# THE HYDROLOGICAL SITUATION IN THE LOWER MEKONG BASIN IN 2006

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ABSTRACT

*To inform the Joint Committee (JC) Meeting of the Mekong River Commission (MRC) on the hydrological situation in the Lower Mekong Basin a report is prepared twice yearly, based on hydro-meteorological data of the MRC Secretariat, the operational data of the Regional Flood Management and Mitigation Centre (RFMMC) and data specially supplied by the four MRC member states.*

*The basin of the Greater Mekong River, among the largest rivers in the world, is usually divided into two parts: the upper basin in Tibet (China), and the Lower Mekong Basin from Yunnan downstream to the South China Sea. The climate of the Mekong Basin is dominated by the Southwest Monsoon, which generates wet and dry seasons of more or less equal length. The wet season last from May to early October, and usually brings heavy rainfall. August and September, and October for the Delta, are the wettest months because tropical cyclones occur over most of the area. The Northeast Monsoon, starting late October, brings lower temperatures.*

*For the 25th JC meeting the RFMMC prepared a report for 2006. Some of the conclusions are:*
*The water levels/river flows at all key stations of the wet season of 2006 up to September were relatively average compared to the long term average. The situation became more extreme in October, when the water level at many stations in the upper parts of Mekong River suddenly increased, reaching a new monthly maximum.*

*In the lower part of the Mekong River from Phnom Penh to the sea the situation was not extraordinary. The alarm level and flood level was reached at Tan Chau and Chau Doc stations respectively; however, the flood level is reached frequently at these stations and this is not a cause of immediate concern.*

*The rainfall for the middle part of the LMB was higher than average during the third quarter, resulting in water levels somewhat higher than normal at several stations in the Mekong River basin. October saw severe rainfall events linked to Typhoon Xangsane in the upper and middle part of LMB with immediate effect on the observed water level at most stations. Finally, Typhoon Durian crossed the Mekong Delta early December, causing considerable damage in the Mekong Delta.*

*The report is important for everyone working in flood management and mitigation in particular and for MRC, member states and JC members in general.*

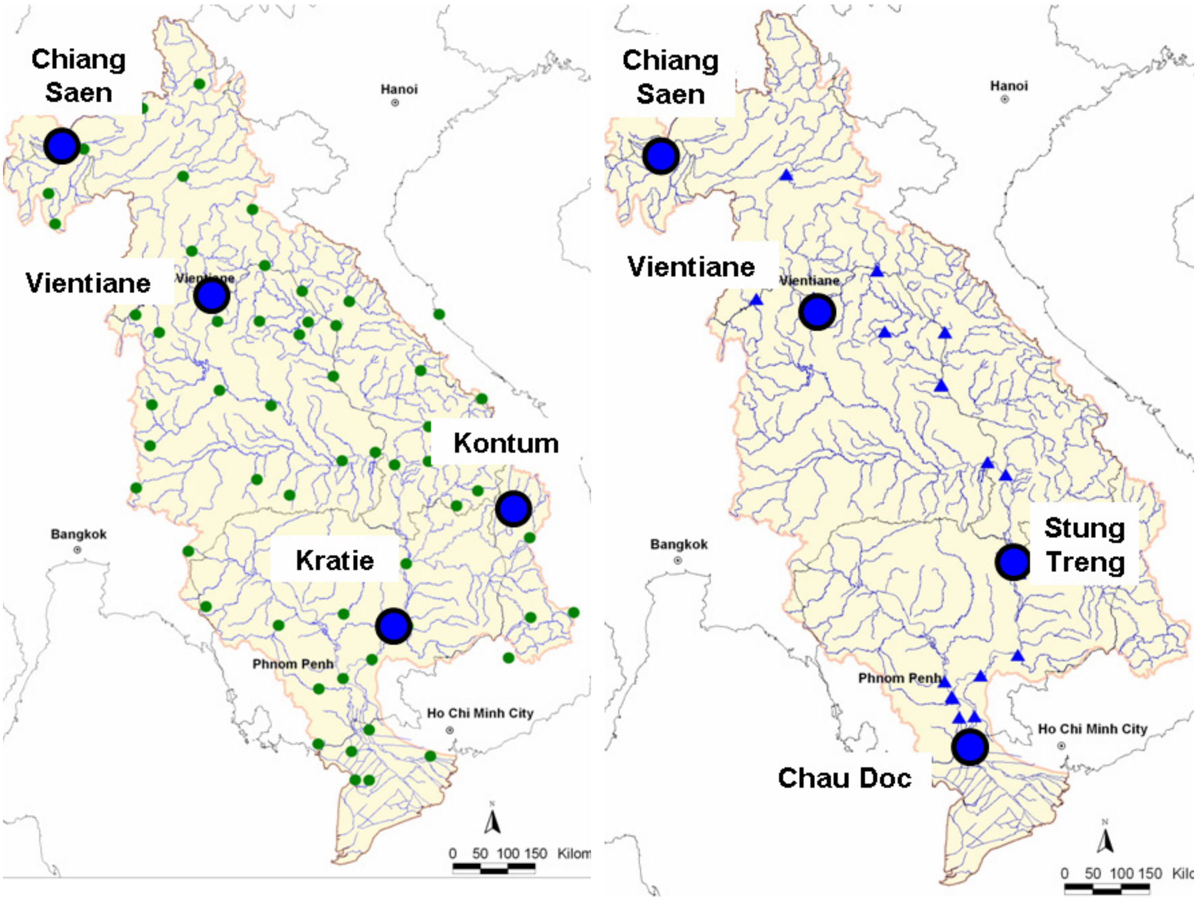
## 1. INTRODUCTION

The report improves on the previous ‘Report on the hydrological conditions in the Lower Mekong River Basin in first and second quarter of 2006’ presented to the 24rd JC Meeting in August 2006, by including data not yet available at the time and by incorporating some additional data analysis up to the end of 2006. More in-depth analysis of rainfall data by increasing the number of on ground observation stations from 25 stations up to 60 stations as recommended by the 24 rd JC Meeting is also incorporated in the present report.

The hydrological report is structured into four major sections: (1) Data and analytical tools used; (2) Meteorological conditions represented by rainfall accumulative, anomaly and percentage versus long-term average rainfall; (3) Hydrological conditions represented by the river discharge/water level hydrographs and their analyses; and (4) Conclusion and recommendations.

## 2. DATA AND ANALYTICAL TOOLS USED

The report is based on the analyses of wide range of archive and operational data (rainfall, water level, stream flow) collected not only from the national hydro-meteorological agencies (DHRW, DMH, WAD, TMD, DWR, HMS) in the four MRC riparian countries but also from other international organizations (USDA, WMO, NASA) through the internet facilities that are currently available, in order to make an integrated and useful hydro-meteorological analyses within the Lower Mekong River Basin. Table 1 shows an overview of the data. Figure 1 shows the locations of hydrological stations and rain gauge stations of data used in the present study.




Rainfall Stations (total used: 60) Hydrological stations (total used: 23)

Figure 1 Location map of the hydrological stations and rain gauge stations data used

Table 1: Data used in the present study

| | Data | Category | Period | Frequency | Area coverage/ No. stations | Data Source |
|---|---|---|---|---|---|---|
| 1 | Raingauge data | Archive | 1980-2005 | Daily | Over the basin | National hydro-meteorological agencies (DHRW, DMH, WAD, TMD, DWR, HMS) |
| | | Operational | 2005- 2006 | Daily | 60 stations | |
| 2 | Satellite rainfall (NOAA) | Archive/ operational | 2004- 2006 | Daily | Over the basin 10x10 km grid | Climate Prediction Centre of NOAA |
| 3 | Water level | Archive | begin-2004 | Daily | 14 stations along mainstream | National hydrological agencies (DHRW, WAD, DWR, HMS) |
| | | Operational | 2005- 2006 | Daily | | |
| 4 | Streamflow | Archive | begin-2004 | Daily | 9 stations along Mekong mainstream | National hydrological agencies (DHRW, WAD, DWR, HMS) |

## 3. METEOROLOGICAL CONDITIONS (RAINFALL)

Rainfall data over the basin that are made available to the Secretariat for the present study are categorized into two types: (1) data from raingauge stations by the national line agencies and (2) data from satellite observation by the Climate Prediction Centre (CPC) of NOAA. To analyze spatial rainfall distribution over the LMB, the data from both sources are used.

For raingauge data, spatial rainfall distribution was analyzed based on monthly rainfall at 60 raingauge stations from January to December 2006. Each location of the station represents a point data and value of point is on a monthly basis. The TOPOGRIDTOOL of the Arc/info was employed to generate every monthly rainfall grid, with cell size of 10 km.

For NOAA derived rainfall, the NOAA's Climate Prediction Center (CPC) uses RFE version 2.0 to better estimate precipitation while continuing the use of cold cloud duration, or CCD (derived from cloud top temperature), and station rainfall data. Meteosat 7 geostationary satellite infrared data are acquired in 30-minute intervals, and areas depicting cloud top temperatures of less than 235 K are used to estimate convective rainfall. WMO GTS data from ~1000 stations provide station rain gauge totals, and are taken to be the true rainfall within 15-km radii of each station.

The satellite rainfall images are generally generated by the CPC 1 or 2 days behind the current date, depending upon the local time zone of the user. The data format is in image (.bil) and associated files are named the same as the .tar.gz file. These data are in geographic projection at 0.1 degree (about 10 km) resolution. The data can be retrieved by GIS or Remote Sensing software. The image coverage also covered the Mekong Basin region. To make an analysis possible in GIS, the image file was converted to grid file by using ArcView 3.2. Grid value copied from the image file is the value of rainfall in millimeter. One grid file is a daily rainfall data. The monthly rainfall data is the total of all daily rainfall grids within a month.

Even though the satellite data enable an estimation of rainfall amount falling in the specific catchments, it is critical to assess the reliability of these products by comparing to ground truth information: rainfall data from raingaugu stations in this case. Figure 2 shows the quarterly mean area rainfall in millimeter from 60 raingauge stations

According to many literature sources concerning NOAA derived rainfall, the WMO GTS data from ~1000 stations over the world are taken to be the true rainfall within 15-km radii of each station. The significant differences in spatial distribution of rainfall were however found in the second quarter of 2006 at the onset of wet season. The possible reasons causing significant differences are as follows:

1. Only few stations are available in the LMB that are included in the WMO GTS dataset and used to remove the bias of satellite data (obtained directly from the maximum likelihood estimation method). In such case, Vientiane, Paksane and Chau Doc stations are unlikely to have been incorporated in the GTS; and/or
2. Comparison is done using lumped values for the sub basins. This may also introduce additional errors.

Among two different datasets, a subset of 60 rain gauge stations data is made available to the Secretariat but considered more reliable and was therefore used for further analysis in the present study. Figure 3 shows the percentage of quarterly mean areal rainfall in 2006 compared with the average rainfall (16-year average during 1985-2000).

Analysis results of the spatial quarterly rainfall (rain gauge data) in each of LMB countries from January 2006 to December 2006 are provided in Table 2. A percentage of rainfall over the LMB is slightly higher (30%) in the first quarter while slightly lower (7%) in the second quarter compared with the average figure , for the third quarter of 2006 quantity of rainfall is higher ( 10%) than the average figure, in the last quarter of year 2006 the quantity of rainfall is lower ( 15%) compared to the average rainfall .

The plots confirmed non-homogeneity of the spatial rainfall distribution in different locations. While the accumulative rainfalls at some stations are higher and some are lower than normal rainfall, mean area rainfall over the LMB until December 2006 is about 3 % higher than the 16-year average rainfall.

Table 2 Spatial quarterly rainfall analysis by country in the LMB, January to December 2006

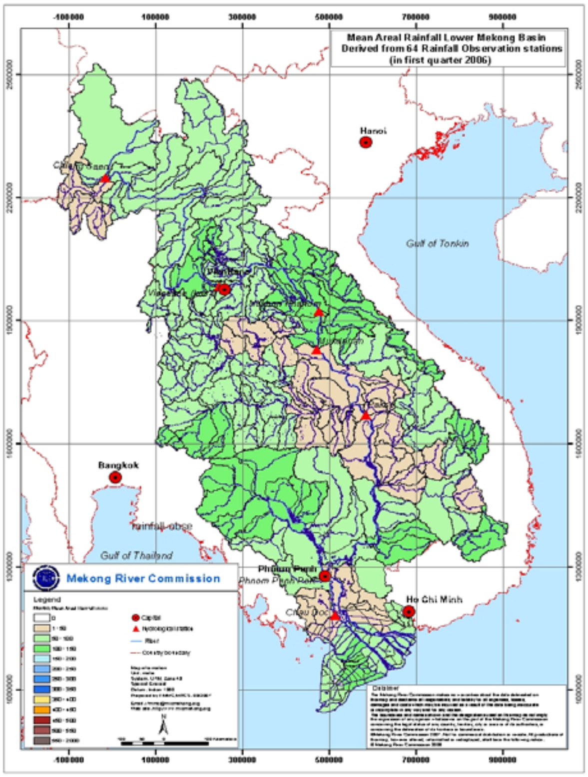
| Rainfall analysis | Quarterly Rainfall (mm) | | | | Annual Rainfall | Data Sources |
|---|---|---|---|---|---|---|
| | Q1(Jan-Mar) | Q2(Apr-jun) | Q3(Jul-Sep) | Q4(Oct-Dec) | | |
| Average 85-2006 | | | | | | 64 raingauge station - Spatial distribution analysis by ArcGIS |
| Cambodia | 56.36 | 455.89 | 725.92 | 270.95 | 1,509.12 | |
| Lao PDR | 69.21 | 573.58 | 992.97 | 131.09 | 1,766.85 | |
| Thailand | 57.21 | 465.98 | 743.50 | 129.53 | 1,396.22 | |
| Vietnam | 39.59 | 490.80 | 808.54 | 361.02 | 1,699.95 | |
| Rainfall in 2006 | | | | | | 64 raingauge station - Spatial distribution analysis by ArcGIS |
| Cambodia | 77.69 | 404.06 | 816.5468 | 179.35 | 1,477.64 | |
| Lao PDR | 88.62 | 479.31 | 1089.5999 | 172.29 | 1,829.83 | |
| Thailand | 67.78 | 429.80 | 754.1661 | 120.28 | 1,372.02 | |
| Vietnam | 85.89 | 535.76 | 984.4456 | 300.40 | 1,906.49 | |
| Rainfall in 2006 | | | | | | NOAA - Spatial distribution analysis by ArcGIS |
| Cambodia | 61.30 | 630.39 | 1,186.75 | 393.58 | 2,272.02 | |
| Lao PDR | 55.88 | 440.49 | 811.58 | 186.03 | 1,493.98 | |
| Thailand | 58.73 | 431.47 | 697.68 | 189.18 | 1,377.05 | |
| Vietnam | 60.79 | 608.30 | 1,068.17 | 427.84 | 2,165.10 | |

| Rainfall analysis | Quarterly Rainfall in Percentage of Average Rainfall | | | | Annual Rainfall | Data Sources |
|---|---|---|---|---|---|---|
| | Q1(Jan-Mar) | Q2(Apr-jun) | Q3(Jul-Sep) | Q4(Oct-Dec) | | |
| Rainfall 2006 | | | | | | 64 Raingauge stations - Spatial distribution analysis by arc GIS |
| Cambodia | 116.7 | 89.2 | 116.5 | 78.2 | 400.5 | |
| Lao PDR | 118.2 | 83.4 | 109.2 | 133.0 | 443.8 | |
| Thailand | 88.0 | 97.5 | 105.7 | 136.9 | 428.0 | |
| Vietnam | 148.2 | 100.8 | 103.1 | 72.6 | 424.7 | |

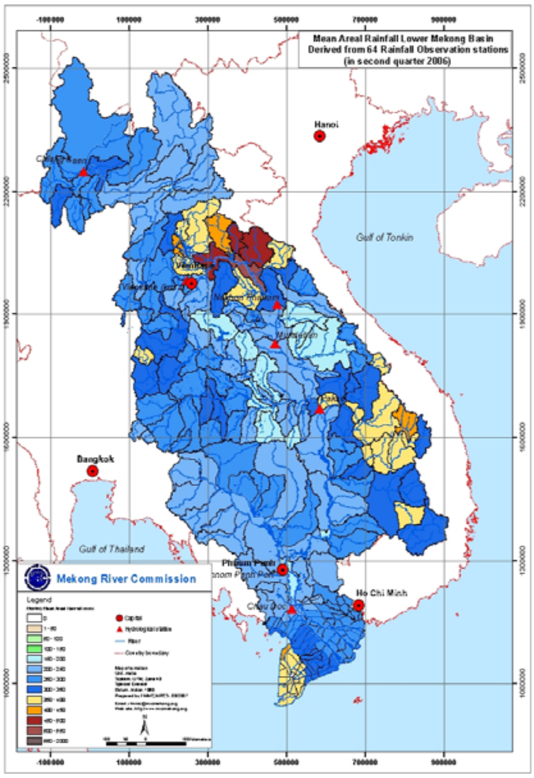
| Rainfall analysis | Quarterly Rainfall Anomaly in (mm) | | | | Annual Rainfall | Data Sources |
|---|---|---|---|---|---|---|
| | Q1(Jan-Mar) | Q2(Apr-jun) | Q3(Jul-Sep) | Q4(Oct-Dec) | | |
| Rainfall 2006 | | | | | 36.0 | 64 Raingauge stations - Spatial distribution analysis by arc GIS |
| Cambodia | 6.4 | -52.4 | 148.3 | -80.5 | 21.8 | |
| Lao PDR | 12.8 | -94.6 | 115.7 | 29.8 | 63.7 | |
| Thailand | -0.2 | -34.1 | 53.0 | 32.4 | 51.1 | |
| Vietnam | 24.3 | 1.7 | 81.6 | -100.2 | 7.3 | |

## 3. HYDROLOGICAL CONDITIONS (WATER LEVEL AND RIVER DISCHARGE)

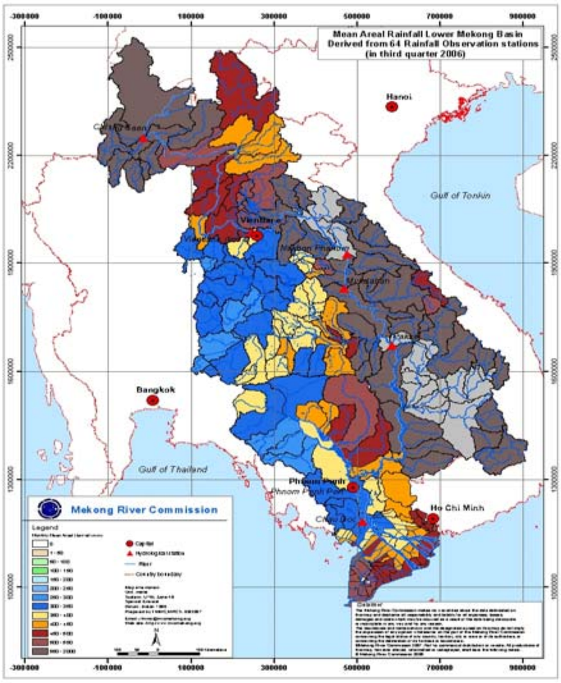
An extreme hydrological situation in the LMB can be regionally assessed in terms of the flows (or water levels) in the mainstream and the degree to which in any year they fall below or above some measure of what is normal or expected. These flows represent the integral sum of regional rainfall surplus and deficit, the strength of the annual Southwest Monsoon and the response of the landscape to the rainfall.



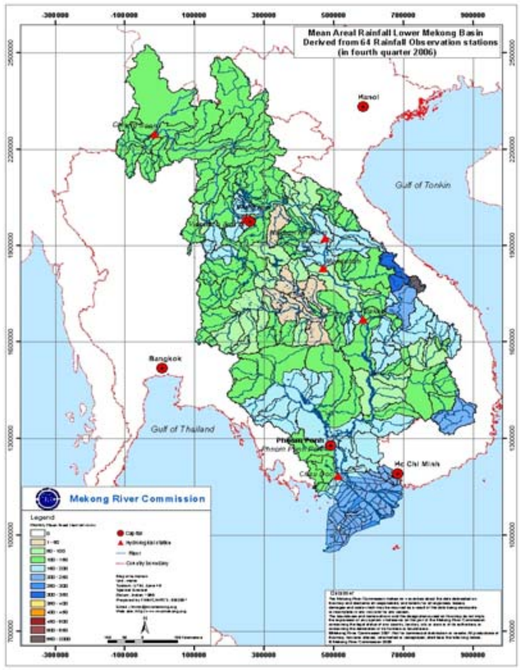

a )Rainfall First Quarter




b) Rainfall Second Quarter

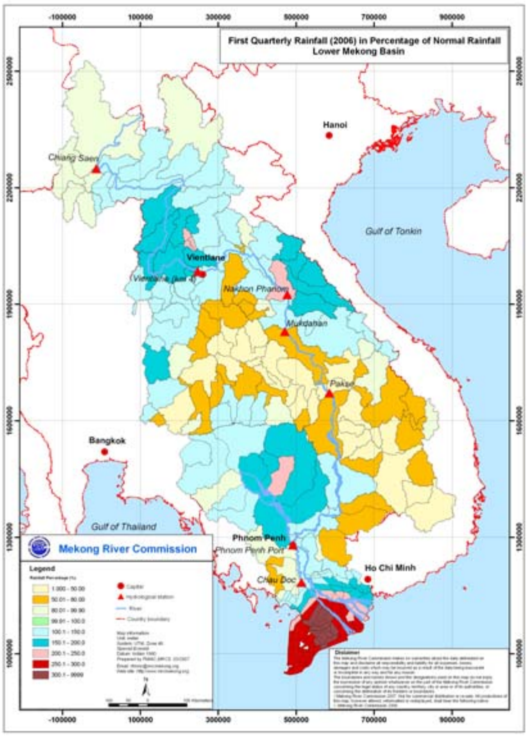



c) Rainfall Third Quarter

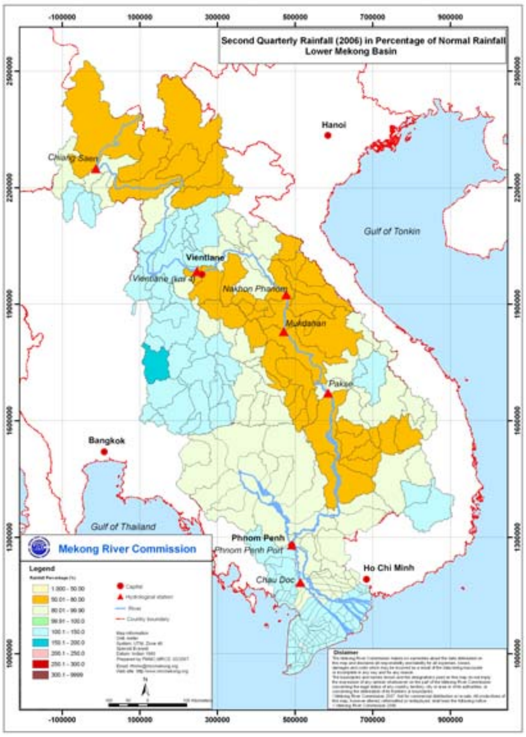



d) Rainfall Fourth Quarter

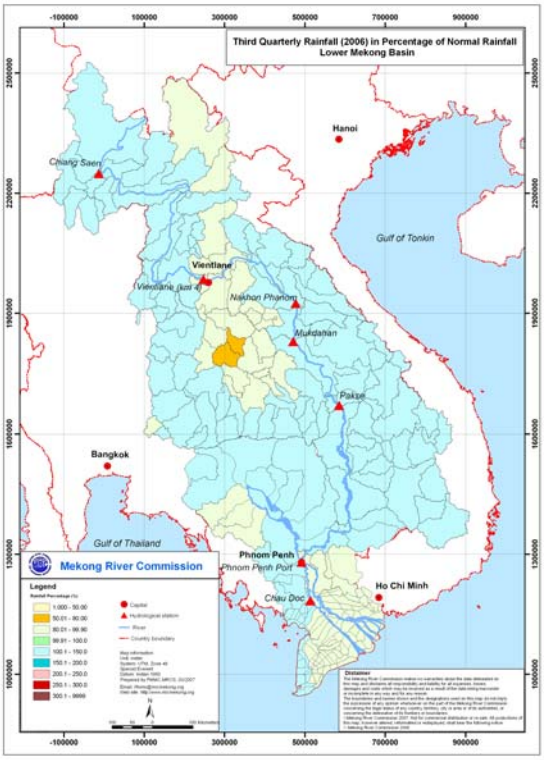
Figure 2 Aerial Rainfall map generated from 64 rain gauge stations



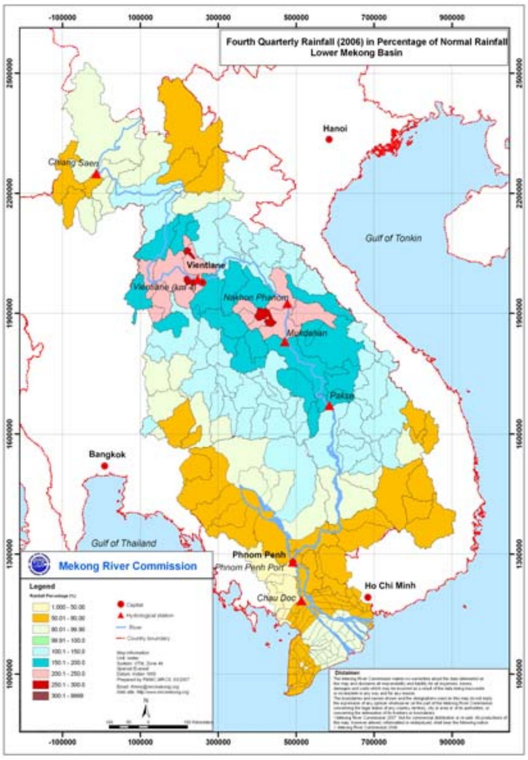

a )Rainfall First Quarter




b) Rainfall Second Quarter




c) Rainfall Third Quarter




d) Rainfall Fourth Quarter

Figure 3 Rainfall 2006 in percentage of Average Rainfall

In the present study, both archive and operational water level and river discharge data collected from the national hydrological services from the MRC member countries are used for the analyses. As the archive and operational data have some differences in nature, special attention has to be paid for the interpretation of their analysis results.

a) The operational water level data is observed daily at 7:00 am while the archive water level data is the average value from several reading points in a day.
b) The operational river discharge data is calculated from the operational water level data and the most updated rating curves (up to year 2004) that are available in the Secretariat.

### a. Hydrological situation during flood season – June to October 2006

Figure 4 shows the water level at selected hydrological stations during the flood season (June to end of October 2006) and compares these with (smoothed) long term averages for different return periods.

- **Chiang Saen**
  Compared to long-term average, the flows fluctuated around the normal in June 2006, then decreased to levels lower than the long term average. At the beginning of July 2006, the flows abruptly decreased for a short while and then dramatically increased to above normal during the second week of July, then decreased again to a nearly 1/10 year low. During the period from mid July to mid August the water level is lower than the long term average. During the first week of September the level even reached the lowest level recorded. From early October the level dramatically increased and reached 9.81 meter, a record for this month, to decrease again to normal levels by mid October. From the end of October to the end of year 2006 the water level continued to decrease and fluctuated around a level lower than normal.

- **Vientiane**
  The pattern of water level is generally similar to that of Chiang Saen station. The hydrograph shows two peaks; the first occurred during the second week of August when the water level reached a 1/10 year high. The second peak occurred early October when the water level reached 10.75 m, also a record for October. From the second week of October the water level went down to a normal level, and continued to go down to lower than normal to fluctuated around the 1/10 year low until the end of 2006.

- **Nakhon Phanom**
  The water Level at this station increased from the middle of July and reached a maximum level of 10.58 during the third week of August. After that the level decreased and went down to a 1/10 year low by mid September. The second peak started from mid September and reached a new record level for October at 9.87 m by mid October. Afterwards the water level decreased to the long term average at the beginning of November and continued to fluctuate around the long term average until the end of 2006.

- **Pakse**
  At the beginning of third quarter the water level at Pakse fluctuated around the normal value, but from the last month of third quarter the water level at this station dropped as far as the observed minimum level. From the middle of September the water level increased and reached 9.22 m during the first week of October. Afterwards the water level decreased to the long term average at the beginning of November and continued to decrease to reach lower than the normal values until the end of 2006.

- **Kratie**
  For the wet season of 2006 the water level at Kratie station was mostly somewhat higher than the long term average, except for October when the water level reached the maximum observed level for this month).

- **In the lower reach (from Phnom Penh to Tan Chau/Chau Doc)**
  At the stations on the lower reach of the Mekong, from Phnom Penh to Tan Chau/Chau Doc, the water levels were much lower than normal in June 2006. At the beginning of July 2006, the water levels dramatically increased to reach normal levels around 9$^{th}$ July 2006. They then decreased for few days before

gradually increasing again, to reach a maximum by mid October for Phnom Penh Bassac, Tan Chau and Chau Doc.

At Tan Chau and Chau Doc the water level reached the alarm level (3 m at Tan Chau station and 2.5 m at Chau Doc station) on 15 August and 18 August respectively. At the Chau Doc Station the flood level at 3.5 m. was reached on 11 October, the flood duration was 19 days. This is not extraordinary; in most years the flood level is reached for Chau Doc and Tan Chao stations.

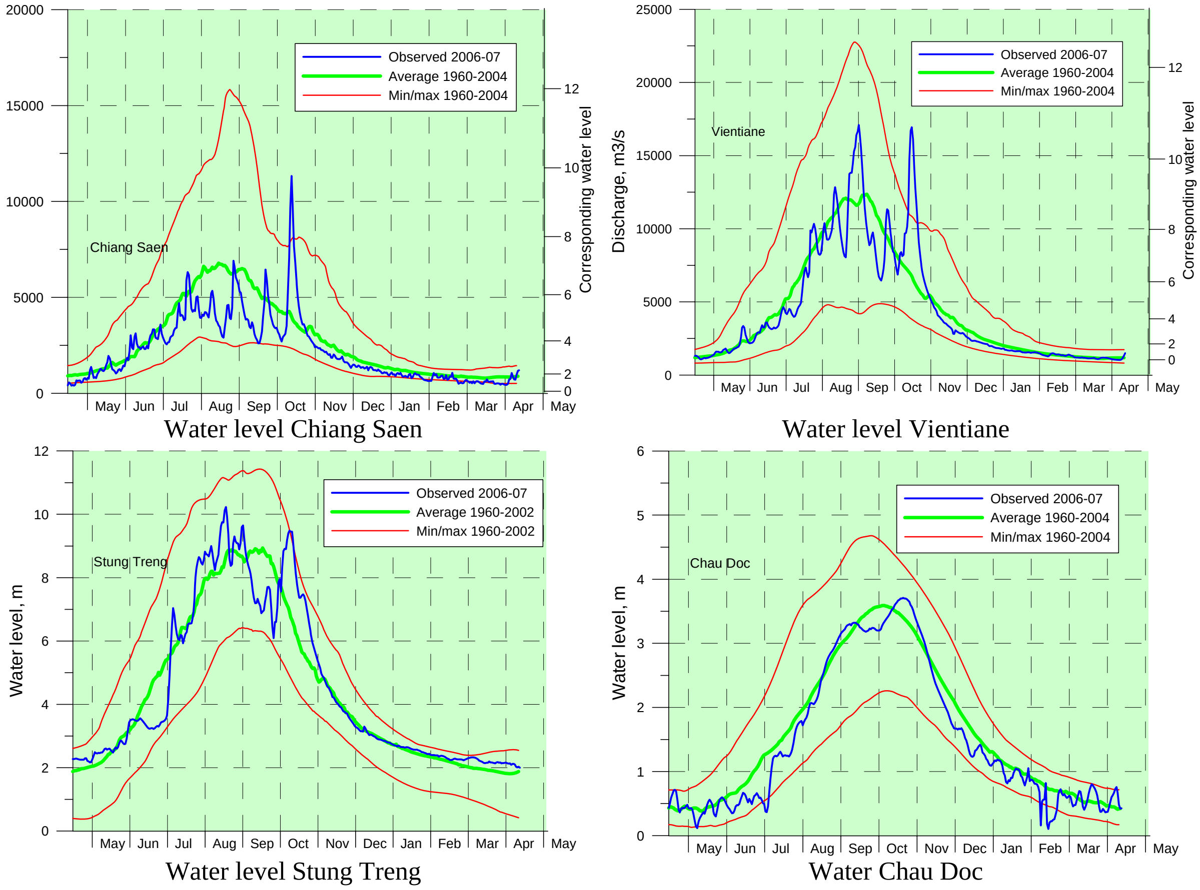



Figure 4: Water level at selected stations along the Mekong Mainstream from May 2006 to April 2007

### b. Hydrological situation during dry season - November 2006 to April 2007

Figure 4 shows the water level at selected hydrological stations from 1 November to 28 February 2007 and compares these with (smoothed) long term averages for different return periods.

- **In the upper reach of the Mekong River (from Chiang Saen to Pakse)**
  The observed water levels at most stations on the upper part of the Mekong River in the LMB are lower that the long term average value for the period November to February. At some stations the 1/15 year low is reached.

- **In the lower reach (from Stung Treng to Tan Chau and Chau Doc)**
  For almost all of the stations on the lower part of the Mekong River water levels fluctuated around the long term average.

## 4. CONCLUSION

Based on the hydro-meteorological data from the MRC member countries and other international organizations available to the MRC Secretariat, it is clearly shown that the water levels/river flows at all key stations in the beginning of wet season 2006 (from June to September) are not high compared to the average of previous wet seasons. The situation is more extreme in October 2006, when water levels dramatically increase and reach to new monthly records between Chiang Saen and Nakon Phanom.

At the last two stations, Tan Chau and Chau Doc, the water level reached alarm level (3 m at Tan Chau station and 2.5 m at Chau Doc station) on 15 August and 18 August respectively. For Chau Doc Station the flood level at 3.5 m was reached on 11 October, the flood duration was 19 days.

The rainfall for the middle part of the LMB was higher than average during the third quarter. This resulted in a water/flow level up to normal or somewhat higher than normal at several stations in the Mekong River basin (from Nakon Phanom to Tan Chau and Chau Doc). At the start of the fourth quarter of 2006 (in October) severe rainfall events caused by Typhoon Xangsane occurred in the upper and middle part of LMB; this had its effect on the observed water level at many stations in the LMB.