FLOOD FORECASTING AND RIVER MONITORING SYSTEM IN THE MEKONG RIVER BASIN

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Abstract

The Flood Forecasting and River Monitoring System in the Mekong River Commission (MRC) has over the years been improved to provide timely and accurate river forecast to its member countries in order to reduce the vulnerability of floods and droughts in the Lower Mekong Basin. During the dry season (November-May), seven-day river monitoring and low flow forecasts are conducted and updated weekly at *http://www.mrcmekong.org* while five-day flood forecasts at 21 key stations along the Mekong mainstream during flood season (June-October) are updated on a daily basis. The MRC Forecasting System consists of three main components; data collection and transmission, forecast operation, and forecast dissemination.

Data collected for the operational forecast are classified into the historical and the operational data. The historical data are updated annually while the operational data are sent by e-mail to MRCS everyday in wet season and weekly in dry season. For timely national forecasts, MRCS will forward the operational data to the countries prior to the operation of regional forecasts. Apart from the data received from the countries, weather data/forecasts from various sources, including those from USGS/NOAA, TRMM, and Thai Meteorological Department, are also used. A variety of forecasting tools is applied for forecasting water levels and discharges: the Streamflow Synthesis and Reservoir Regulation model for the upper part of the basin, multiple regression models for the lower reach of the delta with over bank flow, an Artificial Neural Network model for both, upper and lower reaches, and the MIKE-11 for flood mapping in Mekong Delta. Forecast products including water level forecast bulletin are published on the MRC website and disseminated to the National Mekong Committees, concerned line agencies, National Disaster Management Committee and other interested parties by e-mail.

The existing MRC Forecasting System was deemed adequate in the past. However, rapid population growth in the region, intensification of agriculture, climate change, changes in land use and river morphology, and rapid technology development makes it imperative that the system be upgraded, and a forecasting system, based on modern technology combined with a more effective warning system, be installed. 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. To improve the river monitoring network, data collection and transmission system, the hydro-meteorological network is in the process of being rehabilitated and upgraded to provide more timely and accurate data.

Keywords: flood forecasting; river monitoring; Mekong River Commission; Mekong River Basin.

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1. Background

Flooding in the Mekong River Basin is a recurrent event affecting the entire basin. Almost every year, it takes away a lot of lives and causes damage to infrastructure, agricultural and industrial production and severely affects socio-economic development. 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.

The 2000 flood caused of US$ 400 Million worth of damage and 800 people's lives, mainly children. At the Phnom Penh station water level was recorded with a return period of 70 years. The Mekong River Commission (MRC) Council, at its annual meeting in October 2000, called for immediate action for the establishment of a basinwide Flood Management and Mitigation (FMM) in the Mekong River Basin. In November 2001, the FMM Strategy (FMMS) was approved by the MRC Council and used as a basis for the development of the FMM Programme (FMMP) adopted in November 2002. The overall objective of the FMMP is to prevent, minimize and mitigate people's suffering and economic losses due to floods, while preserving the environmental benefits of floods. It consists of five components: 1. Establishment of the Regional FMM Centre (RFMMC), 2. Structural measures and floods proofing, 3. Mediation of trans-boundary flood related issues, 4. Flood emergency management, and 5. Land use management. The FMMP is based on priorities agreed upon by the four MRC member countries and on the strategic roles of the MRC. The component of the programmes are related to each other and link to MRC's existing programmes, and will contribute to MRC's overall role in knowledge base development, capacity building and regional cooperation.

In parallel to the formulation of FMMS, progress has been made to improve the MRC flood forecasting and early warning operation during the 2001 flood season. In the year 2001, twenty-one key hydrological stations of the mainstream for the flood forecasting in the wet season and nineteen stations for the river monitoring in the dry season were included in the system. Figure 1 shows the location of the flood forecasting stations in the Lower Mekong Basin (six in the Lao PDR and five in Thailand, eight in Cambodia and two in Viet Nam).

This paper intends to provide general information on a case study of the operational flood forecasting and river monitoring system in the Lower Mekong Basin to reduce the vulnerability of floods and droughts rather than an in-depth detailed scientific paper on the forecasting models.

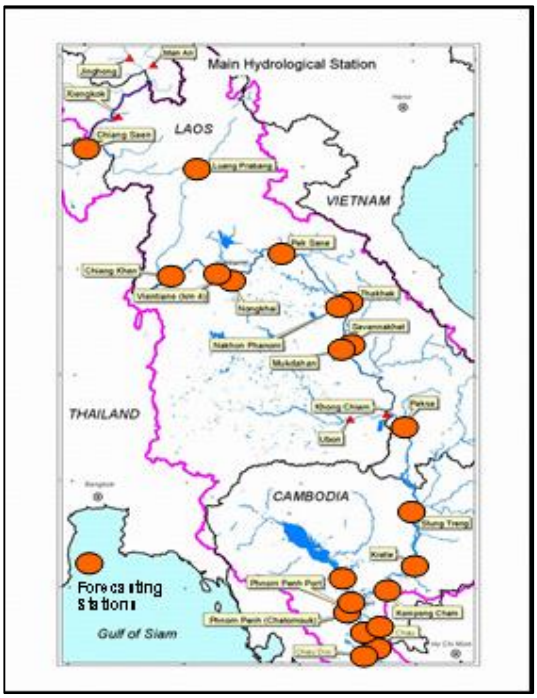


Figure 1 – Flood Forecasting Stations in Lower Mekong Basin

2. MRC Flood Forecasting and River Monitoring System and Its Operation

The Flood Forecasting and River Monitoring System in the MRC has 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. It consists of three main components: 1. Data collection and transmission, 2. Forecast operation and 3. Forecast dissemination.

2.1 Data Collection and Transmission Component

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 regularly in accordance to the Procedures for Data and Information Exchange and Sharing of the MRC (MRC, 2001). 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 necessary for the re-calibration and validation of the model parameters. These data are sent from the national concerned line agencies to the MRCS via the NMCs after their validation process.
- The operational data sent directly from the national concerned line agencies to MRCS by e-mail (about 10 am, local time) daily in wet season (June to October) and weekly in dry season (November to May) are near real-time water level and rainfall data (registered at 7 am and 7 pm of previous day, local time). The operational data collected for flood forecasting and river monitoring activities in the MRCS are given in Table 1. During the wet season, not only the data from 42 stations of the four MRC member countries in the Lower Mekong Basin but also 2 stations data from China are sent to the MRCS. The data are stored in the operational database for inputs into regional forecasts and also disseminated by e-mail to the forecasting agencies in the four member countries for their national forecasts.

Item	Wet season (Jun - Oct)	Dry season (Nov – May)
Forecasting activity	Flood Forecasting	River Monitoring
Data delivery to MRCS	Daily	Weekly
Day-ahead forecast	5-day forecast	7-day forecast
Water level data	44 stations (including 2 sta. from China)	19 stations
Rainfall data	44 stations (including 2 sta. from China)	19 stations
Forecasting point	21 stations	19 stations

Table 1 – Operational data sent regularly to MRCS

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) and the Thai Meteorological Department (TMD) are also carried out. Figure 2 shows an example of rainfall estimation and forecast from USGS/NOAA used for the regional forecasting.

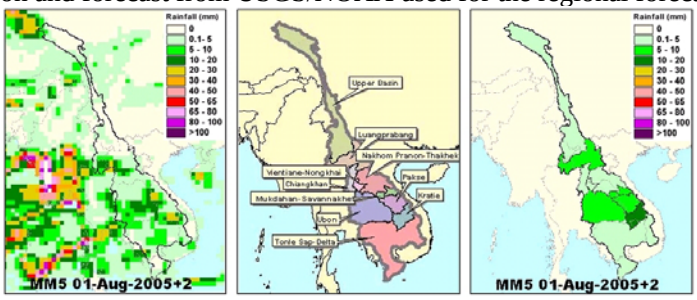


Figure 2 – Rainfall estimation and forecasts from USGS/NOAA (left: rainfall estimation and forecasts from USGS/NOAA on grid base; middle: Mekong sub-basins; right: rainfall forecast in each sub-basin)

2.2 Forecast Operation Component

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 delta with overbank flow (for stations on the three mainstream rivers in Mekong Delta, namely, the Mekong, the Bassac and the Tonle Sap from Strung Treng to Tan Chau/Chau Doc). An Artificial Neural Network (ANN) model is also applied to both, upper and lower reaches. 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. After flood water levels at key stations are forecasted, the MIKE-11 model is employed to simulate flood water depth and flood extension over the Cambodian floodplain.

SSARR model is a river system model. Drainage basins are sub-divided into homogeneous hydrologic units and the outflow from each of the sub-basins or watershed model is derived from rainfall. The watershed model estimates runoff excess based on soil moisture index values, which are computed from rainfall and evaporation relationships. The runoff excess is further divided into baseflow and direct runoff, using empirically estimated baseflow infiltration indices. The direct runoff is further separated into surface and sub-surface flows using an empirical surface/sub-surface separation curve. These three components of runoff are then routed through their respective conceptual storage, each with a different number of storages and time of storage. The routed components are combined to become the sub-basin outflow which is then added to the mainstream flow, routed through the channel to a downstream point and combined with the outflow from the next sub-basin.

After the flows are forecasted, they will be converted into water levels using latest appropriate rating curves. The forecasted water levels and discharges are available for five-day ahead during the wet season and seven-day ahead during the dry season.

Table 2 shows the water level forecasts at 21 key stations in the form of the Mekong Bulletin sent to the concerned parties by e-mail and published on the MRC website on a daily basis.

Table 2 – Mekong Bulletin

Mekong Bulletin

MRC Secretariat

MRC Secretariat, P.O. Box 6101, Vientiane01000,Lao PDR., Tel: (856-21) 263263, Fax: (856-21) 263264, Email: mrcs@mrcmekong.org

Forecast period: 29 July - 2 August

Date: 28 July 2005

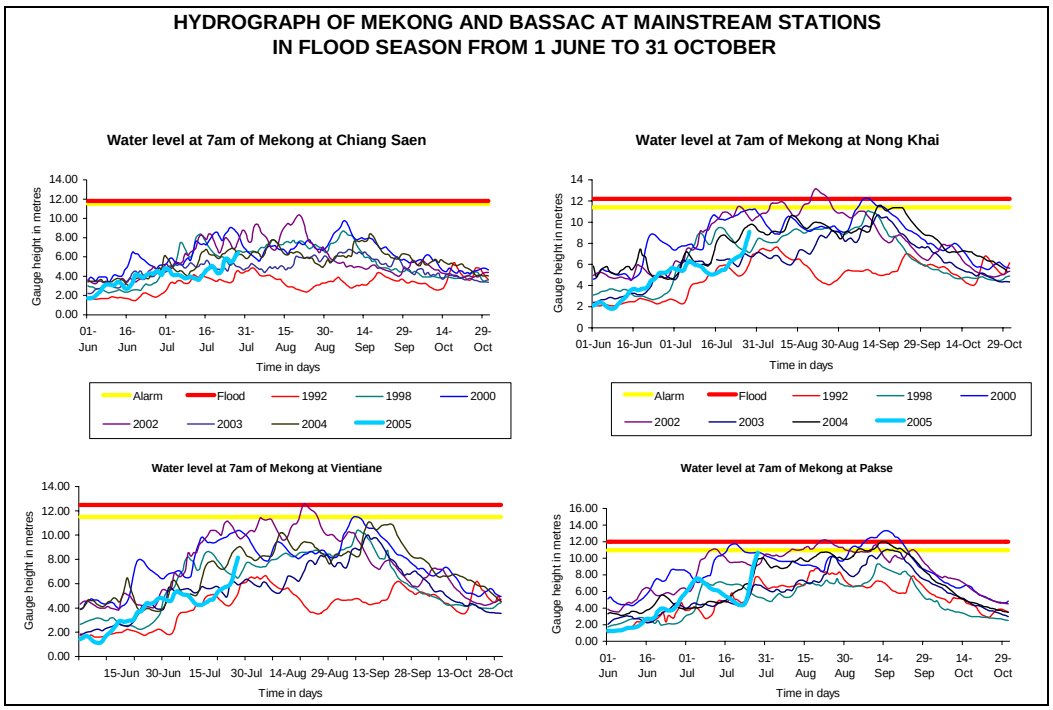
LOCATION	Observed Rainfall (mm)	Zero gauge above M.S.L (m)	Flood stage (m)	Alarm stage (m)	Observed W. level against zero gauge (m)		Forecasted Water Levels (m)				
	27-Jul				27-Jul	28-Jul	29-Jul	30-Jul	31-Jul	01-Aug	02-Aug
Chiang Saen	n/r	357.110	11.80	11.50	6.09	6.37	6.59	6.71	6.82	6.98	7.04
Luang Prabang	n/r	267.195	18.00	17.50	11.90	11.62	11.43	11.20	11.08	10.97	10.83
Chiang Khan	n/r	194.118	17.40	17.32	10.90	11.14	11.16	11.14	11.05	10.96	10.89
Vientiane	n/r	158.040	12.50	11.50	7.34	8.15	8.81	9.34	9.50	9.48	9.43
Nongkhai	1.0	153.648	12.20	11.40	8.27	9.09	9.75	10.28	10.44	10.42	10.37
Paksane	0.4	142.125	14.50	13.50	11.01	11.24	11.36	11.44	11.55	11.47	11.38
Nakhon Phanom	7.4	130.961	12.70	12.60	10.24	10.32	10.40	10.44	10.46	10.45	10.46
Thakhek	6.4	129.629	13.50	13.00	11.38	11.45	11.53	11.57	11.59	11.58	11.59
Mukdahan	104.5	124.219	12.60	12.50	10.47	10.90	11.19	11.29	11.32	11.36	11.35
Savannakhet	126.4	125.410	13.00	12.00	9.32	9.74	10.03	10.13	10.16	10.20	10.19
Khong Chiam*	37.5	89.030	16.20	16.00	11.71	12.86					
Ubon (Nam Mun)*	8.5	105.074	10.50		2.77	2.92					
Pakse	117.2	86.490	12.00	11.00	9.82	10.66	11.43	11.62	11.41	11.22	10.99
Stung Treng	54.0	36.790	12.00	10.70	8.10	9.04	9.75	10.38	10.67	10.58	10.45
Kratie	18.6	-1.080	23.00	22.00	15.47	18.10	19.10	19.93	20.55	20.85	20.68
Kompong Cham	0.6	-0.930	16.20	15.20	8.84	11.48	13.21	13.53	13.99	14.35	14.58
Phnom Penh (Bassac)	n/r	-1.020	12.00	10.50	4.90	6.11	7.08	7.76	7.99	8.20	8.37
Phnom Penh Port		0.000	11.00	9.50	3.96	5.20	6.17	6.85	7.08	7.29	7.46
Koh Khel	n/r	-	7.90	7.40	4.36	5.32	6.22	6.81	6.96	7.09	7.20
Neak Luong	n/r	-0.330	8.00	7.50	3.13	3.97	4.73	5.26	5.43	5.57	5.68
Prek Kdam	n/r	0.080	10.00	9.50	3.94	4.94	5.87	6.60	7.11	7.36	7.46
Tan Chau	10.4	0.000	4.20	3.00	1.20	1.65	1.92	2.19	2.44	2.66	2.84
Chau Doc	16.5	0.000	3.50	2.50	0.86	1.13	1.39	1.61	1.79	1.95	2.09

REMARKS: -: not available. *: reference stations without forecast.

2.3 Forecast Dissemination Component

For further actions on flood preparedness and low flow counter-measures in a timely manner, the water level forecast bulletin (Table 2), forecasted discharges in tabular form and the water level hydrographs at key stations along the Mekong mainstream as shown in Figure 3 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 shows the examples of the forecast products available on the MRC website.

Figure 3 – Water level hydrographs at key stations along the Mekong mainstream sent to the concerned parties by e-mail on a daily basis in the wet season (June-October) and a weekly basis in the dry season (November-May).



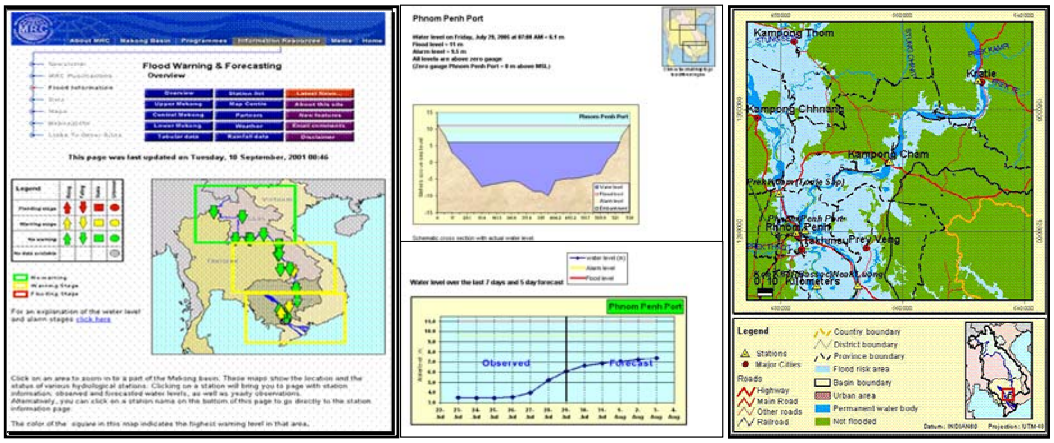


Figure 4 – Examples of forecast products on MRC website (left: overview of flood forecasting and warning; middle: observed and forecasted water level; right: flood map)

The users of the MRC forecast products are the four NMCs, national line agencies, National Disaster Management Committees, mass media, NGOs, UN Organisations and other interested parties. After receiving forecasted information from the MRCS, the national concerned organizations will disseminate the information to other concerned parties including the local communities via various means; i.e. website, e-mail, telephone, facsimile, radio, etc, for further action on flood preparedness or low flow counter-measures in a timely manner.

2.4 The Operation of Flood Forecasting and River Monitoring Activities

Among the five FMMP components, Component 1 of the establishment of the RFMMC is considered the key component. Its ultimate aim is to establish a regional centre of excellence for maintaining the national and regional availability of important flood-related tools, data and knowledge; producing accurate regional forecasts with a suitable lead-time and a timely and effective dissemination; and providing accurate, well-documented and consistent tools for basin-wide flood risk assessment and trans-boundary impact analysis.

The RFMMC was established in early 2005 in Phnom Penh and since July 2005 the flood forecasting and river monitoring activities were transferred from the Hydrology Team of the MRCS into the routine operation functions of the Flood Forecasting and Warning Unit (FWU) in the RFMMC.

3. Future Prospects of the MRC Forecasting and Early Warning System

The Mekong forecasting and early warning activities will continue to play a crucial role in providing accurate and reliable warning information for the lower Mekong riparian countries to enable them to be better prepared and avoid against unnecessary damage and losses.

The existing MRC Forecasting System was adequate in the past. However, rapid population growth in the region, intensification of agriculture, climate change, changes in land use and river morphology, and rapid technology development makes it imperative that the system be upgraded, and a forecasting system, based on modern technology combined with a more effective warning system, be installed. 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.

Improvement of the existing flood forecasting is one of the activities, prioritized by the FMMP. An immediate objective is to develop flood forecasting system that issues reliable forecast for 5 – 10 days and longer in advance. The system would be able to provide daily information on potential flood in Mekong mainstream as well as in major tributaries. The system would be used by member countries that already have a 1 – 5 day forecast, and for the catchments and locations that at present do not have forecasts. The system would allow MRC and its member countries to incorporate both detailed models for specific basins in each country, as well as regional scale (basin-wide) model covering the whole Mekong River.

3.1 Improvement in river monitoring networks and data collection and relevant capacities

Timely operational hydro-met data are indispensable for flood forecasting purpose. At present near-real time data from manual gauge stations, registered at 7 am and 7 pm (of previous day), are sent to the MRC Secretariat at 10 am. Thus there is a delay of at least 3 hours for this type of data. In order to carry out the forecasting and disseminate the forecast products to the users in a timely manner, the operational data should be delivered to the MRCS earlier.

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 and to upgrade 18 hydrological stations on the Lancang-Mekong mainstream and equip them with automatic water level recorders. 15 stations are linked to GSM network for real time data transmission, whereas the remaining 3 stations, of which two are in southern China, will use a satellite communication system. 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 above, the Mekong hydro-meteorological network is now being rehabilitated and improved giving the opportunity to strengthen the operation and maintenance of the existing network. These are medium and long-term measures which directly contribute to the accuracy and reliability of data acquisition and provision for the river forecasting and early warning.

3.2 Improvement in forecasting tools and its application

The improvement of the accuracy of the forecasts could be done by acquiring powerful, accurate and effective models coupled with GIS/mapping facilities that provides reliable flood extent information. Incorporating more key stations in the tributaries' catchment as well as those from the upper Mekong basin into the model along with the upgrading of near real-time data transmission system between the riparian countries and forecasting office at the RFMMC are of vital importance.

In addition emphasis on the improvement of the rainfall forecasts by the Data Collection and Processing Unit in the RFMMC, as an important input into the model, model calibration and regular evaluation of forecasting operation after each flood season could contribute to better performance of the model.

3.3 Improvement in early warning and information dissemination

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.

4. Conclusions

The regional flood forecasting and river monitoring activities in the Lower Mekong Basin have been in operation since 1970 and 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.

The present system provides the users with five-day forecasts during the wet season and seven-day forecasts during the dry season via the MRC website and e-mails. 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. Under the FMMP frameworks in close collaboration with the NMCs and the national concerned line agencies, the MRC forecasting and warning system continues to improve in three main components; river monitoring networks and data collection and relevant capacities to provide timely and accurate data, forecasting tools, and the early warning and information dissemination system to local communities.

As the river basin organisation, the MRC is keen to continue building up and strengthening its capacity in river forecasting and early warning system in order to play its regional role in assisting the four riparian members to manage and mitigate unnecessary damage caused by extreme flood and drought events.

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