

FLOOD FORECASTING AND EARLY WARNING SYSTEMS IN MEKONG RIVER COMMISSION

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Flooding in the Mekong River Basin is a recurrent event affecting the entire basin. The Lower Mekong Basin has a long history of flooding. In last 40 years, severe flooding has struck the basin and caused serious damages in the flood-prone areas, especially in year 2000. Recurring flood of the magnitude and frequency observed in the region is a significant impediment to a more rapid development in the Mekong basin.

The 1966 severe flood called for the establishment of the flood forecasting system of the Lower Mekong Basin. At the beginning of the 1970's the existing regional forecasting system with application of advanced computer techniques and mathematical models was set up in the Mekong Secretariat. Following the floods in 1978 and 1981 the forecasting system was expanded to cover major tributaries. After the catastrophic 2000 floods, followed by serious floods in the year 2001 and 2002, there have been growing concerns about the rising severity of these annual hazards and increasing threat to the livelihood of communities living along the basin. This has led to the development and approval of Mekong River Commission (MRC)'s Flood Management and Mitigation Strategy. Based on the strategy, Flood Management and Mitigation Programme (FMMP) was developed, aiming at preventing, minimizing or mitigating people's suffering and economic losses due to floods, while preserving the environmental benefits of floods.

1. FLOOD FORECASTING SYSTEM IN MRC

The MRC Secretariat basin-wide river forecast has been in operation for more than 30 years since 1970, for benefit of all the riparian countries. The Flood Forecasting and River Monitoring System in the MRC have over the years been improved to provide timely and accurate river forecast to the member countries in order to reduce the vulnerability of floods and droughts. During the flood season (June-October), five-day flood forecasting and flow forecasts are conducted along the Mekong mainstream and updated daily at <http://www.mrcmekong.org>, while seven-day river monitoring during dry season (November-May) are updated on a weekly basis. Flood forecasting system consists of three main components: 1. Data collection and transmission, 2. Forecast operation and 3. Forecast dissemination. The components of flood forecasting system can be shown in Figure 1. The results of forecasting in regional scale from MRC will be utilized by concerned national organizations, Red Cross, NGO and etc. for further warning and dissemination purpose.

1.1 Data Collection and Transmission

In close collaboration with the four National Mekong Committees (NMCs) and the national concerned line agencies, the hydro-meteorological data from the member countries are delivered to the MRCS for the operational forecast. In the year 2005, twenty-one key hydrological stations on the mainstream for the flood forecasting in the wet season and nineteen stations for the river monitoring in the dry season were embraced in the system. Figure 2 shows the location of the flood forecasting stations in the Lower Mekong Basin.

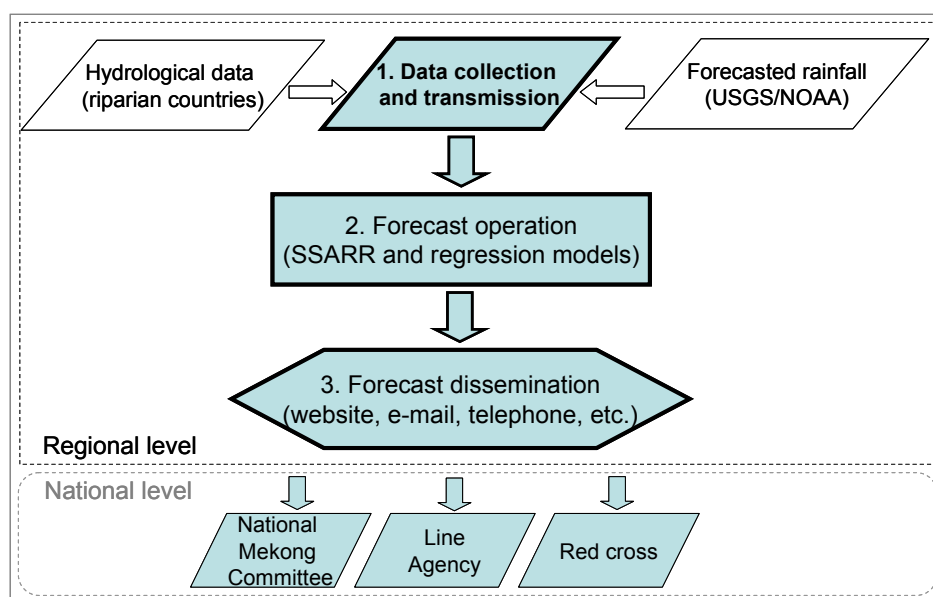


Figure 1 Flood forecasting and dissemination system at MRC

The data collected are classified into the historical data and the operational data.

- The historical data updated annually are discharge, water level, rainfall and other climate data. These data are sent after validation process.
- The operational data sent directly from the national concerned line agencies by e-mail daily in wet season and weekly in dry season are near real-time water level and rainfall data.

Apart from the data received from the countries, the interpretation and analysis of other available weather data such as satellite images, rainfall estimation and forecasts from various sources, including those from US Geological Survey/National Oceanic and Atmospheric Administration (USGS/NOAA), Tropical Rainfall Measurement Mission (TRMM) are also carried out. Figure 3 displays the forecast gridded rainfall from USGS/NOAA over Mekong River Basin and averaged rainfall over sub-basin in Mekong River Basin based on forecast gridded rainfall.

1.2 Forecast Operation

A variety of forecasting tools is applied to forecasting water levels and discharges. The Streamflow Synthesis and Reservoir Regulation (SSARR) model, developed by the US Corps of Engineers, has been operational for more than three decades. At present, the SSARR model is applied to the upper and middle reaches (from Chiang Saen to Pakse) while regression models are used for the lower reaches of the Mekong River (for stations on the mainstream rivers from Cambodia border to Mekong Delta). An Artificial Neural Network (ANN) model is also applied. The ANN model not only has become a forecasting tool but more importantly it serves also for increased forecast accuracy through the process of double checking with the forecasts produced by the SSARR and regression models.

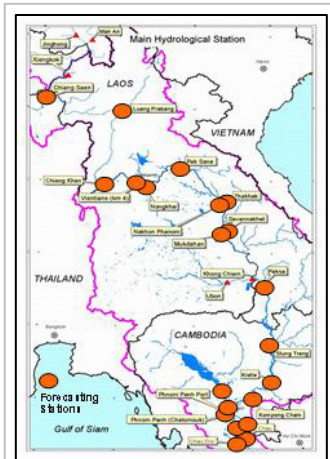


Figure 2 Flood forecasting stations in Lower Mekong Basin

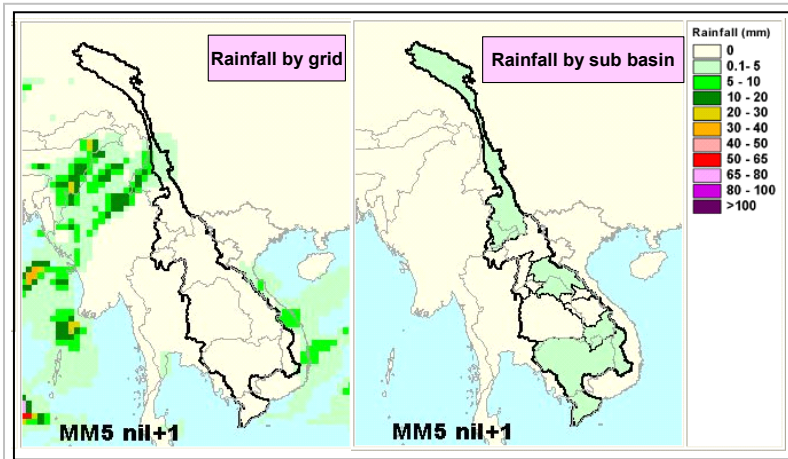


Figure 3 Rainfall forecasts from USGS/NOAA (left: rainfall forecast from USGS/NOAA on grid base; right: rainfall forecast in each sub-basin)

Upper parts (Thailand and Lao PDR) of Lower Mekong basins are divided into 10 homogeneous sub-basin. Based on the input rainfall data and the amount of infiltration, a predicted amount of runoff to downstream is calculated for each sub-basin. Flow is then converted into water level using latest appropriate rating curves. Due to data limitation, a simple approach but with acceptable results has been considered and among these is the application of regression methods. Then, a simple flood forecasting model by using the regression methods to forecast water levels at key stations on the three mainstream rivers in Mekong Delta, namely, the Mekong, the Bassac and the Tonle Sap, is formulated.

1.3 Forecast Dissemination

For further actions on flood preparedness and low flow counter-measures in a timely manner, the water level forecast bulletin, forecasted discharges in tabular form and the water level hydrographs at key stations along the Mekong mainstream are sent regularly (daily in the wet season and weekly in the dry season) to the concerned parties via e-mail and published on the MRC website (www.mrcmekong.org) by noon (12:00 hrs, local time). Figure 4 and Figure 5 show flood the examples of bulletin from MRC and hydrographs of stations along the mainstream, respectively. MRC has responsibility in providing the flood forecast information in regional scale. The users include the four riparian National Mekong Committees, concerned line agencies, national disaster management committees, mass media, NGOs, UN organizations, partners and etc. The information flow from MRC to vulnerable commune level is shown in Figure 6. In parallel to the preparation for the full scale start up of the FMMP, the MRC Secretariat has been implementing a number of priority activities including: the Project on Provision of Flood Early Warning to Flood-Vulnerable Communities in the Lower Mekong River Basin - Phase 1: Cambodia and Lao PDR and the Project on Capacity Building for Preparedness Planning and Response through Using Flood Information Products in the Lower Mekong Basin.

LOCATION	Observed Rainfall (mm)	Zero gauge above M.S.L (m)	Flood stage (m)	Alarm stage (m)	Observed W. level against zero gauge (m)		Forecasted Water Levels (m)				
	30-Oct				30-Oct	31-Oct	1-Nov	2-Nov	3-Nov	4-Nov	5-Nov
Chiang Saen	8.0	357.110	11.80	11.50	4.21	4.71	4.47	4.21	4.00	3.83	3.71
Luang Prabang	2.6	267.195	18.00	17.50	7.33	7.54	7.66	7.58	7.49	7.41	7.22
Chiang Khan	nr	194.118	17.40	17.32	7.15	7.09	7.17	7.22	7.24	7.25	7.19
Vientiane	nr	158.040	12.50	11.50	4.02	3.91	4.10	4.13	4.17	4.20	4.20
Nongkhai	nr	153.648	12.20	11.40	4.70	4.57	4.76	4.79	4.83	4.86	4.86
Paksane	nr	142.125	14.50	13.50	6.13	6.08	6.01	5.96	5.91	5.88	5.87
Nakhon Phanom	nr	132.680	12.70	12.60	4.25	4.13	4.09	4.07	4.00	4.00	4.01
Thakhek	nr	129.629	13.50	13.00	5.45	5.32	5.28	5.26	5.19	5.19	5.20
Mukdahan	nr	124.219	12.60	12.50	4.22	4.12	4.31	4.28	4.23	4.19	4.19
Savannakhet	nr	125.410	13.00	12.00	3.20	3.18	3.12	3.09	3.04	3.00	3.00
Khong Chiam*	nr	89.030	16.20	16.00	5.15	5.00					
Ubon (Nam Mun)*	nr	105.074	10.50		3.59	3.48					
Pakse	nr	86.490	12.00	11.00	3.88	3.72	3.72	3.69	3.68	3.65	3.61
Stung Treng	nr	36.790	12.00	10.70	4.67	4.56	4.41	4.28	4.19	4.12	4.05
Kratie	nr	-1.080	23.00	22.00	12.37	12.11	11.91	11.62	11.39	11.22	11.07
Kompong Cham	nr	-0.930	16.20	15.20	9.20	8.99	8.82	8.68	8.50	8.34	8.21
Phnom Penh (Bassac)	nr	-1.020	12.00	10.50	8.01	7.88	7.77	7.69	7.61	7.53	7.46
Phnom Penh Port	nr	0.000	11.00	9.50	7.27	7.14	7.03	6.95	6.87	6.79	6.72
Koh Khel	nr	-	7.90	7.40	6.64	6.57	6.51	6.47	6.42	6.39	6.35
Neak Luong	nr	-0.330	8.00	7.50	5.88	5.78	5.69	5.61	5.56	5.50	5.45
Prek Kdam	nr	0.080	10.00	9.50	7.89	7.82	7.74	7.67	7.61	7.56	7.51
Tan Chau	nr	0.000	4.20	3.00	3.37	3.31	3.25	3.19	3.15	3.11	3.08
Chau Doc	nr	0.000	3.50	2.50	3.09	3.04	2.98	2.93	2.90	2.87	2.84

REMARKS:
 nr - no rain
 na - data is not available

Figure 4 Flood bulletin showing forecasted water level at stations along the Mekong mainstream in flood season 2005

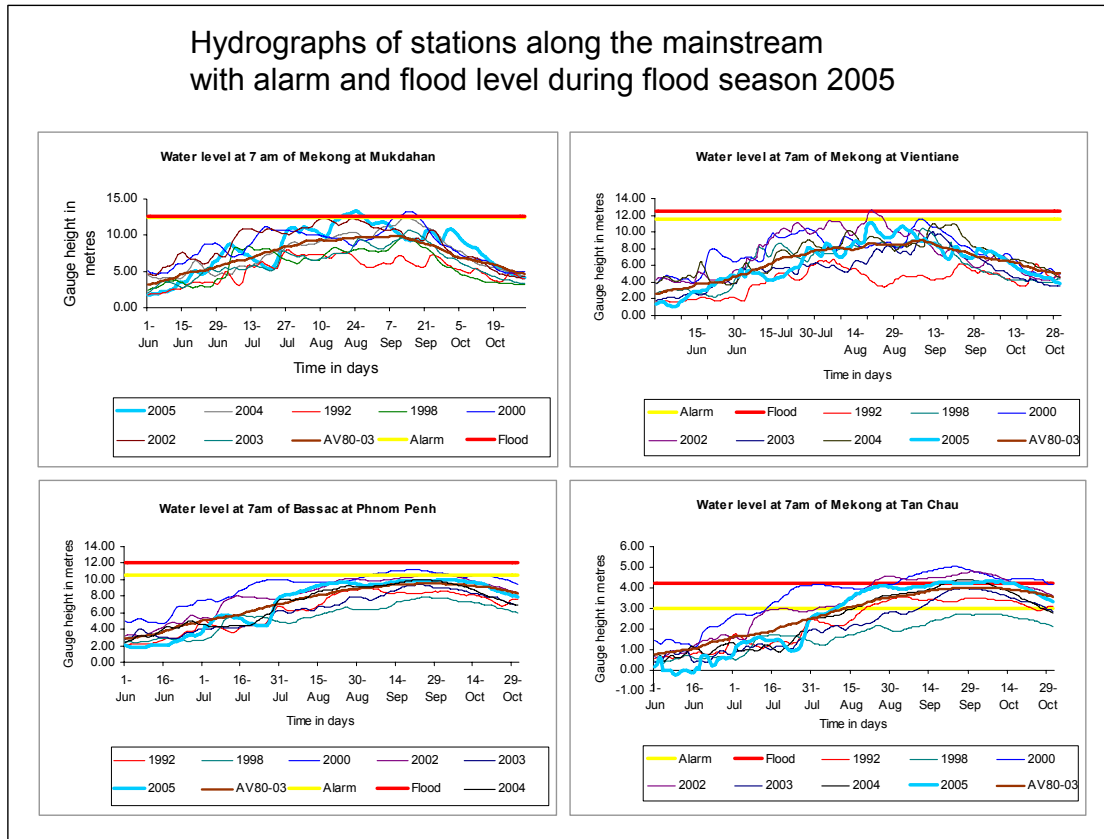


Figure 5 Hydrographs of stations along the Mekong mainstream distributed daily during flood season to concerned agencies

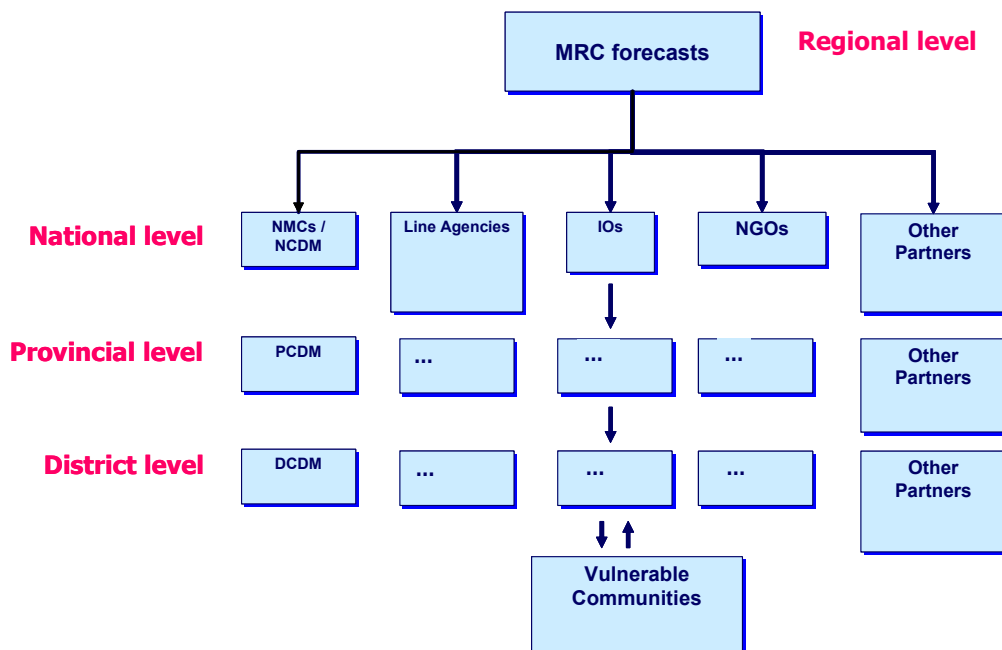


Figure 6 Flood Information Flow from MRC to vulnerable communities

2. PROBLEMS ENCOUNTERED IN FLOOD FORECASTING SYSTEM

Flood in the Lower Mekong Basin can be intensified if two conditions are simultaneously took place; high level of the Mekong river and high intensity rainfall causing the huge flow to the mainstream. Accordingly, rainfall forecast is indispensable for flood prediction. Rainfall forecast and estimation from USGS/NOAA used in flood forecasting at MRC are directly extracted from global-scale gridded rainfall and used as in put for flood forecasting models without the modification and verification. The precision of the forecasted rainfall at global scale is still in doubt when it is applied to regional or basin scale. The accuracy of flood forecasting depends on number of forecast days as shown in Figure 7. In addition, the flood forecasting model itself has been used for nearly three decades with less modification. These can cause the predicted water level along the mainstream deviated from real water level.

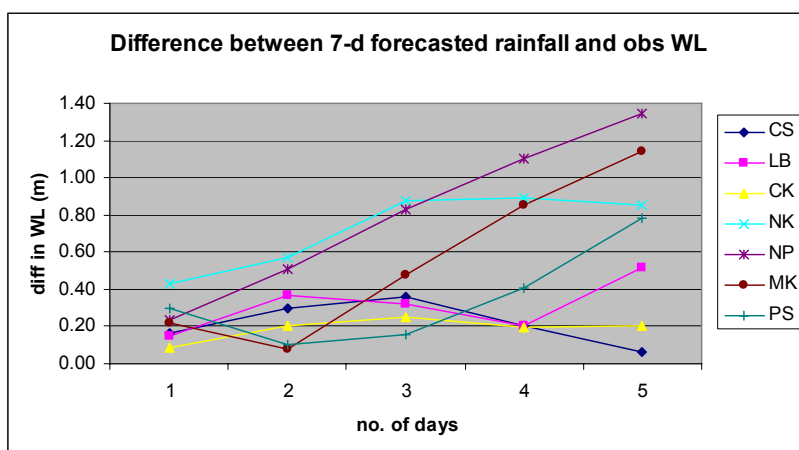


Figure 7 Difference between forecasted water level based on forecast gridded rainfall and observed water level in the upper reach of Mekong River (Chiang Saen to Pakse), simulated on 2nd September 2005 by SSARR model

3. IMPROVEMENT ON FLOOD FORECASTING SYSTEM AND FUTURE PLAN

Improvement of the existing flood forecasting is one of the activities, prioritized by the FMMP. The flood forecasting system would be able to provide daily information on potential flood in Mekong mainstream as well as in major tributaries. Improvement of flood forecasting operations requires continuous efforts in many fields, including river monitoring network, data collection, transmission and processing; development of advanced forecasting techniques, communication network and assessment of forecasts.

3.1. Improvement of Monitoring Network and Data Collection

Timely operational hydro-met data are indispensable for flood forecasting purpose. At present near-real time data from manual gauge stations. Currently, the MRC is implementing the Appropriate Hydrological Network Improvement Project (AHNIP) to strengthen the capacities of the MRC at the MRCS and in the respective riparian countries in dealing with near real-time data. Complementary to the AHNIP, a Mekong Hydrological Cycle Observing System (Mekong-HYCOS) project is now being formulated in cooperation with the World Meteorological Organization (WMO). This project aims to establish a near-real time basin-wide hydro-meteorological information system, spatially covering the mainstream and main tributaries of the Mekong river system. As mentioned before, rainfall forecast from USGS/NOAA is directly used as input for flood forecasting purpose whilst validation and modification is needed before implementation to regional scale like Mekong Basin. In future, validation and modification of

satellite-based forecast rainfall will be accounted including application of rainfall estimation finer-resolution forecast rainfall from NOAA.

3.2 Improvement on Flood Forecasting Tools

FMMP has a plan to substitute the existing forecasting system with effective models based on modern integrated flood risk management system coupled with GIS and mapping facilities that provide reliable flood extent information. New tools in the form of user-friendly interface, replacing traditional dos-command process without improvement of prediction accuracy, have been developed to ease input system of forecasting tool by avoiding retyping of input data from line agencies. Data preparation interface was created to provide flood bulletin and data for line agencies. These tools help minimizing human error and lessening times required for flood forecasting system. Flood forecasting tool in the lower part of LMB has been improved by updating model parameters, giving more accurate forecasting results.

3.3 Improvement of Early Warning and Dissemination System

In parallel to the preparation for the full scale start up of the FMMP, the MRCS has been implementing a number of priority activities including: the Project on Provision of Flood Early Warning to Flood-Vulnerable Communities in the Lower Mekong River Basin, Phase 1, Cambodia and Lao PDR; and the Project on Capacity Building for Preparedness Planning and Response through Using Flood Information Products in the Lower Mekong Basin. The goal of these projects is to reduce the vulnerability of communities in Cambodia and Laos to higher-than-normal annual floods and flash flooding. This goal will be met by providing timely flood warnings to the population in flood-vulnerable communities. Concurrently, communities will be provided with adaptable and useable tools and training that will allow them to refer their communities to MRC-prepared flood information at the forecasting points throughout the basin. The establishment of a continuous dialogue and exchange of information between MRC and the target communities will ensure accuracy of and appropriate applications of flood referencing information and assessment of community flood-warning needs.