COUNTRY ASSESSMENT REPORT FOR LAO PDR

Strengthening of Hydrometeorological Services in Southeast Asia

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Global Facility for Disaster Reduction and Recovery

ACKNOWLEDGMENTS

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

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

The Department of Meteorology and Hydrology (DMH) of Lao PDR supported the country assessment and coordinated the participation of various departments and ministries, including the Water Resources and Environment Administration (now Ministry of Natural Resources and Environment - MONRE), the Ministry of Agriculture and Forestry, Ministry of Public Work and Transport, Ministry of Health as well as the private sector. These agencies also reviewed the draft assessment report and its use within the context of the national consultation on the draft National Early Warning Strategy, organized by DMH and the World Bank Country Office in Lao PDR in February 2012.

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.

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ACRONYMS

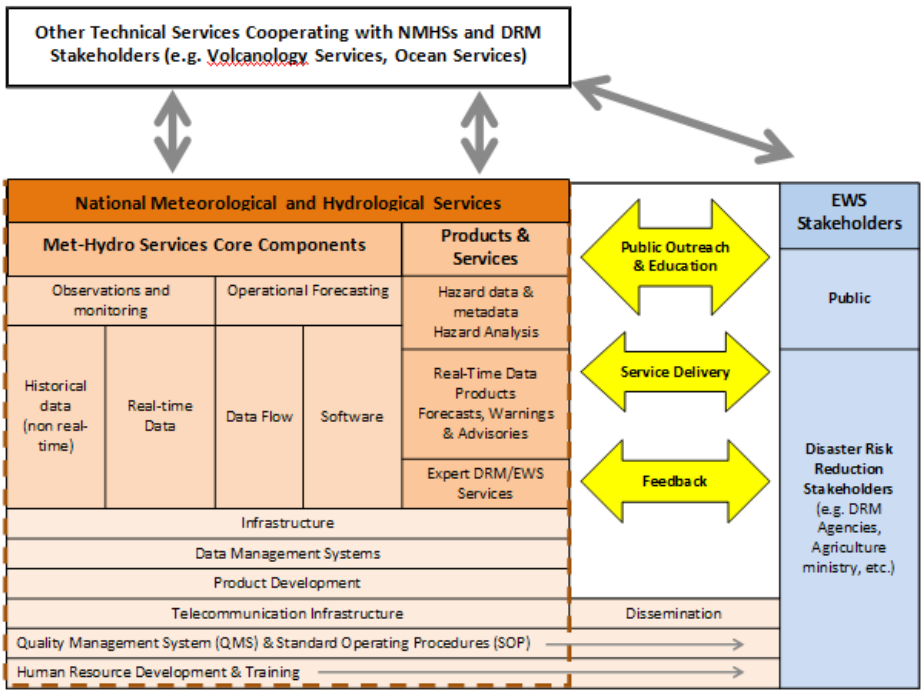
ADB	Asian Development Bank
AGL	Assurances Générales du Laos
ADPC	Asian Disaster Preparedness Centre
ASEAN	Association of South East Asian Nations
AusAID	Australian Agency for International Development
BCA	Benefit-Cost Analysis
DMC	Disaster Management Committee
DMH	Department of Meteorology and Hydrology (of Lao PDR)
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
ECMWF	European Center for Medium Range Weather Forecasting
EIA	Environmental Impact Assessment
ETL	Enterprise of Telecommunication of Laos
EWS	Early Warning System
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GFDRR	Global Facility for Disaster Reduction and Recovery
GTS	Global Telecommunication System
ICAO	International Civil Aviation Organization
IWRM	Integrated Water Resources Management
JICA	Japan International Cooperation Agency
JMA	Japan Meteorology Agency
KOICA	Korean International Cooperation Agency
Lao PDR	Lao People Democratic Republic
LNMC	Laos National Mekong Committee
MAF	Ministry of Agriculture and Forestry
MCTPC	Ministry of Communications, Transport, Post and Construction
MPWT	Ministry of Public Works and Transport
MRC	Mekong River Commission
MRC-HYCOS	Mekong River Commission Hydrological Cycle Observation System
NDMC	National Disaster Management (steering) Committee
NDMO	National Disaster Management Office
NESDP	National Socio-Economic Development Plan
NMHS	National Meteorology and Hydrology Services
NMS	National Meteorological Service
NSCCC	National Steering Committee on Climate Change
NWP	Numerical Weather Prediction
PDMC	Provincial Disaster Management Committee
RIMES	Regional Integrated Multi-Hazard Early Warning System for Africa and Asia
RTH	Regional Telecommunication Hub (assumed by Thailand Meteorological Department in Bangkok – RTH Bangkok)
TAFOR	Terminal Aerodrome Forecast
TMD	Thailand Meteorological Department
USAID	United States Agency for International Development
WB	The World Bank
WIS	WMO Information System
WMO	World Meteorological Organization
WREA	Water Resources and Environment Administration
WRERI	Water Resources and Environment Research Institute

The role of hydro-meteorological services

Weather and climate affect all kinds of human activities. Due to the serious impacts of recent weather and climate events in the region which affected economic and business operations, the various sectors in the country are beginning to demand for the improvement of increasing hydrometeorological products and services. The frequent occurrence and increasing severity of extreme weather and climate events in the country are seen as indications of a changing climate.

As climate change progresses with time, the impacts will exacerbate and will affect all sectors in unprecedented ways, particularly in areas where water is a limited resource. On the other hand, tropical cyclones can bring extreme rainfall resulting in catastrophic flooding. The attendant weather and climate extremes resulting to floods and droughts can considerably decrease agricultural productivity. Accelerated sea level rise due to global warming will expose more people to the risk of coastal flooding and also increase exposure to vector-borne infectious diseases that threaten human health. Moreover, tourism which is an important source of income in many countries will experience severe disruption due to sea level rise and frequent occurrence of extreme weather and climate events associated with climate variability and change.

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



Source : Golnaraghi, mgolnaraghi@wmo.int

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

To be able to address these demands, it is necessary and urgent to put in place or to enhance the very 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 numerical weather prediction;
4) human resource equipped with appropriate trainings; and
5) more interaction with users of weather and climate information.

The trans-boundary 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).

Assessment of needs of improved hydrometeorological services in Lao PDR

For generations, the people of Lao PDR especially those living in remote areas with no access to information and warnings have used traditional knowledge and beliefs to anticipate and cope with environmental hazards. Scientific weather forecasting was formalized in the country in 1955 with the establishment of the National Meteorological Service (NMS). The NMS was mandated to provide weather and climate-related services for the country. In 1976, the NMS received an additional mandate of providing operational hydrological work and it was accordingly renamed as the Department of Meteorology and Hydrology (DMH). Later in 1997, the DMH also took charge of earthquake monitoring activities. It also provides weather services to aviation and land transportation.

Generally, the Department of Meteorology and Hydrology (DMH) of Lao PDR is able to provide basic hydrometeorological services for disaster reduction purposes. However, compared to other countries in the region, the DMH is lagging behind in terms of core capacities and forecasting technology. The department does not undertake research that can support the improvement of its forecast products and other information issued to the public. With its limited physical and human resources, the DMH cannot cope with the increasing demand for better services.

With climate change, there is a great need for improved hydrometeorological and environmental services in Lao PDR. This will entail upgrading of the facilities and observing network of the DMH as well as capacity building. Real-time collection of data from its observing network and dissemination of reliable, timely and accurate forecasts and warnings to national and local disaster management organizations are important for effective disaster reduction management which should be complemented by active community participation, among others. Observed data from its hydrometeorological network also need to be shared to other NMHS through regional/global data exchange in order to improve numerical weather prediction.

National set-up for production of hydro-meteorological services in Lao PDR

The DMH is the provider of weather and climate related services for Lao PDR. It is responsible for the operation and maintenance of all hydro-meteorological observation networks, and provision of weather and flood forecasts, and severe weather warnings all over the country. It plays vital roles jointly with the National Disaster Management Office (NDMO) to serve the National Disaster Management (steering) Committee (NDMC) in decision making for taking prompt actions against hydrometeorological hazards. It also provides weather services to aviation and land transportation. On issues concerning climate change, the DMH is the agency responsible for providing scientific information to decision makers in government. It is also assigned as one of the key agencies for the implementation of the National Strategy and Action Plan on Climate Change, including National Adaptation Programme of Actions (NAPA). The DMH provides hydrometeorological data, forecasts and warnings, and seasonal climate outlook for the climate change adaptation programme of Lao PDR.

The visibility of the DMH to the public and in the science community is generally good but still needs to be enhanced. Lao PDR through the DMH is a member of the World Meteorological Organization (WMO) and the Director-General of the DMH serves as the Permanent Representative with WMO. Lao PDR is also a member of the Mekong River Commission (MRC) with DMH serving the Laos National Mekong Committee (NLMC) and working closely with the MRC Secretariat.

It is a matter of serious concern that the adverse impacts of climate change are seen to be felt in many areas in the country. It is therefore critical to prioritize the upgrading of the capabilities of the DMH in providing improved hydrometeorological products and better delivery of services to minimize the ill effects of climate change in the country.

State of affairs of the DMH

The DMH is a government agency under the Water Resources and Environment Administration (WREA) and directly under the supervision of the Office of the Prime Minister. The headquarters of the Department of Meteorology and Hydrology of Lao PDR is located at Souphanouvong Avenue, Ban Akard, Vientiane Capital. The existing building and its condition does not provide sufficient space and security for modern IT technology.

The DMH is composed of eight (8) divisions and in the early 2011, the Weather Forecasting and Aeronautical Division was split into the Weather Forecasting Division and Aeronautical Division to address the increasing demand of weather services for aviation.

DMH's vision is simple but service oriented, "Making our forecasts essential to everyone everyday". In its current capacity, DMH may have somehow realized this simple vision. But due to the remarkably growing demand in terms of quantity, quality and variety of weather and environmental services, DMH is now having a hard time to meet these demands.

The DMH has relatively limited technical, human and financial resources to carry out its mission, compared to most of the NMHSs in the Southeast Asian region. Its office premises, observation network, production systems, and its current financial resources are not adequate to ensure the delivery of better products and services to all sectors.

The DMH has a total number of 245 personnel, 70 of which are working at the headquarters and 175 are deployed in the provincial stations. Out of these total manpower complement, there are only 14 personnel at the Weather Forecast and Aeronautical Division doing round the clock monitoring and issuance of meteorological and hydrological forecasts and the provision other related services for the entire country. Its workforce is composed of 1 PhD, 9 MSc, 5 BS degree holders and 44 technicians, the others are undergraduates. There is only one IT staff who is responsible for all the IT related requirements of the department.

Although the DMH plans to recruit young engineers to augment its human resources, the current salary level in the government is among the main constraint in attracting qualified and talented applicants. The department also needs to intensify its efforts in international cooperation and networking for the upgrading of the capacities of its personnel.

DMH's production and dissemination of hydrometeorological products and services is on average level. Through collaboration with Meteo-France, the department acquired the SYNERGIE workstation for the processing and display of meteorological charts and other relevant information needed in the production of forecasts and warnings. However, the insufficient observing network in the country leaves the quality and accuracy of its forecast products considerably lower compared with other NMHS in Southeast Asia. Currently, the DMH does not run any numerical weather prediction model in support of its forecasting and warning services. However, this can address by availing access to numerical products from advanced meteorological centers.

Among the deficiencies in the observing network of the DMH are limited meteorological and hydrological stations, absence of upper air station, lack of radar coverage, and reliable telecommunication system for the collection of data and dissemination of forecasts and warnings. Under its environmental services, the DMH lacks capacity in greenhouse gas inventory and monitoring.

Project proposal to strengthen the DMH

To improve the capabilities of the DMH as the warning agency for hydrometeorological hazards in order to meet the needs of key economic sectors in Lao PDR, a proposal is developed for upgrading its physical resources and enhancing the capacities of its human resources. On its physical resources, manual or analogue meteorological instruments should be replaced with automatic weather observation system to enable DMH to establish additional observation sites even with its limited personnel complement. Additional upper-air observation stations and new lightning detection system should also be established to come up with a better representation of the vertical structure of the atmosphere especially during occurrence of tropical cyclones and deep mesoscale convective systems such as thunderstorms.

Composite radar images from all radar equipment in adjacent countries should be made available through stronger regional cooperation. High speed telecommunication system is also necessary for real-time transmission of data from field stations and for fast dissemination of forecasts and warnings to the public and other end-users.

On human resources, it is proposed to enhance capacity building through the conduct of specialized training courses for DMH personnel to keep abreast with the latest advancements in technology and how these can be applied locally.

The DMH has high confidence that the Lao PDR Government will provide funds for the operation and maintenance of the proposed enhancement of its observation network. This willingness is shown when the Ministry of Planning and Investment approved the 5-year (2011-2015) plan for modernization of the DMH. This is important for sustainability of the project and continued strengthening of the services of the NMHS.

Investment plan

The primary objective of the proposed investment plan is for DMH to provide timely, accurate and reliable forecasts and warnings on weather and climate related hazards for the safety and well being of the people and in support of economic development in Lao PDR. This will be achieved through the upgrading of its facilities, capacity building, and research and development. This entails some investment particularly on the automation of hydrometeorological observing network including telecommunication facilities. The cost can be reduced if regional cooperation is considered through data sharing, technology transfer and capacity building. Joint projects on climate change and other regional concerns could also be considered to promote cooperation. Scholarship grants and short-term trainings from international organizations can also be availed to improve the level of education and skill of DMH personnel.

A five-year investment plan is designed and this does not include allocation for operation and maintenance cost for the duration of the project. The two investment options considered are:

A. Strengthening of DMH as "Stand-alone system"
B. Strengthening DMH as part of Re gional Cooperation

LAO PDR	A (USD)	B (USD)
RIMES		
International cooperation of experts	100,000	100,000
Communication systems		
- Hardware + software	500,000	500,000
IT Center		
- Hardware	100,000	100,000
- Consulting	50,000	50,000
Data management		
- Hardware and installation	560,000	560,000
- Storage	125,000	125,000
- Consultation and training	100,000	50,000
Meteorological observation network		
- automatic weather stations (P, T, U, ww, wd, G)	980,000	980,000
- aviation weather observing station (AWOS)	1,000,000	1,000,000
- agrometeorological stations)	340,000	340,000
- climate stations	187,600	187,600
- automatic rain gauge	314,900	314,900
Hydrological observation network		
- automatic hydrological stations	704,000	440,000
Environmental		
- automatic air quality stations	10,000	26,500
- Ozone & UV radiation	10,000	26,500
Remote sensing network		
- upper air observations	1,780,000	890,000
- new weather radars (including towers)	6,000,000	2,000,000
- lightning detection	100,000	135,000
- Satellite receiving station	100,000	135,000
Training	100,000	50,000
Research and development		
- impacts of climate change	100,000	50,000
- socio economic impacts	100,000	100,000
- national seminar on socio-economic benefits	100,000	100,000
- end-user seminar	30,000	30,000
Project management		
- consultant	200,000	100,000
- local project coordinator	100,000	50,000
Total	13,843,00	8,389,000

Economic value of weather forecasts and hydrometeorological services in Lao PDR

For a stand alone 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$18.98 million, discounted total benefits are US$95.21 million, discounted net benefits are US$79.89 million and C/B ratio is 1:5.2.

Under the regional cooperation 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$10.93 million, discounted total benefits are US$95.21 million, discounted net benefits are US$84.28 million and C/B ratio is 1:8.7.

The Table below shows the Costs, Discounted Total Benefits, Discounted Net Benefits and Cost-Benefit ratios for improvements in NMHS in Lao PDR 2010-2029.

Option	Costs (Million US$)	Discounted Total Benefits (Million US$)	Discounted Net Benefits (Million US$)	Cost/benefit Ratio (C/B)
Stand Alone	18.32	95.21	79.89	1:5.2
Regional Cooperation	10.93	95.21	84.28	1:8.7

In retrospect, the following are the main findings of the computations done for Lao PDR:

- The discounted total and net benefits due to the improvements in the NMHS of Lao PDR, 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 generally better than 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.

Environmental impacts of enhancement of the observation network

Automation of observation network and upgrading of the other equipments and facilities of DMH will not produce any harmful effects on the environment. Only the radar towers (typical height) will have some visual impact on the environment and would require the issuance of a permit by the proper authorities prior to the implementation of the project. On the other hand, the radar towers could be used as lookout spots and information centers for the public.

Financing of the proposed project

Funds for the implementation of the proposed project can not be supported out of the existing budget allocation provided by the Government of Lao PDR to the department, hence, outsourcing is necessary. Foreign donors such as JICA, KOICA, USAID, AusAID and the World Bank could be tapped to provide funding support for the project. However, in the implementation of foreign assisted projects the government will be required to provide some counterpart funds. Assistance from advanced national meteorological services in Asia and other regions should also be pursued especially in the area of capacity building in hydrometeorology. In order to ensure sustainability of the project, the Government of Lao PDR should allocate funds every year for the operation and maintenance of the new equipments and facilities after the completion of the project.

LAO PDR IN NUTSHELL 1

1.1 General Description

Modern-day Laos has its roots in the ancient Lao kingdom of Lan Xang, established in the 14th Century under King Fa Ngum. For 300 years Lan Xang had influence reaching into present-day Cambodia and Thailand, as well as over all of what is now Laos. After centuries of gradual decline, Laos came under the domination of Siam (Thailand) from the late 18th century until the late 19th century when it became part of French Indochina. The Franco-Siamese Treaty of 1907 defined the current Lao border with Thailand. In 1975, the Communist Pathet Lao took control of the government ending a six-century-old monarchy and instituting a strict socialist regime closely aligned to Vietnam. A gradual return to private enterprise and the liberalization of foreign investment laws began in 1988. Laos became a member of ASEAN in 1997.

(http://www.retire-asia.com/lao-maps.shtml)

Figure 1.1 Geographical location of Lao People's Democratic Republic

The data and information presented in the following sections are mainly taken from the World Factbook of the Central Intelligence Agency, USA.

Geography and Land Use

- Location: Southeastern Asia, northeast of Thailand, west of Vietnam
- Total area: 236,800 km2; land area: 230,800 km2; water area: 6,000 km2
- Total land boundaries: 5,083 km
- Coastline: 0 km (landlocked)
- Maritime claims: none (landlocked)
- Terrain: mostly rugged mountains; some plains and plateaus
- Elevation extremes: lowest point: Mekong River 70 m; highest point: Phou Bia 2,817 m
- Land use: arable land: 4.01%; permanent crops: 0.34%; other: 95.65% (2005)
- Irrigated land: 1,750 km2 (2003)
- Total renewable water resources: 333.6 km3 (2003)
- Freshwater withdrawal (domestic/industrial/agricultural): total - 3 km3/yr (4%/6%/90%); per capita - 507 m3/yr (2000)

- Current environmental issues: unexploded ordinance; deforestation; soil erosion; most of the population does not have access to potable water
- Main geographical feature: The Mekong river- forms a natural border with Thailand in most areas; flows through nearly 1.900 km of Lao territory; with the main 13 tributaries from Lao PDR; catchment area in Lao PDR: 213.060 km2 (26.8 % of total catchment)

People

- Population: 6,834,345 (July 2009 est.)
- Life expectancy at birth, total population: 56.57 years
- Ethnic groups: Lao 55%, Khmou 11%, Hmong 8%, other (over 100 minor ethnic groups) 26% (2005 census)
- Languages: Lao (official), French, English, and various ethnic languages
- Literacy (definition: age 15 and over can read and write): total population - 68.7%

Government

- Government type: Communist state
- Capital: Vientiane (Viangchan)
- Administrative divisions: 16 provinces (khoueng, singular and plural) and 1 capital city

Transnational issues

- Southeast Asian states have enhanced border surveillance to check the spread of avian flu; talks continue on completion of demarcation with Thailand but disputes remain over islands in the Mekong River; concern among Mekong River Commission members that China's construction of dams on the Upper Mekong will affect water levels.

1.2 Economic overview

The government of Laos, one of the few remaining one-party Communist states, began decentralizing control and encouraging private enterprise in 1986. The results, starting from an extremely low base, were striking - growth averaged 6% per year from 1988-2008 except during the short-lived drop caused by the Asian financial crisis that began in 1997. Despite this high growth rate, Laos remains a country with an underdeveloped infrastructure, particularly in rural areas. It has a rudimentary, but improving, road system, and limited external and internal telecommunications. Electricity is available in urban areas and in many rural districts. Subsistence agriculture, dominated by rice cultivation in lowland areas, accounts for about 40% of GDP and provides more than 70% of total employment. The government in FY08/09 received US$560 million from international donors. Economic growth has reduced official poverty rates from 46% in 1992 to 26% in 2009.

Among others, the GDP growth capita growth performance of the country has slightly fallen from 7.9% in 2007 to 7.5% in 2008. The other economic indicators are as follow:

Gross Domestic Product

- GDP (purchasing power parity): US$14.61 billion (2009 est.)
- GDP (official exchange rate): US$5.721 billion (2009 est.)
- GDP – growth: 3% (2009 est.)
- GDP - per capita (PPP): US$2,100 (2009 est.)
- GDP - composition by sector
  - agriculture: 39.2%; industry: 33.9%; services: 26.9% (2009 est.)
- Budget:
  - revenues: US$937.1 million; expenditures: US$1.123 billion (2009 est.)

Labor market

- Labor force: 2.1 million (2006 est.)
- Labor force - by occupation
  - agriculture: 80%; industry and services: 20% (2005 est.)
- Unemployment rate: 2.4% (2005 est.)
- Population below poverty line: 26% (2009 est.)
- Agriculture - products: sweet potatoes, vegetables, corn, coffee, sugarcane, tobacco, cotton, tea, peanuts, rice; water buffalo, pigs, cattle, poultry
- Industries: copper, tin, gold, and gypsum mining; timber, electric power, agricultural pro cessing, construction, garments, cement, tourism
- Industrial production growth rate: 2% (2009 est.)

Energy

- Electricity
  - production: 3.075 billion kWh (2007 est.)
  - consumption: 3.068 billion kWh (2007 est.)
  - exports: 268 million kWh (2007 est.)
  - imports: 475.9 million kWh (2007 est.)
- Oil
  - production: 0 bbl/day (2008 est.)
  - consumption: 3,000 bbl/day (2008 est.)
  - exports: 0 bbl/day (2007 est.)
  - imports: 3,080 bbl/day (2007 est.)
  - proved reserves: 0 bbl (1 January 2009 est.)
- Natural gas
  - production: 0 m3 (2008 est.)
  - consumption: 0 m3 (2008 est.)
  - exports: 0 m3 (2008 est.)
  - imports: 0 m3 (2008 est.
  - proved reserves: 0 m3 (1 January 2009 est.)
- Pipelines
  - refined products 540 km (2009)

Exports and imports

- Exports - commodities: wood products, coffee, electricity, tin, copper, gold
- Exports – partners: Thailand 35.4%, Viet Nam 15.5%, China 8.5% (2008)
- Imports – commodities: machinery and equipment, vehicles, fuel, consumer goods
- Imports – partners: Thailand 68.3%, China 10.4%, Viet Nam 5.8% (2008)
- Natural resources: timber, hydropower, gypsum, tin, gold, gemstones

Reserve, Debt, Aid

- Reserves of foreign exchange and gold: US$715 million (31 December 2009 est.)
- Debt - external: US$3.179 billion (2006)

Communications

- Telephones - main lines in use: 97,600 (2008)
- Telephones - mobile cellular: 1.822 million (2008)
- Radio broadcast stations: AM 7, FM 14, short wave 2 (2006)
- Television broadcast stations: 7 (includes 1 station relaying Vietnam Television from Ha Noi) (2006)
- Internet hosts: 1,661 (2009)
- Internet users: 130,000 (2008)

Transportation

- Airports - with paved runways
  - total: 9
  - 2,438 to 3,047 m: 2
  - 1,524 to 2,437 m: 4
  - 914 to 1,523 m: 3 (2009)

- Airports - with unpaved runways
  - total: 32
  - 1,524 to 2,437 m: 2
  - 914 to 1,523 m: 9
  - under 914 m: 21 (2009)
- Heliports: 1 (2009)
- Roadways: 29,811 km
  - paved: 4,010 km; unpaved: 25,801 km (2006)
- Waterways: 4,600 km; note: primarily Mekong and tributaries; 2,900 additional km are intermit tently navigable by craft drawing less than 0.5 m (2008)
- Merchant marine: total – 1 ship (1000 GRT or over) 2,370 GRT/3,110 DWT; by type: cargo 1 (2008)

1.3 Climate

Lao PDR has a typical monsoon climate with two distinct seasons: Rainy season from May to October and Dry season from November to April. The southwest monsoon prevails from mid May to early October, while the northeast monsoon dominates from early November to mid March. Generally, the average annual rainfall ranges between 1400 mm and 2500 mm and exceeds 3500 mm over the central and southwest region. Except in the northern part of the country, temperatures remain high throughout the year, with an average highest temperature range between 35-380C and lowest temperature of about 16-18 0C. In the subtropical regions of the north, the temperature range is much wider, cold air from China and Siberia occasionally penetrates during the dry season, lowering air temperature to near zero. The maximum temperature is 40°C (March, over low land) and minimum temperature is 0°C (high land).

Flood and drought are the main hazards in Lao PDR and both are dependent on the amount of rainfall. If the annual rainfall is less than 2000 mm, drought sensitive areas will be affected. When more than 200 mm of rainfall accumulate in 2 days, certainly this will lead to floods along the Mekong plain. Tropical cyclones are not direct hazard, since their force is normally diminished once they have reached Lao PDR from the South China Sea, but they can produce flood as a consequence of heavy rainfall. Up to three cyclones hit the country annually, while flood, drought and landslides occur irregularly.

2 SOCIO-ECONOMIC BENEFITS OF HYDROLOGICAL AND METEOROLOGICAL SERVICES

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

The assessment of the benefits of hydro-meteorological services, particularly the economic benefit-cost analysis (BCA) can be a helpful tool in evaluating the benefits of upgrading the facilities of NMHS's. BCA's can also be used as reference in identifying the investment areas (e.g. monitoring, modeling, research, etc.) where funding support can be provided.

2.1 Weather and climate-dependent economic sectors

Of the weather and climate-dependent economic sectors of Lao PDR, agriculture, hunting, forestry and fishing as well as mining, manufacturing and utilities have been the most dominant contributors to the national economy. In 2008, the individual value added of these sectors respectively shared 44.2% and 27.3% to total value added (Table 2.1). Overall, the weather and climate-dependent economic sectors contributed 91.3% to total value added in the same year. Because of this large contribution, improvements in the NMHS that would reduce the damages due to weather and climate-related disasters will have very significant impacts on the national economy.

2.2 Methodology for computing socio-economic benefits

The methodology employed for computing the potential socio-economic benefits of planned improvements in the NMHS done here is driven by the availability of secondary data. The use of secondary data is necessitated by the limited time and resources available for this work. The secondary data were collected from institutional sources. These secondary data were enhanced by informed assumptions provided by institutional key informants.

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

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

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

Table 2.1 Percent share of value added by weather and climate-dependent economic sector to Total Value Added at 1990 constant prices of Lao PDR, 2000-2008

Sector	2000	2001	2002	2003	2004	2005	2006	2007	2008
Agriculture, hunting, forestry, fishing	52.1	51.2	50.3	48.6	47.1	45.0	42.7	44.9	44.2
Construction	2.3	2.4	2.1	2.3	2.7	3.0	3.3	3.0	3.1
Mining, Manufacturing, Utilities	20.4	21.2	22.5	23.7	24.7	26.6	28.7	26.6	27.3
Transport, storage and communication	5.8	6.0	6.1	6.3	6.5	6.3	6.3	6.4	6.3
Wholesale, retail trade, restaurants and hotels	9.4	9.5	9.6	9.8	10.1	10.3	10.4	10.3	10.3
Total	90.0	90.3	90.6	90.6	90.9	91.2	91.4	91.2	91.3

Source of data : United Nations Statistics Division

Table 2.2 Potential direct impacts of weather and climate-related disasters on different economic and social sectors in Lao PDR

Economic/Social sector		Potential Direct Impacts
Economic Sectors	Agriculture	Lost income, disruption in operations, damaged irrigations, dams and other agricultural infrastructure and facilities, etc.
	Transportation & Communication	Lost income, disruption in operations, damaged transportation and communication infrastructure and facilities, etc
	Energy	Lost income, disruption in operations, damaged energy infrastructure and facilities, etc.
	Tourism	Lost income, disruption in operations, damaged tourism infrastructure and facilities, tarnished image as a tourist destination, etc.
Social Sectors	Human Settlements	Lost and impaired human lives and property, reduction in land and property values in affected areas, etc.
	Health	Lost income due to death or injury, disruption in operations, psychic costs due to death or injury, cost of rehabilitation, etc.
	Education	Lost income, disruption in operations, opportunity costs of cancellation of classes, rehabilitation costs of damaged schools and related property, etc.
	Water	Diminished water access and water availability, management and control cost of water pollution, etc.

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

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

2.3 Results and analysis

Natural hazard-induced disasters

For the period, the country had 18 such disasters causing death to 145 people, homelessness to one million people and injury to 463 persons. The disasters also affected more than 4 million individuals. In the same period, annually on average, there was 1 disaster which occurred, 7 people who died, 50,000 persons who were rendered homeless, 19 persons who were injured and 212.347 people who were affected (Table 2.3).

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

Year	Number of disasters that occurred	Number of persons who died	Number of homeless persons	Number of persons who were injured	Number of persons affected
1990	0	-	-	-	-
1991	3	-	-	-	370,315
1992	2	32	-	252	269,027
1993	1	8	-	120	120
1994	1	-	-	-	190,000
1995	3	26	1,000,000	-	1,591,400
1996	1	30	-	-	420,000
1997	0	-	-	-	-
1998	0	-	-	-	-
1999	1	-	-	-	20,000
2000	1	15	-	-	450,000
2001	1	-	-	-	453,000
2002	1	2	-	-	150,000
2003	0	-	-	-	-
2004	0	-	-	-	-
2005	0	-	-	-	-
2006	0	-	-	-	-
2007	0	-	-	-	-
2008	1	6	-	-	204,190
2009	2	26	-	91	128,887
Total	18	145	1,000,000	463	4,246,939
Average	1	7	50,000	19	212,347

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

Notes:

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

In terms of type of disaster, the disasters which occurred in recent years were mainly floods and storms. From 2005 to 2009, there were 2 floods causing death to 16 people and 1 storm causing death also to 16 people in the country.

Total socio-economic damages

The value of direct socio-economic damages caused by weather and climate-related disasters in Lao PDR for the 1990-2009 period and the estimated damages for the 2010-2029 period are presented in Table 2.5. The estimated annual damages for 2010-2029 were computed as the average of the actual annual damages for the 1990-2009 period adjusted to inflation taken from the World Development Indicators of the World Bank. The average annual socio-economic damages for the 1990-2009 period was at US$21.45 million and in the absence of 2010 data is reflected as the estimated annual damages for that year. For the 1990-2009 period, the total actual damages was US$429 million while for the 2010-2029 period, the total estimated damages was US$5,558.69 or average annual damages of US$277.93. These figures appear large because they are still undiscounted but will drastically go down once discounted.

It should be pointed out that damage data from the Annual Flood Report of the Mekong River Commission are different from the damage data presented in Table 2.5. In particular, this report shows that the value of damages increased from US $28.56 millions in 2005 to US$39.16 millions in 2008 or an aveage annual damages of US33.86 million for the period (Table 2.4). The average annual damages of US$21.45 derived from Table 2.5 are therefore lower and are thus used in the computation here to be relatively conservative in the estimation of damages and consequently benefits of NMHS improvements.

Among the types of disaster, from 2005 to 2009, floods caused no economic damages while storms resulted to economic damages of US$100 million. Furthermore, in 1993 when annual socio-economic damages were highest, these damages were also caused by storms.

The reduction in damages (Table 2.6) is assumed to start in 2012, a year after the start of the prject, and increases up to 2016. A reduction in the economic damages of 2% annually from 2012 to 2015 and 10% thereafter is further assumed meaning that the effects of the improvement gradually occur in equal increments until it reaches maximum effect by 2016 and onwards. While there are no available previous researches which indicate the right percentage of damage reduction in damages which should be assumed, the 10% reduction in damages used here is based on informed opinion of key informants and technical people and considered a conservative estimate. From 2010-2029 the estimated reduction in damages or the socio-economic benefits amount to US$ 542.99 million and the annual average reduction is US$27.15 million.

Table 2.6 also presents the discounted or net present value of the estimated reductions in economic damages, or the socio-economic benefits due to improvements of the NMHS of Lao PDR. The social discount rate used is 12% which is within the 10 to 12% used by the ADB for public projects (Zhuang et al. 2007). The results show that the total discounted socio-economic benefits from 2010 to 2029 are US$95.21 million while the annual average benefits are US$4.76 million. These discounted figures are way lower than the undiscounted figures shown in the same table.

Table 2.4 Summary of damages caused by natural disasters, Lao PDR 2005-2008

Sector	Type of Damage	Unit	2005	2006	2007	2008
Social	Provinces affected	No.	16	5	4	
	Districts affected	No.	84	20	27	30
	Villages affected	No.	2,510	404	614	376
	Families affected	No.	85,553	13,549		35,097
	People affected	No.	480,913	89,849	118,074	104,819
	People evacuated	No.	356			
	Households affected	No.	5,160	21	25,292	2,004
	Households destroyed	No.	29			
	People dead	No.	4	5	2	7
	Schools affected	No.	116	13	11	63
	Schools destroyed	No.	29			
	Hospital/health center locations affected	No.	6	3	2	3
	Hospital severely damaged	No.	1			
Agriculture	Rice Crops affected/damaged	Ha.	87,724	691,322	256,778	363.8
	Rice crops destroyed	Ha.	55,955			
	Subsidiary crops affected/damaged	Ha.			490.62	2005.9
	Seedbed/nursery damaged	kg				35,139
	Cattle	No.	351		343	720
	Poultry	No.	7,861	5,912		2,850
	Livestock	No.	2,124	298		
	Fishponds	Ha.	296	98.2	136	473.8
Infrastructure	Irrigation systems and water channels damaged		3800US$	259 sites	23 sites	197 sites
	Canals destroyed	m	14,787			53
	Bridge damaged	No.	5	2		10
	Pumping Stations	No.	82			
	Feeder roads affected	Km.	119			
	National roads affected	Km.	14	3.8		
	National and provincial roads damaged	m			70	314,378
Other facilities	Water wells	sites				929
	Underground water well	sites				812
	Villagers toilette	No.				4954
Total Estimate of Damage (Million US$)			28.56			39.16

** Note: Natural disasters include floods, tropical storms, and droughts. 2007 data is only for flash floods by tropical storm Lekima.*
Source : Annual Flood Report. Flood Management and Mitigation Programme. Mekong River Commission. Available at http://www.mrcmekong.org/free_download/research.htm.

Table 2.5 Actual and estimated socio-economic damages due to weather and climate-related disasters in Lao PDR, 1990-2029 (million US dollars)

Actual Damages		Estimated Damages	
Year	Value	Year	Value
1990	-	2010	21.45
1991	1	2011	26.32
1992	25	2012	32.29
1993	302	2013	39.62
1994	-	2014	48.62
1995	-	2015	59.66
1996	-	2016	73.20
1997	-	2017	89.81
1998	-	2018	110.20
1999	-	2019	135.22
2000	1	2020	165.91
2001	-	2021	203.57
2002	-	2022	249.78
2003	-	2023	306.48
2004	-	2024	376.05
2005	-	2025	461.42
2006	-	2026	566.16
2007	-	2027	694.68
2008	-	2028	852.37
2009	100	2029	1,045.86
Total	429		5,558.69
Average	21.45		277.93

Source of data: EM-DAT: The OFDA/CRED International Disaster Database; World Development Indicators, World Bank

Note: There is no explanation from the source on what the specific damages are so it is assumed that these only include direct damages. Average annual inflation rate is 22.7% from 1990-2009.

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 be spent at the start of the project for the stand-alone option is US$13.98 million while that with regional cooperation option is US$8.34 million. The discounted and undiscounted operating and maintenance costs for the two options are provided in Table 2.7.

Table 2.6 Estimated 10% reduction in the socio-economic damages, or the socio-economic benefits due to improvements in NMHS in Lao PDR, 2010-2029 (million US dollars)

Year	Undiscounted Value	Discounted Value
2010	0.00	0.00
2011	0.00	0.00
2012	0.65	0.46
2013	1.58	1.01
2014	2.92	1.66
2015	4.77	2.42
2016	7.32	3.31
2017	8.98	3.63
2018	11.02	3.97
2019	13.52	4.35
2020	16.59	4.77
2021	20.36	5.23
2022	24.98	5.72
2023	30.65	6.27
2024	37.61	6.87
2025	46.14	7.53
2026	56.62	8.25
2027	69.47	9.03
2028	85.24	9.90
2029	104.59	10.84
Total	542.99	95.21
Average	27.15	4.76

Source of data: Table 2.5

The total costs of the NMHS improvements are the capital costs which are assumed to be spent at the beginning of the project and therefore not discounted and the discounted O&M costs (Table 2.8). Again, the undiscounted capital costs are US$13.98 million for the stand-alone option and US$8.34 million for the regional cooperation option. The discounted O&M costs of US$4.34 million for the stand-alone option and the US$2.59 million for the regional cooperation option are taken from Table 2.7. The discounted total benefits are taken from Table 2.6. The discounted net benefits and C/B ratio are as defined earlier.

For the stand-alone system, the undiscounted plus discounted total cost of NMHS improvements is US$18.32 million while the discounted total benefits due to NMHS improvements is US$95.21 million when a 10% decrease in damages is considered as benefits (Table 2.8).

For a system based on regional cooperation, the total cost of NMHS improvement is US$10.93 million which is lower than the cost of a stand-alone system. Again, the discounted total benefits due to the NMHS improvements are US$95.21 million when a 10% decrease in damages is considered as benefits. Therefore, the discounted net benefits are US$84.28 million and the C/B ratio is 1:8.71. It is noted that the C/B ratios generated above for both of the systems are similar to the C/B ratios computed by other studies on benefits of meteorological and hydrological services. The derived C/B ratios are also higher than the WMO minimum accepted ratio of 1:7 (Hautala et al., Tammelin 2007, Leviakangas et al. 2007).

Table 2.7 Undiscounted and discounted operating and maintenance costs of improvements in NMHS in Lao PDR, 2010-2029 (Million US$)				
Year	Undiscounted O&M Costs		Discounted O&M Costs	
	Stand Alone	Regional Cooperation	Stand Alone	Regional Cooperation
2010	0.00	0.00	0.00	0.00
2011	0.00	0.00	0.00	0.00
2012	0.14	0.08	0.10	0.06
2013	0.17	0.10	0.11	0.07
2014	0.21	0.13	0.12	0.07
2015	0.26	0.15	0.13	0.08
2016	0.32	0.19	0.14	0.09
2017	0.39	0.23	0.16	0.09
2018	0.48	0.28	0.17	0.10
2019	0.59	0.35	0.19	0.11
2020	0.72	0.43	0.21	0.12
2021	0.88	0.53	0.23	0.13
2022	1.08	0.64	0.25	0.15
2023	1.33	0.79	0.27	0.16
2024	1.63	0.97	0.30	0.18
2025	2.00	1.19	0.33	0.19
2026	2.45	1.46	0.36	0.21
2027	3.01	1.79	0.39	0.23
2028	3.69	2.20	0.43	0.26
2029	4.53	2.70	0.47	0.28
Total	23.86	14.23	4.34	2.59
Average	1.19	0.71	0.22	0.13

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 2.8 Options, Costs, Discounted Total Benefits, Discounted Net Benefits and Cost-Benefit ratios for improvements in NMHS in Lao PDR, 2010-2029				
Option	Total Costs (Million US$)	Discounted Total Benefits (Million US$)	Discounted Net Benefits (Million US$)	Cost/benefit Ratio (C/B)
Stand-Alone	18.32	95.21	76.89	1:5.20
Regional Cooperation	10.93	95.21	84.28	1:8.71

Source of data: Tables 2.6 and 2.7

2.4 Summary of findings

In retrospect, the following are the main findings of the computations done for Lao PDR :

- The discounted total and net benefits due to the improvements in the NMHS of Lao PDR, 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 ratio based on the actual costs of NMHS improvements and the discounted values of the total benefits from the improvements is inferior to the 1:7 ratio set by the WMO in a stand-alone system but superior in a regional integration system;
- 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.

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 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 HYDROMETEOROLOGICAL SERVICES AND INFORMATION

3.1. Emergency preparedness and response

The DMH is the agency providing scientific information to decision makers in the government while the National Disaster Management (Steering) Committee (NDMC) with support from the National Disaster Management Office (NDMO) is responsible for taking prompt actions against hydro-meteorological disasters. The NDMC coordinates with provincial departments, Provincial Disaster Management Committees and Labor and Social Welfare Offices. From the provincial to the district levels, sub-national disaster management committees (DMC) have been created with functions similar to the national DMC. The NDMO provides assistance to provincial and district DMCs to identify the location of disaster, focal points and contact persons and in drafting coordination procedures.

The National Disaster Management Plan for the period 2001-2020 has been formulated. Provincial disaster management plans are being formulated. Priorities for action are capacity building of disaster management personnel from national to community levels, early warning systems for floods and drought, public awareness, disaster preparedness, prevention and mitigation, and response.

Upon receipt of warning from the DMH, the same warning is simultaneously sent to concerned agencies and institutions and the media by the NDMO following the protocol shown in Table 3.1. The NDMO has established communication system for effective dissemination of information from the national to the village levels. For fast transmission of information, the DMCs use mobile phones and high frequency radio transceivers. The warning is also sent to the designated focal point for disaster response at the local level to ensure that warnings reach the target community.

Despite the well-designed dissemination scheme of the DMCs, there are times when the official warning does not reach the village chief. In case of water release from Nam Ngum Dam, the village member who works at the DMH and who has access to the warning information provides such information to the village chief. The Nam Ngum Dam staffs provide warning to the village, two or three days before the gates of the dam are opened. The community also uses its indigenous detection system, such as observing the water levels compared with the perceived danger levels. The village chief uses the public adress system at the temple to disseminate warning or information to the community. The combination of warnings from the DMH, dam office, DMC as well as the indigenous knowledge provide the community some lead time to implement preparedness measures in the event of a flood.

To effectively carry out activities on emergency preparedness and early warning systems, the NDMO needs large-scale hazard maps in order to identify the areas at-risk. It also needs to coordinate with the DMH on the proper interpretation of the forecasts. The Red Cross needs more accurate extreme weather forecasts with sufficient lead time in order to carry out its activities, such as the prepositioning of goods in the event of a disaster, which needs at least a lead time of one week). Since climate change issues and scenarios are new to them, the emergency managers need more explanation on the effects and impacts of climate change. The awareness on meteorological and hydrological information in the local communities still remains low hence there is a need to embark on intensive public information and the reproduction of information materials in coordination with the DMH.

Table 3.1. Protocol in disseminating warning from the DMH to the NDMO	
Institution	Description of Activity
NDMO	Upon receipt of the warning from the DMH, the NDMO sends a short memorandum containing the revised warning intended for the public to the Chairman of the NDMC for approval. The approved warning is sent to PDMC.
PDMC	Upon receipt of the warning, the PDMC calls a meeting to organize a response team that will proceed to the threatened district(s) (based on vulnerability of areas from experience). The PDMC then disseminates the warning to the district(s) at risk.
DDMC	Upon arrival of the response team from the PDMC, the DDMC organizes the data collection team. It transmits the status of flood or typhoon effects to the PDMC which in turn will send the information to the NDMC. The DDMC then disseminates the warning to the public.

3.2 Agriculture and food production

The contribution of agriculture, hunting and fishing to the GDP in 2001 was 47.6% and the sector employed about 70% of the labor force. Rice was the single most important crop which was grown on about 639,000 hectares or approximately 72% of the cultivated area of the country.

The agriculture sector grew by 3.4% per annum between FY2006 and FY2008. Sugarcane production increased from 324,000 tons in FY2007 to 542,000 tons in FY2008. Vegetable production also increased from 734,000 tons in FY2007 to 1,013,000 tons in FY2008. Agriculture exports grew at double-digit rates since 2006 and reached US$64 million in 2008.

A major milestone for agriculture and natural resources sector planning was reached in 1999 with the preparation of the Strategic Vision for Agriculture by the Ministry of Agriculture and Forestry (MAF). In implementing the Strategic Vision for Agriculture, MAF finds it crucial to know the long-term climate trends, particularly the characteristics and trends of extreme climate events. Medium term (1-5 to 10 day) forecasts are crucial for the estimation of irrigation water requirement for rice producing farmers. Due to the limitations in the forecasts provided by the DMH, planning and programming of agricultural activities are based solely on statistical averages of meteorological parameters such as rainfall, evaporation, temperature and relative humidity.

3.3 Fishery

For many Laotians, freshwater fish are the principal source of protein. Per capita consumption averages 5.1 kilograms annually. Fishpond culture had begun in the mid-1960s, and production mainly carp raised in small home lot grew an average 30% annually thereafter, the highest rate in Asia between 1975 and 1985. The Mekong districts in the south have especially high potential for greater increases in fish production. From 1982 to 1984, the average annual catch was 20,000 tons, all of which was consumed domestically by the population.

The needs of the sector are: wind speed and direction, wind forecasts including local wind, like Bora, thunderstorms with gusts, visibility, wave heights and water levels.

3.4 Water resource management

The Water Resources and Environment Administration (WREA) is providing oversight for water resources management and environmental impact assesments. The Government is adopting a river basin approach to water resources management in developing the regulatory and planning framework for integrated water resources management (IWRM). Managing environmental risks to livelihoods, including those posed by climate change, requires multidimensional mitigation and/or adaptation measures. Biodiversity initiatives are being combined with climate change resilience enhancing efforts.

Recent studies in 2008 show that the annual precipitation for the Mekong Basin will increase by 13.5% from the historical average of 1509 mm to 1712 mm by 2030 (Report on Climate Change's Impacts to Water Resource Sector, 2009). The greatest changes are projected for the wet season months (May to September).

The projected changes in dry season precipitation are much smaller, but the median projection indicates small decreases (<3 mm) in mean monthly precipitation in February, March and November. No change in precipitation is projected for January and December, and a small increase of 2 mm or 3% is projected for April. The drier extremes of the model projections indicate precipitation decreasing in all months in the dry season, with decreases of up to 25% from historic values. Other projections indicate precipitation increases in dry months of up to 22%.

The water resource sector has a number of information needs to adapt to climate change. Given the growing importance of hydropower industry in the national socio-economic development in Lao PDR, it is urgent to assess the industry's vulnerability to climate change impacts. In addition, there is a need to develop climate change scenarios for river basins that can be used to simulate future river flows using hydrological models that integrate the results of regional climate models. With the assistance of the DMH, there is a need to develop early warning systems to manage floods and drought effectively. The sector also requires downscaled climate and hydrological models to a watershed level for better risk management strategies and planning processes. All these needs lead to greater access to climate and hydrological data from the DMH.

3.5 Energy Production

The energy sector plays a crucial role in the economic growth and social development of the Lao PDR. Several rivers flowing from the highlands into the Mekong River traversing the country provide considerable hydropower resources. About 18,000 megawatts (MW) could be developed in the Lao PDR. However, only 4% of these hydropower resources have been currently harnessed.

The country is rich in mineral resources. Coal deposits are found in the provinces of Khammouane, Phongsaly, Saravan, Vientiane, and Xieng Khouang. High quality lignite estimated at 220 million tons has also been found near the border with Thailand, particularly in Hongsa district of Xayabury Province. There are plans by private investors to develop the lignite mines for power generation at Hongsa (1,800 MW) and to export power to Thailand. Renewable energy sources in the Lao PDR are still in the development stages. Biomass resources consist of wood fuels, used for cooking and heating purposes by the rural population. Small hydropower and photovoltaic modules are already used in remote areas.

The power sector in Lao PDR is just recently being developed, with only 56% of households having access to electricity in 2007. There are interconnecting transmission lines between the Lao PDR, Thai-

land, and Viet Nam for power export and import. By the end of 2006, the total installed generating capacity in the country was 692 MW; consisting of 310 MW fully-owned by Electricite du Laos (EdL), 362 MW owned by independent power producers (IPPs), and 20 MW belonging to provincial authorities. About 98% of the total generating capacity is hydro-based and the remaining 2% is diesel-based capacity. From 1999 to 2006, demand for electricity increased at 13% per annum, as compared with electricity consumption which increased by 14% per annum. Electricity consumption in the central regions accounted for almost 90% of total consumption; the southern and northern regions account for remaining 10%. The growth rate of the peak load is higher than that of electricity consumption.

The development of the power sector is given a high priority by the Government. It expects to achieve a household electrification ratio of 90% by 2020. Export of hydropower is the single largest foreign exchange source for the country. The Government has emphasized the development of export-oriented hydropower projects and tapped the private sector to invest in the development of power resources.

Private sector participation in power sector development is the key to achieve the power development targets set by the Government. The total investment requirement in the domestic power sector for 2007–2011 is estimated to be about US$150 million–US$200 million. The Government expects that half of the funds required will come from the private sector.

Although Lao PDR has a vast quantity of hydropower resources and has developed a major regional export market for its hydropower resources, its per capita consumption rate (223 kilowatt hours in 2007) and electrification rate (54% in 2006) are among the lowest in Asia.

Large power exports started this FY2010 from the Nam Theun 2 hydropower project and the rising global prices for exports of copper, gold, and silver have improved the current account position of the country. From a deficit of 9.0% in 2010, the forecast deficit will narrow to 8.0% in 2011. Exports of electricity and minerals are set to increase further next year with the commissioning of more hydropower projects and expansion of two mines scheduled for completion by end-2010.

The study on the construction of seven dams for electricity generation in the northern part of Lao PDR is on-going and will be completed in 2011. The project includes the establishment of hydro-meteorological network which is now within the purview of the DMH. In the implementation of this project, the DMH will ensure that the minimum requirement for flood forecasting and warning system for dam operation is satisfied. The project will be funded by private companies. The DMH will also formulate protocols in the operation of the dam during high flows, maintenance of the monitoring stations and the dissemination of warnings to the communities who will be affected by floodwaters from these dams.

3.6 Transport Sector

Lao PDR is a landlocked country surrounded by northern Thailand, northern Viet Nam, northeastern Cambodia, and the southern provinces of the People' Republic of China (PRC). More than 70% of the population lives along the Mekong River while the remaining population resides in the mountainous areas.

In the absence of a railway system, Lao PDR depends primarily on road transport and to a lesser extent, on river and air transport. About 40% of villagers have no access to road system. Although transport demand is growing, the transport of passengers and goods is constrained by inadequate transport network.

Based on the 2009 Annual Report of the Ministry of Public Works and Transport, the entire Lao PDR road network was roughly 37,768 km. It comprised 7200 km of national roads (19%), almost 7255 km of provincial roads (19.2%), and 23313 km of other roads which include district, rural, urban, and special roads (61.7%). The imports of fuel have been gradually increased in 2007, 2008 and 2009 with 539.13; 559.49 and 641.29 million litters, respectively.

The country has a very high incidence of traffic accidents because of rapid motorization. The associated economic losses are now estimated to exceed 2% of GDP. Enhanced traffic management and enforcement to improve safety and preserve infrastructure assets is becoming essential.

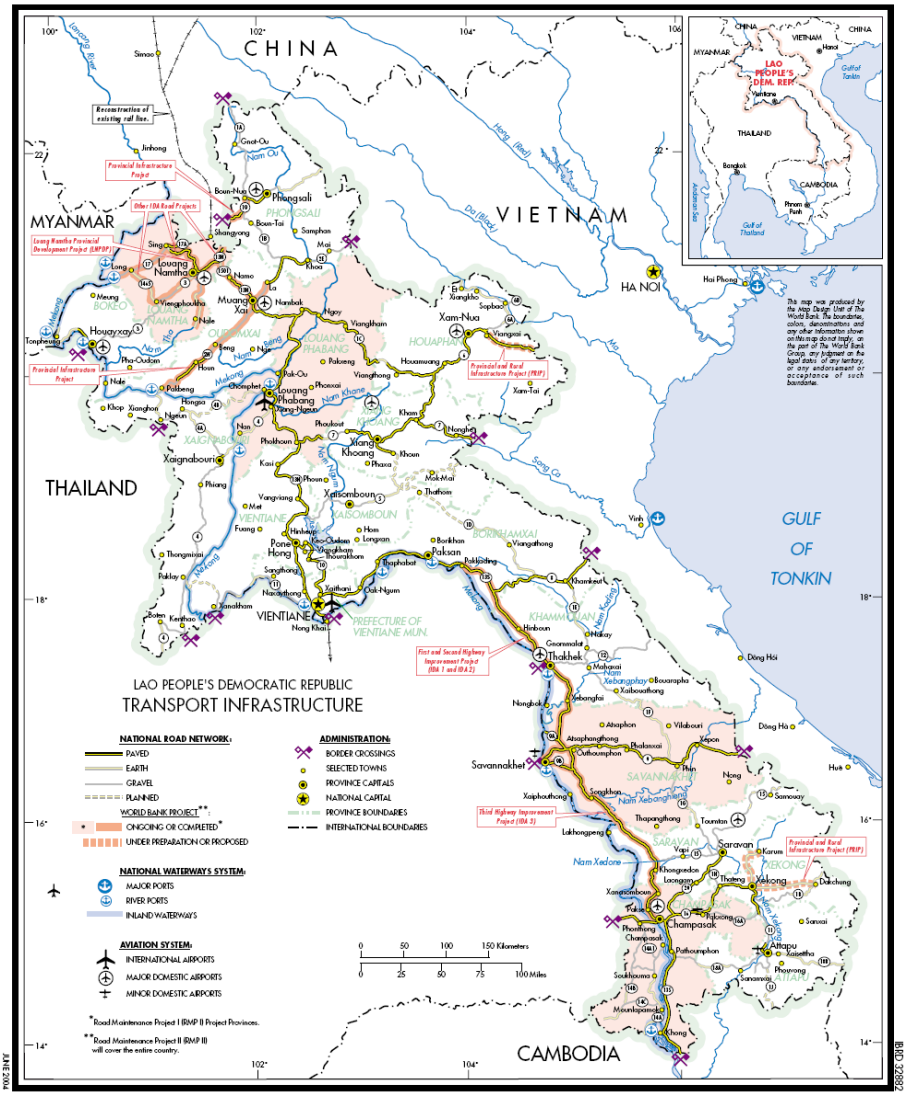


Figure 3.1 Lao PDR Transport infrastructure map from Lao PDR Transport Brief by Alberto Nogales, May 1, 2004 version

Road transport remains a priority for economic development. The transport sector accounts for about 50% of the government budget and about 80% of its official development assistance. The five-year plan 2006–2010 of the Ministry of Public Works and Transport (MPWT) envisions an annual investment of US$200 million. The Lao PDR depends heavily on road transport and has started implementing the Cross-Border Transport Agreement. Transport is a high priority of the Government's Transport Strategy under the NSEDP6.

The MPWT gets extreme weather and flooding forecasts directly from DMH. The MPWT is also a member of the NDMC. The NDMC convenes meeting during the occurrence of typhoon and other weather disturbances and upon the advice of the DMH, briefs the line ministries on contingency plans and preparedness measures.

Climate change is expected to affect transport sector primarily through climate extremes, such as more severe tropical storms and flooding from intense rainfall. It is critical that the DMH provides flood/flash flood early warning information with sufficient lead times to alert motorists and transport operators. Forecasts on extreme weather should also be issued more frequently. Hourly weather updates are necessary. Maps where the heavy rainfall will occur should also be incorporated in the forecasts. Flood hazard maps will be very helpful for transport sector in providing alternate routes for motorists during inclement weather to avoid traffic jams and congestion.

3.7 Aviation

The DMH issues hourly forecasts in all airports. In line with the ICAO requirements, the DMH also provides regular exchange of TAFOR and SIGNET. To address the needs of the aviation sector, the DMH has created the Aeronautical Division and plans to improve the capability of its forecasters and staff based on ICAO and WMO standards. The DMH also plans to install new facilities in all the airports of Lao PDR including SADIS-2G.

3.8 Industry and urban development

The industrial sector in Lao PDR includes mining, quarrying, manufacturing, construction, electricity, gas and water. The manufacturing sub-sector accounts for approximately 70% of the total industrial output. Garments and wood processed products are the leading manufacturing sub-sectors in terms of value added. Agro-processing has been identified as a highly promising sector for future development. Increasing output materials like cement to reduce import dependence is another priority area.

Due to urban migration, the urban population rate has been growing from 15.4% in 1990 to 21.0% in 2006. The average annual urban population growth rate peaked at 5.1% during 1990-1995, declined to 4.1% during 1996-2000 and then stabilized at 3.1% between 2001 and 2006. The urban population at the end of 2006 stood at approximately 1.5 million in 142 districts. In 2010, it is estimated that the Lao population is 6.7 million.

Since most cities in Lao PDR are located in river flood plains, they are highly exposed to extreme climate events. Hence risks to major infrastructure are likely to increase. The sector needs to climate-proof the most vulnerable existing infrastructure to protect the current assets through building of storm barriers for wastewater treatment plants and landfills. Using historical meteorological and hydrological data, new design criteria for infrastructure can be developed to reflect non-stationarity of hydrologic processes. There is also a need to conduct climate change risk audits for each of the key infrastructure services in order to identify climate vulnerability.

3.9 Forest industry

The contribution of forestry, logging and related service activities to the GDP of Lao PDR in 2007 was 3.2%. In the 1950s, forests covered 70% of the land area of the country. By 1992, forest coverage had decreased by nearly one-third, to just 47% of total land area. Despite the dwindling expanse, timber including ironwood, mahogany, pine, redwood, and teak and other forestry products benzoin (resin), charcoal, and sticklac constitute a valuable supply of potential export goods. The forest has also been an important source of wild foods, herbal medicines and related products, and timber for house construction.

The forests of Lao PDR have been threatened over time by various problems. Among others, these problems are slash-and-burn agriculture, uncontrolled fires, commercial and illegal logging, and fuel/wood collection. The deforestation rate has increased moderately since the close of the 1990s, but there is concern that the shift from a command economy toward a market-oriented economy will further put increasing pressure on the forest resources of Lao PDR.

The sector needs include: forest-meteorological observation stations, near real time data on critical parameters (incl. soil humidity), site specific weather forecasts, production of forest fire index, numerical weather forecasting models to produce site specific parameters, forest fire index, modeling and forecasting of dispersion of smoke, estimates of biomass production and its impacts on land use management and studies on the impact of climate change on the forestry sector.

3.10 Construction

Throughout the 1980s, the construction subsector of Lao PDR grew at an average annual rate of 1.1%, surging by 24% in 1989. Vigorous growth continued the following year at a rate of 15%, reflecting a big increase in private demand for new construction. Several sources estimate the construction subsector's contribution to the gross national product at about 5% throughout the decade. According to one estimate, the construction subsector employed more than one-fourth of all industrial workers in the country in 1986.

In support of the construction industry, the DMH is requested to provide the following data and information: climatological data of meteorological parameters (wind strength and prevailing direction, temperature, rainfall, humidity, etc.) in specific locations for building design and constructions, accurate site specific weather forecast (precipitation, wind, temperature, lightning,..): 1 day, now casting, meteorological measurement based load factors (wind, snow, water,..) for a renewed Regulations for Construction, intensities of precipitation for planning of drainage system, in future: mesoscale and micro-scale data on solar radiation on inclined surfaces, local wind, temperature chill factor for planning and site purposes of buildings and improved customer specified dissemination of information.

3.11 Land use and planning

In Lao PDR, a national program on land use planning and land allocation was created in 1996 under the overall responsibility of the Ministry of Agriculture and Forestry. Until 2003, district agricultural and forestry staff had conducted land use planning and land allocation activities in a total of 5,400 villages all over the country. It is estimated that a total of 300,000 Temporary Land Use Certificates had been issued as a result of the land use planning and land allocation activities. The National Land Management Agency has been created thereafter as the central agency in charge of all issues related to land management and administration.

The sector would require the following from DMH: hydro-meteorological hazard map and historical hydro-meteorological data for land use planning.

3.12 Tourism

In line with the Laos Government's desire to increase foreign exchange earnings, western tourists were first permitted to enter Laos in 1988, although just 600 persons visited, well within the official limit of 1,000. The following year, 2,600 tourists visited, and in 1990, the figure increased by 130%, to approximately 6,000 tourists. The Ministry of Trade was assigned with responsibility for the development of the tourism industry in 1989. In the following year, the government monopoly on the industry was removed, and nine private tourist agencies were authorized. As of 1992, tourism was somewhat limited to group travel. However, in later years restrictions have been eased and tourist arrivals in the country increased significantly up to the present. However, for sustainable tourism in Lao PDR, it is important that the Government introduce environmental impact management for tourism projects in the country.

Among the needs of the tourism sector are : weather forecasts tailored for tourist resorts, hydro-meteorological data for environmental impact and risk assessment, monthly and seasonal forecasts and forecast for extreme weather phenomena.

3.13 Insurance

The insurance business of Lao PDR appears limited given the low population, limited banking structures, strong government control, and other factors. The Lao PDR passed an insurance law based on the French model in 1990. The next year saw the opening of the insurer, Assurances Générales du Laos (AGL), as a joint venture insurance company. The company AGL was given an official three-year monopoly. Even in such a limited market, however, AGL has experienced encouraging results, with gross premiums growing from US$3.9 million in 2000 to US$8.9 million in 2005. The significant majority of these premiums are in non-life business.

The sectoral needs are: historical data /climatological normal for risk assessment, localized or site specific hydro-meteorological data for insurance claims due to weather disturbance and hydro-meteorological hazard maps.

3.14 Health

Currently, the state of the country's health services is severely challenged with the burden of diseases as reflected in the high infant and maternal mortality rates, as well as the high prevalence of diarrheal diseases, food poisoning, typhoid fever and hepatitis A. These are observed in areas where potable water supply and environmental sanitation conditions remain a problem. Malaria remains the leading cause of morbidity and mortality, with 70% of the population at risk. Dengue fever incidence seems to have increased in recent years, with 96.9 cases per 100,000 inhabitants in 2006. Outbreaks of dengue and measles are on the rise.Child malnutrition remains high, with 40% of the children stunted and 48.2% of children and 31.3% of females with hemoglobin levels below 11 g/dl. Health care availability and delivery is uneven across the country.

The incidence of air borne and water borne diseases are almost always associated with changes in weather parameters such as, rainfall, temperature, and relative humidity. This is usually observed when season changes from wet to dry or from warm to cold. The changes in the weather patterns are reflected in the weather forecast and bulletins issued by the DMH, however, the rural communities have limited or no access at all to these warnings. The DMH in coordination with the Department of Health and the NDMO must devise ways to improve the readability and extent of the forecasts to the rural communities. In addition, warning bulletin boards at the local community must in place. However, proper interpretation of the warnings should be provided by the DMH to the government agencies concerned and the public and this could be achieved through public information drives, meetings and fora.

3.15 Environment

In general, compared to other ASEAN countries, the natural environment of Lao PDR is relatively better due to a smaller population and slower pace of development. Below is a summary of major environmental areas of concern.

3.15.1 Water quality

The Water Quality Laboratory of the Ministry of Agriculture and Forestry reports that over the past 15 years of monitoring, water quality in Lao PDR has generally been good and is not significantly affected by human activities. This is in agreement with a Mekong River Diagnostic Study by MRC which indicated that "water throughout the Mekong River Basin is generally of good quality, but there are localized exceptions." However, with the pressure of rapid demographic growth, economic development and urbanization, water quality is increasingly likely to deteriorate.

Arsenic contamination is recognized as a potential problem in Lao PDR particularly in the Mekong river and in areas near the border with Viet Nam where arsenic has been found in bores. The disposal of waste is still problematic, and while a wastewater treatment plant had been constructed in Vientiane Capital, others cities continue to use drainage systems to natural canals and rivers. Similarly, solid wastes have a high potential to impact water resources and although the solid waste used for landfill in the capital is well operated and managed, elsewhere waste is disposed of indiscriminately with the attendant risks to health and the environment.

The water resources in Lao PDR have been deveoped and managed by a number of line agencies. The main agencies with responsibilities for water quality management include: Environment Quality Monitoring Center, WREA, Department of Irrigation, National Center for Environmental Health and Water Supply, Department of Meteorology and Hydrology (DMH), Factories Environment Division of the Department of Industry, Waterways Administration Division, Food and Drug Quality Control Center, Ministry of Health, Water Supply Authority, Department of Housing and Urban Planning, and Private Sector (Developers). The DMH in some cases, take water quality samples and forward them to the WQL in the Department of Irrigation for analysis.

The focus of water quality work in Lao PDR has been on general environmental monitoring, project-related environmental protection (EIAs, EMPs, etc) and public awareness and education. The current rapid development of water resources and impacts on watersheds is now bringing about greater risks for water quality deterioration.

It is important that the sector be provided with meteorological parameters that will serve as input in the development of water quality information system and regular rain water sampling analysis to check if polluted/acidic.

3.15.2 Air quality

Air quality (AQ) monitoring is still not a routine practice in Lao PDR. Monitoring of the concentrations of pollutants in the air remains to be on an ad hoc project basis. A relatively recent monitoring conducted was in March to April 2004 in three sites in Vientiane. In general, air quality in Lao PDR is considered very good. Results of the air quality study carried out showed that particulate matter levels were high during the period of study and that PM10 levels exceeded the international 24-hour standard most of the days. Sulfur and nitrogen dioxide levels were relatively low. Wind speed was found to be low during the measurement period indicating poor ventilation around the Vientiane area. Pollution is therefore trapped in the areas where they are generated, such as along roadsides where many people are affected.

The sector needs are: upper air observations to enhance the data on meteorological conditions of dispersion, dispersion modeling (traffic, indus-

try, dumping areas, ..), monitoring network for trans-boundary transportation of airborne pollutants, monitoring of urban air, quality, mobile monitoring stations to enhance some/many of the automatic weather stations to include monitoring of air quality, national database for air quality measurements, quality control and traceability of measurements to international standards, forecasting and warnings of quality of air, dissemination of information to the public and environmental databank.

3.16 Climate change

In May 2008, the Prime Minister established the National Steering Committee on Climate Change (NSCCC) and the Climate Change Office (CCO) within the Water Resources and Environment Administration (WREA) to coordinate the development of both a national strategy to manage climate change and its impacts, and an action plan that details substantive climate change leadership, action, and programmes for Lao PDR.

In Lao PDR, concerns about malnutrition and food insecurity can only be aggravated by the potential impacts of climate change. Problems including drought in the north and east of the country, flash floods in the low-lying Mekong River basin, and low yielding crops amongst the existing causes of food insecurity, all of which may be exaggerated by rising temperatures, changing rainfall patterns and more extreme tropical cyclones.

Lao PDR is a key agent in the mitigation side of the climate change equation in the region. However, it has failed so far to reverse the loss of tropical forests. The combined pressures of commercial interests in logging, copper and gold mining, and wood-pulp plantations have overwhelmed government institutions weakened by corruption and other problems.

3.17 Media

The ruling communists in Lao PDR maintain strict control over the media. The government owns all newspapers and broadcast media. Newspaper circulation figures are very low. Slandering the state, distorting party policies and spreading false rumours are all criminal offences. Many Laotian viewers watch TV stations from neighbouring Thailand. There were some 100,000 internet users by March 2008. The following are the main media institutions in Lao PDR: Press - *Vientiane Times* (English), *Le Renovateur* – (French), *Vientiane Mai*, *Pasaxon*; TV - Lao National TV (TVNL) - state-run, Laos Television 3 - joint venture with Thai company; Radio - *Lao National Radio* - state-run, News agency - *KPL* - state-run. The needs are: access to real time data, like weather radar images and public awareness programs.

4 THE METEOROLOGICAL AND HYDROLOGICAL SERVICE OF LAO PDR IN A NUTSHELL

4.1 Brief History

The Department of Meteorology and Hydrology (DMH) in Lao PDR has been registered as a member of the World Meteorological Organization (WMO) since 1st June 1955. From its original establishment, the DMH was under the Ministry of Transport and Public Work, named as National Meteorological Service (NMS) until 1975.

In 1976 NMS was transferred to the Ministry of Agriculture and Forestry (MAF). It was mandated to be also in charge of operational Hydrological Works and got the new name as Department of Meteorology and Hydrology (DMH). Later in 1997, DMH was given a new mandate to be also responsible for earthquake relate activities.

Due to the government strategy to reform agencies dealing with environment, water resources, climate change, and weather, in July 2007 the DMH was transferred from MAF to the Water Resources and Environment Administration (WREA) under the Prime Minister's Office.

Figure 4.1 DMH Headquarters at Vientiane Capital

4.2 General information

Name of Organization: Department of Meteorology and Hydrology (DMH) Office Address: Luangprabang Road, Ban Akat, P.O. Box 2903, Vientiane, Lao PDR
Website: http://dmhlao.etllao.com/
Telephone Nos. (856-21) 215010 and
T/F (856-21) 223446
Office hours: 0800H to 1700H
Weather service hours and office hours at synoptic stations: 0000 to 2400
Vision: Making Our Forecasts Essential to Everyone Everyday

The DMH headquarters is composed of the administration building, technical offices, instrument shelters and the radar building which house the C-band Doppler radar (Figure 4.1). Trainings and seminars conducted by DMH are usually held at the conference building.

Legal framework:

The DMH is a government agency under the WREA and directly under the supervision of the Office of the Prime Minister. As a government agency, it has the following functions and responsibilities:

- Hydro-meteorological data collection and dis semination
- Data processing and analysis
- Weather forecasting and aeronautical meteoro-logical Service
- Flood forecasting
- Hydro-meteorological network
- Earthquake monitoring
- Climate risk management and disaster early warnings
- Training
- International cooperation

4.3 Evaluation criterion

Concerning the duties and responsibilities of DMH, it has special relationships with and responsibilities with several ministries and state bodies, as follows:

- Ministry of Defense
- Ministry of Agriculture and Forestry,
- Ministry of Public Work and Transport
- Ministry of Labor and Social Welfare
- Ministry of Public Health,
- Ministry of Security,
- Ministry of Finance,
- Ministry of Foreign Affairs,
- Ministry of Industry,
- Ministry of Energy and Mining,
- Ministry of Education,
- Ministry of Information and Culture (Mass-Media)
- Lao Red-Cross

4.4 Annual report

DMH publishes a Yearbook annually where meteorological-hydrological data and important activities are reported.

4.5 Organizational structure

Administratively, DMH is headed by a Director General assisted by two Deputy Director General. The DMH is composed of eight (8) divisions as shown in Figure 4.2. To address the increasing demand of weather services for aviation, the Weather Forecasting and Aeronautical Division was split into the Weather Forecasting Division and Aeronautical Division in early 2010.

The concerns on meteorology, hydrology and disaster management are among the eleven thrusts of WREA's strategic program for 2011–2015. The DMH is committed to implementing this programme in consistency with the declaration of the 1st Summit of the MRC that took place in April 2010. The said programme is in line with the Prime Minister's Decree No19/PM in July 2010 which emphasized on disaster risk management and early warning system. The main components of the strategic program for 2011-2015 are:

- Identify the framework of weather and water related disaster risk management;
- Establish early warning systems;
- Provide meteorological and hydrological services to various concerned sectors;
- Provide earthquake and related data and information; and
- Involve in international and regional programs.

Through the Provincial Hydro-meteorological Services, the DMH maintains 17 provincial meteorological stations and 32 district stations.

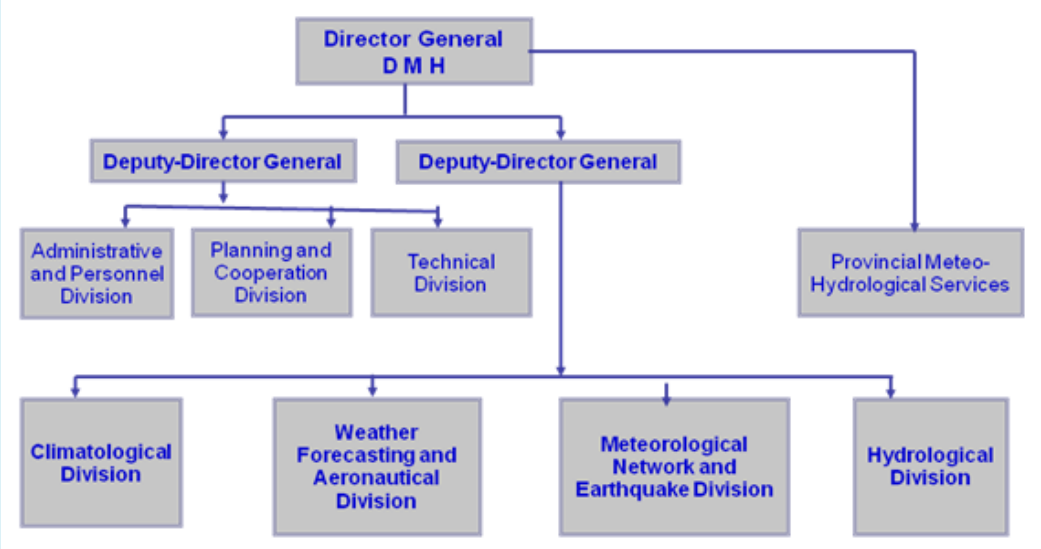


Figure 4.2 Organization Structure of DMH

4.6 Budget

From 2004 to 2009, when the DMH was still under the Ministry of Agriculture and Forestry (MAF), the budget for utilities was meagre ranging from 34,000 Kip to 54,000 Kip. It increased to 800,000 Kip from 2008 to 2009. The DMH budget for utilities was increased by more than 100% (Table 4.1) when the DMH was transferred to WREA.

Table 4.1 Annual budget of DMH
Exchange rate: US$1 = 8,250 kip; Unit: 1,000 Kip

Component	2004/2005 (by MAF)	2005/2006 (by MAF)	2006/2007 (by MAF)	2007/2008 (by MAF)	2008/2009 (by MAF)	2009/2010 (by WREA)
Electricity	13,000	14,000	16,000	17,000		
Water utilization	7,000	8,000	9,000	10,000	800,000	1,650,000
Telecommunication	14,000	15,000	16,000	17,000		
Technical	460,000	500,000	750,000	850,000	200,000	1,020,000
Administration	70,000	75,000	78,000	80,000	140,000	1,713,000
Salary	250,000	280,000	382,000	458,000	550,000	It is not include in the budget; it is remitted in the bank
Total	814,000	892,000	1,351,000	1,432,000	2,127,000	4,383,000

Remarks:
(1) Technical budget = operation and maintenance costs (equipment purchase and per diem of technicians to travel to the sites in questions)
(2) Expenses for one Radar per year has been allocated = US$7272.73 (60 Million Kip)
(3) DMH Lao PDR has no practices in purchasing land hence no budget is allocated for this issue.

The technical budget in Table 4.1 covers operation and maintenance (O&M) which includes the purchase of equipment and travel expenses and per diem of technicians. This does not include the annual O&M for the lone radar amounting to 60 million Kip. Although there has been a tremendous increase in the budget of DMH under the WREA, the O&M cost is not sufficient to address the current requirements of the DMH.

For the year 2009-2010, the total budget does not include the salary of the personnel but if it is maintained at the rate of the previous year, the total budget is around US$597,939.

4.7 Accounting system

The accounting is managed by the financial unit with only 2 staff.

4.8 Human resources

Currently, the total number of personnel in the DMH is 245. Out of which, 70 are detailed at the head-quarters while 175 are deployed in the provinces. There are 18 meteorologists, 10 hydrologists, 71 meteorology technicians, 11 hydrology technicians, 1 electronic engineer, 4 electronic technicians and 130 observers and support staff. There is only one IT specialist in the DMH. In terms of educational background, there is only 1 Ph.D. graduate, 22 M. Sc. graduates while the rest are undergraduates. The Weather Forecast and Aeronautical Division, which is responsible of issuing weather forecasts and other information, has 14 staff.

The DMH hires additional staff every year however, the new recruits are non-professionals and are more often deployed in the field stations. In 2010, it was able to recruit 5 staff and in 2011 the DMH will recruit about 6 more staff. It seems that new graduates in

engineering and allied courses have very limited motivation to work in the DMH. This is a challenge that the DMH has to address if the agency is serious enough to upgrade its human resource complement.

4.9 Training programmes

The DMH technical staffs have participated in training activities conducted by international institutions such as WMO, UNESCAP Typhoon Committee, JICA, Asian Disaster Preparedness Center (ADPC), and RIMES. The DMH also conducts its own Observers Training Course and Meteorologist Training Course based on WMO curricula, however these training courses are not conducted regularly due to budgetary constraint and limited young recruits to be trained. There is also a lack of technical personnel with expertise in meteorology and/or atmospheric science who will conduct the training courses.

With the increasing utilization of more computers and demand for timely dissemination of forecasts and warnings and the increasing demand for forecasts, the DMH considers the hiring of IT personnel and training of personnel in IT as urgent. To address the current issues and challenges, the DMH would require the following trainings:

- Training of engineers and technicians on the calibration of instruments including the provision of standards & toolkits;
- Operation & maintenance of AWS;
- IT specialists (including ICT skilled staff for coping with WIS framework and new GTS TDCF protocols);
- Data base system and management (including metadata collection and delivery techniques);
- NWP development & products utilization;
- Downscaling of Global Models for local Climate Analysis and Prediction; and
- Forecasters and observers training in conformity with WMO & ICAO standards.

4.10 Visibility of DMH

DMH air its daily forecast through TV and radio and publish it in newsprint which are all run by the state. It also maintains a website that provides daily weather forecasts, advisories, climatological data and other information related to DMH activities. About 100,000 internet users in Lao have visited the site in March 2008.

In the region, DMH is visible because Lao PDR is a member of the Mekong River Commission (MRC) with DMH serving the Laos National Mekong Committee and working closely with the MRC Secretariat. In the education sector, DMH is open to school children (Figure 4.3) to provide them with the basic knowledge about hydro-meteorological hazards in Lao PDR and the functions and activities of DMH to mitigate the impacts of these hazards as well as enhance the interest of students in science and technology.

4.11 International memberships and networking

Lao PDR is a Member of the Mekong River Commission, which was established by the 1995 Mekong Agreement signed by the Governments of Cambodia, Thailand, Viet Nam and Lao PDR. The countries work together to promote, coordinate, supervise and control the planning, investigation and implementation of water resource projects in the Lower Mekong River Basin. The MRC has the history of more than 50 years of cooperation since the establishment of the Mekong River Committee in 1957 among the four countries.

Lao PDR, through the DMH, is a member of the World Meteorological Organization since June 1955. It is also a member of the Typhoon Committee (TC), ASEAN Sub-Committee on Meteorology and Geophysics (SCMG), and the Regional Integrated Multi-Hazard Early Warning System (RIMES) that was organized through the Asian Disaster Preparedness Center (ADPC).

4.12 Cooperation with other providers of hydro-meteorological services in Lao PDR

The DMH maintains a good level of cooperation with WMO and the Typhoon Committee and avails of its hydro-meteorological services for the benefit of Lao PDR. It also maintains a good working relationship with the Department of Environment, Ministry of Agriculture and Forestry, Ministry of Public Work and Transport (MPWT) and the National Disaster Management Committee in providing hydrometeorological services to the country.

Figure 4.3 DMH on open house for elementary and secondary students

CURRENT SERVICES OF DMH 5

5.1 Weather services

The DMH provides meteorological information to users based on available tools and existing data from surface, satellite, and weather radar stations. Daily weather forecasts (table format) contain forecasts on maximum and minimum temperature and expected weather for synoptic stations in the country. These are issued daily every 10 AM. Three-day forecast are issued for key cities in Lao PDR and weekly forecasts are also available in the DMH website (Figure 5.1).

Tropical cyclone forecast is made based on the analysis of weather maps and tropical cyclone warnings derived from numerical weather prediction (NWP) products issued by global and regional forecast centers such as European Center for Medium Range Weather Forecasting (ECMWF), RSMC Tokyo, Korean Meteorological Agency (KMA), Hongkong Observatory, Vietnam National Hydrometeorogical Service, and Regional Integrated Multi-hazard Early warning System (RIMES), and products from other centers that are available in the internet.

Station	Temperature in C		Weather	
	Minimal	Maximal	Icon	Significant
Phongsaly	18	26		Scattered showers
Viengxay	21	28		Scattered showers
Samnue	21	29		Scattered showers
Xiengkhuang	20	27		Scattered showers
Oudomxay	23	29		Isolated showers
Bokeo	24	30		Isolated showers
Luangnamtha	23	29		Isolated showers
Luangprabang	24	32		Isolated showers
Sayaboury	24	30		Isolated showers
Vientiane Cap	24	30		Isolated showers
Phonhong	24	28		Moderate rain to heavy rain

Figure 5.1 Weather forecast displayed at the DMH website

Dissemination of forecasts & warnings

Weather forecasts and warnings for floods and severe weather events are disseminated to different sectors through telephone and the public through radio, TV and newspaper. The dissemination of forecasts and warnings is illustrated in Figs. 5.2 and 5.3.

State of forecast and warning dissemination in Lao PDR:

- Radio is the most powerful for public awareness on weather, flood forecast and warning.
- Television has less coverage in the country because the network does not cover all its territory.
- The internet services are available in most urban areas.
- People who are living in the remote areas can obtain weather and flood forecasts and warning information through radio broadcast.
- The remote areas people can also receive warning and announcement through local authority.
- The HF/SSB Radio transceivers network of DMH, public telephone, facsimile, e-mail, and web site are also used for delivering the weather and flood forecasts and tropical cyclone warnings to public.

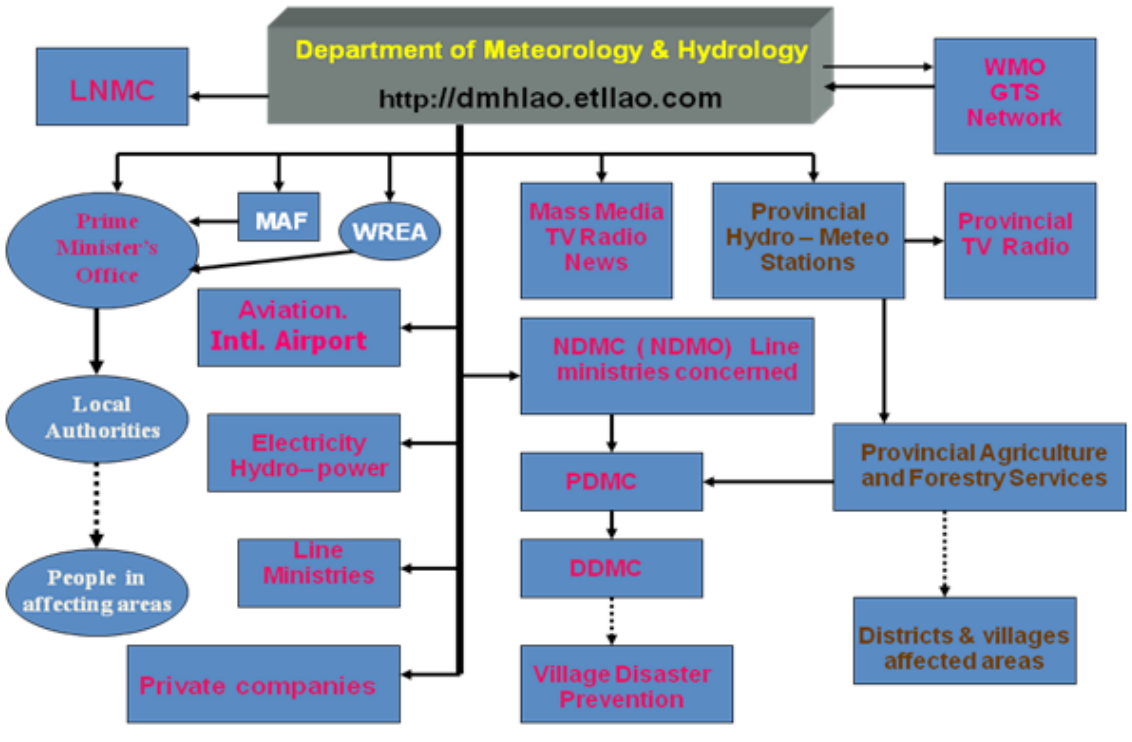


Figure 5.2 Flowchart of Forecast & Warning Dissemination in Laos

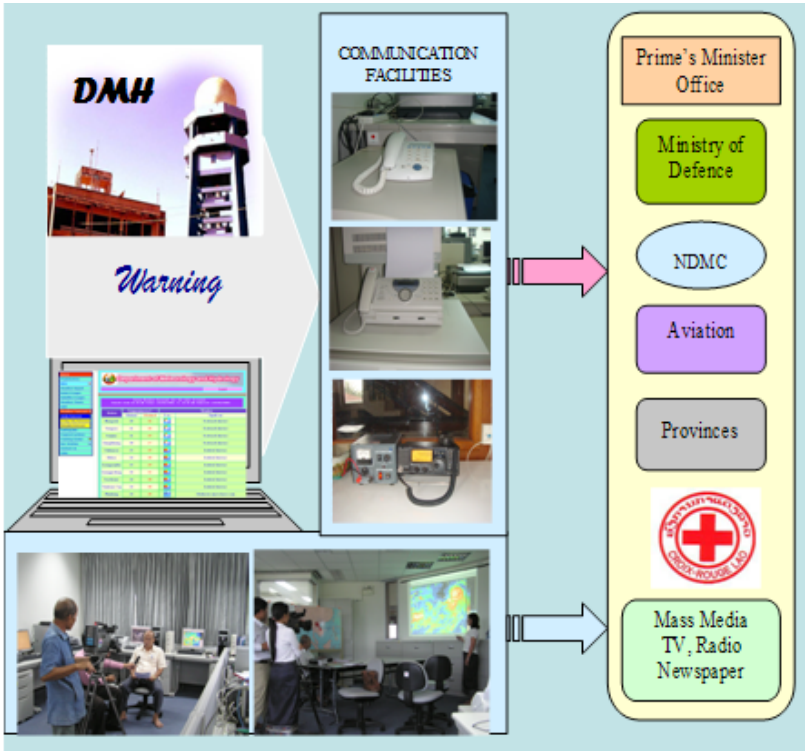


Figure 5.3 Severe weather warning dissemination

5.2 Early Warning System

The DMH has formulated criteria for the issuance of tropical cyclones, tropical storms, strong winds and heavy rains. The warning protocol for tropical cyclones and tropical storms are based on wind speed. Strong wind forecast is issued when there are no tropical disturbances while heavy rain forecasts are based on rainfall intensities. The categories for warnings of the various weather systems are shown in Table 5.1.

Table 5.1 Warning Criteria for Tropical Cyclones, Storm and Strong Winds and Heavy Rains

Hazard	Warning Category	Location of Storm/validity of forecast
Tropical Cyclones (with storm wind of 22 - 33 knots (10 – 15 meters per second or mps)	Near warning	When a tropical depression is located between 1100 to 1150E and issued once a day and valid for 24 hours.
	Urgent warning	Issued every 6 hours when the tropical depression is located nearest the west of 1100E.
Tropical Storms (when storm wind reaches 35 knots (15 mps) or greater)	Far warning	When the tropical storm is located between 1150 to 1200E, issued once a days and valid for 24 hours.
	Near warning	When the tropical storm is located 1100 to 1100E, issued once a day and valid for 24 hours.
Strong winds	Strong winds advisory	Strong wind is expected in the area and with sustained speed of more that 10-12 mps
	Strong winds warning	Strong wind is expected in the area and with sustained speed of more that 13-15 mps
Heavy rains	Heavy rain advisory	Issued when heavy rain of 60 to 80 millimetres per hour every 12 hours is expected
	Heavy rain warning	Issued when heavy rain of 100 millimetres per hour every 12 hours is expected

Table 5.2 shows the warning accuracy rate issued by the DMH in 2008. The current accuracy of DMH forecasts is generally acceptable based on WMO standards.

With the planned enhancement of the DMH capacities to meet the ever growing needs for improved weather, flood and climate related forecasts the DMH is working hard to increase the accuracy of its forecasts as shown in Table 5.3.

Table 5.2 Accuracy rate of forecasts and warnings issued by DMH in 2008

Forecast/ warning	Yes/No	Warning accuracy rate (hit rate %)	Number of warnings issued
Flash flood	Yes	80%	3
Tornado	No		
Strong winds	Yes	80%	2
Thunderstorm or lightning	Yes	85%	3
Tropical cyclone	Yes	85%	3
Drought	Yes	80%	0
River flooding	Yes	90%	5

Table 5.3. Desired accuracy of weather forecasts (in %) that could be achieved through better observations, new tools and general strengthening of the DMH

Forecast range	Accuracy of warnings (% of correct forecasts)		Lead-time of warnings (hours/days)	
	In 2 years	In 5 years	In 2 years	In 5 years
Short-range	85%	90%	1 day	3 days
Mid-range	80%	85%	2 days	5 days
Long-range	75%	80%	5 days	10 days

5.3 Climatological services

The DMH monitors drought and issues drought forecast if necessary. Drought forecast issuance is based on statistical method using Markov's Chain method for some selected areas such as Vientiane, Pakse and others. Warnings are made through the routine communication channel.

The DMH also provides daily, monthly and annual normal mean maps of precipitation, minimum and maximum temperature and published in the website. Monthly and annual mean maps are produced and included in the DMH Yearbook. The usual climate data clients include policy makers, public authorities, educational institutes, economic sectors and the Department of Environment.

However, considering the increasing demand for meteorological and hydrological data by the various sectors, the DMH considers it a priority to upgrade its database management, increase its storage capacity, use of GIS, and automate the process in the production of analyzed climate data and dissemination of data and information in electronic format.

5.4 Agrometeorological services

Crop yield forecast is issued by the DMH in the website to provide information for farmers and agriculturists. The forecast is derived using the Agrometshell Crop Modeling system which is capble of deriving crop features during growing season. The model simulates water balances at the station and interpolates water balance parameters. It can also provide a graphic presentation of the model outputs. Agro-meteorological bulletins containing information on weather and crop related information are also prepared and posted in their website.

5.5 Services for aviation

The DMH provides hourly forecasts for aviation based on the requirement of the International Civil Aviation Organization (ICAO). The main international airport in Wattay is connected with the DMH headquarters via High Data Rate Spread Spectrum Transceiver (SST) and a 2.4GHz, Wireless Link to access the radar data of DMH for safety in air navigation.

5.6 Hydrological services

The Mekong River runs longitudinally in the country and its catchment encompasses almost the whole of Lao PDR. Hence the hydrological services of DMH are closely coordinated with the Laos National Mekong Committee and the MRC Secretariat. The DMH is responsible for hydrological services including flood forecasting for low-lying areas of the Mekong River basin on the Laos side.

Flood forecasts are issued for low-lying areas of the Mekong River basin using empirical method, SSARR model from the Hydrology Unit provided by the MRC Secretariat. For tropical cyclone and rainfall forecasts, DMH makes use of forecasts and information from Hong Kong Observatory and Japan Meteorological Agency (JMA). Flood warning messages are issued through radio, TV, and press as well as to the different government agencies.

The daily hydrological forecast is prepared by the DMH using stage correlation techniques with manual adjustment under certain conditions. In other flood-prone tributary areas, short-term forecasts (based on three-hourly reports) are also disseminated to the local authorities when a rapid change in a weather condition is expected or when heavy rainfall is forecast in the central and southern provinces.

The DMH provides the 0700H water level report and two-day forecasts in nine stations of the Mekong River in its website (Figure 5.4). Another feature of the display is the graphical presentation of the water level per station. The observed water level at the 16 tributaries of the Mekong River including the warning and danger levels at each station are also provided in the hydrological services of the DMH webpage (Figure 5.5.).

The DMH also monitors the levels of dams/reservoirs and provides flood forecasts to private companies that manage the dams. In case of high flows and the danger level is expected to be reached or exceeded and warrants the operation of the spillways, the DMH informs the Government Board which the Deputy Prime Minister chairs. Once the decision to open the spillways has been decided by the Board, the Minister of Energy issues the warning to operate the spillways to the operator of the dam. As far as flood forecasting and warning system for dam operation is concerned, the DMH provides advice to the Government Board when to open and close the gates based on the weather forecasts.

Meanwhile, the WREA is responsible for water-related natural disaster prevention and preparedness activities in cooperation with the communities and other organizations responsible for the maintenance and protection of dikes.

Mekong River

Station	Water Level Observation (m)			Warning Level (m)	Danger Level (m)	Water Level Forecast (m)	
	29 Oct 09	30 Oct 09	Graphic			31 Oct 09	01 Nov 09
Hoaysai(Mekong)	2.72	2.80		15.00	16.00		
Pakbeng(Mekong)	7.51	7.51		29.00	30.00		
Luangprabang	6.23	6.08		17.50	18.00	6.06	6.00
Vientiane (km4)	3.79	3.75		11.50	12.50	3.71	3.70
Paksane	5.50	5.55		13.50	14.50	5.53	5.38
Thakhek	4.85	4.73		13.00	14.00	4.76	4.75
Savannakhet	2.50	2.39		12.00	13.00	2.33	2.32
Pakse	4.14	0.00		11.00	12.00	4.04	4.01
Nam Ngum Dam(Up)	210.18	210.16		212.00	212.31	210.15	210.14

Figure 5.4 A sample display of the water level report at the website of DMH

Mekong's tributaries

Station	Water Level Observation (m)		Warning Level in (m)	Danger Level in (m)
	29 Oct 09	30 Oct 09		
Muang Ngoy (Nam ou)	1.48	1.45	---	---
Naluang (Num Ngum)	2.67		7.00	8.00
Hineheup (Nam Lik)	2.68	2.62	14.00	15.00
Pakkagnoung (Nam Ngum)	3.89	3.88	11.00	12.00
Veunekham (Nam Ngum)	2.76	2.60	12.00	13.00
Muang Mai (Nam Ngiep)	2.26	2.22	10.40	11.40
Muang Kao (Nam Sane)	2.41	2.39	7.00	8.00
Phonesy (Nam Kading)	2.58	2.45	13.75	14.75
Mahaxay (Sebangfai)	4.41	4.26	13.64	14.64
Sebangfai at Bridge	8.30	0.00	17.50	18.50
Lahanam (Sebanghieng)	0.00	0.00	15.30	16.30
Khongsedone (Sedone)	2.52	2.37	12.30	13.30
Attapeu (Sedone)	6.72	6.69	15.00	16.00
Tonhene (Sebangfai)	3.04	2.90	12.00	13.00
Sopnam (Sebanghieng)	3.64	3.54	16.00	17.00
Kengkok (Sechamphone)	1.30	1.27	7.50	8.50
Remark: 00.0 = No data				

Figure 5.5 Water level information at Mekong's tributaries displayed at the DMH website

5.7 Marine services

Since Lao PDR is a landlocked country, the DMH does not provide marine services but only hydrological information for waterways transportation.

5.8 Climate change related services

The DMH through its Climatology Division provides scientific background and climatology reports to the Climate Change Office.

5.9 Environmental services

Water quality

As one of the Water Quality Management Agencies, water quality samples at some cases are taken by DMH staff and forward them to the Water Quality Laboratory of the Department of Irrigation for analysis.

Air quality

As regards air quality, the Environmental Protection Law (EPL) mandates the Science Technology and Environment Agency under the Prime Minister's Office as the main government agency responsible for environmental protection. The Department of Energy (DoE) the Ministry of Communications, Transport, Post and Construction (MCTPC) and the Environment Research Institute (ERI) are also involved in air quality monitoring. DHM provides information on various meteorological parameters (e.g. wind speed and direction) during air quality monitoring.

5.10 UV radiation: None

5.11 R&D based Expert Services

DMH personnel are not involved in any research activities. Under WREA, the Water Resources and Environment Research Institute (WRERI) conducts research including the application of appropriate science and technology for the management of water resources, environment, meteorological and hydrological activities. It would be beneficial for DMH to conduct collaborative researches with the WRERI to improve and enhance its services.

In order to significantly improve its services, the DHM needs to embark on R&D activities. Since this is not part of the institutional set-up and functions of DMH, the agency must start with simple applied research activities internally or within the different divisions and/or collaborate with WRERI and the Laos National Mekong Committee. The DMH can also participate in studies on severe weather systems affecting Indochina in coordination with Viet Nam.

Currently, the Graduate School of Science of the Kyoto University is conducting a cooperative study towards mitigation of water disasters in Indochina. The study is focused on analysis of remote sensing and in-situ observation by downscaling meteorological numerical model to understand extreme weather phenomena such as monsoon and tropical depressions in South-east Asia. The study makes use of 4 radars (1 in Vientiane, 1 in Viet Nam and 2 in Thailand) covering the target area (Figure 5.6). The ultimate objective of the study is to increase the lead-time to predict extreme weather in order to improve the understanding and prediction skills of extreme weather (Satomura, 2010). The DMH has been providing data to facilitate the conduct of the study.

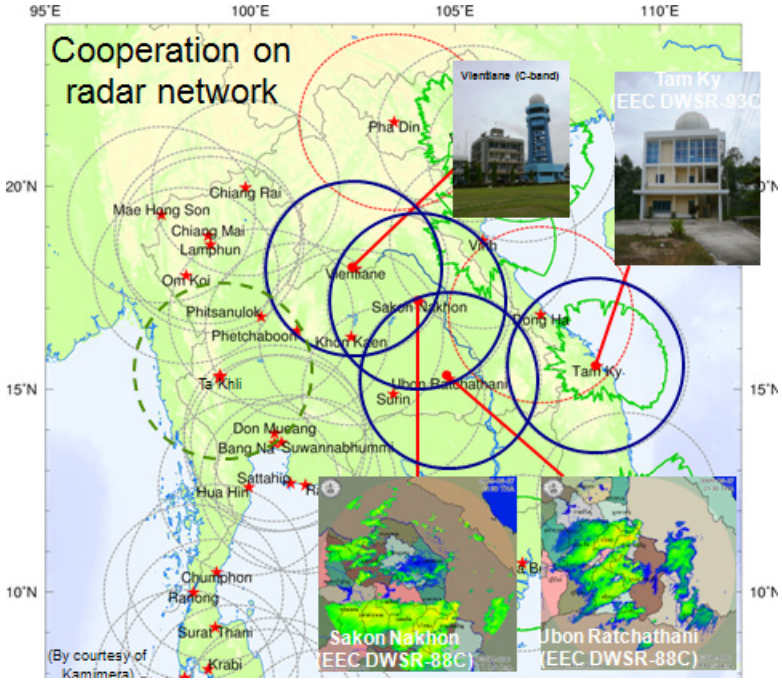


Figure 5.6 Network of radars used in the study

Figure 5.7 Homepage of the Department of Meteorology and Hydrology, Lao PDR

5.12 Information services

All forecasts and warnings are directly transmitted to the Prime Minister's Office, Ministry of Defense, National Disaster Management Committee, airport stations, provinces, Lao Red Cross and the mass media (TV, radio and print). Press conferences are also carried out during inclement weather.
The DMH publishes the Yearbook, which contains archived meteorological, climatological and hydrological data and information.

The DMH maintains a website, *http://dmhlao.etllao.com* (Figure 5.7) which provides weather report including weather charts, radar images, water level along Mekong River, climatological data, tropical cyclone forecast, other related information, news and activities. The DMH website also provides links to different international agencies and forecasting centers, such as

WMO, *http://www.wmo.ch/pages/index_en.html*

Severe Weather Information Center, *http://severe.worldweather.wmo.int*

International Civil Aviation Organization, *http://www.icao.int*

JMA, *http://www.jma.go.jp/jma/index.html*

China Meteorological Administration, *http://www.cma.gov.cn*

Hydro-Meteorological Viet Nam, *http://www.nchmf.gov.vn*

6 LAO PDR NETWORK OF OBSERVING STATIONS

All observed data from the network of ground observations and those from satellite and radar are transmitted and stored at the data collection and dissemination center for processing and analysis as illustrated in Figure 6.1.

6.1 Surface network

The DMH operates 17 main synoptic stations and 32 secondary synoptic stations (Figure 6.2) and out of the 49 synoptic stations, 10 are located at airports and are utilized for providing aviation services (Figure 6.3). The DMH has 128 manual rainfall stations but only 93 are currently operational (Figure 6.4). The DMH also operates 109 staff gauges and 49 discharge stations (Figure 6.5) and 3 seismic stations located in Luang Prabang, Lak Sao and Vientiane (Figure 6.6). The seismic stations are equipped with modern seismic equipment and facilities shown and described in Figure 6.7. All synoptic stations are manned. The DMH has a future plan to migrate gradually to unmanned Automatic Weather Stations (AWS).

The DMH is operating 28 climatological stations, however at the time of assessment only 20 climate stations are operational. There are no agrometeorological observations as well as air quality observations.

The Mekong River Commission Hydrological Cycle Observation System (MRC-HYCOS) has also established 3 stations along the Mekong river and 9 stations along the Mekong tributaries which are fully automatic (Figure 6.7). The MRC-HYCOS is equipped with an automated data acquisition and telemetry communication system.

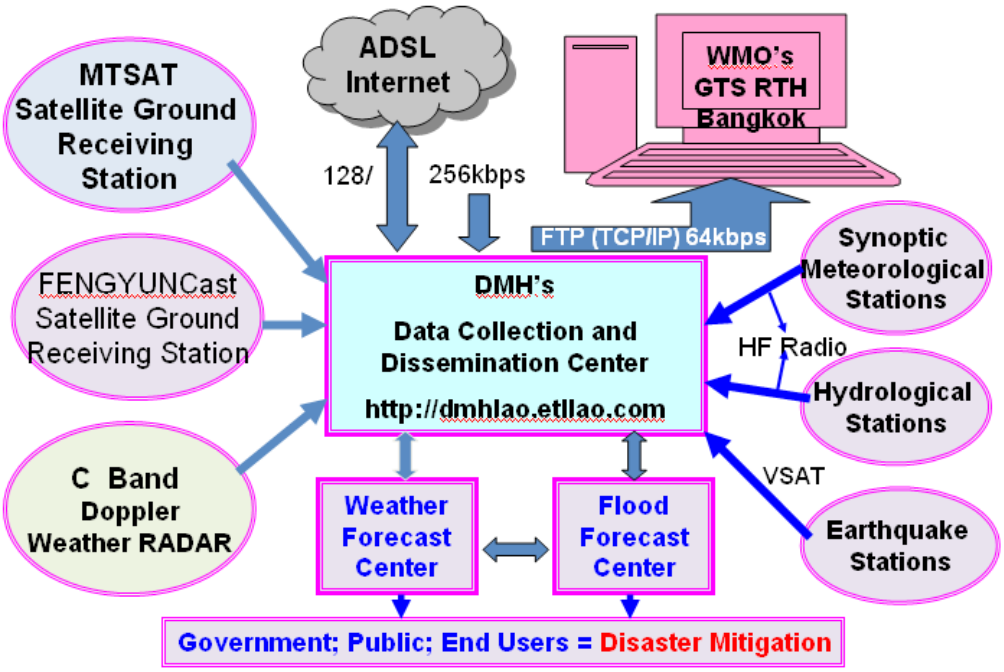


Figure 6.1 Network of observing stations and facilities of DMH Lao PDR

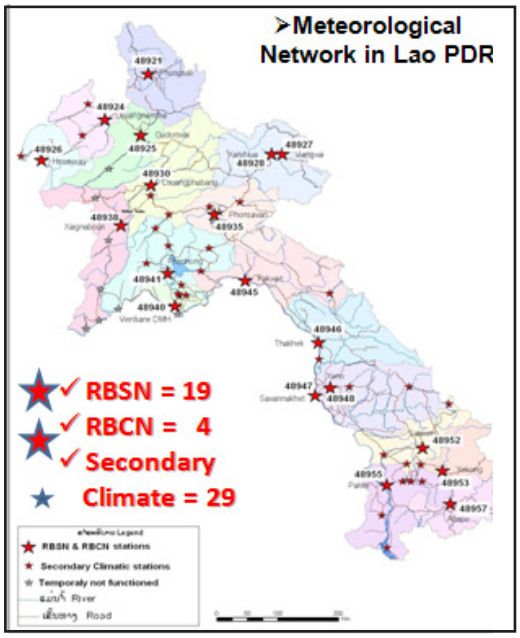


Figure 6.2 Meteorological network

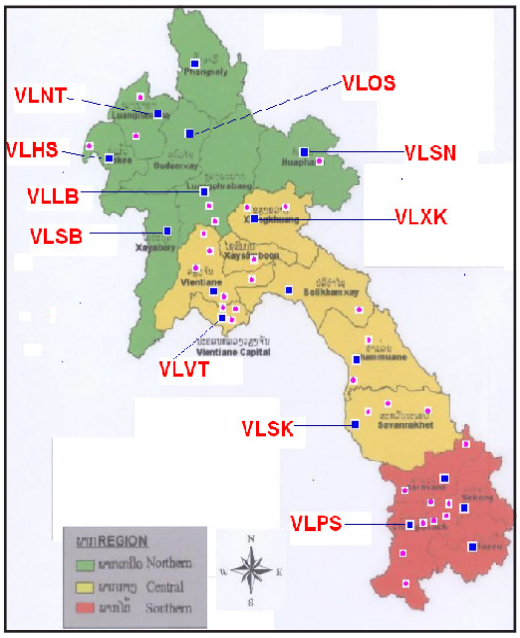
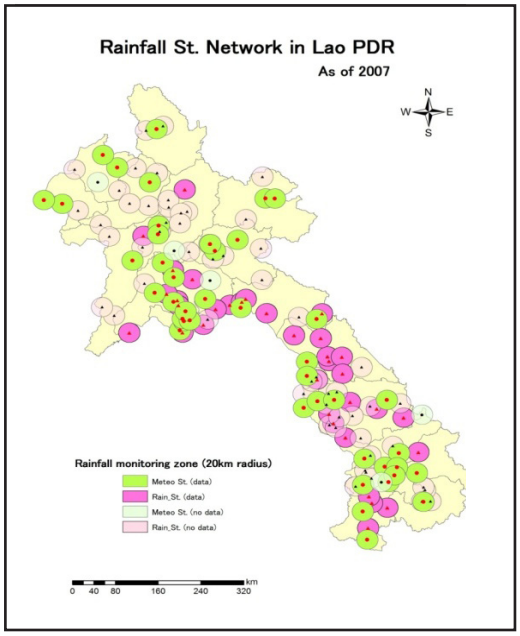


Figure 6.3 Meteorological stations serving the aviation sector



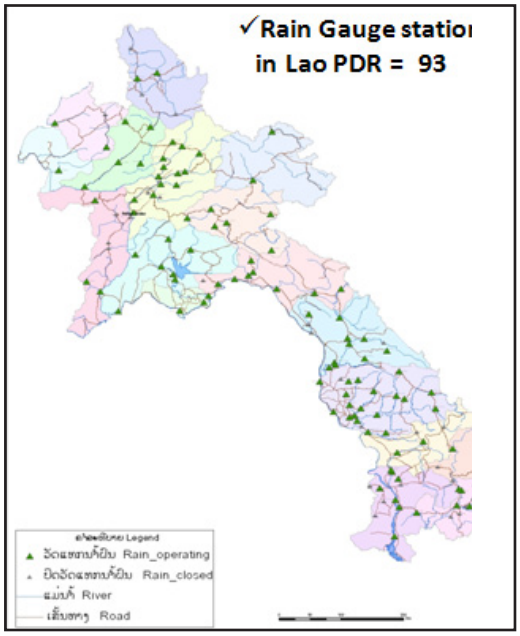


Figure 6.4 Network of rainfall stations in 2007(left) and current (right)

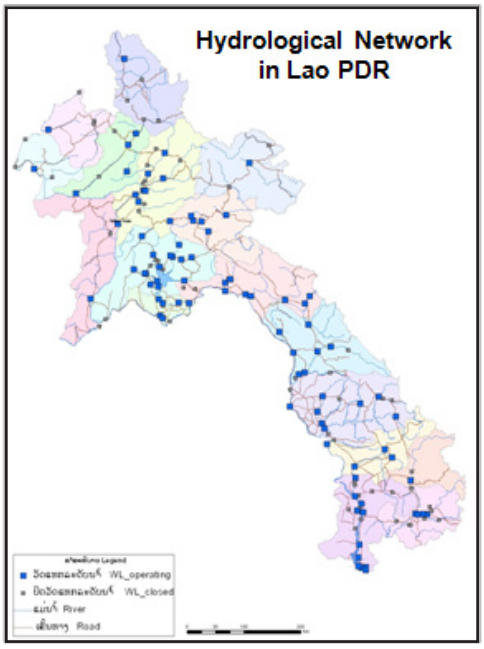


Figure 6.5 Hydrological network

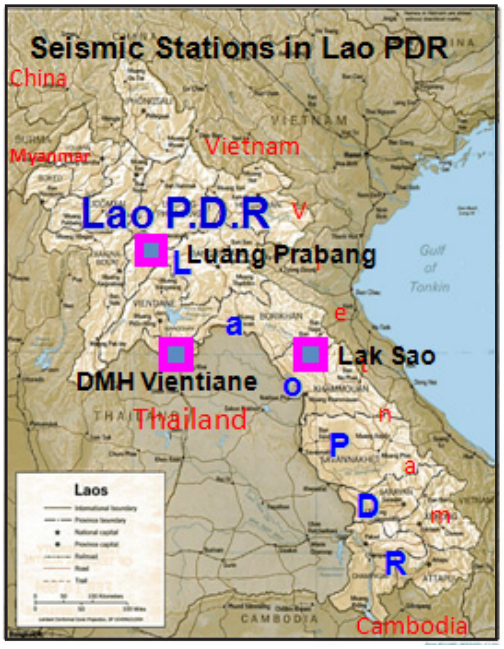
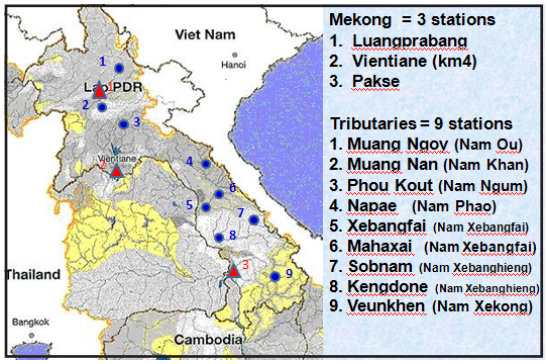


Figure 6.6 Network of seismic stations

Seismograph	Specifications	Gallery
Very Broadband	**CTS-1 Very Broadband** Flat-to-velocity response band at 3dB level: 360s～0.02 s Sensitivity: 2×1000 V/m/s	
	BBAS-2 fore-balanced accelerometer Flat-to-acceleration response band at 3dB level: 3600s～360s Sensitivity: 2×10000 V/m/s²	
	EDAS-24L6/EDAS-IPU digitizer	
	EDSP software for single station	

Figure 6.7 Main components (left) of a seismic station (right) in Lao PDR



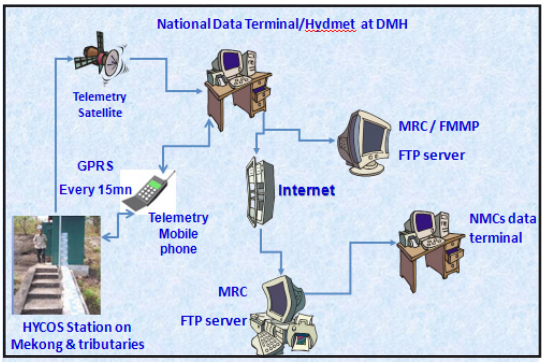


Figure 6.8 MRC Hydrological Cycle Observation Stations (HYCOS) in the left figure and data acquisition system in the right

6.2 Remote sensing

There is no upper station in Lao PDR. The DMH operates 1 C-Band Doppler weather radar (Intensity mode 400 Km; Doppler mode 120 km) in Figure 6.9 that was acquired through a JICA grant. The radar is installed at the DMH Headquarters in Vientiane and operated by technical staff trained by the JICA experts. Its annual operation cost is about US$7272.73 (60 million Kip).

The DMH has two (2) satellite receiving facilities: the MTSAT from Japan (Figure 6.10) and the FENYUNCast, FY-Series from China), Receiver FY-2C/2D.

Figure 6.9 C-Band Doppler Weather

Figure 6.10 Satellite Ground Receiving Station

7 MAINTENANCE, CALIBRATION AND MANUFACTURING OF MEASUREMENT SYSTEMS

7.1 Meteorological observations

7.1.1 Maintenance

Proper maintenance of instruments and equipment under the DMH is a basic requirement to ensure the quality of observed data in the country. Maintenance of measurement systems is performed by DHM or in cooperation with the manufacturer.

7.1.2 Calibration

One of the important issues on instrumentation is the calibration of observation instruments. DMH Lao PDR does not have the standard calibration facilities. The technician team of DMH attends to the instrument installation and maintenance.

7.1.3 Metadata

Metadata including description of the environment and location/size/height of nearby obstacles (trees, buildings etc) for synoptic stations is not completely available.

7.1.4 Traceability

Traceability of the meteorological measurements to international and national standards and references is maintained by Hydro-Meteorological Network and Earthquake Division

7.2 Hydrological observations

For hydrological stations, the quality and quantity of stations along the Mekong River are sufficient thanks to the support of the Mekong River Commision. However, the major tributaries of the Mekong River have still limited gauging stations.

Private electric companies are conducting studies in the construction of seven major dams in northern Lao PDR and part of the project will be the establishment of rainfall, water level and weather stations. Since the DMH is involved in the project, it must ensure that the monitoring facilities to be acquired will meet WMO standards.

The calibration of measurement systems and traceability of the hydrological measurements to international and national standards and references is maintained by the Hydrology Division.

NUMERICAL WEATHER PREDICTION

8

The existing facilities of DMH are not sufficient to run numerical weather prediction models. In addition, the DMH lacks trained personnel to use NWP tools to improve its weather forecasts, as well as the software and hardware.

Currently, DMH prepares and formulates its weather forecasts based on its network of ground observations, radar (Figure 8.1) and satellite data (Figure 8.2), and from downloaded NWP products from global and regional meteorological centers. However, since there are already available numerical weather forecasts in the region such as those daily forecasts provided by RIMES (Figure 8.3) specifically for DMH Lao PDR and also ECMWF, there is no need to acquire the expensive software and hardware for numerical weather prediction. Apart from the high cost of NWP software and hardware, maintenance of these tools would also require considerable budget and manpower.

The DMH has one radar and quantitative rainfall forecasts can only be carried out within the range of the Doppler radar. Because the radar is located at the headquarters near the airport, the weather forecasting capability of the radar can serve well the requirement of the main international airport in Lao PDR. For rai nfall forecasting in the country, the DMH Lao PDR accesses the network of the real-time radar imageries of the Thailand Meteorological Department (TMD) which are published in the TMD website. The radar information serves as guidance in the formulation of weather forecasts for several provinces in the country. The DMH would benefit from the use of the mosaic digital rainfall estimates from the TMD radars to improve its meteorological services.

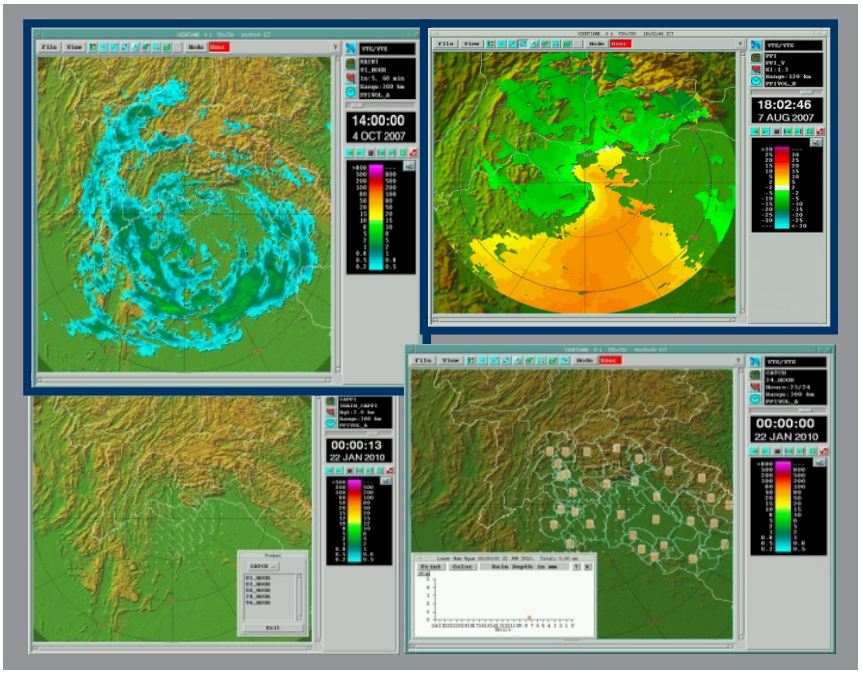


Figure 8.1 Radar image showing estimated

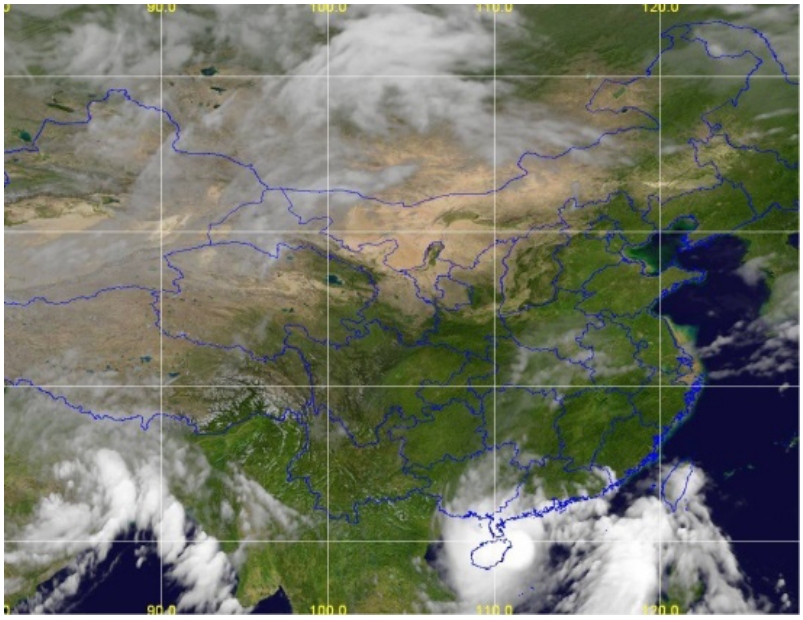


Figure 8.2 Satellite image (MTSAT)

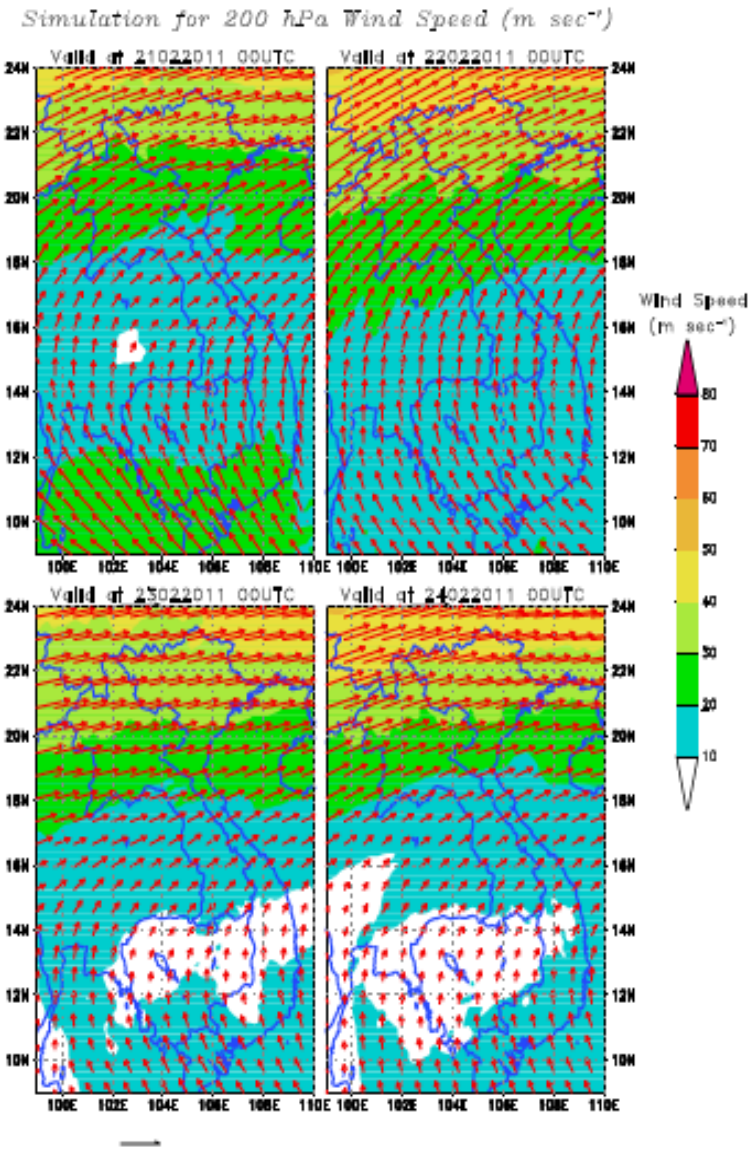


Figure 8.3 Wind at 200 hPa product of RIMES

The NWP outputs (Figure 8.3) from RIMES have been utilized as guidance in the formulation of daily weather forecasts and 3-day city weather forecast in the country since 2009. Based on the validation made by DMH, level of accuracy of the forecast products from RIMES is medium to high as follows:

- The 24-hour product is very useful information, but sometimes overestimated especially in rainy season.
- MSLP products serve as good guidance but it's a bit overestimated.
- Wind at 850 hPa product is perfect.
- Wind at 200 hPa is perfect.
- The 850 hPa geopotential height bit overestimated while temperature product is perfect.
- The 500 hPa Geopotential height is a bit overestimated.

During the RIMES Regional Council meeting in February 2011, Lao PDR requested RIMES to address its current needs which include:

- Provision of 6 hour or 12 hourly NWP products
- Add the surface temperature NWP product
- Daily access of NWP products if possible before 0930H (Lao PDR time).

The DMH has the Synergie Version 3.4.0 software capable of automatic plotting of meteorological parameters and forecasts (1 day up to 3 days) of various parameters at different levels in the atmosphere. The software combines observations, satellite data, radar images and NWP model outputs (e.g. RIMES shown) to improve the presentation of analysis (Figure 8.4).

The most important need of the DMH to be addressed is the training of technical personnel on the use and interpretation of these NWPs. Verification of NWPs should also be conducted. The access and use of the mosaic digital rainfall data from the TMD radars should also be pursued.

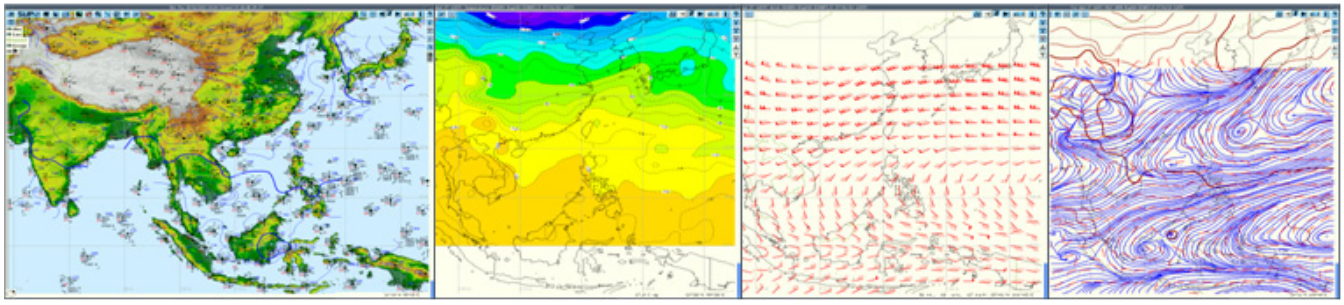


Figure 8.4 Outputs from the SYNERGIE software (from left to right): Surface drawing parameter, 850 hPa temperature, upper wind and forecast chart overlay

9 INFORMATION AND COMMUNICATION TECHNOLOGY (ICT)

Communication and information technology are important components for an NHMS to carry out its mandates. Information technology is the backbone of an operational NMHS because it enables the dissemination of forecasts and warnings timely to the threatened communities so that they can plan and act accordingly before the occurrence of a disaster.

9.1 Communication facilities

DMH utilizes various types of communication systems to collect and disseminate data and other information. The communication facilities of DMH are summarized in Table 9.1.

At the national level data collected from the National Meteorological Telecommunication Network (NMTN) is manually operated using HF single side band radio, public telephone, and fax (Figure 9.1) then the data are compiled into the prescribed format in the switching computer to the GTS link.

At the international level, GTS leased line, FTP (TCP/IP 64 kbps) is used to transmit and receive observation data including ECWMF products. DMH Vientiane is connected to Ha Noi by 9600 BPS satellite link PSTN (receive only) through which data are received. Internet is used to access SADIS data and products for aviation from the UK Met Office.

9.2 Data management

For data management, the facility of the Data Center in DMH is composed of 2 servers, one for data processing and the other for the database (Figure 9.2). In 1996, the DMH acquired and installed CLICOM software. For climate data management, the INSTAT software is used.

Using the SYNERGIE workstation (Meteor France), automatic processing and display of weather charts and other forecasting tools are utilized by DMH (Figure 9.3).

Forecast products can be generated using Dream Weaver to create a statistic web page of meteorological and hydrological information in DMH webpage (Figure 9.4).

DMH has not completely developed a real-time quality control system based on logical checking for manned stations. Additionally a non real-time quality control system, based on extended logical and time & space checking is in use for all stations.

9.3 IT infrastructure

For its IT infrastructure, the DMH network is provided by the Enterprise of Telecommunication of Laos (ETL), which includes one Broadband (ADSL) Intenet connection with a speed of 128/256 kbps. But the coverage of the DMH infrastructure does not reach the remote areas in the country. The HF radio still serves as the primary channel to communicate in far-flung areas.

Figure 9.1 Data collection facility for domestic stations

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

RD = to receive data/observations, RI = to receive information/products, SD = to send data/ observation, SI = to send information/products, RW = to receive warnings, SW = to send warnings.

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

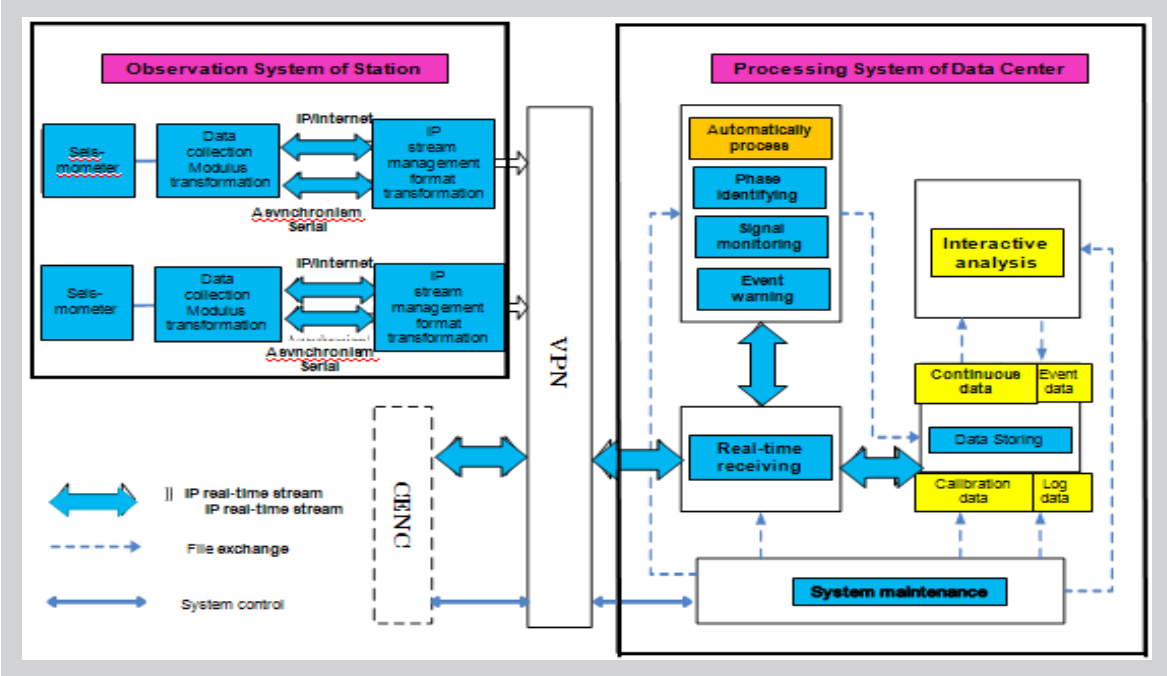


Figure 9.2 Topology of the Data Center

9.4 IT Personnel

The lone IT personnel employed by DMH cannot fully maintain IT equipment such as PC help desk, operation of the main computers, communication system and other related tasks. The DMH should recruit young IT graduates or have the maintenance of its equipment be contracted to private IT companies to ensure the continuous operation of the facilities.

9.5 Needs to improve communication system and data management

The plan of the DMH to increase the number of automatic stations must be coupled with the upgrade of its data communication network from HF to GSM (from field stations to the headquarters). However the DMH has yet to prepare a concrete plan or study to improve its existing meteorological and telecommunication system. Any study on communication upgrade should take into consideration robustness, redundancy and seamless communication system and must be coordinated with the ETL of Laos. The ETL can provide advice on the most appropriate IT system and facilities that will meet the needs or requirements of the DMH. The use of GPRS can increase data observation every 10 minutes.

The DMH is planning to embark on integrated decision and information system to forecast severe hydro-meteorological and environment events. This is being planned in cooperation with stakeholders and end-users to promote collection and sharing of data and extending their use to meet local, regional and international commitments

Other needs include:

- Automation in collection real-time hydro-meteorological data
- Increase data density to 10 min on GPRS
- Develop data base system and data management system
- Upgrade disk storage and backup system
- Historical data in electronic database
- Upgrade of safety systems
- Development of real-time data QC systems
- Promote common real-time use of all hydro-meteorological and environmental data
- Upgrade the IT infrastructure, both hardware and software

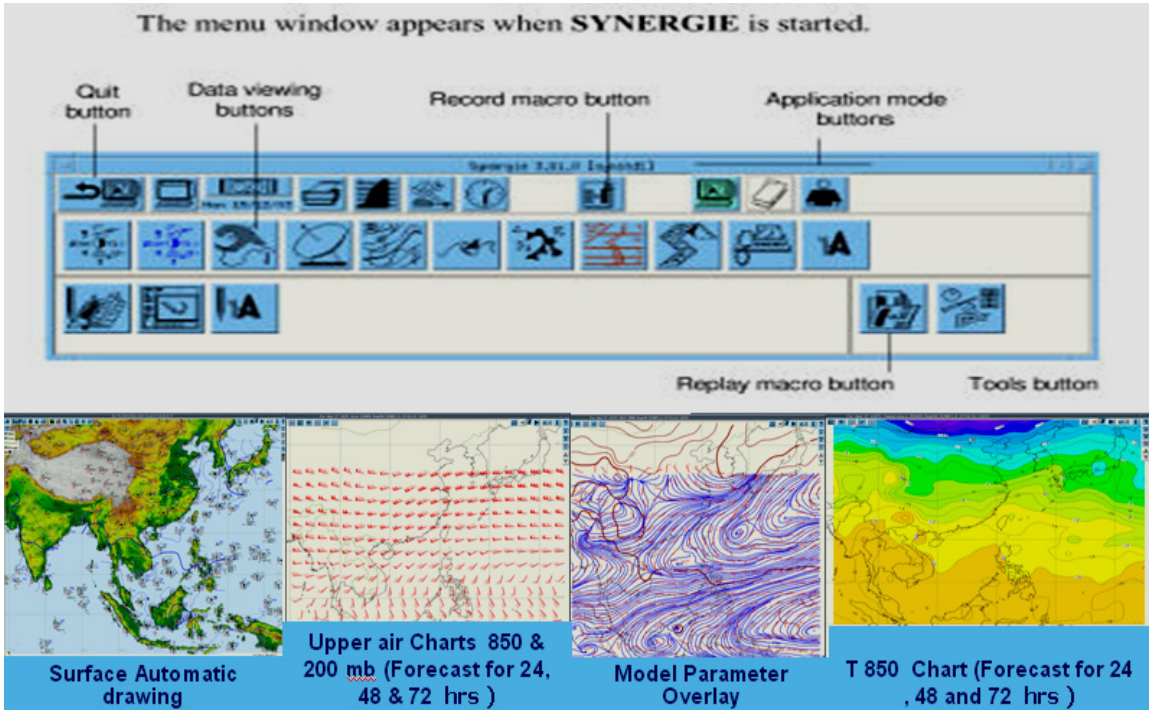


Figure 9.3 NWP products from ECMWF for Severe Weather monitoring and forecasting in Laos using Synergie Version 3.4.0

Figure 9.4 Statistic webpage created by Dream Weaver software

10 NATIONAL AND INTERNATIONAL COOPERATION AND DATA SHARING

10.1 National

Data sharing between DHM and the users of its information is still very limited considering the quality of the data and the condition of the DMH database. Currently, the data and other information are shared to the public through DHM's webpage while processed data are provided upon request. Historical data are not complete hence the DMH was not able to provide the necessary input data for deriving the climate change scenarios for Lao PDR.

The DMH Lao PDR does not have any upper air station. To augment the limited data of Lao PDR, the DMH must start negotiating with other NMHS in the region especially China, Viet Nam, Cambodia and Thailand. Through the Mekong River Commission, the DMH Lao PDR has access to two upstream hydrologic stations in the upper Mekong River, which is utilized for flood forecasting and warning purposes. But hydrometeorological data are limited along the major tributaries of the Mekong River.

Since September 2010, the UN Food and Agricultural Organization (FAO) in collaboration with RIMES is implementing a project on enhance the use of seasonal forecasts for decisions related to food security. Part of the project is the setting up of a Monsoon Forum where users of weather and climate information can interact with DMH. The first forum Monsoon Forum was held in February 2011 and attended by 60 agencies. This interaction will also facilitate the full utilization of the existing forecasts and further improvement of the forecasts based on the needs of the users.

There are simple but effective ways to share data and information to the public such as putting info boards in disaster stricken areas. This requires a minimal budget, which the DMH Lao PDR can readily afford or its undertaking can be negotiated with the private sector.

10.2 International

At the international level, the DMH uses a GTS leased line, FTP (TCP/IP 64 kbps for transmission and receipt of observed data to RTH Bangkok including ECMWF NWP products (Figure 10.1). DMH Vientiane is connected to Hanoi by 9600 BPS satellite link PSTN (receiving only) through which data are received. Internet is used to access the FTP Server of UK SADIS data and products for aviation.

International exchange of hydro-meteorological information; types and codes of information:

- Single Station report described in the WMO/ ICAO documents and Validity
  Time: METAR, SPECI, TAF
- Reports (e.g. SYNOP, PILOT etc.): SYNOP, CLIMAT
- Imaged products (e.g. satellite and/or radar images): None
- Table-driven code format (BURF, CREX, GRIB): None

The limitation can also be seen in the data shared within the region through the GTS (Figure 10.2). The current data-sharing protocols does not meet the standards of WMO and some errors have been notes in the past as a result of the monitoring and checking done by RSMC Tokyo.

DMH Lao PDR has been connected as one GTS terminal to RTH Bangkok with dedicated leased line of 64 kbps speed. Since its establishment in 1988

through the support of WMO VCP, the stand alone message switching runs on Linux OS. Only synoptic and climatological data are collected manually from domestic stations, then input into the GTS message switching PC in TAC, then transmitted manually. This GTS function is still being used until the migration into WIS and TDCF. DMH Lao PDR was aware of the WIS since September 2007 when it participated in the meeting on the WIS and GTS in RA II, Kahbarovsk. Again in March 2010, DMH Laos attended another meeting on WIS in Tokyo, Japan. Although Lao PDR has expressed its willingness to participate in the VPN pilot project for RAs II and V, so far the plan was not yet been undertaken due to financial difficulties.

As a reference in the implementation of WIS and migration to TDCF, DMH Lao PDR has to study the framework on WIS that is already in place in RTH Bangkok both for WIS Part A and WIS Part B. Currently, RTH Bangkok has upgraded its GTS connections to TCP/IP. The main problem is the current connection for IP VPN via internet for the Bangkok-Yangon and Bangkok-Phnom Penh circuits. It is hoped that two internet connections will be changed to IPLC in the near future.

For WIS Part B, DMH Lao PDR has to ensure that its system is compliant with RTH Bangkok by taking note of the following:

a. Real time systems (GTS Message Switching System (MSS))
- Metadata catalogue as produced by MSS to be accessed by WIS metadata service.
- Notification of WIS by MSS when new data is available.
- Implementation of push/pull mechanisms for WIS to exchange data with MSS and to disseminate (push) data toward WIS subscribers using the MSS telecommunications capabilities and channels

b. Non-real time systems (Climate Database Management System)
- Metadata catalogue exchange with WIS metadata service.
- Specific interfaces for pull/push service for climate data and product retrieval
- Data service for notification of WIS when new climate data/product is available
- Metadata service allowing WIS to access produced metadata catalogue

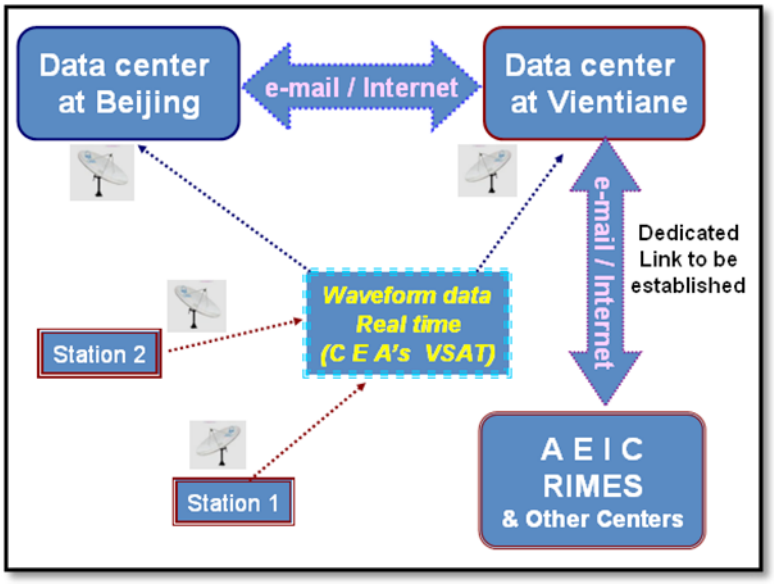


Figure 10.1 Data Sharing Topology in Lao PDR

In addition, since internet is increasingly crucial both as a complement to GTS and a means to DAR in WIS, DHM should make its internet connection permanent and the connection speed to ISP is 2M both local/International.

The upgrade of GTS message switching system for both hardware and software to comply with WMO Information System (WIS) and migrate to TDCF should be given utmost priority by the DMH to ensure the continuous sharing of meteorological data and fulfil the country's commitment as member of the WMO. Due to its very limited capacity in IT, DMH should seek assistance from more advanced NMHS in the region such as JMA.

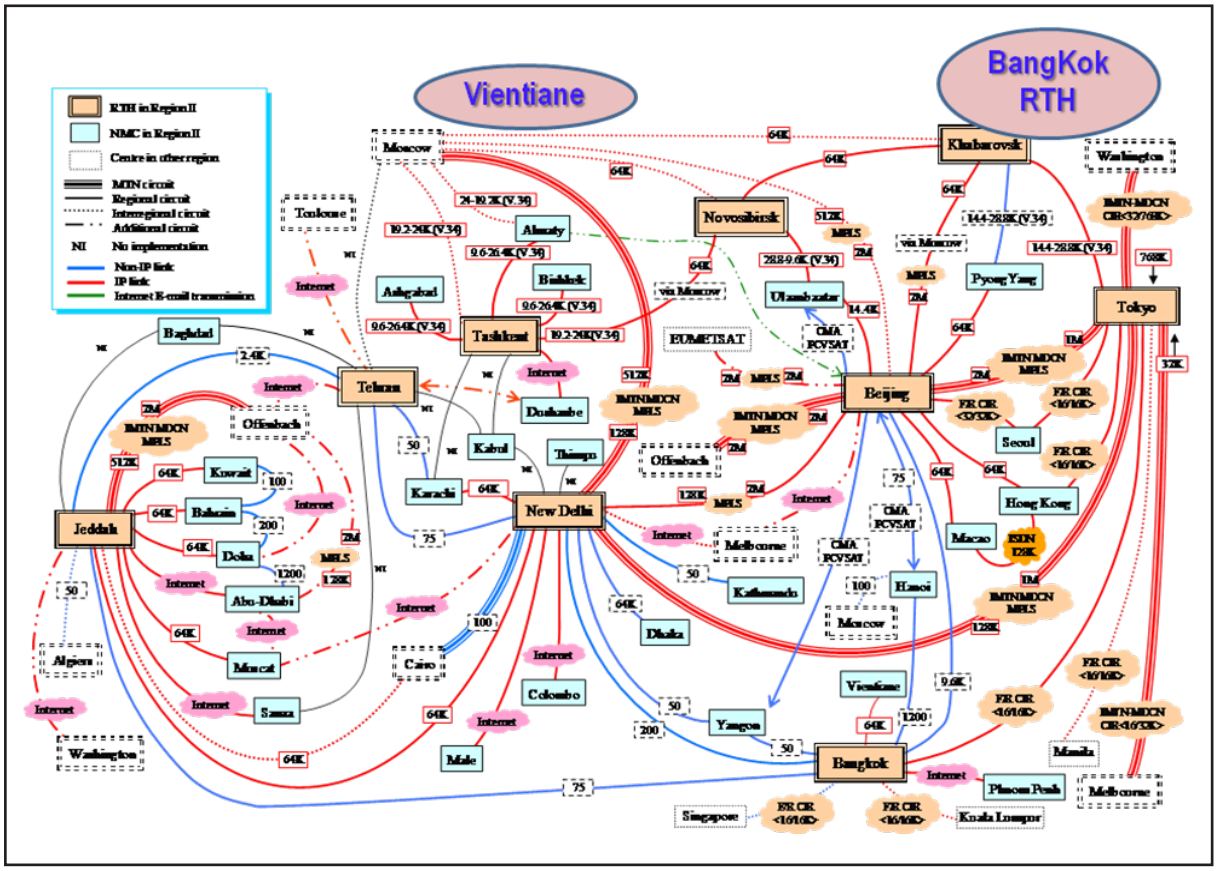


Figure 10.2 Data Exchange via WMO's GTS in Region II (Asia)

RECENT DEVELOPMENT PLANS PROPOSED BY LAO PDR

11

DMH has been working actively during the last few years to improve its facilities and capacity to produce better services through submission of proposals for national and regional projects for possible funding support. The following are the ongoing and proposed projects for upgrading of its facilities.

Table 11.1 On-going and proposed projects of DMH Lao PDR

Project Name	Objective, Components and Outputs	Expected Results and Deliverables
Pilot-testing Climate Change Adaptation (C-CDTA for US$0.4 million) Donor: ADB	Strengthen adaptation capacity and socioeconomic and ecosystem resilience to climate change impacts in the Lao PDR. Duration: 24 months	The project is expected to produce three major outputs: (i) pilot testing options for climate adaptation and resilience in selected climate-sensitive sectors; (ii) development of a plan for sector-wide up-scaling and replication in other key sectors; and (iii) Awareness and capacity building for key stakeholders for formulation and implementation of policies and exchanges. Priority sectors for adaptation: agriculture, water, forestry, health, and public infrastructure Possible sources of financing for the up-scaling and replication plan will be identified.
Mapping of Flood Prone Area (Under NAPA) Implementing Agency: DMH & Irrigation Department, Project Cost: USD 0.65 million Time Frame: 2 years	Conduct mapping of flood prone areas in Lao PDR Location: - Vientiane Capital - Vientiane - Borikhamxay - Khammouane - Savannakhet - Saravane - Attapeu - Champasack	*Activities:* Review and select appropriate mapping tools, taking into consideration compatibility with national information system; Training of personnel in mapping (US$0.05 million); Purchase of software and hardware needed for mapping (US$ 0.1 million); Conduct mapping of flood prone areas, linking maps and associated databases into a national information system (US$0.5 million). *Short-term outputs:* National capacities related to the use of mapping technologies enhanced; Software and hardware for mapping purchased and utilized; Information system for flood prone areas developed; and National information system for planning processes improved. *Potential long-term outcomes:* National development planning processes actively consider and plan for climatic variability and floods.

Early Warning System for Flood Prone Areas and Improve and Expand Meteorological and Hydrological Networks and Weather Monitoring Systems (Project proposal under NAPA) Implementing Agency: DMH	Establish an effective early warning system for priority flood prone areas Location: - Three flood prone areas located in Luang Namtha, Khammouane, Savannakhet, and Attapeu provinces Time Frame: - 2 years Project Cost: - USD 2.2 million	*Activities:* Identify and select 3 prioritized flood prone areas (US$0.1 million); review the existing warning, meteorological and hydrological networks in the prioritized areas (US$0.1 million); and review and develop an early warning system for the prioritized areas (US$2.0 million). *Short-term outputs:* Early warning system for floods established for three critical areas; and meteorological and hydrological network in 3 critical areas enhanced. *Potential long-term outputs:* Damages to properties and lives are reduced through the effective use of early warning systems; enhancement of meteorological and hydrological network; vulnerability of communities to floods in 3 priority areas reduced, while adaptive capacity is increased; EWS serves as a model that can be expanded to include all flood prone areas in Lao PDR; and EWS integrated with related regional and global systems and networks.
Renovation of some met and hydro equipment with funding from Japan's TCP	Upgrade of existing stations	Under the TCP, 6 meteorological stations and 4 hydrological stations were upgraded from 2006 to 2010 and short term experts conducted trainings during project period. Budget for the project was not provided.
Renovation of some hydrological stations	Upgrade of existing stations	Under the Mekong-HYCOS, rehabilitation of 12 staff gauges with 12 rain gauges was completed in December 2010. Budget for the project was not provided.
National Integrated Water Resources Management Support Project (N-IWRMSP).	Funded by the Mekong Integrated Water Resources Management Program (M-IWRMP) DMH component is 1.8M USD and to be implemented for four years (2011-2014).	Under the N-IWRMSP, the DMH is involved in the strengthening monitoring network in two prioritized river basins, namely, Xebangfai (Khammouame province) and Xebang-Hieng (Savanakhet province). Observed data from the network will be transmitted on real-time (through mobile phone) from the remote stations to the provincial offices of DMH and consequently to the DMH headquarters through GPRS or internet. The N-IWRMSP also include the construction of the National Flood and Drought Forecasting Center building and renovation of the existing DMH building.
Renovation of hydromet stations	Proposed budget = USD 340,000	Renovation of hydromet network in selected southern provinces of Attapeu, Sekong and Salavan from 2011 to 2013. The project is under the Mekong Integrated Water Resources Management Programme for possible funding under GFDRR.

Early Warning System for Flood Strengthening of hydromet network	Budget for DMH ~ 300,000USD ~ under WB-GFDRR; Technical training for DMH personnel on the use of new equipment (in coordination with ADPC) ~ 10,000USD	There is an on-going project under the WREA Cabinet which aims to strengthen the hydromet network in three (3) provinces affected by Typhoon Ketsana, particularly in Xekong river basin. Project duration is form 2010-2012. Training for NDMO personnel and the community on preparedness and response will also be undertaken.
Linking Information and Decision-making to Improve Food Security in selected countries of the greater Mekong Sub-region Proponent: DMH Lao PDR	EC-FAO Food Security Project 2010-2013 Implementing inst.: RIMES Project Countries: Cambodia, Lao PDR and Myanmar	*Activity 1:* Monsoon Forum: enhancing the utility of seasonal climate forecasts *Activity 2:* Managing climate change risks •Strengthen meteorological services – better tools, better observations and training •Institutionalize monsoon forum process •Connect national, sub-national and community levels for managing climate risks •Drought monitoring system •Decision making tools for community level use (crop weather calendar, sector applications for fisheries, animal health, human health)

The major concerns to strengthen DMH services are as follows:

- Improve severe weather monitoring capability, especially for tropical cyclone forecast as it approaches Indochina.
- Improve of precision of rainfall monitoring.
- Exchange real time rainfall observation data during passage of tropical cyclones.
- Request to WMO establish Sub-Regional Forecast Support Center to provide severe weather guidance for Southeast Asian countries.
- Stronger collaboration with regional and international organizations in disaster prevention and mitigation.

12 SUMMARY

Table 12.1 enumerates the institutional capacities, gaps and needs that have to be addressed to enable DMH to fulfil its mandate and improve its services for the major economic sectors in the country including the disaster management sector

Table 12.1 National capacities, gaps and needs of DMH Lao PDR

Issues	National institutional Capacities	Gaps & Needs
Data products	Data products are accessed from ECMWF and other centers; NWP products are also provided by RIMES through email	Does not run any NWP; capacities on hazard analysis is very limited
Hazard analysis to support risk assessment	Very limited	Limited skilled personnel to do risk assessment; training and involvement in regional research initiatives
Forecasts and warnings	Issues weather and flood forecasts and warnings regularly	Forecasts must be simple and understandable to the users; develop user-specific forecasts
EWS expertise and advisory service	Provides advisory service to NDMO	Advisory service is limited and based on available data products.
Cooperation with other technical agencies	Have existing cooperation with the NDMO and Mekong River Commission	
Dissemination mechanisms Principles	Online, Printed, 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	Establish good partnership with the media & mobile phone providers

The following table summarizes the assessment of the different activities and services of the DMH Lao PDR:

Table 12.2 Evaluation of DMH Forecast and Services
5= excellent, 4= good, 3= moderate, 2= poor, 1= very bad

Service/forecast	Score	Remarks
Forecasts and services for disaster reduction	3	Lack of on-line real-time data; no flood forecasting and dispersion modeling
Data sharing / GTS Networking to Asian hydromet organizations	3	Shares synoptic observations to the Regional hub in Bangkok but required to upgrade its link and be compliant with WIS
International cooperation	3	Maintains good membership with international organizations
Weather forecast	4	Prepares forecasts regularly
Number of WF products/d	2	Partially manual production system
NWP	2	Depend only on NWP from international forecast centers
Hydrological forecast	3	Lacking use of NWP
Agrometeorological services	2	No agromet stations
Automated processing and visualization	4	Uses SYNERGIE Version 3.4.0
Climate Change	3	Staff of 10 related to this issue
Support of R&D to improve services	0	none
Surface synoptic network	2	Low number of on-line stations
Upper-air data	0	No upper-air station
Radar data	2	Limited coverage
Lightning detection	0	No instrument
Hydrological Obs. Network	2	No automatic stations
Environmental observation	0	No environmental observations
Maintenance and calibration	2	Conducts maintenance checks & minor repairs but no standard calibration facility
Communication system	2	Low number of real-time and on-line stations
Data management	2	Needs data storage
Webpage	3	Updating some sections in the webpage
Human resources	3	Lacks IT staff, only one at present
Level of education of staff	3	Only one PhD
Training programme	2	Limited training for staff
Competitiveness on labor market	2	Low salary level; out dated facilities at headquarters
Management	3	Smooth operation
Organization	3	Needs improvement on coordination
Competitiveness	2	No incentives
Public visibility	4	Use tri-media and has a website
Public appreciation	2	Needs feedback mechanism
Customer orientation	2	Needs to conduct IEC for customers
Cooperation with media	4	Good partnership maintained with the media
Market position	-	Not included
Foreseen possibilities for sustainable development	4	Mobilization of international funding support
Total Score	78	

13 RECOMMENDATIONS TO STRENGTHEN THE HYDROMETEOROLOGICAL SERVICES

There has been a number of initiatives to improve the services of DMH Lao PDR however, these come in piecemeal or are just small components of bigger projects. It seems that the impacts of extreme events in the recent years did not provide sufficient justification for the government to prioritize the enhancement of meteorological and hydrological services in the country. Without the willingness of the government to allocate counterpart funds for foreign funded projects and the corresponding budget for operation and maintenance of new e quipment and facilities, it would be difficult to upgrade the existing DMH. The most crucial is the recruitment of young engineers to beef up the human resources of the DMH. Given this backdrop, there are three critical activities to improve the services of DMH Lao PDR:

(i)Low-cost capacity building and data processing, and dissemination initiatives

Capacity building holds the highest priority to improve the services of DMH. Training needs include calibration of existing equipment, operation and maintenance of new equipment such automatic weather station, aviation forecasting based on new ICAO standards, information technology within the WIS framework and new GTS TDCF protocols, database management and interpretation and application of remote sensing data for forecasting.

As a Least Developed Country, Lao PDR has several avenues to address its training requirements. The WMO under its Voluntary Cooperation Programme offers special training on the calibration of equipment. The Mekong-HYCOS for which Lao PDR is a member can also assist the DMH in training its personnel on the calibration of its monitoring facilities including the application of flood forecast and flash flood guidance tools developed by MRC. In its 4th Regional Council Meeting in February 2011, RIMES vowed to consider the trainings requested by DMH Lao PDR that include:

- Capacity building by secondment of Lao DMH staff for hydro-met and climate NWP analysis
- Secondment on earthquake data analysis and utilization of models , e.g. Seiscomp
- Expert & Fund support for establishment of Server and workstation for Seiscomp in Laos
- Expert mission & Technical Guidance on Early Warning Systems and Operational tasks

There is an existing Viet Nam-Laos protocol headed by the Deputy Minister where the two countries can collaborate and share information to improve their relationship. Considering the more advanced state of NMHS Vietnam, DMH Laos can request experts to train in various fields of engagements. DMH can request RSMC Tokyo for assistance in setting up the WIS framework and new GTS TDCF protocols.

On the application of remote sensing data, DMH Laos can request the JMA and the China Meteorological Administration for training. The Lao PDR can propose partnership with Thai Meteorological Department and NMHS Viet Nam for the access and utilization of the digital data from the network of radars in Indochina.

A simple and low-cost database management can be set up using Microsoft Excel or Access. In addition, the DMH Laos must come up with a proposal to retrieve all the available hydromet data from various institutions within the country and the region to complete its database. Part of the project will be the creation of a databank unit where its personnel

will be specifically trained on the management of its database including metadata collection. However, it must be ready to allocate some resources to upgrade its storage capacity. Since this will entail resources, the DMH can present this proposal to the various users of information such as agriculture, disaster management, energy, and other sectors and request for assistance in exchange of provision of the hydrometeorological data.

(ii)High-priority investments in modernization of the basic observational and IT infrastructure (communications and basic observation equipment)

With the climate change issue creating more demand for climate services, it is timely for DMH Laos to formulate its Modernization Plan taking a holistic approach based on the prioritized needs of the country for meteorological and hydrological information. There are ongoing and proposed projects (Table 11.1) that could become part of the DMH plan for modernization.

(iii)Phased modernization of the main elements of NMHS infrastructure, institutional strengthening and technical capacity building

Due to the limitation of funds to upgrade the NMHS infrastructure, phased modernization is the most feasible strategy. Currently, training of DMH staff is a top priority, next is the increase the level of automation and improving the density of network. The third priority is the improvement of telecommunication facilities since this will require a substantial budgetary requirement. The country's NAPA can provide the basis of the DMH modernization

(iv)Strengthening of operational cooperation of NMHS with sectoral users in disaster risk management, water resource management and agriculture through projects involving standardization and implementation of capacities for hazard analysis to support risk assessment and early warning systems

All the projects listed in Annex IV highlight cooperation of DMH Laos with sectoral users. For instance, the project on the construction of seven reservoirs for power generation in the northern part of the country by the private sector has involved the DMH in providing their technical expertise of putting up a network of monitoring stations within the catchment areas of these dams for purposes of flood forecasting and warning. This is consistent to the mandate of the DMH. The FAO/RIMES project also targets to increase the utilization of forecast products and information of DMH by the agriculture sector and other sectors relevant to enhancing food security.

Although there are current and proposed initiatives to strengthen cooperation with the various users of hydrometeorological information, there are more gaps to address as far the capacity for hazard analysis is concerned, considering the increasing frequency of extreme events. As an example, even if a regional institution like RIMES is able to produce accurate NWP products for DMH Laos, the capacity to interpret these products as bases in the formulation of useful and understandable forecasts to the users at the country level still remains a constraint. The usefulness of forecasts entails focused group discussions and continuous dialogue between the forecast provider and the users of information. The Monsoon Forum is an attempt to forge and strengthen the link between DHM and the users of its forecast. DMH Laos should institutionalize this kind of dialogue or forum.

The DMH endeavors to realize the following recommendations under the strategic programme for 2011 – 2015:

- Good cooperation with development partners, including Mekong – Japan;
- Establishment of National Flood and Drought Forecasting and EWS Center;
- Institutional strengthening;
  - NDMC, Decision makers;
  - WREA & MLSW, supervisors;
  - Closed cooperation among line agencies and regional organizations;

- Sound hydro-met network and data collection & dissemination network;
- Advanced forecasting and early warning sys tems;
- Sound data management system (database and metadata), QA & QC;
- Awareness, preparedness and responses; and
- Support the Implementation of N-IWRM Pro gramme & River Basin Development.

PROJECT PROPOSAL 14

After identifying the institutional capacities of the DMH and considering the needs of the users of meteorological and hydrological data and information, a project proposal has been formulated (shown in Table 14.1) which will address the requirements of the DMH to improve its products and services that will cover the needs of key economic sectors in the country in order to promote economic growth as well as ensure the safety and wellbeing of the people. The investment on the automation of the hydrometeorological observing network including telecommunication facilities and equipment will entail considerable budget requirement and this can only be realized through foreign assistance. The cost will be reduced if cooperation with adjacent countries is strengthened. This could be achieved through data sharing and technology transfer. Joint projects on climate change and other regional or global concerns should also be considered to promote cooperation. But among the priorities of the upgrading, focus should be on capacitating the existing staff of DMH. Scholarship grants and short-term trainings from international organizations can be availed to improve the level of skills of its staff.

A five-year investment plan is designed and this does not include allocation for operation and maintenance cost for the duration of the project. The two investment options considered are a) Strengthening of DMH as "stand-alone system" and as a b) Regional cooperation project. A summary of the items covered in this project proposal under Regional cooperation is shown below.

14.1 International cooperation

As a Least Developed Country, the DMH PDR will be most benefited through strengthening of international linkages and collaboration.

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

14.2 ICT and data management

Activity: Upgrade communication system, establish IT Centre and improve data management
Proposed budget:

- Telecommunication=US$500,000
- IT Center=US$150,000
- Data management= US$735,000.

Implementation responsibilities: consultant on turnkey basis

14.3 Meteorological observation network

Activity: Increase the density of monitoring network
Proposed budget:

- 49 automatic weather stations (covers 10 airport stations) - US$ 980,000
- 2 aviation weather observing station (AWOS)=US$1,000,000
- 60 automatic raingauge stations=US$402,000
- 13 agrometeorological stations=US$260,000
- 28 climat stations=US$187,600

Implementation responsibilities: consultant on turnkey basis

14.4 Hydrological stations

Activity: Establish hydrological/stream gauging stations
Proposed budget:
- 65 automated hydrological/stream gauging stations=US$704,000

Implementation responsibilities: consultant on turnkey basis

14.5 Environmental stations

Activity: Establish environmental monitoring stations
- 10 automatic air quality monitoring station=US$10,000
- 4 spectrophotometers (Ozone and UV radiation)=US$26,500

Implementation responsibilities: consultant on turnkey basis

14.6 Remote sensing network

Activity: Improve remote sensing network
Proposed budget:
- 2 upper air stations=US$ 890,000
- 1 weather satellite receiving station=US$135,000
- 1 weather radar including tower= US$2,000,000
- lightning detection system=US$100,000

Implementation responsibilities: consultant on turnkey basis

14.7 Visualization and editing tools

At present, the SYNERGIE Version 3.4 software is sufficient but due to the growing demands and fast technological advancement, upgrading of the system is a necessity in the future.

14.8 Research and Development

Activity: Undertake studies related to climate change and its impacts
Proposed budget: US$280,000

14.9 Training

Additional assistance is also required for the development of forecasting system through support for human resources development. This will include scholarship grants for post graduate courses, training of personnel on equipment operations and maintenance, IT, climate change, numerical modelling, etc. The budget proposed could be reduced if assistance for scholarship grants, trainings and seminars will be provided by other funding agencies or universities.
Proposed budget: US$ 50,000

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

	A (USD)	B (USD)
RIMES		
International cooperation of experts	100,000	100,000
Communication systems		
- Hardware + software	500,000	500,000
IT Center		
- Hardware	100,000	100,000
- Consulting	50,000	50,000
Data management		
- Hardware and installation	560,000	560,000
- Storage	125,000	125,000
- Consultation and training	100,000	50,000
Meteorological observation network		
- automatic weather stations (P, T, U, ww, wd, G)	980,000	980,000
- aviation weather observing station (AWOS)	1,000,000	1,000,000
- agrometeorological stations)	340,000	340,000
- climate stations	187,600	187,600
- automatic raingauge	314,900	314,900
Hydrological observation network		
- automatic hydrological stations	704,000	440,000
Environmental		
- automatic air quality stations	10,000	10,000
- Ozone & UV radiation	26,500	26,500
Remote sensing network		
- upper air observations	1,780,000	890,000
- new weather radars (including towers)	6,000,000	2,000,000
- lightning detection	100,000	100,000
- Satellite receiving station	135,000	135,000
Training	100,000	50,000
Research and development		
- impacts of climate change	100,000	50,000
- socio economic impacts	100,000	100,000
- national seminar on socio-economic benefits	100,000	100,000
- end-user seminar	30,000	30,000
Project management		
- consultant	200,000	100,000
- local project coordinator	100,000	50,000
Total	13,843,000	8,389,000

ANNEX 1

People met during the Mission

No	Name	Organization	Telephone	E-mail
1	Madame Monenamy NHOYBOUAKONG	WREA Cabinet Secretary	(856-20) 5520907	monenamy@yahoo.com
2	Ms. Keomany THANASACK	DOI, MAF	(856-20) 662861	keomanypsv@yahoo.com
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4	Mr. Bounchoum ONEMIXAY	DMH	(856-20) 5595437	kbounchoum@yahoo.com
5	Mr. Chansamone	DOE	(856-20) 2450045	airtopsyl@yahoo.com
6	Ms. Souvanny PHONEVILAY	DMH	(856-20) 2204729	S_phonevilay@yahoo.com
7	Mr. Bounteum SYSOUPHANTHAVONG	DMH	(856-20) 6505997	Bounteum_dmh@etllao.com
8	Mr. Somkhit KHATIYA	Cabinet of MAF	(856-20) 2247345	Kh_rabbit2000@yahoo.com
9	Mr. Anouphak Pranouvong	GMS	(856-20) 5502097	
10	Mr. Thongphou VONGSIPRASOM	W.W Company	(856-21) 414841	
11	Mr. Linglong SITHIXAY	DOA, MAF	(856-21) 412350	
12	Dr. Vankeo RASBOUTH	DOHP, MOH	(856-20) 5702533	Rasbouth_1@yahoo.com
13	Mr. Khammoun KENDARA	DMH	(856-20) 2429229	
14	Mr. Vinliam BOUNLOM	DMH	(856-20) 2416081	vinliam@hotmail.com
15	Ms. Thongsavanh BOUPHA	NAFES	(856-20) 2243480	thongsavanhboupha@yahoo.com
16	Ms. Vimala KHOUNTHALANGSY	NDMO	(856-20) 5606269	Ping_khoun@yahoo.com
17	Mr. Phonepaseuth PHOULIPHANH	DWR	(856-20) 2207415	South06@hotmail.com
18	Mr. Xayxana VONGSIPRASOM	DMH	(856-20) 5405820	
19	Mr. Somsack INTHIRATH	Lao Red Cross	(856-20) 5666769	S_inthi@hotmail.com
20	Mr. Bounkham	WREA	(856-20) 7711330	
21	Mr. Bountheung SOUMONTHA	Lao DCA	(856-20) 5121314	b.soumontha@yahoo.com
22	Mrs. Savanchay	DLF	(856-20) 6906042	Mime3012@yahoo.com
24	Ms. Khanthala KEOVONGPHANH	LATM	(856-20) 5628950	Khanthala_ke@hotmail.com
25	Mr. Nikhom KEOSAVANG	DMH	(856-20) 2209181	
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ANNEX 2

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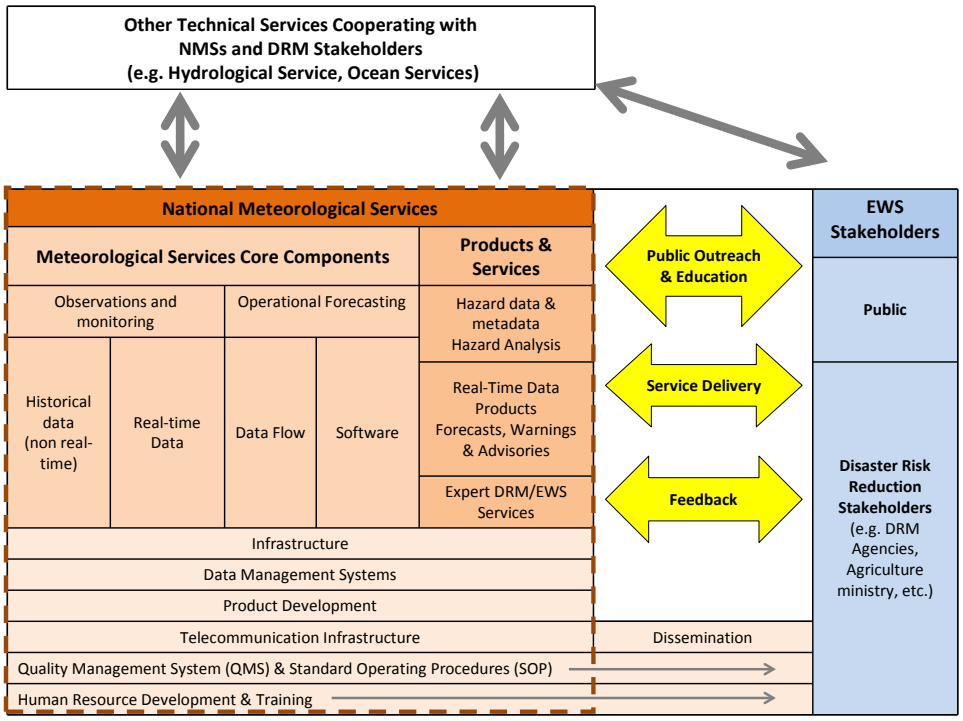
ANNEX 3

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.