeric codes (TAC) to table driven coded form (TDCF) effective November 2010 (Figure 10.4). This was undertaken with the assistance of Oriental Electronics of the Weather, Environment and Education Center of Japan. The PAGASA has not only complied with its link with Regional Specialized Meteorological Center (RSMC) Tokyo but has also migrated to MPLS IP-VPN for the link with Singapore.

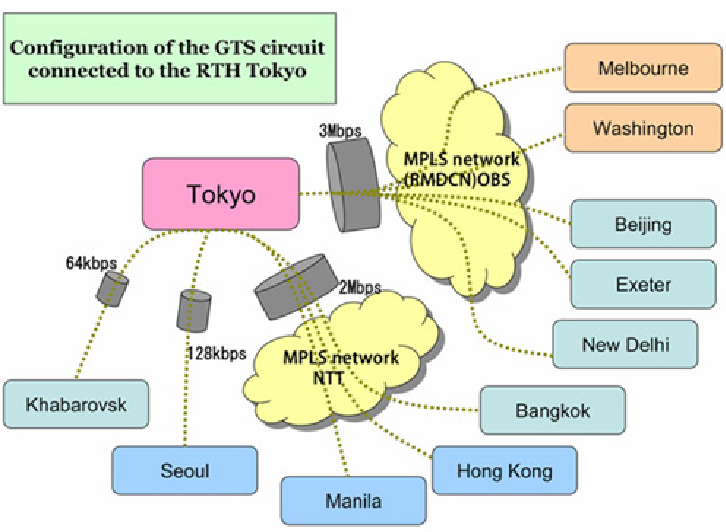
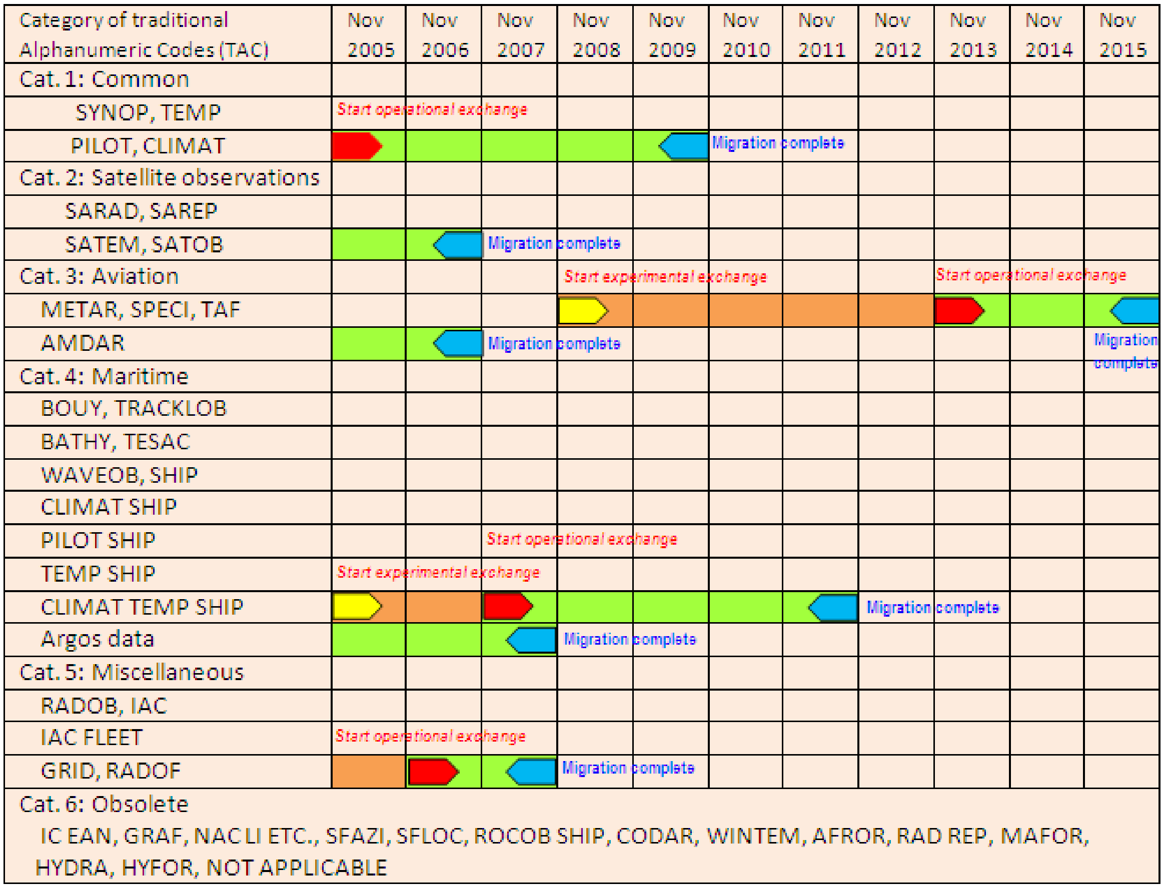


Figure 10.3 Multiprotocol label switching.

(Source: http://www.jma.go.jp/jma/jma-eng/jma-center/rth/RTH_current_status.html).



Notes: (1) Aviation Codes require ICAO coordination and approval, except for AMDAR.

(2) SAREP and RADOB require coordination by the ESCAP/WMO Typhoon Committee.

Figure 10.4 TDCF migration matrix

11 DEVELOPMENT PLANS PROPOSED BY PAGASA

After the onslaught of Tropical Storm Ketsana in Metro Manila, public-private partnerships for the reconstruction of damage facilities including preparedness measures was initiated with the issuance of an executive order by the President of the Philippines. As a result, private institutions have expressed willingness to support PAGASA's undertakings to improve its services.

PAGASA's COMMITMENT FOR THE COMING YEARS

Meteorological, hydrological, climatological and astronomical services are essential to every human activity and to national development, in the long term. PAGASA, therefore, needs to be a dynamic proactive institution that anticipates the ever changing requirements of the various sectors and the general public for weather, climate and flood information services. There is also the changing physical environment and the progressive scientific and technological development that need to be integrated into the agency's development activities. PAGASA envisions that in the coming years, it shall face more challenges and opportunities, which are imperative in meeting the demands of emerging global community. As in the past years, PAGASA is always committed to give the best services and products. To meet these challenges, PAGASA has identified its priorities to be implemented in 2012 and for the coming years in order to achieve its main goal of improved and enhanced services to better serve the needs of the people. These priorities are consistent with the DOST's vision. They are within the framework of the Philippine Development Plan 2011-2016 (PDP), specifically, on climate change adaptation, disaster preparedness and hazard mitigation. These are:

ENHANCEMENT OF WEATHER FORECASTING CAPABILITIES

- Automated Data Integration, Analysis and Display System for Timely and Reliable Weather Information for Disaster Mitigation and Decision Support

1. HydroMet Decision Support System (HDSS) Multi-sensor (radar, satellite, gauge network) precipitation measurement and multi-hour forecasting system designed for managing water resources and mitigating risk from heavy rain and flooding.
2. Mesoscale Forecast Decision Support System Highly customized numerical weather prediction using the Weather Research and Forecast (WRF) model and the Uncoupled Surface Layer (USL) model
3. Quantitative Precipitation Estimate (QPE) and Quantitative Precipitation Forecasting/ Nowcasting system (up to 4 hour forecast)
4. Severe storm prediction system

- Doppler Weather Radar Program

1. Operationalize 14 Doppler weather radars (11 GOP funded: Baguio, Baler, Subic, Hinatuan, Tagaytay, Mactan, Tampakan, Zamboanga, Busuanga, Panay and Puerto Princesa; three (3) JICA radars: Catanduanes, Aparri, and Guiuan) – [100% coverage]
   Note: Panay radar and infrastructure r equirement for Zamboanga and Busuanga are funded out of Disbursement Acceleration Program (DAP) of the Department of Budget and Management.

2. Radar data validation/calibration

- Rolling-out of Automated Weather Stations (AWS), Rain gauges, and Water level sensors
  1. Installation of 150 AWS, more water level sensors and rain gauges (in collaboration with ASTI and DOST Regional Offices.)
  2. Identified probable sites for AWS, water level sensors, and rain gauges
  3. Perform data validation
  4. Conduct IEC

- Warning system for Marine Navigation and Transport
  1. Procurement and installation of five (5) locally fabricated meteorological buoys (in coordination with ASTI).
  2. Identified and surveyed probable sites

- Redundant Communication System

IMPROVING CAPACITIES OF PAGASA ORECASTING PERSONNEL

- Increasing the pool of operational forecast ers/hydrologists
- 10 Ph.D/M.Sc graduates (from foreign universities)
- Meteorologist Training Course (40 new meteorologists)
- Meteorological Technician Trainin Course, MTTC (30 weather observers)
- Hydrologist Training Course (20 new hydrologists)

STRENGTHENING FLOOD MONITORING, FORECASTING AND WARNING SYSTEM

- Upgrading of the Cagayan River Basin telemetered FFWS
- Upgrading of the Bicol River Basin telemetered FFWS
- Installation of more WLS in 13 major River Basins (in collaboration with ASTI)
- Establishment of FFWS in major river basins in the country
- Survey of river systems
- Application of satellite-based information to improve river management

R&D: STRENGTHENING SUPPORT TO CLIMATE CHANGE ADAPTATION RELATED MEASURES

- Rolling-out of climate change projections
- Climate seasonal forecast

DRR RELATED S&T PROGRAM/ AWARENESS PROMOTION

- Hazard mapping using geographic information system (GIS)
- IEC on storm surge, tropical cyclone and other severe weather hazards
- Establishment of National Meteorological and Climate Center (NMCC).

The Agency also came up with a roadmap for its modernization within the framework of the following plans and programs:

- PAGASA Investment Portfolio (PIP), which is reviewed annually
- PAGASA Towards 2020
- PAGASA Strategic Plan 2008-2012, which fol lows a five-year cycle
- National Science and Technology Plan (NSTP)
- Philippine Development Plan (PDP),
- President Aquino's 16th point agenda.

The following are on-going and completed projects of PAGASA:

Table 11.1 Locally funded projects of PAGASA		
Project	Funding Institution	Cost
1. Establishment of Doppler Weather Radar Network for Disaster Prevention and Preparedness in Metro Manila	Office of the President /NDCC Calamity Fund (Completed in 2011)	PhP110M
2. Enhancement of Radar System in Visayas	Government of the Philippines (GoP) (To be completed in 2012)	PhP86M
3. Enhancement of Radar System in Mindanao (Hinatuan, Surigao del Sur and Tampakan, South Cotabato))	GoP (On-going)	PhP200M
4. Upgrading of Baguio Radar for Enhanced Early Warning Forecasting and Typhoon Warning Services	GoP (Completed in 2009)	PhP18M
5. Upgrading of Baler Radar	GoP (Completed in 2009)	PhP18M
6. Climate-based Information Sup port System for the Management of Angat-Umiray Reservoir	Metropolitan Waterworks and Sewerage System (MWSS) (On-going)	PhP3.4M
7. Disaster Reduction through Establishment of Back-up Communication and Enhancement of Quick Tropical Cyclone Impact Assessment and Forecast Evaluation System	GoP (Completed in 2010)	PhP18M
8. Improvement of Domestic Marine Forecasting System	GoP (Completed in 2010)	PhP100M
9. Automation of PAGASA's Forecasting System	GoP (On-going)	PhP316M
10. Enhancement of Doppler Radar Network for National Weather Watch, Accurate Forecasting and Flood Early Warning	GoP (To be completed in 2016)	Php 425M

Note: GoP – Government of the Philippines; NDCC-National Disaster Coordinating Council (the predecessor of the National Disaster Risk Reduction and Management Council).

Recent development plans include the upgrading of observation network, telecommunication system and IT infrastructure, establishment of facilities for Regional Service Divisions, capacity building, and enhanced linkages with private companies and other NMHSs which include the signing of MOUs with the Korean Meteorological Administration (KMA) and the Department of Meteorology, Hydrology and Climate Change of the Ministry of Natural Resources and Environment of Viet Nam for research collaboration, data exchange, and capacity building.

Table 11.2 Foreign-assisted projects

Project	Funding Institution	Cost
1. Climate Forecast Applications for Disaster Mitigation	USAID through the Asian Disaster Preparedness Center (ADPC), Bangkok, Thailand	PhP1.2M
2. Bridging the Gap Between Seasonal Climate Forecasts and Decision Makers in Agriculture	Australian Center for International Agricultural Research (ACIAR) – (2005 – 2009)	PhP5M
3. Hazards Mapping and Assessment for Effective Community Based Disaster Risk Management (READY Project)	Australian Agency for International Development (AusAID) through the United Nations Development Programme (UNDP) – 2006-2011	PhP30M
4. Strengthening the Flood Forecasting and Warning System (FFWS) in the Pampanga and Agno River Basins (Phases 1 and 2)	JICA Grant Aid Program – Phase 1 – 2008-2009 Phase 2 – 2010 -2011 (Completed)	PhP400M PhP258M
5. Improvement of Meteorological Radar System (Phases 1, 2 and 3)	JICA Grant – 2010 - 2013	PhP1.6B
6. Feasibility Study for the Improvement of Hydrometeorological Telecommunication System	United States Trade and Development Authority (USTDA) – 2009-2010	PhP48M
7. Establishment of Early Warning and Monitoring System for Disaster (Flood) Mitigation in the Philippines	Korea International Cooperation Agency (KOICA) - August 2008 – July 2009 (Completed)	PhP48M
8. Strengthening of Flood Forecasting and Warning System for Dam Operation (FFWSDO)	JICA Technical Cooperation Project – Oct 2009 – March 2012	PhP160M
9. Improvement of Flood Forecasting and Warning System for Magat Dam and Downstream Communities	Norwegian Agency for Development Cooperation (Norad) – 2010 - 2012	PhP80M
10.Establishment of Early Warning and Response System for Disaster Mitigation Metro Manila	KOICA – 2010 – 2012 (Extended)	PhP150M
11.TECO-MECO Cooperative Project Towards Strengthening the Disaster Preparedness Capacities for Meteorological and Hydrological Hazards	National Science Council - Phase 1 - completed Phase 2 – on-going	PhP18M PhP28M
12. PH-Climate Change Adaptation Project	World Bank – Grant from the Global Environment Facility Thrust Fund – 2009 (Extended until 2011)	USD 5.831M – total project cost

13. MDG-F 1656: Strengthening the Philippines' Institutional Capacity to Adapt to Climate Change	Government of Spain through the MDG Achievement Fund Thematic Window on Environment and Climate Change (2008-2010) (Extended in 2011)	USD8.0M – total project cost
14. Establishment of Communication, Ocean, and Meteorological Satellite (COMS) Analysis System	KOICA 20112-2014	US 4,824M
15. Strengthening Flood Forecasting and Warning System in Bicol River Basins	JICS – 2011-2013	US 400M

SUMMARY 12

Despite the investments made so far in monitoring infrastructure and upgrading of the skills of staff, R&D activities, among others, there are still institutional capacity gaps (Table 12.1) to be addressed to be able to fulfil PAGASA's mandate and improve its services for disaster risk management and EWS stakeholders. The PAGASA still falls short of becoming at par with the so-called advanced meteorological centers in the region. However, its sustained efforts and current programs are leading towards that direction.

Table 12.1 Institutional capacities, gaps and needs of PAGASA

Issues	Institutional capacities	Gaps and needs
Data products	Synoptic data, climate data, METAR, SPECI, SIMET,TAFOR, satellite, radar, AWS, time standard/ almanac, hydromet data and information, marine met data, rainfall intensity duration frequency (RIDF), rainfall depth-area-duration (DAD) map	- Data rescue of historical climate data is urgently needed - High performance Data Quality Management system to support NWP system - Integrated database system for NWP data assimilation - Replacement and timely calibration schedule of met.and climate Instru ments in some remote stations - Reliable and low-cost observation data communication system needed for efficiency
Hazard analysis to support risk assessment	Provide expert in disaster mitigation (still limited number) Climate impact Assessment Bulletin for agriculture, hazard maps on flood, storm surge and severe wind, press release on significant events, information on the onset and termination of monsoon	- Sufficient number of expert in disaster mitigation and risk assessment - Applied R&D products for domestic weather and climate forecasting still relatively limited
Forecasts and warnings	Daily weather forecast, severe weather bulletins, shipping forecasts, tropical cyclone warning for shipping, gale warning information, airways and terminal forecasts, METAR, TAFOR, forecast for selected Philippine cities/municipalities, flood bulletins for monitored river basins and dams, general flood advisories, daily farm weather forecast & advisories, 10-day Philippine Agroclimatic Review & Outlook, monthly Weather Situation and Outlook, El Niño/La Niña advisory, seasonal forecasts, Philippine agri-weather forecast,	- High performance NWP assimilation system in place and operational - Radar and satellite data assimilation and remote sensing-based observa tion product development - Redundancies in communication, hardware and software so that the system functions even during inclement weather - Development of human resources in weather and climate modelling (NWP and climate models) - Flood forecasts showing height and limits of inundation areas - Extended hydrological forecasts - Tailor made forecasts for various sectors

EWS expertise and advisory service	Approximately 72 meteorologists, hydrologists and forecasters in PAGASA's headquarter and regional offices supporting EWS and advisory services	PAGASA's operational staffs to utilize and manage the latest technology instruments and systems
Cooperation with other technical agencies	National level: - Various Departments: Disaster Risk Reduction and Management, Public Works, Energy, - Agriculture, Health, - Transport, - National Mapping, - Mines &Geoscience, - Civil Defense, etc. - Local/provincial governments - Universities: University of the Philippines, Ateneo de Manila International level : - ASEAN's SCMG - JAMSTEC Japan - KOICA Korea - KMA Korea - JICA Japan - JMA Japan - CMA China - DMHCC Viet Nam - TECO Taiwan - Norad Norway - UNDP - AusAID - USTDA - USAID - ADPC - RIMES	
Dissemination mechanisms Principles	Online, Printed, Voice, Multimedia	
Means	Telephone, cellular phone, facsimile, internet (e-mail/website), television, radio, newspaper, public space online display	
Communication and media	State and private TVs, radios, newspapers, internet website, mobile phone providers	

The following table summarizes the rating of the different activities and services of PAGASA.

Table 12.2 Evaluation of level of attainment of PAGASA

Parameter	Score	Remarks
Disaster reduction	3	Limited on-line real-time data; lack dispersion modelling
Data sharing / GTS	4	None
Networking to Regional hydrometeorological organizations	2	None
International cooperation	4	None
Weather forecast	3	Lack nowcasting
Number of WF products	3	Partial manual production system
NWP	3	Limited NWP models
Hydrological forecast	3	Need to provide more effective and user-friendly bulletins i.e. use of GIS
Agrometeorological service	3	Too technical
Automated processing and Visualization	2	Partially manual; need to acquire high computing system and more real-time monitoring facilities
Climate Change	4	None
R & D	2	Need for collaboration with regional NMHS
Support of R&D to main lines	3	None
Surface synop network	3	Low number of on-line stations
Upper-air data	4	Six operational stations but maintenance cost is high
Radar data	2	Lack coverage
Lightning detection	1	Only one is operational – operated by academe
Hydrological Obs. network	3	Good coverage in Luzon island only
Environmental obs.	1	Very limited
Maintenance and calibration	3	Need to upgrade existing facilities
Communication system	2	Luzon coverage is fairly moderate, poor in Visayas and Mindanao; Limited real-time and on-line stations
Data management	2	Some data – still in charts, need data rescue & upgrade software, data storage
Webpage	4	Interactive through Twitter and Facebook
Human resources	3	Limited young technical personnel
Level of education of staff	3	Limited tech. personnel w/ appropriate skills & training
Training programme	3	Limited training for staff
Competitiveness on labour market	3	Low salary level; good visibility on TV
Management	3	Three Deputy Administrator positions – still vacant
Organization	3	Rationalization program – being implemented
Competitiveness	4	Good
Public visibility	4	Good
Public appreciation	3	Need to provide tailor made forecasts
Customer orientation	3	More IEC needed
Cooperation with media	4	Good
Market position	3	Many providers of hydrometeorological data; private sector
Foreseen possibilities for sustainable development	4	Active mobilization of international financing
Total Score	107	

Note: 5= Excellent, 4= Good, 3= Moderate, 2= Poor, 1= Very bad. Perfect score=180.

Nine (9) were given a score of “Good”, among which are data sharing/GTS, international cooperation, and climate change. About half (19) out of the 36 parameters scored moderate.   (None was rated “Excellent”), henceforth, parameters which scored “Moderate” and below need more attention. It is also helpful to bear in mind that certain parameters may not be as significantly important as the rest. For instance, lightning detection has a score of “1” because only “one is operational,” however lightning may not be a major national hazard. This must also be seen in the context of national priorities, as well as relative position when compared with other Asian countries.

While the components that make up the NHMS are enhanced further, there remains a challenge to link these together to provide the services adequately. For instance, use of data generated from the radar systems can be maximized, say for running or testing a model (such as WRF) for 72-hour weather. This concern is shown by the score given to data management.

RECOMMENDATIONS TO STRENGTHEN THE METEOROLOGICAL AND HYDROLOGICAL SERVICES OF PAGASA

13

Within the context of changing socio-political environment and other external factors, PAGASA's Strategic Plan 2008-2012 has six key result areas (KRAs) to advance its service. In 2011, a strategic planning workshop participated by PAGASA staff was facilitated by WMO scientist, Dr. Rodolfo de Guzman, who came to the country under DOST's Balik Scientist Program.

The KRAs and 39 means to achieve these are shown in the first column of Table 13.1. In the second column is the output from the 2011 strategic planning workshop - the key expected results (KERs) that were identified as concrete manifestations of how PAGASA's role as NHMS might be strengthened. The PAGASA Strategic Plan 2008-2012 is on its last year at the time this report is finalized. Fittingly, PAGASA's administration has adopted the 28 KERs formally, as a 'successor' to the 2008-2012 plan, taking into account the extent to which its objectives have been attained.

Progress in strengthening PAGASA over the last five years has had its ups and downs. Significant increases in government budget and of support from development agencies have enabled PAGASA to undertake activities as demanded. Apart from the many challenges of PAGASA in the context of increasing disaster risks and vulnerability, and uncertainties related to climate change, it is facing typical operation issues of an NHMS. These are the operation and maintenance (O&M) of acquired instruments, equipment and facilities; communication; improving the rapport with the public, media and other stakeholders through a working EWS; and staff requirements, particularly in the area of ITC, and the corresponding budget allocation.

Comments obtained from the consultation meeting held on 30 April 2012 with various stakeholders emphasized the need for upgrading O&M in PAGASA. This should extend to each project such that a project must include O&M plan and implementation strategies with corresponding monitoring and evaluation procedures. Due to budget limitations, a system of prioritization based on a clear set of established criteria should also be established; this can be applied, for example, in the selection of potential projects for the major river basins which have already been identified.

Table 13.1 Desired results from strategies of PAGASA

PAGASA Strategic Plan 2008-2012	Output of 2011 strategic planning workshop
Key result areas (KRAs)	KEY EXPECTED RESULTS (KERs)
11. Leading role in hydrometeorological early warning system; 12. Public access to quality meteorological, climatological, hydrological, oceanographic and astronomical products and services; 13. Strong advocacy on climate change, its mitigation and adaptation;	1. Increased accuracy in tropical cyclone track forecast; 2. Improved rainfall warning and thunderstorm warning on specific location(through telephone inquiries); 3. Operationalization of nowcasting; 4. Enhanced data manipulation and visualization tools; 5. Improved accuracy, usefulness and timeliness of flood forecasts in major river basins and dams by 80% based

14. Excellence in tropical cyclone forecasting in the ASEAN region;
15. Strong and dynamic organization with inspired and dedicated workforce; and
16. Well managed PAGASA resources.

These KRAs can be achieved with the realization of the following:

1. Optimal mix of composite observation system and data processing facilities;
2. Provide advisories/warnings for extreme small scale and short duration weather systems, such as tornados, thunderstorms, severe storm phenomena, etc.;
3. Upscale the community-based early warning system;
4. Expand coverage of telemetered flood forecasting and warning system to all major river basins;
5. Increase supply of dependable meteorological, climatological, hydrological, oceanographic and astronomical products and information;
6. Improve data and information visibility in the web and other public network;
7. Promote and enhance user-friendly products and services;
8. Improve observation network and monitoring systems to further support the science-based indicators of climate change;
9. Improve understanding and prediction of long-term climate variability;
10. Produce solid and validated climate change scenario on a more localized scale;
11. Enhance capability to identify and understand impacts, vulnerability and adaptation responses
12. Intensify information and education campaign on climate change;
13. Use ensemble prediction and improve data assimilation scheme for numerical models;
14. Expand satellite- and radar-derived products, focusing on rainfall estimates;
15. Operationalize expanded wave and storm surge forecasting models;
16. Improve capabilities in tropical cyclone forecasting and warning;
17. Advance meteorological instrumentation, tools and techniques;
18. Implement best practices in the management of PAGASA in support of its vision;
19. Capitalize on the diversity of its work force to improve overall organizational performance;
20. Encourage, recognize, and reward innovation at all levels, especially for improved services to end-users;
21. Enhance professional development and training of its work force to include teamwork, leadership, diversity, customer service, and implementing change;
22. Aggressive recruitment and proper placement of personnel. Active participation and linkages in national and international scientific activities;

on the 2009 baseline;

6. Implementation of a Rainfall Alert System;
7. Application of QPE/QPF for effective FFWS and Severe Weather Forecasting System;
8. Established Rainfall Warning Signal;
9. Nowcasting/Thunderstorm Forecasting/Flash floods in cities;
10. Established integrated-regional forecasting center for the specific needs of areas by extreme climate events;
11. Expanded scenario modelling of climate change projections;
12. Improved climate forecast thru the use of dynamic and statistical models;
13. Establishment of Climate Information System in CDMS/ Data Rescue (PAGASA Unified Meteorological Information System or PUMIS);
14. Enhanced R&D for improved forecast;
15. Established guidance in forecasting using radar data, in volume of rain, rain rate in Metro Manila and urbanized areas;
16. Established National Database Management System (DBMS);
17. Operationalized storm surge forecasting and thunder storm forecasting models;
18. Enhancement of weather forecasting using Radar Satellite and NWP Model;
19. State-of-the-art robust telecommunication system;
20. Improved organizational structure based on functions;
21. Proper placement of personnel based on functions;
22. Pool of well-trained personnel in meteorology, hydrology, climatology and weather observation;
23. Capacity of a pool of well-trained personnel in the various relevant fields;
24. Improved human resource capacity;
25. Improved performance evaluation system;
26. Development of succession plan
27. Collaborative and mutually beneficial relationship with media taken into consideration the social responsibility of both parties in the dissemination of information crucial to the life and welfare of the Filipino
28. Enhanced agency communication and public outreach program

23. Implement an integrated policy, planning, budgeting, assessment and accountability that links decision making and goals to program implementation and evaluation;
24. Utilize ICT to improve the cost effectiveness of PAGASA systems, programs and operations;
25. Enhance collaboration with RIMES and other atmospheric research centers;
26. Implement the outcome of the feasibility study conducted by USTDA on the strengthening of meteorolological and hydrological telecommunication system of PAGASA;
27. Cooperation and improved data sharing with aviation, road sector and other sectors gathering hydrometeorological and environmental data;
28. Adequate radar coverage of the country and production of real-time composite images;
29. Increase number of buoys equipped with oceanic and meteorological sensors;
30. Develop local scale projections using higher resolution models to study the impacts of Climate Change;
31. Promote coordination, quality control and possibilities of common use of hydrometeorological measurements taken by different organizations in the country;
32. Plan activities in cooperation with stakeholders and end-users to promote collection, sharing and use of data, extending their use to meet local, regional and international demand;
33. Raise the quality of observations, equipment maintenance, automatic quality control and data management;
34. Promote cooperation and data sharing within the region;
35. Promote IT-supported data collection, smooth and user friendly data management, and automated generation of products;
36. Implement data rescue and upgrade the data base management; Automated production and dissemination of weather service products;
37. Enhance use of data for R&D activities;
38. Promote the manufacturing of services and products in cooperation with end-users;
39. Enhance capacity building, international networking, and training programme for personnel;
40. Promote awareness of stakeholders, political leaders, and various economic sectors on the relevance and value of PAGASA’s services for the well-being of the people and in support of the development of the country.

14 PROJECT PROPOSAL

This project proposal is developed in order to enhance the capability of PAGASA to address the requirements for preparing and producing the products and delivering the services that will cover the national needs of various socio-economic sectors that need such products and services. It also takes into consideration the investments from the national government and grants from foreign donors to upgrade the observing network and facilities of PAGASA. (Note: The tentative budget is an estimate should a regional system be adopted.)

14.1 Regional cooperation

There are a number of advantages and benefits for international cooperation which covers sharing of data and technical expertise among others. The urgency of closer international cooperation can be depicted in the recent passage Tropical Storm Ketsana that devastated four (4) countries namely the Philippines, Viet Nam, Cambodia and Lao PDR. Among the initiatives that need to be pursued are:

- Membership in the Regional Integrated Multi-hazard Early Warning System (RIMES)
- Implementation of the MOU (signed in 2009) between PAGASA and DHMCC and MoNRE on data sharing, training and joint research undertaking on oil spill dispersion modelling and storm surge modelling;
- Continuous collaboration with the Korean Meteorological Administration on telecommunication among forecasters during the passage of typhoons, technology transfer, capacity building and implementation of KOICA projects
- Access to short-term forecasts and products of the European Centre for Medium Range Forecast

Activities: International cooperation and networking;
Tentative budget: US$100,000

14.2 ICT and Data management

Vital to the modernization of PAGASA's hydrometeorological services is the implementation of a robust telecommunication system which is reliable especially during emergency situations.

Activities: Telecommunication System
Tentative budget: US$14,800,000
Implementation responsibilities: equipment and training; consultant on turnkey basis

14.3 Meteorological observation

Activities: additional automatic weather/rainfall stations to increase density – 150 stations
Tentative budget: US$1,005,000
Implementation responsibilities: equipment and training; consultant on turnkey basis

14.4 Hydrological stations

A flood forecasting and warning system is proposed to be established in the Mindanao River Basin which is one of the most flood prone areas in the country. It is also the second largest river basin in the country, with Cagayan River Basin as the largest.

Activities: establishment of hydrological monitoring network and flood forecasting and warning system.
Tentative budget: US$6,160,000
Implementation responsibilities: equipment and training; consultant on turnkey basis

14.5 Maritime observation network

Activities: establishment of one (1) additional marine buoy
Tentative budget: US$1,200,000
Implementation responsibilities: equipment and training; consultant on turnkey basis

14.6 Upper air stations

Currently, PAGASA operates six (6) upper air-stations located in Tanay, Laoag, Legaspi, Cebu, Davao and the newly installed station in Puerto Princesa. The network is already sufficient to cover the country.

14.7 Weather radars network

The ideal number for a network of Doppler radars cover the entire country is 14. The radars have been funded by the national government and the Government of Japan.

14.8 Software tool for visualizing and editing meteorological data

The government has funded the purchase of hardware and software for editing/visualizing output products amounting to US$2.97 million. The proposal includes work stations and visualization tools.

Activities: Purchase an editing tool for forecasters + visualizing software package
Tentative budget: US$400,000
Implementation responsibilities:

- equipment with basic visualizing software package: consultant on turnkey basis
- training

Note: PAGASA shall have acquired the visualization tool (hardware and software for editing/visualizing output products) with government funding by December 2012.)

14.9 Lightning detection system

Activity: Lightning detection system is critical for the power sector. It is also useful for nowcasting and outdoor sports activities. The proposal seeks to install 6 LF sensors in strategic locations.
Tentative budget for ligthing detection system: US$100,000
Implementation responsibilities: equipment and training; consultant on turnkey basis

14.10 Research and development

- Budget: US$310,000
- Research activities in support of climate change adaptation measures of the Philippines such as study on climate variability and change
- Assessment of climate impacts on major socio-economic sectors
- Development of adaptation measures to address extremes climate events, as follows:
    a. Disaster mitigation – establishment of com munity based flood early warning system in highly vulnerable areas in the Philippines
    b. Replication of climate field schools in various agricultural areas in the country

It is also critical to study the impacts of climate change in Southeast Asia using global models with appropriate downscaling to regional and local level. This can be undertaken as a regional collaboration to enable other NMHS with insufficient computing facility and limited knowledge in numerical modelling to meet their local requirements on climate change. The PAGASA have on-going initiatives on climate change funded by various sources.

14.11 Training

Tentative budget: US$200,000

The description of the proposed training is as follows:

Technical training (for Operation and Maintenance of facilities)
Proposed budget:

- 2 month training for 5 technical personnel – numerical weather prediction
- 2 month training for 5 technical personnel – application of remote sensing data
- 1 month training for 5 IT personnel

The table below shows small savings from strengthening PAGASA's capabilities as part of a regional cooperation project. This is because a large portion of the proposed project involves the upgrading of the hydrometeorological telecommunication system of the agency which will enable real-time collection of hydrometeorological data for use in local forecasting and warning as well as for data sharing in the region.

Table 14.1 Distribution of costs of the 5-year project for strengthening PAGASA considering (A) Stand-alone and (B) Regional system

Item	Cost (US$)	
	A Stand-alone	B Regional cooperation
International cooperation of experts	100,000	30,000
Telecommunication system		
- Hardware + software	14,800,000	14,800,000
- Annual operation		
Data management		
- Hardware including storage and installation	300,000	300,000
- Consultation and training	50,000	50,000
- Annual maintenance		
Meteorological observation network		
- Automatic rainfall stations	1,005,000	1,005,000
- Communication costs		
Hydrological observation network		
-Telemetered hydrological stations	6,160,000	6,160,000
Maritime observation network		
- Marine buoys	1,200,000	1,200,000
- Data communication + maintenance		
Remote sensing network		
- Lightning detection	100,000	100,000
Forecasting and production tools		
- Visualization system	300,000	300,000
- Training	100,000	100,000
Training	300,000	200,000
Research and development	310,000	310,000
- Impacts of climate change		
- Socio economic impacts		
- National seminar on socio-economic benefits		
- End-user seminar		
Project management		
- Consultant	250,000	125,000
- Local project coordinator	100,000	50,000
Total	25,075,000	24,730,000

Note: At the completion of the review to finalize the report, four (4) project components are already being undertaken through funded projects or have been assured of funding through commitments by a few donors. These are: the Meteorological Observation Network, the Hydrological Observation Network, Maritime Observation Network, and Forecasting and Production Tools (for visualization).

ANNEX 1

People met during the Mission

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18	Nathaniel T. Servando	Deputy Administrator for R&D, PAGASA	4342537
19	Catalino L. Davis	OIC, Deputy Administrator for Admin & Engineering Services, PAGASA	9286461
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25	Ma. Cecilia A. Monteverde	Chief, Hydrometeorological and Climate Change Research Section	
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34	Thelma A. Cinco	Chief, Climate Impact Application Section	4342698
35	Aida M. Jose	Philippine Meteorological Society	

ANNEX 2

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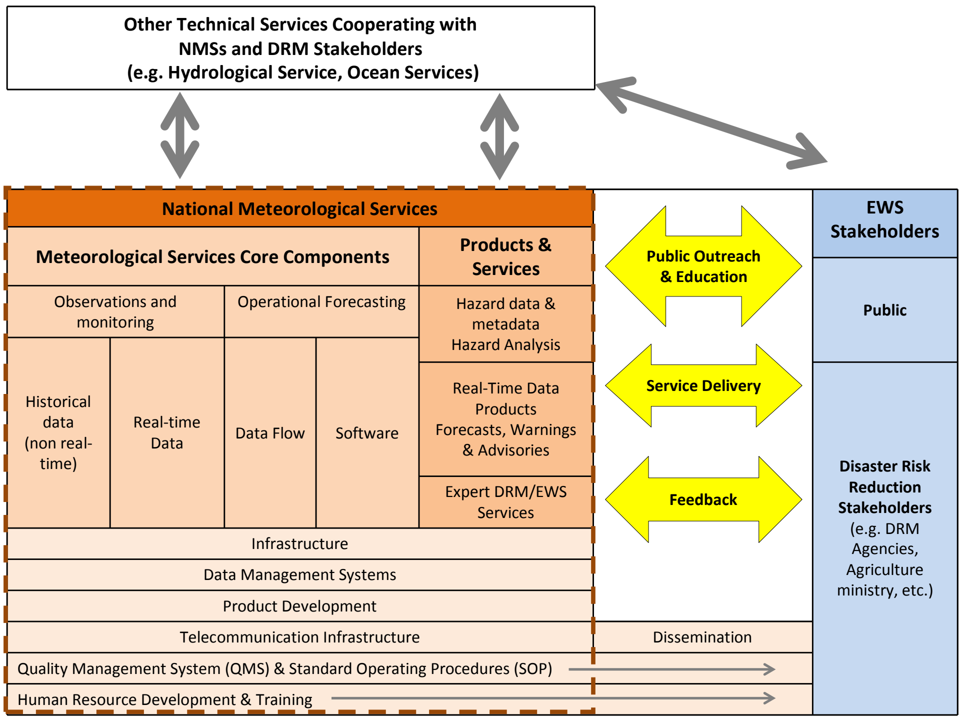
ANNEX 3

A systematic Framework for Presentation of the Analysis of Meteorological and Hydrological Services

A fundamental mission of Meteorological and Hydrological Services and the World Meteorological Organization (WMO) is to contribute to the protection of the lives and livelihoods of people by providing early warnings of meteorological and hydrological hazards and related information to reduce risks. They are crucial support for DRM agencies and EWS stakeholders with regard to disaster prevention and preparedness, mitigation of the impacts of disasters, emergency response, recovery and reconstruction.

The schematic presented in the figure is an illustration of the core aspects of the support that Meteorological Services provide to DRM agencies and EWS stakeholders (e.g., Emergency Preparedness and Response, Agriculture, Health, Infrastructure and Planning, Water Resource Management, Tourisms, Fisheries and Marine, Transportation, etc) . Starting from a user requirements perspective (blue column) the figure illustrates the products and services, core services required to develop these products and services, and the interface between the Meteorological Services and the EWS stakeholders. This interface comprises Public Outreach and Education, Service Delivery as well as Feedback.



Schematic of linkages of Meteorological Services with EWS and DRM stakeholders

As identified in many countries of good practice in EWS, feedback mechanisms such as routine or post-event meetings, workshops, training and simulation exercises are crucial to increase bilateral and multi-sectoral understanding and for continual improvement of the service delivery on the Meteorological Service side. Meteorological Services must ensure that the interface between their activities and the EWS stakeholders are operational and efficient. Thus, the goal of the Meteorological Services is to provide and deliver useful, usable and credible products and services such as forecast and warning products or hazard information to meet country or territory needs, especially when an extreme weather-related event occurs.

The set of services and products not only comprises forecasting and warning products but also a wide variety of data products, of hazards information and analysis as well as services of expertise for specific EWS-oriented studies and research, for products design and to support decision-making. For this, it is critical that the Meteorological Service has adequate core capacities for observation, monitoring and operational forecasting. The forecasting system should enable accurate and timely forecasts via access to a wide variety of numerical weather products, monitoring information and integrated guidance systems with up-to-date tools, software and functionalities.

Observation networks are essential in many dimensions in the MHEWS, in real-time hazard monitoring and models verification and adjustment but also for climatological matters and hazard analysis. Thus, Meteorological Services have to manage real-time and historical observation networks with sufficient space and time coverage.

These basics capacities need essential supporting functions and activities such as data management, product development and the relevant information technology (IT) and telecommunication. Data management includes quality controls and also access and exchange at national and regional level. Product development capacities are essential to guarantee the provision of adequate products according to user needs and specifications.

All these activities rely on robust and up to date IT and telecommunication with redundancy and back up procedures for internal aspects as well as for dissemination capacities to DRM agencies, other institutions or general public including the Media.

For an effective management of these activities, overarching capacities such as human resources, training capacities, standard operational procedures (SOPs) or quality management systems (QMS) are essential. Multi-hazard Watch and Warning System is part of these sets of SOPs or QMS and serve as an umbrella for comprehensive warning delivery to DRM agencies, stakeholders and the general public. It frames all the relevant activities from forecasting and warning to dissemination and communication matters.

All of this is possible only with a sufficient number of qualified and trained meteorologists, not only from a forecasting point of view but also for all the supporting activities like computer and network engineering, Web management, maintenance, communication, etc.

The figure above highlights that other technical institutions, especially hydrological institutions, can play an essential role in many areas through direct input on the DRM side and through synergies and collaboration with the Meteorological Services in terms of forecasting, warning and data exchange.