COUNTRY ASSESSMENT REPORT FOR VIET NAM

Strengthening of Hydrometeorological Services in Southeast Asia

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Global Facility for Disaster Reduction and Recovery

ACKNOWLEDGMENTS

This Country Assessment Report for Viet Nam is part of a study that aimed to strengthen the hydro-meteorological services in South East 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 National Centre for Hydro-meteorological Forecasting (NCHMF) under the Ministry of Natural Resources and Environment (MONRE) of Viet Nam supported the country assessment and coordinated the participation of various departments and ministries, including the Department of Hydro-Met and Climate Change, the Institute of Strategy and Policy for Health, the Institute of Hydro-Met and Environment (IHMEN), the Central Committee for Flood and Strom Control (CCFSC), the Aviation Department, the Railway Department, the Viet Nam Red Cross as well as media agencies.

The GFDRR team in the World Bank Country Office provided comments on the draft country assessment report.

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.

The final draft report was reviewed by concerned national agencies and NCHMF supported the report finalization.

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ACRONYMS

AADMER	ASEAN Agreement on Disaster Management and Emergency Response
ADB	Asian Development Bank
ADPC	Asian Disaster Preparedness Centre
ACIAR	Australian Center for International Agricultural Research
ASCMG	ASEAN Subcommittee on Meteorology and Geophysics
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
BDRFDM	Board of Day River Flood Diversion Management
CAMET	Centre for Agricultural Meteorology (under IMHEN)
CCA	Climate change adaptation
CCC	Climate Change Commission
CCFSC	Central Committee for Flood and Storm Control
CDM	Clean Development Mechanism
CMC	Centre for Meteorology and Climatology (under IMHEN)
COST	ASEAN Committee on Science and Technology
DARD	Department of Agriculture and Rural Development
DDMFC	Department of Dike Management and Flood Control
DHMCC	Department of Meteorology, Hydrology and Climate Change
DRR	Disaster Risk Reduction
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
HMITC	Hydro-Meteorological Information Technology Centre
HMS	Hydro-Meteorological Service
ICAO	International Civil Aviation Organization
IMHEN	Institute of Meteorology, Hydrology and Environment
IOC	International Oceanographic Commission
IPCC	Intergovernmental Panel on Climate Change
ITST	Institute of Transport, Science and Technology
IWRM	Integrated Water Resources Management
JICA	Japan International Cooperation Agency
MARD	Ministry of Agriculture and Rural Development
MHDARS	Meteo-Hydrological Data Archival and Retrieval System
MOF	Ministry of Finance
MONRE	Ministry of Natural Resources and Environment
MPI	Ministry of Planning and Investment
MRC	Mekong River Commission
NCHMF	National Centre for Hydro-meteorological Forecasting
NMHS	National Meteorology and Hydrology Services
NTP	National Target Programme (NTP) to Respond to Climate Change
NWP	Numerical Weather Prediction
PHMC	Provincial Hydro-Meteorological Centres
RIMES	Regional Integrated Multi-Hazard Early Warning System for Africa and Asia
RHMC	Regional Hydro-Meteorological Centres
SEDP	Socio-Economic Development Plan
SEDS	Social Economic Development Strategy
TIPS	Tropical cyclone Information and Prediction System
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
UNISDR	United Nations Office for Disaster Risk Reduction
USAID	United States Agency for International Development
UNRE	Universities of Natural Resources and Environment
USTDA	U.S. Trade and Development Agency
WB	The World Bank
WIS	WMO Information System
WMO	World Meteorological Organization
WTO	World Trade Organization

EXECUTIVE SUMMARY

The role of hydro-meteorological services

Weather and climate have always influenced human activities and natural systems. Climate and changes in the climate, including extreme weather events are increasingly being seen to impact adversely on human safety, health and security, natural ecosystems, food production and food security, and livelihood resilience. Temperature increases coupled with shifts in rainfall patterns and changes in rainfall amounts have resulted to reduced agricultural yields. Increases in tropical cyclone frequency and/or intensity have led to disastrous events such as loss of lives, damage to infrastructure and properties. Floods and droughts have also been seen to result to increased incidence of vector-borne and water-based diseases; thus, endangering human health.

Accelerated sea level rise will expose more people to the risk of coastal flooding. Moreover, tourism which is an important source of income would be affected by severe disruption from climate change and sea level rise.

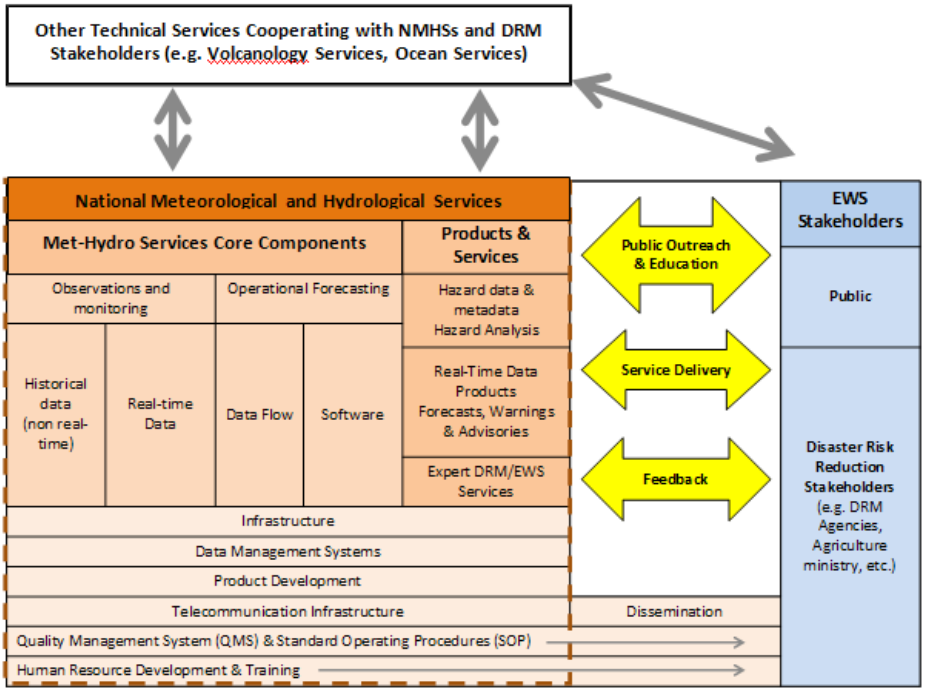
These adverse impacts are projected to increase with time as a result of anthropogenic climate change. With the felt impacts of climate change, there is now a growing appreciation of the value of hydrometeorological forecast and other information among end-users in the various sectors. For example land, marine and aviation transportation could utilize forecast information such as severe weather advisories and warnings. Agriculture and food production decision makers and producers/workers will be able to improve their production outputs when provided with timely and accurate climate forecasts. Disaster risk managers/practitioners could effectively reduce the number of exposed communities if given the appropriate early warnings and other information such as climate hazards/risks in order to ensure disaster preparedness. Public health practitioners can limit, if not totally prevent exposure of communities to triggers of climate-sensitive diseases if timely advisories are issued.

There is thus, a growing demand for tailored, accurate and reliable forecasts and warnings issued in a timely manner and in a user-friendly and easy-to-understand language.

As the impacts of climate change continue to unfold and accelerate due to global anthropogenic climate change, the National Meteorological and Hydrological Services (NMHSs) will be faced with increasing challenges and demands of providing more useful forecasts and other information that cater to the needs of the various sectors. 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.

To address the emerging demands of the different sectors, it is necessary to put in place the basic requirements for an NMHS to function effectively, as follows: 1) adequate networks to monitor hydro-meteorological 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 ensemble forecasting; 4) human resource equipped with appropriate trainings; and 5) more interaction with users of weather and climate information.

The transboundary nature of weather-causing phenomena would require collaboration among NMHS 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).



Source: Golnaraghi, mgolnaraghi@wmo.int

Figure 1. Schematic of linkages of Meteorological Services with EWS

Assessment of needs of improved hydrometeorological services in Viet Nam

Located in the tropical monsoon area, adjacent to the East Sea and the North West Pacific Ocean, Viet Nam has diverse and favorable climate resources. At the same time it is also affected by numerous natural hazards, especially typhoons and floods. Since ancient times, the Vietnamese people have had experience in taking advantage of climate conditions, as well as in natural-hazard induced disaster prevention and preparedness. Hydrometeorological observations and measurements under feudal dynasties have been recorded and well archived up to now. However, the hydrometeorological activities in Viet Nam have only been systematically carried out since the late 19th century. After the National Independence Day of Viet Nam (2 September 1945), they were restored and strengthened for effectively serving the country's construction and defense.

As demonstrated by recent climate experiences, Viet Nam has still quite a number of limitations in the adaptive capacity to reduce its vulnerability to climate change, including extreme events. The capacity for managing climate risks, including seasonal forecasting, early warning systems, disaster preparedness, mitigation and relief, needs to be improved. In most farming systems, adaptation has not been implemented to account for inter-annual or inter-seasonal variations in current climate.

The National Hydro-Meteorological Service (NHMS) of Viet Nam, like all the NMHS in other countries, plays an important and vital role for the safety, well-being and welfare of its population, and economic development of the country. It has been given the mandate to protect man and society from the vagaries of weather, climate and water induced disasters and provide for ways the country can use weather, climate and hydrological information in pursuing sustainable economic development, through the timely provision and issuance of timely, accurate and reliable information.

NHMS Viet Nam provides its forecasting services through its operational units at various levels: i) the National Centre of Hydro-Meteorological Forecasting (NCHMF) at the central level, ii) regional hydro-meteorological centers (RHMC) at regional level, and iii) provincial hydro-meteorological centers (PHMC) at provincial level.

NHMS Viet Nam is the main provider of weather forecasts (including nowcasts, very short-range, short-range, medium-range and long-range forecasts) in the country and enjoys a good visibility in the media. However, the NHMS needs to improve its relations with the media and explain the limitations of their forecasts. It takes a lead role in the provision of marine forecasts along the coastal and surrounding seas from the North Bacbo Gulf to the South Bien Dong Sea.

Hydrological forecasts and warnings are issued by the NMHS covering rivers in the Northern, Central, Central Highlands and Southern regions of Viet Nam including the trans-boundary river that traverses Viet Nam such as the Mekong River.

Climate services are carried out by the Institute of Meteorology, Hydrology and Environment (IMHEN) through the provision of climate outlook. IMHEN is a functional organization for science under the jurisdiction of the Ministry of Natural Resources and Environment (MONRE) with mandate on research and development in science and technology on meteorology, hydrology, oceanography, water resources, and environment. The Institute also issues agro-meteorological outlook and crop yield forecasts which are very useful to the agricultural sector.

There are however, numerous challenges, which could be classified as physical infrastructure, human resources, institutional arrangements, policy environment, and technology-related, among others. These include:

- inadequate office infrastructure, observation/monitoring networks, forecasting tools and systems, and financial resources;
- insufficient manpower skills ;
- poor communication system, specifically for timely and fast data transmission and dissemination of forecasts and advisories;
- need to expand services in order to sustainably meet the growing demand for user-specific forecast and information in various economic sectors;
- need to provide specific and tailored forecasts to each economic and specialized sector (e.g., agriculture, water resource managers, tourism, disaster managers/practitioners, energy producers/providers, etc.), including those for the rivers within the country (Northern, Central, Central Highlands and South regions of Viet Nam) and for the transboundary river traversing the country, the Mekong River;
- need to provide for weather/climate forecasts and information at regional and local scales in the country;
- need to transform forecasts, advisories and warnings and other information into a user-friendly, and easy-to-understand language ;
- addressing the need for improved weather/climate forecasts and information in the light of increasing severity of adverse impacts due to climate change;
- addressing the crucial role of the NHMS in disaster reduction and disaster risk reduction; and
- increasing severity of adverse impacts of climate change on human and natural systems in the country.

On the other hand, there also are a few significant opportunities which could enhance the provision of services required in order that the NHMS can effectively carry out its mandated role. These opportunities could also facilitate the acquisition of

funds for equipments and facilities for the observing networks for monitoring hydromet parameters, robust communication system for real-time data assimilation and transmission, dissemination of forecasts and early warning advisories including data and information sharing, high-speed computing systems for data assimilation and numerical weather prediction, hiring of highly-skilled and competent staff and manpower, sustained interaction with users of forecast products and information, and close collaboration with other NHMSs in the region.

Another important opportunity of the NHMS is to tap the expertise of the Institute of Meteorology, Hydrology and Environment (IMHEN) as well as the Department of Meteorology, Hydrology and Climate Change (DHMCC), both under the Ministry of Environment and Natural Resources (MONRE). The IMHEN was upgraded into a scientific organization to conduct research and development activities in meteorology, climatology, agrometeorology, hydrology, water resources, oceanography and environment. On the other hand, the DHMCC is a policy-making body which provides advice to MONRE, formulates plans, projects, programs and strategies for meteorology, climatology, natural hazard-induced disaster forecasting and warning, management and coordination of climate change-related activities and ozone layer protection. There are overlapping activities in these two agencies but both can provide excellent support to the NHMS.

There are also a number of government institutions which maintains observing systems for atmospheric, oceanic, terrestrial and environmental fields which the NMHS can tap and collaborate to enhance its observing network.

The NHMS Viet Nam has existing linkages and coordinates with the various economic sectors within the country which they can leverage for support.

In addition, the NHMS Viet Nam also have existing linkages with several international and regional organizations (e.g., UNDP, UNEP, UNESCO, UNISDR, ADPC, RIMES, IHP, MRC, WB, ADB, etc.) and collaboration as well as bilateral agreement with other NHMSs in the area of exchange of hydrometeorological products, technology transfer, research, training , and others.

National setup for production of hydrometeorological services in Viet Nam

The National Hydro-Meteorological Service (NHMS) of SR Viet Nam was officially established in 1976. In 2003, the Ministry of Natural Resources and Environment (MONRE) was established on the basis of incorporating the 6 components such as land administration, water resources, geology and mineral resources management, environmental protection, meteorology and hydrology, survey and mapping. The National Hydro-Meteorological Service is an operational unit under MONRE. Under the NHMS, the National Centre for Hydro-meteorological Forecasting (NCHMF), 9 regional hydro-meteorological centers and 54 provincial hydro-meteorological centers carry out the meteorological and hydrological forecasting and warning for the whole country from central to provincial levels in order to meet all the requirements for the provision of meteorological and hydrological services in support of disaster prevention and preparedness, socio-economic development, and national security of the country. The Hydro-Meteorological Information Technology Center implements the specialized hydro-meteorological telecommunication network for data transmission and collection as well as for products/services delivery to the public and various socio-economic sectors.

The NHMS operates and maintains more than 90% of all weather, climate and hydrological observation networks in Viet Nam. The network density of surface synoptic stations is about one station per 1916 square kilometers, while the rainfall stations have a higher density of one rain station for every

824 square kilometers.

Hydrological forecasts and warnings are issued by the NMHS covering rivers in the Northern, Central, Central Highlands and Southern regions of Viet Nam including the transboundary river that traverses the country, the Mekong River.

Weather service for aviation is carried out by the Institute of Transportation, a government agency under the Institute of Transport, Science and Technology (ITST). The institute maintains meteorological monitoring stations in all airports in Viet Nam. The ITST has expressed its willingness to collaborate with NHMS on the sharing of data to improve their forecasting services for aviation.

Climate prediction services are carried out by IMHEN through the provision of climate outlook, agro-meteorological outlook, and crop yield forecasts which are very useful to the agricultural sector.

State of affairs of the NHMS

The NHMS is a government agency under MONRE and it is headed by a Director General. Viet Nam is a member of the WMO and the Vice Minister of MONRE is the country's designated Permanent Representative with WMO.

Although the NHMS's vision is not articulated, its mission is to assist the Minister of MONRE to manage, exploit national meteorological and hydrological networks (including basic investigation activities, forecasts, meteorological and hydrological data management), monitor air and water environment in support of natural disaster prevention and preparedness, socio-economic development, national security and defense over the country. It is critical for the NHMS to enhance its linkages and collaboration with other government agencies as well as private institutions to facilitate the improvement and sustainability of the provision of forecasting and warning services and information.

The NHMS has good technical and support staff; however, it has to facilitate the full implementation of its cost-recovery measures to help sustain its operation and maintenance budget. Its cost recovery program is about US$2.5M per year which is approximately 10% of the total budget of the NMHS. Although the government is ready to invest in the modernization of NHMS facilities, MONRE has called upon the NHMS to start its commercialization program.

The existing NHMS office premises, observation network, forecasting systems, and especially its financial resources are not adequate to enable the agency to meet the increasing needs of regional and local forecasting of weather and climate related hazards and the issuance of early warning for the public and different socio-economic sectors.

The staff at the NCHMF and other technical support personnel are engaged on a 24/7 operation throughout the year.

The NCHMF has a total of 140 personnel. About 85% has academic degree which include 12 PhD's (comprising 10%), 18 with Masters degree (13%), 85 Engineers and Bachelors degree holders (60%), and the others are non-degree holders. One of the priorities of the NHMS is to keep a high level of qualification standard for its technical staff.

The NMHS headquarters is temporarily housed in a new building in Central Ha Noi. However, the rooms and laboratory are not spacious enough to accommodate a modern information technology facility.

The training of technicians and engineers of NHMS are conducted by the Center for Hydro-Meteorological Technology Application and Personnel Training of NHMS. The NHMS have also coordinated with foreign experts in holding training courses for the staff on various specialised topics such as operational weather, flood forecast, seasonal climate prediction, climate change, and monsoons. Besides, the NHMS sends its experts to Ha Noi and Ho Chi Minh City Universities of Natural

Resources and Environment (UNRE), Hanoi National University, Hanoi Water Resources University, ect. for various professional courses.

The higher level training is implemented by IMHEN and national universities which offer post graduate programs in Atmospheric Physics, Meteorology/ Climatology, Hydrology/Hydraulics, Water Resources/River and Coastal Management and Dynamics, and Marine Hydrology. IMHEN has already produced a total of 31 graduates in the PhD program and has 10 new PhD students.

The NHMS has existing linkages with many international and regional organizations (UNDP, UNEP, UNESCO, ESCAP, ADB, IHP, RIMES, etc,). The NHMS served as Chair of the ASEAN Subcommittee on Meteorology and Geophysics (SCMG) for the period 1996-1998. Numerous countries from all over the world have collaborations with NHMS in hydrometeorological products exchange, technological transfer, research and training, and others. NHMS has also signed agreements on bilateral cooperation with many National Meteorological Services and international organizations.

As far as data collection is concerned, observation stations are unevenly distributed. Most of the collected data are processed and provided in non-real time basis and their observation equipments are already old and exceeded their life span and need replacement.

The NHMS's existing forecasting system is not adequate to enable it to issue warnings on intense rainfall events that can trigger flash floods and landslides. Marine meteorological forecasts are also limited. Its technology for data processing, quality control and archiving is also old and needs upgrading.

Most forecast products of the NHMS are monotonous and do not meet the increasing demands for disaster prevention and preparedness activities as well as for sustainable socio-economic development.

Weather radars were acquired by the NHMS at lower price however, the software for the interpretation as well as for calibration of rainfall intensities was not included in the package. Currently, the NHMS has not yet utilized the radar imagery for rainfall estimation purposes.

On regional cooperation, the NHMS is providing support to Lao PDR in terms of data sharing, strengthening forecasting capability, and training of staff. For Cambodia, similar arrangement is being developed. Under the WMO forecast demonstration project, the Viet Nam NHMS serves as the focal point in providing NWP products to Lao PDR and Cambodia.

Drawing from the lessons learned from the inaccuracy of forecasts in the past couple of years, the NMHS has initiated some measures to improve its services which include enhancing relationship with media and communications organizations through press conferences before storms make landfall and conduct of training of reporters and journalists on hydrometeorological issues; construction of two wireless aerial scouting stations in the cities of Vinh and Dien Bien by MONRE which guarantee a fast connection between central and local hydrometeorological centres; compliment synoptic method of forecasting with the use of numerical weather prediction models; avail of foreign experts to conduct training of its personnel on climate change, monsoons, seasonal climate forecasting, and applications of weather radar.

To facilitate coordination with other agencies in the provision of timely and frequent updates on weather and climate information especially during the occurrence of extreme weather and climate events, an Information and Communications Technology Center has been established recently in the NHMS and is responsible in coordinating and providing media organizations with the most updated weather and climate forecast and other information.

A regulation has also been issued for its local and regional hydrometeorological forecasting centres,

on what should be done to deal with weather and climate information for each centre in the event of a disaster. Should there be differences in forecast information between centres, the local and regional hydrometeorological forecasting centres will have to follow the national centres' reports. For the twenty major rivers in the country monitored by the NHMS, the local personnel are responsible for keeping track of the local hydrological situation and inform the national centre of their findings.

The NMHS has also started online forecasting conferences and meetings with the nine regional hydrometeorological forecasting centres using video conferencing facilities. Apart from sharing of important information, the on-line meetings will help the Central Committee for Flood and Storm Control (CCFSC) in making timely decisions for evacuation and other preventive measures.

Currently, the biggest challenge to the NHMS is the upgrading of its telecommunication system to enable it to receive real-time data from its field observing stations.

Project proposal to strengthen the NHMS

The NHMS plans and programs are linked to the Government's main strategy for development, as follows: 10-year Social Economic Development Strategy (SEDS) and the five year Socio-Economic Development Plan (SEDP), Decision 16/2007/QD-TTg, the Government Decree on River Basin Management, National Target Programme (NTP) to Respond to Climate Change, Natural Resource and Environment - NRE's five-year plan of MONRE, and the WMO RA II Strategic Plan 2008-2011.

The enhancement of the services of NHMS encompasses equally important components that should be integrated to ensure its effective operation and delivery of services, namely:

a. Improvement of meteorological, hydrological, and environmental data processing, archiving, and service systems.
   - Improving the management of meterological and hydrological data to meet increasing needs of socio-economic activities, sientific research and others
   - Strengthening technical capacity on hydro meteorological documentation
   - Strengthening partnership with relevant agencies

b. Improvement of hydrometeorological observing network and telecommunication system for weather and hydrological forecasts and warnings.
   - Upgrading of hydrometeorological observation network to meet the requirements for the severe weather and flood forecasting and warning services;
   - Upgrading of hydrometeorological calibration facilities; and
   - Strengthening of hydrometeorological survey and hazard mapping capabilities

c. Development of hydrometeorological forecasting system
   - Modernize telecommunication system for real-time collection of data
   - Upgrading of computing system for numerical weather prediction (NWP);
   - Development of new forecasting models and techniques;
   - Improvement of hydrometeorological forecasting and warning system
   - Strengthening of coordination mechanism with other agencies and institutions

d. Data sharing to improve regional forecasts through collaboration with other NHMS and in compliance with the WMO's Information System

e. Research and development to focus on:
   - Improvement of forecasting models and techniques
   - Improvement of telecommunication facilities
   - Forecasting applications of satellite and radar data

- Development new of observation equipments and technologies
- Improvement of forecast products and other services

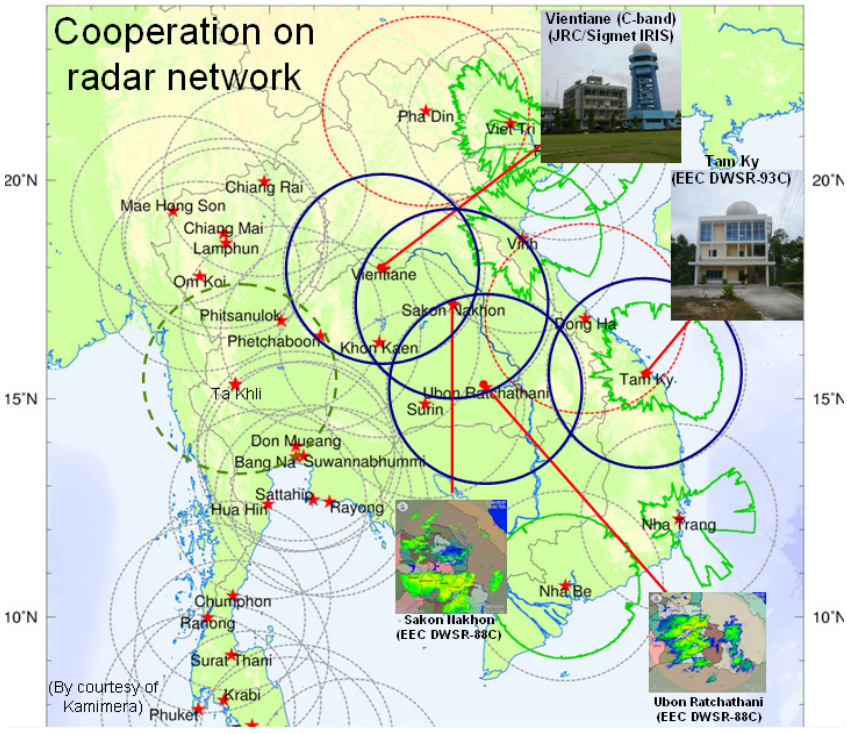
Investment plan

The proposed project is based on the required complementation of observing network for hydrometeorological monitoring that can provide the desired level of quality of products and services to cater to the needs of key economic sectors in the country including disaster management. The project also considers the concept of data sharing in the Indochina region in order to optimize the utilization of resources. The project is proposed to be implemented for a period of 5 years considering two options:

A. Strengthening of NHMS as a "stand-alone system"
B. Strengthening of NHMS as a cooperative Indochina project

The enhancement of NHMS as a stand-alone system is well captured by a number of proposals to modernize the meteorological and hydrological services in line with the government's Decision 16/2007/QD-TTg (projection up to 2020) and the Viet Nam Meteorological and Hydrological Development Strategy up to 2020 which is part of the National Target Programme to Respond to Climate Change and the National Strategy on Disaster Prevention, Preparedness and Mitigation.

Although the Mekong River Commission (MRC) exemplifies the cooperation among Indochina and its neighbouring countries, sharing of hydrometeorological data and information is not yet fully achieved since some countries like Thailand and China are not yet sharing meteorological data such as radar observation. The NHMS has 7 operational radars and with 8 radars being planned to be established in addition to the existing network as shown in the Figure below. The resulting network will adequately cover Viet Nam, Lao PDR and Cambodia. The project should include the design of a mechanism for sharing of remote sensing and other relevant data.



Source: Takehiko Satomura, Graduate School of Science, Kyoto University

Figure 2. Existing network of weather radars in Indochina

Table 1 Proposed Project to Enhance NHMS Services in Viet Nam		
Viet Nam	A (US$)	B (US$)
International cooperation of experts	100,000	100,000
Communication systems		
- Hardware + software	1,500,000	1,500,000
IT Centre		
- Hardware	300,000	150,000
- Consultation and training	150,000	100,000
Data management		
- Hardware and installation	150,000	150,000
- Storage	120,000	120,000
- Consultation and training	100,000	50,000
GIS Database system for DMHCC	3,000,000	3,000,000
Meteorological observation network		
- automatic rainfall stations	4,073,600	4,073,600
- automatic weather stations	4,900,000	4,900,000
- agrometeorological stations	2,560,000	2,560,000
Hydrological observation network		
- automatic hydrological stations(1 river basin)	3,586,000	3,586,000
Maritime observation network		
- maritime observations	3,600,000	3,600,000
Remote sensing network		
- upper air stations	4,005,000	4,005,000
- wind profiler	1,750,000	1,750,000
- upgrade existing radars	1,350,000	1,350,000
- new radars including towers	12,000,000	8,000,000
- lightning detection	100,000	100,000
Forecasting and manufacturing tools		
- visualization system	350,000	350,000
- training	50,000	25,000
Training	600,000	400,000
Project management		
- consultant	600,000	300,000
- local project coordinator	240,000	120,000
Total	45,184,600	40,289,600

With a concrete plan for its modernization, the NHMS of Viet Nam is in the best position among the countries in Indochina to be the hub for sharing of critical hydrometeorological data and information to Cambodia and Lao PDR.

Through enhanced cooperation, the financial requirement for a regional project on the improvement of capabilities in hydrometeorological forecasting and warning in Indochina will be considerably reduced.

Socio-economic value of weather forecasts and hydrometeorological services in Viet Nam

Sustainability in the provision of reliable hydrometeorological services through the modernization and strengthening of the hydrometeorological organization can only be attained when there is full support from the Government, funding donors, and the private sector.

Any program to strengthen the hydrometeorological service should be considered as an investment and not as expenditure because of the tangible and intangible benefits of early warning systems.

For the stand-alone option, the results of the computations show that using a 10% reduction in damages as a measure of benefits, the undiscounted and discounted total costs of NMHS improvements are US$71.40 million, discounted total benefits are US$277.94 million, discounted net benefits are US$206.54 million and C/B ratio is 1:3.9.

For the regional integration option, the results of the computations show that using a 10% reduction in damages as a measure of benefits, the total costs of NMHS improvements are US$65.44 million, discounted total benefits are US$277.94 million, discounted net benefits are US$212.50 million and C/B ratio is 1:4.3.

Table 2 Options, Costs, Discounted Total Benefits, Discounted Net Benefits and Cost-Benefit ratios for improvements in NMHS in Viet Nam, 2010-2029

Option	Total Costs (Million US$)	Discounted Total Benefits (Million US$)	Discounted Net Benefits (Million US$)	Cost/benefit Ratio (C/B)
Stand-Alone	71.40	277.94	206.54	1:3.9
Regional Cooperation	65.44	277.94	212.50	1:4.3

In retrospect, the following are the main findings of the computations done for Viet Nam:

- The discounted total and net benefits due to the improvements in the NMHS of Viet Nam, 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.

Environmental impacts of enhancement of the observation network

Only the weather radar towers (typical height) will have some visual impact on the environment and would require permit for its construction. However, the radar towers could be used as lookout spots and information centres for the public.

Financing of the proposed project

The proposed project is based on the modernization plan for the Viet Nam NHMS which involves several donors. In the implementation of foreign assisted project, local counterparts (both financial and in kind) are required. Although the Government of Viet Nam has manifested its increasing support for NHMS, it is crucial to get the commitment of the Government to allocate additional fund to sustain the operation and maintenance of the new investment and to promote enhanced cooperation in Indochina and neighbouring countries.

It is critical at the national level that involvement of beneficiaries (other ministries, marine and aviation sectors, insurance and even private telecommunication companies, etc.) is tapped to provide assistance to reduced costs and facilitate project implementation.

1 VIET NAM IN A NUTSHELL

1.1 Background

Viet Nam lies in the eastern part of Indochina, bounded by the East Sea and the Gulf of Tonkin to the east and by the Truong Son mountain range to the west. Extending between latitudes 8-240N Viet Nam is thus effectively within the tropics. Its coastline stretches over 3,260 km. Viet Nam has a tropical monsoon type of climate with frequent tropical cyclones affecting the northern and central regions. They also occur in southern areas but less frequently. The seasonal distribution of rainfall is closely related to the monsoons. Rainfall intensity can be high, producing a rapid rate of runoff and serious flooding.

Viet Nam was conquered by France beginning in 1858 and became part of French Indochina in 1887. Viet Nam declared independence after World War II but France continued to rule until its 1954 defeat by the Vietnamese People's Army Communist forces. Viet Nam was later divided into Democratic Republic of Viet Nam in the North and Republic of Viet Nam backed by the United States of America in the South. In 1975, South Viet Nam was fully liberated, and the country was reunited. In 1976, Viet Nam was renamed as the Socialist Republic of Viet Nam. Despite the return of peace, for over a decade the country experienced little economic growth because of conservative leadership policies and growing international isolation. However, since the enactment of Viet Nam's "doi moi" (renovation) policy in 1986, Vietnamese authorities have committed to increase economic liberalization and enacted structural reforms needed to modernize the economy and to produce more competitive, export-driven industries.

Figure 1.1 Map of Viet Nam

Geography and Land Use

- Location: Southeast Asia, bordering the Gulf of Thailand, Gulf of Tonkin, and East Sea, alongside China, Laos, and Cambodia.
- Total area: total: 331,210 km2; land area: 310,070 km2; water area: 21,140 km2
- Total land boundaries: 4,639 km
- Coastline: 3,444 km (excludes islands)
- Maritime claims: territorial sea: 12 nm; contiguous zone: 24 nm; exclusive economic zone: 200 nm; continental shelf: 200 nm or to the edge of the continental margin
- Climate: tropical in south; monsoonal in north with hot, rainy season (May to October) and warm, dry season (November to April)
- Terrain: low, flat delta in south and north; central highlands; hilly, mountainous in far north and northwest
- Elevation extremes: lowest point: East Sea 0 m; highest point: Fan Si Pan 3,144m
- Land use: arable land: 20.14%; permanent crops: 6.93%; other: 72.93% (2005)
- Irrigated land: 30,000 km2 (2003)
- Total renewable water resources: 891.2 km3 (1999)
- Freshwater withdrawal (domestic/industrial/ agricultural): total: 71.39 km3/yr (8%/24%/68%); per capita: 847 m3/yr (2000)
- Natural hazards: occasional typhoons (May to January) with extensive flooding, especially in the Mekong River delta
- Current environment issues: logging and slash-and-burn agricultural practices contribute to deforestation and soil degradation; water pollution and overfishing threaten marine life populations; groundwater contamination limits potable water supply; growing urban industrialization and population migration are rapidly degrading environment in Hanoi and Ho Chi Minh City

People

- Population: 88,576,758 (July 2009 est.)
- Life expectancy at birth, total population: 71.71 years
- Ethnic groups: Kinh (Viet) 86.2%, Tay 1.9%, Thai 1.7%, Muong 1.5%, Khome 1.4%, Hoa 1.1%, Nun 1.1%, Hmong 1%, others 4.1% (1999 census)
- Languages: Vietnamese (official), English (increasingly preferred as a second language), some French, Chinese, and Khmer; mountain area languages (Mon-Khmer and Malayo-Polynesian)
- Literacy (definition: age 15 and over can read and write): total population - 90.3%

Government

- Government type: Communist state
- Capital: Hanoi (Ha Noi)
- Administrative divisions: 58 provinces (tinh, singular and plural) and 5 municipalities (thanh pho, singular and plural)

Transnational issues

- China occupies the Paracel Islands also claimed by Viet Nam and Taiwan; Viet Nam is involved in complex dispute with Brunei, China, Malaysia, the Philippines, and Taiwan over the Spratly Islands.

1.2 Economic overview

Viet Nam has reaffirmed its commitment to economic liberalization and international integration and has moved to implement the structural reforms needed to modernize the economy. Agriculture's share of economic output of Viet Nam has continued to shrink from about 25% in 2000 to about 21% in 2009. Deep poverty has declined significantly and Viet Nam is working to create jobs to meet the challenge of a labor force that is growing by more than one million

people every year. The global recession has hurt Viet Nam's export-oriented economy with GDP growing less than the 7% per annum average achieved during the last decade. In 2009, exports fell nearly 10% year-on-year, prompting the government to consider adjustments to tariffs to limit the trade ing, including a subsidized lending program, to help the economy through the global financial crisis, and foreign donors have pledged US$8 billion in new development assistance for 2010.

As in many other ASEAN countries, the GDP growth performance of the country has significantly fallen from 2007 to 2008, a fact which is related to the global financial crisis that started in 2008. The other important economic indicators of Viet Nam are as follow:

Gross Domestic Product

- GDP (purchasing power parity): US$258.2 billion (2009 est.)
- GDP (official exchange rate): US$91.76 billion (2009 est.)
- GDP – growth: 5.3% (2009 est.)
- GDP - per capita (PPP): US$2,900 (2009 est.)
  - agriculture: 20.7%
  - industry: 40.3%
  - services: 39.1% (2009 est.)
- Budget:
  - revenues: US$21.89 billion
  - expenditures: US$30.42 billion (2009 est.)

Labor market

- Labor force: 43.87 million (30 April 2009 est.)
- Labor force - by occupation
  - agriculture: 51.8%
  - industry: 15.4%
  - services: 32.7% (30 April 2009)
  Unemployment rate: 7.5% (2009 est.)
- Population below poverty line: 12.3% (2009 est.)
- Agriculture - products: paddy rice, coffee, rubber, cotton, tea, pepper, soybeans, cashews, sugar cane, peanuts, bananas; poultry; fish, seafood
- Industries: food processing, garments, shoes, machine-building; mining, coal, steel; cement, chemical fertilizer, glass, tires, oil, paper
- Industrial production growth rate: 4.7% (2009 est.)

Energy

- Electricity
  - production: 86.9 billion kWh (2009 est.)
  - consumption: 74.5 billion kWh (2009 est.)
  - exports: 535 million kWh (2009 est.)
  - imports: 3.85 billion kWh (2009 est.)
- Oil
  - production: 305,000 bbl/day (2009 est.)
  - consumption: 276,400 bbl/day (2009 est.)
  - exports: 29,400 bbl/day (2009 est.)
  - imports: 134,200 bbl/day (2009 est.)
  - proved reserves: 4 billion bbl (1 January 2009 est.)
- Natural gas
  - production: 7.9 billion cu m (2008 est.)
  - consumption: 8.1 billion cu m (2008 est.)
  - exports: 0 cu m (2009 est.)
  - imports: 380,000 cu m (2009 est.)
  - proved reserves: 610 billion cu m (1 January 2009 est.)
- Pipelines
  - condensate/gas 42 km; gas 66 km; refined products 206 km (2009)

Exports and imports

- Exports - commodities: crude oil, marine products, rice, coffee, rubber, tea, garments, shoes
- Export partners: US 18.9%, Japan 13.6%, China 7.2%, Australia 6.7%, Singapore 4.2% (2008)
- Import commodities: machinery and equipment, petroleum products, fertilizer, steel products, raw cotton, grain, cement, motorcycles
- Import partners: China 22.4%, Singapore

13.4%, Taiwan 12%, South Korea 10.1%, Thailand 7% (2008)
- Natural resources: phosphates, coal, manganese, bauxite, chromate, offshore oil and gas deposits, forests, hydropower

Reserve, Debt, Aid

- Reserves of foreign exchange and gold: US$15.1 billion (31 December 2009 est.)
- Debt - external: US$31 billion (31 December 2009 est.)

Communications

- Telephones: main lines in use: 29.591 million (2008)
- Mobile/cellular telephones: 70 million (2008)
- Radio broadcast stations: AM 65, FM 7, short wave 29 (1999)
- Television broadcast stations: 67 (includes 61 relay, provincial, and city TV stations) (2006)
- Internet hosts: 170,689 (2009); Internet users: 20.834 million (2008)

Transportation

- Airports - with paved runways
  - tal: 37;
  - over 3,047 m: 9;
  - 2,438 to 3,047 m: 5
  - 524 to 2,437 m: 14
  - 914 to 1,523 m: 9 (2009)
- Airports - with unpaved runways
  - total: 7
  - 1,524 to 2,437 m: 1
  - 914 to 1,523 m: 3
  - under 914 m: 3 (2009)
- Heliports: 1 (2009)
- Railways: total - 2,347 km
  - standard gauge: 178 km 1.435-m gauge
  - narrow gauge: 2,169 km 1.000-m gauge (2008)
- Roadways: 222,179 km
  - paved: 42,167 km; unpaved: 180,012 km (2004)
- Waterways: 17,702 km (5,000 km navigable by vessels up to 1.8 m draft) (2008)
- Merchant marine: total – 387
  - by type: barge carrier 1, bulk carrier 36, cargo 280, chemical tanker 12, container 14, liquefied gas 6, passenger 1, passenger/cargo 1, petroleum tanker 32, refrigerated cargo 2, roll on/roll off 1, specialized tanker 1
  - foreign-owned: 2 (Hong Kong 1, Japan 1)
  - registered in other countries: 64 (Honduras 1, Liberia 4, Mongolia 23, Panama 30, Tuvalu 5, unknown 1) (2008)

1.3 Climate

Viet Nam has a tropical monsoon type of climate, being situated in the tropics, with frequent tropical cyclones affecting the northern and central regions. They also occur in southern areas but less frequently. The seasonal distribution of rainfall is closely related to the monsoons. Rainfall intensity can be high, producing a rapid rate of runoff and serious flooding. Most of Viet Nam experiences an annual rainfall of 1,800-2,500 mm, distributed unevenly through the year. Approximately 70% of the rainfall occurs during the main rainy season from May to September/ October. The uneven distribution of rainfall is one of the main causes of river flooding. For the Mekong River, for example, the discharge during the rainy season is about 20 times greater than in the dry season.

Because of its low coastal topography, Viet Nam is exposed to the high winds and storm surges brought by tropical cyclones. Furthermore, the whole country can be affected by the weather conditions over the ocean to the east. The northwest Pacific Ocean is the principal spawning ground for tropical cyclones which often track through the Philippines and then strike the Indochinese mainland through Viet Nam.

The winter season which lasts from December to February is characterized by fine drizzle. January is the coldest month. In the north, the spring lasts

for about two months (March - April) with the temperature between 15 and 20̊C. In April, the north may have heavy rainfall with the central part of the country having noticeably drier weather, while the south experiences a scorching heat. The monsoon season which normally affects the north region lasts from June to September when the temperature is at its highest (30 - 400C).

From October, the cool weather starts, with temperatures of less than 20̊C. At this time, the season of heavy rainfalls and typhoons commences in central Viet Nam resulting to traffic from the north to the south. In November the dry season begins in the north while the monsoon season ceases in the south, however the rain continues in the central region. Annual rainfall averages about 1830 mm with high humidity (85 - 88%) throughout the year.

2 SOCIO-ECONOMIC BENEFITS OF HYDROMETEOROLOGICAL SERVICES

Of the weather and climate-dependent economic sectors of Viet Nam, manufacturing, agriculture, and construction have been the most dominant contributors to the national economy. In 2008, these sectors respectively shared 25.5%, 14.4%, and 8.7% of the GDP (Table 2.1). In totality, the weather and climate-dependent economic sectors contributed 67.3% of the GDP in the same year. Because of this large contribution, improvements in the NMHS that would reduce the damages due to weather and climate-related natural disasters on these sectors will have significant impacts on the overall economy.

Table 2.1 Percent share of value added by weather and climate-dependent economic sector to Gross Domestic Product at 1990 constant prices of Viet Nam, 2000-2008

Gross Domestic Product Structure	2000	2001	2002	2003	2004	2005	2006	2007	2008
Agriculture, hunting and related service activities	19.9	19.0	18.5	17.8	17.1	16.3	15.5	14.7	14.4
Forestry, logging and related service activities	0.9	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.6
Fishing	2.4	2.5	2.5	2.5	2.5	2.6	2.6	2.6	2.6
Mining and quarrying	6.7	6.6	6.2	6.1	6.2	5.8	5.4	4.7	4.3
Manufacturing	18.8	19.6	20.4	21.2	21.8	22.7	23.6	24.7	25.5
Electricity, gas and water supply	2.3	2.5	2.6	2.7	2.8	2.9	3.0	2.9	3.0
Construction	7.5	8.0	8.2	8.5	8.6	8.8	9.0	9.3	8.7
Hotels and restaurants	3.2	3.2	3.2	3.2	3.2	3.4	3.6	3.7	3.8
Transport storage and communication	3.9	3.9	3.9	3.8	3.9	3.9	4.0	4.1	4.3
Total	65.9	66.1	66.4	66.6	66.8	67.1	67.2	67.3	67.3

Source of Data: United Nations Statistics Division

2.1 Methodology for computing socio-economic benefits

The methodology employed here for computing the potential socio-economic benefits from planned improvements in the NMHS of a country is based on secondary data available from institutional sources. These secondary data were enhanced by informed assumptions provided by institutional key informants.

The monetized net socio-economic benefits from planned improvements in the NMHS of a country are defined as the monetized total decrease in socio-economic damages due to weather and climate-related natural disasters less the cost of the NMHS improvements as follows:

$$b = \Delta D - C$$

where b is the discounted net benefits from planned improvements in the NMHS; ΔD is the discounted total decrease in socio-economic damages due to the planned improvements; and C is the discounted total costs of the planned improvements.

2.2 Data

The socio-economic sectors of a country and the potential direct socio-economic damages due to weather and climate-related natural disasters on each sector are outlined in Table 2.2. In addition to the potential direct damages, there are potential indirect damages on the other sectors that have backward and forward linkages to the mainly affected sectors. For instance, damages in agriculture may impact on the other sectors of the economy through increases in the prices of agricultural input and output goods and services in the market.

Table 2.2. Socio-economic sectors and the potential direct damages due to weather and climate-related natural disasters on different economic and social sectors

Sector	Potential Direct Impacts
Economic Sectors	
Agriculture	Lost income, disruption in operations, cost of damaged irrigations, dams and other agricultural infrastructure and facilities, etc.
Transportation & Communication	Lost income, disruption in operations, cost of damaged transportation and communication infrastructure and facilities, cost of accidents, etc.
Energy	Lost income, disruption in operations, cost of damaged energy infrastructure and facilities, etc.
Tourism	Lost income, disruption in operations, cost of 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, water pollution control and management costs, etc.

The secondary data available from the institutional sources, however, measure only the direct damages due to weather and climate-related natural disasters. Thus, the damages considered here are only this kind of damages and may be considered as conservative estimates or just a fraction of total damages.

Aside from the decrease in damages as socio-economic benefits, improvements in NMHS may have productivity effects on the national economy of a country. In particular, better forecasting of weather and climate-related events will allow economic sectors to operate better and increase their productivity.This productivity effect is not included in the measurement of socio-economic benefits because of lack of secondary data available for this purpose.

In the case of the costs of NMHS improvements, the total costs include the sum of all expenditures related to the improvements made. If some of these costs occur beyond the first year of the project, these are discounted. If all expenditures occur in the first year, then the actual and undiscounted cost figures apply. After measuring the discounted costs and benefits, the cost-benefit ratios (C/B) are computed as follows:

$$C/B = C/\Delta D$$

where the variables are defined as before. The computed C/B ratios are then compared to the C/B ratio of at least 1:7 set by the WMO.

2.3 Results and analysis

Natural hazard-induced disasters

The data on total number of disasters, number of persons who died, number of persons who were rendered homeless, number of persons who were injured and total number of persons affected by natural disasters in Viet Nam for the period 1990-2009 are presented in Table 2.3. For the 1990 to 2009 period, the country had 117 disasters causing death to more than 11,000 people and injury to more than 6,500 persons. The disasters also affected more than 1.5 million individuals and rendered homeless approximately 72,000 persons.

The most prevalent disasters are due to water induced hazards such as floods and storms. From 2005 to 2009, there were a total of 22 floods causing death to 794 people and 19 storms causing death to 1,173 people. The other type of disaster which ccurred in the same period was drought.

Based on the Government data from the Central Committee for Flood and Storm Control (CCFSC), on the other hand, the physical losses due to natural hazard-induced disasters in Viet Nam for 1989 to 2008 are presented in Table 2.4. For the period, the disasters resulted to more than 13,000 killed and missing persons, more than 729,000 collapsed houses, more than 6 million hectares of damaged rice fields, about 175,000 tons of lost fish and shrimps, about 16,000 sunk and damaged boats, and more than 67,000 forest fires. In the same period, annually on average, there were 652 killed and missing persons, more than 36,000 collapsed houses, more than 342,000 damaged houses, more than 8,000 tons of lost fish and shrimp, 799 sunk and damaged boats and more than 6,000 hectares of forest fires.

From 1989 to 2008, there were 193 natural hazard-induced disasters in Viet Nam of which 162 had recorded values of damages or an annual average of about 10 disaster and 8 disasters respectively. Of these disasters, the most prevalent were floods and storms while the other disasters were flash flood/ landslide, tornado, cold wave and other disasters.

Total socio-economic damages

The value of direct socio-economic damages caused by weather and climate-related disasters in Viet Nam from 1990-2009 based on the OFDA/CRED International Disaster Database Data and for 1989-2008 period based on CCFSC data are provided in Table 2.5. The CCFSC data have lower figures for total and annual average value of damages and are thus used in the succeeding computation being relatively more conservative and Viet Nam government generated.

Table 2.3 Selected statistics related to weather and climate-related disasters in the Viet Nam based on the OFDA/CRED International Disaster Database Data, 1990 to 2009

Year	Number of disasters that occurred	Number of persons who died	Number of persons who were rendered homeless	Number of persons who were injured	Total number of persons affected
1990	4	184	2,000	308	512,308
1991	7	492	456,505	236	773,219
1992	5	287	48,789	33	227,056
1993	4	270	12,185	52	53,757
1994	3	361	1,000	34	394,034
1995	2	269	-	51	423,051
1996	6	1,011	-	591	1,042,091
1997	4	3,692	383,045	907	4,081,177
1998	4	413	44,980	97	2,557,742
1999	5	799	143,555	576	7,183,281
2000	11	592	11,860	215	5,039,580
2001	7	392	23,100	95	1,809,090
2002	6	147	-	116	2,733,616
2003	4	128	18,880	81	421,841
2004	6	189	-	23	535,923
2005	10	308	18,205	31	870,053
2006	11	579	352,680	2,010	3,349,410
2007	6	326	47,525	322	1,647,602
2008	10	411	12,660	163	789,153
2009	2	194	-	629	700,629
Total	117	11,044	1,576,969	6,570	35,144,613

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

Notes:
a) In this table, the weather and climate-related natural disasters specifically include drought, extreme temperature, flood, mass movement wet, storm and wildfire. Ground movement includes rockfall, landslide, avalanche and subsidence.
b) EM-DAT is a global database on natural and technological disasters that contains essential core data on the occurrence and effects of more than 17,000 disasters in the world from 1900 to present. EM-DAT is maintained by the Centre for Research on the Epidemiology of Disasters (CRED) at the School of Public Health of the Université catholique de Louvain located in Brussels, Belgium. The database is compiled from various sources, including UN agencies, non-governmental organizations, insurance companies, research institutes and press agencies. Priority is given to data from UN agencies, governments and the International Federation of Red Cross and Red Crescent Societies.

The annual estimated socio-economic damages for 2010-2029 were computed as the average of the annual actual damages for the 1989-2008 period adjusted to inflation taken from the World Development Indicators of the World Bank. The average annual actual socio-economic damages for the 1989-2008 period using the CCFSC data was at US$322 million and in the absence of 2009 data is reflected as the annual estimated damages for that year adjusted to inflation. The 2010 data is then reflected as the 2009 data again adjusted to inflation. For 2010, the estimated damages were US$360 million (Table 2.6). From 2010-2029, the total estimated damages was US$12,962 million while the annual average damages was US$648 million.

Table 2.4 Physical losses due to natural disasters based on CCFSC Data, 1989 to 2008

Year	No. People Killed (+Missing)	No. Houses collapsed	Rice Fields Damaged (Ha)	Fish Shrimps Lost (Tons)	No. Boats sunk, damaged	Area of forest fire (Ha)
1989	516	235,729	765,365	30	2,299	n.a.
1990	354	14,521	237,800	25	598	n.a.
1991	490	15,063	211,377	52	1,130	n.a.
1992	452	8,211	366,572	3,550	321	n.a.
1993	420	29,475	171,560	60	1,097	n.a.
1994	508	7,302	658,676	6,364	43	8,322
1995	399	11,043	198,434	120	1,117	9,648
1996	1,243	96,927	927,506	4,761	1,017	12,758
1997	3,083	111,037	641,393	34,619	3,008	1,361
1998	434	12,171	103,422	215	231	14,812
1999	901	52,585	131,267	1,419	845	1,139
2000	775	12,253	655,403	2,877	109	850
2001	629	10,503	132,755	1,002	2,033	1,845
2002	389	9,802	46,490	310	26	15,548
2003	186	4,487	209,764	10,581	183	1,402
2004	212	1,192	422,806	1,334	68	n.a.
2005	399	7,586	504,098	3,663	381	n.a.
2006	612	74,783	139,231	566	1,151	n.a.
2007	495	9,908	173,830	3,308	266	n.a.
2008	538	5,180	146,945	100,104	52	n.a.
Total	13,035	729,758	6,844,704	174,960	15,975	67,685
Ave	652	36,488	342,235	8,748	799	6,769

Source of Data: Central Committee for Flood and Storm Control, Wang et al. (2010).

The reduction in damages in Table 2.7 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. This assumption of 10% reduction in damages is based on informed opinion of key informants. From 2010-2029, the estimated reduction in damages or the socio-economic benefits amount to US$1,137.62 million and the annual average reduction is US$56.83 million.

The social discount rate used is 12% (Table 2.7) which is within the 10 to 12% 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$277.94 million while the annual average benefits are US$13.90 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$51.43 million while that for the regional cooperation option is US$46.54 million. The discounted and undiscounted operating and maintenance costs for the two options are provided in Table 2.8.

Table 2.5 Socio-economic damages due to weather and climate-related natural disasters in Viet Nam, 1989-2009 (Million US$)

OFDA/CRED Data		CCSFC Data	
Year	Value	Year	Value
1990	0.7	1989	54
1991	57	1990	31
1992	66	1991	71
1993	75	1992	42
1994	253	1993	66
1995	107	1994	258
1996	751	1995	103
1997	887	1996	725
1998	122	1997	667
1999	310	1998	136
2000	291	1999	390
2001	172	2000	360
2002	284	2001	229
2003	105	2002	128
2004	38	2003	103
2005	346	2004	26
2006	1,099	2005	368
2007	981	2006	1159
2008	674	2007	716
2009	1,065	2008	808
Total	7684		6440
Average:	384		

Sources of data: EM-DAT: The OFDA/CRED International Disaster Database, Central Committee for Flood and Storm Control, Wang et al. (2010)

Note: Available data from the CCFSC was only up to 2008.

Table 2.9 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. Again, the undiscounted capital costs are US$51.43 million for the stand-alone option and US$46.54 million for the regional cooperation option. The discounted O&M costs of US$4.24 million for the stand-alone option and the US$3.84 million for the regional cooperation option are taken from Table 2.8. The discounted total benefits are taken from Table 2.7. The discounted net benefits and C/B ratio are as defined earlier.

Table 2.6 Estimated socio-economic damages due to weather and climate-related natural disasters in Viet Nam based on CCFSC Data, 2010-2029 (Million US$)

Year	Estimated Damages
2010	360
2011	381
2012	403
2013	426
2014	451
2015	477
2016	505
2017	534
2018	565
2019	598
2020	633
2021	669
2022	708
2023	749
2024	793
2025	839
2026	887
2027	939
2028	993
2029	1,051
Total	12,962
Average	648

Sources of data: Table 2.5, World Development Indicators, World Bank

Note: Average annual inflation rate is 5.8% from 1989-2008. This inflation rate was used to estimate the annual estimated damage for 2010 onwards.

Table 2.7 Estimated 10% reduction in the socio-economic damages, or the socio-economic benefits due to improvements in NMHS in Viet Nam, 2010-2029 (Million US$)		
Year	Undiscounted Value	Discounted Value
2010	0.00	0.00
2011	0.00	0.00
2012	8.06	5.74
2013	17.04	10.83
2014	27.06	15.35
2015	38.16	19.33
2016	50.50	22.84
2017	53.40	21.57
2018	56.50	20.37
2019	59.80	19.25
2020	63.30	18.20
2021	66.90	17.17
2022	70.80	16.23
2023	74.90	15.33
2024	79.30	14.49
2025	83.90	13.69
2026	88.70	12.92
2027	93.90	12.21
2028	99.30	11.53
2029	105.10	10.90
Total	1,137.62	277.94
Average	56.83	13.90

Source of data: Table 2.6

For the stand-alone system, the undiscounted plus discounted total cost of NMHS improvements is US$71.40 million while the discounted total benefits due to NMHS improvements is US$277.94 million when a 10% decrease in damages is considered as benefits (Table 2.9). Therefore, the discounted net benefits are US$206.54 million while the C/B ratio is 1:3.9. The C/B ratio is lower than the 1:7 ratio set by WMO.

Table 2.8 Undiscounted and discounted operating and maintenance costs of improvements in NMHS in Viet Nam, 2010-2029 (Million US$)				
Year	Undiscounted operating & maintenance costs		Discounted operating & maintenance costs	
	Stand Alone	With Regional Cooperation	Stand Alone	With Regional Cooperation
2010	0	0	0.00	0.00
2011	0.00	0.00	0.00	0.00
2012	0.55	0.50	0.39	0.36
2013	0.58	0.53	0.37	0.34
2014	0.62	0.56	0.35	0.32
2015	0.65	0.60	0.33	0.30
2016	0.69	0.63	0.31	0.29
2017	0.73	0.67	0.29	0.27
2018	0.77	0.71	0.28	0.25
2019	0.82	0.75	0.26	0.24
2020	0.86	0.79	0.25	0.23
2021	0.91	0.84	0.23	0.21
2022	0.97	0.89	0.22	0.20
2023	1.02	0.94	0.21	0.19
2024	1.08	0.99	0.20	0.18
2025	1.14	1.05	0.19	0.17
2026	1.21	1.11	0.18	0.16
2027	1.28	1.17	0.17	0.15
2028	1.35	1.24	0.16	0.14
2029	1.43	1.31	0.15	0.14
Total	16.67	15.28	4.53	4.15
Average	0.83	0.76	0.23	0.21

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. The O&M costs are discounted using the social discount rate.

Table 2.9 Options, Costs, Discounted Total Benefits, Discounted Net Benefits and Cost-Benefit ratios for improvements in NMHS in Viet Nam, 2010-2029				
Option	Total Costs (Million US$)	Discounted Total Benefits (Million US$)	Discounted Net Benefits (Million US$)	Cost/benefit Ratio (C/B)
Stand-Alone	71.40	277.94	206.54	1:3.9
Regional Cooperation	65.55	277.94	212.50	1:4.3

Source of data: Tables 2.7 and 2.8

For a system based on regional cooperation, the total cost of NMHS improvement is US$65.55 million which is lower than the cost of a stand-alone system. Again, the discounted total benefits due to the NMHS improvements are US$277.94 million when a 10% decrease in damages is considered as benefits. Therefore, the discounted net benefits are US$212.50 million and the C/B ratio is 1:4.3. The C/B ratio is better than that for the stand-alone system and inferior to the 1:7 ratio provided by WMO.

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 studies derived C/B ratios which are also higher than the WMO minimum accepted ratio of 1:7 (Hautala et al., Tammelin 2007, Leviakangas et al. 2007)

Summary of findings

In retrospect, the following are the main findings of the computations done for Viet Nam:

- The discounted total and net benefits due to the improvements in the NMHS of Viet Nam, 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 a bit inferior to the 1:7 ratio set by the WMO;
- The C/B ratio for the system with regional integration are 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.

It should be emphasized that the accuracy of the computations done here is dependent on the veracity of the secondary data on the socio-economic damages caused by weather and climate-related natural disasters from the institutional sources. 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 NEEDS ASSESSMENT OF SERVICES AND HYDROMETEOROLOGICAL INFORMATION

3.1 Agriculture and food production

Agriculture contributes a fair share (14%) to the GDP of Viet Nam. The country is self-sufficient in rice production, and is the world's third rice exporter (next to Thailand and the United States). Other important export crops are coffee, tea and rubber. Viet Nam is second in robust production in Asia, and coffee is its second leading agricultural export.

Among the user needs articulated are:

- on short-term forecasts
- more accurate 10 to 15-day forecasts;
- simpler and easier to understand (less technical) forecasts; and
- more frequent issuance of forecasts, including that of the situation in the Mekong River
- on long-term (climate) forecasts
- up to 6-month climate forecasts
- on weather and climate information
- need for more explanation of the forecasts and weather/climate information contained in the NHMS website; and
- more information on climate change scenarios for better planning in the longer term
- on data and data sharing
- access to historical data of rainfall, temperature, humidity, wind speed and direction, etc.;
- access to satellite data; and
- enhanced data sharing /more data to be made available.

3.2 Fishery

The fishing industry in Viet Nam has two important contributions; one, a 2.6% contribution (as of 2008) to the country's GDP (employment, income and foreign currency generation), and two, to the animal protein consumption of the population. It consists of marine, aquaculture and inland fishing in the order of their contributions to the sector. Its current share of total export of the country is estimated to be 10%, ahead of rice.

User needs are three-fold; these include provision of marine forecasts to improve fish catch, more accurate shipping forecasts, and regional cooperation on dispersion modelling for oil spill in the East Sea.

3.3 Forest industry

The contribution of forestry, logging and related service activities to the GDP of Viet Nam in 2008 was only 0.6% (Table 2.1). Furthermore, while the overall forest cover in Viet Nam has been increasing, the quality of forest cover is decreasing. Rich and medium stocked forests are now concentrated mainly on hilltop or steep slope areas that are unsuitable for other land uses. In 2000, forests covered 30% of the total land area of Viet Nam. Important forestry products include bamboo, resins, lacquer, quinine, turpentine, and pitch. Depletion of forests, however, has been serious, not only through US defoliation campaigns in the south during the war, but also because of the slash-and-burn farming techniques used by nomadic tribal groups in mountainous areas.

User needs include establishment of meteorological observing stations in the forests, near real-time critical weather parameters (such as humidity), modelling and forecasting of smoke dispersal, and impacts of climate change studies on forests.

3.4 Water management

Viet Nam is a naturally rich country of surface and ground water resources. The country has around 2,360 rivers which are longer than 10km if arrayed all over of the country from the North to the South. All rivers in Viet Nam supply approximately a total surface water volume of 255 billion cubic meters per year. In addition, total potential exploitation of ground water is around 60 billions cubic meters per year. The country also has many natural lakes. However, over exploitation of water resources has caused increased degradation of water resources in particular and degradation of environment and other related resources in general. First concerns of water resources management and sustainable use had been raised in Viet Nam in the 1980s.

Viet Nam has developed the National Strategy on Water Resources Management up to 2020 which will be a direction for water resources planning at local and national level as well as fundamental for collaboration of related agencies and stakeholders. Organizationally, the Ministry of Natural Resources and Environment has the function of state management of water resources in Viet Nam.

With 14 large river systems, which cover 10,000 km^2, Viet Nam is considered to have a complex and dense river network with most of the large river systems linked. Amongst those 13 main river systems, 9 have basins which contribute to 90% of total river basin area in the whole country. The 9 main river basins are the Thai Binh, Red, Bang Giang-Ky Cung, Ma, Ca La, Thu Bon, Ba, Dong Nai, and Cuu Long river. The Red river and the Mekong river systems have the largest basin areas (155,000 and 795,000 km^2, respectively) as well as the highest total volume of water flow. Other than that, each river system has its own distinctive characteristics, thus environmental management approaches may vary greatly from one river basin to another, depending on socio-economic conditions, land use, environmental factors, and their economical and ecological values.

The Japan International Cooperation Agency (JICA) and MoNRE signed the scope of works for "The study for water environmental management on river basins in Viet Nam" in Ha Noi on March 4, 2008. The main purpose of the study is to develop an effective water environment management plan for the model area of the study; to enhance the knowledge and the know-how for developing effective water environment management plan on river basins for MoNRE and departments in provinces; and to enhance capacity of the MoNRE in supervising, supporting, coordinating and facilitating the enforcement of water environment management of river basins by provincial governments, line ministries of concerns, industrial stakeholders and communities. The study will be implemented for a period of 20 months in the model area of Cau river in the north.

The user needs assessment in this sector indicates that there are 7 important needs as follows:

- more real-time gauges along the Mekong River tributaries;
- GIS-based visualization;
- risk assessment analysis;
- real-time hydrological data and forecasts;
- rainfall estimates from radar;
- flood forecasting and warning system in ungauged catchments; and international data sharing in the Mekong River.

3.5 Energy

In Viet Nam, petroleum is the main source of commercial energy, followed by coal. Viet Nam's oil reserves are in the range of 270–500 million tons. Oil production rose rapidly to 403,300 barrels per

day in 2004, but output is believed to have peaked and is expected to decline gradually. Viet Nam's anthracite coal reserves are estimated at 3.7 billion tons. Coal production was almost 19 million tons in 2003, compared with 9.6 million tons in 1999. Crude oil is Viet Nam's leading export, amounting to 17 million tons in 2002. In 2004 crude oil represented 22% of all export earnings. Much of the large rural population of Viet Nam, however, relies heavily on non-commercial biomass energy sources such as wood, dung, and rice husks. As a result, the per capita commercial energy consumption of the country ranks among the lowest in Asia. Coal production is also increasing. However, much of the rural communities use non-commercial biomass to fuel its energy needs. User needs include;

- more observing stations for solar radiation;
- modeling of solar radiation energy potential;
- increased real-time observation of rainfall and river discharge;
- accurate site-specific weather forecasts for energy consumption estimates and optimization of energy production;
- wind data for assessment of wind power potential;
- 0 to 24-hour forecasts for wind power production;
- lightning monitoring and forecasting;
- information of atmospheric icing;
- seasonal forecasts; and
- severe wind risk mapping during tropical cyclone occurrences.

3.6 Transportation

3.6.1 Air transportation

Viet Nam operates 17 major airports, including three international gateways: Noi Bai serving Ha Noi, Da Nang serving Da Nang City, and Tan Son Nhat Airport serving Ho Chi Minh City. Vietnam Airlines, the national airline, has a fleet of 30 aircraft that link Viet Nam with 19 foreign cities. In 2004 Vietnam Airlines had 5 million passengers, up by 25% from the prior year, and management expects the number of passengers to reach 12 milion by the current year, 2010.

User needs include sharing of NHMS data, access to regional real-time radar images, upper air soundings, and better dialogue and cooperation with the NHMS.

3.6.2 Water transportation

The principal ports in Viet Nam, from north to south, are Hai Phong, Quang Ninh, Da Nang, Qui Nhon, Ho Chi Minh City, and Can Tho. Altogether, Viet Nam has seven international sea ports and five additional ports that specialize in transporting oil and coal. However, total traffic is below its capacity. Vietnamese ships carry only about 20% of the country's international trade, although plans exist to expand the merchant fleet substantially. Viet Nam's inland waterways, primarily the Mekong River and Red River systems, carry more freight than the railroads, and the volume of freight is rising slowly.

User needs are river discharge forecasts, water level monitoring and forecast, and flood forecasts.

3.6.3 Land transportation

Viet Nam's roads extend over 210,000 km. However, the condition of the roads is generally poor with only 13.5% of the roads are considered to be in good condition. Only 29% of the roads are tarred, and road access is cut off to more than 10% of villages for at least one month per year because of monsoon rains. Despite government efforts to promote the use of buses, motorcycles remain the preferred mode of local transport. There is one motorcycle for every seven people in Viet Nam. Poorer citizens rely on bicycles, while only the affluent can afford cars.

Viet Nam has 6 single-track railroad routes with a total length of 3,260 km. The network's density is

only about one-third the average for low-income countries. The longest railroad line measures 1,730 km from Ha Noi to Ho Chi Minh City and requires 32 hours to traverse on the Reunification Express. Of the nation's inventory of rolling stock, 25% is not operational.

In general, Viet Nam's transportation system is in need of modernization and expansion. Ports are operating at only one-third of capacity. Roads are in generally poor condition, and the underdeveloped railroad system carries less freight than the inland waterways. Motorcycles are more popular than buses.

User needs include more real-time rainfall and cloud cover data, real-time satellite (cloud cover) and radar data, more frequent weather forecasts, and better cooperation with the NHMS.

3.7 Construction

In Viet Nam, construction is one of the most important industries at present. In particular, there is now more than 890 million m2 of housing, 260 million m2 of which is in urban areas, and it's increasing by about 58 million m2 per year. Housing construction is a major national target and the Government had targeted that its citizens would have an average of 12 m2 of living space per person. In year 2008, however, while the industrial production value of the country has increased by a substantial 15.8 to 16%, the construction industry has decreased by 2%.

User needs are site-specific weather forecasts, nowcasting for some weather parameters, rainfall intensities for drainage systems planning, access to historical data, such as surface winds, temperature and wind chill factor for infrastructure design, mesoscale and microscale data on solar radiation on inclined surfaces, and improved dissemination of weather/climate information.

3.8 Land use and planning

The 1980 Constitution of Viet Nam vested all rights in land to the state. This principle was later changed to people's ownership and state management in the 1992 Constitution and 1993 Land Law. The Law on Land of 1993 set out 6 main principles governing land: (1) land belongs to the entire people; (2) is uniformly administered by the state; (3) which promotes effective and economical usage, (4) the state protects agricultural land; (5) encourages investment in land; and (6) stipulates the value of land. In Viet Nam, the local authorities are responsible for promulgating zoning and land use regulations, registration and settling certain types of land use disputes.

User needs are long-term historical data series, information on climate variability and climate change scenarios, and GIS-based/mapped risk assessments.

3.9 Tourism

Viet Nam is one of the most popular tourist destinations in the Asia-Pacific region and its tourism industry has been growing unprecedentedly over the past few years. In 2009, despite the global recession, the travel and tourism industry is estimated to have contributed 13.1% of the GDP to the Vietnamese economy. Being a source as well as destination market, the Vietnamese tourism industry has grown nearly twice as fast as GDP in recent years. The tourism sector of Viet Nam is projected to grow at double-digit growth rate in near future.

User needs include weather forecasts tailored to fit tourists' needs, forecasts on extraordinary meteorological and hydrological conditions from a few hours to as long as 3 days and monthly and seasonal climate forecasts.

3.10 Insurance

Viet Nam is one of countries with highest and most stable growth rate for insurance market in the world. From 1993 to 2004, annual growth rate of the insurance industry was about 29%. The proportion of insurance to GDP increased from 0.37% in 1993 to 2.0% in 2004. The industry plans to obtain sales in 2010 as much as 4.2% of GDP. There are many opportunities for and also challenges against the insurance industry of Viet Nam, especially those from Viet Nam's accession to the WTO. To achieve their projected targets, insurance companies need further renewal, restructuring and supervision as well as promote international cooperation.

User needs identified are site-specific analyses/ data weather phenomena covering claims (using modern observation technology, high-resolution models, etc,), access to long-term historical data for risk assessment and actuarial studies, studies of impacts of climate change on climate variability and extremes, and collaboration with the NHMS.

3.11 Health

In Viet Nam, the overall quality of healthcare is regarded as good, as reflected by 2005 estimates of life expectancy of 70.61 years and infant mortality of 25.95 per 1,000 live births. However, malnutrition is still common in the provinces and the life expectancy and infant mortality rates are stagnating. In 2001 government spending on health care was 0.9 percent of the GDP. Government subsidies covered only about 20% of health care expenses, with the remaining 80% coming out of individuals' own pockets.

About half of the population of Viet Nam has no access to clean water, a deficiency that promotes such infectious diseases as malaria, dengue fever, typhoid, and cholera. Inadequate funding also has contributed to a shortage of nurses, midwives, and hospital beds. In 2000 Viet Nam had only 250,000 hospital beds, or 14.8 beds per 10,000 people, a very low ratio among Asian nations. Viet Nam, however, has made progress in combating malaria, for which the mortality rate declined sharply, to about 5% of the rate in the early 1990s, after the country introduced anti-malaria drugs and treament.

User needs include improved forecasts on expected extreme temperatures and air quality, statistics on air quality, warnings of poor air quality when conditions warrant it, and flood forecasts.

3.12 Environment

While Viet Nam is among the world's fastest-growing economies, such rapid economic growth, coupled with a growing population and a shrinking natural resource base is straining the nation's environmental quality. Below is a summary of the environmental situation in Viet Nam by major area of concern:

3.12.1 Water quality

There is increasing evidence of pollution of Viet Nam's surface, ground and coastal waters. Although the quality of upstream river waters is generally good, downstream sections of major rivers reveal poor water quality and most of the lakes and canals in urban areas are fast becoming sewage sinks. Groundwater shows pockets of contamination and some salinity intrusion. Rapid urbanization and industrialization in coastal areas, port and marine transport development, expansion in coastal tourism, and an increase in the number of oil spills contribute to the deterioration of coastal water quality.

User needs indicated are sharing of hydromet data, transboundary data in the Mekong River and international cooperation between the countries sharing the Mekong River.

3.12.2 Air quality

The air quality of both indoor and outdoor in Viet Nam has deteriorated in recent years. This is mainly due to the increase in the usage of vehicles and an increasing number of industries in and around the city. Compared with other cities in Asia, however, the level of SO^2 pollution in Ho Chi Minh City is lower while the levels of CO^2 and NO^2 are approaching those of other cities. In the case of particle pollution, the peak particle level at some heavy traffic sites in the city is very high and exceeds those of Bangkok and Manila. The lead pollution is less than that of Bangkok but the level will be rapidly increasing unless concrete action is implemented.

User needs include:

- upper-air data to enhance meteorological data on conditions of dispersion;
- dispersion modeling of traffic, industrial sources and dumping areas, etc.;
- monitoring network for transboundary transport of airborne pollutants;
- monitoring of urban air quality;
- mobile monitoring stations, enhancing of AWS to include monitoring of air quality;
- establishment of national database for air quality measurements;
- quality control and traceability of measurements to international standards; and
- forecast and warning for air quality.

3.13 Disaster Risk Reduction

Viet Nam is affected generally by floods/ flashfloods, typhoons, droughts, landslides, and storm surges. Among these hazards, the greatest losses come from floods and typhoons. There are 14 major river systems including two large international river basins such as the Red River in the North and Mekong River in the South.

Recent reports from UNDP and World Bank indicate that Viet Nam is one of four countries in the world most vulnerable to climate change given its location and with two big cities with a population of six million and about ten cities with 1-3 million, and its topography.

Since 1984, Ha Noi and Ho Chi Minh cities have experienced heaviest rainfall intensities of about 600 to 900 mm in 24 hours resulting to devastating floods. The intense rainfall caused large, deep inundation of about 1.5 to 2.5 meters within a period of 5-10 days in Ha Noi and some provinces in North Viet Nam in November 2008. Historic tidal surges also flooded Ho Chi Minh City. In addition, high tidal surges, plus the discharge of water from the Dau Tieng Reservoir on 13 November 2008 breached several sections of the Saigon River dike system and flooded many parts of Ho Chi Minh City. The tidal surge were considered to be the biggest in the past 50 years and caused traffic and chaos in major roads of the city.

The Basic Legal Frameworks for Disaster Prevention and Mitigation are: The Water Law, Land Use Law, Forest Protection Law, Environment Protection Law, Dyke Management Law and other related laws. The institutional framework for flood protection is carried under 4 levels, namely: National, Provincial, District and Commune levels.

At the national level, the Ministry of Agriculture and Rural Development (MARD) has the responsibility for all flood protection works. It leads the Central Committee for Flood and Storm Control, an inter-branch organization, dealing with flood management in times of emergency. Within MARD, the Department of Dike Management and Flood Control (DDMFC) has full responsibility for management, supervision and technical assistance of flood protection projects. The DDMFC also includes the Board of Day River Flood Diversion Management (BDRFDM).

At the provincial level, almost all functions and responsibilities of MARD are within the Department

of Agriculture and Rural Development (DARD). Within each provincial DARD, there is a Department of Dike Management and Flood Control with similar duties and responsibilities as the central level MARD DDMFC.

At the district level, all agricultural provinces with district water engineers report to the provincial Departments of Dike Management and Flood Control as well as to the District People's Committee. They provide technical assistance for small scale flood protection works.

At the commune level, there is a dike management team in each commune throughout the country. These teams depend on the technical assistance of district water engineers for advice and technical support.

Flood forecasting is carried out by the NHMS based on a real-time network of meteorological and hydrological stations. Together with satellite information and weather forecasts, the data are used as inputs to the hydrological and hydraulic models to forecast the flows and river water levels in various areas. The forecasts of the NHMS are submitted to the Central Committee for Flood and Storm Control for decision making and subsequently conveyed to the Committees for Flood and Storm Control (CFSC) at provincial, district, and village level.

The strategy for disaster reduction in Viet Nam depends on specific locations. For North Viet Nam, the strategy is to execute structural measures associated with nonstructural solutions, and measures of strengthening dike systems, of diverging flood courses, and of improving safety standards of disaster mitigation works.

For Central Viet Nam, disaster risk management is focused on the promotion of flood and storm prevention measures with the policy: "proactive prevention, mitigation and adaptation". Management and mitigation measures include construction of upstream reservoirs and dike systems. These works should be combined with irrigation systems for stabilizing agricultural production.

For the Mekong (Cuu Long) River Delta, people are advised to live with flood and flood control measures with specific solutions such as planning of residential clusters, construction of irrigation systems for supplying clean water, and preventing salt water intrusion.

Currently, the Central Committee for Flood and Storm Control is responsible for assisting the Government of Viet Nam in disaster mitigation in the entire country. On the other hand, the People's Committees of all levels establish the Committees for Flood and Storm Control at each level which are responsible for assisting the government in disaster reduction and management.

User needs indicated are as follows:

- increased number of AWS monitoring stations to include monitoring of air quality and water levels;
- more accurate and frequent site-specific weather forecasts;
- more real time weather and hydrology data;
- real-time radar images, including sharing of real-time satellite and radar data;
- improved flood forecasts;
- forecasts on drought and its duration, including more explanation for outlooks on droughts;
- improved communication system for timely dissemination of forecasts;
- better information on climate variability;
- a national database for impacts of weather/climate-related disasters;
- assessment of vulnerability to natural disasters
- inundation and flood hazard maps;
- enhanced public awareness, and media training; and
- regional cooperation on data sharing.

3.14 Military

Viet Nam has one of the region's largest and most powerful military. Furthermore, the People's Army of Viet Nam remains politically influential, and many senior officers have obtained leadership positions in the Central Committee and Politburo of the Viet Nam Communist Party (VCP). Viet Nam's active-duty military consists of a 412,000-member army, a 42,000-member navy, a 30,000-member air and air defense force, and a 40,000-member paramilitary border defense corps. In addition, the country has 4 to 5 million member paramilitary reserve force, consisting of the People's Self-Defense Force and the Rural People's Militia. The People's Army plays leading role in the National Committee for Search and Rescue.

User needs are specific weather forecasts for defined regions (inland and on sea), timely and accurate severe weather forecasts and warnings, information and forecast on cloud heights, upper-air observations, and Doppler radar data/images (vertical and horizontal cross-sections).

3.15 Climate Change

Viet Nam is highly susceptible to climate change problems due to its geographical location. For one, the long coastline of Viet Nam is vulnerable to tropical cyclones between June and November, which contribute significantly to wet season rainfall. Inter-annual variations in the climate of Viet Nam are also caused by the El Niño Southern Oscillation. El Niño episodes influence the behavior of the monsoons in the region where Viet Nam is located, and generally bring warmer and drier than average winter conditions while La Niña episodes bring cooler than average summers in general in the entire country.

Furthermore, as would be expected given the rapid rate of industrialization and rising incomes, greenhouse gas (GHG) emissions in Viet Nam are rising. The impact of a 13-94 centimeter rise in sea level by 2100 as a result of GHG emissions could cause extensive saltwater intrusion and reduce a significant portion of agricultural lands.

The flood, storm control and disaster mitigation network of Viet Nam provides a strong political and social structure, under the leadership of CCFSC. This network is closely structured from the central to the local and community level. However, most personnel undertake flood and storm control responsibilities as an addition to their normal role - no specific facility exists to support the activities, which are mostly reactive. At the provincial level, the same issues exist. Under MONRE, the NHMS provides forecasts and warnings on natural phenomena to the CCFSC, the National Committee for Search and Rescue, and local authorities and agencies, so that these bodies can organize and guide the people's efforts of preparedness and responses. Every province has a hydrometeorological forecasting centre.

On 16 November 2007, the Prime Minister issued the Decision No. 172/2007 approving the National Strategy for Natural Disaster Prevention, Response and Mitigation until 2020. MARD and CCFSC are leading the implementation of the Strategy. The Ministry of Planning and Investment (MPI), in coordination with the Ministry of Finance (MOF), the National Committee for Search and Rescue, and other ministries and agencies are to arrange annual investment funds for effective implementation of the Strategy.

Proposed solutions for preventing inundation in urban areas include non-structural and structural measures as follows:

A. Non-structural solutions:

- Strengthen legal and institutional arrangements
- Urban planning is required with long-term vision.
- Strengthening of the forecast capacity: the

hydrometeorological events that could cause flooding should be forecasted and warned accurately and timely to mitigate negative impacts;
- Changing and improving awareness:
- Adjusting policies related to urban land use: identifying the reasonable targets of urban land use;
- Associating urban planning with the National Action Program to adapt and minimize the impact of global climate change;
- Increasing the national flood prevention funds for cities;
- Decentralizing the function of drainage;
- Encouraging privatization in the field of drainage to provide drainage service;
- Encouraging public participation in monitoring, management, and mitigation of flooding;
- Preparing and organizing relief assistance and evacuation of people and their properties during floods.
- Participation of cities in the Sustainable Cities Task Force established by the Board of Pacific Economic Cooperation Council (PECC)

B. Structural solutions:
- Construction of upstream reservoirs and structures for flood diversion to control the flood in cities (such Hanoi, HCM, Da Nang, etc.);
- Planting and protecting upstream forests;
- Strengthening the dike system to protect the cities (river dikes, sea dikes);
- Dredging and clearing river bed;
- Strengthen the Network of Committees for Floods and Storms Control at all levels (including infrastructures, equipments, and operation and management);
- The urban drainage systems should be designed, at least based on 10-year flood events;
- Enhance operation and maintenance for flood control works of cities; and
- Construction of rainwater impounding system

that can be utilized for many purposes.

The user needs include assessment of impacts on the different economic sectors for implementation of climate change adaptation, climate risk analyses, information on climate variability and extremes, local climate change projections, and regional cooperation for bigger climate change projects.

3.16 Media

The mass media of Viet Nam are supervised by the Ministry of Culture and Information and communicate officially approved information. The government also controls Internet access via Viet Nam's sole gateway, Viet Nam Data Communications. Likewise, the government has tightened control over cybercafés. In 2004 the government reprimanded 65 cybercafé owners for violating restrictions on Internet access, including the viewing of pornography materials.

User needs include more frequent updates of tropical cyclone warnings, access to real-time data such as radar images, and workshops to increase understanding and awareness of forecasts.

4 THE METEOROLOGICAL AND HYDROLOGICAL SERVICE OF VIET NAM IN A NUTSHELL

4.1 Brief History

The National Hydro-Meteorological Service (NHMS) of Viet Nam made a great landmark in the history of Viet Nam on 16 September 1902, when the Governor General of Indochina signed the Decree on defining the organization and personnel of the Indochina Magnetic and Hydro-Meteorological Observatory.

In 1945, just after the setting up the interim government of the Democratic Republic of Viet Nam, President Ho Chi Minh signed the Resolution to establish Meteorological Agency given the importance of the role of meteorological services. On 28 September 1955, the Government of the Democratic Republic of Viet Nam issued the Decree No. 588/TTg on moving the Meteorological Department from the Ministry of Communications and Public works and putting it directly under the Government. A year later, the Meteorological Department was renamed to the Hydro-Meteorological Administration by the Government's Decree No. 916/TTg.

On 29 December 1958, the Prime Minister signed the Decree No. 563/TTg to transfer hydrological activities from the Hydro-Meteorological Administration to the Ministry of Water Resources. In 1976, the Hydro-Meteorological Service (HMS) of Viet Nam was officially established on basis of corporation of Meteorological Agency and Department of Hydrology from the Ministry of Water Resources. HMS was an Agency directly under the Government of the S.R. Viet Nam.

On 11 November 1994, the Government issued the Decree No. 62/CP to define the functions, powers and organizational structure of HMS consisting of 9 regional hydro-meteorological Centres (RHMC), and 8 institutional units. Since August 2002 the National Hydro-Meteorological Service has been an institutional organization under the Ministry of Natural Resources and Environment (MONRE).

On 09 January 2003, the Minister of the Ministry of Natural Resources and Environment signed the Decision No.15/2003/QD-BTNMT on defining the functions, responsibilities, powers and organizational structure of the National Hydro-Meteorological Service. In September 2008, the Prime Minister signed Decision 128/2008/QD-TTg stipulating the functions, tasks, powers, and organizational structure of NHMS.

4.2 General Information

Name of Organization:
National Hydro-Meteorological Service (NHMS)
Office Address: No. 3 - Dang Thai Than Str,
Hoan Kiem District, Hanoi, Viet Nam
Website: *www.nchmf.gov.vn*
Contact person for this study:
Dr. NGUYEN Dai Khanh
Email address: daikhanh@kttv.gov.vn
Office hours: 0800H to 1700H
Weather service hours and office hours at synoptic stations: 0000 to 2400

Mission:

NHMS is a state organization under MONRE assisting the Minister to manage, exploit national meteorological and hydrological networks (including basic investigation activities, forecasts, meteorological and hydrological data management), monitor air and water environment in support of natural disaster prevention and preparedness, socio-economic development, national security and defense of the country.

4.3 Evaluation criterion

On the functions of the NHMS of Viet Nam, it has relationship with all ministries in the government.

4.4 Annual report

The NMHS prepares annual report regularly and this can be made available to any entity upon prior request.

4.5 Organization

The NHMS is headed by a Director General and three (3) Deputy Director-Generals that oversee four (4) support departments and seven (7) operational and technical Centres/departments including nine (9) Regional Hydro-Meteorological Centres (RHMCs) as shown in Figure 4.1. Under RHMCs are 54 Provincial Hydro-Meteorological Centres (PHMCs) and hundreds of observation stations.

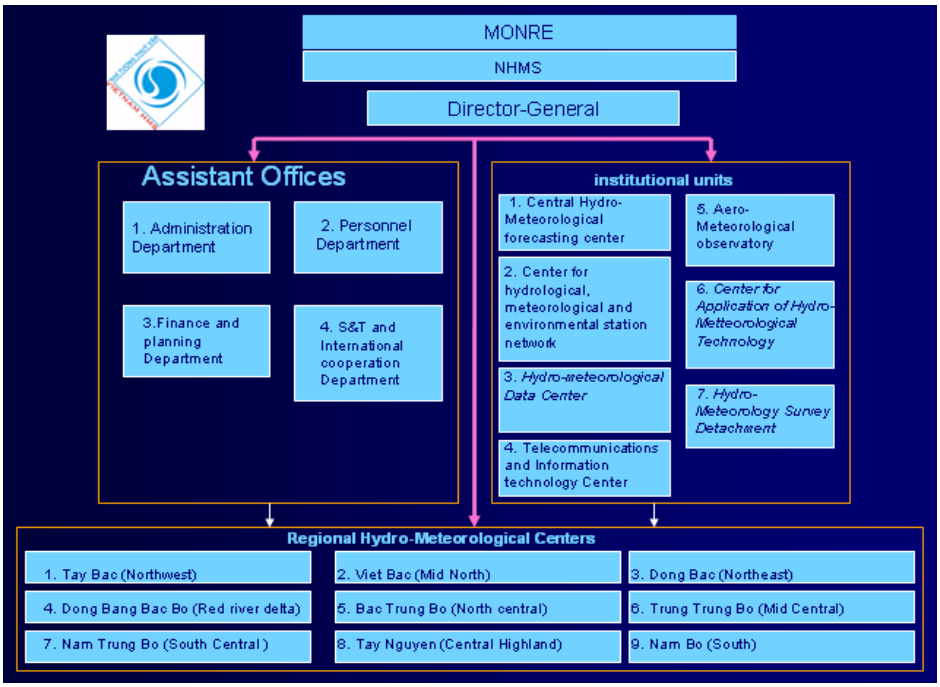


Figure 4.1 Organizational structure of NHMS

The responsibilities of the NHMS are:

- Undertake hydrometeorological monitoring in Viet Nam's area of responsibility;
- Formulate and disseminate operational forecasts, warnings, and other related information;
- Establish and maintain hydrometeorological information network for national forecasting and international data exchange through GTS;
- Provide hydrometeorological services to various national and international organizations;
- Apply new technologies and undertake research to improve forecast skill and quality;
- Conduct training to improve professional skill in hydrometeorological forecasts and information;
- Develop guidelines and technical procedures for hydrometeorological forecasting operations; and
- Collaborate with international institutions in hydrometeorological forecasting and related issues.

The operational forecasting activities of the NHMS are carried out by the National Centre for Hydro-Meteorological Forecasting (NCHMF). Its organizational set up is presented in Figure 4.2.

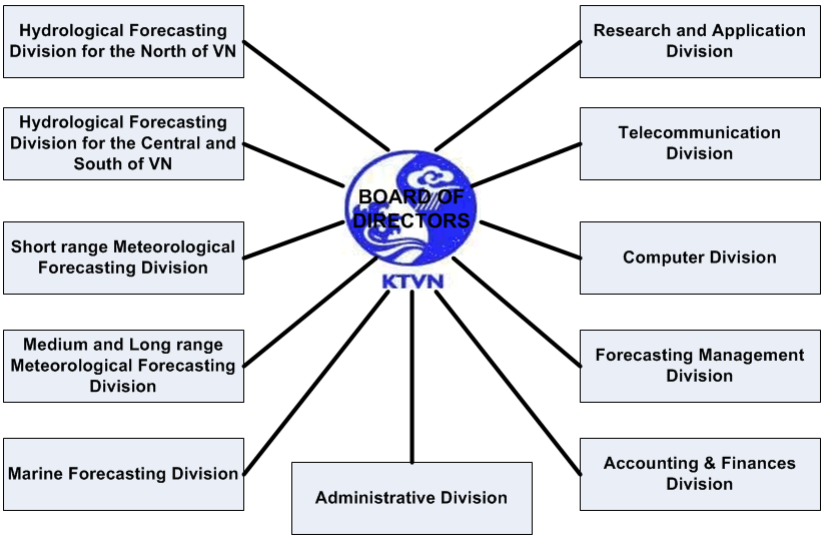


Figure 4.2 Organizational structure of NCMHF

4.6 Budget

The total income of MONRE for 2001-2005 is 19,519 billion VND, mainly from fees by schools within MONRE, fees for granting mineral operation permit, and income from land survey, geological and mineral exploration. The total expenditure during 2001-2005 is 3,091,670 billion VND, increasing on average by 5%. Regular expenditure for main activities is shown in Table 4.1. The sector for hydrometeorology has a total allotment of 336.907 billion VND.

Table 4.1. Total income and expenditure for period of 2001-2005 (Unit: Million VND)

No.	Items	2001	2002	2003	2004	2005	Total
A	Total income						19.519
1	Fee, charges						19.519
B	Total expenditure	469.966	505.945	608.988	657.356	849.157	3,091.670
I	Development investment expenses	123.901	131.200	101.500	140.700	142.913	640.214
1	Survey and mapping, land administration	27.127	38.900	37.087	59.141	45.963	208.218
2	Water resources				600	2.610	3.210
3	Geology and minerals	6.104	3.650	6.913	21.244	18.904	56.815
4	Environment	6.600			4.666	500	11.766
5	Hydrometeorology	84.070	88.650	56.500	52.916	54.771	336.907
6	Others				933	18.456	19.398
7	Project 112			1.000	1.200	1.700	3.900
II	Publication subsidy	35	50	120	180	250	635
III	Economic activities expenses	277.524	290.597	437.647	440.282	621.939	2.067.989
1	Land administration	2.310	4.259	10.146	11.039	50.588	78.342
2	Water resource			1.300	3.120	6.539	10.959
3	Geology & minerals	98.500	114.200	127.949	135.415	145.755	621.819
4	Environment	600		32.000	30.250	38.850	101.700
5	Hydrometeorology	76.220	81.600	101.361	99.749	138.374	497.304
6	Survey and mapping	99.894	90.538	163.459	157.620	233.961	745.472
7	Magazines, information, office			1.432	3.089	7.872	12.393
IV	Administrative management	11.736	13.406	19.123	21.539	25.546	91.350
V	Scientific research	42.414	55.197	32.365	35.387	38.024	203.387
VI	Training (retraining)	11.993	13.577	15.385	16.366	17.260	74.581
VII	Health	363	438	486	540	675	2.502
VIII	Targeted programme	2.000	1.480	2.362	2.362	2.550	11.012
1	Training & education	1.600	1.400	2.262	2.262	2.400	9.924
2	Malaria prevention	400	80	100	100	150	1.088

4.7 Accounting system

NHMS is a second level accounting entity. It has its own stamp and has a right to open an account at the bank and at the State Treasury. The NHMS's Administration Office and the NHMS's units have their own stamps and have the right to open their accounts.

4.8 Visibility of NMHS

Although the NMHS has good exposure with the media through its provision of meteorological and hydrological services, it needs to establish more rapport with the media as well as the various economic sectors to improve its visibility. This is one of the priority concerns of the Director General of the NHMS.

4.9 Human resources

The NHMS has 3,200 personnel at headquarters and field offices. The NCHMF has a total of 140 staffs, including 12 PhD's, 18 MSc's and 85 engineers and bachelors' degree holders.

4.10 Training programmes

The training of technicians and engineers of NHMS is conducted mainly by the Universities of Natural Resources and Environment (UNRE) in Ha Noi and Ho Chi Minh City, the Ha Noi National University, Ha Noi Water Resources University and others.

The NHMS also collaborates with foreign experts in holding training courses for its personnel on seasonal climate, climate change and monsoons. In June and July 2009, several courses on climate forecasting and weather radar applications were conducted.

The post-graduate program or higher level training is implemented by the IMHEN and the national universities in the country. IMHEN offers post graduate programs such as Ph.D. program in atmospheric physics, meteorology/climatology, hydrology/hydraulics, water resources/river and coast management, ocean dynamics, and marine hydrology. At present, IMHEN has already produced 31 graduates in its Ph.D. program and there are 10 ongoing Ph.D. students.

IMHEN also collaborates with international organizations in the conduct of its training programs.

With the aim of strengthening the capacity of its personnel, the NHMS also avails of advanced training opportunities to enable its technical personnel to fully utilize new equipment and technologies through participation in short term and long-term training courses in other countries.

In 2010, Viet Nam NHMS dispatched 2 forecasters to CMA and KMA for follow-up training in Tropical cyclone Information and Prediction System (TIPS).

4.11 International memberships and networking

Viet Nam became an official Member of WMO in 1955 and continued to be an active Member of the organization up to the present. Viet Nam belongs to the Regional Association II (ASIA) of WMO and also a Member of the UNESCAP/WMO Typhoon Committee.

The NHMS also have linkages with a number of international and regional organizations such as UNDP, UNEP, UNESCO, ESCAP, ADB, and IHP, among others. The NHMS also served as Chairman of the ASEAN Subcommittee on Meteorology and Geophysics for the period 1996-1998. Several countries likewise have collaborations with the NHMS in hydrometeorological data and products sharing, technological transfer, research, and training. NHMS also have bilateral agreements with other national meteorological and hydrological services.

In the coming years, the NHMS will continue to strengthen and expand its international cooperation through multilateral and bilateral agreement; explore additional ODA funding sources; enhance cooperation with international organizations such as WMO, UNESCAP, and ASCMG, and strengthen collaboration with National Meteorological Services in the ASEAN, US, France, Japan, Australia, Russia, China, Norway, Finland, and Italy in the fields of meteorology and hydrology.

4.12 Cooperation with other providers of meteorological and hydrological services in Viet Nam

The NMHS provides both meteorological and hydrological services in Viet Nam. However, the Institute of Transportation has its own observing facilities in airports for their use in the issuance of forecasts for aviation. The NMHS has to collaborate with the Institute of Transportation on data sharing.

CURRENT SERVICES OF NHMS 5

The NHMS is responsible for providing various hydrometeorological and marine forecasts to meet the growing requirements of the various socio-economic sectors in Viet Nam. The system of NHMS services consists of three levels, namely:

- National Centre for Hydro-Meteorological Forecasting is responsible for the issuance of a general forecasts for the whole country.
- Regional Hydro-Meteorological Centre is responsible for the issuance of forecasts for their respective regions.
- Provincial Hydro-Meteorological Forecasting Centre is responsible for the issuance of forecasts for their respective provinces.

Figure 5.1 shows the services for decision-making and for general public under the public hydrometeorological services which includes weather, hydrological and early warning services.

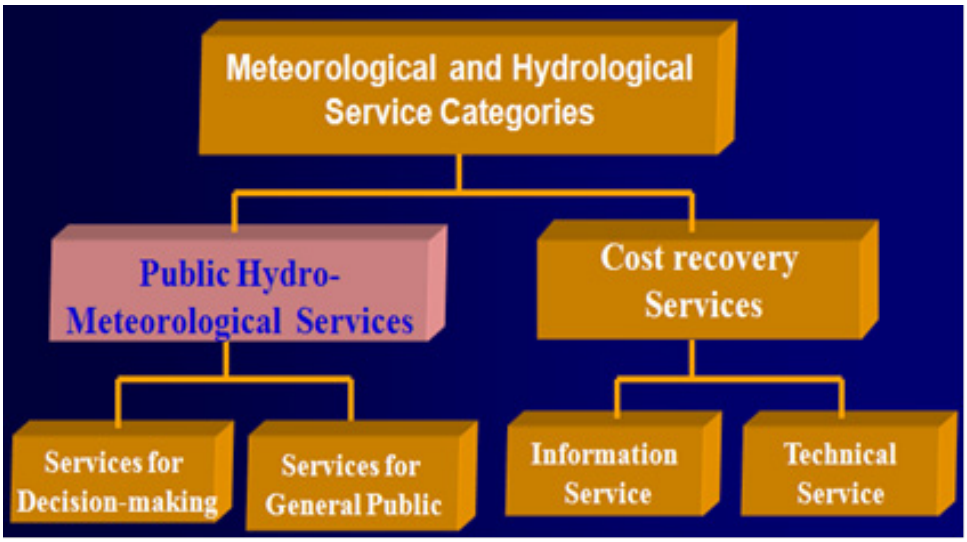


Figure 5.1 Categories of meteorological and hydrological services

5.1 Weather and marine services

Weather forecasts are produced for decision makers as well as for the public. The products include marine weather forecasts, medium range weather forecast, and monthly and seasonal outlooks. The marine weather forecast is issued in Vietnamese sea waters and vicinity which are divided into 12 coastal areas as shown in Figure 5.2. Weather forecasts are updated twice a day. Nowcasting weather services are implemented for some major cities.

Daily marine hydrometeorological forecasts are broadcasted via national and local radio, television programs, and also via special channels for fishermen and ships.

The medium range weather forecast provides a five-day forecast for 24 key cities and provinces in Viet Nam. The monthly outlook describes the ranges of temperature and rainfall expected based on data from 10 stations within the Viet Nam Area of Responsibility (VAR) (Figure 5.2) as follows: Son La, Ha Noi, Hai Phong, Thanh Hoa, Vinh, Hue, Da Nang, Nha Trang, Buon Ma Thuot and Chau Doc.

Severe weather forecasts and warnings are issued during inclement weather such as tropical cyclones and cold surges within its area of responsibility.

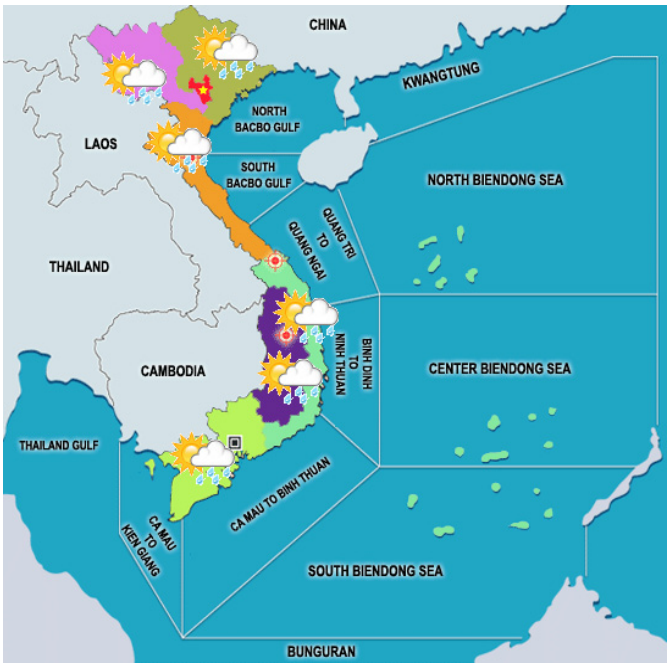


Figure 5.2 Viet Nam Area of Responsibility

5.2 Early warning system

Tropical cyclones and the northeast monsoon have adverse impacts that often cause serious human sufferings and material damages in Viet Nam, especially for the population living near the coastlines. Tropical cyclone and northeast monsoon forecasts are issued several times a day according to special regulations.

In 2008, the NMHS experienced a lot of difficulties and made some mistakes in weather forecasting and warning according to Mr. Tran Van Sap, Deputy Director General of the NHMS (Viet Nam Net Bridge, 2009). There were 10 storms, five typhoons, 19 floods, and numerous unexpected and complicated weather changes. The centre released hundreds of news bulletins. However, five of these contained inaccurate information. The record rain in Hanoi in early November 2008 was much heavier than the forecast. Other inaccuracies in the central provinces come from storms which suddenly changed its direction hence the path of the storms were not accurately predicted. The traditional/synoptic forecasting technology can no longer address the technical requirements of the NHMS, despite of some improvements. For storms hitting the coastal areas that change direction of movement, the warnings issued may have significant deviations from the actual situation.

Its technology for recording and predicting rainfall is also outdated which leads to incorrect flood forecasts. In addition, climate change is causing changes in weather patterns that make forecasting more complicated.

The daily weather forecast is one of the most important and popular type of forecasts for the public. These forecasts are aired via national and local radio, television, and also published in daily newspapers as well as posted in the website of NMHS as shown in Figure 5.3.

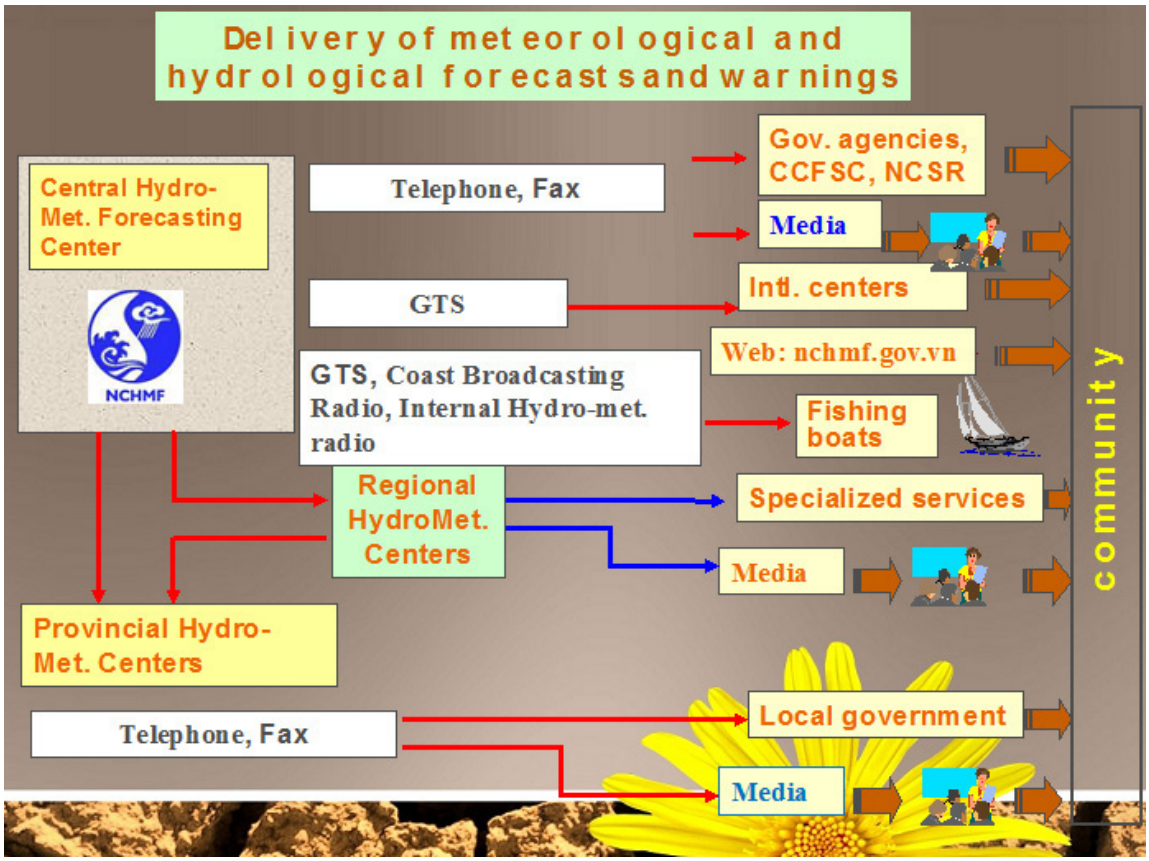


Figure 5.3 Forecast & Warning Dissemination in Viet Nam

5.3 Climate services

Climate services for the country are provided by IMHEN through the issuance of climate outlooks with a validity of up to 3 months.

5.4 Agrometeorological services

The Centre for Agricultural Meteorology (CAMET) is a scientific functional unit under IMHEN. The function of the Centre is to conduct research for improved agrometeorological services in support of agricultural production, livestock, aquaculture and pest management, environmental management, and forestry for sustainable economic development.

The CAMET provides agrometeorological outlook and crop yield forecasts. Reporting of agrometeorology and forecast of crop yield is a regular activity of IMHEN. The outputs are sent to relevant agencies and posted in the Institute's website at http://www.imh.ac.vn.

5.5 Hydrological services

The NHMS also monitors the 15 major rivers in the country. Localities are responsible for keeping track of the local hydrological situation and to transmit the observed data to the national centre.

The NHMS issues the following forecasts: short-range, medium-range, monthly, and seasonal forecasts.

Short range forecasts such as daily hydrological bulletins are issued for 6 forecasting points in the Northern River Systems and 23 forecasting points in the Central Highland and Southern Viet Nam. The daily hydrological bulletin provides the warning level status, observed water and forecast water

levels. Warning levels range from normal to warning water levels I, II and III depending on the rainfall situation. Urban inundation warnings are issued for some big cities such as Ha Noi (due to heavy rainfall), Ho Chi Minh City (due to heavy rainfall, high sea tide), etc.

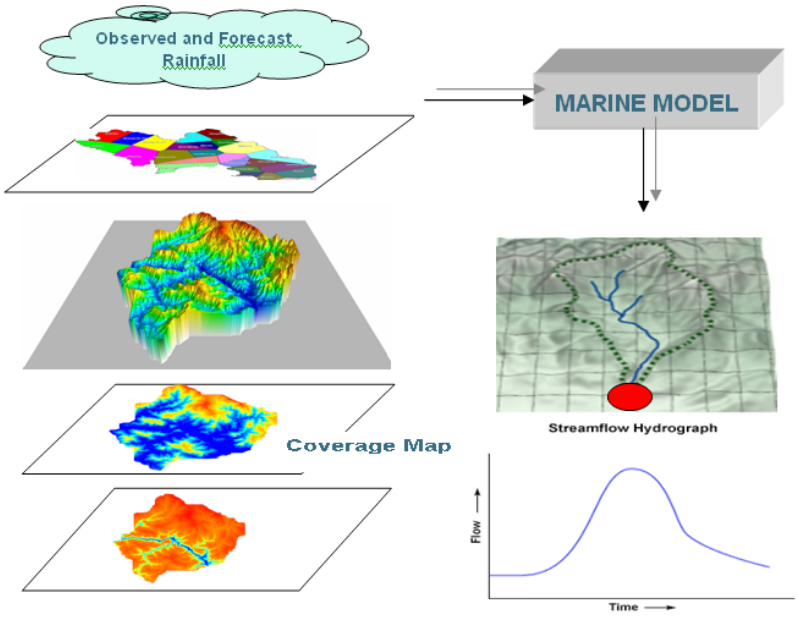


Figure 5.4 Techniques of short-term hydrological forecast

Short-term hydrological forecast (Figure 5.4) is formulated using the MARINE (France) distributed hydrologic model utilizing DEM and GIS to calculate the inflow at Hoa Binh reservoir from precipitation data at Da and Ma river basins. There are 14 major river systems in Viet Nam including two large transboundary river basins, the Red River in the North and Mekong River in the South.

During the flooding season, river water level and flood warnings in main river systems are issued for each river system according to various alarm or warning categories (Figure 5.5).

Drought warnings are also issued including bulletins on water releases to prevent drought. Medium range hydrometeorological forecasts (5 day, 10 day, monthly and seasonal forecasts) are also issued to selected ministries and other offices.

Table 5.1 Rainfall-runoff models are used for flood forecasting in a number of rivers in Viet Nam		
River/reservoir	Software/model	Lead Time
Tuyen Quang reservoir inflow on Lo river	TANK model; the Muskingum-Cunge and reservoir water balance method	
Hong river basin	SH2 model; Using SSARR model and forecasting error update	48- forecast lead time
Red River system for Ha Noi forecast station	MIKE 11	
Ca river system	NAM, Muskingum+Cunge models	
Vu Gia – Thu Bon river system	NAM and Hydraulic model; Wetspa and HECRAS model	
Tra Khuc river	SSARR model; HMS-HecGeoRAS	
Mekong river	Nam and hydraulic models	

DAILY HYDROLOGICAL BULLETIN
FOR RIVERS IN THE CENTRAL HIGHLAND AND SOUTHERN VIETNAM

Ha Noi, Thursday, October 01, 2009

Unit: cm

RIVER	STATION	Warning Water Level			Observed water level		Forecasted Water level			
		I	II	III	19h-30/9	7h-1/10	19h-1/10	7h-2/10	19h-2/10	Date 5/10
Ma	Ly Nhan	900	1050	1200	473	472				
Ma	Giang	350	500	650	146	83	130	75		
Lam	Nam Dan	540	690	790	637	595		575	580	
La	Linh Cam	400	550	650	360	408	475	500		
Gianh	Mai Hoa	300	500	600	619	665	490			
Thach Han	Thach Han	190	390	540	650	493	360			
Huong	Kim Long	50	150	300	271	242	180			
Bo	Phu Oc	100	300	450	427	427	360			
Vu Gia	Ai Nghia	640	770	880	938	844	740			
Thu Bon	Cau Lau	210	310	370	485	397	310	250		
Tra Khuc	Tra Khuc	270	420	570	485	392	340			
Ve	Song Ve	210	310	410	310	235				
Con	Thanh Hoa	550	650	750	574	591				
Ba	Cung Son	2950	3150	3350	3196	3195	3150			
Ba	Phu Lam	170	270	320	231	231	200	170		
Cai Nha Trang	Dong Trang	800	900	1000	421	420				
Cai Phan Rang	Tan My	3600	3700	3800	3490	3492				
DakBla	KonTum	51800	51950	52000	51953	51852				

REMARKS:

Legends	Warning status
	Normal
	Warning water level I
	Warning water level II
	Warning water level III
	No data available

Figure 5.5 Example of the daily hydrological information on the NCHMF homepage

5.6 Environmental services

Environmental services in terms of air and water quality forecasts are the responsibility of IMHEN. The institute is equipped with an environmental laboratory (Figure 5.6) that analyzes most of the parameters of air, water, and environment.

Figure 5.6 Environmental Laboratory of IMHEN

Air quality forecasts for urban areas of Viet Nam (Figure 5.7) as well as water quality forecasts are published in the INHEM website (http://www.cenre.ac.vn/).

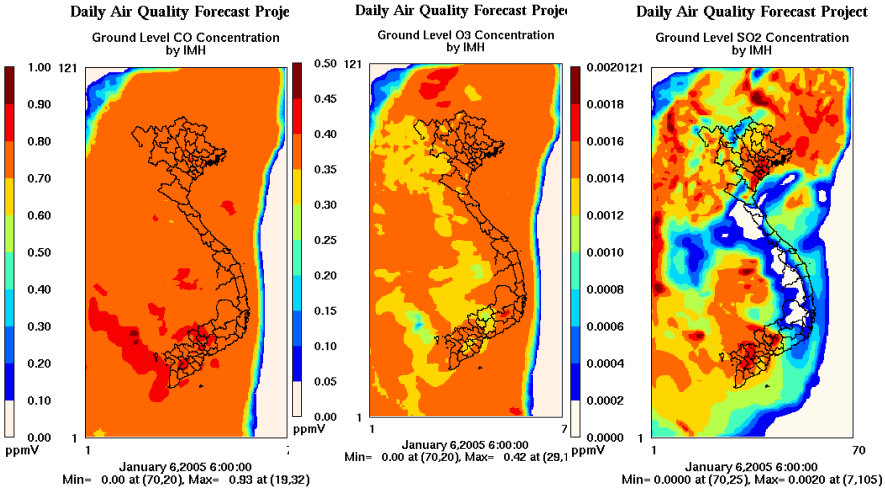


Figure 5.7 Air quality forecast for urban areas of Viet Nam

5.7 Climate Change related services

Viet Nam signed UNFCCC in June 1992 and ratified it on 16 November 1994. It also ratified the Kyoto Protocol on 25 September 2002.

The Ministry of Natural Resources and Environment (MONRE) is assigned by the Government of Viet Nam to be the National Focal Point to take part and implement UNFCCC and the Kyoto Protocol.

In Viet Nam, the Clean Development Mechanism (CDM) Designated National Authority is the International Cooperation Department of MONRE.

Climate Change Country Teams and National Technical Experts Groups were also established to implement climate change projects.

Climate change related service is not the responsibility of the NHMS but under the IMHEN and the Department of Meteorology, Hydrology and Climate Change (DMHCC).

The Centre for Meteorology and Climatology (CMC) under IMHEN has the function to undertake scientific research, implementing science and technology related to meteorology, climatology, atmospheric physics, and air-sea interaction. Activities are focused on general meteorology, climatology, and prediction; applied climate, atmospheric circulation system and monsoon; climate variability and extreme events; climate change and prediction; tropical meteorology and typhoons, air-sea interaction; CLICOM; and numerical modelling.

Apart from its R&D activities, the CMC also publish meteorological and climate bulletins, and climate prediction.

Disseminating information on climate is a regular activity of IMHEN. The climate outlook for Viet Nam is based on downscaling of outputs from Global Climate Models. Climate outlook for a three- month period is regularly issued and sent to relevant agencies and posted in the Institute's website (http://www.imh.ac.vn).

IMHEN has also developed climate change scenarios for Viet Nam based on different emission scenarios: low (B1), medium (B2), and high (A2, A1FI). The results are shown in Figure 5.8.

Based on the outputs, by middle of 21st century the sea level is projected to increase by about 30 centimeters. Sea level would rise by about 75 centimeters by the end of 21st century as compared to the period 1980 – 1999 (baseline data).

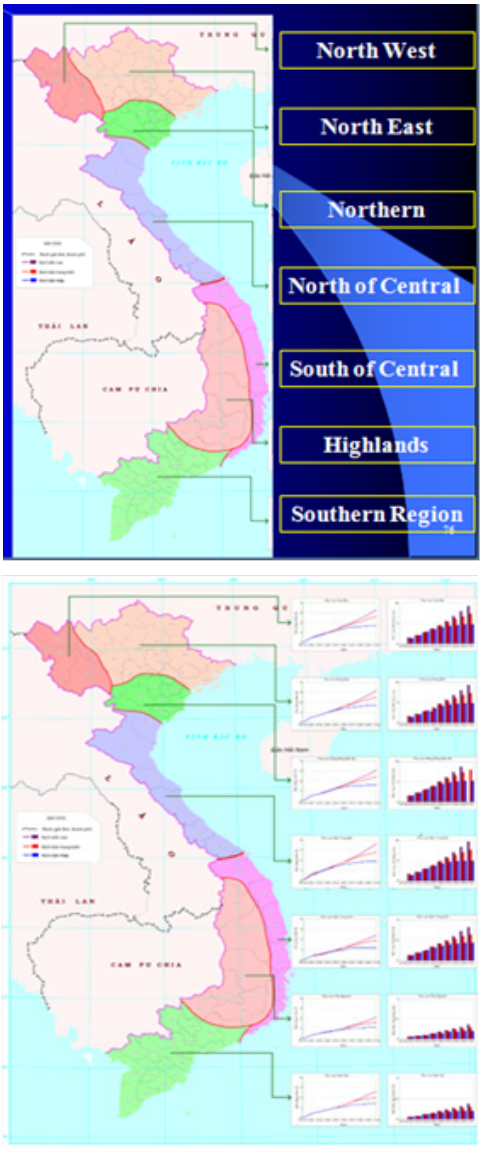


Figure 5.8 Changes in Annual Mean Temperature & rainfall

Table 5.2 Derived climate change scenarios for Viet Nam									
SLR scenario	Decades in the 21st Century								
	2020	2030	2040	2050	2060	2070	2080	2090	2100
Low (B1)	11	17	23	28	35	42	50	57	65
Medium (B2)	12	17	23	30	37	46	54	64	75
High (A1F1)	12	17	24	33	44	57	71	86	100

5.8 UV radiation

UV index forecasts for Viet Nam are available in the website of the following private organizations:
http://www.intellicast.com/,
http://abclocal.go.com/wtvg/areaweather?cityId=10457&cn=Bang&cty=Viet Nam&region=int,
http://www.weather.com/weather/today/Lang+Son+Viet Nam+VMXX0023,
http://www.timeanddate.com/weather/Viet Nam/hai-phong/ext
http://www.eldoradocountyweather.com/canada/forecast-maps/heatindex.html

5.9 R&D based Expert Services

The IMHEN is the leading scientific research centre on meteorology and hydrology in Viet Nam and also serves as the postgraduate training centre in meteorology and hydrology. At the Institute, there are five Centres undertaking research as follows: climate and meteorological application, agrometeorology, hydrology, tropical meteorology and typhoon, and environment. The research units and centres under IMHEN have participated in national, international, and ministerial scientific and technological programmes on natural disasters, climate change, oceanography, environment, hydrology, and water resources.

Table 5.3 Research activities and projects of IMHEN	
Country/Agency/ Organization	Training/Research Activity/Project
US-WMO:	Climate information and prediction service; Flood modeling and prediction; Training of experts; Exchange and discussion
UNDP-WMO:	Technical assistance in strengthening; agrometeorological capacity; Agrometeorological experimental stations; Agrometeorological survey equipment; Training of experts; Agrometeorological service program
GEF-UNDP-ADB:	Global climate change: Asia – Viet Nam; GHG emission inventory in 1990; Global impact on Viet Nam; Asia Least Cost Greenhouse Gas Abatement Strategy (ALGAS)
UNEP-RISO:	Economic assessment of the measures for GHG control; Portfolio of feasible projects
UNEP-UNFCC:	Viet Nam initial communication on climate change to UNFCCC; GHG inventory in 1994; Impact of climate change on socioeconomic development of Viet Nam; Response strategy and adaptation
World Bank:	National strategy study on CDM; World GHG market and opportunity; Response strategy; CDM feasible projects
Mekong River Commission (MRC):	Salinity intrusion in the Mekong River Delta; Wetland inventory and management; Soil erosion and sedimentation study; Water Utilization Programme (WUP); Basin Development Programme (BDP); Environment Programme
Acid deposition monitoring network in East Asia (EANET):	Monitoring activities; Awareness activities
Laos:	Hydrometeorological study programme for Laos areas; Training of Laos experts
China:	Agrometeorological field; Expert exchange; Technology transfer; Training of experts
Russia:	Tropical meteorology and typhoon studies; Weather modification (rain making)
Australia:	Climate prediction, data processing, training, climate change (Greenhouse partnership, CDM study...)
Japan:	Southeast monsoon study; AIJ under UNFCCC; Acid deposition monitoring network in East Asia
Netherlands	Sandwich programme for training of agrometeorological experts; Climate change
Sweden	Flood warning and integrated flood management; Postgraduate training
DANIDA	Benefits on Climate Change Adaptation from Small and Medium Scale Hydropower Plants: Synergies and Trade-offs with Rural Development; Climate Change and Disaster Check of Danish Sector Program in Viet Nam; Sea Water Level Rise Scenarios and possible disaster risk reduction in Viet Nam; Impact of Climate Change on Water Resources and Adaptation Measures

IMHEN has also conducted numerous researches in the following fields:

a. Meteorology, Climatology and Agro-meteorology

- Application of numerical model for weather forecast, typhoon forecast and heavy rainfall forecasts, drought forecast and warning
- Cause, measure for prevention and mitigation of desertification in the Central Viet Nam
- Climate change and hydrometeorological extremes
- Impact of ENSO on weather, climate, environment and socio-economy of Viet Nam
- Investigation, assessment of agro-climate for resettlement for Son La large hydroelectric project Inventory, assessment of climate resources of Viet Nam

b. Hydrology, Hydraulics and Water Resources

- Application of NWSRFS model for flood forecast for the Red river
- Development of flood forecast system for the Red-Thai Binh river
- Flood forecast for the Huong river
- Computation of tsunami in the east Asia and development of tsunami risk maps
- Development of flash flood risk maps
- Assessment of role of reservoirs in the Red river in flood regulation for the downstream
- Hydraulic computation for an assumed failure of Hoa Binh and Son La dams
- Scientific base for distinguishing river, river mouth and sea dikes
- Investigation, study and development of flood warning for Central Viet Nam
- Flood forecast and inundation computation for Thu Bon river system
- Study on flood drainage for the plan of Reeds, Mekong river delta
- Characteristics of flood and flood water balance computations for the Mekong river delta
- Development of a decision support framework for integrated water resources management of Ca river
- Integrated water resources planning for the economic zone of Red river delta
- Flash flood: Investigation, risk zoning and warning fro mountainous areas of Viet Nam

c. Environment

- Air quality computations
- Air quality forecast for urban areas of Viet Nam
- Application of numerical model for air quality computation and forecast
- Poverty and environment (PEP)
- Water quality modeling for the three river basins: Cau, Nhue-Day and Saigon-Dong Nai rivers
- Air quality study and planning for Phu Quoc island
- Study on acid deposition in Viet Nam
- Sediment transport computation for Ha Long Bay
- Pollutant Sources Quick Identification Software (PSQIS)
- Computations of oil spill in the East Sea

d. Climate Change Impact and Adaptation Studies

- Climate Change in Asia: Viet Nam
- CC: TRAIN (Phase 1)
- Asia Least - Cost Greenhouse Gas Abatement Strategy (ALGAS) Project
- Economics of GHG Limitation – Phase 1: Establishment of a Methodological Framework for CC Mitigation Assessment
- Viet Nam Coastal Zone Vulnerability Assessment
- Viet Nam Initial National Communication - 2003
- Viet Nam National Strategy Study on Clean Development Mechanism
- Preparedness for Disasters Related to Climate Change

- Climate Change Impacts in Huong River Basin and Adaptation in its Coastal District Phu Vang, Thua Thien Hue Province
- Benefits on Climate Change Adaptation from Small and Medium Scale Hydropower Plants: Synergies and Trade-offs with Rural Development
- Climate Change and Disaster Check of Danish Sector Program in Viet Nam
- Sea Water Level Rise Scenarios and possible disaster risk reduction in Viet Nam
- Impact of Climate Change on Water Resources and Adaptation Measures
- Strengthening National Capacities to Respond to Climate Change in Viet Nam, Reducing Vulnerability and Controlling GHG Emissions
- Climate Change Scenarios for Viet Nam

5.10 Information services

The NMHS, IMHEN and DMHCC have their own libraries which feature documents and technical or scientific papers however most of the articles are in Vietnamese.

Internet

The NMHS has its own website but the forecasts and warnings are found in the NCHMF website (Figure 5.9). Likewise, the IMHEN and DMHCC maintain their own website.

Web Site of NCHMF: http://www.nchmf.gov.vn
Website of IMHEN: http://www.imh.ac.vn/

Figure 5.9 NCHMS website

For its public services in 2010, the NHMS held a workshop with mass media practitioners in Ha Noi. It also conducted four climate outlook forums at both central and regional levels for all relevant agencies and end users. To assess the demand on hydrometeorological data and thereby improve its various services, the agency conducted very general public survey.

Dissemination of Forecasts & Warnings in Viet Nam

Forecasts and warnings from the NCHMF are disseminated to central government authorities, Central Committee on Flood and Storm Control, National Committee for Search and Rescue, and relayed to the community through the media. Simultaneously, NCHMF send the bulletins and warnings to the regional and provincial hydrometeorological centres that likewise disseminate the information to local authorities and community through the media (Figure 5.10).

Just recently, a communications department has just been established in the centre which is responsible for contacting and providing media agencies with the most updated weather and climate information that are also updated regularly in its website (http://english.Viet Namnet.vn/tech/2009/04/844880/).

A regulation has also been issued for local and regional hydrometeorological forecasting centres on what should be done to deal with weather and climate information for each centre in case of natural disasters. If the forecasting information differs between centres, then the local and regional hydrometeorological forecasting centres will have to follow the national centres report.

From April 2009, the NHMS has conducted online conferences and meetings with the participation of nine regional hydro-meteorological forecasting centres through, at first, skype then teleconferencing facilities and this paved for better interaction with the public. The users can now post their comments on weather and climate situation. In addition, the Central Committee for Flood and Storm Prevention and Control receives prompt information from central and local centres in order to make timely decisions.

Online television has been operational since September 2009. Through this system, climate maps and diagrams are shown to make the information more understandable to the public.

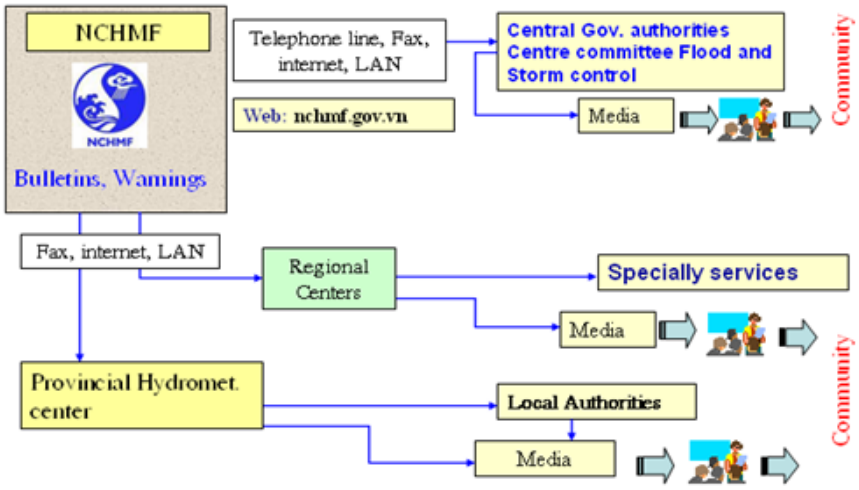


Figure 5.10 Dissemination of forecasts and warnings

NHMS's NETWORK OF OBSERVING STATIONS 6

The meteorological, hydrological, marine, and environmental observation network covers a large part the whole territory, including urban, rural, mountainous areas and islands such as Truong Sa, Tho Chu, Phu Quoc, Con Dao, etc. This network provides observations for use in hydrometeorological forecasting and provision of data and other information.

6.1 Surface network

6.1.1 Synoptic stations

- Surface Meteorological Stations: 176, 4-8 observations/day
  Raingauge sites : 764 (371 raingauges located in hydrometeorological station network +393 raingauges located outside of hydrometeorological station network)
- Radiation: 14
  Classifications: 57 class I, 69 class II, 48 class III
  Among this: 25 International reported stations
  125 Synoptic reported Stations
  27 Agro Meteorological reported stations

6.1.2 Hydrological stations

This network maintains 232 stations, including 60 stations of 1st Category, 20 stations of 2nd Category and 152 stations of 3rd Category. In this network there are 88 automatic stations and 100 stations in tidal areas.

6.1.3 Agrometeorological observations

There are 27 agrometeorological stations including 15 principal and 12 ordinary stations.

6.1.4 Marine Hydrometeorological Stations

Seventeen (17) stations: 11 are located along islands and 5 along coastal areas and all these observe waves, sea level height and tides together with hydrometeorological elements. In addition, there is one scientific research ship for sea expeditions.

6.1.5 Air quality observations

Ozone and UV: 3 (Sa Pa, Hanoi and Tan Son Hoa (Ho Chi Minh City). Observation equipment: Brewer MkIII.

6.1.6 Seismological observations

- 26 seismic stations operating under the Seismological Department, Institute of Geophysics;
- 3 broadband seismic stations established by Asian Disaster Preparedness Centre (ADPC)
- 12 Broadband station network under Viet Nam-Japan Cooperation

6.1.7 Environmental observations

This network consists of 155 stations and observation points, including 10 air quality automatic observation stations, 22 stations for dust and chemical concentration of precipitation, 48 river water quality control stations, 9 lake water quality control stations, 6 sea water quality control stations taking sea water samples for analysis once a month, and 68 observation points for recording river salinity concentration.

Most of the stations are manually operated with manual or self recording equipments. The operator will report through telephone or ICOM to the

Regional Hydro-Meteorological Centre, wherein such communication system is not stable during bad weather and some stations are located in less accessible mountain areas; From the Regional Hydro-Meteorological Centre the data will be sent to IT Centre through the dialup network or internet.

Table 6.1 Site information of Viet Nam Seismic Network

No	Station name	Code	Latitude (N)		Longitude (E)		Elevation (m)	Foundation	Seismometer
			deg	min	deg	min			
1	Phu Lien	PLV PLVO	20	48.36	106	37.81	90	Quartizite	L-4C-1D STS-2
2	Bac Giang	BGV	21	17.41	106	13.65	15	Sandstone	L-4C-1D
3	Tam Dao	TDV	21	27.88	105	38.74	1200	Sandstone	L-4C-3D
4	Chua Tram	HNV	20	56.29	105	41.33	50	Limestone	L-4C-3D
5	Doan Hung	DHV	21	37.61	105	11.03	70	Aleurolite	L-4C-1D
6	Ba Vi	BVV	21	06.13	105	22.12	182	Sandstone	L-4C-1D
7	Met	MTZ	21	32.88	106	20.52			L-4C-1D
8	Doi Son	DSV	20	35.14	105	53.24	70	Quartizite	L-4C-1D
9	Yen Tu	YTV	21	09.42	106	43.02			L-4C-1D
10	Da Lat	DLVO	11	57.91	108	28.89	1550	Aleurolite	CMG-3T
11	Dien Binh	DBV DBVO	21	23.38	103	01.10	480	Clay-sale	L-4C-3D CMG-3T SSA-2, K2
12	Hoa Binh	HBV	20	47.77	105	20.32	80	Sandstone	L-4C-3D
13	Hue	HUVO	16	25.01	107	35.13	8	Aleurolite	L-4C-3D
14	Lai Chau	LCV	22	0.32	103	09.26	1100	Aleurolite	L-4C-3D SSA-2
15	Lang Chanh	LAV	20	09.19	105	14.85		Sandstone	L-4C-3D
16	Moc Chao	MCV	20	50.65	104	38.13			L-4C-3D SSA-2
17	Sa Pa	SPVO	22	20.30	103	50.11	1150	Aleurolite	CMG-3T, SSA-1
18	Son La	SLV	21	20.03	103	54.30	700	Aleurolite	L-4C-3D
19	Song Ma	SMV	21	03.42	103	44.66			L-4C-3D, K2
20	Thanh Hoa	THV	19	51.05	105	46.92		Sandstone	L-4C-3D
21	Tram Tau	TTV	21	28.36	104	21.66		Sandstone	L-4C-3D
22	Tuan Giao	TGV	21	35.39	103	25.09			L-4C-3D, SSA-1, K2
23	Vinh	VIVO	18	32.88	105	42.00	5	Quartizite	CMG-3T
24	Nha Trang	NTV	12	16.00	109	11.66	5	Ryolite	L-4C-3D
25	Cat Ba	CBV	20	47.64	106	57.54		Limestone	L-4C-1D
26	Binh Thanh	BTV	20	45.60	105	16.80	30	Clay-sale	L-4C-3D
27	Tu Ly	TLV	20	52.74	105	15.60	30	Sandstone	L-4C-3D
28	Ky Son	KSV	20	52.50	105	5.36	30	Sandstone	L-4C-3D

Remarks:

Tam Dao Station of Hanoi telemetry Network*

L-4C-3D Short-period Seismometer (T=1,0), 3 components (Mark Product)

L-4C-1D Short-period Seismometer (T=1,0), 1 component (Mark Product)

CMG-3T Guralp Systems Limited

STS-2 Portable Very-Broadband Tri-axial Seismometer

LE-3D Short-period Seismometer (Lennartz Electronic)

SSA-1, SSA-2 Solid-State Recording Accelerograph

K2 Altus Digital Recorder

6.2 Remote sensing

6.2.1 Upper air observations

There are 6 radiosonde DIGICORA (VAISALA) stations. The upper-air observations record geopotential height, temperature, humidity, wind speed and direction. Hanoi, Da Nang, Tan Son Hoa (Ho Chi Minh City) stations conduct two observations per day at 00Z and 12 Z while the rest (Vinh, Dien Bien, Bach Long Vy) stations conduct one observation daily at 00Z. The upper air network also includes 8 pilot balloon stations with o1 observation per day at 00Z.

6.2.2 Weather Radars

There are 7 weather radars operating 24 hours daily for detection and monitoring of severe weather events such as tropical cyclones, thunderstorms, and heavy rainfall (Figure 6.2). The French radars are located in Phu Lien (Hai Phong), Viet Tri (Vinh Phuc), and Vinh (Nghe An). The American Doppler radars are located in Dong Ha (Quang Tri), Tam Ky (Quang Nam) (DWSR 2501C), Nha Trang (Khanh Hoa) and Nha Be (Ho Chi Minh City) (DWSR 2500C).

To cover the whole country, a network of 15 radars is required. Currently, there is a need to calibrate rainfall estimates from the radars so that these can improve rainfall forecasts. Currently composite images from all of the radars are not yet available and needs to be addressed. For its radar composite, the main problem is the lack of usable volume data. During the acquisition of these radars, emphasis was focused on the cost of the hardware while the after installation costs or operational requirements such as the software was not included in the purchase. The NHMS Viet Nam is currently working on the compositing program and adjustments on the display software in coordination with a private consultant and the supplier.

Figure 6.1 Regional and Distant Earthquake Monitoring System in Viet Nam

Figure 6.2 Existing network of weather radars

The existing operational radars installed in Vinh, Tam Ky and Nha Trang would also require adjustment and further study on the VAD algorithm (PILOTs from doppler radar for assimilation) or any alternatives so that the outputs from these radars can be utilzed operationally.

A series of in house workshops is being planned on Thresholding of TRS radars' "black" display software, under/overlay map details to match nowcasting needs in the regional offices and headquarters, transmission of airport radar data to regional offices and utilization of lightning data.

As far as utilization of radar data is concerned, the NHMS undertakes the following activities:

- Polar volume data decoding (EEC data)
  • Volume data is essential for all kind of quality control and not only for compositing
- Modification of NHMS's own compositing program to accept data of different resolutions and ranges, e.g. the data from Ha Noi airport radar
- Full metadata decoding of EEC product data
- Decoding of MRL-5 volume data

There is urgency in carrying out these activities as more and more sectors rely on nowcasts provided by radars for emergency purposes.

An interesting study entitled "Toward the mitigation of water disaster in Indochina: Efforts to make radar composite maps over borders" is currently being conducted by Takehiko Satomura, Graduate School of Science, Kyoto University. The results of the study will likely benefit the countries in Indochina by addressing the problems on the utilization of existing radar data. Some of the issues, however, are currently being ddressed by the NHMS, as follows:

- Inconsistency at multiple radar overlap regions
- Some radar observation areas have insufficient rain gauges
- Un-optimized Z-R relationship
- Attenuation by strong rain
- Discrepancies between raingauge rainfall and radar rainfall at raingauge points.

The study emphasized the need for cooperation among countries in near real-time and over border issues.

6.2.3 Satellite

MTSAT, NOAA Polar orbiting Satellite, FY-2, and other satellite imageries are received by the NMHS through ground receiving systems and internet.

7 MAINTENANCE, CALIBRATION AND MANUFACTURING OF MEASUREMENT SYSTEMS

7.1 Meteorological observations

7.1.1 Maintenance

The NHMS maintains all meteorological and hydrological stations in Viet Nam.

7.1.2 Calibration System

In the Hydrometeorological Service there are equipment for calibrating instruments on basic hydrometeorological elements such as temperature, humidity, atmospheric pressure, solar radiation, wind speed and rainfall. Equipment for calibrating solar radiation, wind speed and flow speed were installed in 1997.

Figure 7.1 Calibration equipment

NHMS has an advanced laboratory for hydrometeorological equipment calibration. Barometers, anemometers, thermometers and other hydrometeorological instruments in its observation network are regularly calibrated to ensure the quality of meteorological and hydrological data.

There are three well-equipped laboratories located in Ha Noi, Da Nang and Ho Chi Minh City for environmental quality control used to analyze samples collected from 9 regional hydro-meteorological centres. Laboratories are strategically located in North, Central and South Viet Nam.

7.1.3 Metadata

Metadata including description of the surrounding environment which includes the location, size, and height of nearby obstacles for synoptic stations is not yet completely available in digital form. There is a need to standardize the production of metadata.

7.1.4 Traceability

Traceability of the meteorological measurements to international and national standards and references is maintained at the laboratories of the NMHS.

7.2 Hydrological observations

Maintenance of measurement systems is performed by NHMS in cooperation with the manufacturers. Equipment for calibrating solar radiation, wind speed and flow speed were installed in 1997.

Calibration of measuring equipment and systems is conducted by the NHMS.
Traceability of hydrological measurements to international and national standards and references is maintained by the Hydrometeorological Instrument Calibration Division.

7.3 Environmental observations

Traceability of environmental measurements to international and national standards is performed by the NHMS and IMHEN.

8 NUMERICAL WEATHER PREDICTION (NWP)

8.1. Computing facilities

High performance computer: There are 3 HPC systems installed at NCHMF to run regional modeling system including HPC of 8 nodes (2006), 16 nodes (2008) and 6 nodes (2011) as following:

- HPC 8 nodes: 4CPU/node, 2GB RAM/node, Rpeak: 28GFlops
- HPC 16 nodes: 4CPU/node, 8GB RAM/node, Rpeak: 200GFlops
- HPC 6 nodes: 8CPU/node, 16GB RAM/node, Rpeak: 1.2TFlops

Data storage: SAN system with usable capability of 40TB

Network: High-speed internet line based onTEIN3 network

8.2 Operational models

The NHMS utilizes the following operational numerical weather prediction (NWP) System.
Sample outputs of these models are shown in Figure 8.1

- Global products:
  - GSM from JMA (0.5 x 0.5, 4 times/day, up to 72hrs)
  - GFS from NCEP (0.5 x 0.5, 4 times/day, up to 96hrs)
  - NOGAPS from US Navy (0.5 x 0.5, 4 times/day, up to 72hrs)
  - GME from DWD (0.3 x 0.3, 4 times/day, up to 72hrs, the resolution is currently increased)
  - GEM from CMC (0.6 x 0.6, 2 times/day, up to 72hrs)
  - UM from KMA (0.5 x 0.5, 2 times/day, up to 72hrs, the resolution is currently increased)
  - IFS and VarEPS from ECMWF since 1st Dec 2011 for all forecasting ranges (medium, monthly and seasonal range)
- NAEFS (North American EPS): A combination of the two global ensemble forecast systems: GEFS from NCEP and CEFS from CMC; Forecast range: 2 weeks; 2 times/day; Resolution: 10 x 10 (first week), 2.50 x 2.50 (second week), Total member: 42
- Deterministic Regional Models: HRM (14km; 4 times a day), ETA (23km, 2 times a day)
- Short Range Ensemble Forecast (SREF): 17km, 15 members, multi-model multi-analysis, up to 60h
- Limited-area Ensemble Prediction System (LEPS): 22km, 21 members, HRM nested in EPS of GFS, up to 120h
- NWP Post-Processing: UMOS + Kalman filter

For marine forecasts, the NHMS is running the storm surge model DELF 3D and the wave models WAM and SWAN (VNWave model).

The NMHS uses two steps in forecasting tropical cyclones: 1) TC eye fixing and TC intensity, and 2) track forecasting. In the first step, the scheme makes use of synoptic method in locating the eye of a tropical cyclone based on synoptic chart, satellite images, radar images and outputs from Quickscat (Figure 8.2). NWP products are mainly utilized in step 2.

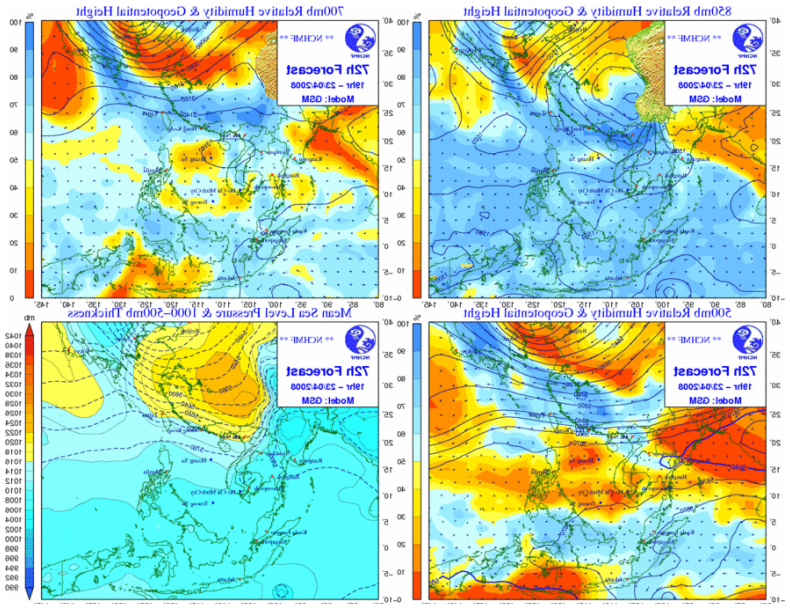


Figure 8.1 Outputs from the Global Spectral Model (GSM)

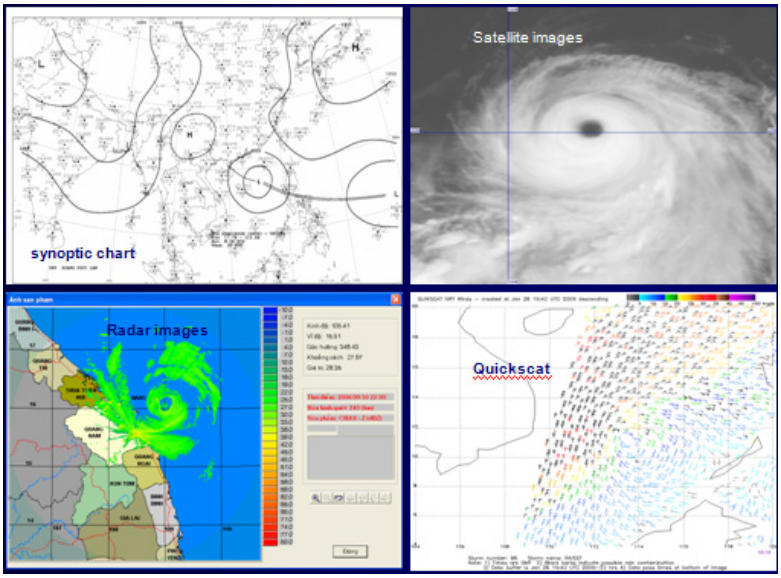


Figure 8.2 TC eye fixing

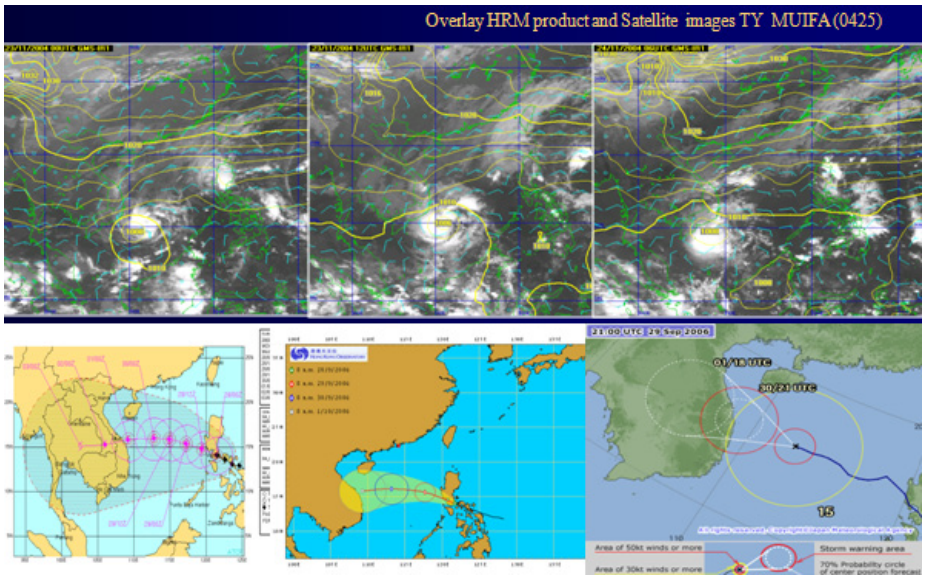


Figure 8.3 Tools for TC track forecasting

The NHMS also have the following operational hydrological system:

- Short-range flood forecasts: conceptual and distributed models such as SSARR, TANK, NAM; FIRR model and MARINE model
- Medium range flood forecasts: The rainfall-Runoff model TANK (Japan) , regression and identify methods
- The Monthly flood forecasts: ARIMA model, similar method
- The Long-range flood forecasts: The historical flow process analysis, regression, objective statistics, similar method

  Sample outputs of the hydrologic models used by NHMS are shown in Figures 8.5.

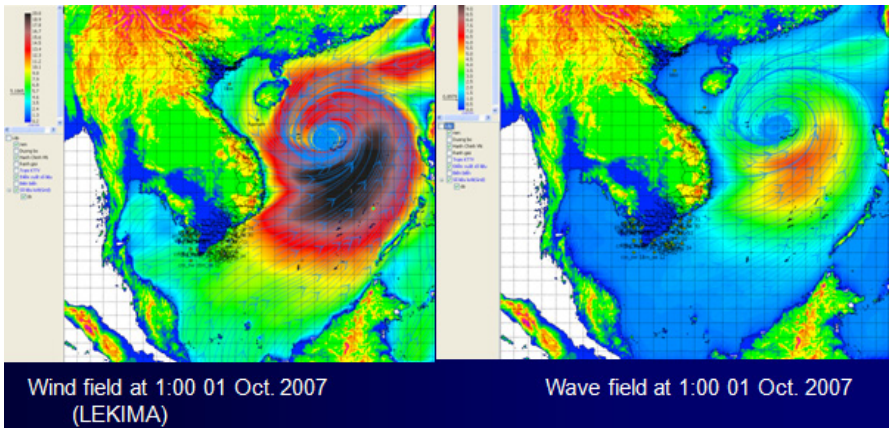


Figure 8.4 Wind field observed at 01UTC 01 October 2007 (left) and wave field at 01UTC 01 October 2007 (LEKIMA)

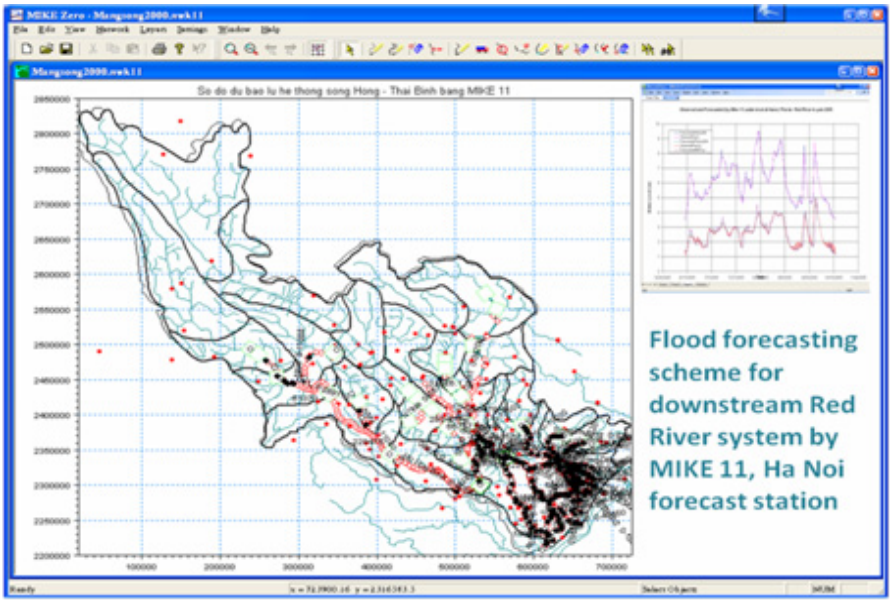


Figure 8.5 Flood forecasting scheme for downstream Red River system by MIKE 11, Ha Noi forecast station

8.3 Verification of NWP's

NWP Post-Processing is carried out by using UMOS + Kalman filter. Verification of NWP outputs is undertaken by NHMS.

8.4 Future plans

A new PC cluster will be purchased under the modernization project of NHMS for the period 2011-2012 (already approved by the Prime Minister) and this has the following features:

- 64 nodes
- Processor per node: 4
- Memory per node: 8 Gbytes
- Peak performance: 16 TFlops

A new global data: NCHMF purchases all NWP dataset (products and raw data) from ECMWF starting June 2011.

A new deterministic forecast system: Figure 8.6 shows the proposed NWP system based on WRF model which will be used to run the 4 domains as follows:

- *Region grid* (abbreviation of R) will cover graphical domain from 100S-500N; 650-1500E. The WRFARW model will be run with 12km resolution and up to 72 hours. The initial and boundary conditions can be from IFS (ECMWF) or GSM (JMA) global model (NHMS will purchase all products of ECMWF). The boundary condition updating cycle is 3 or 6 hours. The data assimilation system will be is 3DVAR with every 6 hour cycle. The local data is used for 3DVAR except for TCBOGUS source.
- *Viet Nam grid* (abbreviation of VN) will cover graphical domain from 00-300N; 950-1350E. The WRFARW model will be run with 4km resolution and up to 48 hour. The initial and boundary conditions is get from analysis and forecast of R grid (nesting one way). The boundary condition updating cycle is 3 hours. The data assimilation system to be used is one of following scheme (3DVAR/4DVAR/EnKF) with every 6 hour cycle. The local data is used for data assimilation system except for TCBOGUS source and along with humidity data from analysis of cloud based on LAPS scheme (this scheme is being used in Hong Kong Observatory).
- *City grid* (abbreviation of C) has an integrated domain depending on the size of the city for now casting. The WRFARW model will be run with 2km resolution and up to 12 hour. The initial and boundary conditions will be taken from analysis and forecast of VN grid (nest ing one way). The boundary condition updating cycle is 1 hour. The data assimilation system will be used is one of following scheme (3DVAR/4DVAR/EnKF) with every 3 hour cycle. The local data is used for data assimilation system except for TCBOGUS source and along with humidity data from analysis of cloud based on LAPS scheme. In case computing resources will not be sufficient, the forecast for this domain will be derived from VN grid by applying dynamic downscaling method.
- *TC grid* (abbreviation of TC) will cover a domain has size of 100 x 100 with the present TC center locate at domain center. The HWRF model will be run with 12km or higher depending on computing resources and up to 72 hour. The initial and boundary conditions will come from IFS (ECMWF) or GSM (JMA) global model (NHMS will purchase all products of ECMWF). The boundary condition updating cycle is 3 hours. The data assimilation system will be used is 3DVAR with every 6 hour cycle. The local data is used for 3DVAR including TCBOGUS source. The integrating domain will move according to analyzed TC center with the same size (100 x 100).

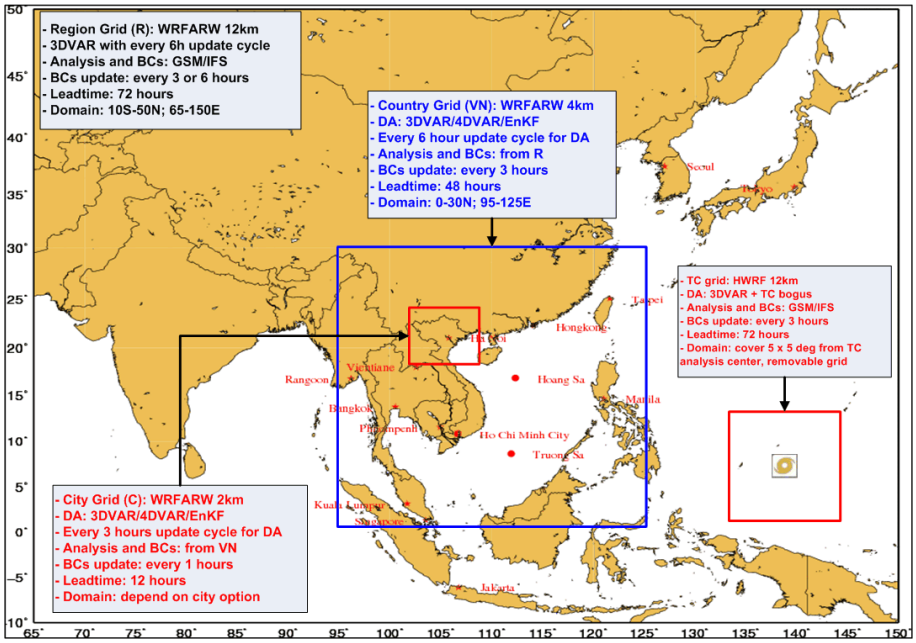


Figure 8.6 Proposed NWP system which will be used to run the 4 domains

9 INFORMATION AND COMMUNICATION TECHNOLOGY

9.1 Communication facilities

A telecommunication system has been established at the Hydro-Meteorological Information Technology Centre (ITC) to collect local hydrometeorological data and for international data exchange through the GTS.

The domestic telecommunication system uses a combination of radio, telephone, computer network, and VSAT to collect hydrometeorological information and data from localities to ITC and transmission of information and forecast from NCHMF to Regional Hydro-Meteorological Centres and to Hydro-Meteorological Forecast and Services Station in every province. The high resolution satellite pictures and radar data are also transmitted between NCHMF and localities in the same manner.

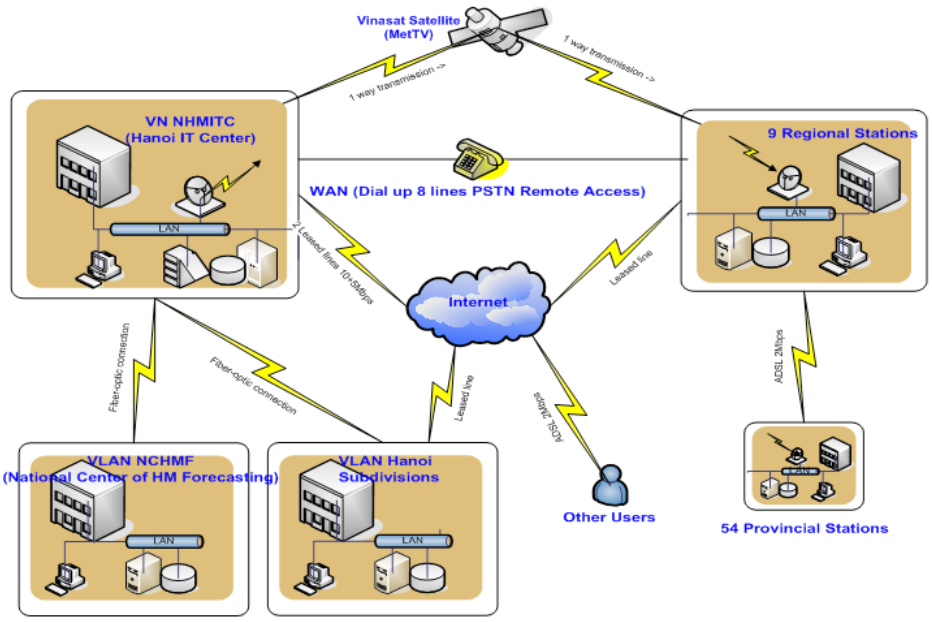


Figure 9.1 NHMS's Communication network

The MONRE has initiated some improvements in the telecommunication system by constructing two wireless aerial scouting stations in the cities of Vinh and Dien Bien, which guarantees a fast connection between the central and local hydrometeorological centres.

Being aware of the importance of information technology in the operations of the NCHMF, the Hydro-Meteorological Information Technology Centre was established in 2009 with the main function of managing, building, and developing information system for hydrometeorological services.

9.2 Data management

9.2.1 Database and archives

Current database: Meteo-Hydrological Data Archival and Retrieval System (MHDARS)

Observation data flow: very fragmented and complex. It is recommended that detailed map of data should include the following: transferred observations/ parameters and their formats, schedules, units and departments, computer names or IP-numbers, used protocols or communication methods and description of data storage and usage at each level.

Receipt of observed data is insufficient, mainly for Temp, Synop and Pilot data.

Storage system remains manual (decoded in file and stored in CD).

Data management and its utilization to support forecasters are not optimal; data management system needs to be upgraded.

9.2.2 Quality monitoring of collected data

The NHMS do not yet have a real-time quality control system for data from AWS and manned stations. However, a non real-time quality control system for data is already implemented in all stations.

9.2.3 Data rescue

Hydrometeorological data rescue in Viet Nam began in 2002 under Document No. 258/KTTV-HTQT on 23 April 2002 by Viet Nam Hydro-Meteorological Service on the implementation of Data Rescue Projects by international sponsors (NOAA, World Meteorological Organization). The Hydro-Meteorological Data Centre (HMDC) has rescued meteorological data delivered by the French Republic in 1986, including:

- Meteorological data reports for the period 1867-1925 with 6486 pages of 32 stations, equivalent to 6486 image file format .Jpg, recorded on 7 CDROM.
- Documentation of meteorological "original observation" for the period 1950-1954 with 18,192 pages of data capture sheet A3-size paper of 12 stations, equivalent to 18,192 image file format .Jpg, recorded on 9 CDROM. All data are kept at HMDC.

From the types of hydrometeorological data that NHMS keep, the data rescue program was focused on rainfall. The project on "Building hydrometeorological database" is under a big program of MONRE “Building National Database of natural resources and environment”.

Currently, there are daily rainfall data (obtained from rainfall at 7h and 19h), hourly rainfall data (taken from rainfall charts). There are no available rainfall data for shorter time intervals (5 minutes, 10 minutes, 30 minutes, 45 minutes), or longer, because all rainfall charts are not yet digitized. In the archives of the NHMS, rainfall data constitute a relatively large volume. As of 2008, the total number of stations with rainfall recorder are about 203 stations (170 stations are operational), with average time series of 35 years (some stations has more than 50 years of record). The total chart sheet is about 130,000.

The initial activity of the project is to save all charts by scanning or digital photography. Products will be stored in the storage center for convenient access, utilization, and sharing; the second is digitizing these rainfall charts and create rainfall data set.

The NHMS is collaborating with KMA through KOICA on several projects which include data rescue.

9.3 IT infrastructure

In terms of IT-Network analysis, there is no common country-wide network at NHMS and even in Hanoi area, separate networks are being used. Most often, the regional centres cannot directly access or link with the Headquarters or vice versa. As a result of the current situation, cooperation and data transfer between centres or units is a major challenge.

Considering the present status of its IT infrastructure, the NHMS need to develop a common unified internal, agency-wide network to improve the basic IT-network services (DNS, DHCP) through the creation of a plan for network development and infrastructure management. Coupled with this is the introduction of an IT-team or department that has responsibility of the entire IT network and services at all levels.

Networking infrastructure: LAN, WAN, internet access, routers, firewalls, switches (100/1000).

Internet connections:

- In the Hydrometeorology Information Technology Centre there are two internet leased lines with speed of 5Mbps and with 2Mbps for the backup.
- In Regional Hydro-Meteorological stations,there is one internet leased line with speed of 2 Mbps
- In Provincial Hydro-Meteorological Stations, there is one internet ADSL line with speed of 2 Mbps

Mail server: equipped with free mail server, but only limited to 50 accounts.

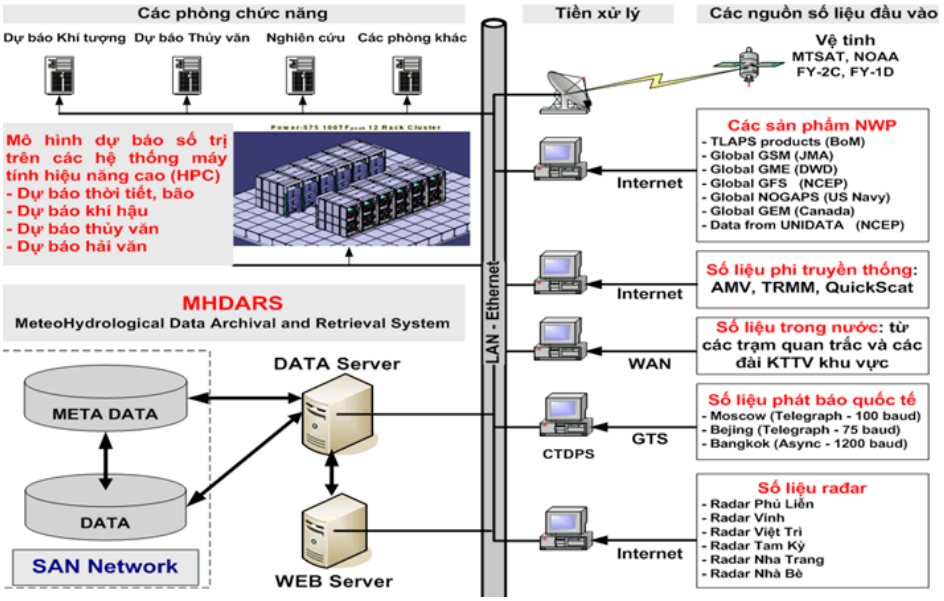


Figure 9.2 IT infrastructure of NHMS

9.4 IT Personnel

The IT staff is responsible for PC help desk, operation of the main computers, communication, and other IT related matters.

At present, the Hydro-Meteorological Information Technology Centre only have 20 personnel, 10 among these are technicians. Thus, the management, development, and operation and maintenance of IT system encountered many difficulties.

Figure 9.3 NHMS computing system

9.5 Needs to improve communication system and data management

- Develop data base and data management system
- Upgrade telecommunication backbone
- Develop real-time data quality control system
- Upgrade disk storage and back-up system
- Digitization of historical data
- Upgrade the IT infrastructure (software and hardware)
- Increase level of automation
- Increase number of real-time data
- Develop user-friendly data management and information system
- Training of IT staff

10 NATIONAL AND INTERNATIONAL COOPERATION AND DATA SHARING

10.1 National

NHMS shares information via the internet through its webpage, the telephone/mobile phone/SSB radio, WAN and MetTV. Hydrometeorological data can also be made available by request.

10.2 International

In terms of network system, Viet Nam has upgraded its international data transmission channels for data exchange through GTS that includes:

- 2 leased lines with speed of 64Kbps to Bangkok and Beijing
- 2 links through Internet (FTP/IP) to Beijing and Moscow

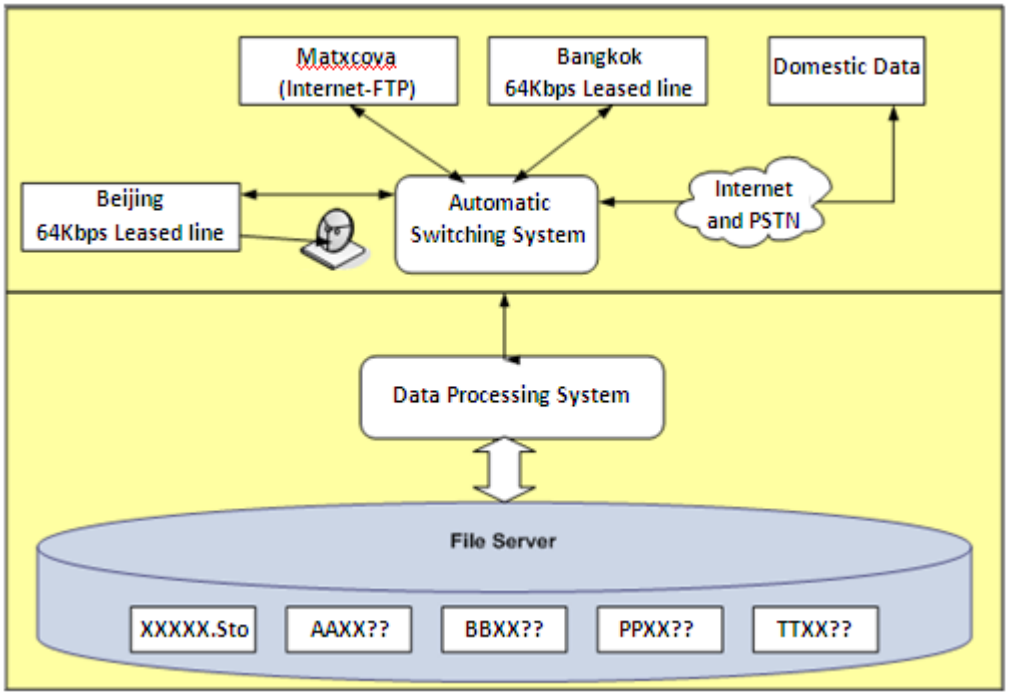
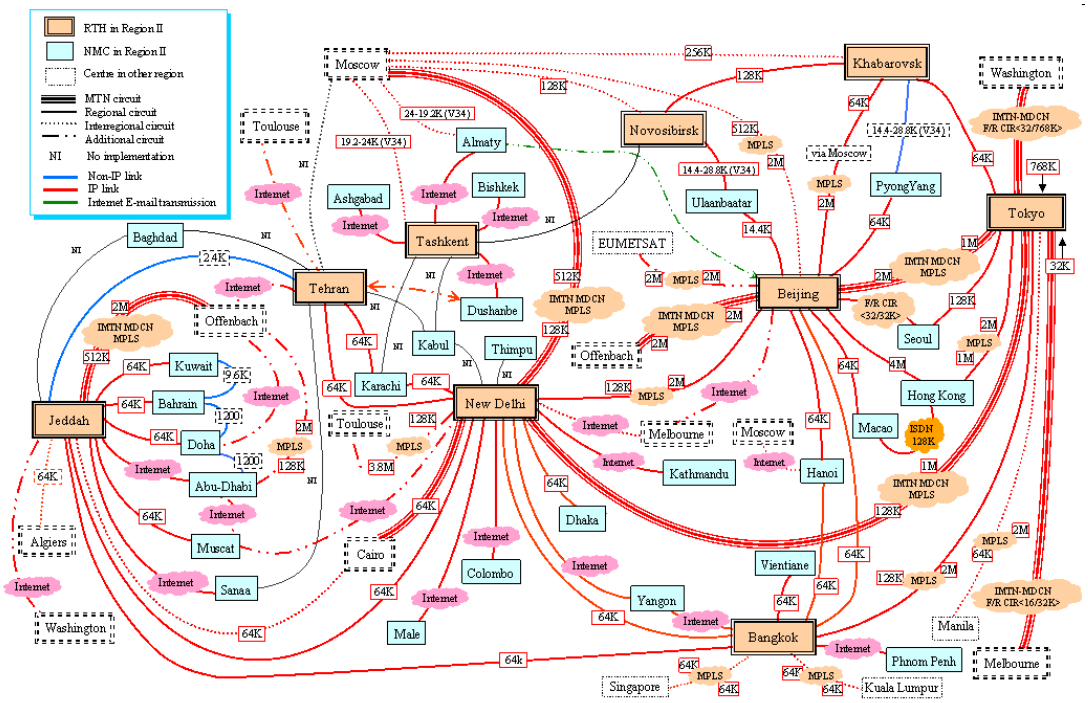


Figure 10.1 Viet Nam NHMS's GTS system

In terms of data deployment applications, Viet Nam has implemented the most recent project which is to build Data Processing System under binary code format of the WMO, which includes:

- Standardization of data under binary format from Provincial Hydro-Meteorological Centre and Regional Hydro-Meteorological Centre to Hydro-Meteorological Information Technology Centre for data collection for use in forecasting;
- Design and establishment of domestic and international observation data storage system for hydrometeorology;
- Build shared software to support technicians in collection, pre-processing data before transferring to Hydro-Meteorology Information Technology Centre of Provincial and Regional Hydrometeorology Centres;
- Install server for the system to ensure high data processing speed in Central Hydro-Meteorology Forecasting Centre;
- Equip devices to set up VPN network information channel and GTS system to connect and exchange data with member countries of WMO;
- Training on transfer of software products to various units;
- Build systems of software modules to automatically process received data from GTS and internet for use in forecasting operation at the Central Hydro-Meteorology Forecasting Centre; and
- Build software modules to transfer traditional observation data to standard format of binary code of WMO and vice versa for international data exchange and archiving including Temp, Synop, and Pilot data.



Regional Meteorological Telecommunication Network for Region II (Asia)
Current status as of 14 August 2009

http://www.jma.go.jp/jma/jma-eng/jma-center/rth/common/RA2-RMTN-Status_14Aug2009.gif

Figure 10.2 Data Exchange via WMO's GTS in Region II (Asia)

In order to be compliant with the WMO Information System (WIS), the NMHS needs foreign support in reception and international data exchange, including the following:

- Support on software to use all data received through GTS;
- Build data management system to support forecasters;
- Support from international experts on system development and training of IT personnel.

11 RECENT DEVELOPMENT PLANS PROPOSED BY VIET NAM

The Vietnamese Government's main strategy for development comprises the 10-year Social Economic Development Strategy (SEDS) and the 5-year Socio-Economic Development Plan (SEDP). This five-year plan is based on extensive and fully participatory consultations about the country's development goals with local people, civil society groups, academe, private sector organizations and other stakeholders inside and outside government. It is designed around four "pillars" that define the country's future reform agenda: structural reform, social inclusion, environmental sustainability, and good governance. As one of the most important documents of the Government of Viet Nam, each SEDP provides a framework and directions for different ministries and sectors to develop their own plans of actions and annual plans. In 2010 the Government prepared the Socio-Economic Development Plan for 2011-2015 and the Social Economic Development Strategy for 2011-2020.

Based on SEDP, the five year plan for 2006-2010 for Natural Resources and Environment Sector was developed by MONRE. Under the promotion of basic survey, serving effective management and sustainable use of natural resources, a national water resources database is being established. For hydrometeorology, the following activities are being undertaken:

- Maintain stable operation of hydrometeorological network in the whole country. Regular and timely collection of hydrometeorological information is undertaken to support the economic sectors. Since 2003, information networks of hydrometeorological forecasts have connected all provincial hydrometeorological centres with the Central Hydro-Meteorological Forecasting Centre.

- The operation of the hydrometeorological network in the country is being enhanced using digital technology which is also contributing to the accuracy of the forecast, with the use of modern monitoring equipment such as satellite cloud images and weather radar being applied to forecast storms, cold air, rain, and other hazardous weather phenomenon.

- Quality of hydrometeorological forecasting has been significantly enhanced to address the increasing requirements in calamity prevention and socio-economic development. Ensure timely and accurate forecasting of hazardous weather phenomena such as storm, flood, cold air, very cold period, hot sunlight, and drought in order to meet the requirements of socio-economic development and damage prevention and reduction.

- Documentation has been modernized for information management and storage, including software and databases, in line with characteristics of the weather in Viet Nam.

- International initiatives have attracted bilateral and multilateral aid sources to enhance capacity and modernize the monitoring network, early incident warning and enhance hydrometeorology staff skill. MONRE is the national focal point for the UNFCCC and Kyoto protocols on CDM; the Vienna Convention on Ozone Protection and the Montreal Protocol on ODS.

An assessment of the Five Year Plan showed some weaknesses and shortcomings, which include: the Legal systems for land, water, and mineral resources have been issued but some are inconsistent and incomplete, and the implementation of law is slow.

Scientific and technological R&D development, application and equipment renovation is limited in terms of quality and effectiveness; Base surveys have not been comprehensively and effectively implemented and do not meet requirements on information and data sharing and exchange, previous survey data has not been updated and rectified, and proper management of data is not followed. Remaining activities in the past 5 years are carried over in the NRE Five Year Plan (2011 – 2015). The targets set by MONRE in the field of hydrometeorology from 2011 to 2020 are as follows:

- Strengthening capacity for NRE state management agencies from central to local levels, and other political and social organizations;
- Promotion of training and development of human resources;
- Development of Science and Technology;
  - Improve on technology and apply scientific improvements in undertaking base surveys; improve the quality of investigation, monitoring and forecasting, in which marine areas will be considered, to assist plans on socio-economic development and defense or security issues.
- Strengthening of facilities and equipment
  - Prepare Plan for NHMS monitoring network in line with proposal of the national NRE monitoring network development until 2020;
  - Renovate the technical facilities for NHMS management: Upgrade equipment for investigation, survey and monitoring of hydrometeorology, mapping and survey toward using digital technology;
  - Upgrade technology and apply advanced science: strengthen technology application leading to rapid implementation of base surveys; modernize the NHMS to meet requirements of industrialization and modernization of the country, such that the level of scientific technology of Viet Nam will be equal to that of the advanced countries in Southeast Asia;
  - Strengthen the information, communication system capability of NHMS: NHMS newsletter or bulletin, scientific periodicals/ publication, electronic information network (internet, intranet, and website).
- Enhance the participation of the community in making management decisions and on financial status
  - Train and improve public awareness on NHMS; and
  - Prepare promotional material and procedures.
- Enhance international cooperation for NHMS development and improvement
  - Maintain and develop partnership and collaboration among associations in which Viet Nam is a member, such as ASEAN, WMO, RIMES, and others.

There are several initiatives of the NHMS, DM-HCC and IMHEN geared towards enhancing the capabilities of the meteorological and hydrological services in Viet Nam. These initiatives are in line with Decision 16/2007/QD-TTg (projection up to 2020) and the Viet Nam Meteorological and Hydrological Development Strategy up to 2020 which is part of the National Target Programme to respond to climate change and the National Strategy on Disaster Prevention, Preparedness and Mitigation. The activities in the implementation of Decision 16/2007/QD-TTg are in line with MONRE's Five Year Plan and include the following targets:

- Surface meteorological station: 231
- Rain gauge site: 1000
- Hydrological station: 344
- Marine meteorological station: 35
- Radiosonde: 11
- Weather radar: 15

- Optical upper air wind measurement: 11
- Ozone and UV station: 4
- Agro-meteorological station: 79
- Air and water monitoring site/station: 193
- Salinity measurement site: 141

Starting from 2007 some small but urgent projects have been implemented in conjunction with the recent development plans to automate and modernize the meteorological and hydrological services. Among the projects that were undertaken by the NMHS from 2007 to 2009 include:

- Upgrading and providing new wind and air pressure equipment for 74 meteorological and hydrological stations along the coast;
- Re-establishment of 2 radiosonde stations (Dien Bien and Vinh);
- Upgrading/building 18 marine hydrometeorological stations;
- Upgrading 2 radar stations in Tam Ky and Phu Lien;
- Building 3 new weather radar stations in Son La, Dong Ha and Quy Nhon;
- Upgrading NOAA satellite receiving and processing station;
- Providing equipment and upgrading of computing facilities for the Central Hydro-Meteorological Forecasting Centre;
- Upgrading of telecommunication system from central to local levels;
- Improving forecasting technology (increasing TC forecast lead time from 24 to 48 hours and 72 hours);
- Enhancement of products and services; and
- Transfer of specialized forecast technology to regional and provincial centres.

The DMHCC has also formulated the "Modernization of forecast technology and hydrometeorological observation network for the period 2010-2012" under its climate change program: The project cost is US$100 Million which includes the following components:

- Forecast system using numerical model, for marine, hydrological/flood and meteorological forecast, including nowcasting;
- Rainfall and flood forecast technology for reservoir operation;
- Network of 412 auto rainfall stations for the whole country, supporting accurate and necessary information for flood and flash flood forecast and warning;
- A network of 127 AWS in the north area in support of NWP;
- 25 gauging stations in the Red river system with automatic water level and raingauge equipment; 19 water level gauging stations of the Da, Thao and Lo river system to be replaced with new equipment to provide data for improved flood forecast for the northern river systems;
- 5 radar weather stations, 2 radio-sonde observation stations;
- Operation, maintenance and of weather radars the radar image compositing;
- 61 automatic wind measuring equipment of the stations located along the coastal line, islands installed with automatic data transmission equipment for strengthening of tropical cyclone and storm surge forecast capability; and
- Equipment (server, PC, printer, network equipment and peripherals), and technology to ensure the collection and quick analysis/assessment of data and information, automatic network management of all the provincial hydrometeorological centres, regional hydrometeorological and the ministry level management agencies.

Listed in Table 11.1 are the on-going and proposed projects to improve NHMS.

Table 11.1 Recently completed or existing projects of Viet Nam NHMS

Title of Project	Project Duration	Project Cost/ Donor Brief	Description/Objectives
Strengthening flood forecasting and warning capability for Mekong river delta		World Bank	• Upgrading of 14 surface meteorological stations; • Upgrading of 18 hydrological stations; • Modernizing equipment for measuring overflow 5 flood routes; • Upgrading of 132 in-field water level sites; and • Building of 8 provincial hydrometeorological centres
Strengthening flood forecasting system for central Viet Nam provinces		Italian ODA	Providing equipment for 74 stations which include 31 new stations; 16 met stations; 43 hydro stations and 15 new raingauges Strengthening computing facilities for 6 local forecasting centres Establishment of specialized link from stations to forecasting centres Building infrastructure for 34 stations
Modernization of observation and forecasting systems	2010-2012		• Modernization and automation of observation network (338 raingauges, 22 salinity sites); Pilot network for very short range forecasting for Red river Delta (100 AWS, 46 raingauges; 18 water level gauges); 4 weather radars: Vinh, Viet Tri, Nha Trang (upgrading) & Pleiku (new); 2 new radiosondes (Ca Mau & Cam Ranh); Computing facilities in local centres • Strengthening telecommunication, data processing & archiving • setting up hydrometeorological forecasting system and applying very short range forecast technology – data assimilation, high resolution LAM, software, etc.
Modernization efforts to realize Decision 16	15.423M US$	ITALIAN ODA-2	• 245 automated stations: 38 AWS, 2 marine met stations, 53 hydrological stations, 152 raingauges • Upgrading 6 provincial centres, 02 regional centres
Modernization efforts to realize Decision 16		JICA Grant	2 new S-band radars + 3 display units; GTS MSS in Hanoi; 1 Wind profiler; 26 AWOS; 18 rain gauges, data transmission through GSM; VSAT communication system
Digitalization and establishment of data base for medium and long range weather forecasts	223,000 US$ (12 mos.)	KOICA	To contribute to strengthening weather forecasting capacity of the Central Hydro-Met. Forecasting Centre
Rainfall chart rescue and creation of short time – interval rainfall data set in Viet Nam	3 years (2011-2013) Cost: 2M US$ (ODA:1.5M US$, Local: 0.5M US$)	KOICA	Rescue of climate data of rainfall from charts of weather surface station;Digitizing rainfall charts and creating short time-interval rainfall data set; Strengthening capacity in processing, storage, integration and analysis of short time-interval rainfall data; and Training of technical staff.
Joint Research Project for the Development of a Typhoon Forecast System Using Multi-Model Ensemble	2010 to 2012	Global Environment Division (GED) of Keimyung University (Korea)	Establish a typhoon analysis and prediction system at NCHMF based on the Typhoon Analysis and Prediction System – 2 (TAPS-2); Enhance the typhoon forecast system using multi-model ensemble; and - Strengthen the relationship between both Sides in the field of typhoon forecast and related DRR activities

The DMHCC has also prepared a proposal on Developing GIS Database System in support to the management of national activities in meteorology, hydrology and climate change. The project includes software development, acquisition of hardware, workstations and GIS software, training of personnel. Estimated cost is US$3 million.

Under the Global Facility for Disaster Reduction and Recovery (GFDRR), the World Bank is considering for funding an action plan for the “Strengthening of the Hydrological and Meteorological Capability of Viet Nam” which include the following priority activities:

- Review the meteorological and hydrological observational networks, data collection, processing and information dissemination systems;
- Based on identified gaps, establish requirements for effective meteorological and hydrological monitoring, forecasting and end-to-end warning system and service delivery, at the same time addressing hazard management and climate change needs;
- Review and develop institutional arrangements to support a sustainable level of service;
- Implement institutional and sustainable service arrangements;
- Design and implement system tools to support regular meteorological and hydrological monitoring, forecasting, end-to-end warning and effective service delivery;
- Enhance the climate database and operational systems for effective climate change monitoring, prediction and evaluation; and
- Identify skills gap and assist through training and capacity building.

The implementing agencies are MONRE, DMHCC and the National Centre of Hydro-meteorology. The total project cost is US$15 million including program monitoring, evaluation and oversight.

In the May 2010 Viet Nam Innovation Day competition organized by the MONRE, the Youth Union, and the World Bank, on the theme of "Climate Change" awarded 30 community projects with total costs above US$ 415,000. The innovative ideas were designed to scale up efforts to respond to climate change, from the mountainous areas to delta, from urban to rural areas, and reflected the willingness of civil society and local communities to partner with Government in finding solutions to climate change and its impacts.

The government has also sought additional financing from the World Bank for post-disaster reconstruction support under the Viet Nam Natural Disaster Risk Management Project. The additional credit will scale up the current project by helping: (a) fill a substantial post-disaster reconstruction financing gap in the wake of two recent storms, storm Ketsana and storm Mirinae; and (b) further anticipated short-term reconstruction financing gaps resulting from future major natural disasters in Viet Nam.

SUMMARY 12

Despite the efforts of NMHS to upgrade its facilities, enhance capacity building of staff, and strengthen R&D activities, there are still institutional capacities and gaps (Table 12.1) that need to be addressed to be able to fulfil its mandate and improve its services for disaster management and EWS stakeholders.

Table 12.1 Institutional capacities, gaps and needs of Viet Nam NHMS

Issues	Institutional Capacities	Gaps & Needs
Data products	Synoptic data, climate data, METAR, SPECI, SIGMET, TAFOR, ROFOR, satellite, radar, AWS, air quality (O3, SO2, NO2, SPM, rain water acidity), lightning, earthquake, gravity, geomagnetic, time standard/almanac,	- Digitization and recovery of historical climate data is urgently needed - High performance Data Quality Management system to support NWP system - Integrated database system for NWP data assimilation - Reliable and low-cost observation data communication needed for efficiency
Hazard analysis to support risk assessment	Provide expert in disaster mitigation (still limited number)	- Sufficient number of expert in disaster mitigation and risk assessment - Applied R&D products to for domestic weather and climate forecasting still relatively limited
Forecasts and warnings	- Daily and 5-day weather forecast , monthly and seasonal outlooks for 24 key cities and provinces - Severe weather forecasts and for inclement weather such as tropical cyclones and cold surges, flood forecast, climate forecast - Tsunami warning, earthquake information - Air and water quality forecasts	- High performance NWP assimilation system needed - Radar and satellite data assimilation and r remote sensing-based observation product development - Development of human resources in weather and climate modeling (NWP and climate models)
EWS expertise and advisory service	Has a number of meteorologists/hydrologists at the headquarters regional and local offices supporting EWS and advisory services	Continuous upgrading of the skills of NHMS's operational staffs to utilize and manage the latest technology, instruments, and systems

Cooperation with other technical agencies	National level: - Various Ministries: MARD, Health, Transport, Communication and Culture, Labour and Social Welfare, MONRE Local/provincial governments Universities: - Ha Noi and Ho Chi Minh Natural resources and environment, Ha Noi Water Resources University, Ha Noi University	International level : - NOAA-NWS, USA - Ministry of Earth Science, India (India Met Dept) - ASEAN's SCMG - Meteo France - GTZ Germany - KOICA Korea - JICA Japan - JMA Japan	
Dissemination mechanisms Principles	Online, Printed, Voice, Multimedia		
Means	Telephone, cellular phone, facsimile, internet (e-mail/ website), television, radio, newspaper, public space online display, siren		
Communication and media	State and private TVs, radios, newspapers, internet website, mobile phone providers		Need to enhance linkage/collaboration w/ the media

The following table summarizes the rating of different activities and services of the NHMS:

Table 12.2 Evaluation of level of different skills of NHMS
5= excellent, 4= good, 3= moderate, 2= poor, 1= very bad

	Score	Remarks
Forecasts and services for disaster reduction	3	Too technical; Need to develop user-friendly forecasts
Data sharing/GTS 4 Networking to Asian hydromet organizations	3	Viet Nam has implemented the most recent project under binary code format of the World Meteorology Organization, however, it needs support on software to use all data received through GTS.
International cooperation	4	
Weather forecast	3	Need to “laymanize” the forecast
Number of WF products	4	
NWP	4	
Hydrological forecast	4	
Agrometeorological services	2	Need to enhance linkage with other sectors in order to address the needs of agriculture
Automated processing and visualization	3	Need to acquire a visualization tool of its forecasts
Climate Change	4	Support from DMHCC and IMHEN
Support of R&D to main lines	4	Strong support from IMHEN
Surface synoptic network	3	Data in most stations are observed manually.
Upper-air data	3	Need to put up 8 additional radars
Radar data	3	Data not yet fully used for operational purposes
Lightning detection	2	With the increasing frequency of lightning events, need to put up lightning detection network
Hydrological Observation network	3	Some projects are ongoing to increase the automation of the network
Environmental observation	4	
Maintenance and calibration	3	Need more budget for maintenance and calibration
Communication system	2	The main telecommunication system for data collection and transmission needs upgrading.
Data management	2	The technology for recording rainfall is outdated and often leads to incorrect flood forecasts.
Webpage	3	Need to translate some products to English
Human resources	3	Recruitment of more IT personnel in conjunction with the automation program
Level of education of staff	3	Needs to increase the number of staff with post graduate courses
Training programme	3	More training is needed in technical fields
Management	4	
Organization	3	The NHMS has a robust organization based on the recent reorganization to keep up with the changing trends in technology; organization is stable.
Competitiveness	3	With the ongoing improvement of its products and services, the NHMS will become very competitive with the other hydromet services in the region.
Public visibility	3	The NHMS has high public visibility mostly during the occurrence of severe weather disturbances which has to be sustained even during off-season months.

Public appreciation	2	More public education drive both at the national and local levels
Customer orientation	2	Some clients still get weather information from other centres
Cooperation with media	2	One of the immediate priorities is to educate the media.
Market position	3	The NHMS needs to push through with its commercialization program to gain better market position.
Foreseen possibilities for sustainable development	4	With the significant support of the MONRE, efforts to improve the NHMS can be sustained.
Total score	101	

RECOMMENDATIONS TO STRENGTHEN THE HYDROMETEOROLOGICAL SERVICES 13

The following needs to be undertaken to strengthen and improve the delivery of hydrometeorological services in order to address the needs of the various socio-economic sectors in Viet Nam:

- Increase density of monitoring stations
- Improve data assimilation and data quality control
- Increase computing facility
- Upgrade telecommunication system
- Increase automation of observation and data transmission
- Develop user-friendly information system
- Adopt state-of the-art data processing and storage techniques and tools
- Develop tailor-made forecasts
- Enhance marine meteorological forecasts
- Develop more accurate forecasts and warnings on significant phenomena such as typhoons, storm surges, and floods
- Dense data resources for regional data assimilation system
- Upgrade calibration facilities
- Strengthen material-technical base for forecasting operations
- Strengthen coordination mechanism among NHMS units and with other relevant agencies outside NHMS
- Improve the management system of meteorological and hydrological data to meet the needs of economic activities, scientific research and others
- Strengthen the material technical base for hydrometeorological documentation
- Improve application of satellite and radar images in hydrometeorological forecasting
- Enhance capacities of human resources through trainings and postgraduate programs
- Promote cooperation and data sharing with Cambodia, Lao PDR and Thailand to access upper air and radar data
- Strengthen collaboration with members of the Mekong River Basin Authority
- Enhance collaboration with the media by providing training on hydromet hazards
- Promote the implementation of integrated water resources management
- Promote the role of NHMS as lead agency in early warning
- Promote the use of hydrometeorological data for R&D and the application of research products for the improvement of its services
- Implement WMO information system
- Utilize state-of the-art visualization and editing tools
- Establish an early warning system for hydrometeorological hazards for Indochina
- Implement commercialization to generate funds for repair and maintenance
- Strengthen collaboration with Viet Nam Red Cross

14 PROJECT PROPOSAL

This project proposal is developed in order to enhance the capability of the NMHS to address the requirements for preparing and producing various products and delivering the services that will address the national needs of key economic sectors that need such products and services.

The proposal requires funding support from the government as well as foreign donors to implement the various projects formulated by the NHMS, DMHCC and IMHEN. All of these projects are geared towards the modernization of the NMHS which include the enhancement of observation network, increasing the level of automation of forecast systems, upgrading of telecommunication facilities, and training of technical staff in order to come up with improved products and services.

The NHMS of Viet Nam is in the best position among the countries in Indochina to serve as the hub for sharing of hydrometeorological data and information to Lao PDR and Cambodia. Having the edge in technology and resources, the NHMS has earlier initiated some data sharing arrangements with Lao PDR and Cambodia.

The project proposal was formulated considering the on-going initiatives of the NMHS, IMHEN and DMHHC. It considers two options: a) Stand alone and b) Regional collaboration. The project will be implemented over a period of 5 years. A summary of the items covered under the Regional option is shown below:

14.1 International cooperation

Activity: International cooperation and networking
Proposed budget: US$100,000

14.2 Communication systems

Activity: Upgrade existing communication system
Proposed budget:
- Hardware & software: US$1,500,000

14.3 IT Centre

Activity: Upgrade IT Centre
Proposed budget:
- Hardware = US$150,000
- Consultancy and training = US$ 100,000

Implementation responsibilities: consultant on turnkey basis

14.4 Data management

Activity: Improve data management
Proposed budget:
- Hardware = US$150,000
- Storage = US$120,000
- Consultancy and training = US$50,000

14.5 GIS Database system for DMHCC

Activity: Improve data management system
Proposed budget: US$3,000,000

14.6 Meteorological observation network

Activities: To increase the density of monitoring network
Proposed budget:
- 608 automatic rainfall stations = US$ 4,073,600
- 245 automatic weather stations (P, T, U, ww, wd, G) = US$4,900,000
- 128 agrometeorological stations (conventional) = US$2,560,000

14.7 Hydrological stations

Activities: Install additional telemetered water level, rainfall and discharge stations
Proposed budget:
- automatic hydrological stations = US$3,586,000

Implementation responsibilities: consultant on turnkey basis
Includes: Red river basin

14.8 Maritime observation network

Activity: install new automatic maritime observation stations
Proposed budget:
- 6 marine buoys = US$3,600,000

Implementation responsibilities: consultant on turnkey basis

14.9 Remote sensing network

Activity: Aviation weather forecast and services and to improve NWP products which are the basis for the issuance of forecasts and warnings for significant weather events

Proposed budget:

- 9 upper air station= US$ 4,005,000
- 1 wind profiler= US$1,750,000
- 3 radars for upgrading= US$1,350,000
- 4 new weather radars including towers= US$8,000,000
- lightning detection= US$100,000

Implementation responsibilities: consultant on turnkey basis

14.10 Software tool for Visualizing and Editing of Meteorological Data

Activity: Acquire synergy for visualization and editing of data
Proposed budget= US$350,000; training= US$25,000
Implementation responsibilities: consultant on turnkey basis

14.11 Climate change

This is an activity of the DHMCC and IMHEN. The study of the impacts of climate change in Viet Nam using global models and downscaling to regional and local levels is carried out by the IMHEN. The PRECIS model was used in deriving climate change scenarios for Viet Nam.

14.12 Training

Capacity building include training of IT personnel, forecasters and middle management officials. Technicians and engineers in the headquarters and field offices should also undergo training to enhance their knowledge and skills in the operation and maintenance of modern equipment.

Proposed budget: Total = US$400,000

Table 14.1 Distribution of costs of the 5-year project for strengthening Viet Nam as a "Stand-alone" system (A) and based on Regional Cooperation (B)		
	A (US$)	B (US$)
International cooperation of experts	100,000	100,000
Communication systems		
- Hardware + software	1,500,000	1,500,000
IT Centre		
- Hardware	300,000	150,000
- Consultation and training	150,000	100,000
Data management		
- Hardware and installation	150,000	150,000
- Storage	120,000	120,000
- Consultation and training	100,000	50,000
GIS Database system for DMHCC	3,000,000	3,000,000
Meteorological observation network		
- automatic rainfall stations	4,073,600	4,073,600
- automatic weather stations	4,900,000	4,900,000
- agrometeorological stations	2,560,000	2,560,000
Hydrological observation network		
- automatic hydrological stations(1 river basin)	3,586,000	3,586,000
Maritime observation network		
- maritime observations	3,600,000	3,600,000
Remote sensing network		
- upper air stations	4,005,000	4,005,000
- wind profiler	1,750,000	1,750,000
- upgrade existing radars	1,350,000	1,350,000
- new radars including towers	12,000,000	8,000,000
- lightning detection	100,000	100,000
Forecasting and manufacturing tools		
- visualization system	350,000	350,000
- training	50,000	25,000
Training	600,000	400,000
Project management		
- consultant	600,000	300,000
- local project coordinator	240,000	120,000
Total	45,184,600	40,289,600

ANNEX 1

People met during the Mission

No	Name	Organization
1	Dr. Bui Van Duc, DG	National Hydro-Meteorological Service of Viet Nam
2	Dr. Nguyen Dai Khanh	
3	Ms. Do Quynh Hoa	
4	Ms. Nguyen Phuong Thanh	
5	Ms. Le Tu Anh	
6	Mr. Le Thanh Cong	
7	Mr. Tran Quang Ngoc	
8	Ms. Dao Thanh Thuy	
9	Mr. Le Ngoc Quyen	
10	Mr. Pham Viet Tien	
11	Mr. Nguyen Dinh Ky	
12	Mr. Le Thanh Hai	
13	Mr. Hoang Phuc Lam	
14	Mr. Vo Van Hoa	
15	Ms. Trinh Thu Phuong	
16	Mr. Bui Duc Long	
17	Mr. Nguyen Huu Hai	
18	Mr. Tran Lam.	Central Centre for Flood and StormControl, MARD
19	Mr. Tran Hiep	Central Centre for Flood and StormControl, MARD
20	Mr. Nguyen Thang Long	Institute of Tourism
21	Ms. Do Cam Tho	Institute of Tourism
22	Mr. Tran Vu Hiep	Central Centre for Flood and Storm Control, MARD
23	Ms. Bui Phuong loan	Search and Rescue Office
24	Mr. Hoang Ngan Giang	Search and Rescue Office
25	Mr. Bui Duc Son	Department of Hydro-Met and Climate Change, MONRE
26	Ms. Nguyen Thanh Huyen	Department of Health Preparation and Environment
27		Institute of Strategy and Policy for Health
28	Mr. Hoang Duc Loc	Department of International Cooperation, MONRE
29	Mr. Lam Thi Ha Bac	Department of Science – Technology, MONRE

No	Name	Organization
30	Mr. Tran Hun	People Newspaper
31	Mr. Hong Ninh	Viet Nam News
32	Mr. Duong Quoc Dung	Tien phong newspaper
33	Ms. Nhat Tan	Natural Resources and Environment Journal, MONRE
34	Ms. Pham Thu Ha	Science Hydro-Met Journal, NHMS
35	Mr. Tran Phuoc	VTC 9, Viet Nam Television
36	Mr. Phung Van Hoang	Red Cross Society of Viet Nam
37	Mr. Nguyen Huu Thang	Red Cross Society of Viet Nam
38	Mr. Nguyen Van Thang	
39	Mr. Ngo Sy Giai	Institute of Hydro-Met and Environment, MONRE
40	Mr. Nguyen Dang Mau	Institute of Hydro-Met and Environment, MONRE
41	Mr. Phan Huu Viet	Aviation Department
42	Mr. Hoang Trung Kien	Railway Department
43	Mr. Tran Van Tuan	Department of Water Resources, MONRE
44	Mr. Le Thu Huyen	Institute of Irrigation
45	Mr. Nguyen Van Giang	Institute of Irrigation
46	Mr. Nguyen Manh Hung	Department of Environment, MONRE
47	Mr. Nong Thanh Huyen	Voice of Viet Nam
48	Mr. Hoang Ngan Giang	Department of Irrigation
49	Mr. IAN Wilderspin	UNDP
50	Mr. Tran Quang	UNDP
51	Mr. Miguel Coulier	UNDP
52	Ms. Tran Thi Tu Anh	Department of Marine
53	Ms. Nguyen Ky Nam	MeKong River Commission
54	Mr. Le Nguyen Trung	Institute of Energy
55	Ms. Pham Minh Hoa	Institute of Energy
56	Ms. Thu Huyen	Institute of Transportation
57	Ms. Thanh Nga	Institute of Transportation
58	Mr. Le Dinh Cung	Committee/People

No	Name	Organization
59	Mr. Nguyen Binh Minh	Department of Forest
60	Ms Nguyen Thi Kim Dung	Department of Forest
61	Ms. Nguyen Thu Thao	Institute of Construction Economic
62	Mr. Nguyen Van Chuong	Institute of Construction Economic
63	Dr. Tran Thuc	Institute of Meteorology. Hydrology and Environment
64	Dr. Nguyen Van Thang	
65	Mr. Bao Thanh	
66	Dr. Dang Thi Hong Nga	
67	Dr. Hoang Duc Cuong	
68	Dr. Duong Van Kham	
69	Dr. Nguyen Van Liem	
70	Mr. Ngo Tien Giang	
71	Dr. Hoang Minh Tuyen	
72	Dr. Duong Hong Son	
73	Dr. Dinh Thai Hung	
74	Mr. Nguyen Xuan Hien	
75	Dr. Le Cong Thanh	Department of Meteorology, Hydrology and Climate Change
76	Ms. Nguyen Binh Minh	Department of Meteorology, Hydrology and Climate Change

ANNEX 2

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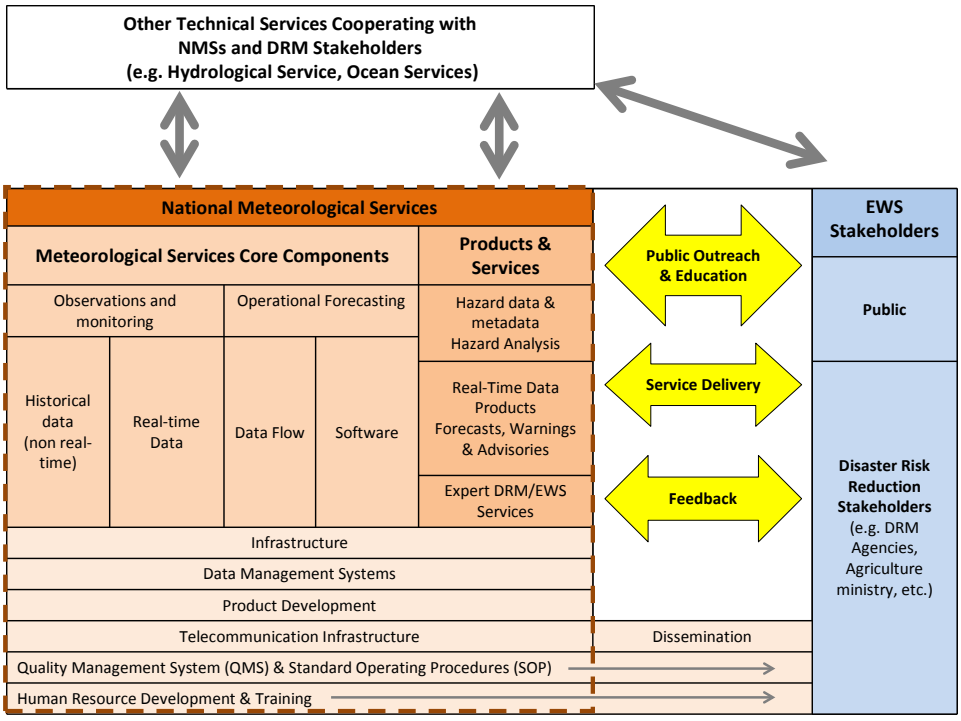
ANNEX 3

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.