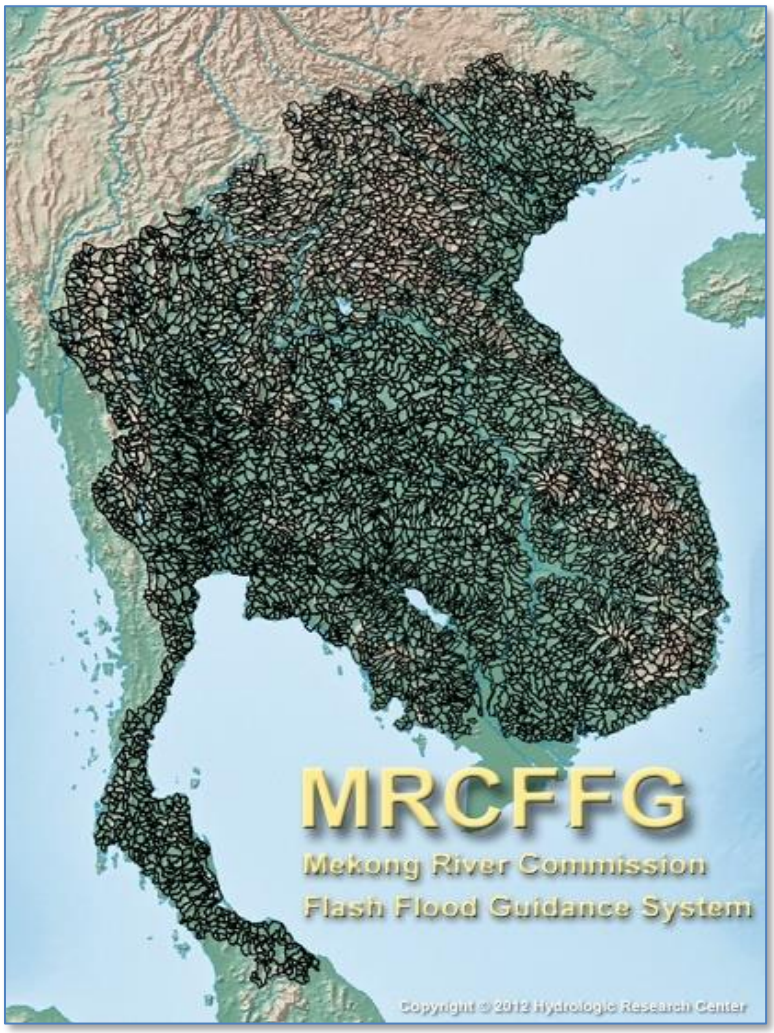
Mekong River Commission
Regional Flood and Drought Management Centre

Seasonal Flash Flood Situation Report 2022

Analysis of the MRC - Flash Flood Guidance System (MRC-FFGS)
Covering period from 1st June – 31st December 2022



Prepared by the
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Table of Contents

List of Figures

List of Tables

List of Abbreviations

ASM	Average Soil Moisture
FFG	Flash Flood Guidance
FFGS	Flash Flood Guidance System
HE-sat	Hydro-estimator Satellite Precipitation
HRC	Hydrological Research Centre in San Diego, California (USA)
ITCZ	Inter Tropical Conversion Zone
JMA	Japan Meteorological Agency
JTWC	Joint Typhoon Warning Center
LLCC	Low Level Circulation Center
LMB	Lower Mekong Basin
LTA	Long-Term Average
MAP	Mean Areal Precipitation
MCs	Member Countries
MRC	Mekong River Commission
MRC-FFGS	Mekong River Commission Flash Flood Guidance System
OFDA	Office of US Foreign Disaster Assistance
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Services Administration
RFDMC	Regional Flood Management and Mitigation Centre
TMD	Thai Meteorological Department
U.S.NWS	U.S. National Weather Service
USAID	US Agency for International Development
UTC	Coordinated Universal Time
WMO	World Meteorological Organization

1. Introduction

1.1 Main objective of the report

The Regional Flood and Drought Management Centre (RFDMC) is part of the Technical Support Division (TD) of the MRC Secretariat (MRCS), the operational arm of the MRC, an intergovernmental organization established by the 1995 Agreement on Cooperation for the Sustainable Development of the Mekong River Basin, between the governments of Cambodia, Laos, Thailand, and Viet Nam, further referred to as member countries (MCs).

This seasonal flash flood situation reports on the wet season 2022 presents an analysis of the MRC Flash Flood Guidance System (MRC-FFGS) of the RFDMC.

The purpose of this report is to give an overview of the flash flood situation in the Lower Mekong Basin (LMB) during the wet season 2022 from June until the mid of December (one and a half months after the wet season) and to evaluate the performance of MRC-FFGS for the detection of flash flood risk areas in the LMB during that time. The first evaluation report on the MRC-FFGS was issued in 2011. The report has been produced to evaluate the performance of MRC-FFGS for the wet season 2011 from May (one month before the wet season) until late October. The present report is the eleventh evaluation report of the MRC-FFGS. The FFG warnings are issued for the respective national territories of Cambodia, Lao PDR and Viet Nam. The RFDMC provides flash flood risk information for Thailand only in the Thai territory located within the LMB.

1.2 Further References

The products of the MRC-FFGS are updated daily during the wet season and can be accessed from: http://ffw.mrcmekong.org/ffg.php

The Weekly Wet Season Situation Report in the LMB is available at:

http://ffw.mrcmekong.org/reportflood.php

Further information about the hydrological situation in the LMB can be found in the following reports of the RFDMC:

- Annual Mekong Hydrology Report
- Seasonal Mekong River Situation Report
- Seasonal Drought Situation Report in the LMB

1.3 The MRC-FFGS

Like many parts of the world, flash floods are destructive in the countries of the LMB. To respond to regional and national needs and in order to address the problem of flash floods in

each MC of the MRC, the MRC and the US Agency for International Development (USAID), and the Office of US Foreign Disaster Assistance (OFDA), have with the technical support from the Hydrologic Research Centre (HRC) and through a program of the U.S. National Weather Service (U.S.NWS) jointly implemented a flash flood mitigation program in Cambodia, Lao PDR, Thailand, and Viet Nam.

The MRC-FFGS is designed as a diagnostic tool for meteorological and hydrologic services to analyse weather-related events that can initiate flash floods (e.g., heavy rainfall or rainfall on saturated soils) and then to make a rapid evaluation of the potential for a flash flood to occur at a location inside the LMB. The system provides values of flash flood guidance and flash flood threat for small stream basins - the basins most prone to flash flooding. Evaluations of the threat of flash flooding may provide estimations from one-hourly to six-hourly time scales (depending on timely reporting of hydrometeorological data).

The system has been developed since 2005 and fully completed in August 2009 including the capacity building for the MRC-FFGS operators at 4 national Line Agencies (LAs), one in each MC. From 2009 to now, the system has been improved and developed further. Since the beginning of 2018, the system has implemented a bias correction of high-resolution satellite rainfall as input to the system (Figure 1-1)

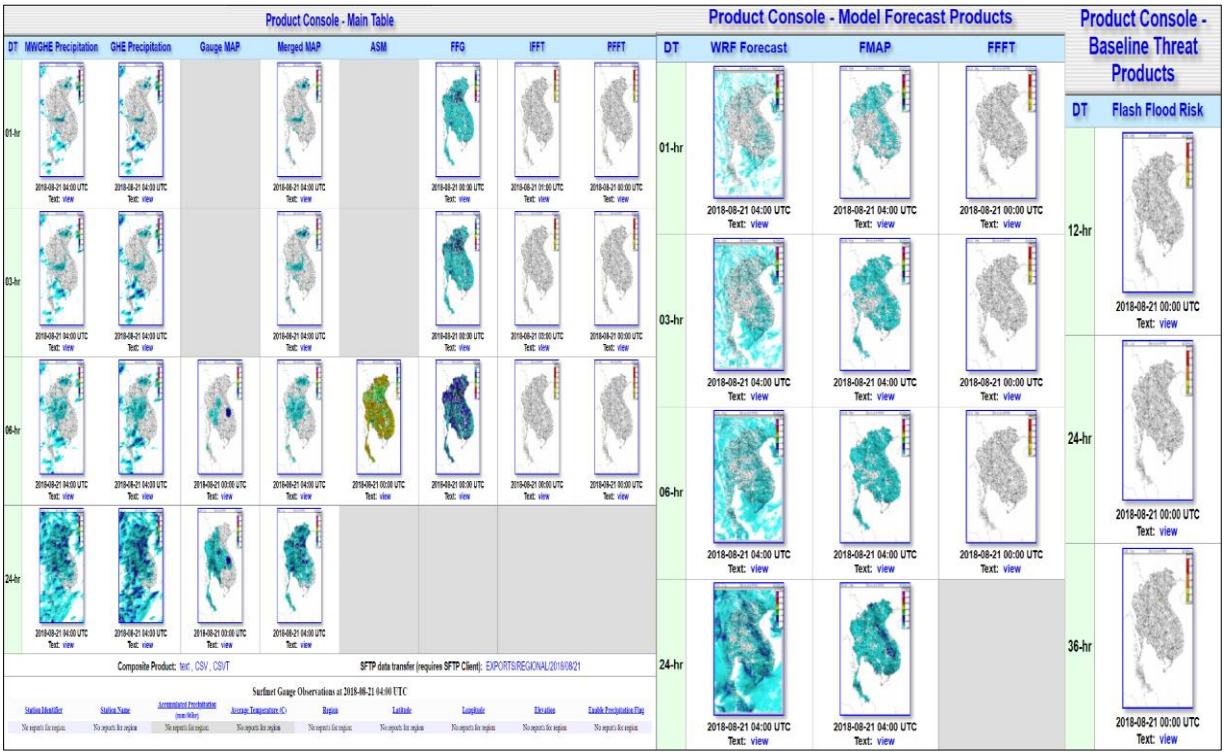


Figure 1-1: MRC-FFGS dissemination server user interface

In August 2019, the HRC completed and provided the Map-Server console interface for the MRC-FFGS to the RFDMC. It is very visual for forecasters to directly analyse the MRC-FFGS's products on the map during the routine work of flash flood operations (Figure 1-2).

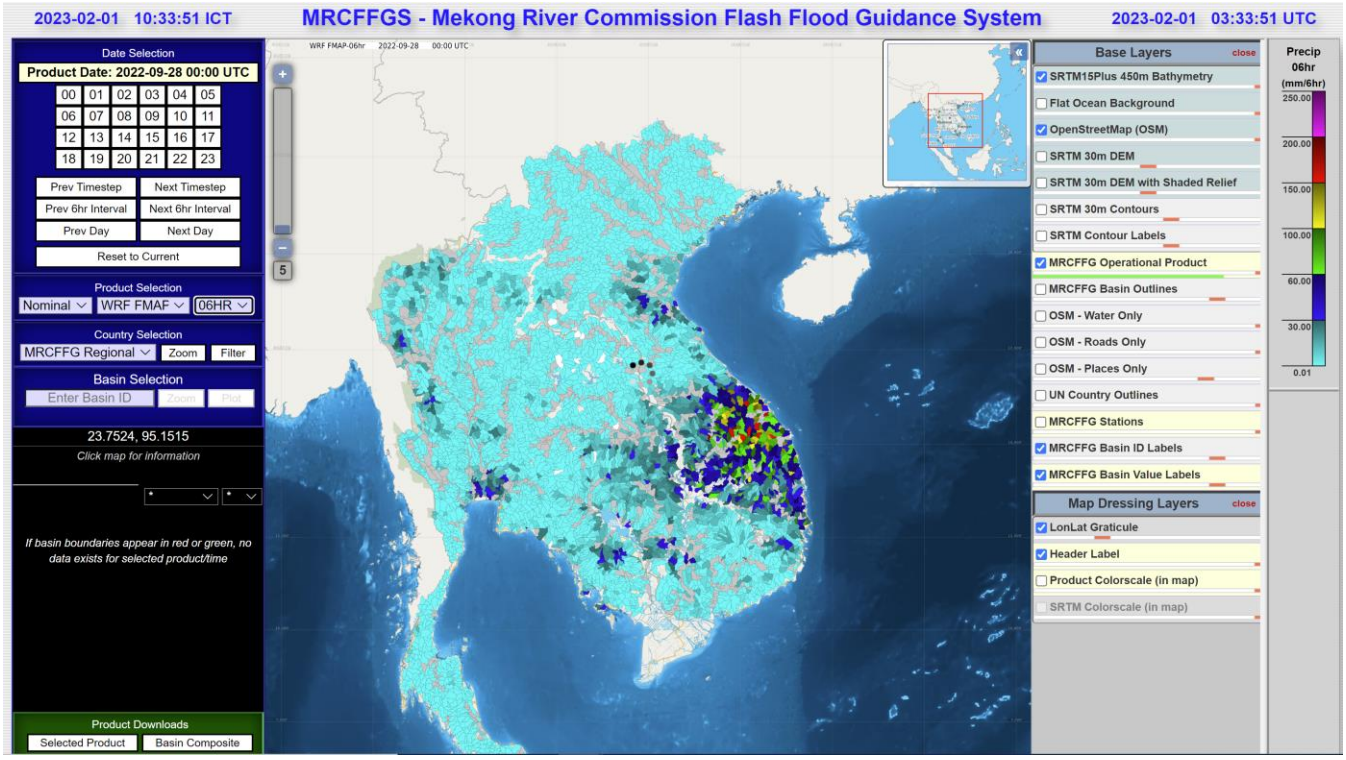


Figure 1-2: MRC-FFGS Map-server interface

Currently, the system has two console interfaces for flash flood operations with user-friendly interfaces providing a lot of essential products to support the forecasters.

The MRC-FFGS is a soil accounting model that needs satellite rainfall estimates as input data. The output is a warning for the next 1, 3 and 6 hours for sub-basins with a mean area of approximately 150 - 200 km^2 in size, that have a plausible chance of suffering from flash floods. The primary purpose of the MRC-FFGS is to provide near real-time guidance products pertaining to the imminence of potential small-scale flash floods (see Figure 1-3). For further detailed description of the MRC-FFGS output products see Annex C2.

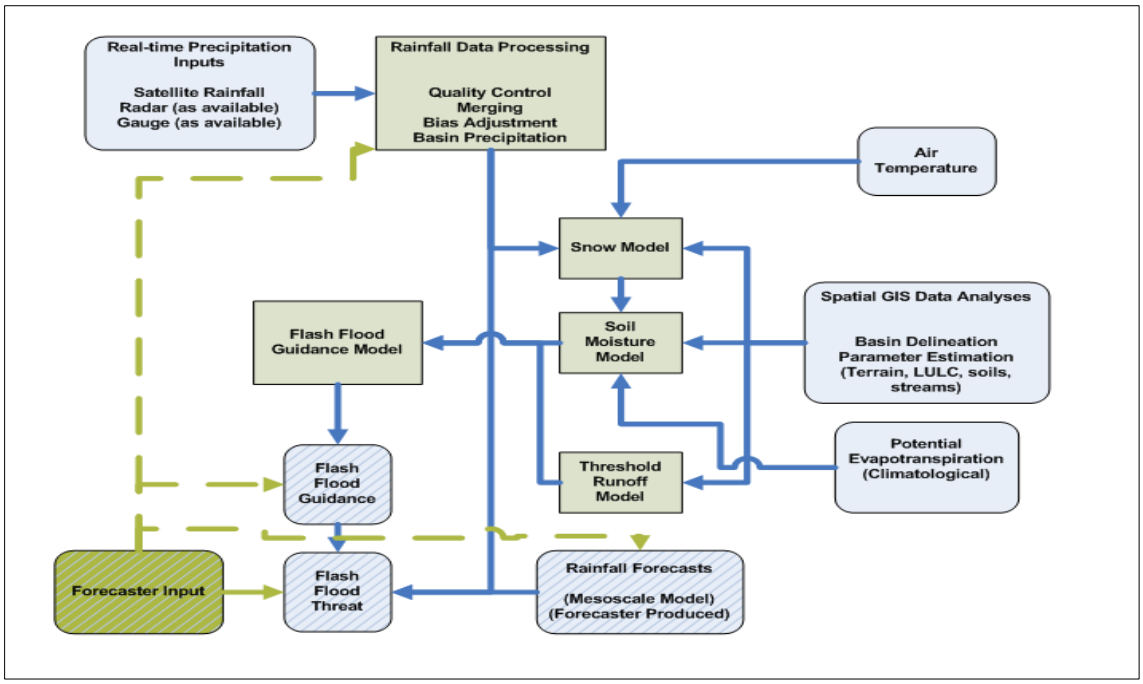


Figure 1-3: Key technical components of the FFGS (source: HRC)

If a warning is released depends on the hydrological characteristics of the watershed. The FFG is an index that indicates how much rainfall is needed to cause minimal flooding in that basin. The FFG value indicates the total volume of rainfall of a given duration (1-6 hours) over a given small catchment that is just enough to cause bank-full flow in the draining stream outlet. Consequently, rainfall volumes of the same duration that are greater than the FFG value indicate a likelihood of overbank flows at the draining stream outlet. The FFG warning scale is shown in Figure 1-4.

Scale of Flash Flood risk	FFG-1H (mm/1hr)	FFG-3H (mm/3hr)	FFG-6H (mm/6hr)
Extreme-Risk	0.01<FFG-1H<10	0.01<FFG-3H<10	0.01<FFG-6H<15
High-Risk	10.01<FFG-1H<25	10.01<FFG-3H<25	15.01<FFG-6H<30
Moderate-Risk	25.01<FFG-1H<40	25.01<FFG-3H<40	30.01<FFG-6H<60
Low-Risk	40.01<FFG-1H<60	40.01<FFG-3H<70	60.01<FFG-6H<100

Figure 1-4: FFG warning scale

The new computer server was installed and located in the RFDMC of the MRC since mid-May 2018. During the wet season 2020, the forecaster of RFDMC has continued operating routinely the MRC-FFGS daily for the provision of flash flood guidance products. The information on flash flood risk areas that were detected by the MRC-FFGS was uploaded on the MRC flood forecasting webpage (http://ffw.mrcmekong.org/ffg.php, see Figure 1-5) in parallel with the Mekong mainstream river flood forecast. The warnings that the MRC-FFGS

has identified according to the warning scale in Figure 1-4 are daily analysed and can be downloaded from the website in Excel and Google Earth KML format. Additionally, information regarding 'critical' weather conditions and the risk of flash floods is disseminated through e-mail to alert the LAs and non-governmental organization.

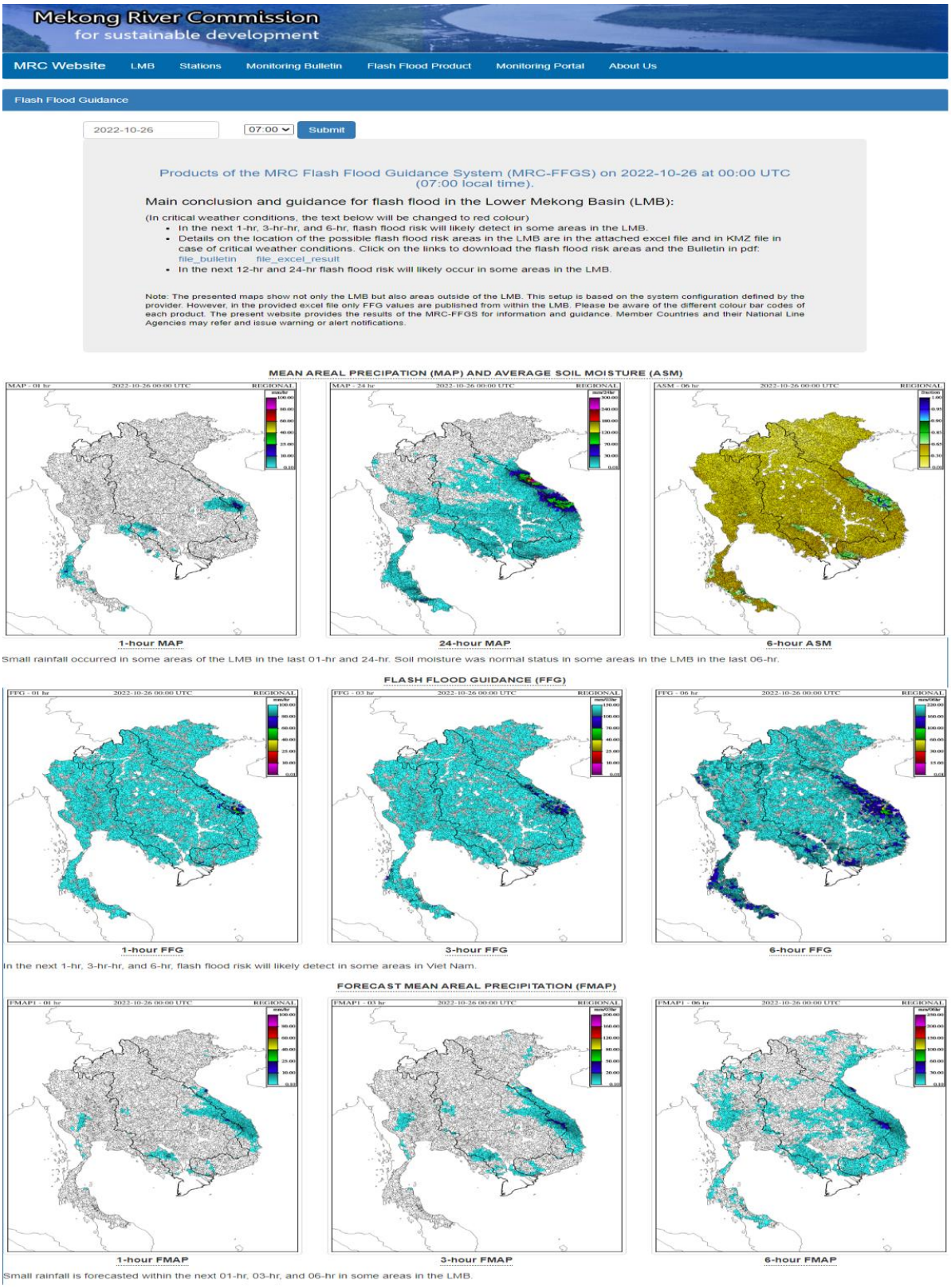


Figure 1-5: MRC-FFGS on the MRC flood forecasting website

2. Flash Floods in the Lower Mekong Basin (LMB) during the wet season 2022

2.1 Weather phenomena impact to flash floods in the LMB

In general, climate of the Mekong Basin is dominated by the Southwest (SW) Monsoon, which generates wet and dry season of equal length. Monsoon season usually lasts from May until late September or early October. There is usually heavy rain (50 – 100 mm/day) over most of the region. Later in the season, tropical cyclones occur over most areas so that August and September and even October (especially in the Delta) are the wettest months of the year. The Northeast (NE) Monsoon, which sets in toward late October, brings lower temperature. Rainfall during the months of the NE Monsoon is generally confined to Viet Nam since the rest of the LMB lies in the lee of Animate Mountains of the Central Highland.

Table 2-1: Generalized climate season in the LMB

Cool/Cold			Hot/Dry		Wet					Cool/Cold	
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NE Monsoon			Transition		SW Monsoon					NE Monsoon	

In total 25 tropical storms occurred, which developed over the Pacific Ocean or over the East Sea (Figure 2-1). There were 6 tropical storms, namely (1) CHABA, (2) MULAN, (3) MA-ON, (4) NORU, (5) SONCA, and (6) NESAT, which caused serious flash floods affecting the LMB (Table 2-2). The other cause of flash floods in the LMB is the Inter Tropical Convergence Zone (ITCZ), producing low pressure and tropical depression which lead to flash floods in some areas in the LMB.

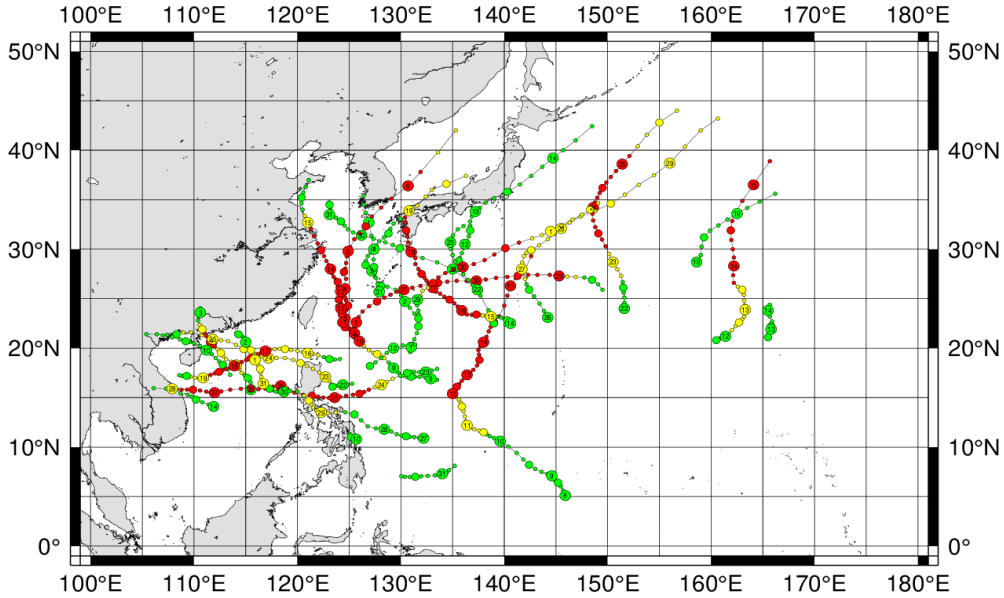


Figure 2-1 Tropical storm track for the Western Pacific in 2022 (Source: Digital typhoon, National Institute of Informatics, Japan)

Table 2-2: Tropical storm developed over the Pacific Ocean and East Sea in 2022 (Source: Digital typhoon, National Institute of Informatics, Japan)

No	Number	Name	Basin	Birth (UTC)	Death (UTC)	Duration	Min. Pres.
1	202201	MALAKAS	W. N.	08-04-2022 0:00	15-04-2022 12:00	7 Days 12	945
2	202202	MEGI	W. N.	09-04-2022 18:00	11-04-2022 0:00	1 Days 6	996
3	202203	CHABA	W. N.	30-06-2022 0:00	03-07-2022 6:00	3 Days 6	965
4	202204	AERE	W. N.	30-06-2022 18:00	05-07-2022 0:00	4 Days 6	994
5	202205	SONGDA	W. N.	28-07-2022 12:00	31-07-2022 18:00	3 Days 6	996
6	202206	TRASES	W. N.	31-07-2022 0:00	01-08-2022 12:00	1 Days 12	998
7	202207	MULAN	W. N.	09-08-2022 6:00	11-08-2022 0:00	1 Days 18	994
8	202208	MEARI	W. N.	11-08-2022 12:00	14-08-2022 12:00	3 Days 0	996
9	202209	MA-ON	W. N.	21-08-2022 18:00	26-08-2022 0:00	4 Days 6	985
10	202210	TOKAGE	W. N.	22-08-2022 0:00	25-08-2022 18:00	3 Days 18	970
11	202211	HINNAMNOR	W. N.	28-08-2022 6:00	06-09-2022 12:00	9 Days 6	920
12	202212	MUIFA	W. N.	07-09-2022 18:00	16-09-2022 0:00	8 Days 6	950
13	202213	MERBOK	W. N.	11-09-2022 12:00	15-09-2022 6:00	3 Days 18	965
14	202214	NANMADOL	W. N.	13-09-2022 18:00	19-09-2022 18:00	6 Days 0	910
15	202215	TALAS	W. N.	22-09-2022 0:00	23-09-2022 12:00	1 Days 12	1000
16	202216	NORU	W. N.	22-09-2022 18:00	28-09-2022 12:00	5 Days 18	940
17	202217	KULAP	W. N.	26-09-2022 0:00	29-09-2022 12:00	3 Days 12	965
18	202218	ROKE	W. N.	28-09-2022 12:00	01-10-2022 18:00	3 Days 6	975
19	202219	SONCA	W. N.	14-10-2022 0:00	15-10-2022 0:00	1 Days 0	998
20	202220	NESAT	W. N.	15-10-2022 6:00	20-10-2022 0:00	4 Days 18	965
21	202221	HAITANG	W. N.	18-10-2022 0:00	19-10-2022 12:00	1 Days 12	1004
22	202222	NALGAE	W. N.	27-10-2022 0:00	02-11-2022 18:00	6 Days 18	975
23	202223	BANYAN	W. N.	30-10-2022 18:00	01-11-2022 0:00	1 Days 6	1002
24	202224	YAMANEKO	W. N.	12-11-2022 12:00	14-11-2022 6:00	1 Days 18	1004
25	202225	PAKHAR	W. N.	11-12-2022 12:00	12-12-2022 12:00	1 Days 0	998

2.2 Features of precipitation

- In general, the mean monthly rainfall during the wet season 2022 over LMB was less than the LTA – 6.53 %, however, it was unevenly distributed over time and space.
- In the upstream part of the LMB from Chiang Sean to Paksane, a shortage of -6.85 % of rainfall compared to the LTA was estimated.
- In the middle part of the LMB (from Thakhek to Pakse) the mean monthly amount of rainfall was less than about -8.28 of the LTA.

- In the meanwhile, in the lower part of the LMB, the average rainfall was about +8.51% higher than the LTA. Heavy rainfall concentrated in late September and October due to the influence of tropical storms.

Table 2-3: Mean monthly rainfall distribution along the Mekong mainstream

2022														
Month (%) comparison LTA	-45.81 %	-18.21 %	+2.69 %	+0.14 %	+27.44 %	-45.08 %	-19.36 %	+24.88 %	+29.43 %	-31.3 %	-15.69 %	+42.27 %	+14.47 %	+32.45 %	-30.95 %
(%) in regions comparison LTA	-6.75 %					-8.28 %					+8.51 %				
(%) over LMB comparison LTA	-6.53 %														
2021															
Month (%) comparison LTA	+15.87 %	-12.73 %	-35.26 %	-9.61 %	-5.7 %	+5.39 %	-6.29 %	-46.13 %	+23.71 %	+92.95 %	-34.39 %	+2.81 %	-6.22 %	+17.05 %	+22.23 %
(%) in regions comparison LTA	-9.49 %					+13.93 %					+0.3 %				
(%) over LMB comparison LTA	+ 4.73%														

The scattered moderate rainfall that occurred in the LMB from May to November 2022 is shown in **Figure 2-2 compared to 2019, 2020,2021and its LTA**.

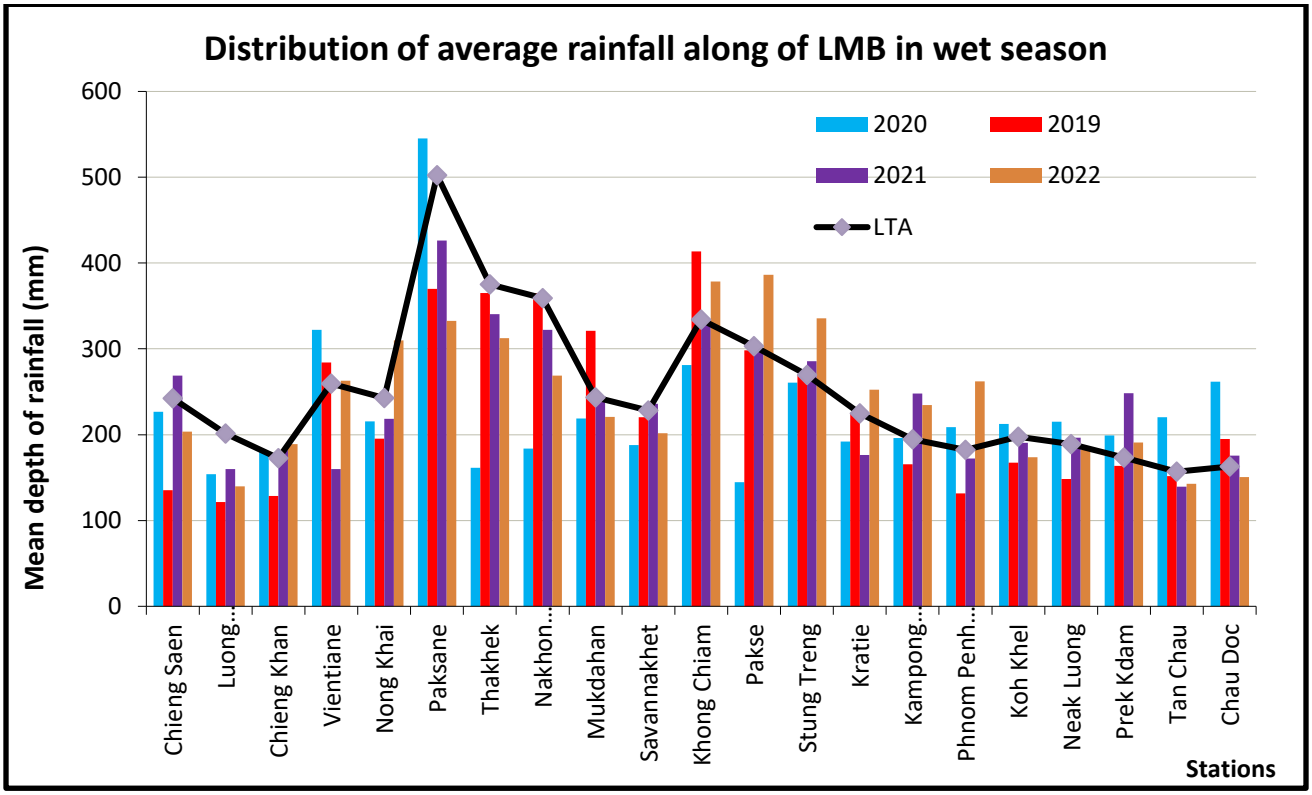


Figure 2-2: Distribution of total rainfall along the MRC Mekong mainstream stations

2.3 Flash flood events on 03rd July 2022 caused by the circulation of storm CHABA

2.3.1 Weather condition from 01st to 06th July 2022

SW Monsoon which prevailed over the Gulf of Thailand was strengthened during the late period. In addition, the low-pressure cell covered the upper Lao PDR and upper Viet Nam. Moreover, the monsoon trough lay across the upper northern and the upper portion of the northeastern part toward the lower pressure cell over the mentioned areas during the second half of the period. These conditions caused heavy rainfall over the upper northern and northeastern parts. **Figure 2-4** shows the weather maps.

Tropical storm CHABA: A low-pressure area west of Luzon developed into a tropical depression on June 28 at 20:00, the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) had recognized the storm's development into a tropical depression, began issuing advisories. The following day, the Joint Typhoon Warning Centre (JTWC) issued a Tropical Cyclone Formation Alert (TCFA) for the system remained almost stationary in the East Sea before slowly moving northwestwards, eventually leaving the Philippine Area of Responsibility by 15:00 UTC. The PAGASA issued its last bulletin on the tropical depression, the JTWC began issuing warnings for the storm and was given the designation 04W. Later, the Japan Meteorological Agency (JMA) upgraded system into a tropical storm, naming it CHABA. CHABA continued to intensify in the East Sea, later being upgraded into a severe tropical storm east of Hainan. On July 1 at 21:00 UTC, the JTWC upgraded Chaba to a typhoon, with the JMA doing the same 3 hours later July 2 at 0:00 UTC. Later that day at 07:00 UTC, it made landfall on Maoming. Shortly after its landfall, both the JMA and the JTWC assessed that Chaba lost typhoon status, downgrading Chaba to a severe tropical storm and to a tropical storm respectively. The JTWC then issued their final warning on Chaba at 15:00 UTC. Shortly after, the JMA downgraded Chaba to a tropical storm, it was further downgraded to a tropical depression on July 3 at 06:00 UTC **Figure 2-3**.

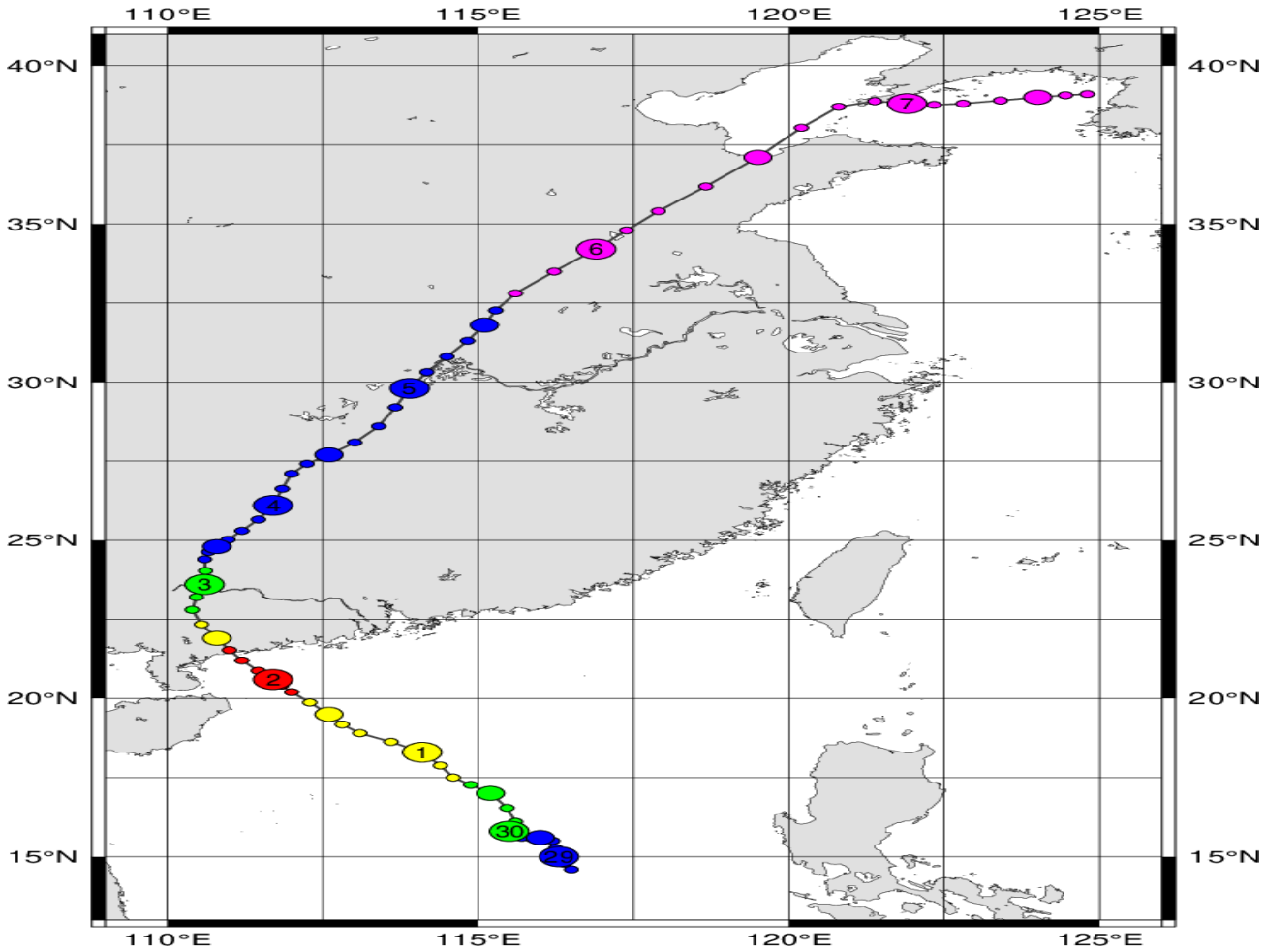


Figure 2-3: The track of CHABA (Source: JMA)

These conditions caused increasing amount and distribution of rainfall in some areas in the LMB including upper Thailand and North of Viet Nam and Lao PDR.

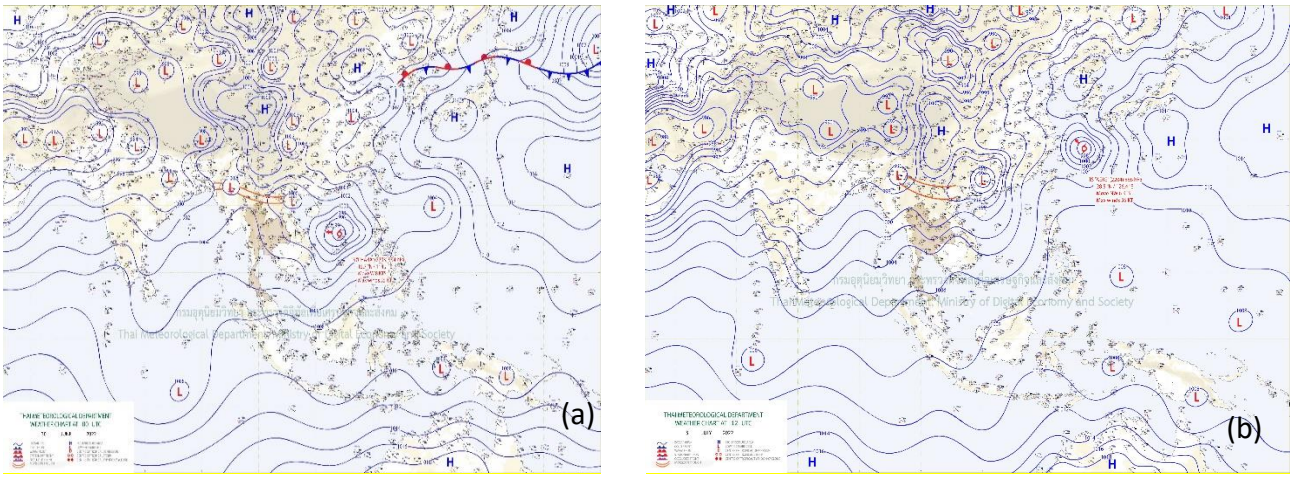


Figure 2-4: Weather map for (a) 30th June 2022 and (b) 03rd July 2022 (Source: Thai Meteorological Department -TMD)

2.3.2 Moderate and heavy rainfall from 01st to 06th July 2022

Due to the influence of the meteorological factors mentioned above, heavy rain has

concentrated mainly in the northeast parts of Lao PDR, north parts of Thailand, and highlands parts of Viet Nam from 01 - 06 July 2022. **Table 2-4** shows the daily rainfall observed at some locations in the LMB during July 01 -06. The total rainfall measured during this period at some stations is moderate as 186.30 mm at Veun Khen and 176.60 mm at Muong Mai in Lao PDR, 171.20 mm at Chieng Rai, Thailand and 113.10 mm at Muong Te, Lai Chau of Viet Nam. The rainfall distribution over the LMB is depicted in **Figure 2-5**.

Table 2-4: Daily rainfall observed at some stations in the LMB (01 -06 July 2022)

Name / Date	Muong Mai	Ban Phone Si	Veun Khen	Chiang Rai	Kon Tum	Muong Te
01-07-2022	0.00	0.00	25.30	85.40	29.00	0.10
02-07-2022	21.00	28.40	**148.00**	42.60	59.00	0.00
03-07-2022	60.20	54.30	0.00	20.60	1.50	20.00
04-07-2022	64.20	33.80	0.30	22.60	0.00	18.00
05-07-2022	24.00	1.00	0.00	0.00	22.90	44.00
06-07-2022	7.20	0.00	12.70	0.00	0.00	31.00
Sum	176.60	117.50	186.30	171.20	112.40	113.10

Unit: mm

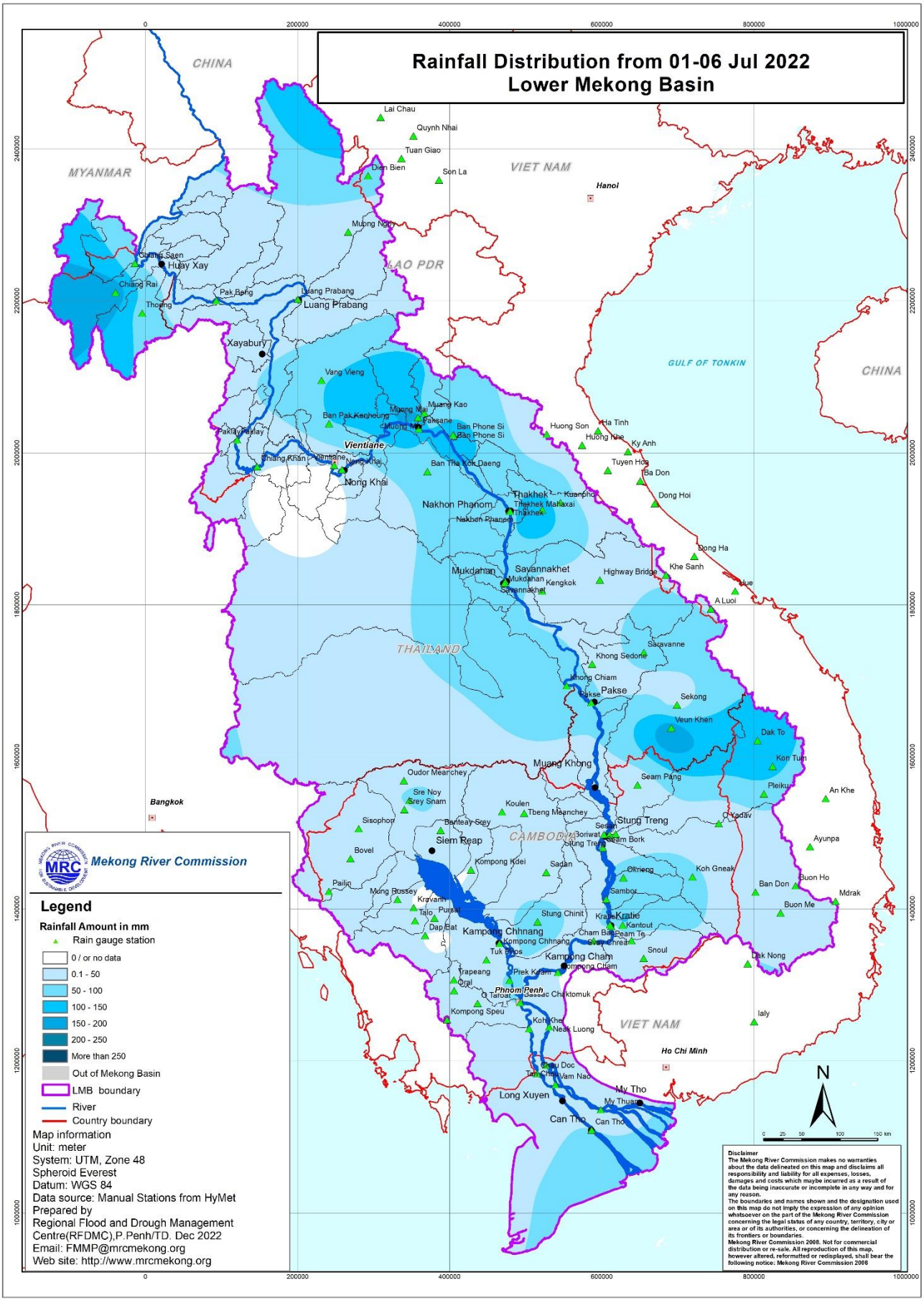


Figure 2-5: Rainfall distribution in the LMB from 01 -06 July 2022

2.3.3 Flash flood in Viet Nam on 03rd July 2022.

Based on the MRC-FFGS' products, the satellite rainfall Mean Areal Precipitation (MAP24h) and the Average Soil Moisture (ASM), heavy rain occurred in some locations in the northern parts of Viet Nam, southern parts of Lao PDR and north-eastern parts of Thailand (**Figure 2-6**). The comparison between MAP24h and the observed rainfall at some stations in the LMB during the period from 01- 06 July is shown in **Figure 2-7**.

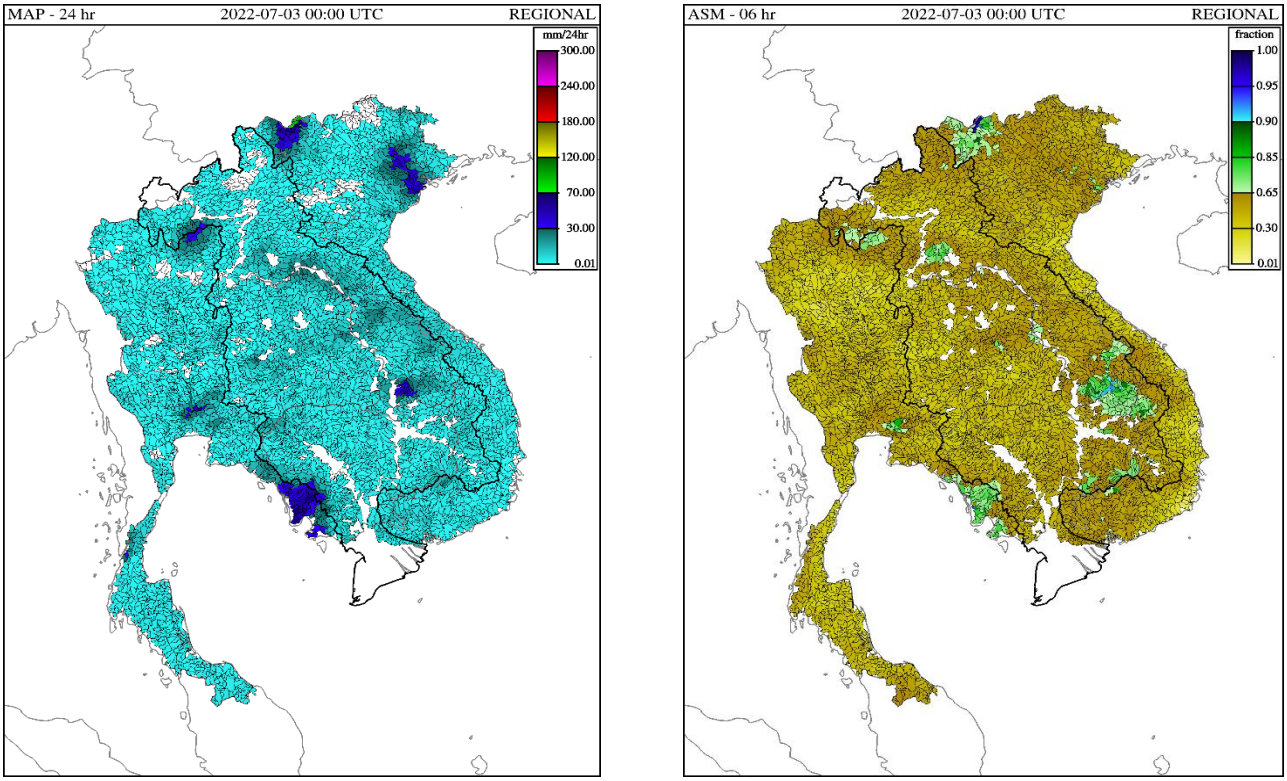
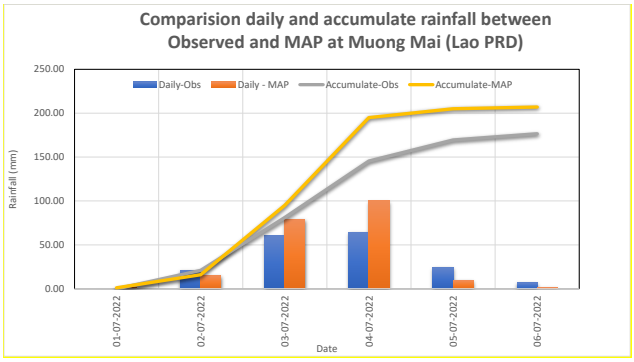
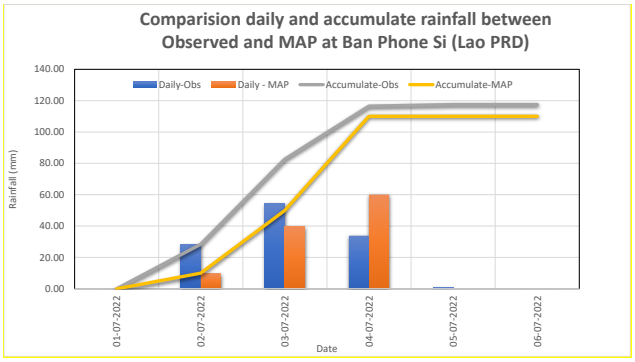


Figure 2-6: MAP24h and ASM on 03rd July 2022 at 00:00 UTC (07: 00 local time)





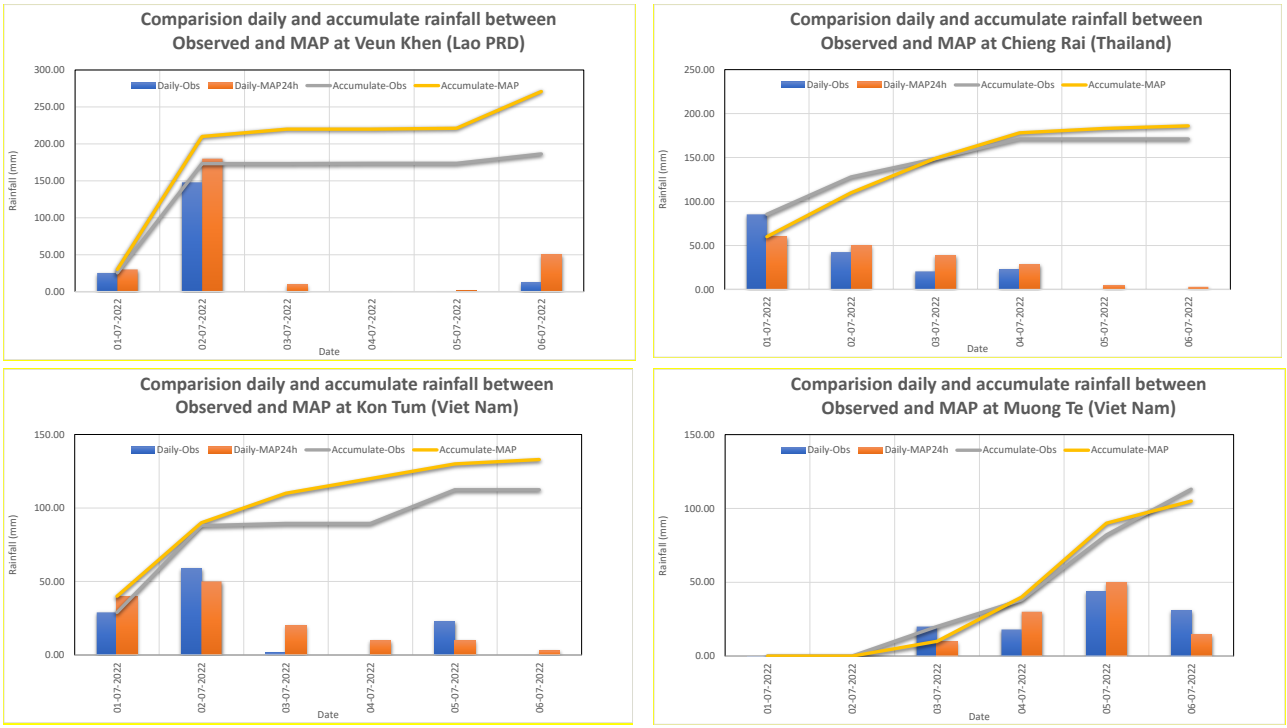


Figure 2-7: Comparison of observed rainfall and MAP at some stations in the LMB (July 01-06)

Based on the analysis of the FFG from the MRC-FFGS (**Figure 2-8**) and actual measurements available in RFDMC, the RFDMC made the decision to submit the warning of flash flood guidance for 1, 3, and 6 hours as shown in

Table 2-4.

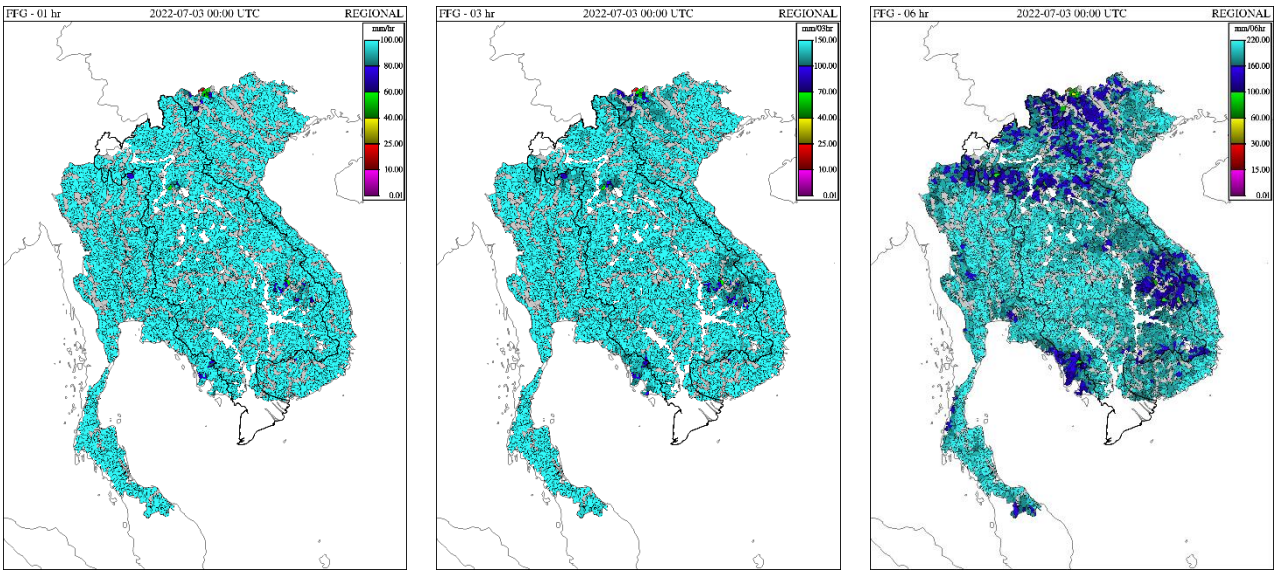


Figure 2-8: FFG 01, 03 and 06 on 03rd July 2022 at 00:00 UTC (07: 00 local time)

Table 2-4: FFG detected by MRC-FFGS on 03rd July 2022 at 00 UTC (07: 00 AM Local time)

Rate-risk and location of the flash flood may occur in the next 1, 3, and 6 hours in Viet Nam

Date of FFG products 03/07/2022 00:00 UTC time

01-Hour Flash Flood Risk and Location				3-Hour Flash Flood Risk and Location in Vietnam				6-Hour Flash Flood Risk and Location in Vietnam			
Provinces	Districts	Region	Level Risks	Provinces	Districts	Region	Level Risks	Provinces	Districts	Region	Level Risks
Lao Cai	Bat Xat	Northwest	Low-Risk	Lao Cai	Bat Xat	Northwest	Low-Risk	Gia Lai	Chu Pah	Central Highlands	Low-Risk
Lai Chau	Phong Tho	Northwest	High-Risk	Lai Chau	Phong Tho	Northwest	High-Risk	Kon Tum	Sa Thay	Central Highlands	Low-Risk
Lai Chau	Sin Ho	Northwest	Low-Risk	Lao Cai	Bat Xat	Northwest	Low-Risk	Lao Cai	Bat Xat	Northwest	Low-Risk
Lao Cai	Bat Xat	Northwest	Low-Risk	Lao Cai	Bat Xat	Northwest	Low-Risk	Lao Cai	Bat Xat	Northwest	Low-Risk
Lao Cai	Bat Xat	Northwest	Low-Risk					Lao Cai	Bat Xat	Northwest	Low-Risk
								Lai Chau	Phong Tho	Northwest	Moderate-Risk
								Lai Chau	Sin Ho	Northwest	Low-Risk
								Lai Chau	Phong Tho	Northwest	Low-Risk
								Lao Cai	Bat Xat	Northwest	Moderate-Risk
								Lao Cai	Bat Xat	Northwest	Low-Risk
								Lai Chau	Muong Te	Northwest	Low-Risk
								Lai Chau	TX. Lai Chau	Northwest	Low-Risk

2.3.4 Conclusions

- During the period 01-06 July 2022, the main cause for heavy rain in the LMB was influenced by the tropical storm CHABA.
- Heavy rain brought flash floods at some areas in the central parts of Lao PDR, north-central parts of Viet Nam, and north-eastern parts of Thailand which were detected by the MRC-FFGS.
- The comparison between rainfall observed and the MAP24h results shows that at some locations the rainfall was overestimated about 25 % by the FFGS.
- Flash flood risk areas detected by the MRC-FFGS on 13th June 2022 at 00:00 UTC corresponded to the reported flash flood areas via newspaper or internet (see AnnexA.1).

2.4 Flash flood events on 12nd August 2022 caused by typhoon MULAN.

2.4.1 Weather conditions from 11 -16 August 2022

During this period, the LMB was affected by three weather factors including (i) The monsoon trough laid across the northern and north-eastern parts towards the active low-pressure cell over the East Sea on the first day of the week. Then the low-pressure cell intensified and transformed into the tropical depression and reached the Tropical Storm (TS) “MULAN”. The TS moved through the Gulf of Tonkin before making landfall over Quang Ninh province of Viet Nam in the early morning of Aug 11. Then it downgraded into the tropical depression over Lang Son province, Viet Nam on 07:00 a.m. After that, it degenerated into an active low-

pressure cell covering the upper portion of the northern part of Myanmar on Aug 12; (ii) the monsoon trough which shifted further north to lie across Myanmar and upper northern Lao PDR towards a low-pressure cell over upper Viet Nam and the Gulf of Tonkin on Aug 13, and (iii) the moderate to rather active southwest monsoon prevailed over the Andaman Sea, Thailand and the Gulf of Thailand during the first half of the week then it weakened afterward. These conditions caused heavy rainfall over the upper part of the LMB during the early and middle week with flooding in some areas.

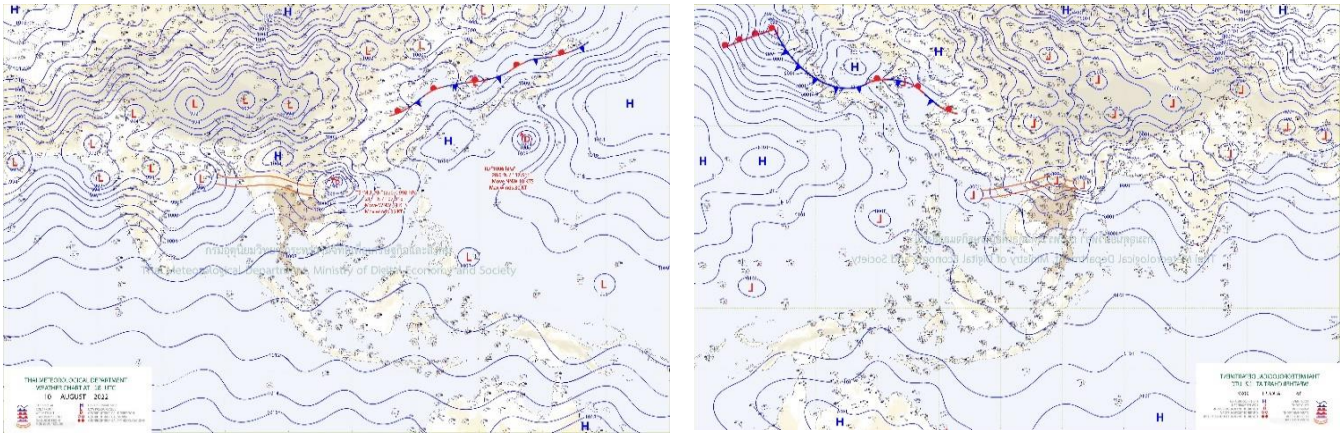


Figure 2-9: Weather map for (a) 10th August 2022 and (b) 16th August 2022 (Source: TMD)

Tropical Storm MULAN (Source World Meteorological Organization (WMO)): On August 5, the JTWC noticed an area of convection with a consolidating low-level circulation center at approximately level 7 to the south of Malina, Philippines. The system then subsequently moved over and emerged into the East Sea, where it organized but its circulation remained broad, having two distinct vortices present in satellite imagery. The JMA then upgraded the system into a tropical depression by 00:00 UTC on August 8. The JTWC designated the system as a "monsoon depression" six hours later due to many centers present in the system. By the next day, the JMA upgraded it into a tropical storm, and it was given the name MULAN. The storm did not intensify further, according to the JMA, and by 02:50 UTC on August 10, MULAN made landfall on the coastal areas of southern parts of China. The JTWC subsequently canceled the TCFA and downgraded its formation chances to medium. The JMA then downgraded the storm into a tropical depression as it moved inland in Viet Nam by the next day and was last noted six hours later the same day.

The circulation of this tropical storm caused heavy rainfall in the upper and middle reaches of the LMB. In fact, the common heavy rainfall of 20-50mm/day occurred in these areas on August 12, leading to flash floods and landslides that also occurred in some locations of the LMB. The track of Tropical Storm MULAN is shown in **Figure 2-10**.

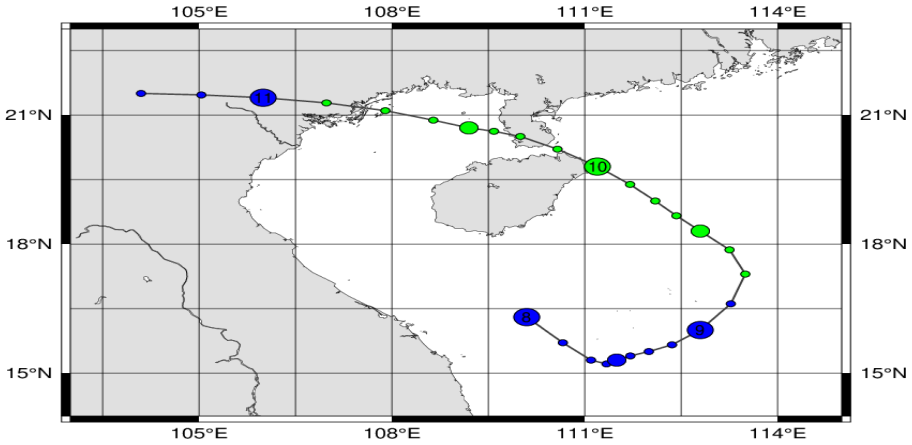


Figure 2-10: The track of tropical typhoon MULAN (Source: JMA)

2.4.2 Heavy rainfall during 11-16 August 2022

Rainfall was observed from the upper and middle parts of the Lower Mekong Basin. The total rainfall measured during this period at some stations is very large such as at Mai Chau (Viet Nam), Chiang Rai (Thailand), Muong Ngoy, Thakhek (Lao PDR), Nakhon Phanom (Thailand) (**Table 2-5**). The rainfall distribution over the LMB is depicted in **Figure** 2-11.

Table 2-5: Daily rainfall observed at some stations in the LMB (11 –16 August 2022)

Unit: mm

Stations / Date	Thakhek	Muong Ngoy	Nakhon Phanom	Chiang Rai	Mai Chau	Vang Vieng
11/08/2022	0,30	8,30	0,00	49,00	108,00	3,40
12/08/2022	141,00	24,10	155,50	193,00	145,00	51,20
13/08/2022	8,20	29,10	9,10	5,00	39,10	23,00
14/08/2022	0,00	7,30	0,70	0,00	0,00	15,00
15/08/2022	16,30	54,20	17,40	0,20	26,00	62,40
16/08/2022	0,00	64,10	0,00	5,30	0,00	3,70
Sum	165,80	187,10	182,70	252,50	318,10	158,70

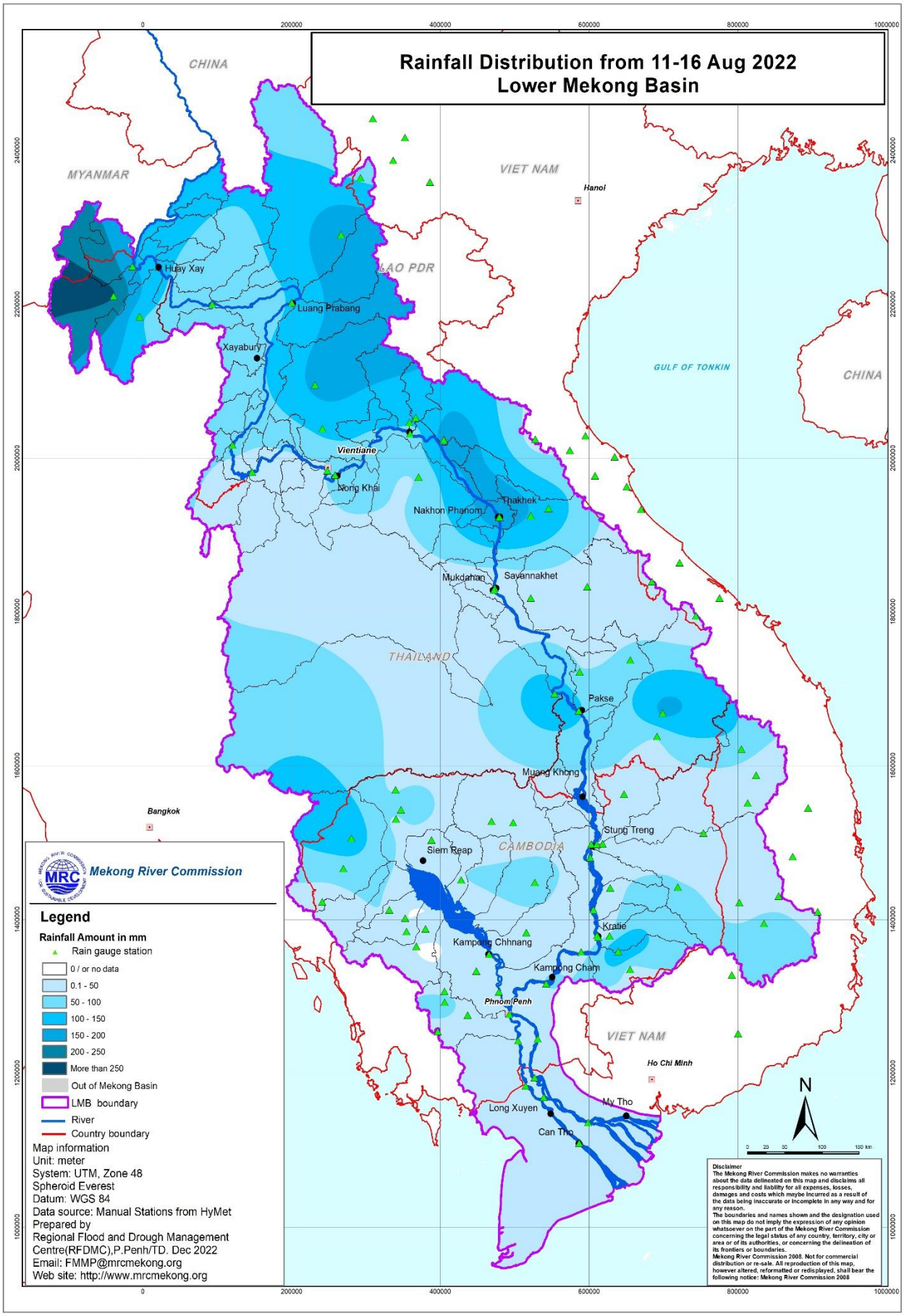


Figure 2-11: Rainfall distribution during 11-16 August 2022 in the LMB

2.4.3 Flash Flood over the LMB on 12 August 2022, caused by the MULAN tropical storm's circulation.

Based on the MRC-FFGS' products, MAP24h and ASM heavy rainfall was detected north-eastern of Lao PDR and northwest Viet Nam at 12:00 UTC (19:00 local time), (**Figure 2-12**). The comparison between MAP24h and the observed rainfall at some gauging stations during the period from 11 -16 August is shown in **Figure 2-13**.

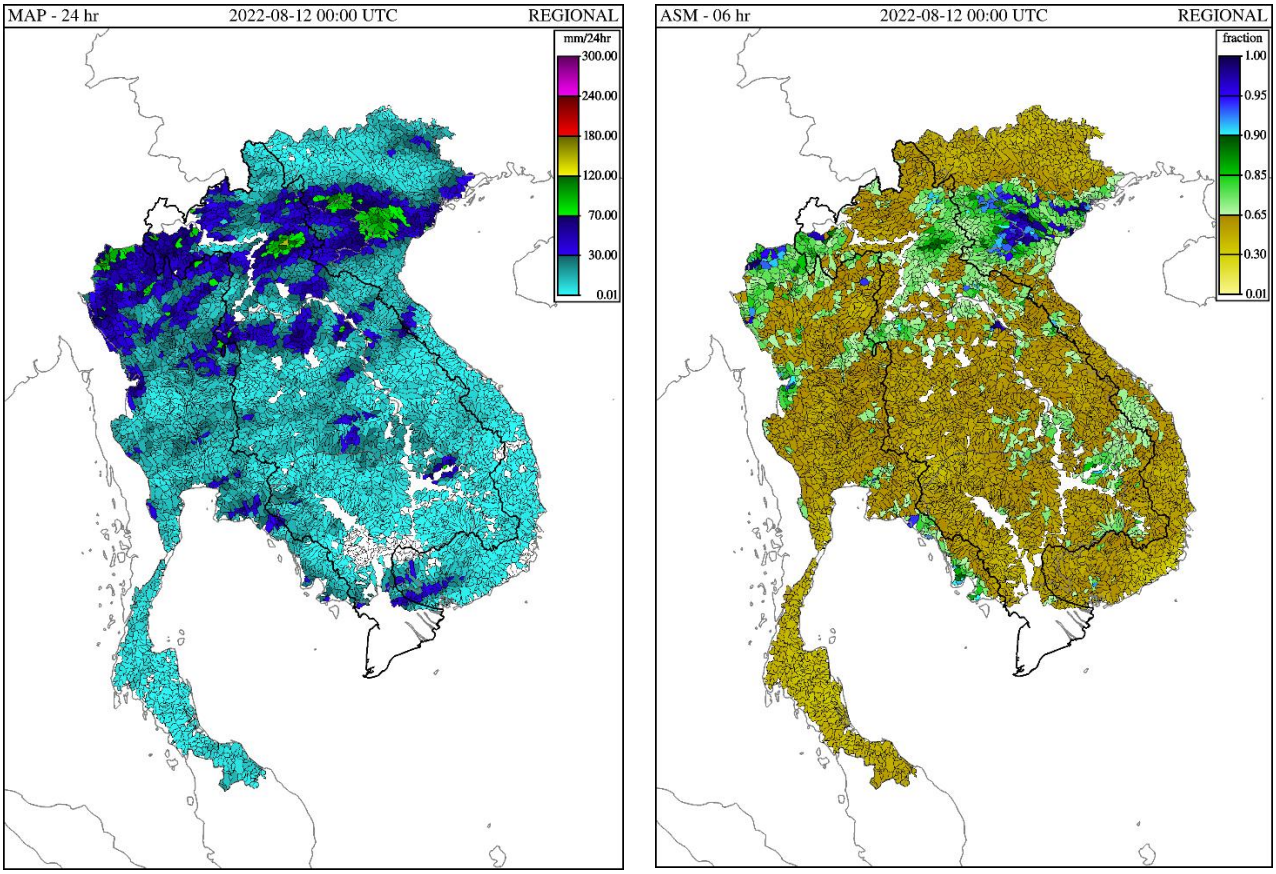
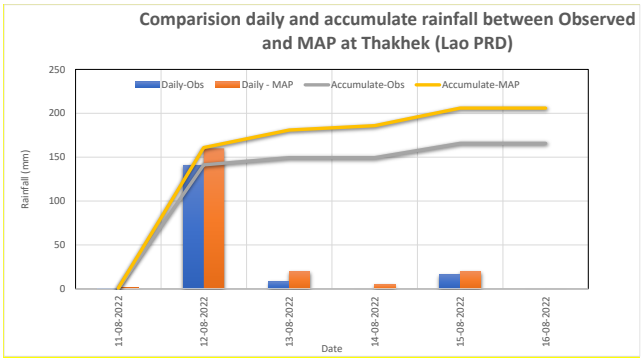
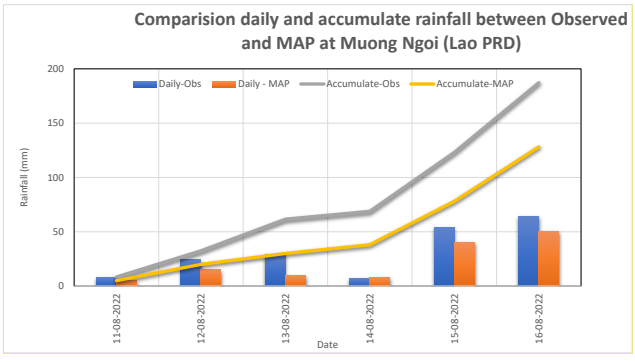


Figure 2-12: MAP24h and ASM on 12 August 2022 at 12:00 UTC (19: 00 local time)





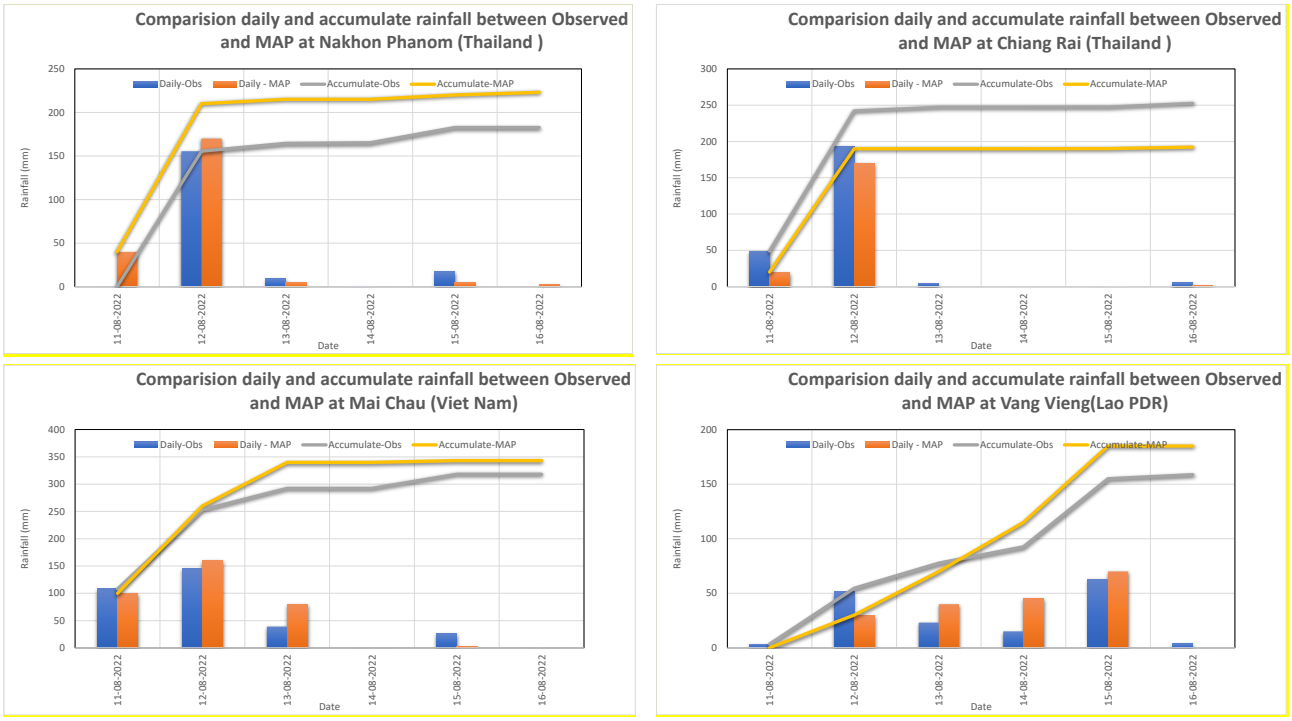


Figure 2-13: Comparison of observed rainfall and MAP24h at some stations in the LMB from 11- 16 August 2022

Based on the analysis of the FFG from the MRC-FFGS (**Figure 2-14**) and on actual measurements available in RFDMC, the RFDMC made the decision to submit the warning of flash flood guidance for 1, 3, and 6 hours as shown in Table 2-6.

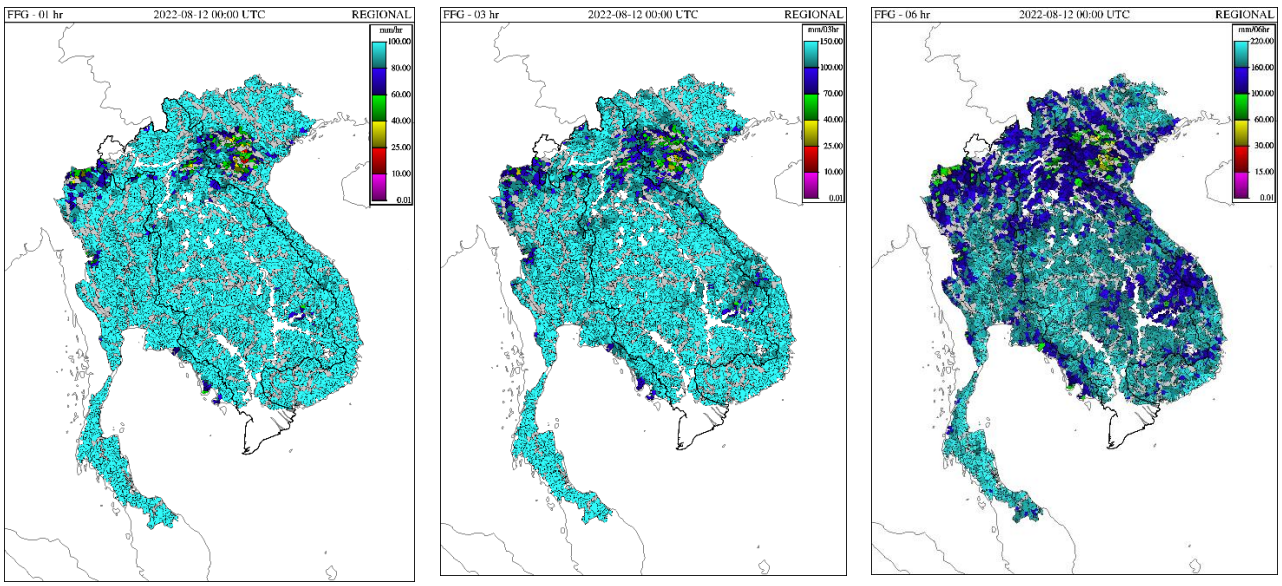


Figure 2-14: FFG 01, 03 and 06 on 12 August 2022 at 00:00 UTC (07: 00 local time)

Table 2-6: FFG detected by MRC-FFGS in (a) Cambodia (b) Lao PDR, (c) Thailand and (d) Viet Nam on 12 August 2022 at 00:00 UTC (07: 00 Local time)

Rate-risk and location of the flash flood may occur in the next 1, 3, and 6 hours in Cambodia

(a)

Date of FFG products 12/08/2022 0:00 UTC time

01-Hour Flash Flood Risk and Location					03-Hour Flash Flood Risk and Location					06-Hour Flash Flood Risk and Location				
Provinces	Districts	Villages	Region	Level Risk	Provinces	Districts	Villages	Region	Level Risk	Provinces	Districts	Villages	Region	Level Risk
Koh Kong	Botum Sakor	Bak Ronoas	Southwestern	Low-Risk	NO ANY DETECTION OF FLASH FLOOD WITHIN NEXT 03-HOUR					Koh Kong	Botum Sakor	Bak Ronoas	Southwestern	Low-Risk
										Sihanouk Ville	Prey Nob	Chumpu Khmau	Southwest	Low-Risk

Rate-risk and location of the flash flood may occur in the next 1, 3, and 6 hours in Lao PDR

(b)

Date of FFG products 12/08/2022 0:00 UTC time

01-Hour Flash Flood Risk and Location					03-Hour Flash Flood Risk and Location					06-Hour Flash Flood Risk and Location				
Provinces	Districts	Villages	Region	Level Risk	Provinces	Districts	Villages	Region	Level Risk	Provinces	Districts	Villages	Region	Level Risk
Luangprabang	Phonxay	HUAYKHING	North	Low-Risk	Luangprabang	Phonxay	HUAYKHING	North	Low-Risk	Xiengkhuang	Khoune	POUNG	Northeast	Low-Risk
Luangprabang	Phonxay	HUAYPOTE	North	Low-Risk	Luangprabang	Phonxay	HUAYPOTE	North	Low-Risk	Bolikhamxay	Pakxanh	XAYSAVA	Central La	Low-Risk
Luangprabang	Phonxay	MOKCHONG	North	Low-Risk	Luangprabang	Phonxay	MOKCHONG	North	Low-Risk	Vientiane	Kasy	PHONEN(	Northwest	Low-Risk
Luangprabang	Phonxay	HEUADOI	North	Low-Risk	Luangprabang	Phonxay	HEUADOI	North	Low-Risk	Luangprabang	Phonxay	PHOUNG(	North	Low-Risk
Luangprabang	Phonxay	HUAYCHANG	North	Moderate-Risk	Luangprabang	Phonxay	HUAYCHANG	North	Low-Risk	Luangprabang	Viengkham	NAMXAI	North	Low-Risk
Luangprabang	Phoukhoun	NAKUEN	North	Low-Risk	Luangprabang	Phoukhoun	NAKUEN	North	Low-Risk	Luangprabang	Phonxay	HUAYKHI(	North	Low-Risk
Luangprabang	Xieng nge	PHALAK	North	Low-Risk	Luangprabang	Xieng nge	PHALAK	North	Low-Risk	Luangprabang	Phonxay	NONG OI	North	Low-Risk
Huaphanh	Xamtay	HINTANG	Eastern	Moderate-Risk	Huaphanh	Xamtay	HINTANG	Eastern	Low-Risk	Luangprabang	Phonxay	HUAYPOT	North	Low-Risk
Huaphanh	Xamtay	HOUAYSAMONG	Eastern	Low-Risk	Huaphanh	Xamtay	HOUAYSAMONG	Eastern	Low-Risk	Luangprabang	Phonxay	MOKCHO	North	Low-Risk
Huaphanh	Xamtay	GNORT-INN	Eastern	Moderate-Risk	Huaphanh	Xamtay	GNORT-INN	Eastern	Moderate-Risk	Luangprabang	Luangprab	LONGWA	North	Low-Risk
Huaphanh	Xamtay	NAMMORN	Eastern	High-Risk	Huaphanh	Xamtay	NAMMORN	Eastern	Moderate-Risk	Luangprabang	Phonxay	HEUADOI	North	Low-Risk
Huaphanh	Xamtay	LONGKUANG	Eastern	Moderate-Risk	Huaphanh	Xamtay	LONGKUANG	Eastern	Low-Risk	Luangprabang	Xieng nge	PHAKHAC	North	Low-Risk
Huaphanh	Viengxay	TA-AN	Eastern	Low-Risk	Huaphanh	Viengxay	TA-AN	Eastern	Low-Risk	Luangprabang	Phonxay	HUAYCHA	North	Low-Risk
Huaphanh	Xiengkhor	HOUAYLO	Eastern	Low-Risk	Huaphanh	Xiengkhor	HOUAYLO	Eastern	Low-Risk	Luangprabang	Phoukhoun	NAKUEN	North	Low-Risk
Huaphanh	Xamtay	PHALOM	Eastern	Low-Risk	Huaphanh	Xamtay	PHALOM	Eastern	Low-Risk	Luangprabang	Phoukhoun	VIENGKE(	North	Low-Risk
Huaphanh	Xamtay	PHAKHAO	Eastern	Moderate-Risk	Huaphanh	Xamtay	PHAKHAO	Eastern	Moderate-Risk	Luangprabang	Xieng nge	PHALAK	North	Low-Risk
Xiengkhuang	Nonghed	SUAN OI	Northeast	Low-Risk	Xiengkhuang	Nonghed	SUAN OI	Northeast	Low-Risk	Huaphanh	Xamtay	HINTANG	Eastern	Moderate-Risk
Xiengkhuang	Nonghed	DAN	Northeast	Low-Risk	Xiengkhuang	Nonghed	DAN	Northeast	Low-Risk	Huaphanh	Xamtay	NAMOUAI	Eastern	Low-Risk
Xiengkhuang	Nonghed	SANGKET	Northeast	Low-Risk	Xiengkhuang	Nonghed	SANGKET	Northeast	Low-Risk	Huaphanh	Xamtay	HOUAYS/	Eastern	Low-Risk
Xiengkhuang	Nonghed	DONGKOR	Northeast	Low-Risk	Xiengkhuang	Nonghed	DONGKOR	Northeast	Low-Risk	Huaphanh	Xamtay	GNORT-I	Eastern	Moderate-Risk
										Huaphanh	Xamtay	NAMMOR	Eastern	Moderate-Risk
										Huaphanh	Xamtay	LONGKU/	Eastern	Moderate-Risk
										Huaphanh	Viengxay	TA-AN	Eastern	Low-Risk
										Huaphanh	Xiengkhor	HOUAYLC	Eastern	Low-Risk

Rate-risk and location of the flash flood may occur in the next 1, 3, and 6 hours in Thailand

(c)

Date of FFG products 12/08/2022 0:00 UTC time

01-Hour Flash Flood Risk and Location				03-Hour Flash Flood Risk and Location				06-Hour Flash Flood Risk and Location			
Provinces	Districts	Region	Level Risk	Provinces	Districts	Region	Level Risk	Provinces	Districts	Region	Level Risk
Mae Hong Son	Pai	Northern	Moderate-Risk	Mae Hong Son	Muang Mae Hong Son	Northern	Low-Risk	Chanthaburi	Laem Sing	Eastern	Low-Risk
Tak	Um Phang	Northern	Low-Risk	Mae Hong Son	King Amphoe Pangmapha	Northern	Low-Risk	Mae Hong Son	King Amphoe Pangmapha	Northern	Low-Risk
Mae Hong Son	King Amphoe Pangmapha	Northern	Low-Risk	Nan	Song Kwae	Northern	Low-Risk	Mae Hong Son	Muang Mae Hong Son	Northern	Moderate-Risk
Mae Hong Son	Muang Mae Hong Son	Northern	Moderate-Risk	Mae Hong Son	Pai	Northern	Moderate-Risk	Mae Hong Son	Pai	Northern	Moderate-Risk
Chiang Mai	Fang	Northern	Low-Risk	Chiang Mai	Fang	Northern	Low-Risk	Chiang Rai	Wiang Pa Pao	Northern	Low-Risk
Chiang Rai	Mae Suai	Northern	Low-Risk	Chiang Rai	Mae Suai	Northern	Low-Risk	Tak	Phop Phra	Northern	Low-Risk
Tak	Phop Phra	Northern	Low-Risk	Tak	Um Phang	Northern	Low-Risk	Chiang Mai	Mae Chaem	Northern	Low-Risk
Tak	Um Phang	Northern	Low-Risk					Chiang Mai	Fang	Northern	Low-Risk
Mae Hong Son	Pai	Northern	Low-Risk					Chiang Mai	King Amphoe Chaipakan	Northern	Low-Risk
Chiang Mai	Wang Haeng	Northern	Low-Risk					Chiang Rai	Mae Suai	Northern	Low-Risk
Nan	Song Kwae	Northern	Low-Risk					Mae Hong Son	Khun Yuam	Northern	Low-Risk
								Chiang Mai	King Amphoe Chaipakan	Northern	Low-Risk
								Mae Hong Son	Mae La Noi	Northern	Low-Risk
								Mae Hong Son	Sobmuai	Northern	Low-Risk
								Mae Hong Son	Pai	Northern	Low-Risk
								Chiang Mai	Wang Haeng	Northern	Low-Risk
								Chiang Mai	Mae Taeng	Northern	Low-Risk
								Chiang Mai	Chiang Dao	Northern	Low-Risk
								Tak	Um Phang	Northern	Low-Risk
								Phayao	Pong	Northern	Low-Risk
								Nan	Song Kwae	Northern	Low-Risk
								Nan	King Amphoe Bokuai	Northern	Low-Risk
								Phetchaburi	Kang Krachan		Low-Risk

Rate-risk and location of the flash flood may occur in the next 1, 3, and 6 hours in Viet Nam

(d)

Date of FFG products 12/08/2022 0:00 UTC time

01-Hour Flash Flood Risk and Location				3-Hour Flash Flood Risk and Location in Vietnam				6-Hour Flash Flood Risk and Location in Vietnam			
Provinces	Districts	Region	Level Risks	Provinces	Districts	Region	Level Risks	Provinces	Districts	Region	Level Risks
Quang Binh	Minh Hoa	North Central	Low-Risk	Quang Binh	Minh Hoa	North Central	Low-Risk	Lai Chau	Dien Bien	Northwest	Low-Risk
Hai Phong	An Hai	Red River Delta	Low-Risk	Hoa Binh	Da Bac	Northwest	Low-Risk	Quang Binh	Minh Hoa	North Central	Low-Risk
Hoa Binh	Da Bac	Northwest	Low-Risk	Thanh Hoa	Quan Son	North Central	Moderate-Risk	Hai Phong	An Hai	Red River Delta	Low-Risk
Son La	Phu yen	Northwest	Low-Risk	Son La	Moc Chau	Northwest	Low-Risk	Hoa Binh	Da Bac	Northwest	Low-Risk
Son La	Moc Chau	Northwest	Moderate-Risk	Son La	Phu yen	Northwest	Low-Risk	Son La	Mai Son	Northwest	Low-Risk
Hoa Binh	Mai Chau	Northwest	Low-Risk	Hoa Binh	Mai Chau	Northwest	Low-Risk	Son La	Moc Chau	Northwest	Moderate-Risk
Thanh Hoa	Thuong Xuan	North Central	Moderate-Risk	Thanh Hoa	Thuong Xuan	North Central	Low-Risk	Son La	Phu yen	Northwest	Low-Risk
Thanh Hoa	Lang Chanh	North Central	Low-Risk	Nghe An	Que Phong	North Central	Moderate-Risk	Hoa Binh	Mai Chau	Northwest	Low-Risk
Son La	Song Ma	Northwest	Low-Risk	Nghe An	Tuong Duong	North Central	Moderate-Risk	Hoa Binh	Yen Thuy	Northwest	Low-Risk
Son La	Yen Chau	Northwest	Moderate-Risk	Nghe An	Quy Chau	North Central	Low-Risk	Thanh Hoa	Thuong Xuan	North Central	Moderate-Risk
Thanh Hoa	Quan Hoa	North Central	Moderate-Risk	Thanh Hoa	Quan Hoa	North Central	Low-Risk	Nghe An	Que Phong	North Central	Moderate-Risk
Thanh Hoa	Quan Son	North Central	High-Risk	Thanh Hoa	Muong Lat	North Central	Low-Risk	Nghe An	Quy Chau	North Central	Low-Risk
Nghe An	Quy Chau	North Central	Low-Risk	Son La	Yen Chau	Northwest	Moderate-Risk	Nghe An	Tuong Duong	North Central	Moderate-Risk
Nghe An	Que Phong	North Central	High-Risk	Son La	Song Ma	Northwest	Low-Risk	Thanh Hoa	Muong Lat	North Central	Moderate-Risk
Nghe An	Tuong Duong	North Central	Moderate-Risk					Son La	Song Ma	Northwest	Low-Risk
Thanh Hoa	Muong Lat	North Central	Moderate-Risk					Lai Chau	Dien Bien Dong	Northwest	Low-Risk
								Son La	Yen Chau	Northwest	Moderate-Risk
								Thanh Hoa	Quan Hoa	North Central	Moderate-Risk
								Thanh Hoa	Quan Son	North Central	Moderate-Risk
								Hoa Binh	Ky Son	Northwest	Low-Risk
								Nghe An	Con Cuong	North Central	Low-Risk

2.4.4 Conclusions

- The circulation after tropical storm MULAN is the cause of heavy rain in some areas in the LMB; especially in north central of Viet Nam, northern Thailand, and eastern parts of Lao PDR in the period 11-16 August. Due to saturated soil combined with heavy rain at the same time, flash flood events took place in these areas.
- The MRC-FFGS detected heavy rain quite well; based on a comparison result at some stations in the LMB, the system's result at peak values has a difference of about 8-31 % (over and underestimates). Such us, at Thakhek (Thailand) with the total rainfall from 11-16 August of MAP24h was 206 mm and the observed rainfall was 165.8 mm (overestimated 24 %), at Muong Ngoi (Lao PDR) with MAP24h was 128 mm and observed 187,1 mm (underestimated 31 %), at Mai Chau (Viet Nam) with MAP24h was 343 mm and observed 318 mm (overestimated 7,8 %).
- The MRC-FFGS correctly detected several locations where flash floods were likely to occur, which corresponded with the reported flash flood areas via newspaper or the internet (see Annex A.2).

2.5 Flash flood event during 26-30 September 2022 caused by NORU tropical storm's circulation.

2.5.1 Weather conditions during 26-30 September 2022

From 26-30 September, the LMB was affected by two weather factors including (i) The typhoon Noru made landfall in Da Nang province of Viet Nam early on September 28 then downgraded into the tropical storm and moved to Lao PDR before entering north-eastern part of Thailand, (ii) the southwest monsoon which prevailed over the Gulf of Thailand then strengthened during the last day of the week. These conditions caused heavy and moderate rainfall, especially the circulation of Noru caused heavy rain over large areas from north to south-central coast of Viet Nam and the middle part and lower parts of the LMB (including Thailand, Lao PDR, and Cambodia). (Figure 2-16).

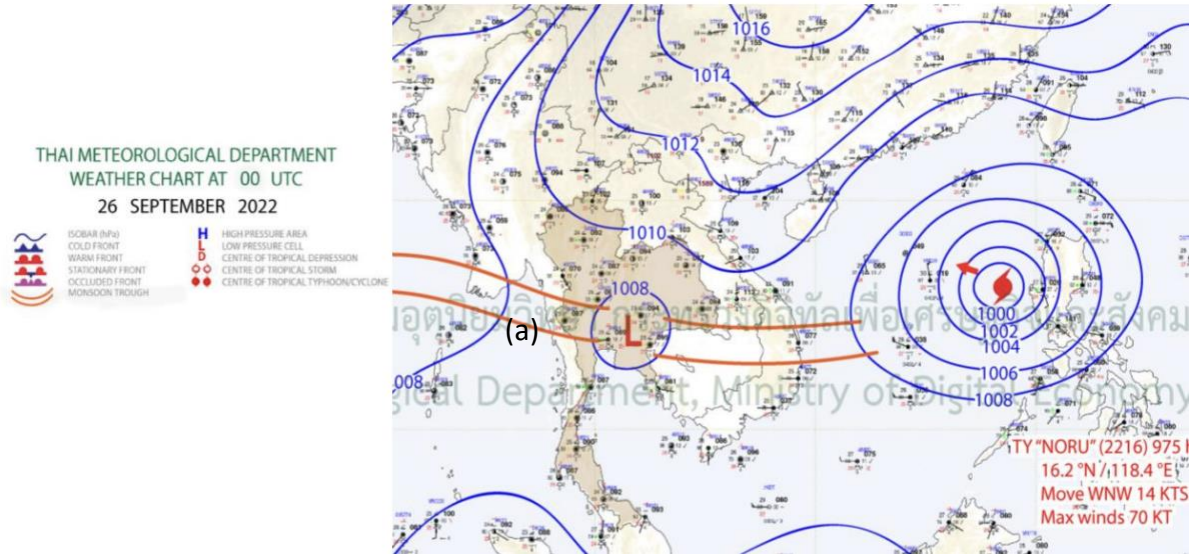


Figure 2-15: Weather map on 26 September (Source: TMD)

Tropical Storm NORU (Source: -WMO): On September 21, a disturbance developed into tropical depression near the Philippines, according to the JMA. The JTWC designated this disturbance as Invest 95W and issued a bulletin noting that the low-pressure system could have reasonable intensification due to low wind shear and warmer water. On 00:00 UTC of September 22, the tropical depression was assigned the name KARDING. A few hours later, the system reached tropical storm intensity and the JMA assigned it the name NORU. At 21:00 UTC on September 23, it was raised a day later as the storm rapidly intensified into a typhoon. On 24 September, NORU entered the Philippine area of responsibility and reached typhoon intensity. At 00:00 UTC on September 25, the JTWC classified NORU as a Category 5-equivalent super typhoon, and it made landfall in the northern Philippines, the cyclone was downgraded to Category 4 when came to East Sea areas and then hit to North central of Viet Nam at Quang Nam, Quang Ngai on 28 September 2022 (see figure 2-17).

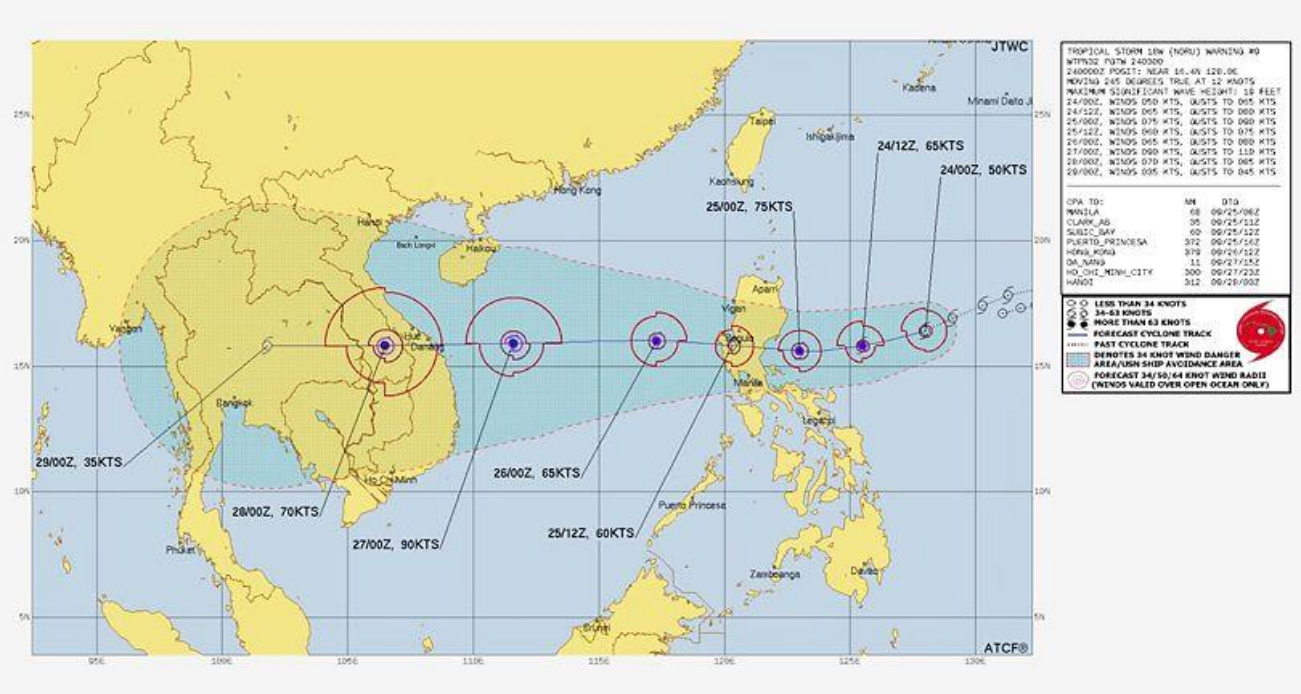


Figure 2-17: The track of tropical typhoon NORU (Source: Joint Typhoon Warning Centre- JTWC)

2.5.2 Heavy rainfall for 26 -30 September.

During the period 26-30 September 2022, the daily rainfall observed shows that influenced by NORU's circulation very heavy rainfall occurred, in fact, it was concentrated from 28 and 29 September in some areas in the LMB.

Table 2-7 shows the daily rainfall observed on 28 September in Viet Nam at A Luoi (228 mm), and in Lao PDR at Saravanne (121,80 mm) and on 29 September in Viet Nam at Huong Son (230 mm), at Con Cuong (196 mm) and Huong Khe (212 mm), in Lao PDR at Pakse (106 mm), in Thailand at Khong Chiam (153,70 mm) and in Cambodia at Kompong Cham (81 mm) on 27 September. The rainfall distribution during 26-30 September 2022 in the LMB is shown in **Figure 2-20**.

Table 2-7: Daily rainfall observed at some stations in the LMB (26-30 September 2022)

Unit: mm

Time	Huong Son	Con Cuong	Huong Khe	A Luoi	Seam Pang	Pakse	Khong Chiam	Kompong Cham
26-09-2022	10.0	6.0	2.7	10.0	11.6	13.0	46.1	45.6
27-09-2022	0.0	4.0	1.5	9.0	0.0	8.6	14.6	91.3
28-09-2022	41.0	11.0	124.0	228.0	35.6	57.0	47.2	1.6
29-09-2022	230.0	196.0	212.0	26.0	67.8	106.0	153.7	17.5
30-09-2022	103.0	168.0	72.0	0.0	35.6	10.2	3.0	0.0
Sum	384.0	385.0	412.2	273.0	150.6	194.8	264.6	156.0

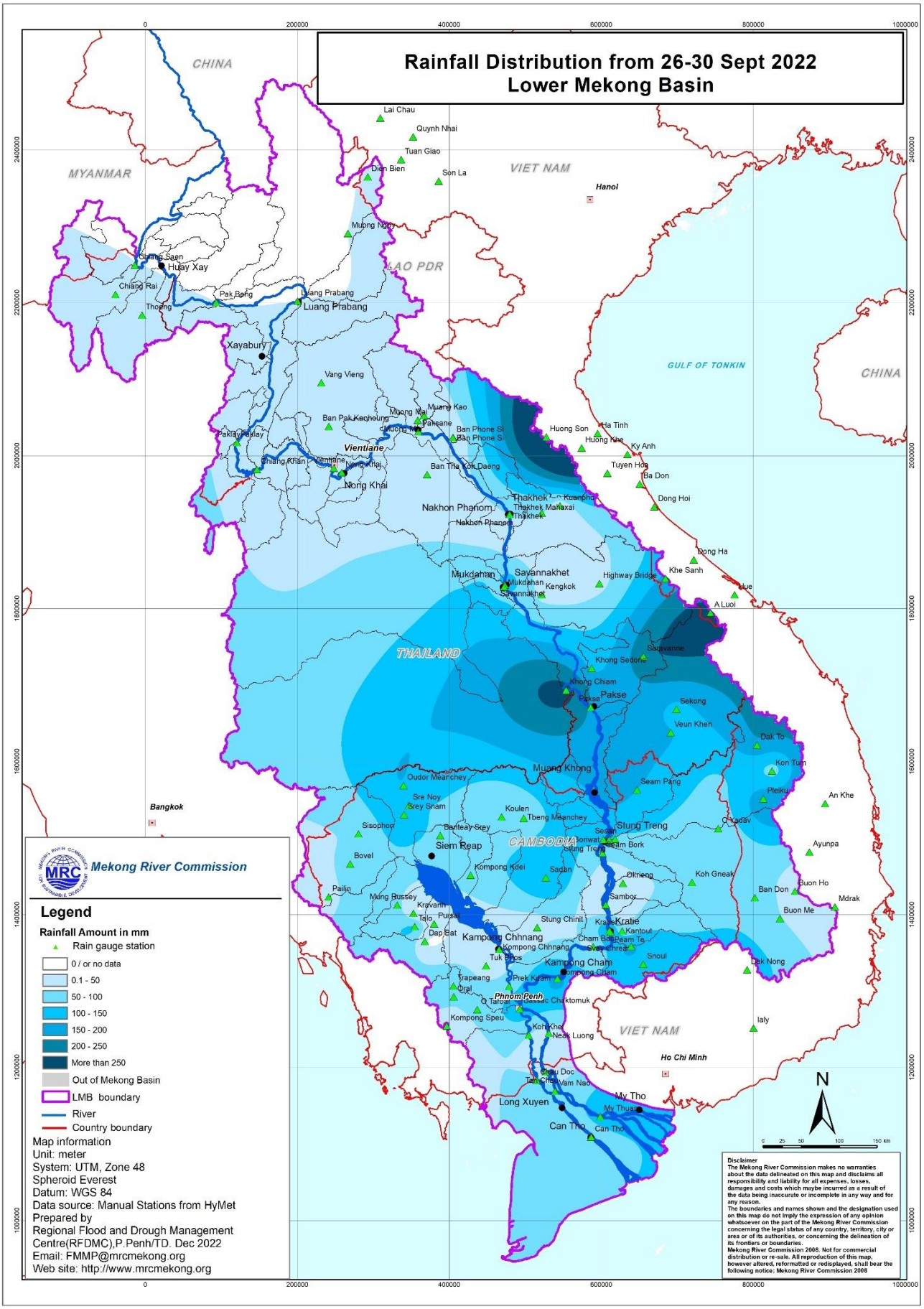


Figure 2-16: Rainfall distribution during 26-30 September 2022 in the LMB

2.5.3 Flash flood event on 28 September 2022

Based on the MRC-FFGS' products, MAP24h and ASM, very heavy rain was detected in some areas from the middle to lower parts of the LMB. Especial some areas of northwest part of Lao PDR and in the central part of Viet Nam at 00:00 UTC (00:00 local time). Those results show that the rainfall in many areas was more than 200 mm/24h and the resulted soil moisture in those areas was also very wet, and saturated in a wide range (**Figure 2-17**).

The comparison between MAP24h and rainfall observed at some gauging stations during the period from 26-30 September is shown in **Figure 2-18**. From the comparison, it is shown that satellite data and measured data (24-hour time step) are good in terms of time and space.

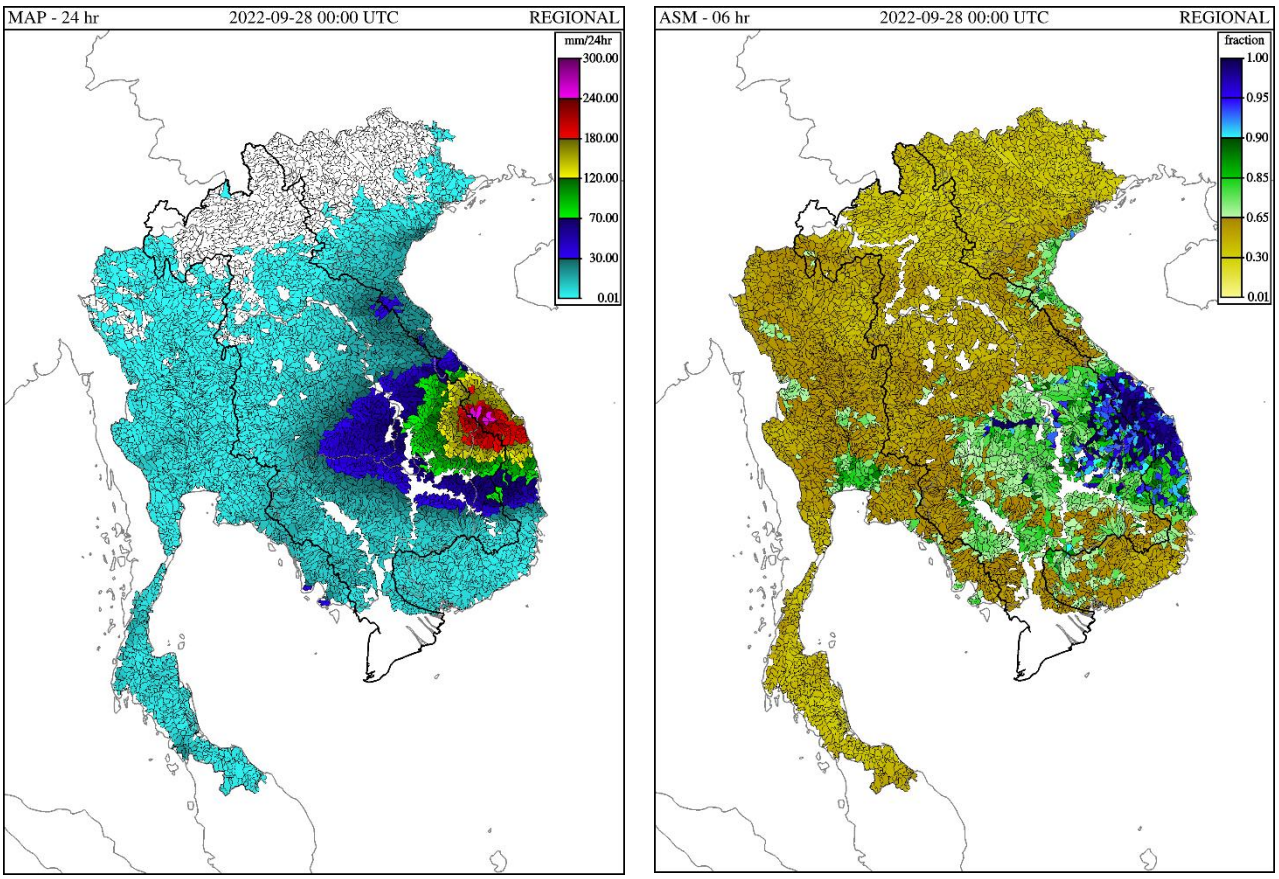
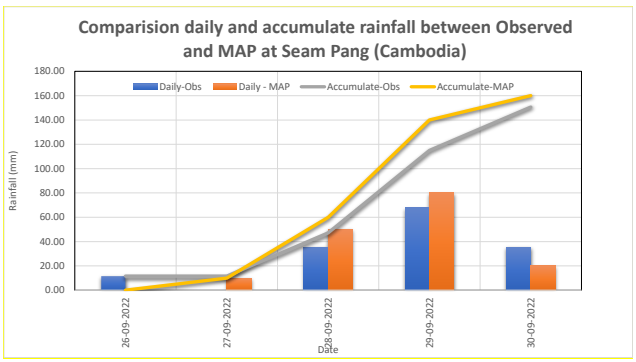
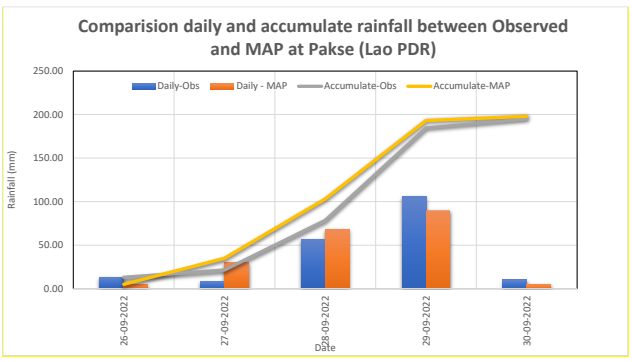


Figure 2-17: MAP24h and ASM on 28 September 2022 at 00:00 UTC (07: 00 local time)





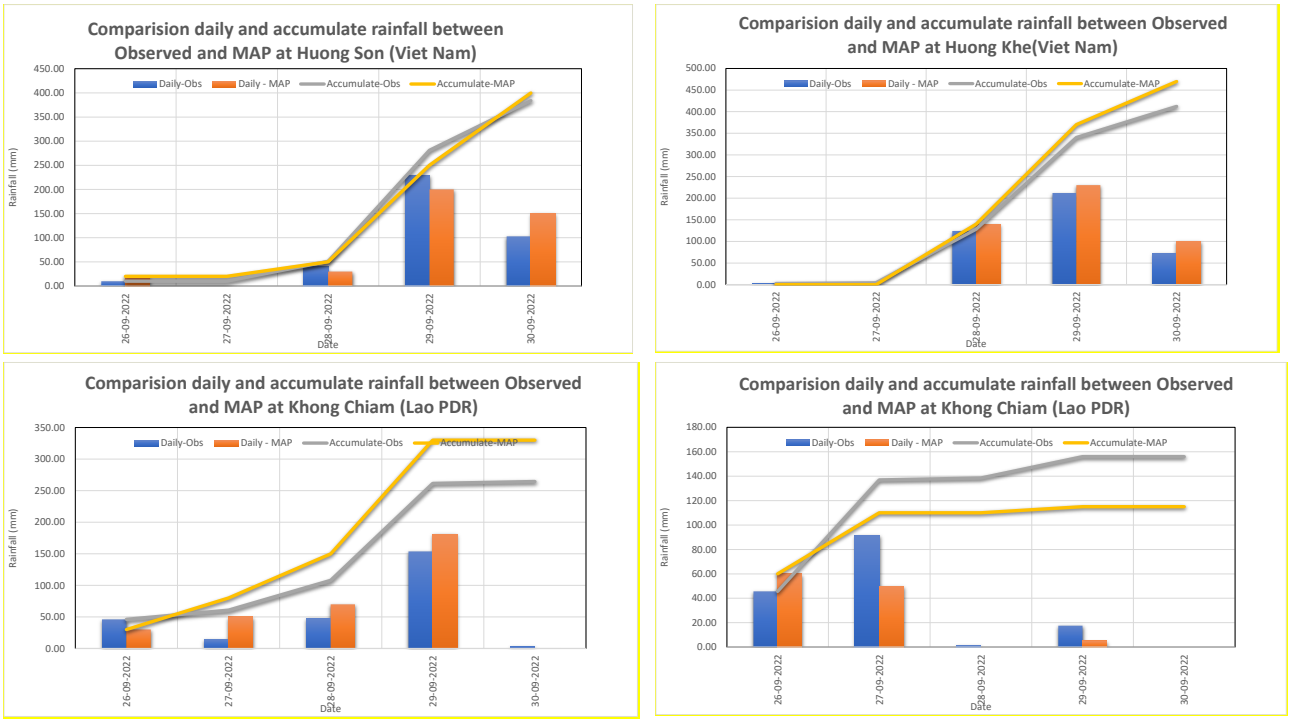


Figure 2-18: Comparison rainfall observed and MAP24h at some stations in LMB from 26-30 September 2022

The RFDMC submitted the warning with flash flood guidance for 1, 3, and 6 hours on 00:00 UTC 28 September 2022. Some areas in Viet Nam and Lao PDR were predicted from low to high risk of flash flood as shown in the

Table 2-8 and **Figure 2-19**.

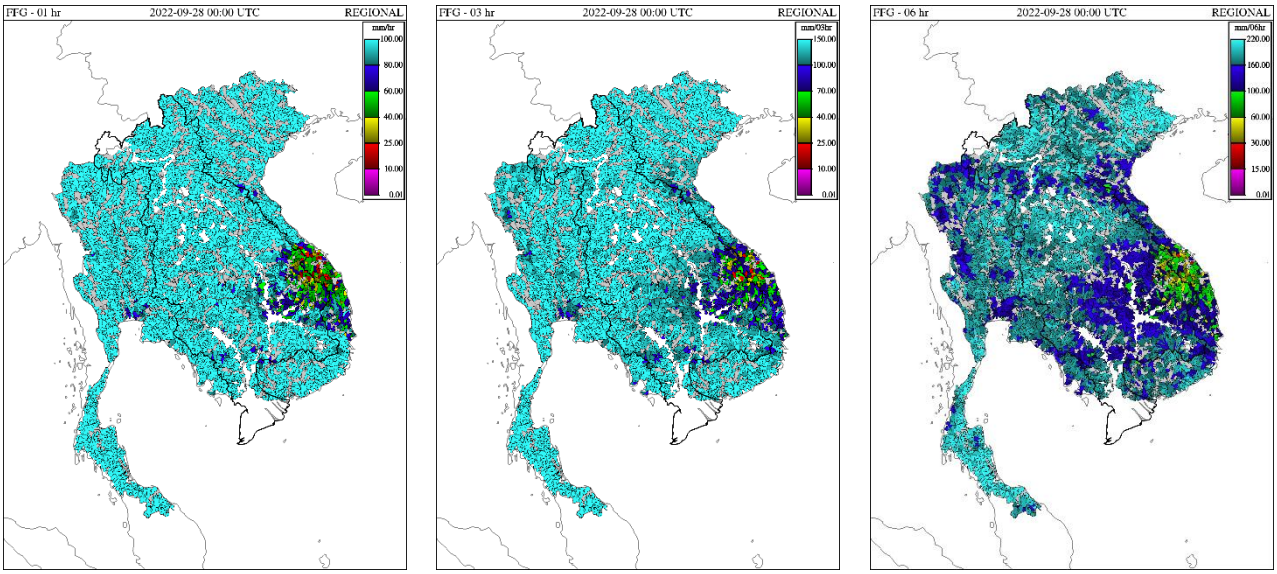


Figure 2-19: FFG 01, 03 and 06 on 28 September 2022 at 00:00 UTC (07: 00 local time)

Table 2-8: FFG detected by MRC-FFGS (a) Cambodia; (b) Lao PDR, (c) Thailand and (d) Viet Nam on 28 September 2022 at 06:00 UTC (13: 00 Local time)

Rate-risk and location of the flash flood may occur in the next 1, 3, and 6 hours in Cambodia (a)

Date of FFG products 28/09/2022 06:00 UTC time

01-Hour Flash Flood Risk and Location					03-Hour Flash Flood Risk and Location					06-Hour Flash Flood Risk and Location				
Provinces	Districts	Villages	Region	Level Risk	Provinces	Districts	Villages	Region	Level Risk	Provinces	Districts	Villages	Region	Level Risk
Stung Treng	Thala Barivat	Sralau	Northeast	Low-Risk	Stung Treng	Thala Barivat	Sralau	Northeast	Low-Risk	Preah Vihear	Chhaeb	KAANLEUANG	North	Low-Risk
Ratana Kiri	Koun Mom	Ko Hokseb	Northeast	Low-Risk	Battambang	Batdambang	Tumpung Cheung	Northwest	Low-Risk	Stung Treng	Thala Barivat	Sralau	Northeast	Low-Risk
Stung Treng	Thala Barivat	Mon	Northeast	Low-Risk	Siem Reap	Chi Kraeng	Rovieng	Northwest	Low-Risk	Ratana Kiri	Koun Mom	Ko Hokseb	Northeast	Low-Risk
Stung Treng	Thala Barivat	Anlong Chrey	Northeast	Low-Risk	Siem Reap	Svay Leu	Bet Phka	Northwest	Low-Risk	Stung Treng	Thala Barivat	Mon	Northeast	Low-Risk
Battambang	Batdambang	Tumpung Cheung	Northwest	Low-Risk	Siem Reap	Chi Kraeng	Krang	Northwest	Low-Risk	Stung Treng	Thala Barivat	Anlong Chrey	Northeast	Low-Risk
Pursat	Bakan	Kampout Ang	Western	Low-Risk	Kampong Chhnar	Tuek Phos	Kdol	Central	Low-Risk	Battambang	Batdambang	Tumpung Cheung	Northwest	Low-Risk
Siem Reap	Chi Kraeng	Rovieng	Northwest	Low-Risk	Preah Vihear	Choam Khsant	Krala Peas	North	Low-Risk	Siem Reap	Banteay Srei	Srah Khvav	Northwest	Low-Risk
Siem Reap	Svay Leu	Bet Phka	Northwest	Low-Risk	Kampong Chhnar	Tuek Phos	Ta Nay	Central	Low-Risk	Battambang	Moung Ruessei	Koun Khlong	Northwest	Low-Risk
Siem Reap	Chi Kraeng	Krang	Northwest	Low-Risk	Kampong Speu	Aoral	Peam Lvea		Low-Risk	Pursat	Bakan	Kampout Ang	Western	Low-Risk
Siem Reap	Chi Kraeng	Ou	Northwest	Low-Risk						Siem Reap	Chi Kraeng	Rovieng	Northwest	Low-Risk
Preah Vihear	Sangkom Thmei	koukThkov	North	Low-Risk						Siem Reap	Svay Leu	Bet Phka	Northwest	Low-Risk
Kampong Chhnang	Tuek Phos	Kdol	Central	Low-Risk						Siem Reap	Chi Kraeng	Krang	Northwest	Low-Risk
Kampong Cham	Stueng Trang	Sampieng Kraom	Central Lowland	Low-Risk						Siem Reap	Chi Kraeng	Ou	Northwest	Low-Risk
Preah Vihear	Chhaeb	Praeus K'ak	North	Low-Risk						Preah Vihear	Sangkom Thmei	koukThkov	North	Low-Risk
Preah Vihear	Choam Khsant	Krala Peas	North	Low-Risk						Kampong Chhnar	Tuek Phos	Kdol	Central	Low-Risk
Preah Vihear	Kuleaen	Kaoh Ker	North	Low-Risk						Kampong Cham	Stueng Trang	Veal Preah	Central Lowland	Low-Risk
Kampong Thom	Baray	Kokir Thum	Nothwest	Low-Risk						Kampong Cham	Stueng Trang	Sampieng Kraom	Central Lowland	Low-Risk
Kampong Chhnang	Tuek Phos	Ta Nay	Central	Low-Risk						Preah Vihear	Chhaeb	Praeus K'ak	North	Low-Risk
Kampong Speu	Aoral	Peam Lvea		Low-Risk						Preah Vihear	Choam Khsant	Krala Peas	North	Low-Risk
Tboung Khmum	Tboung Khmum	Phum Pram Dab	Central Lowland	Low-Risk						Preah Vihear	Choam Khsant	Ou Khsan	North	Low-Risk
										Preah Vihear	Kuleaen	Kaoh Ker	North	Low-Risk
										Kampong Thom	Sandan	Srae Veal Khang	Nothwest	Low-Risk
										Kampong Thom	Baray	Kokir Thum	Nothwest	Low-Risk
										Tboung Khmum	Memot	Kantuot	Central Lowland	Low-Risk
										Tboung Khmum	Memot	Chamkar Thmei	Central Lowland	Low-Risk
										Tboung Khmum	Tboung Khmum	Phum Prammuoy	Central Lowland	Low-Risk
										Kampong Chhnar	Tuek Phos	Ta Nay	Central	Low-Risk
										Kampong Speu	Thpong	Chreav		Low-Risk
										Kampong Speu	Aoral	Peam Lvea		Low-Risk
										Tboung Khmum	Tboung Khmum	Phum Pram Dab	Central Lowland	Low-Risk
										Tboung Khmum	Tboung Khmum	Thnal Thmei	Central Lowland	Low-Risk

Rate-risk and location of the flash flood may occur in the next 1, 3, and 6 hours in Lao PDR (b)

Date of FFG products 28/09/2022 06:00 UTC time

01-Hour Flash Flood Risk and Location					03-Hour Flash Flood Risk and Location					06-Hour Flash Flood Risk and Location				
Provinces	Districts	Villages	Region	Level Risk	Provinces	Districts	Villages	Region	Level Risk	Provinces	Districts	Villages	Region	Level Risk
Saravane	Samuoi	ATUK	South	Low-Risk	Savannakhet	Nong	KOR	Southern	Low-Risk	Saravane	Samuoi	ATUK	South	Low-Risk
Savannakhet	Nong	KOR	Southern	Low-Risk	Savannakhet	Nong	LAGNENG KHOK	Southern	Low-Risk	Savannakhet	Nong	KOR	Southern	Low-Risk
Savannakhet	Nong	LAPID	Southern	Low-Risk	Savannakhet	Nong	PASANEIR TAI	Southern	Low-Risk	Savannakhet	Nong	LAPID	Southern	Low-Risk
Savannakhet	Nong	LAGNENG KHOK	Southern	Low-Risk	Saravane	Ta oi	TUMLEKHAO	South	Low-Risk	Savannakhet	Nong	LAGNENG	Southern	Low-Risk
Savannakhet	Nong	PASANEIR TAI	Southern	Low-Risk	Saravane	Ta oi	PHOBEUI	South	Low-Risk	Savannakhet	Nong	PASANEIF	Southern	Low-Risk
Saravane	Ta oi	TUMLEKHAO	South	Low-Risk	Saravane	Ta oi	PHOR SANH	South	High-Risk	Saravane	Ta oi	TUMLEKH	South	Low-Risk
Saravane	Ta oi	PHOBEUI	South	Low-Risk	Saravane	Ta oi	TUMLE KAO	South	Low-Risk	Saravane	Ta oi	PHOBEUI	South	Low-Risk
Saravane	Ta oi	PHOR SANH	South	High-Risk	Savannakhet	Phine	PHAY	Southern	Low-Risk	Saravane	Ta oi	PHOR SAI	South	High-Risk
Saravane	Ta oi	TUMLE KAO	South	Low-Risk	Savannakhet	Xaybuly	PHAKKHAGNA	Southern	Low-Risk	Saravane	Ta oi	TUMLE KA	South	Low-Risk
Savannakhet	Phine	PHAY	Southern	Low-Risk	Champasak	Pathoomph	NAMPHAAK	Southwestern	Low-Risk	Saravane	Ta oi	KANG	South	Low-Risk
Savannakhet	Xaybuly	PHAKKHAGNA	Southern	Low-Risk	Sekong	Kaleum	PRO	Southeast	Low-Risk	Savannakhet	Phine	PHAY	Southern	Low-Risk
Saravane	Saravane	LA KOUB	South	Low-Risk	Sekong	Kaleum	AR-HOR NEUA	Southeast	Low-Risk	Savannakhet	Xaybuly	PHAKKHA	Southern	Low-Risk
Champasak	Pathoomph	NAMPHAAK	Southwestern	Low-Risk	Sekong	Kaleum	KA-OUANG	Southeast	Low-Risk	Saravane	Saravane	NONSAVA	South	Low-Risk
Saravane	Ta oi	THONG KA TAI	South	Low-Risk	Sekong	Kaleum	PANORM	Southeast	Low-Risk	Saravane	Saravane	LA KOUB	South	Low-Risk
Sekong	Kaleum	PRO	Southeast	Moderate-Risk	Sekong	Kaleum	AR-PEUANG	Southeast	Moderate-Risk	Champasak	Pathoomph	NAMPHAA	Southwest	Low-Risk
Sekong	Kaleum	AR-HOR NEUA	Southeast	Low-Risk	Sekong	Kaleum	PALAENG	Southeast	Low-Risk	Saravane	Ta oi	THONG K	South	Low-Risk
Sekong	Kaleum	KA-OUANG	Southeast	Moderate-Risk	Sekong	Kaleum	VAK TAI	Southeast	Low-Risk	Sekong	Kaleum	PRO	Southeast	Moderate-Risk
Sekong	Kaleum	PANORM	Southeast	Low-Risk	Sekong	Kaleum	TIN	Southeast	Moderate-Risk	Sekong	Kaleum	AR-HOR N	Southeast	Low-Risk
Sekong	Kaleum	AR-PEUANG	Southeast	Moderate-Risk	Sekong	Kaleum	STTHORN	Southeast	Moderate-Risk	Sekong	Kaleum	KA-OUAN	Southeast	Moderate-Risk
Sekong	Kaleum	PALAENG	Southeast	Low-Risk	Sekong	Lamarm	KANONG MAI	Southeast	High-Risk	Sekong	Kaleum	PANORM	Southeast	Low-Risk
Sekong	Kaleum	VAK TAI	Southeast	Moderate-Risk	Sekong	Lamarm	TAVI	Southeast	Low-Risk	Sekong	Kaleum	AR-PEUAI	Southeast	Moderate-Risk
Sekong	Kaleum	TIN	Southeast	Moderate-Risk	Sekong	Lamarm	KADONE	Southeast	Low-Risk	Sekong	Kaleum	PALAENG	Southeast	Low-Risk
Sekong	Kaleum	TANGKAAD	Southeast	Low-Risk	Sekong	Dakcheung	DAKPORK	Southeast	Low-Risk	Sekong	Kaleum	VAK TAI	Southeast	Moderate-Risk

Rate-risk and location of the flash flood may occur in the next 1, 3, and 6 hours in Thailand (c)

Date of FFG products 28/09/2022 06:00 UTC time

01-Hour Flash Flood Risk and Location				03-Hour Flash Flood Risk and Location				06-Hour Flash Flood Risk and Location			
Provinces	Districts	Region	Level Risk	Provinces	Districts	Region	Level Risk	Provinces	Districts	Region	Level Risk
Ubon Ratchathani	Buntharik	Northeastern	Low-Risk	NO ANY DETECTION OF FLASH FLOOD WITHIN NEXT 03-HOUR				Chanthaburi	Pong Nam Ron	Eastern	Low-Risk
Mukdahan	Don Tan	Northeastern	Low-Risk					Ubon Ratchathani	Buntharik	Northeastern	Low-Risk
Mukdahan	Don Tan	Northeastern	Low-Risk					Mukdahan	Don Tan	Northeastern	Low-Risk
Ubon Ratchathani	Kut Kao Pun	Northeastern	Low-Risk					Ubon Ratchathani	Kut Kao Pun	Northeastern	Low-Risk
Ubon Ratchathani	Kut Kao Pun	Northeastern	Low-Risk					Ubon Ratchathani	Kut Kao Pun	Northeastern	Low-Risk
Yasothon	Pa Tiu	Northeastern	Low-Risk					Yasothon	Pa Tiu	Northeastern	Low-Risk
Surin	Sri Narong	Northeastern	Low-Risk					Surin	Sri Narong	Northeastern	Low-Risk
Surin	Prasat	Northeastern	Low-Risk					Ubon Ratchathani	Buntharik	Northeastern	Low-Risk
Samut Prakarn	Phra Samut Chedi		Low-Risk					Surin	Prasat	Northeastern	Low-Risk
Samut Prakarn	Muang Samut Prakarn		Low-Risk					Surin	Prasat	Northeastern	Low-Risk
Nonthaburi	Bang Bua Thong	Central	Low-Risk					Samut Prakarn	Phra Samut Chedi		Low-Risk
Nonthaburi	Bang Krui	Central	Low-Risk					Samut Prakarn	Muang Samut Prakarn		Low-Risk
Rayong	Klaeng	Eastern	Low-Risk					Chachoengsao	Muang Chachoengs	Eastern	Low-Risk
								Samut Sakhon	Ban Phaeo	Northeastern	Low-Risk
								Nonthaburi	Bang Bua Thong	Central	Low-Risk
								Nonthaburi	Bang Krui	Central	Low-Risk
								Samut Sakhon	Krathumbaen	Northeastern	Low-Risk
								Rayong	Klaeng	Eastern	Low-Risk

Rate-risk and location of the flash flood may occur in the next 1, 3, and 6 hours in Viet Nam (d)

Date of FFG products 28/09/2022 06:00 UTC time

01-Hour Flash Flood Risk and Location				3-Hour Flash Flood Risk and Location in Vietnam				6-Hour Flash Flood Risk and Location in Vietnam			
Provinces	Districts	Region	Level Risks	Provinces	Districts	Region	Level Risks	Provinces	Districts	Region	Level Risks
Kon Tum	Sa Thay	Central Highlands	Moderate-Risk	Kon Tum	Dak Glei	Central Highlands	Moderate-Risk	Kon Tum	Sa Thay	Central Highlands	Moderate-Risk
Gia Lai	Ia Grai	Central Highlands	High-Risk	Thua Thien Hue	Phong Dien	North Central	Moderate-Risk	Gia Lai	Ia Grai	Central Highlands	Moderate-Risk
Gia Lai	Duc Co	Central Highlands	Low-Risk	Thua Thien Hue	A Luoi	North Central	High-Risk	Quang Nam	Nam Giang	South Central Coa	Moderate-Risk
Gia Lai	Chu Prong	Central Highlands	Low-Risk	Kon Tum	Ngoc Hoi	Central Highlands	Low-Risk	Gia Lai	Duc Co	Central Highlands	Low-Risk
Quang Tri	Da Krong	North Central	Low-Risk	Quang Nam	Nam Giang	South Central Coast	Moderate-Risk	Gia Lai	Chu Prong	Central Highlands	Low-Risk
Nghe An	Thanh Chuong	North Central	Low-Risk	Da Nang	Hoa vang	South Central Coast	Moderate-Risk	Gia Lai	Chu Se	Central Highlands	Low-Risk
Thua Thien Hue	A Luoi	North Central	High-Risk	Quang Nam	Dai Loc	South Central Coast	Moderate-Risk	Quang Tri	Huong Hoa	North Central	Low-Risk
Quang Nam	Nam Giang	South Central Coast	High-Risk	Gia Lai	Ia Grai	Central Highlands	Moderate-Risk	Quang Tri	Da Krong	North Central	Low-Risk
Thua Thien Hue	Phong Dien	North Central	High-Risk	Gia Lai	Duc Co	Central Highlands	Low-Risk	Nghe An	Con Cuong	North Central	Low-Risk
Thua Thien Hue	Nam Dong	North Central	Moderate-Risk	Quang Tri	Da Krong	North Central	Low-Risk	Thua Thien Hue	A Luoi	North Central	Moderate-Risk
Kon Tum	Ngoc Hoi	Central Highlands	Moderate-Risk	Nghe An	Thanh Chuong	North Central	Low-Risk	Kon Tum	Ngoc Hoi	Central Highlands	Moderate-Risk
Da Nang	Lien Chieu	South Central Coast	Low-Risk	Quang Nam	Hien	South Central Coast	High-Risk	Thua Thien Hue	Phong Dien	North Central	Moderate-Risk
Quang Nam	Hien	South Central Coast	High-Risk	Thua Thien Hue	Nam Dong	North Central	Low-Risk	Quang Nam	Tra My	South Central Coa	Moderate-Risk
Da Nang	Hoa vang	South Central Coast	High-Risk	Kon Tum	Dak To	Central Highlands	Moderate-Risk	Quang Nam	Que Son	South Central Coa	High-Risk
Quang Nam	Dai Loc	South Central Coast	High-Risk	Quang Nam	Tra My	South Central Coast	High-Risk	Quang Ngai	Tra Bong	South Central Coa	Moderate-Risk
Kon Tum	Dak Glei	Central Highlands	High-Risk	Quang Nam	Que Son	South Central Coast	High-Risk	Kon Tum	Dak To	Central Highlands	Moderate-Risk
Kon Tum	Dak To	Central Highlands	High-Risk	Quang Ngai	Son Tinh	South Central Coast	Low-Risk	Quang Ngai	Son Tinh	South Central Coa	Low-Risk
Quang Ngai	Tra Bong	South Central Coast	High-Risk	Quang Ngai	Son Tay	South Central Coast	Low-Risk	Quang Ngai	Son Ha	South Central Coa	Low-Risk
Quang Nam	Phuoc Son	South Central Coast	Moderate-Risk	Quang Ngai	Tra Bong	South Central Coast	Moderate-Risk	Quang Nam	Nui Thanh	South Central Coa	Low-Risk
Kon Tum	Kon Plong	Central Highlands	High-Risk	Quang Ngai	Son Tay	South Central Coast	Moderate-Risk	Quang Nam	Hien	South Central Coa	High-Risk
Quang Nam	Tra My	South Central Coast	High-Risk	Quang Nam	Phuoc Son	South Central Coast	Moderate-Risk	Thua Thien Hue	Nam Dong	North Central	Moderate-Risk
Quang Nam	Que Son	South Central Coast	High-Risk	Quang Ngai	Minh Long	South Central Coast	Moderate-Risk	Kon Tum	Dak Glei	Central Highlands	Moderate-Risk
Quang Nam	Nui Thanh	South Central Coast	Low-Risk	Binh Dinh	Hoai An	South Central Coast	Low-Risk	Nghe An	Thanh Chuong	North Central	Low-Risk
Quang Ngai	Son Tay	South Central Coast	Moderate-Risk	Binh Dinh	Phu Cat	South Central Coast	Low-Risk	Da Nang	Hoa vang	South Central Coa	Moderate-Risk
Quang Ngai	Son Tinh	South Central Coast	Low-Risk	Gia Lai	Krong Pa	Central Highlands	Low-Risk	Quang Nam	Dai Loc	South Central Coa	Moderate-Risk
Quang Ngai	Son Ha	South Central Coast	Low-Risk	Kon Tum	Kon Plong	Central Highlands	Moderate-Risk	Quang Nam	Phuoc Son	South Central Coa	Moderate-Risk
Quang Ngai	Ba To	South Central Coast	Moderate-Risk	Quang Ngai	Ba To	South Central Coast	Moderate-Risk	Da Nang	Lien Chieu	South Central Coa	Low-Risk
Quang Ngai	Minh Long	South Central Coast	High-Risk	Phu Yen	Tuy Hoa	South Central Coast	Low-Risk	Quang Ngai	Son Tay	South Central Coa	Moderate-Risk
Quang Ngai	Duc Pho	South Central Coast	Low-Risk	Khanh Hoa	Van Ninh	South Central Coast	Low-Risk	Kon Tum	Kon Plong	Central Highlands	Moderate-Risk

2.5.4 Conclusions

- The influence of the tropical storm NORU's circulation caused heavy rain and very heavy rain in some areas in the north-central parts of Viet Nam and some provinces in the south and southeast of Lao PDR.
- From this analysis and through the operation of the system, the accuracy in determining the amount of precipitation of the MRC-FFGS system is quite good for precipitation between MAP24h and observed accordingly.
- During this time of intense heavy rainfall, the MRC-FFGS has correctly detected almost all serious flash flood events in the north-central provinces of Viet Nam, south and southeast of Lao PDR. Some of them are corresponded with the reported flash flood areas via newspaper or the internet (see **Annex A.3**)

2.6 Flash flood event during 10-17 October caused by tropical storm SONCA.

2.6.1 Weather conditions during 10-17 October 2022

From October 10 to 17, the LMB was affected by two weather factors including (i) the moderate high-pressure system from China extended its ridge to cover northern parts during the early week and then moved to cover the upper part, and (ii) the monsoon trough laid across the middle-southern part throughout the week. The mentioned monsoon trough laid across the tropical depression in the central East Sea on October 13. Then the mentioned tropical depression intensified into the tropical storm "SONCA" in the afternoon of October 14. It made landfall in Quang Ngai province, Viet Nam during October 15. After that, it downgraded into the tropical depression in Da Nang, Viet Nam. This storm degenerated into an active low-pressure cell covering Lao PDR in the afternoon of the same day. These conditions caused heavy rainfall over the upper and middle parts during the entire week. (See **Figure 2-20**).

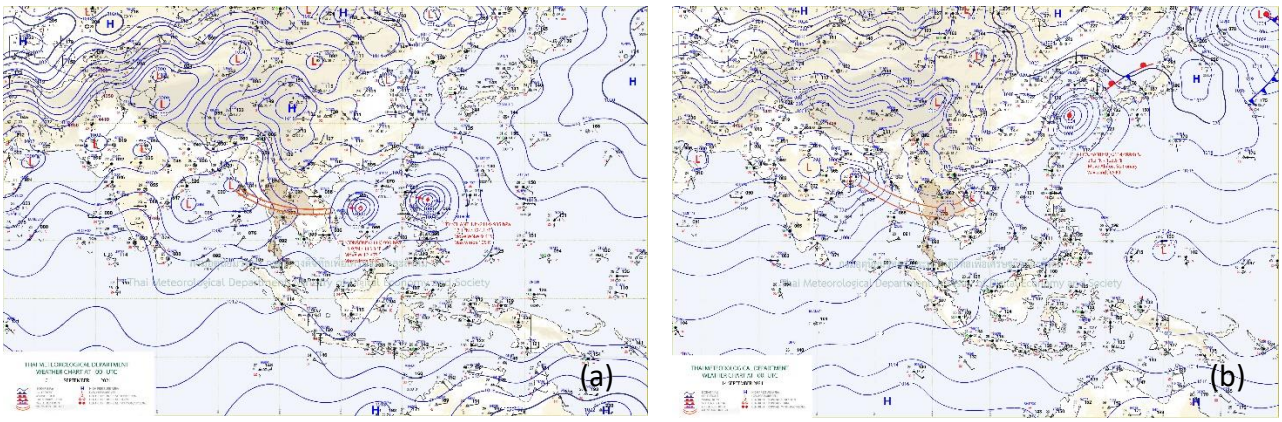


Figure 2-20: Weather map for (a) 10 September and (b) 14 September (Source: TMD)

Tropical storm SONCA: Late on October 11, the JTWC started to monitor a scattered area of convection with a poorly organized broad low-level center to the west-southwest of Manila, Philippines. Within a marginally favorable environment of no distinct outflow established, low to moderate wind shear, and warm sea surface temperatures, the system slightly organized by the next day, with flaring convection and its center remaining exposed. Nonetheless, the JMA upgraded the system into a tropical depression on October 13.

The JTWC later issued a TCFA on the system on the same day, noting fragmented deep convection was wrapping into its broad low-level center. By the next day, the JTWC initiated advisories on the storm. Moving westward, the storm intensified into a tropical storm six hours later, with the JMA naming it SONCA. It failed to intensify further as its center remained exposed, with deep convection displaced to the west due to strong wind shear, and it soon made landfall in Da Nang, Viet Nam late on the same day. The JMA followed suit by October 15, as Sonca weakened into a tropical depression. **Figure 2-21**.

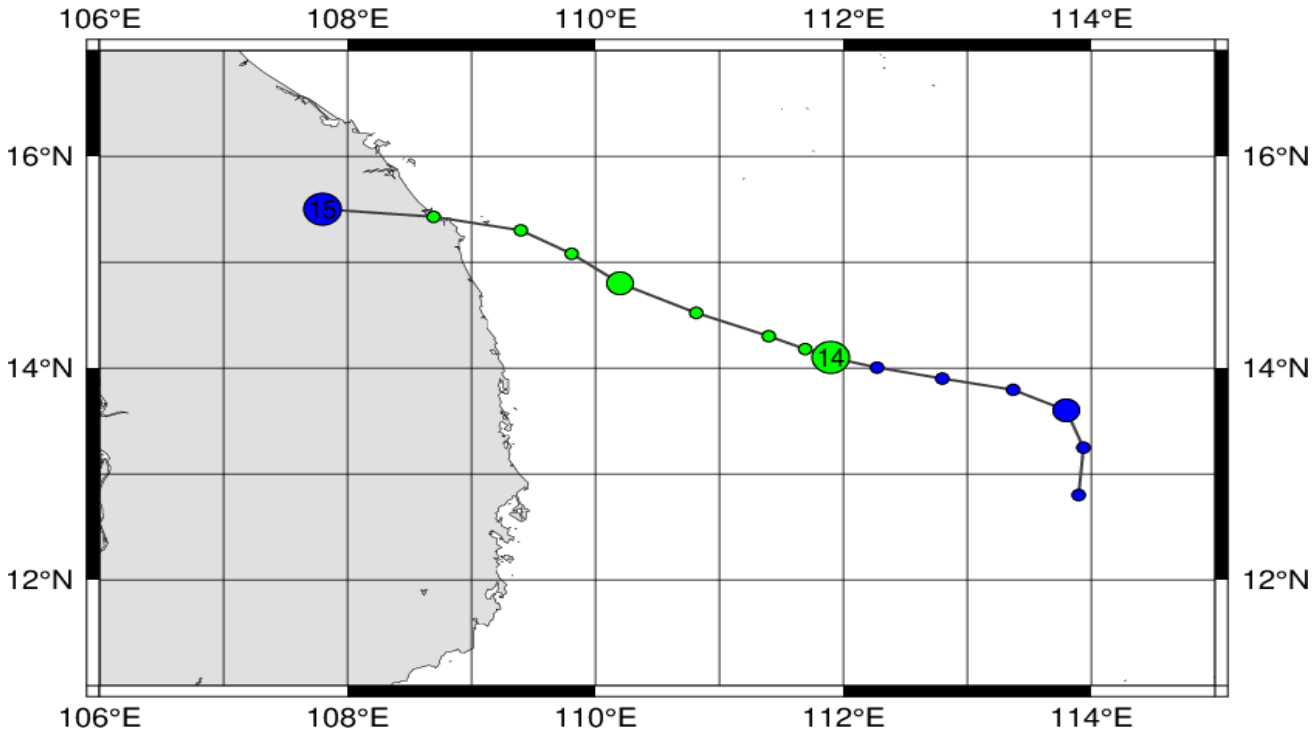


Figure 2-21: The track of tropical storm SONCA (Source: JMA)

2.6.2 Heavy rainfall during 10-17 October 2022

Regarding the daily rainfall observed from the MCs, very heavy rainfall was concentrated from 10 to 16 October due to the influence of SONCA 's circulation at some areas in the LMB such as in Viet Nam at A Luoi (572 mm) on 15 October, at An Khe (230 mm) on 13 October. In particular, the total rainfall measured during this time at A Luoi is **1061.1mm**. The map of rainfall distribution during 10 – 17 October 2022 in the LBM is shown in **Figure 2-22** and daily rainfall observed at some stations in the LMB is shown in

Table 2-9.

Table 2-9: Daily rainfall observed at some stations in the LMB (10 – 17 October 2022)

Unit: mm

	Khe Sanh	A Luoi	An Khe	Vang Vieng	Bovel	Kompong Chhnang
10/10/2022	82.00	160.00	3.80	44.50	57.10	30.50
11/10/2022	20.10	150.00	29.20	44.50	41.80	15.50
12/10/2022	0.00	15.70	122.00	12.10	0.00	42.30
13/10/2022		5.30	230.70	0.00	0.00	0.00
14/10/2022		6.10	35.30	0.00	0.00	0.00
15/10/2022	108.00	572.00	61.00	0.00	0.00	0.00
16/10/2022	109.00	127.00	0.50	0.00	0.00	0.00
17/10/2022	1.00	25.00	0.20	0.00	0.00	0.00
Sum	320.10	1061.10	482.70	101.10	98.90	88.30

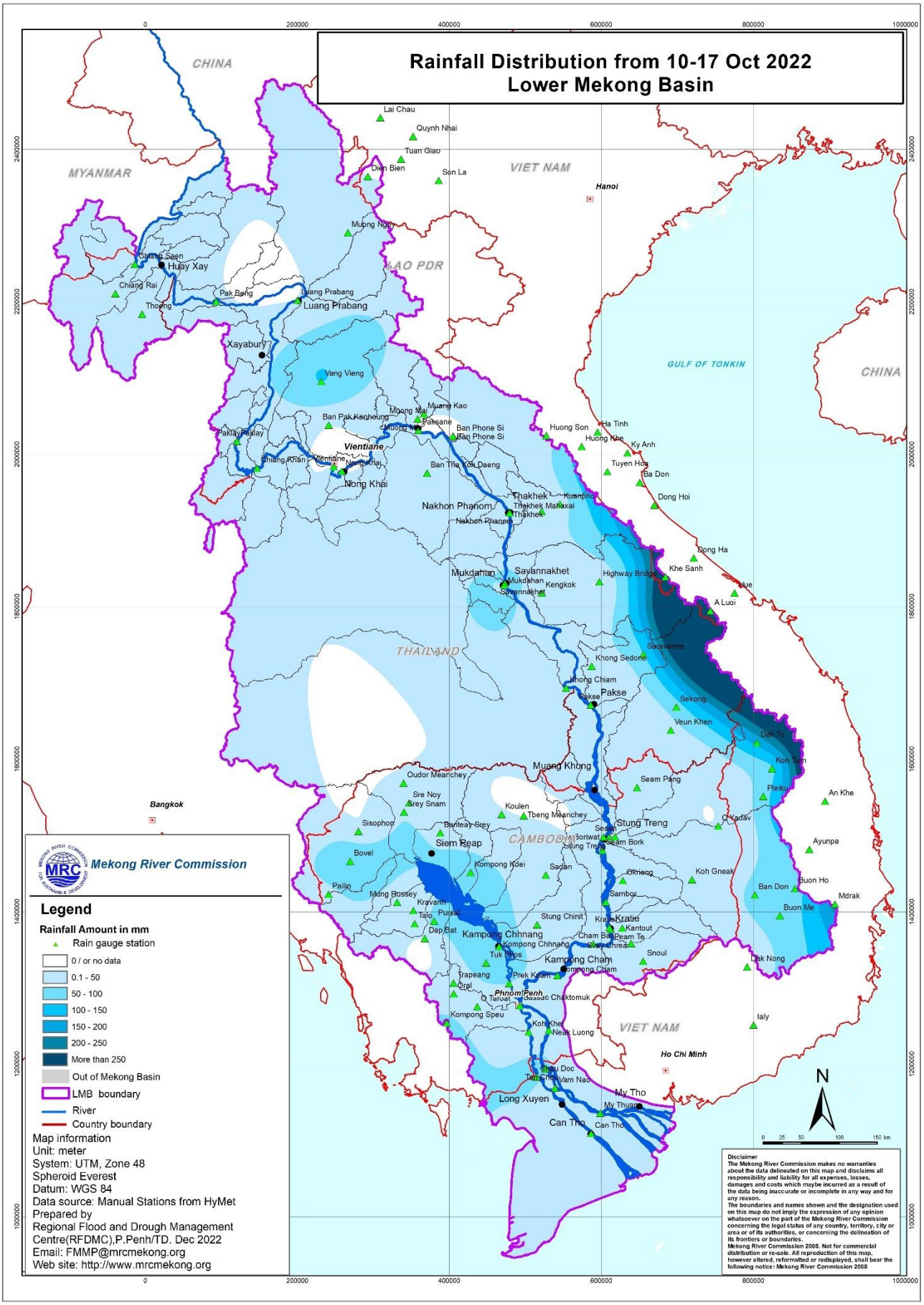

Rainfall Distribution from 10-17 Oct 2022
Lower Mekong Basin
CHINA
MYANMAR
LAO PDR
VIET NAM
THAILAND
CAMBODIA
GULF OF TONKIN
Hanoi
Vientiane
Bangkok
Phnom Penh
Ho Chi Minh
Luang Prabang
Xayabury
Pakse
Savannakhet
Nakhon Phanom
Thakhek
Muang Khong
Stung Treng
Kampong Chhnang
Kampong Cham
Siem Reap
Long Xuyen
Can Tho
My Tho
Mekong River Commission
Legend
Rainfall Amount in mm
Rain gauge station
0 / or no data
0.1 - 50
50 - 100
100 - 150
150 - 200
200 - 250
More than 250
Out of Mekong Basin
LMB boundary
River
Country boundary
Map information
Unit: meter
System: UTM, Zone 48
Spheroid Everest
Datum: WGS 84
Data source: Manual Stations from HyMet
Prepared by
Regional Flood and Drough Management
Centre(RFDMC),P.Penh/TD. Dec 2022
Email: FMMP@mrcmekong.org
Web site: http://www.mrcmekong.org
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Figure 2-22 Rainfall distribution during 10 – 17 October 2022 in the LMB

2.6.3 Flash flood event on 15 October 2022

Based on the MRC-FFGS products, the satellite rainfall MAP24h and the ASM, very heavy rainfall was detected in the middle parts of the LMB including north-parts of Viet Nam, south and southeast areas of Lao PDR at 00:00 UTC (00:00 local time) on 15 October 2022. Those results show that the soil moisture in those areas was also very wet, saturated in a wide range of the areas where heavy rainfall is described above (see **Figure 2-23**).

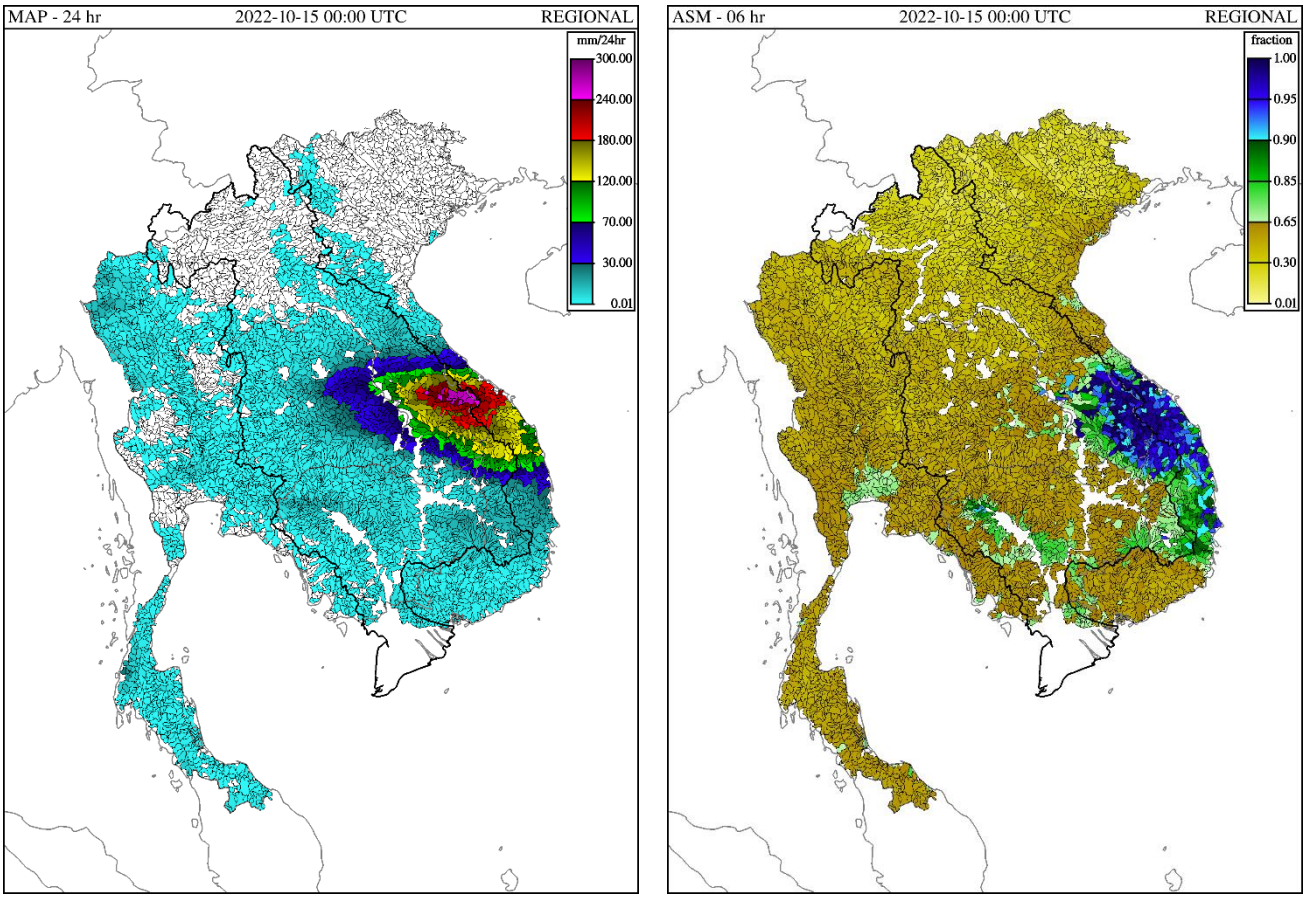

Figure 2-23: MAP24h and ASM on 15 October2022 at 00:00 UTC (07: 00 local time)

The comparison between MAP24h and rainfall observed at some gauging stations during the period from 10 -17 October 2022 is shown in Error! Reference source not found..

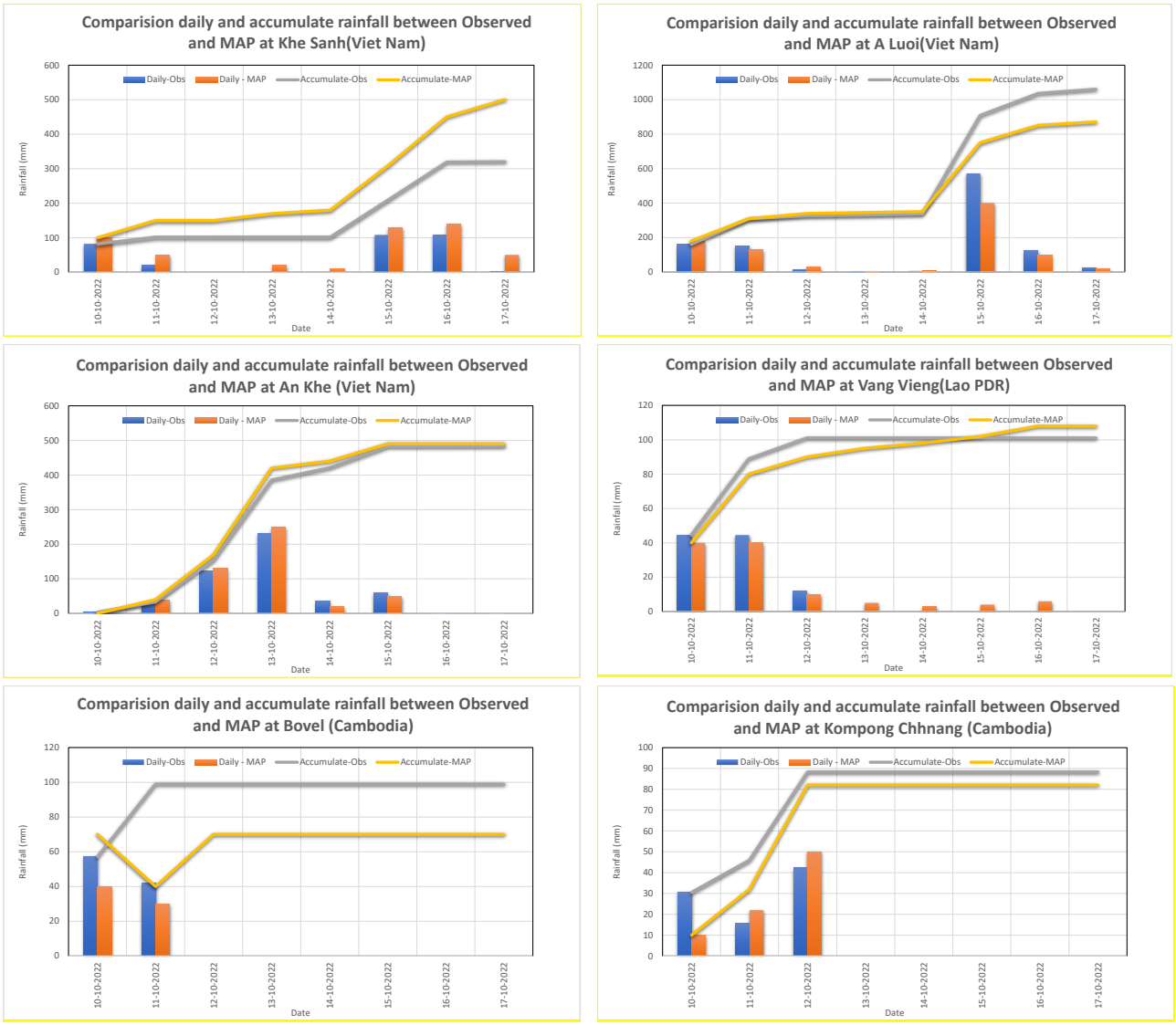

Figure 2-24: Comparison rainfall observed and MAP24h at some stations in LMB from 10-17 October 2022

RFDMC's forecaster submitted the flash flood warning for 1, 3, and 6 hours on 00:00 UTC 15 October 20220. Some areas in Viet Nam and Lao PDR were predicted with high risk of flash flood as shown in **Figure 2-25** and

Table 2-10.

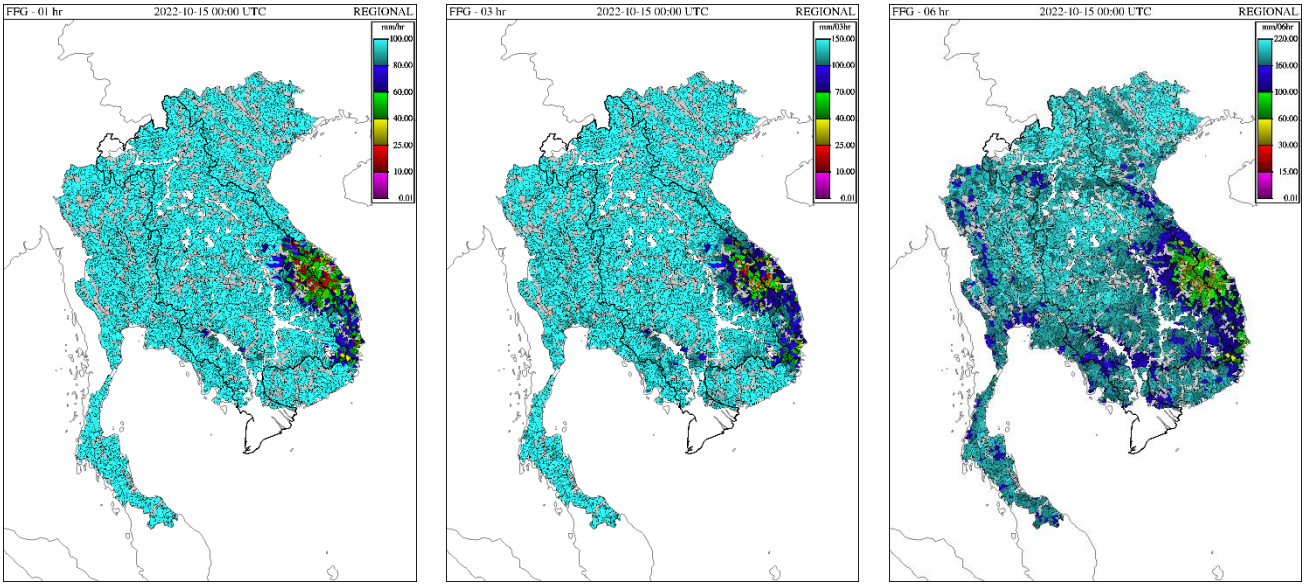

Figure 2-25: FFG 01, 03 and 06-hour on 15 October 2022 at 00:00 UTC (07: 00 local time)

Table 2-10: FFG detected by the MRC-FFGS (a) Lao PDR, (b) Viet Nam, on 15 Octoberr 2022 at 00:00 UTC (07: 00 Local time)

(a)

Rate-risk and location of the flash flood may occur in the next 1, 3, and 6 hours in Lao PDR

Date of FFG products 15/10/2022 00:00 UTC time

01-Hour Flash Flood Risk and Location					03-Hour Flash Flood Risk and Location					06-Hour Flash Flood Risk and Location				
Provinces	Districts	Villages	Region	Level Risk	Provinces	Districts	Villages	Region	Level Risk	Provinces	Districts	Villages	Region	Level Risk
Savannakhet	Nong	TALING	Southern	Low-Risk	Savannakhet	Nong	PASANEIR TAI	Southern	Low-Risk	Saravane	Samuoi	ATUK	South	Low-Risk
Savannakhet	Nong	KOR	Southern	Low-Risk	Saravane	Ta oi	TUMLEKHAO	South	Low-Risk	Savannakhet	Nong	TALING	Southern	Low-Risk
Savannakhet	Nong	PASANEIR TAI	Southern	Low-Risk	Saravane	Ta oi	PHOBEUI	South	Low-Risk	Savannakhet	Nong	KOR	Southern	Low-Risk
Saravane	Ta oi	TUMLEKHAO	South	Low-Risk	Saravane	Ta oi	PHOR SANH	South	High-Risk	Savannakhet	Nong	LAGNENG KHOK	Southern	Low-Risk
Saravane	Ta oi	PHOBEUI	South	Low-Risk	Saravane	Ta oi	TUMLE KAO	South	Low-Risk	Savannakhet	Nong	PASANEIR TAI	Southern	Low-Risk
Saravane	Ta oi	PHOR SANH	South	High-Risk	Sekong	Kaleum	PRO	Southeast	Moderate-Risk	Saravane	Ta oi	TUMLEKHAO	South	Low-Risk
Saravane	Ta oi	TUMLE KAO	South	Low-Risk	Sekong	Kaleum	AR-HOR NEUA	Southeast	Low-Risk	Saravane	Ta oi	PHOBEUI	South	Low-Risk
Saravane	Ta oi	PATEUM	South	Low-Risk	Sekong	Kaleum	KA-OUANG	Southeast	Moderate-Risk	Saravane	Ta oi	PHOR SANH	South	High-Risk
Sekong	Kaleum	PRO	Southeast	High-Risk	Sekong	Kaleum	PANORM	Southeast	Low-Risk	Saravane	Ta oi	TUMLE KAO	South	Low-Risk
Sekong	Kaleum	AR-HOR NEUA	Southeast	Low-Risk	Sekong	Kaleum	AR-PEUANG	Southeast	High-Risk	Saravane	Ta oi	PATEUM	South	Low-Risk
Sekong	Kaleum	KA-OUANG	Southeast	High-Risk	Sekong	Kaleum	PALAENG	Southeast	Low-Risk	Savannakhet	Phine	PHAY	Southern	Low-Risk
Sekong	Kaleum	PANORM	Southeast	Low-Risk	Sekong	Kaleum	VAK TAI	Southeast	Moderate-Risk	Champasak	Pathoomph	NAMPHAAK	Southwestern	Low-Risk
Sekong	Kaleum	AR-PEUANG	Southeast	High-Risk	Sekong	Kaleum	TIN	Southeast	Low-Risk	Champasak	Paksong	THONGYAO	Southwestern	Low-Risk
Sekong	Kaleum	PALAENG	Southeast	Moderate-Risk	Sekong	Kaleum	STTHORN	Southeast	Moderate-Risk	Sekong	Kaleum	PRO	Southeast	Moderate-Risk
Sekong	Kaleum	VAK TAI	Southeast	High-Risk	Sekong	Dakcheung	DAKVANG	Southeast	Low-Risk	Sekong	Kaleum	AR-HOR NEUA	Southeast	Low-Risk
Sekong	Kaleum	TIN	Southeast	Moderate-Risk	Sekong	Dakcheung	DAKXAM	Southeast	Low-Risk	Sekong	Kaleum	KA-OUANG	Southeast	Moderate-Risk
Sekong	Kaleum	STTHORN	Southeast	High-Risk						Sekong	Kaleum	PANORM	Southeast	Low-Risk
Sekong	Dakcheung	DAKKE	Southeast	Low-Risk						Sekong	Kaleum	AR-PEUANG	Southeast	Moderate-Risk
Sekong	Dakcheung	DAKVANG	Southeast	Moderate-Risk						Sekong	Kaleum	PALAENG	Southeast	Moderate-Risk
Sekong	Dakcheung	DAKXAM	Southeast	Low-Risk						Sekong	Kaleum	VAK TAI	Southeast	Moderate-Risk
										Sekong	Kaleum	TIN	Southeast	Moderate-Risk
										Sekong	Kaleum	STTHORN	Southeast	Moderate-Risk
										Sekong	Lamarm	KANONG MAI	Southeast	Low-Risk
										Sekong	Dakcheung	DAKYUENG	Southeast	Low-Risk

(b)

Rate-risk and location of the flash flood may occur in the next 1, 3, and 6 hours in Viet Nam

Date of FFG products 15/10/2022 00:00 UTC time

01-Hour Flash Flood Risk and Location				3-Hour Flash Flood Risk and Location in Vietnam				6-Hour Flash Flood Risk and Location in Vietnam			
Provinces	Districts	Region	Level Risks	Provinces	Districts	Region	Level Risks	Provinces	Districts	Region	Level Risks
Quang Tri	Huong Hoa	North Central	Moderate-Risk	Quang Tri	Huong Hoa	North Central	Low-Risk	Kon Tum	Sa Thay	Central Highlands	Low-Risk
Thua Thien Hue	A Luoi	North Central	Low-Risk	Quang Nam	Hien	South Central Coast	Moderate-Risk	Gia Lai	Ia Grai	Central Highlands	Low-Risk
Thua Thien Hue	A Luoi	North Central	High-Risk	Quang Nam	Nam Giang	South Central Coast	High-Risk	Quang Tri	Huong Hoa	North Central	Moderate-Risk
Quang Nam	Hien	South Central Coast	High-Risk	Quang Tri	Da Krong	North Central	Low-Risk	Quang Nam	Nam Giang	South Central Coast	Moderate-Risk
Quang Nam	Nam Giang	South Central Coast	High-Risk	Thua Thien Hue	Phong Dien	North Central	Low-Risk	Kon Tum	Dak Glei	Central Highlands	Moderate-Risk
Kon Tum	Dak Glei	Central Highlands	Moderate-Risk	Thua Thien Hue	A Luoi	North Central	Moderate-Risk	Quang Tri	Da Krong	North Central	Moderate-Risk
Quang Tri	Da Krong	North Central	Moderate-Risk	Da Nang	Hoa Vang	South Central Coast	Moderate-Risk	Thua Thien Hue	Phong Dien	North Central	Low-Risk
Da Nang	Hoa Vang	South Central Coast	Moderate-Risk	Thua Thien Hue	Nam Dong	North Central	Low-Risk	Thua Thien Hue	A Luoi	North Central	Moderate-Risk
Da Nang	Lien Chieu	South Central Coast	Low-Risk	Kon Tum	Dak Glei	Central Highlands	Moderate-Risk	Thua Thien Hue	Nam Dong	North Central	Low-Risk
Quang Nam	Dai Loc	South Central Coast	High-Risk	Quang Nam	Dai Loc	South Central Coast	High-Risk	Da Nang	Hoa Vang	South Central Coast	Moderate-Risk
Quang Nam	Phuoc Son	South Central Coast	Moderate-Risk	Quang Nam	Phuoc Son	South Central Coast	Low-Risk	Da Nang	Lien Chieu	South Central Coast	Low-Risk
Quang Ngai	Tra Bong	South Central Coast	Low-Risk	Quang Ngai	Son Tinh	South Central Coast	Low-Risk	Quang Nam	Hien	South Central Coast	Moderate-Risk
Kon Tum	Dak To	Central Highlands	Moderate-Risk	Quang Ngai	Son Tay	South Central Coast	Moderate-Risk	Quang Nam	Dai Loc	South Central Coast	Moderate-Risk
Quang Nam	Tra My	South Central Coast	High-Risk	Quang Ngai	Tra Bong	South Central Coast	Moderate-Risk	Kon Tum	Dak To	Central Highlands	Moderate-Risk
Quang Nam	Que Son	South Central Coast	High-Risk	Kon Tum	Kon Plong	Central Highlands	Low-Risk	Quang Nam	Phuoc Son	South Central Coast	Moderate-Risk
Quang Ngai	Tra Bong	South Central Coast	High-Risk	Quang Ngai	Ba To	South Central Coast	Low-Risk	Kon Tum	Dak To	Central Highlands	Moderate-Risk
Quang Nam	Nui Thanh	South Central Coast	Low-Risk	Quang Ngai	Minh Long	South Central Coast	Low-Risk	Kon Tum	Dak To	Central Highlands	Moderate-Risk
Quang Ngai	Son Tinh	South Central Coast	Low-Risk	Quang Ngai	Duc Pho	South Central Coast	Low-Risk	Quang Nam	Tra My	South Central Coast	Moderate-Risk
Quang Ngai	Son Ha	South Central Coast	Low-Risk	Binh Dinh	Hoai An	South Central Coast	Low-Risk	Quang Nam	Que Son	South Central Coast	Moderate-Risk
Quang Ngai	Son Tay	South Central Coast	Moderate-Risk	Binh Dinh	Phu Cat	South Central Coast	Low-Risk	Quang Nam	Nui Thanh	South Central Coast	Low-Risk
Kon Tum	Kon Plong	Central Highlands	Moderate-Risk	Gia Lai	Krong Pa	Central Highlands	Low-Risk	Quang Ngai	Son Tinh	South Central Coast	Low-Risk
Quang Ngai	Ba To	South Central Coast	Low-Risk	Phu Yen	Son Hoa	South Central Coast	Low-Risk	Quang Ngai	Son Ha	South Central Coast	Low-Risk
Quang Ngai	Minh Long	South Central Coast	Low-Risk	Gia Lai	Kbang	Central Highlands	Low-Risk	Quang Ngai	Son Tay	South Central Coast	Moderate-Risk
Quang Ngai	Duc Pho	South Central Coast	Low-Risk	Phu Yen	Dong Xuan	South Central Coast	Low-Risk	Quang Ngai	Tra Bong	South Central Coast	Moderate-Risk
Binh Dinh	Hoai An	South Central Coast	Moderate-Risk	Phu Yen	Tuy Hoa	South Central Coast	Moderate-Risk	Quang Ngai	Minh Long	South Central Coast	Low-Risk

2.6.4 Conclusions

- Due to the influence of the consecutive tropical storm SONCA, its circulation caused heavy rain in some areas in north – central of Viet Nam and border provinces of Lao PDR.
- During that time, the MRC-FFGS detected most observed rainfall by space and time. However, compared with the observed rainfall data it was over/underestimate about 10-20 %.
- During this time of intense heavy rain, the MRC-FFGS has correctly detected the flash flood events in Viet Nam and in Lao PDR. The time of flash flood occurring was detected quite well. MRC-FFGS has correctly detected them according to the reported flash flood areas via newspaper or the internet (see Annex A.3).

3. Evaluation of the MRC-FFGS

3.1 Methodology to evaluate the MRC-FFGS

Many verification studies rely on a categorical approach that considers a range of values to be classified into a prescribed category. The categorical approach often refers to the occurrence or non-occurrence of a specific meteorological or hydrological event. The exact nature of the event must be clearly identified with respect to the event characteristics, spatial extent, and time span. For instance, the forecast and observed time series pertaining to the occurrence of a flash flood event can be converted to a categorical time series that contain values of 1 and 0, with the former indicating occurrence and the later indicating non-occurrence in both observed and forecast/simulated time series.

Probability of Detection (PoD) or Hit Rate (HR): $$\boldsymbol{PoD} = \boldsymbol{HR} = \frac{a}{a+c}$$

Where:

a Hits: Number of observed flash floods that were correctly forecasted to be flash floods.

c Misses: Number of observed flash floods that were forecasted to be non – flash flood, or misses.

The HR has a range of 0 to 1 with 1 representing a perfect forecast. It uses only observed events in the contingency table which is sensitive only to missed events and not to false alarm. Therefore, the HR can generally be improved by systematically over-forecasting the occurrence of the event. HR also is incomplete by itself and should be used in conjunction with either the false alarm ratio or the false alarm rate.

To estimate the **a** and **c** numbers above, the methodology for evaluation of flash flood guidance products used in this flash flood report is based on two concepts:

(i) The first concept evaluates the feedback from the MRC-FFGS detected risk areas. As no direct link between the RFDMC and the local population is established, the feedback information on flash flood areas was mainly collected from the national media, such as online newspapers, and from LAs' forecasters of MCs via communication with RFDMC's forecasters.

(ii) The second concept evaluates the MRC-FFGS results through the recorded water levels that are available in the operational database of RFDMC. If MRC-FFGS detected flash flood warnings in the sub-areas where a gauging station is available, the MRC-FFGS results can be evaluated by comparing with the water level data of the gauging station located in the downstream part of the sub-catchment.

The recorded daily rainfall available at the flash flood risk areas was also used to evaluate if

a flash flood really occurred. However, occasionally it is difficult to evaluate the MRC-FFGS results using media information because flash floods occur in areas that are difficult to access, and reporting of flash floods is lacking. Although the MRC-FFGS often successfully had indicated a flash flood risk in the flooded areas, the information of the occurred flash flood was not accurate or incomplete, which makes the validation of the system difficult. Unfortunately, during the wet season 2022 there were numerous periods in which "missing data" were reported, especially at Phongsaly, Muong Namtha, Oudomxay, Ban Mixay, Vang Vieng, Muong Techpon, Xieng Khoang, and Sayaboury and Moung Ngoy stations located within the northern province of Lao PDR. Limiting the "missing data" in these areas is highly necessary to improve the verification of flash floods and getting 'grip' on the accuracy of the system in these areas.

Detailed assessment of PoD is found in **Annex B.**

3.2 Flash flood operation at the RFDMC during wet season 2022

Analysing the flash flood situation in the wet season 2022 and the operation of the MRC-FFGS, the following has been observed:

- The total number of flash flood events across the Mekong region was about 81 events, which is more than the LTA and more than 2021 (46 events). **Table 3-1** shows the total number and distribution in space and time of flash flood events in the wet season 2022 in the LBM.

Table 3-1: Distribution of flash flood events in the LMB in 2022

Month	FF events	Lao PDR	Thailand	Cambodia	Viet Nam
June	7	3	0	1	3
July	10	2	2	3	3
August	18	4	2	6	6
September	28	5	8	7	8
October	18	1	5	6	6
Total	**81**	**15**	**17**	**23**	**26**

- Most high-intensity flash floods are concentrated in September due to the extreme climatic conditions with tropical storms from the Pacific Ocean causing heavy rainfall in the LMB. Besides, some flash food events occurred due to the impact of the ICTZ and Low Pressure on June and August.

Table 3-2: Calendar date of flash flood recorded in the LMB during wet season 2022.

2022 June

MONDAY	THỨ BA	THỨ TƯ	THỨ NĂM	THỨ SÁU	THỨ BẢY	CHỦ NHẬT
30	31	01 L,V	02	03	04	05
06 L,C	07	08	09	10 V,L	11	12
13	14	15	16	17	18 V	19
20	21	22	23	24	25	26
27	28	29	30	01	02	03
04	05					

2022 July

THỨ HAI	THỨ BA	THỨ TƯ	THỨ NĂM	THỨ SÁU	THỨ BẢY	CHỦ NHẬT
27	28	29	30	01	02	03 V,L,C
04 V	05 V	06	07	08	09	10
11	12	13	14	15	16	17 T,C
18	19	20 L	21	22 V,L	23	24 T,C
25	26	27	28	29	30	31
01	02					

2022 August

THỨ HAI	THỨ BA	THỨ TƯ	THỨ NĂM	THỨ SÁU	THỨ BẢY	CHỦ NHẬT
01	02 V,L,C	03	04	05 V,L,C,	06	07
08	09 L,C	10	11 L,V,T	12	13	14
15	16	17	18	19	20	21
22	23	24 C,V	25	26 V,C	27	28
29	30	31 V,C	01	02	03	04
05	06					

2022 September

THỨ HAI	THỨ BA	THỨ TƯ	THỨ NĂM	THỨ SÁU	THỨ BẢY	CHỦ NHẬT
29	30	31	01 T,C,V	02 T,C,V	03	04
05	06	07	08	09	10 L,T,C,V	11 L,T,C,V
12	13	14	15	16	17 L,T,V	18
19	20 T,V,C	21	22	23	24	25
26	27 L,T,C,V	28 L,T,C,V	29	30	01	02
03	04					

2022 October

THỨ HAI	THỨ BA	THỨ TƯ	THỨ NĂM	THỨ SÁU	THỨ BẢY	CHỦ NHẬT
26	27	28	29	30	01	02
03	04	05	06	07	08	09
10	11	12	13	14 V,T,C	15 V,T,C	16 V,T,L,C
17	18	19	20	21	22	23 V,T,C
24 V,T,C	25	26	27	28	29 V,C	30
31	01					

2022 November

THỨ HAI	THỨ BA	THỨ TƯ	THỨ NĂM	THỨ SÁU	THỨ BẢY	CHỦ NHẬT
31	01	02	03	04	05	06
07	08	09	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	01	02	03	04
05	06					

- In general, during wet season 2022 the MRC-FFGS operated very smoothly during the whole wet season. There were a few times minor errors on server connection, but the RFDMC was technically supported from the HRC (see **Annex C1** for correspondence).
- There was a total of 310 flash flood bulletins uploaded on the RFDMC's website. In general, the MRC-FFGS detected flash flood events during the wet season 2022 with a PoD of around 73 % (higher then 2021: 71 %).

  Please see **Annex B** for the evaluation of the MRC-FFGS in each country of the LMB.

4. Conclusions and recommendations

4.1 Conclusions

Flash floods in the LMB are recurrent events that have the potential to adversely affect economic, human, livelihoods, properties, and infrastructures. Moreover, the wet season in 2022 has been affected by unusual climatic factors (e.g., rain appeared late, heavy rain due to storms is concentrated in September and October). It makes the MCs increasingly more concerned about flash floods and they are looking for ways to improve flood preparedness to limit the extent of damage. According to the media reports, flash floods and landslides occur very often in mountainous areas in the upper and central parts of the Mekong region.

In total 25 tropical storms occurred, which developed over the Pacific Ocean or over the East Sea (Figure 2-1). There were 6 tropical storms, namely (1) CHABA, (2) MULAN, (3) MA-ON, (4) NORU, (5) SONCA, and (6) NESAT, which caused serious flash floods affecting the LMB (Table 2-2). The other cause of flash floods in the LMB is the Inter Tropical Convergence Zone (ITCZ), producing low pressure and tropical depression which lead to flash floods in some areas in the LMB.

During wet season 2022, there were 25 tropical storms that developed over the Pacific Ocean and or over the East Sea. There were six tropical storms, namely (1) CHABA, (2) MULAN, (3) MA-ON, (4) NORU, (5) SONCA, and (6) NESAT which caused serious flash floods affecting the LMB. The other causes of flash floods in the LMB are the ITCZ, low pressure and tropical depression which also led to flash flood occurrence at some areas in the Mekong mainstream and its tributaries. Most of the flash flood risk areas in the Mekong region that were detected by the MRC-FFGS occurred in the provinces of Mekong Countries of LMB.

The MRC-FFGS has been operating successfully during wet season 2022. The RFDMC provides products to support the development of warning and estimate the risk of flash flooding from rainfall events in the sub-basins of the MRC MCs. The average percentage of accuracy for the correct detection of flash floods is about **73 %** (higher than 2022, which was 71%). See **Annex B** for more detail.

The main aim of this report is to evaluate the performance of the MRC-FFGS in areas of the MRC MCs for the detection of the risk areas of potential flash floods during the wet season 2022 from June until the late of October. The report does not cover all the flash flooding that occurred in 2022 wet season, it is based on the available flash flood information that was collected from the media and information from the Annual of Flood and Drought report from Country Member. However, it is difficult to evaluate the MRCFFG results using media information because flash floods occurred in areas which are difficult to access and there are no reports available. The MRC-FFGS often indicated a flash flood risk in flooded areas, but it

is lacking an accurate and complete database of flash flood events. This makes it difficult to put a number on the success rate.

Finally, it can be stated that the MRC-FFGS performance during wet season 2022 could predict expected rainfall amounts with reasonable accuracy; the system is potentially a very effective tool for flash flood forecasting in the LMB.

4.2 Recommendations

The recommendations for further development of the MRC-FFGS for enhancing the accuracy of flash flood forecasting, and to reduce damage, the risk of lives and properties caused by flash floods are listed below:

1. Based on the results of the MRC-FFGS there are still many missing detections of flash flood risk areas by the MRC-FFGS. It is recommended to improve the MAP product for reliable rainfall measurement the bias correction factor needs to be reviewed. Once the bias correction factor is updated, the MRC-FFGS should be re-run to review and verify the results.
2. In order to develop, implement and operate the MRC-FFGS, data and information such as climatological data (hourly, daily, monthly), precipitation data (hourly, daily, monthly), air temperature (hourly, daily, monthly), soil moisture data, the updated land use/ land cover map, streamflow discharge data for tributary streams to the Mekong River or upstream (hourly, daily, monthly), stream stage data for tributaries (hourly, daily, monthly), radiation data for computation of evapotranspiration (daily, monthly), wind and humidity data for computation of potential evapotranspiration (daily, monthly), etc. are needed for system operations and bias correction. Especially, the data from the MCs should be available to support the operational task and valuation of the MRC-FFGS.
3. For the more effective evaluation of the MRC-FFGS and to improve the accuracy of the system, it is recommended to build a mechanism for the collecting and sharing information of flash flood events between national and regional in the LMB.
4. GIS database of village, district and province information is a significant input to address the high-risk area of flash floods. Since 2010 until present, the RFDMC still lack on information about the village database in GIS format (ArcGIS point file) of Thailand and Viet Nam for the GIS database. This information would help to improve the capability of the MRC-FFGS to issue a warning on possible flash floods occurrence in Thailand and Viet Nam. It is recommended to figure out how to coordinate with the respective LAs to provide and support village database of Thailand and Viet Nam (GIS point file).

5. The current GIS database with the village, district and province name and boundary was received from national LAs in 2003. This information may not be consistent and out of date compared to the current GIS database of each country. The updated GIS database is a significant input to issue warnings on possible flash floods occurrences.
6. The RFDMC can further contribute by offering training courses in the use of the MRC-FFGS and by urging the countries to alert flash flood warnings. It is recommended to conduct refreshment training courses of the MRC-FFGS operation to improve FFG operation, and to exchange knowledge and experiences on FFG operation between the national centres and the RFDMC.
7. It is recommended to strengthen the capacity of the staff at all levels to be able to handle flash flood forecasting and warnings.
8. For effective disaster flash flood risk reduction community awareness of flash floods is essential.
9. Southeast Asia Flash Flood Guidance System (SeAFFGS) with further data input, such as Radar, and weather forecast with high solution was located in Viet Nam at a regional center. for supporting flash flood warnings in Southeast Asia RFDMC- MRC should officially use this system for operation duty on flash flood guidance.

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[8] University Corporation for Atmospheric Research (2010). "Flash flood early warning system reference guide." USA: 204.

6. Annex A. Newspaper/ Internet/ Media of flash flood events in 2022 in the LBM

A.1. Flash flood event caused by tropical storm CHABA.

Source: Vientiane Times

LAO PRESS
IN FOREIGN LANGUAGES

Vientiane Times

www.vientianetimes.org.la www.vientianetimes.la

Villages inundated as heavy rain lashes provinces

Thousands of people in many provinces are suffering from flash floods after heavy rain in recent days has inundated their communities.

Xayaboury, Bokeo, Xieng Khuang and Vientiane provinces have all been affected by varying degrees of flooding since June 13 and 14. In northwestern Xayaboury province, the swollen Houng River overflowed its banks, swamping riverside villages and partially submerging houses.

Local authorities have been battling to move people to higher ground, the province's Deputy Governor Mr Phetthixay Sounvilay told *Vientiane Times* on Monday.

Xayaboury district has been the hardest hit and more than 10 villages are affected. Roads, water and electricity supply in flooded areas have been cut off, making it hard to move people and their belongings from flooded houses to higher ground.

"As roads are cut off, we are having to use boats to evacuate people, but we have only a limited number," Mr Phetthixay said. Villagers have been evacuated to places on higher ground, such as schools and other public facilities, while others are staying with relatives in unaffected areas.

The number of people left homeless has not yet been assessed because local authorities are busy evacuating people and providing emergency relief, the deputy governor said.

Many people are now in need of shelter, food and drinking water and some need boats to move around.

In Bokeo province, authorities are preparing safe places where people whose homes have been flooded can take shelter, head of the province's Information, Culture and Tourism Department, Dr Somkhit Vongpanya, said.

As a result of the floods, people need clothing, food and drinking water, while authorities are assessing the extent of the flooding and collecting information about the number of people affected.

Vangvieng district in Vientiane province has also been affected after the Song River overflowed its banks, inundating local communities and resorts in the tourist hotspot. A well-known orange bridge that crosses the river on the way to Chang Cave has been broken.

Parts of Xieng Khuang province are also flooded and local authorities will report details of the situation as more information becomes available, according to Lao Youth Radio. Photos and video clips posted on social media by official mainstream news channels and local people showed how villagers in the provinces were struggling to move their belongings and vehicles.

The Meteorology and Hydrology Department warned that heavy rain and wind gusts would occur throughout the country until June 14, with flooding and landslides possible in many areas. The department says there will be no storms from June 15-18 but there will be more rain in some parts of the country. Authorities warn everyone to be prepared for weather extremes and to follow forecasts regularly in order to mitigate the effects of severe conditions.

A.2. Flash flood event caused by tropical MULAN.

7. Viet Nam, Storms, and Floods in the Northern Region (Storm Mulan) (13 Aug 2022)

Format

News and Press Release

Source

- AHA Centre

Posted

15 Aug 2022

Originally published

13 Aug 2022

Origin View original

Lào Cai, Viet Nam

Event Date: Sat, 13 Aug 2022

AHADID: AHA-ST-2022-000866-VNM | **GLIDE Number**

Impact Update Date: Sat, 13 Aug 2022 09:37:46

AFFECTED AREA/S Lạc Thủy

DESCRIPTION

A total of six people has been confirmed dead with several others missing throughout the northern region following torrential rains and floods caused by Storm Mulan's circulation.

This information was released by the Standing Office of the National Steering Committee for Natural Disaster Prevention and Control at noon on August 12.

The victims include a 15-year-old boy residing in the northern province of Lao Cai, three people in Lac Thuy district, and two others in Kim Boi district of Hoa Binh province.

The National Centre for Hydro-Meteorological Forecasting (NCHMF) said that the northern region, Thanh Hoa province, and Hanoi have experienced torrential rain and thunderstorms, with rainfall measuring between 20mm and 50mm on August 12.

Furthermore, there is also a high risk of flash floods and landslides occurring in mountainous provinces and flooding hitting low-lying areas.

In order to deal with this situation, the National Steering Committee for Natural Disaster Prevention and Control has requested that northern localities arrange forces to warn and guide traffic flow at submerged routes, thereby preventing both people and vehicles from passing through dangerous areas.

Tropical Depression Mulan triggers flash floods at Thai, Myanmar border towns: https://www.straitstimes.com/asia/se-asia/tropical-depression-mulan

Mae Sai township in Thailand's northern Chiang Rai province was flooded after waters of the Sai River rose rapidly. PHOTO: THE NATION/ASIA NEWS NETWORK

PUBLISHED

4:40 CH 14 THG 8, 2022 SGT

BANGKOK (REUTERS) - Heavy rains from Tropical Depression Mulan caused flash floods on Saturday (Aug 13), with towns at the Thai - Myanmar border submerged after rising water levels breached an earthen dam in Myanmar's Shan State, local media reported.

The flood water, which had mostly receded on Sunday, inundated more than 2,000 households in Mae Sai township in Thailand's northern Chiang Rai province as well as Myanmar's Tachilek border town, local media Thai PBS reported.

A Thai official said an earthen dam located 37km north of the border had been breached since Friday, causing waters of the Sai River to rise rapidly and triggering the flood.

"The dike along the river that used to keep water levels under control were breached and water overflowed into the streets and people's homes," said Mr Narongphol Kid-arn, the mayor of Mae Sai.

"In some parts, the water was at waist and chest levels."

Thai PBS footage show relief personnel wading through flooded streets to distribute food to people stranded in their homes in Mae Sai.

Separately, Thailand's National Water Command Centre on Saturday issued a warning that heavy rain in Laos could cause water levels in the Mekong River to rise by up to 2m between Aug 14 and 18.

A.3. Flash flood event caused by tropical storm NORU.

https://asianews.network/typhoon-noru-brings-flash-floods-at-least-16-dead/

Banteay Meanchey provincial governor Um Reatrey told The Post that rain was continuing to fall, and authorities were evacuating the most vulnerable. PROVINCIAL ADMINISTRATION

September 29, 2022

PHNOM PENH – An official warned that that the 16th typhoon of the season, Noru, had brought heavy rains to areas the Mekong River and flooded thousands of homes in the provinces bordering Thailand. As of September 27, the death toll from the flooding had risen to 16.

National Committee for Disaster Management spokesman Soth Kim Kolmony told The Post that in the past few days it had rained hard in the mountain areas and highlands of the north and north-west of Cambodia. Thousands of houses had been submerged and many roads had been damaged.

He said that Koh Kong, Pursat, Battambang, Pailin, Banteay Meanchey, Oddar Meanchey, Preah Vihear, Siem Reap, Kampong Thom and Kampong Chhnang provinces are now facing flooding caused by the typhoon.

Preah Vihear province's Cheb district governor Soksan Dara told The Post that several days of heavy rain had flooded many houses and damaged roads, including sections of National Road 9.

"In order to avoid bridge collapses and ensure the safety of traffic, district authorities have suspende all heavy goods trucks from operating on the following section of National Road 9: from kilometres 560 to 561 in M'lou Prey I commune's M'lou Prey I village of Preah Vihear province's Chheb district," h said.

National Road 6 from kilometres 220 to 224 in Kampong Chen Choeung commune's Trach village of Kampong Thom province's Stoung district were also flooded, with director of the Provincial Department of Public Works and Transport Chou Kolla deciding to close the affected parts of the roa to all traffic on September 26.

Provincial governor Nguon Rattanak ordered his officials to manage traffic flow and stand by to evacuate residents whose homes were inundated.

"For the safety of the public, we intervened to improve traffic flow. We are also prepared to relocate people whose homes are affected," he said.

Banteay Meanchey provincial governor Um Reatrey told The Post that following two days of heavy rain, a lot of houses in Preah Netr Preah district had been flooded. He said rain was continuing to fall and authorities were evacuating the most vulnerable.

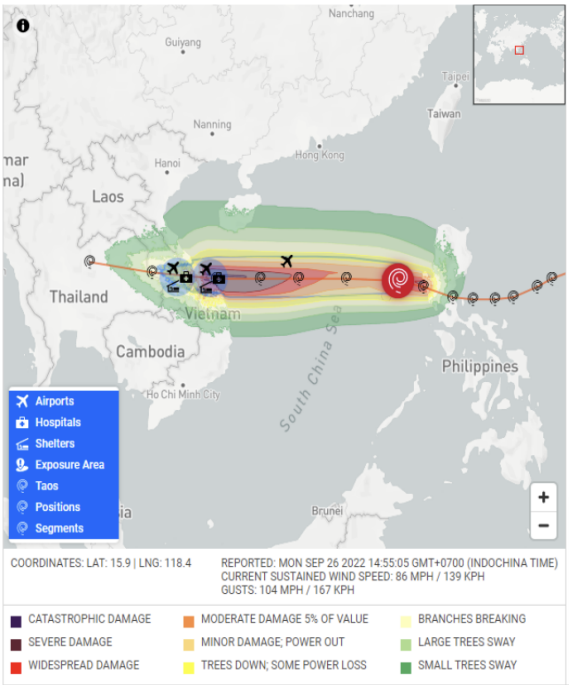
Ministry of Water Resources and Meteorology spokesman Chan Yutha said that for the time being, the typhoon Noru had hit the east of the Philippines and moved to the central part of Vietnam.

"The typhoon will weaken slowly, evolving into a depression as it brings areas of precipitation to the Mekong River in Thailand and Lao. The effects of the typhoon brought heavy rains in Cambodia from

TROPICAL CYCLONE NORU

Countries affected: Philippines (25 Sep), Viet Nam (potentially on AM of 28 Sep), and Lao PDR (potentially on PM of 28 Sep)

Forecast as of 1455 HRS WIB/ICT; 1355 HRS PST



COORDINATES: LAT: 15.9 | LNG: 118.4

REPORTED: MON SEP 26 2022 14:55:05 GMT+0700 (INDOCHINA TIME)
CURRENT SUSTAINED WIND SPEED: 86 MPH / 139 KPH
GUSTS: 104 MPH / 167 KPH

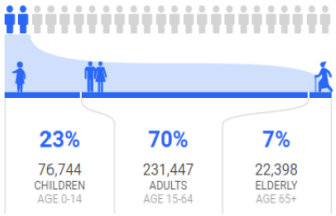
- CATASTROPHIC DAMAGE
- SEVERE DAMAGE
- WIDESPREAD DAMAGE
- MODERATE DAMAGE 5% OF VALUE
- MINOR DAMAGE; POWER OUT
- TREES DOWN; SOME POWER LOSS
- BRANCHES BREAKING
- LARGE TREES SWAY
- SMALL TREES SWAY

POPULATION EXPOSED

ESTIMATED POPULATION EXPOSED
4.19 MILLION

ESTIMATED HOUSEHOLDS EXPOSED
1.07 MILLION

ESTIMATED VULNERABLE POPULATION EXPOSED
330,589



23%	70%	7%
76,744 CHILDREN AGE 0-14	231,447 ADULTS AGE 15-64	22,398 ELDERLY AGE 65+

ESTIMATED HOSPITALS EXPOSED
64

ESTIMATED SCHOOLS EXPOSED
83

LIKELIHOOD OF IMPACT TO LIFELINES

POWER: SEVERE

COMMUNICATION: SEVERE

TRANSPORTATION: SEVERE

BREAKDOWN OF KEY NEEDS

FOR EXPOSED VULNERABLE POPULATION

694 MILLION CALORIES PER DAY

991,776 LITERS OF WATER PER DAY

33,060 100-LITER WASTE BINS

1.14 MILLION SQUARE METERS OF SHELTER

From 22-24 September 2022, Tropical Cyclone (TC) NORU (local name: Karding) developed from a Low-Pressure area into a Tropical Storm (TS) over the Philippine Sea while moving towards Central Luzon. In the early morning of 25 September, NORU underwent a series of rapid intensifications and a period of explosive intensification and reached Super Typhoon (STY) Category. On 25 September, 1630 UTC+7, NORU made its initial landfall in the vicinity of Burdeos, Quezon and again at 1920 UTC+7 in Dingalan, Aurora as a TY-category cyclone. As of reporting, TC NORU has been detected based on all available data to be continuously moving west-northwestward away from Luzon towards West Philippine Sea-South China Sea-Viet Nam East Sea.

According to the initial reports from the Department of Social Welfare (DSWD), as of 26 September 2022 at 0500 UTC+7, about 9.8K people were reportedly affected by TC NORU.

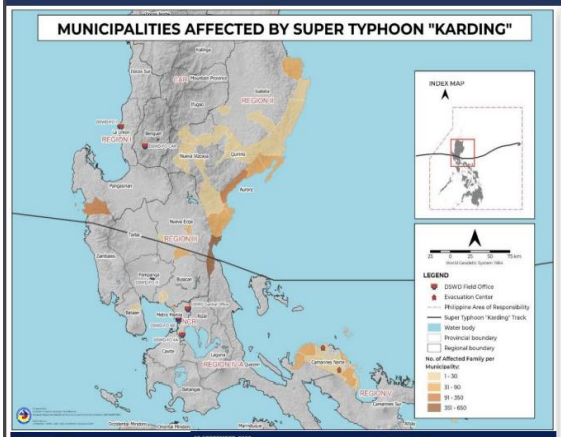
Page 1 of 3

MONDAY
26 SEP 2022
1530 HRS UTC +7 (IDN, LAO, VNM), 1630 HRS UTC+8 (PHL)

TROPICAL CYCLONE NORU (local name: KARDING)
PHILIPPINES
FLASH UPDATE #2

ONE ASEAN ONE RESPONSE

MUNICIPALITIES AFFECTED BY SUPER TYPHOON "KARDING"



KEY FIGURES

Disclosure(s): Estimations are based on data reported/confirmed by National Disaster Management Organisations of the respective ASEAN Member State (National Disaster Risk Reduction and Management Council – Office of Civil Defense (NDRRMC-OCD) and Department of Social Welfare and Development (DSWD)) and other verified sources

9.1K AFFECTED PERSONS

9.7K DISPLACED PERSONS

194 EVACUATION CENTRES

428 USD WORTH OF ASSISTANCE

23.4M USD TOTAL STANDBY FUNDS AND STOCKPILE IN DSWD CO AND FO

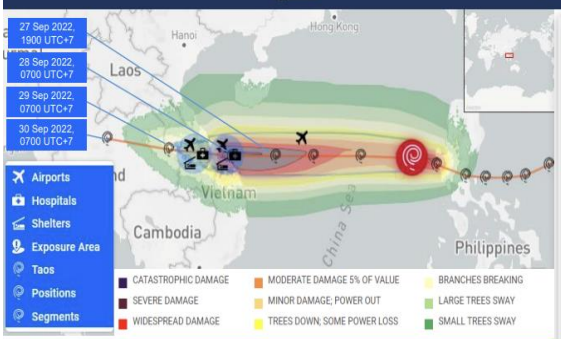
- **OVERVIEW:** As of 10:00AM UTC+7/11:00 AM UTC+8, the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) reported that **NORU** slightly weakened as it continues to move west-northwestward away from Luzon.
- **LOCATION:** The center of the eye of Typhoon KARDING was estimated based on all available data at 230 km West of Dagupan City, Pangasinan (16.0 °N, 118.2 °E)
- **INTENSITY:** Maximum sustained winds of 130 km/h near the center, gustiness of up to 160 km/h, and central pressure of 975 hPa; Strong to typhoon-force winds extend outwards up to 270 km from the center
- **OUTLOOK:**
  - **NORU** will begin to move generally westward in the next 12 hours and will continue its westward track as it moves over the West Philippine Sea towards Vietnam. On the track forecast, it will exit the Philippine Area of Responsibility tonight. This tropical cyclone is forecast to re-intensify beginning tonight or tomorrow early morning as the typhoon moves over the West Philippine Sea
- **TROPICAL CYCLONE WIND SIGNAL (TCWS):**
  - **TCWS no. 1** (minimal to minor threat to life and property): the central and western portions of Pangasinan, Zambales, the western portion of Tarlac, and the northwestern portion of Pampanga (full list from PAGASA).
- **IMPACTS:**
  - **2,408 families (9,765 persons) affected** in **154 barangays** in Regions II, III, MIMAROPA, and V.
  - **2,370 families (9,697 persons) displaced** in Regions II, III, MIMAROPA, and V, 2,238 families (9,103 persons) of which taking temporary shelter in 194 evacuation centres in Regions II, III, MIMAROPA, and V; 132 families (594 persons) others temporarily staying with their relatives and friends.
  - **2 roads** are currently **not passable**.
  - **2 areas** in Region 1 and 6 experiencing **communication outage/issues**.
  - **12 cities/municipalities** experienced **power outage** of which, power was restored to 1.
  - **20K USD worth of damage to infrastructure** in MIMAROPA.
- **HAZARDS:** According to PAGASA, heavy rainfall until afternoon today may still be experienced in Zambales, Bataan, Lubang Islands, and the western portion of Pangasinan. Under these conditions, scattered flooding and rain-induced landslides are still possible. Gale-force winds remain possible in areas under Signal no. 1.
- **PREPAREDNESS AND RESPONSE:**
  - The Philippines NDRRMC Alert Status was raised to **Red Alert** (highest level of alert to address an ongoing or in anticipation of an imminent emergency situation) on 23 Sep.
  - National Meteorological and Hydrological Services (NMHS) in the Philippines, continue to release tropical cyclone warning/advisories for **NORU**.
  - A total of 3.2M USD worth of standby funds available in DSWD CO and FOs (1.8M USD is the available Quick Response Fund). A total of 16.8M USD worth of available family food packs (FFPs), other food items and non-food items.
  - 50 teams (275 personnel) deployed in Regions II, III, CALABARZON, VI & CAR, and 1,213 teams (8,552 personnel) are on standby in Regions I, II, III, CAR, VI for Search, Rescue, and Retrieval (SRR).
  - 2,798 standby transportation and 10.6K road clearing and engineering assets.
  - 59 deployed emergency ICT equipment.
  - A total of 1.4M USD worth of medical logistics available in Regions I, II, III, IV-A, IV-B, VI, CAR Metro Manila and DOH Central Office. 1,356 medical responders and 24 vehicles on standby in Regions I, II, III, CALABARZON, MIMAROPA, V, VI, NCR, and CAR
- **AHA CENTRE:**
  - Raised EOC Alert Level to Orange (Preparedness for Response)
  - Coordinated with NDRRMC Philippines through the OCD
  - Alerted and readied ASEAN-ERAT and DELSA for potential deployment
  - Assigned National Logistics Officer in the Philippines as In-country Liaison Team
  - Conducted Emergency Operations Centre Briefing attended by the Deputy Secretary-General of ASEAN, Disaster Management and Humanitarian Assistance Division of the ASEAN Secretariat, and AHA Centre.
- The AHA Centre will continue to monitor and issue necessary updates.

Page 2 of 3

MONDAY
26 SEP 2022
1530 HRS UTC +7 (IDN, LAO, VNM), 1630 HRS UTC+8 (PHL)

TROPICAL CYCLONE NORU (local name: Storm no. 4)
VIET NAM & LAO PDR
FLASH UPDATE #2

ONE ASEAN ONE RESPONSE



- **LOCATION:** According to the National Centre for Hydro-Meteorological Forecasting Vietnam (NCHMF), the centre of STS NORU (Karding) was estimated based on all available data at 16.0 degrees North latitude and 117.0 degrees East longitude, about **580 km east of the Paracel Islands**.
- **INTENSITY:** The strongest wind in the area near the centre of the storm is 118-133 km/h equivalent to a Category 1 Hurricane in the Saffir-Simpson Hurricane Wind Scale.
- **OUTLOOK:**
  - **STS NORU (Karding)** is forecasted to move towards the East Sea at the lock and Tho Quang fishing port (Son Tra district, Da Nang city), traveling 20-25 km per hour, moving inland to the Mid-Central region, and gradually weakening into a tropical depression on Wednesday, 28 Sep 2022 at 08:00 local time.
  - According to ASEAN Disaster Monitoring and Response System (DMRS), **STS NORU (Karding)** is forecasted to make a landfall at the Viet Nam coast and move to Lao PDR border on Wednesday, 28 Sep 2022 at 15:00 local time.
- **POTENTIAL IMPACTS:**
  Viet Nam
  - According to local news, forecast models show that storms are likely to **directly affect 4 localities**, namely Da Nang, Quang Nam, Quang Ngai, and Binh Dinh
  - In addition, it will affect **indirectly affect 4 localities**, the areas are Quang Tri, Thua Thien-Hue, Phu Yen, and Kon Tum.

  Lao PDR:
  - **Heavy to very heavy rains** caused by NORU are also possible in the southern parts of Lao PDR and the North and Northeast Region of Thailand during 27 - 29 Sep 2022.
- **EXPOSURE:**
  - According to the ASEAN Disaster Monitoring and Response System (DMRS), in Vietnam, an estimated **3.85 million people, 1.01 million households, and $7.96 Billion (USD) of infrastructure** (total replacement cost) are potentially exposed to moderate to severe damaging winds.
  - In Lao PDR, an estimated **334,407 people, 63,097 households, and $1.38 Billion (USD) of infrastructure** (total replacement cost) are potentially exposed to moderate to severe damaging winds.
- **PREPAREDNESS AND RESPONSE:**
  - The National Steering Committee for Disaster Prevention and Control of Viet Nam has dispatched letter No. 29/CD-QG dated September 24, 2022 to respond to the potential impacts of NORU especially in Quang Ninh to Binh Thuan and Than Hoa to Quang Ngai Province (VNDMA)
  - National Meteorological and Hydrological Services (NMHS) in the Philippines, Thailand, and Viet Nam have released tropical cyclone warning/advisories for NORU.
- The AHA Centre has initiated coordination with VNDMA Viet Nam and NDMO Lao PDR and will continue to monitor and issue necessary updates.

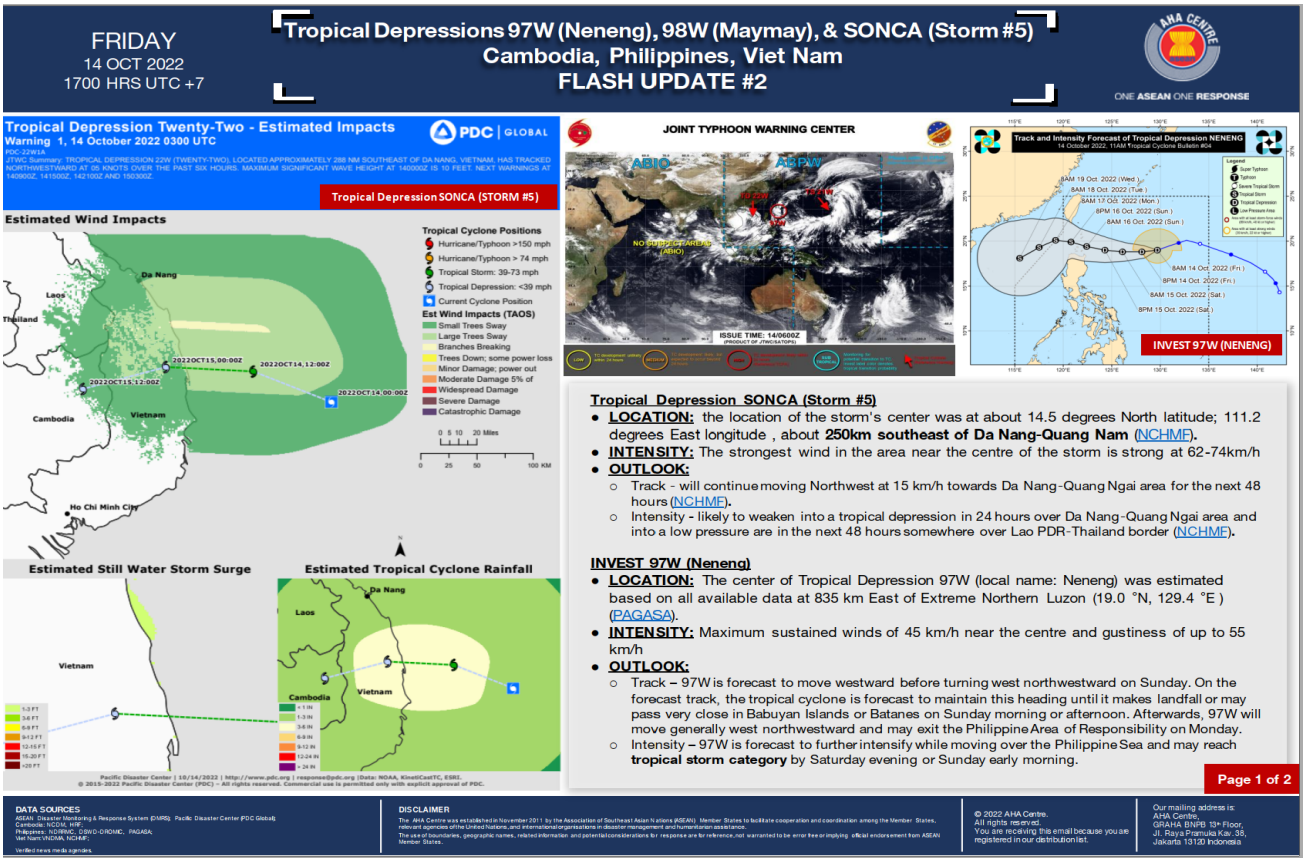
Page 3 of 3

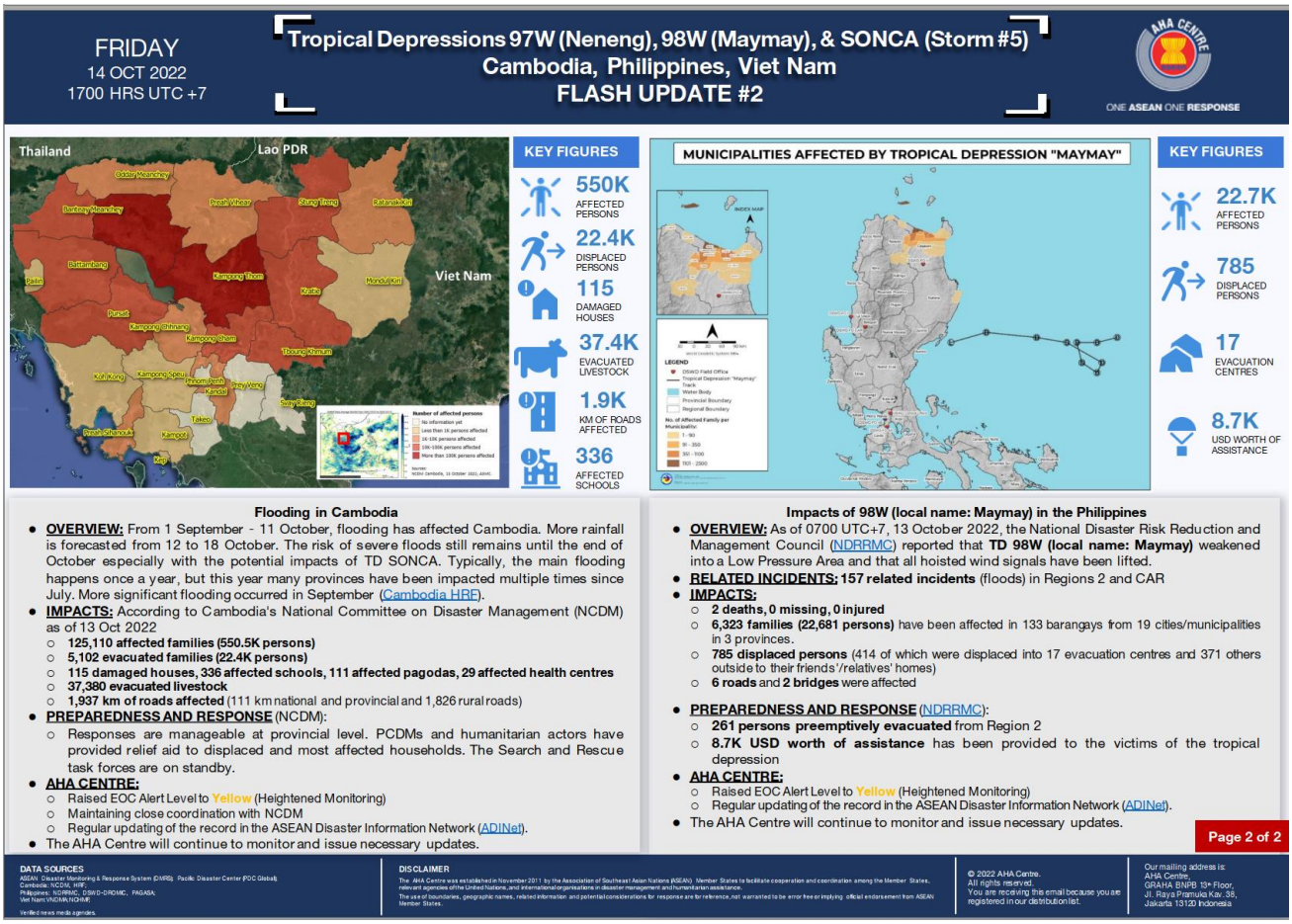
DATA SOURCES
ASEAN Disaster Monitoring & Response System (DMRS); Pacific Disaster Center (PDC Global); Lao PDR; Philippines: NDRRMC, PAGASA; Thailand: DDPM, TMD; Viet Nam: VNDMA, NCHMF; Verified news media agencies.

DISCLAIMER
The AHA Centre was established in November 2011 by the Association of Southeast Asian Nations (ASEAN) Member States to facilitate cooperation and coordination among the Member States, relevant agencies of the United Nations, and international organisations in disaster management and humanitarian assistance.
The use of boundaries, geographic names, related information and potential considerations for response are for reference, not warranted to be error free or implying official endorsement from ASEAN Member States.

Our mailing address is:
AHA Centre,
GRAHA BNPB 13th Floor,
Jl. Raya Pramuka Kav. 38,
Jakarta 13120 Indonesia

A.4. Flash flood event caused by by tropical storm SONCA.





Floods brought by rain from Tropical Storm Sonca swept away part of a road Tuesday in tambon Sai Yoi of Phrae's Den Chai district in the North, forcing the evacuation of about 50 families. (Photo by Thaweeporn Sukkhasem)

8. ANNEX B. Accuracy of detected flash floods in the Countries by the MRC-FFGS 2022

a = Hits b= False alarms c= Misses d= Correct negatives		CAMBODIA		
		EVENT OBSERVED		
		Yes	No	Total
EVENT FORECASTED	Yes	23	2	25
	No	10	4	14
	Total	33	6	39
	Hit rate (POD)	0,697		
	False Alarm Ratio (FAR)	0,080		
	False Alarm Rate (POFD)	0,333		
	Threat Score (TS)	0,057		

a = Hits b= False alarms c= Misses d= Correct negatives		LAO PDR		
		EVENT OBSERVED		
		Yes	No	Total
EVENT FORECASTED	Yes	15	10	25
	No	5	5	10
	Total	20	10	30
	Hit rate (POD)	0,75		
	False Alarm Ratio (FAR)	0,40		
	False Alarm Rate (POFD)	1,00		
	Threat Score (TS)	0,33		

	THAILAND			
a = Hits **b= False alarms** **c= Misses** **d= Correct negatives**		**EVENT OBSERVED**		
		Yes	**No**	**Total**
EVENT FORECASTED	**Yes**	**17**	**3**	**20**
	No	**7**	**4**	**11**
	Total	**24**	**7**	**31**
	Hit rate (POD)	**0,71**		
	False Alarm Ratio (FAR)	0,15		
	False Alarm Rate (POFD)	0,43		
	Accuracy correlation coefficient (ACC)	0,68		

	VIETNAM			
a = Hits **b= False alarms** **c= Misses** **d= Correct negatives**		**EVENT OBSERVED**		
		Yes	**No**	**Total**
EVENT FORECASTED	**Yes**	**26**	**5**	**31**
	No	**8**	**17**	**25**
	Total	**34**	**22**	**56**
	Hit rate (POD)	0,76		
	False Alarm Ratio (FAR)	0,16		
	False Alarm Rate (POFD)	0,23		
	Threat Score(TS)	0,13		

9. ANNEX C. MRC-FFGS Operation and Output Product Descriptions

MRC-FFGS Products descriptions

MRCFFG Operational Output Product Descriptions				
Label	**Definition**	**Format**	**Updated**	**Description**
HE Sat	Hydroestimator Satellite Precipitation	Images	Hourly	The images display gridded hourly, 3-hourly, 6-hourly and 24-hourly totals of precipitation (mm) ending on the current hour as estimated in real-time from geostationary satellites using the Hydroestimator algorithm. The satellite rainfall estimates are provided on a grid having approximately 10x10 km resolution which is displayed over a background of MRCFFG sub-basin boundaries. The HE Sat data products are updated every hour and reflect rainfall accumulations ending on the current product hour.
				SAT 01-hr: Total of precipitation as estimated by the Hydroestimator over the last hour ending on the current product hour. (mm/1hr)
				SAT 03-hr: Total of precipitation as estimated by the Hydroestimator over the last 3 hours ending on the current product hour. (mm/3hr)
				SAT 06-hr: Total of precipitation as estimated by the Hydroestimator over the last 6

				hours ending on the current product hour. (mm/6hr)
				SAT 24-hr: Total of precipitation as estimated by the Hydroestimator over the last 24 hours ending on the current product hour. (mm/24hr)
.	.	.	.	.
Merged MAP	Mean Areal Precipitation	Text & Images	Hourly	Text tables and images of hourly, 3-hourly, 6-hourly and 24-hourly totals of mean areal precipitation (mm) for each MRCFFG catchment. It includes real-time or climatological bias adjustment of the real-time satellite rainfall and substitution of interpolated precipitation of 6-hourly raingauge data for sub-basins with no available satellite information (either by unavailability or masking). The Merged MAP data products are updated every hour and reflect accumulations of basin-average precipitation of a given duration ending on the current product hour.
				MAP 01-hr: Total mean areal precipitation estimated over the last hour ending on the current product hour. (mm/1hr)
				MAP 03-hr: Total mean areal precipitation estimated over the last 3 hours ending on the current product hour. (mm/3hr)

				MAP 06-hr: Total mean areal precipitation estimated over the last 6 hours ending on the current product hour. (mm/6hr)
				MAP 24-hr: Total mean areal precipitation estimated over the last 24 hours ending on the current product hour. (mm/24hr)
.	.	.	.	.
ASM	Average Soil Moisture	Text & Images	00, 06, 12 & 18 UTC	Text tables and images provide soil water saturation fraction (dimensionless ratio of contents over capacity) for the upper zone (down to 20-30 cm depth) of the Sacramento Soil Moisture Accounting Model for each of the MRCFFG sub-basins. The products are updated every 6 hours at the model processing hour (i.e. 00, 06, 12 and 18 UTC).
				ASM 06-hr: Average soil water saturation at most recent model processing hour. (fraction of soil capacity in the upper zone)
.	.	.	.	.
FFG	Flash Flood Guidance	Text & Images	00, 06, 12 & 18 UTC	Text tables and images of hourly, 3-hourly and 6-hourly flash flood guidance (mm) for each MRCFFG sub-basin are provided. The FFG value indicates the total volume of rainfall over the given duration which is just enough to cause bankfull flow in the draining stream outlet. Consequently, rainfall volumes of the same duration that are greater than

				the FFG value indicate a likelihood of overbank flows at the draining stream outlet. Each of the FFG products is updated at every model processing hour (00, 06, 12 and 18 UTC). **This product is appropriate to use in real time with nowcasts or forecasts of rainfall and other local information to estimate the risk of flash flooding in the MRCFFG sub-basins.**
				FFG 01-hr: Required precipitation over the next hour following the most recent (current) model processing hour to cause bankfull flow. (mm/1hr)
				FFG 03-hr: Required precipitation over the next 3 hours following the most recent (current) model processing hour to cause bankfull flow. (mm/3hr)
				FFG 06-hr: Required precipitation over the next 6 hours following the most recent (current) model processing hour to cause bankfull flow. (mm/6hr)
				Prev FFG 01-hr: Required precipitation over the hour following the previous model processing hour to cause bankfull flow. (mm/1hr)

				Prev FFG 03-hr: Required precipitation over the 3 hours following the previous model processing hour to cause bankfull flow. (mm/3hr)
				Prev FFG 06-hr: Required precipitation over the 6 hours following the previous model processing hour to cause bankfull flow. (mm/6hr)
.	.	.	.	.
PFFT	Persistence Flash Flood Threat	Text & Images	00, 06, 12 & 18 UTC	PFFT products include text tables and images of hourly, 3-hourly and 6-hourly flash flood threat (mm) for each MRCFFG catchment. The values indicate the difference of recent persisted merged estimates of mean areal rainfall of the given duration and the corresponding current FFG of the same duration for a given MRCFFG sub-basin. The last 1-hour, 3-hour and 6-hour durations of MAP are persisted and considered with current corresponding FFG in the computation of PFFT.
				For example, the 6-hr PFFT at 12:00 UTC = 06-hr MAP from 12:00 UTC - 06-hr FFG from 12:00 UTC

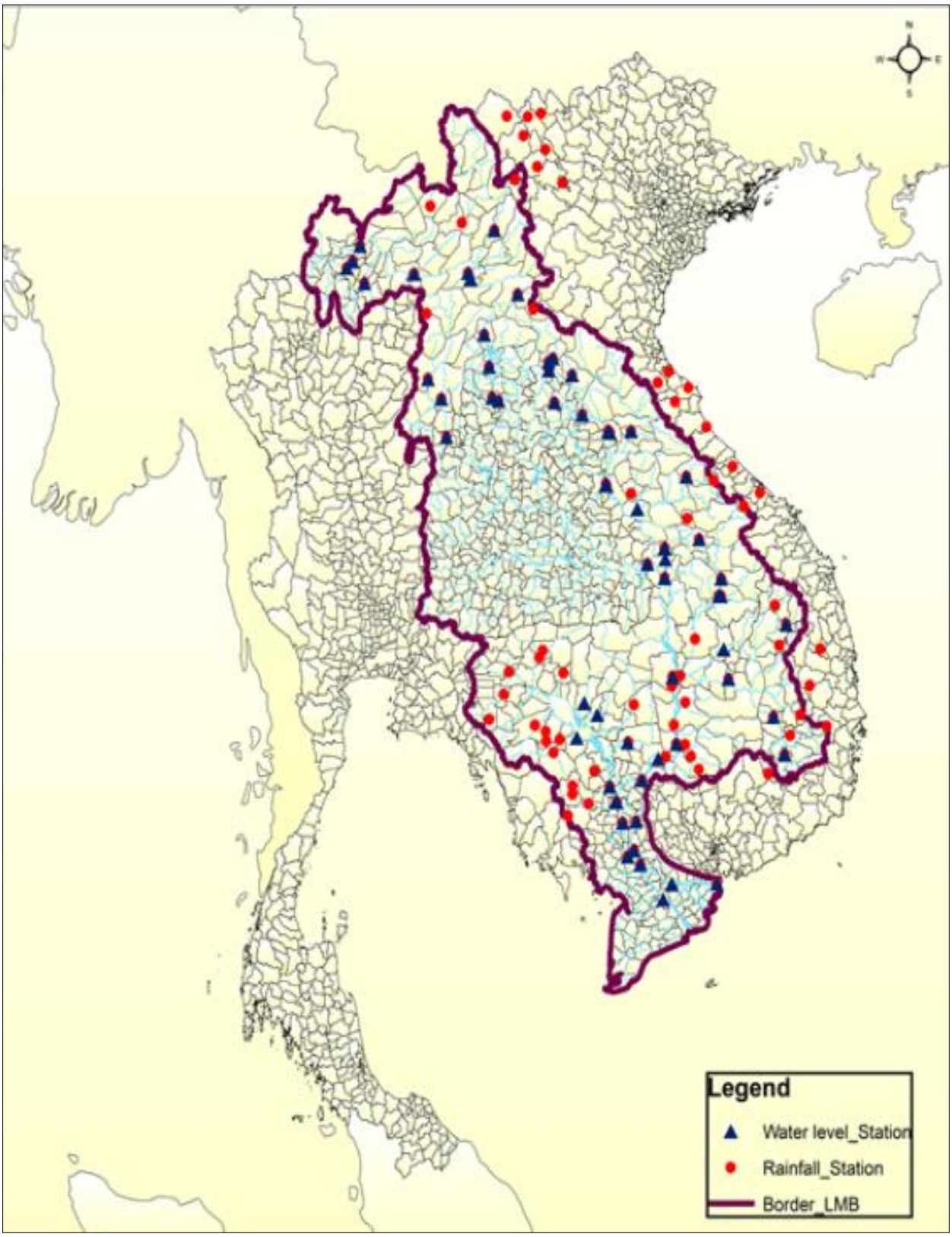
				In the images, an approximate measure of uncertainty in the PFFT estimates is indicated by the ranges in the color scale (with yellow indicating the range of values that are unlikely to be of concern for flash flooding and with orange and red indicating progressively higher risk of flooding for the sub-basin of interest). The hourly, 3-hourly and 6-hourly PFFT products are updated at model processing hours (00, 06, 12, 18 UTC). **Note that this set of products uses a crude rainfall forecast and probably contains large uncertainties. PFFT is offered as a baseline product that must be carefully evaluated by the forecaster in real-time.**
				PFFT 01-hr: Difference of 01-hr FFG for current model processing hour and current 01-hr MAP persisted for the next 1 hour. (mm/1hr)
				PFFT 03-hr: Difference of 03-hr FFG for current model processing hour and current 03-hr MAP persisted for the next 3 hours. (mm/3hr)
				PFFT 06-hr: Difference of 06-hr FFG for current model processing hour and current 06-hr MAP persisted for the next 6 hours. (mm/6hr)

.	.	.	.	.
FFT	Flash Flood Threat	Text & Images	1, 3 and 6 hours after previous model processing hour	FFT products include text tables and images of hourly, 3-hourly and 6-hourly flash flood threat (mm) for each MRCFFG catchment. The values indicate the difference of the observed mean areal rainfall of the given duration and the corresponding past FFG of the same duration for a given MRCFFG sub-basin. The last 1-hour, 3-hour and 6-hour durations of FFG are considered with current corresponding MAP in the computation of FFT.
				For example, the 06-hr FFT at 12:00 UTC = 06-hr MAP from 12:00 UTC - 06-hr FFG from 6:00 UTC
				The most recent FFT product for each time-scale is provided in the Baseline Threat Product table and displayed with the MAP and FFG products that were used in the respective calculation. In the images, an approximate measure of uncertainty in the FFT estimates is indicated by the ranges in the color scale (with yellow indicating the range of values that are unlikely to be of concern for flash flooding and with orange and red indicating progressively higher risk of flooding for the sub-basin of

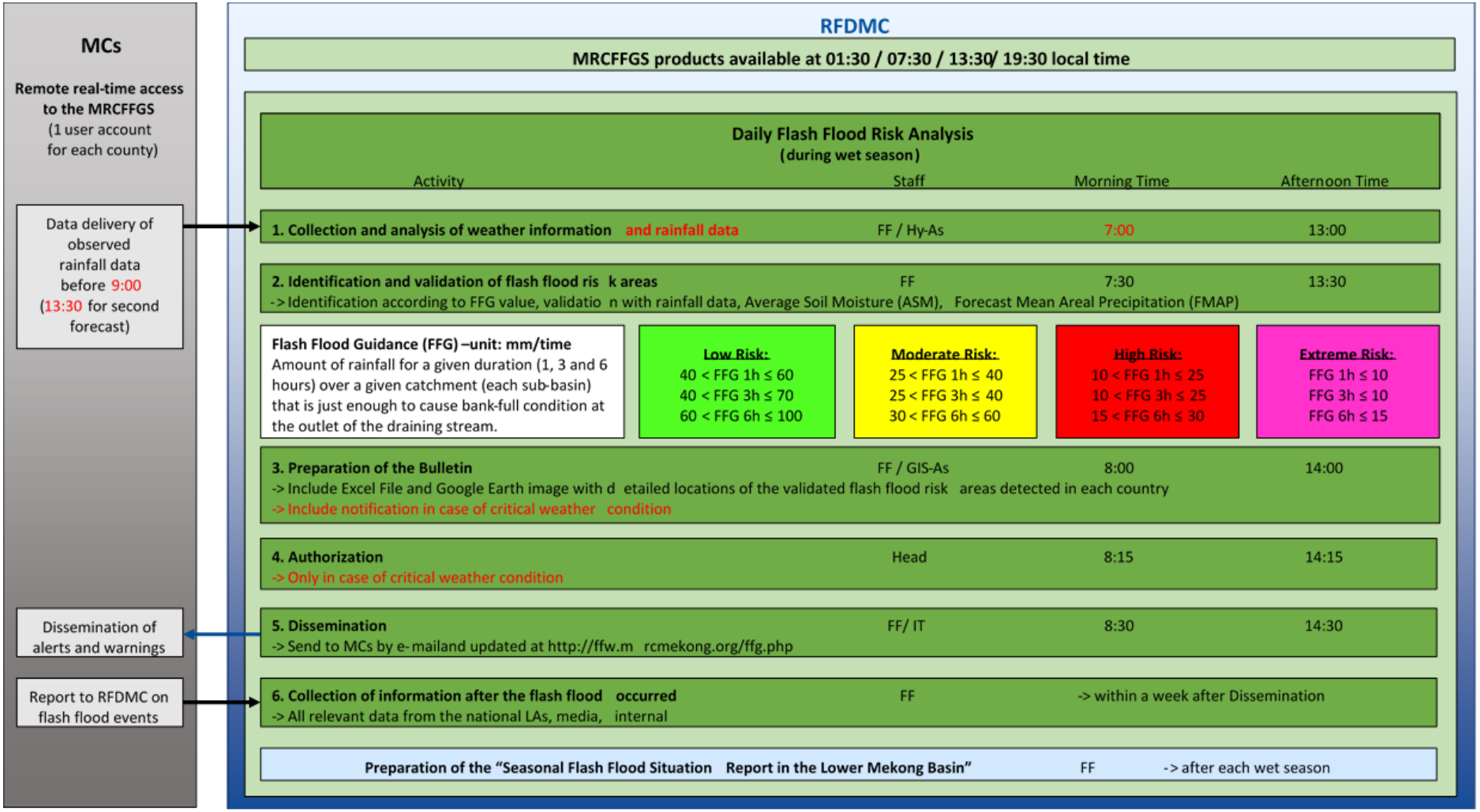
				interest). The hourly, 3-hourly and 6-hourly FFT products are respectively updated at 1, 3, and 6 hours after the preceding model processing hour. FFT provides the forecaster with an idea of likely regions of imminent flash flood threats. **Note that this set of products concerns the past and may not be appropriate to use for real-time warning. FFT is offered as a baseline product that must be carefully evaluated by the forecaster in real-time.**
				FFT 01-hr: Difference of 01-hr FFG from a previous model processing hour and 01-hr MAP observed over the following 1 hour. (mm/1hr)
				FFT 03-hr: Difference of 03-hr FFG from a previous model processing hour and 03-hr MAP observed over the following 3 hours. (mm/3hr)
				FFT 06-hr: Difference of 06-hr FFG from a previous model processing hour and 06-hr MAP observed over the following 6 hours. (mm/6hr)

10. ANNEX D. Hydmet database and daily operation of MRC-FFGS

D.1. The map of rainfall and water level stations of the Hydmet database network



D.2. Daily Operation of the MRC-FFGS



Abbreviations :

FF	Flood Forecaster	Head	Head of the RFDMC	MCs	Member Countries (Cambodia, Lao PDR, Thailand, Viet Nam)
FFGS	Flash Flood Guidance System	Hy-As	Hydrology Assistant	MRC	Mekong River Commission
GIS-As	GIS/ Mapping Assistant	IT	IT Assistant	RFDMC	Regional Flood and Drought Management Centre