Mekong River Commission

THE COUNCIL STUDY

STUDY ON THE SUSTAINABLE MANAGEMENT AND DEVELOPMENT OF THE MEKONG RIVER INCLUDING IMPACTS OF MAINSTREAM HYDROPOWER PROJECTS

FLOOD PROTECTION AND FLOODPLAIN INFRASTRUCTURE THEMATIC AREA

INTERIM ASSSESSMENT REPORT

UPDATED

31 October 2016

TABLE OF CONTENTS

ANNEXES

1. INTRODUCTION

1.1 General

The object of the Council Study (CS) is to address current uncertainties is assessing the impacts of different development opportunities in the Mekong River Basin, and so provide a set of clear, strategic, pragmatic and actionable recommendations to facilitate informed development planning along the mainstream and floodplains of the Lower Mekong Basin. The Council Study will focus on the following seven themes1:

Theme 1 Agriculture and land-use change;

Theme 2 Domestic and industrial water use;

Theme 3 Flood protection structures and floodplain infrastructure, including roads on major floodplains;

Theme 4 Hydropower development;

Theme 5 Navigation;

Theme 6 Irrigation; and

Theme 7 Cumulative assessment

Seven 'Thematic Teams' will implement the Council Study. For Theme 3 Flood Protection Works & Floodplain Infrastructure the FMMP is lead Programme. In this report the status of the Interim Asessment is described. The scenarios as formulated by the various thematic teams will be presented, discussed and approved by the 6th RTWG meeting on 17 and 18 December 2015. Due to the non-availability of these scenarios no assessment in terms of flooding behaviour is possible yet and this interim assessment report describes the existing situation and approach for the next steps only. A full assessment will be possible when scenarios from all thematic teams are completed and available.

1.2 Task and special status of FMMP

From the start of the Council Study to date numerous and extensive discussions about the role of FMMP towards the Council Study have taken place. FMMP is the lead agency for theme 3: Flood protection structures and floodplain infrastructure. But future developments in the field of flood protection structures will depend on future developments in other fields such as agriculture, urban development, economic developments, etc. So instead of an "autonomous" development, the development for flood protection structures will be based on requirements of other themes. The thematic approach as applied in the Council Study may be appropriate for other themes but is less appropriate for the flood protection structures and results in confusion about roles and activities. Several discussions were needed to clarify the role of FMMP and reach agreement on this subject which resulted in a late start of activities.

[1] 'The Council Study on the Sustainable Management and Development of the Mekong River, Including Impacts of Mainstream Hydropower Projects, Terms of Reference'. Mekong River Commission, November 2013.

Fig 1.1 Lower Mekong Basin

By the end of July a draft workplan was prepared by FMMP for the contribution to the Council Study and the following roles are identified for FMMP:

1. To formulate three 'development scenarios' for the 'flood protection works and floodplain infrastructure' thematic area;
2. To formulate up to three 'thematic sub-scenarios' for the 'flood protection works and floodplain infrastructure' thematic area;
3. To assess the need to protect future developments (other thematic areas) from flooding;
4. To assess the impact of scenarios and thematic development sub-scenarios on flooding behaviour; and
5. To assess the impact of cumulative development scenarios and thematic development sub-scenarios on flood risk.

2. CURRENT STATUS OF THE FLOOD PROTECTION AND FLOODPLAIN INFRASTRUCTURE THEMATIC AREA

In this section an overview is given of flood damage in the LMB and especially attention is given to the larger flood events in the year 2000 and 2011. In addition the approach for flood damage assessment as applied in the FMMP Component 2 Study (2010) and in the Initial Study is described. Same approach is proposed for the Council Study.

2.1 Flood damage and losses – 2000 and 2011 compared

The flood conditions that prevailed in 2000, particularly over the Cambodian floodplain and the Mekong Delta, are generally acknowledged to have caused the greatest levels of total damage and loss documented since systematic assessments began in the 1980's. The 2000 floods affected all four countries in the Mekong River Basin - Cambodia, Lao PDR, Thailand and Viet Nam. According to the Mekong River Commission, however, Cambodia suffered the most severe effects of the floods with 43% of the total number of deaths recorded and 40% of the estimated damage.

The Royal Government of Cambodia (RGC) stated that the 2000 floods were the worst in more than 70 years and caused damage to infrastructure and livestock, population displacement, food shortages and disease. A report, compiled by the National Committee for Disaster Management (NCDM) in November 2000, put the death toll at 347 (80 percent of whom were children). Of the 750 600 households affected, comprising almost 3.5 million people, equivalent to over 25% of the national population, about 85 000 families had to be temporarily evacuated from their homes to safe areas.

Other statistics released by the RGC indicated that the agricultural and infrastructure losses were:

- Rice crop destroyed 374,100 ha
- Other crops destroyed 47,460 ha
- 988 schools affected (7,000 classrooms damaged)
- 158 health centers and hospitals damaged
- Almost 318 000 houses were damaged
- Over 7 000 houses destroyed.

Based on the NCDM report, the Council of Ministers estimated the total physical and direct damage at US$ 157-161 million.

In the Delta in Vietnam there were a reported 319 fatalities of whom almost 240 were children. Severe flash flooding across the Khorat Plateau in NE Thailand caused 25 deaths and in the Northern and Eastern Highlands of Lao PDR 15. In the Delta total economic losses were estimated to have been US$ 125.5 million.

The public health situation following the floods was precarious. The overcrowded and unsanitary conditions in safe areas raised fears of major waterborne epidemics, such as cholera or acute diarrhea. The loss of life due to water borne disease was a major factor that explains why juveniles accounted for by far the greater proportion of the flood related fatalities. In the post-emergency phase therefore the focus was to be on preventative health activities; specifically water and sanitation, the prevention of flood associated diseases and health education to affected populations.

The estimation of flood damage and losses in economic terms is difficult, as it is with other geophysical hazards such as droughts and earthquakes. Different sources can reveal substantial disparities. In the overview that follows it are the relative figures that provide the focus of interest rather than the absolute values, which are drawn from a wide spectrum of MRC and other documents and reports. A key observation is that within the Lower Mekong Region as a whole damage and loss is fundamentally a rural issue. The major towns and cities, such as Vientiane, Phnom Penh and those in the Delta are protected by engineering works, whereas rural areas are not. As a consequence they are the most exposed, with agricultural damage and losses in terms of local domestic property, schools and clinics at the forefront.

The image below confirms this perspective. It shows the flood inundation local to Phnom Penh on 15 October 2011. The city itself is largely free from flooding but to the east and along the Bassac River there is widespread inundation.

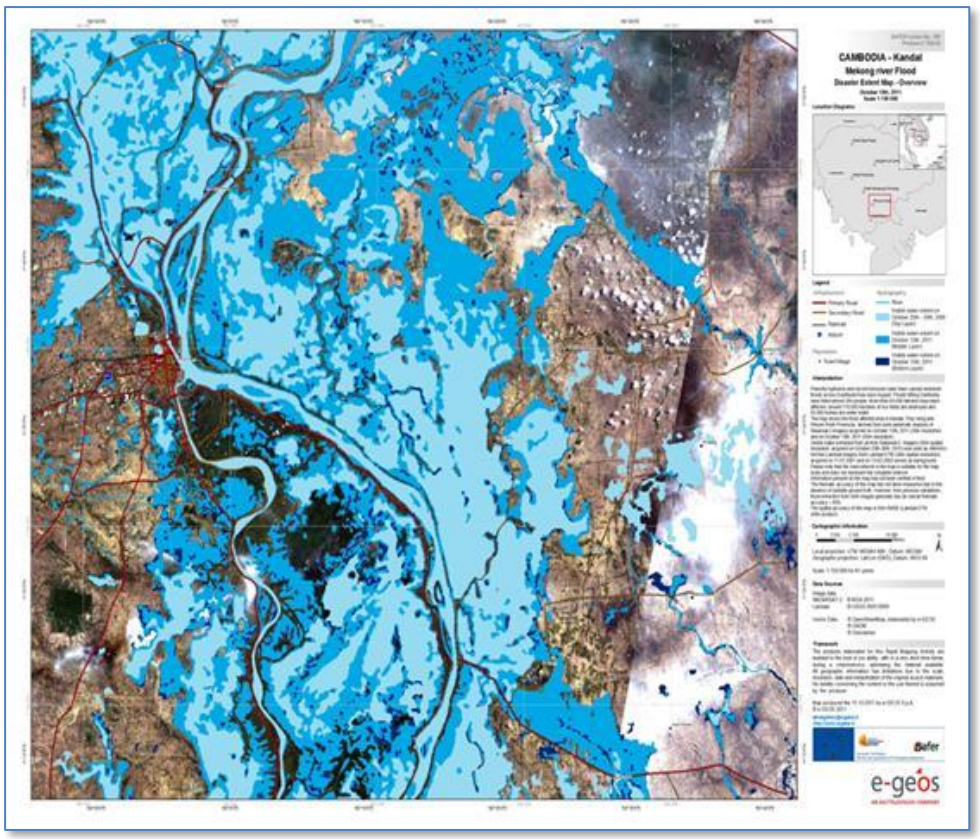


Figure 2-1 The flood situation local to Phnom Penh on 15 October 2011. The city itself is largely free from inundation, but the unprotected rural areas to the east and south reveal widespread flooding.

Table 2-1 2011 Flood – fatalities and damage within the Mekong Basin in each of the four riparian countries.

Country	Deaths	Property units affected	Property units damaged	Schools affected	Rice crop lost or damaged (ha)	Other crops lost or damaged (ha)
Cambodia	250	268 600	13 000	1 360	267 000	17 300
Lao PDR	42	-	82 500	250	77 000	-
Thailand	na	na	na	na	na	na
Viet Nam Delta	89		176 000	1 260	250 000	-
Viet Nam Mekong highlands	15		85 000	-	3 300	-

With these considerations in mind, Table 2-1 reveals the 2011 flood fatalities and damage that occurred in each of the riparian countries during 2011. The geography of the event, in that it was largely confined to areas downstream of the Se Kong, Se San and Srepok tributary system from which most of the flood water originated, means that Cambodia and the Delta suffered by far the most. Of the recorded fatalities 85% occurred here, with 63% in Cambodia alone. The damage estimates are dominated by losses in the same areas of the Basin. In Thailand no excessive flooding occurred in 2011 in the LMB part and also no fatalities and damage were recorded for the LMB part.

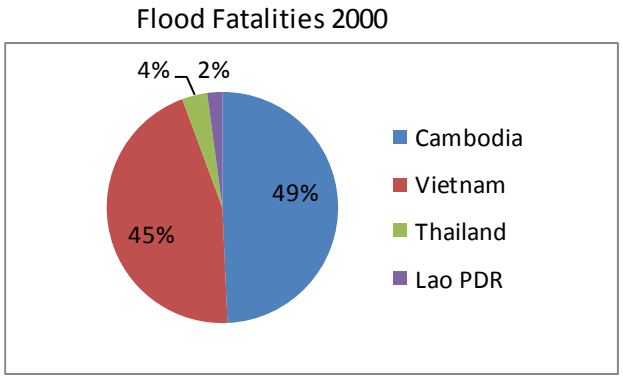
A comparison between the 2000 and 2011 floods (Table 2-2) shows a repeat of this pattern.

Table 2-2 Preliminary comparison of fatalities and economic damage between the 2000 and 2011 flood events in the Lower Mekong Basin.

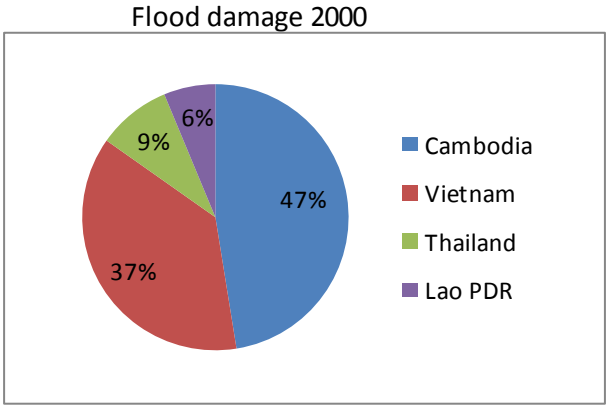
Country	2000 Flood		2011 Flood	
	Fatalities	Economic damage (million US$)	Fatalities	Economic damage (million US$)
Cambodia	350	157 - 161	250	634
Lao PDR	15	30	42	208
Thailand	25	21	na	na
Viet Nam	320	125	104	260

In terms of fatalities almost 90% occurred in Viet Nam and Cambodia while they also accounted for more than 80% of total regional economic damage and loss according to the estimates (Figure 2-2 and 2-3).

*Figure 2-**2** Flood fatalities and damage in the Lower Mekong Basin by riparian country in 2001.*

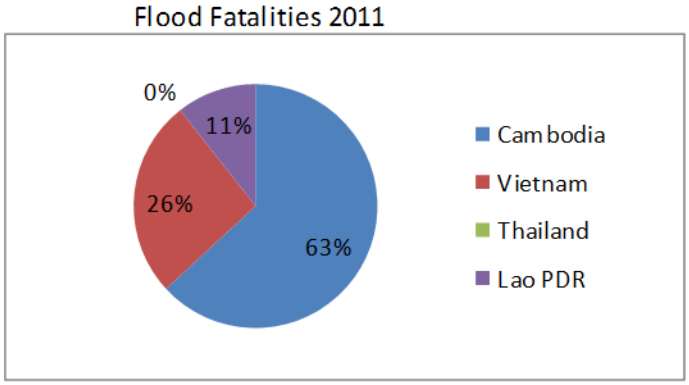


Country	Number	% total
Cambodia	350	49%
Vietnam	320	45%
Thailand	25	4%
Lao PDR	15	2%
Total	710	100%

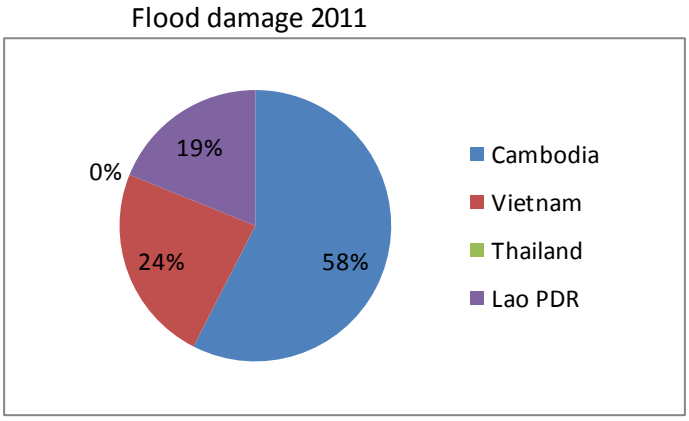


Country	Total losses Millions U$	% total
Cambodia	159	47%
Vietnam	125	37%
Thailand	30	9%
Lao PDR	21	6%
Total	335	100%

Figure 2-3 Flood fatalities and damage (millions of US $) in the Lower Mekong Basin by riparian country in 2011.



Country	Number	% total
Cambodia	250	63%
Vietnam	104	26%
Thailand	n.a.	#VALUE!
Lao PDR	42	11%
Total	396	100%



Country	Total losses Millions U$	% total
Cambodia	634	58%
Vietnam	260	24%
Thailand	n.a	#VALUE!
Lao PDR	208	19%
Total	1102	100%

These results clearly reveal the vulnerability of the Cambodian floodplain and the Mekong Delta to the regional flood hazard and its impacts. The reasons are largely demographic. Here are the highest regional population densities, attracted in the main by the agricultural potential of the floodplain and deltaic soils. This is not to say that floods and flooding in NE Thailand and Lao PDR are inconsequential in comparative terms. It is simply that the scale of impacts is much less.

Floods and flooding over the greater part of the Cambodian floodplain and the Mekong Delta are the result of hydrological factors in the form of critically high water levels in the Mekong mainstream.

Over the greater part of Lao PDR and the Thai Mekong region, remote from the Mekong itself, floods and flooding are the result of meteorological conditions resulting in more local flash flooding and storm induced inundation when drainage infrastructure cannot cope.

In other words meteorological factors are either direct or indirect. Tropical depressions and typhoons cause high water levels in the Mekong resulting in flooding. Or extreme storm rainfall is the primary cause of flooding elsewhere. In effect the direct cause of floods is either hydrological or meteorological.

Upstream of the Cambodian floodplain in Lao PDR and Thailand there are areas adjacent to the mainstream that are susceptible to overbank flooding but these are nowhere near as extensive as those further downstream. One of the principal effects that exacerbates the extent of flooding in these upstream zones is that high water levels in the mainstream causes significant backwater effects in the large left bank tributaries in Lao and in the Mun-Chi Basin in Thailand, thus extending the flooding laterally.

2.2 Flood damage and losses period 2000 – 2009

For the period 2000- 2009 the various AMFR reports provide details for the flood damage. The results are listed in the tables 2-3 (Thailand), table 2-4 (Lao PDR), table 2-5 (Cambodia) and 2-6 (Vietnam) hereunder.

In the table for Thailand the flood damage is listed for the whole country; damage in Mekong Basin is limited compared with the damage for the whole Thailand. The relevant districts affected by Mekong flooding are Meung Chiang Rai and Chiang Saen districts. In annex 3 details for flood damage for these districts are given.

In the table for Lao PDR only three years are listed 2006, 2007 and 2008. The years 2007 and 2008 show considerable losses.

In the table for Cambodia the year 2000 shows a severe flood while other years such as 2001 and 2004 are less severe but still show considerable damage. In the other years the flood damage is limited.

The table for Vietnam shows that the floods in 2006, 2007 and 2008 much less severe than the very severe flood in 2000.

Table 2-3 Thailand: Flood damage compared to those of recent years (extracted from AMFR 2008)

Descriptions		2008	2007	2006	2005	2004	2003
Areas	Provinces	65	46	47	63	59	66
	Districts	584	486	482	541	337	349
	Villages	22,874	20,499	20,625	10,326	9,964	5,281
Human	People	4,494,187	3,640,978	5,198,814	2,874,673	2,324,441	1,882,017
	Households	1,197,253	940,663	1,430,085	763,847	619,797	485,436
	Casualties	97	62	340	88	31	54
Assets	House	18,258	7,369	49,611	6,040	5,947	10,329
	Fish ponds	42,424	34,767	125,683	13,664	12,884	22,339
	Live stock	504,737	38,079	142,211	696,123	71,889	301,343
	Agriculture field (rai)	3,023,477	2,645,982	5,605,559	1,701,450	3,298,733	1,595,557
Infrastructures	Roads	12,133	8,330	10,391	5,697	4,173	5,071
	Bridges	573	309	671	667	173	393
	Hydraulic structures	595	591	778	22,527	716	179
	Institute buildings	197	271	1,425	2,123	827	174
	Drains	561	163	1,085	1,482	594	282
US$ million		72	48	202	170	24	58

These figures are for the country as a whole. Of the US$72 million flood damage figure for 2008 about US$20 million occurred in the Thai Mekong region.

Table 2-4 Lao PDR: Flood damage assessment (extracted from AMFR 2006, 2007 and 2008)

Description	**2006**	**2007**	**2008**
Provinces affected	5 provinces (Luangnamtha, Attapeu, Xekong, Saravane, and Champasack)	4 provinces	4 provinces (Luangprabang, Vientiane Capital, Bolikhamxay and Khammuane)
Districts affected	20	27	26
Villages affected	404	614	664
Houses affected	13,549 (21 houses and 17 rice stock swept away)	25,292	32,610
People affected	89,849 persons	118,074 persons in Khammouane, Savannakhet and Saravane provinces	95,158 persons in Bolikhamxy and Khammuane provinces
People killed	5	2 persons died	3
Agriculture			
Hectares of Rice and other Crop damaged	6,913.22	256,778	28,516.67

Hectares of Industry log damaged			53.54
Hectares of vegetable fields		490.62 (of 1,384.03 planted area)	
Kilogram of seed bed / nursery			860
Livestock			
Cattle	298 head (buffalos, cows, and pigs) lost	343 (buffalos, cows, pigs and goats)	702 head (buffalos, cows, pigs and goats) lost
Poultry	5,912 head lost	74,980 head lost	995 head lost
Fish ponds, aquaculture and Mekong fish net	168 sites and 98.2 ha damaged	136 sites and about 1,000,000 fish damaged	44 sites fish ponds 355.59 ha aquaculture and 71 sites of Mekong fish net damaged
Infrastructure			
Schools	13 sites affected	11 primary schools inundated	63 sites affected
Health Center	3 sites affected	2 health centers affected	3 health centre of Hinboun village affected and 50 sites and medicine cabinets
Bridges damage	2 (in Xekong and Attapeu provinces)		3 sites
Erosion along the Mekong river			18 sites destroyed 27 kilometres of length
Road damage		60-70 meters length of road at 3 locations	40 places damaged 314.38 kilometres of length
Canal systems damaged	8 km		48 sites
Irrigation	259 sites. Damages to reinforce concrete, masonry weirs, gabions and traditional earth weirs	29 sites affected (23 sites damaged)	
Headworks damage	20		
Drainage tubes affected			53 metres
Water wells damage			929 sites
Underground water well damage			812 sites
Natural water spring damage			1 site
Villagers toilets affected			4,954 sites
Temple		2 temples affected	
Market	Namtha market inundated with 0.6 m depth	Mahaxay District market affected	
Boat	21 damaged or lost	27 boats swept away by strong flow	
Total Flood Damage (US$)	3.1 million	NA	56 million

Table 2-5 Cambodia: Flood Damage Assessment (extracted from AMFR 2008)

Year	Total Flood Damage (US$)	Major area affected	Type of flood	Major components of loss
1996	86,500,000	Along Mekong, Bassac and around Tonle Sap Lake	Mekong flood and flash flood	Crops (250,218 ha), Livestock (327) Houses (3,768), Schools (173) Roads (802 km), Bridges (290 sites) Culverts (2,499 sites), Dams (65 sites) Dead (169 persons)
2000	161,000,000	Along Mekong, Bassac and around Tonle Sap Lake	Mekong flood and flash flood	Crop s(421,568 ha), Houses (7,086) Schools (6,620), Roads (908,710 km) Bridges (1,856 km), Culverts (17 sites) Dams (397 sites), Dead (347 persons)
2001	36,000,000	Along Mekong, Bassac and around Tonle Sap Lake	Mekong flood and flash flood	Crops (164,173 ha), Houses (2,251) Schools (911), Roads (7,976 km) Bridge s(175 sites), Culverts (44 sites) Dams (201 sites), Livestock (956) Dead (62 persons)
2002	12,450,000	Along Mekong, Bassac and around Tonle Sap Lake	Mekong flood and flash flood	Crops (45,003 ha), Houses (35) Schools (2), Health centre (7) Roads (12 km), Dams (201 sites) Livestock (956)
2004	55,000,000	Along Mekong, Bassac and around Tonle Sap Lake	Mekong flood and flash flood	Crop (247,393 ha)
2005	3,810,000	Along Mekong, Bassac and around Tonle Sap Lake	Mekong flood and flash flood	Crops (1,500 ha), Houses (1,700 flooded, 32 collapse), Schools (30

				flooded), Dead (4 persons)
2006	11,800,000	Along Mekong, Bassac and around Tonle Sap Lake	Mekong flood and flash flood	Crops (13,787 ha), Roads (70 km) Dams (41 sites), Bridges (24 sites) Dead (11 persons),
2007	9,000,000	Along Mekong, Bassac and around Tonle Sap Lake	Flash flood	Crops 18,786 ha, Houses 11 Roads 34 km
2008	5,750,000		Flash flood	Crop 18,907

Table 2-6 Vietnam: Flood damage (extracted from AMFR 2007 and 2008)

Mekong Delta

Description	Flood impacts 2006	Flood impacts 2007	Flood impacts 2008 *	Flood impacts 2000
Number of affected provinces	5	5	5	13
Number of affected families	15,530	13,500	0	800 000
Number affected people	77,650	67,500	0	10 million
Number of people killed	42	30	7	453
Rice & upland crop damaged (ha)	15,223	14,688	68	2.0 million
Total estimated cost (US$ million)	2.00	1.50	*	250

Central Highlands

No.	1990	1994	1995	1996	1998	1999	2000	2002	2003	2006	2007	2008
People												
Killed	22	2	3	4		13	>20	2	6	0	29	6
Missing				5		41			2	0	4	1
Injured								1	1	0		
Houses												
Lost	22								7	5	166 d	
Inundated								1500			12,447	
Agriculture												
Lost		400								24	20,344	79
Inundated								9000	1000	126	24,393	
Fish ponds damaged											593	
Bridges												
Destroyed		32				10				1	59	8
Damaged											14	
Water containers												
Damaged		4									37	
Eroded											331,837	
Number of provinces effected	4	4	4	4	4	4	4	4	4	4	4	4
Total Cost (US$10 million)	0.5	1.0	n/a	n/a	n/a	0.2	n/a	3.0 .	0.5.	n/a	50.8	1.0

2.3 Flood damage and losses period 2010 – 2014

In

Table 2-7 the damages for years 2010 to 2014 are shown and it can be seen that the amount of damage varies greatly from year to year 2011 and 2013 being disastrous. The figures for the whole Thailand and Viet Nam are shown for comparison.

In 2013 the reported losses in Lao PDR and Thailand were 62 and 210 Million USD, respectively. They were the consequences of floods in tributaries during several tropical storms hitting the region.

Table 2-7 Average annual flash flood and river flood loss and damage in the Lower Mekong Basin 2010-2014 in Millions USD (Source: MRC National Flood Reports, MRC 2015, Desinventar.net).

	2010	2011	2012	2013	2014	Mean annual loss
Cambodia	N/A	634	N/A	356	N/A	-
Lao PDR	21	208	1.5	62	12	64
Thailand (LMB part)	47	N/A	N/A	210	6	88
Viet Nam, Delta	55	260	16	23	2.7	71
Viet Nam, C. Highlands	N/A	60	1	0.2	5.7	17
Entire Thailand	1 200	45 000	176	295	N/A	12 000
Entire Viet Nam	750	700	N/A	1 200	132	700

Inundation floods in the floodplains of Cambodia and in the Delta of Viet Nam cause a lot of damage when they happen, because these areas are densely populated and have much infrastructure. Also in Thailand and Lao PDR river inundation floods may cause huge damages, as in 2008, but in other years flash floods are the main cause of flood damage. However, in many cases it may be difficult in tributaries to make a strict distinction between river and flash floods.

Table 2-8 Average annual number of fatalities due to floods in the Lower Mekong Basin. (Source: MRC National Flood Reports)

	2010	2011	2012	2013	2014	Total
Cambodia	8	250	26	168	49	501
Lao PDR	7	42	5	17	5	76
Thailand (LMB part)	N/A	N/A	N/A	17	4	
Viet Nam, Delta	78	104	38	35	12	267

Viet Nam, C. Highlands	N/A	15	0	45	17	77
Entire Thailand	79	655	5	80	4	1 200
Entire Viet Nam	238	265	N/A	285	133	230

In whole Viet Nam 250 flash floods have been recorded between 2000 and 2014, causing more than 600 fatalities and costing more than 150 Million USD (Viet Nam Annual Flood Report 2014). In the LMB part only areas in the Central Highlands experience flash floods, 77 fatalities were recorded here in the period 2010-2014.

In Cambodia there are some occurrences of flash floods but losses from inundation from the mainstream Mekong cause the most economical damages and fatalities. Since 2010 more than 500 fatalities has been reported in Cambodia. In Lao PDR and Thailand (Mekong part) the losses are mainly caused by flash floods, with 76 fatalities recorded in Lao PDR and 27 in Thailand during 2010 to 2014. In Table 2-8 a summary of fatalities in the 4 countries is presented.

Flash floods have a significant impact on the lives of people affected, causing loss of lives and inflicting damage on houses and infrastructure. Preparedness on flash floods is restricted to assessment the local risk in terms of soil saturation and forecasted rainfall intensity for the catchment, and to issue warnings to at least minimize the risk to people's life.

2.4 Results FMMP Component 2 study.

As part of the FMMP Component 2 Study flood damage estimation curves and flood risk has been calculated for the 59 districts in the Cambodian/Vietnam transboundary floodplain.

In short the approach applied in the Component 2 study is as follows:
There are basically two approaches for flood risk assessment[1]: Absolute approach (a topdown) and relative approach (a bottom-up). In the absolute approach historical damage data for an (administrative) area are used to assess the flood damage risk in that area. In the relative approach inundation-damage relationships are developed on a per unit (ha, % of house value) basis, and the flood damage risk is assessed by applying the per unit risk to the number of units in the concerned area.
In the Component 2 study, considering resource, time and data availability, absolute approach has been applied for flood damage assessment to Housing, Agriculture, and Infrastructure.
Housing damage covers individual houses, structures and properties of flood affected families.
Agriculture damage covers crops and aquaculture which is an important in lower Mekong Delta.
Infrastructure damage covers all remaining items such as public infrastructure and utilities, industries, institutions etc.
The grand total of damages caused by a flood in a certain district is the total of direct damages plus the total of indirect damages. Direct damages are obtained from local authorities at provincial and district levels from 2000-2008. It covers loss of life, damages to housing, crops, aquaculture, and infrastructure broken down into irrigation, transportation, power and water supply, education, health etc. The indirect-direct damage ratios were taken from results of the detail survey during the Stage 1 for the focal areas to estimate the grand total of damages.

A **first step** in this approach is the proper assessment of the flood hazard, i.e. the flood levels

with different exceedance probabilities with the help of the MRC ISIS model.
The **second step** is to establish damage functions for three damage group categories with maximum flood water level for individual district.
The **third step** is to develop flood damage probability curves and hence calculating expected damage at selected flood return period of 100, 50, 25, 10 and 2 years.

A similar approach is proposed for the Council Study; an example of damage curve and flood risk is shown hereunder. In the framework of the Initial Studies these damage curves and flood risk calculations are updated to the existing situation 2014 and the flood risk is calculated for the future situations 2030, 2060 and 2090.

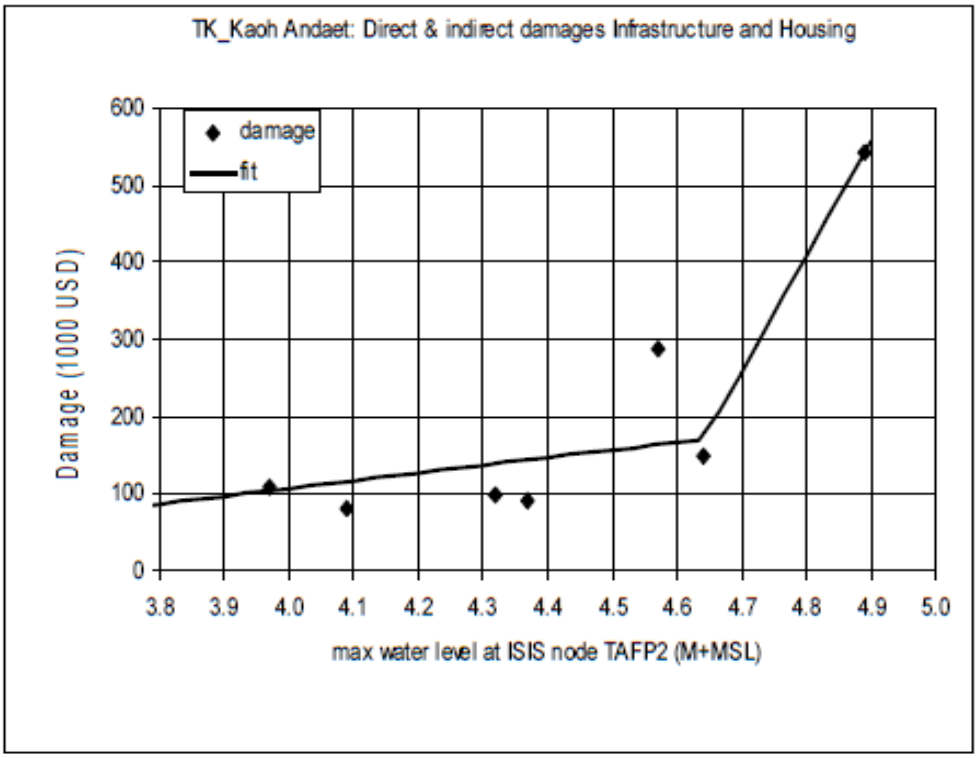


Fig 2-4: Flood damage estimation curve for Kaoh Andaet for Infrastructure and housing

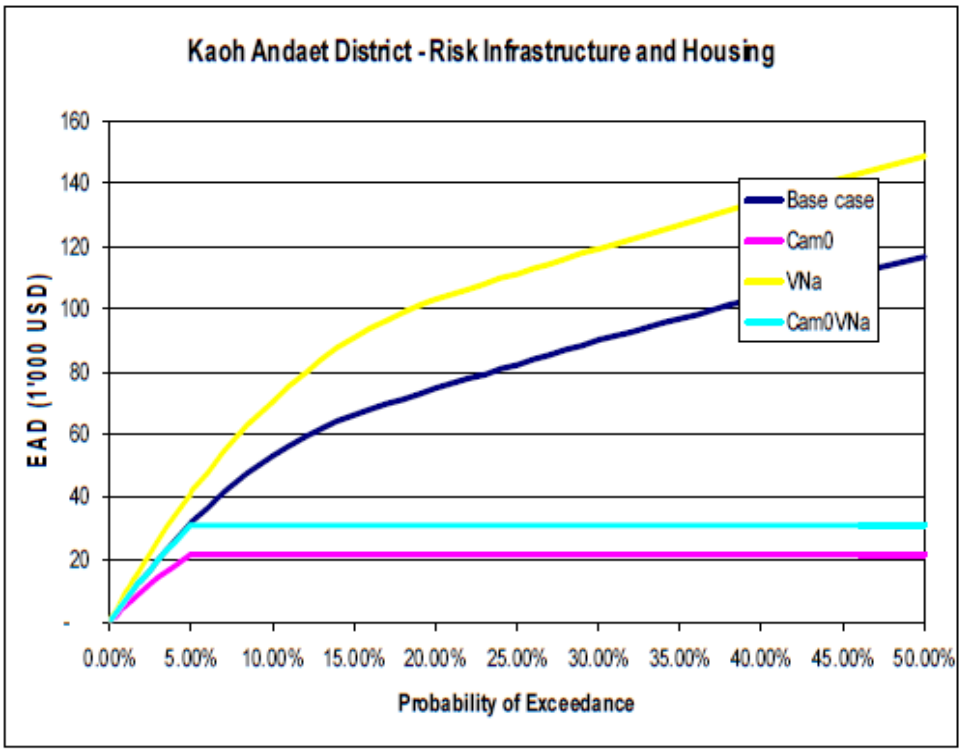


Fig 2-5: Flood risk calculation for Kaoh Andaet for Infrastructure and housing

3. DEVELOPMENT TRENDS

3.1 Formulation of development scenarios

During the 4th RTWG Meeting, the Member Countries agreed to assess the following development scenarios:

- Early Development using estimates of physical/socio-economic condition as of 2007
- Definite Future Scenario using a projected physical/socio-economic condition as of 2020
- Planned Development Scenario using a projected physical/socio-economic condition as of 2040

In addition, during the 5th RTWG Meeting, the Member Countries have also expressed interest in assessing the impact of development estimates of physical/socio-economic condition in 2000, particularly in relation to the impact of Chinese dams as compared to the physical/socio-economic condition in 2007.

3.1.1 Data collection

For the Development Scenario 2000, the Early Development Scenario (EDS-2007) and the Definite and Planned Future Development Scenarios (DFS-2020 and PFS-2040) FMMP will seek details of *significant* flood protection works, together with floodplain infrastructure likely to *significantly* affect flooding behaviour (eg major road and irrigation embankments across floodplains), from the four Member Countries (MCs).

FMMP has good information on EDS-2007 flood protection works and floodplain infrastructure across the Lower Cambodian Floodplains and the Mekong Delta of Viet Nam. FMMP will seek

information on significant flood protection works and floodplain infrastructure along the mainstream reach of the Mekong River from the Chinese border to Kratie.

Regarding planned developments in 2020 and 2040, FMMP can only seek and use information on proposed flood protection works and floodplain infrastructure provided by the four MCs.

In the framework of task 3 for the Initial Studies sector reports describing the existing and future conditions for the floodplains for various sectors. These reports were completed in September 2015. The sector experts for each MC were also requested to collect the data for the flood protection structures for the year 2040.

In addition the MCs were requested by e-mail to provide data for the current and future plans related to the flood protection works and floodplain infrastructure. Lao PDR provided FMMP with information on on- going and planned flood protection works but without details about level and length of the planned levees reinforcement works. Cambodia requested clarification. A visit was paid to the office of CNMC to provide clarification.

During the Workshops for task 3 which were held in the first half of September, again the MCs were reminded to this request but to date no additional information was received.

A new workplan is prepared to collect this information from the Agencies in the MCs and will be presented at the 6th RTWG. Guidelines for identifying "significant" flood protection and floodplain infrastructure are included in Annex 1.

3.1.2 Meeting with other thematic teams for Impact Assessment Locations

Several meetings were arranged with other thematic teams to determine special requirements for the location of the IALs and the flood behaviour characteristics.

Fisheries (meeting 11 September)

Fisheries emphasize the timing of spawning and start of flooding as a most important aspect for fisheries development. Next to the timing the extent of flooding and the duration of flooding is important. Some monitoring locations in the Tonle Sap River connecting Tonle Sap Lake with the Mekong River are required to follow the start of the flood season.

Agriculture (meeting 7 October 2015)

For Agriculture the frequency of flooding as well as the intensity (level) and duration are important. But it is difficult for Agriculture to indicate the location where monitoring would be appreciated. Agriculture has a gross list of possible irrigation projects but out of these projects still a selection has to be made, so it is difficult to indicate the location of IALs for Agriculture.

Navigation (meeting 8 October 2015)

Navigation is more interested in the dry season than in the flood season. After every flood season soundings are implemented between Phnom Penh and the sea. If needed the navigation buoys are relocated or dredging is started.

Important aspect is the depth of the navigation route in the Mekong River. During flood season the clearance under bridges and electricity lines might become critical and shipping has to be suspended for a short period. Navigation is mainly present on the Mekong River between Kratie and river mouth. Existing IALs will provide sufficient information about the maximum clearance at bridges and electricity poles.

5th Regional Technical Working Group Meeting 13-14 August 2015

The 5th Regional Technical Working Group meeting (5th RTWG) identified weaknesses in the communication with particularly Thailand and requested clarification about national consultants

being involved in the Initial Studies and their relationship in supporting the FMMP led "Flood Protection Works and Floodplain Infrastructure" theme, as part of the Council Study.

A special meeting, on 10 September 2015 in Bangkok, Thailand, between FMMP and the TNMC has brought clarity in these issues and follow-up steps had been agreed.

3.1.3 Regional Consultation Meeting 4 November 2015

A Regional Technical Meeting was held with MCs representatives to discuss the draft development scenarios and to obtain endorsement for presentation at the 6th RWTG meeting. During the meeting the approach towards the Development Scenarios was agreed in general; but Thailand requested a clear detailed workplan for implementation separated from the Initial studies activities. Furthermore Thailand requested to consider the possibility of upgrading the existing ISIS model in the upstream part of the Mekong so that it is suitable to use as a flood model. At present the corridor upstream of Kratie is covered by SWAT/IQQM only. Of course such an approach will require more budget and time to develop but will improve the quality of the results. A proposal for such alternative approach will be presented at the 6th RWTG meeting.

3.2 Development scenarios

3.2.1 Formulation of ''thematic scenarios"

2000 –Development Scenario

During the 5th RTWG Meeting some Member Countries called for the need for a 2000 - Development Scenario as an additional Reference Scenario. As the available models reflect the present day status (2014) or the 2007 status, the preparation of a 2000 version would imply that latest updates have to be skipped again to have a model with the 2000 infrastructure.

2007 – Early Development Scenario

The SWAT, IQQM and ISIS models reflecting the 2007 situation are available with IKMP as they were used for simulation runs for CCAI in the past. These models will be checked and modified if necessary to incorporate any more recent improvements that have been made to the model, for example to improve channel representation, that are not related to infrastructure or floodplain development.

2020 Definite Future Development Scenario

The SWAT, IQQM and ISIS models were updated during the last years to accommodate the latest developments in flood protection works and roads. The models reflect the situation in 2014 and are used for the Initial Studies as reference situation. In 2013 a special survey was carried out in Cambodia to have updated levels of the NR 6A, 8, 1 and 2.

As no additional information on floodplain development or flood protection works was received from the MCs for future plans the 2014 version will be used for the 2020 Definite Future Development Scenario. The models providing upstream inputs to the ISIS model will be updated to include the Dams which are planned to be constructed and to be in operation by 2020.

2040 – Planned Development Scenario

Due to the limited additional information provided by MCs for future plans it is proposed that the PDS-2040 scenario be based upon the work currently being carried out under task 3 of the Initial Studies project. In October and November 2015 a second and third round of workshops were held for Initial Studies in order for teams of the MCs to produce draft development plans for the year 2060. In these plans future developments of various sectors are presented in an integrated manner. A 2040 Development Scenario for the Council Study can be formulated based on the results of the

workshops. In addition to the floodplain developments identified by the Initial Study upstream developments such as dams which are planned to be constructed and in operation between 2020 and 2040 will be included in the hydrological models.

Information on flood protection works and floodplain infrastructure relevant to the 2000, 2007, 2020 and 2040 scenarios will be provided to IKMP for incorporation in the various hydrologic and hydraulic models used to simulate daily flow behaviour across the Lower Mekong Basin (LMB).

1960 – Historic Development Scenario

In addition to the abovementioned development scenarios, the following two development scenarios listed in Table 2 be considered for assessment as per agreement by the Member Countries during the Small Technical Workgroup Meeting on Reference Scenario. For additional details, the reader is referred to the Draft Working Paper on Reference Scenario and Meeting Minutes which are available in the Council Study Team Site. It should be noted that the assessment of the 1960 development scenario will focus on impacts on flow and sediment.

3.2.2 Formulation of "thematic sub-scenarios"

Based on the discussion on the phase 2 implementation, there will be on 6 main development scenarios with and without climate change (as part of the Cumulative Study) and it is proposed to focus on 3 thematic sub-scenarios as follows:

- FPF 1: Flood protection for all urban areas in 1:100 ARP
- FPF2: Urban protection at 1:100 ARP + floodplain management 1:20 ARP
- FPF 3: Joint Operation among mainstream dams and selected tributary dams for flood management and protection

4. SCENARIO IMPACT ASSESSMENT

FMMP proposes to assess changes to flood characteristics in terms of changes to the *frequency distribution of that characteristic*. Baseline distributions will be developed for:

- The EDS-2007 development situation, which will be used to assess future changes under the DFS-2020 and PFS-2040 cumulative development situations; and
- The PFS-2040 cumulative development situation, which will be used to assess changes under the various thematic sub-scenario development situations.

FMMP takes 'flood risk' to mean average annual damage (AAD). FMMP will assess changes to flood risk in terms of changes to AAD between the baseline and future periods (cumulative scenarios) and between the PFS-2040 cumulative scenario and perturbed variations of that scenario (thematic sub-scenarios). Also this activity is planned after December 2015.

In addition to formulating the flood protection works and floodplain development component of the cumulative scenarios and thematic sub-scenarios FMMP will also assess the need for flood protection works in the cumulative scenarios (other thematic areas) and thematic sub-scenarios (all thematic areas). Also this activity will start after December 2015 as these data will become available after the 6th RTWG in December 2015.

An example of flood risk calculation for the transboundary floodplain in the framework of the Initial Studies is shown in fig 4-1.

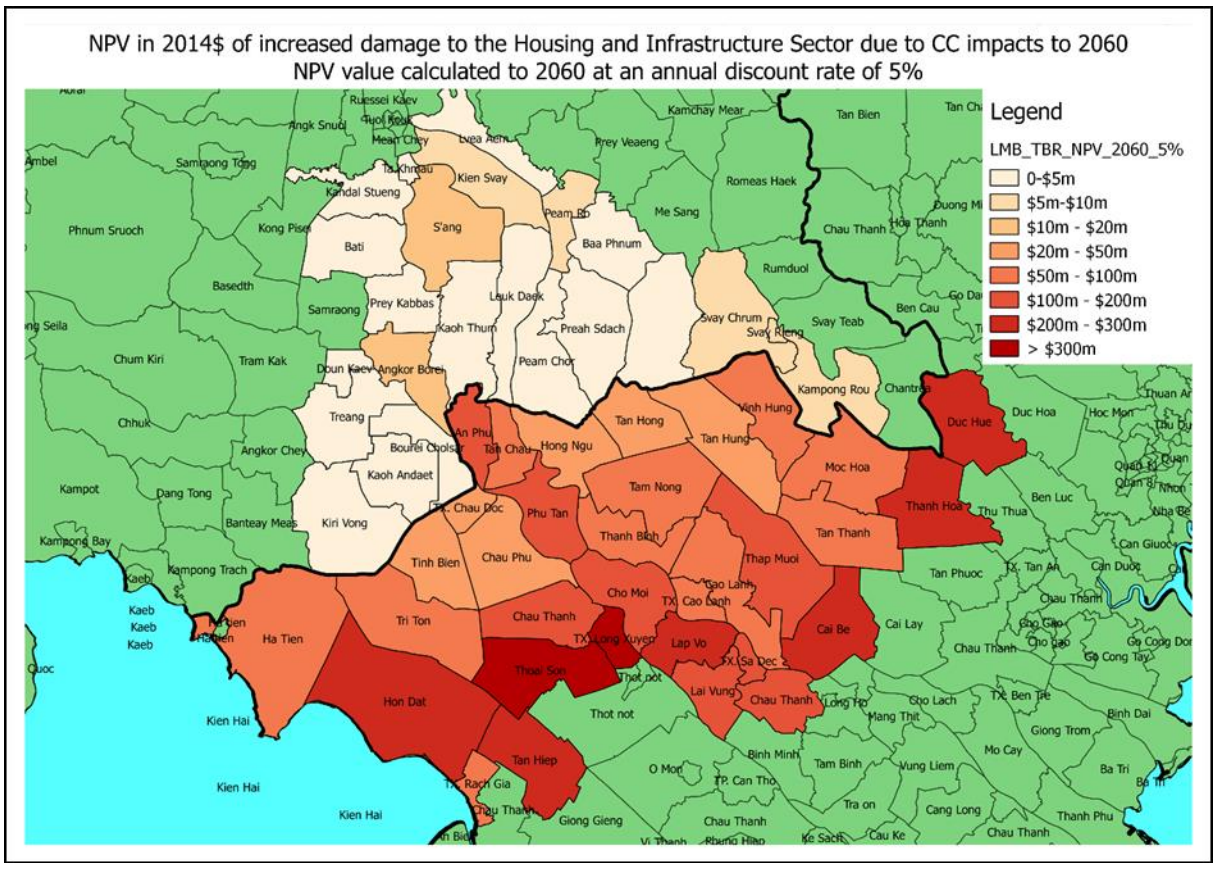


Figure 4.1: NPV of Climate change impacts to 2060 for the Housing & Infrastructure Sector

5. ANTICIPATED FINDINGS AND NEXT STEPS.

5.1 Findings

Certainly the maximum annual flooding levels will increase for the future 2020 and 2040 scenarios. Driving factors behind the increase of the flooding levels are Climate Change and Floodplain developments resulting in a decrease of storage volume for the peak flows. When results from phase 2 of the Initial Studies are available indicating the location, type and extent of the floodplain development in 2020 and 2040, then a more exact calculation of the loss of flood plain storage volume will be possible. Nevertheless, in the V2 study some preliminary simulations were implemented for 6 test cases:
The six test cases simulated were:

1. Urbanisation of Phnom Penh and Kampong Cham to maximum extent projected for 2090
2. Case 1+ Loss of 50% of Floodplain Storage on the Mekong left bank
3. Case 2 + Loss of 50% Storage on Mekong right bank and Tonle Sap (not Great Lake)
4. Case 3 but with loss of 50% Storage in BassacBassac and Trans Bassac also
5. Case 4 but loss of 75% Storage
6. Case 5 but TS/Great Lake confined to dry season extent

These test cases reflect possible situations of loss of storage in the Lower Mekong Basin in Cambodia and Vietnam and show an increase of the storage loss with case 1 (Phnom Penh Urban area only flood free) up to case 6 with a loss of 75% of the floodplain storage and a confinement of Tonle Sap to the dry season limits only. Although these cases are theoretical and not based on an actual development scenario they do show the extent of flood level increase associated with the loss of storage area in the Mekong flood plain area in Cambodia and Vietnam.

These are illustrated graphically in Figure 5.1 where green shading is 50% loss of floodplain storage, orange is 75% loss and yellow is flood free.

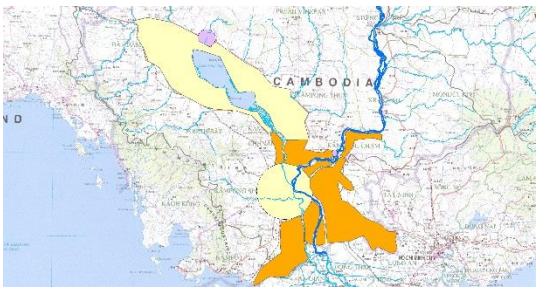
Case 1 Phnom Penh Urban area (2090) flood free

Case 2 Phnom Penh + 50% loss of storage on Mekong left bank

Case 3 As 2 but 50% loss of storage on right bank

Case 4 As 3 but 50% loss on Transbassac and Bassac right bank

Case 5 – As 4 but 75% Loss of floodplain storage



Case 6 – as 5 but Great Lake confined to dry season extent

Figure 5.1 Test Cases for Loss of Floodplain Storage

The simulation results at key locations is given in Table 5-1. The main river stations closest to the floodplain loss areas are clearly the most affected and Kampong Cham, Phnom Penh and Neak Luong are all significantly impacted by the loss of floodplain and conveyance. The importance of the Great Lake storage is highlighted by the large increases at all stations for that test case (6).

There are also other potential effects and results need to be carefully examined further. One aspect is that on the floodplain some areas have a large rise when water levels had previously been limited by the connection to the main river and there was a good path for floodplain flows. Once the floodplain flow path is blocked then water levels rise closer to that in the main river. This can occur for example to the west of Kampong Cham and could cause floods in the city from the west side whereas defences are orientated only to the east side.

Test Case Number	**Urbanisation**	Urbanisation + 50% loss on left bank	Urbanisation + 50% loss on LB and RB	Urbanisation +50% loss of all floodplain	Urbanisation +75% loss of storage	Urbanisation, 75% loss of storage + Great Lake confined
	1	2	3	4	5	6
Kratie	0.01	0.01	0.14	0.14	0.16	0.19
Kampong Cham	0.08	0.08	0.86	0.88	0.96	1.12
Phnom Penh Port	0.17	0.16	0.35	0.39	0.46	1.45

Prek Kdam	0.09	0.08	0.18	0.22	0.28	1.41
Kampong Luong	0.13	0.12	0.18	0.22	0.28	1.43
Nek Luong	0.06	0.06	0.18	0.23	0.29	0.83
Koh Khel	0.45	0.44	0.57	1.06	1.05	1.60
Tan Chau	0.04	0.04	0.07	0.13	0.13	0.54
Chau Doc	-0.18	-0.18	-0.12	-0.20	-0.22	0.19

Table 5-1 Indicative Changes at Key locations in peak flood levels (m) during a major flood (the simulation uses 2011 representing a 1:10-1:20 year event) for 6 floodplain development test cases

The results shown do not include sea level rise which has a considerable impact in the Viet Nam Delta and also in the Cambodian floodplain area near the Viet Nam border.

More detailed calculations including the future development in the flood plains and the future sea level rise will be implemented during the second phase of the Initial Studies which is planned for 2016.

Expectation is that an increase of flood levels between 0.2 and 1 m in transboundary floodplain for the year 2040 is realistic. The damage in terms of flood risk may increase 1 – 8 times depending on development which means that flooding problems in the LMB will be serious.

5.2 Strategic directions

For developing strategic directions for *integrated* flood risk management to reduce impact of flooding and associated damage the Mekong River Basin should be divided in two parts:

1. Upstream of Kratie; mainstream corridor with many tributaries
2. Downstream of Kratie with a wide floodplain with concentration of population, economic activities, but with a large storage area for flooding.

As was shown in section 2 most of flooding and damage occurs in the downstream part of the Mekong River. Also the occurrence of flooding in the upstream part does not mean a flooding in the downstream part. The flood in the year 2000 was mainly in the downstream part while the upstream part experienced much less little flooding; in the year 2008 the situation was reversed.

Ad 1 Mainstream corridor upstream of Kratie

In the upstream part the creation of storage volume at the dam reservoirs to "shave off" the peak flow during flooding conditions might be an effective measure to avoid or reduce flooding. The impact of retaining the peak flow will be visible mainly in the upstream part; however downstream the effect is rapidly reduced. In case a volume of 20% the total reservoir volume is reserved for flood mitigation, the total storage volume at the major dams will arrive at 22 000 MCM which is substantial compared with the total storage volume of 125 000 MCM on the floodplain. To decrease future flooding in Luang Prabang or Vientiane this option might be feasible. As the purpose of the upstream dams is generating electricity this option requires special attention in terms of dam operation.

Ad 2 Floodplain downstream of Kratie

For the floodplain downstream of Kratie are several options for reducing the impact of flooding.

- ***Tonle Sap Lake***

Already since centuries the Tonle Sap Lake functions as a temporary overflow reservoir during the flood season. More than 70% of the flood storage area is created by the Tonle Sap Lake. Any development reducing the storage volume should be avoided and moreover possibilities to increase the volume or regulate in/outflow should be investigated.

- ***Emergency channel***

A second possibility to reduce the impact of flooding in the transboundary floodplain might be the creation of an emergency overflow "channel" connecting Mekong/Bassac Rivers directly with the Gulf of Thailand. Especially the Viet Nam Delta would benefit from such solution although the impact of such channel is strongly influenced by the size of the channel (width estimated to be >10 km) and the tidal regime in the Gulf of Thailand.

- ***Land use planning***

The third option is an integrated land use planning; i.e. combining land use with the function of securing the **conveyance routes** for the flood waters securing '*room for the rivers'* based on considerations of extreme flood conditions, and **storage areas** during flooding. Floodplain zoning is aimed at '*keeping people away from the water*', i.e. attempting to ensure that land-use is appropriate to flood hazard and that flood-sensitive land use (housing, roads, urbanization and industrial activities) are encouraged to relocate to less hazardous areas of the floodplain. Land-use controls can limit flood risk exposure to infrastructure, assets and the population at risk and are the most cost-effective means of reducing exposure to future flood risk. In addition land-use controls are necessary to maintain conveyance corridors free of unwanted developments. However, land-use controls will be difficult to implement in the Lower Mekong because of unrelenting and increasing population pressures across flood-prone areas of the basin.

These controls are expected to increasingly play a crucial role in the management of floodwaters and in reducing flood damages in the floodplains, and will need strong commitment from policy- and decision makers, as these controls can only be successful instruments in case these are accompanied by proper packages of legislature and law-enforcement.

Annex 1 - Guidelines for identifying "significant" flood protection and floodplain infrastructure expected to be completed by 2020 or/and by 2040 and process for engaging Agencies

- **Significant** increase of crest levels of embankments/dikes/levees, expansion of the length of embankments/dikes/levees, and construction of new embankments/dikes/levees
- **Significant** expansion of the network of highways and national roads, construction and expansion of ring roads around cities and towns
- **Significant** land-use changes through landfills
- **Significant** sized new irrigation structures (with incorporation of flood protection)
- **Significant** expansion of urbanization in floodplains

ab1 New levees, dikes, embankments:

Overall length > 5 km;

Crest level/height > 1.0 m above surrounding terrain level.

Indicate crest levels in m above surrounding terrain, or in m above MSL

ab2 Existing levees, dikes, embankments:

Overall lengths > 5 km

Crest level increase of levees, dikes, embankments by > 0.5 m

Indicate crest levels in m above surrounding terrain, or in m above MSL

cd1 New (auto/rail) roads:

Overall length > 5 km;

Crest level/height foundation height > 1.0 m above surrounding terrain level

Indicate crest levels in m above surrounding terrain, or in m above MSL

cd2 Existing (auto/rail) roads:

Overall length > 5 km

Auto/rail road crest level increase by > 0.5 m

Indicate crest levels in m above surrounding terrain, or in m above MSL

e1 New ring roads around towns and cities:

Overall length > 1 km

Ring roads crest level > 1.0 m above surrounding terrain level, or in m above MSL

Estimate flood protected ("flood free") town/city area in km^2

e2 Existing ring roads:

Overall length > 1 km

Increase of ring road crest level > 1.0 m

Estimate flood protected ("flood free") town/city area in km^2

fg Agricultural (irrigation/drainage) areas with year round flood control

Overall length of (outer) flood protection > 1 km

Estimate overall protected area in ha.

h1 New landfilling of low lying areas, rice fields or lakes

Overall landfill area > 20 ha

Indicate area of original situation / new situation in ha

Indicate average height prior to and after the landfilling in m above surrounding terrain, or in m above MSL

h2 Existing landfilling of low lying areas, rice fields or lakes

Overall landfill area > 20 ha

Indicate area of existing situation and new situation in ha

Indicate average height increase prior to and after the additional landfilling in m above surrounding terrain, or in m above MSL

Process for engaging Agencies in data collection

Data transfer between MRC Member Countries and MRCS/MRC programmes was based on clear definition of the needs of the MRC Secretariat. MRC Programmes consulted Member Countries through the mechanism of consultation workshop on the needs that then would be consolidated in well-defined lists of requirements, be it hydrologic data, cross sections of rivers, land-use maps, land cover maps, socio-economic data etc. Under a regular pattern of meetings and workshop, the MRC MCs made systematically data and information available for the MRCS/MRC programmes.

The Information and Knowledge Management Programme (IKMP) is the MRCS Information and Knowledge Keeper, however in its programme document little is stated about the function of collecting data and information from the MRC Member Countries. That is obvious as it is the responsibility of each of the MRC programmes as most of the programmes have different data and information requirements.

The requirements for the thematic area Flood Protections and Floodplain Infrastructure (FP&FPI) for the Council Study are therefore additional and not allocated within the standard programme activities. For the thematic area FP&FPI the scope is wider thus involving a larger set of data and information and data of a special character, while the timeframe for collecting data is limited.

The FMM team for the FP&FPI has indicated to limit its interest to “significant” contributions, as the basinscale is too large to enter into a high degree level of detail, while the positive effect of more details is highly questionable. The process should be logic, targeted and as simple as possible.

A data collection process is therefore proposed. The FMM team will contract and interact closely with a national flood management consultant in each of the four member countries, especially regarding the proper understanding of the scale and variety of the data requirements and the character of the data and how these data will be used. The data are particularly required for the development scenarios 2020 and 2040. To discuss these development scenarios and the needs for the thematic area of the Council Study requires inputs from experienced persons, particularly of Director- / Director General level of the agencies, like technical departments and planning departments, at the National, Provincial and if needed Districts levels. These persons are expected to have good knowledge and a good overview of the projects and plans in the FP&FPI sectors. FMMP proposes to ask the National Flood Management Consultant to identify a list of officers to be contacted for interviews. The interviews will be facilitated by questionnaires that will be developed by FMMP and which can be send to the resource persons prior to the interviews. As part of the interviews data can be identified to be shared with the MRCS/FMMP.

Annex 2 – Datasheet on Models to be used for the Development Scenarios

2007- Early Development scenario

SWAT, IQQM and ISIS models are available for the 2007 situation for use by IKMP. These models will be checked and modified if necessary to incorporate any more recent improvements that have been made to the model, for example to improve channel representation, that are not related to infrastructure or floodplain development.

Proposed 2020 scenario

We would propose utilizing the existing 2014 ISIS model as used as the baseline for the FMMP initial studies project and update this model to 2020. The modifications relative to the 2007 Base condition include the following model updates carried out in 2014. FMMP will work with other thematic areas to define the development expected in terms of flood defense and floodplain development as these will be closely linked with the socio-economic development (urban expansion and change in flood exposure and thus damages) the agricultural developments on the floodplain (often irrigation development is accompanied by flood protection) and the impact of hydropower on flows and flood peaks and water levels in the mainstream affected by mainstream dams. The impact of changes in the river morphology in terms of bank erosion threats to flood infrastructure may also be part of the assessment if this does not already fall in the remit of other sector studies.

Table 2: Data and amendments required to produce 2020 scenario

	Data and amendments required relative to 2007 Baseline Infrastructure
Upstream of Kratie **(SWAT/ IQQM & ISIS upstream model)**	Collate data on levels of defences along mainstream corridor considering Flood Warning levels, Known Flood Improvements and Flood Events, data on hydrographic Atlas and onset of flooding along mainstream and in confluence areas relative to analysis of rated flow/level at gauging sites. For Damage Calculations assess Land Use Changes in Flood Corridor, people, assets and agriculture exposed in 2000 and adjust damage curves if necessary using recorded totals at province level. The upstream developments such as dam construction on tributaries are detailed by ISH. The floodplain infrastructure associated with Irrigation and agricultural/ aquaculture development within the corridor (as defined by other sectors). Embankments and areas of bank protection will be identified and used in the modelling and impact assessment for damages.
ISIS **Flood Protection**	The 2020 development model should start from the 2007/2014 baseline model so that it incorporates the improvements made in modelling

and Floodplain Infrastructure 2020	representation made since the early versions of DSF. Add or raise the representation of roads that were already raised by 2014 and upgraded to 2020 planned condition. **Cambodia:** Koh Pich development near Phnom Penh (modified channel); Roads surveyed for the 2014 model used under the FMMP Initial Studies; NR 6A, NR 8, NR 1 and NR 2 as detailed in FMMP Initial Studies reports; Phnom Penh Ring Roads already nearing completion in 2015 and expected urban expansion; Expanded Irrigation areas on the floodplain and likely associated flood protection. **Vietnam** The dike system in Vietnam for 2007 and 2014 models is as defined in the 2004 DSF model, so updating is needed based on level data and verification against satellite data of actual extents; The majority of salinity control gates should be removed; Consider if necessary to model Sea Dykes and Storm Surges (large event 1997).
Damage Data 1998 – 2007 and 2008 - 2014	The damage data has only previously been collated for districts of Cambodia and Vietnam downstream of Phnom Penh, and for Lao and Thailand in flood focal areas of Nam Mae Kok and Xe Bang Fai.

- The model was updated in the Cambodian part to reflect new information including that for upgraded roads in the floodplain and around Phnom Penh. This incorporated results from a survey carried out in 2013 by Aruna Technology Ltd to capture level information for the banks along the river (frequency minor roads and in addition the survey of roads NR 6A, NR 8, 1 and NR 2 as detailed in FMMP Initial Studies reports.
- In 2014 the model also updated in the Viet Nam part by a National expert to improve the representation of a number of canals. Viet Nam model further updated to improve stability and accuracy of floodplain representation.
- The more recent flood control structures and raised banks present in Viet Nam have not yet been updated and will need to be included.

Any additional information provided by MCs, including development planned for the period between 2014 and 2020, will also be included however this information is currently lacking.

- In the upper part of the basin above Kratie information on flood infrastructure will be collected and collated along the mainstream for use in flood modelling and risk assessment.
- In the lower part there is still rapid change occurring but the current 2014 model probably needs updating only for a limited number of known changes in floodplain infrastructure such as the project currently ongoing in Cambodia to irrigate 300,000 hectares of rice fields in Prey Veng, Svay Rieng and Kampong Cham provinces which should be included as there may be transboundary impacts on flooding.

Proposed 2040 scenario

The draft development plans for 2060 formulated as part of Task 3 of the FMMP Initial Studies project have been used to formulate a 2040 scenario for 2040. After completing the simulation runs to assess the impact of this scenario on flood behaviour, FMMP will be able to identify plausible flood protection infrastructure for the 2040 scenario. At present FMMP envisages running a number of sub-scenarios for other thematic areas to assess the specific impact in terms of flood damages.

The proposed 2040 scenario will include:

- *Expansion of Urban Centres*
  - Upstream Centres above Pakse such as Chiang Saen, Luang Prabang, Vientiane, Nong Khai, Nakhon Phanom, Thakhek, Mukdahan Khong Chiam
  - Middle reaches Pakse, Stung Treng, Kratie
  - Tonle Sap Kampong Chhnang, Kampong Thom, Siem Reap, Battambang, Sisophon
  - Cambodia Floodplain Phnom Penh, Ta Khmao, Takeo, Kampong Cham, Prey Veng
  - Vietnam Delta Chau Doc, Tan Chau, Long Xuyen, Cau Lanh, Can Tho, My Tho, Rach Gia, Soc Tran, Vinh Long etc., compatible with Mekong Delta Plan (2013).

- *Upgrading National Road Networks*
  - NR 1, NR 2, NR 3, NR 4, NR 5, NR 6, NR 7 in Cambodia

- *Ring Roads around Phnom Penh*
  - Second Ring Road (2040)
  - Third Ring Road (2060)

- *Expansion Industrial Areas in Cambodia*
  - Expansion along NR 3 and NR 4 towards southwest
  - Areas in Vietnam as proposed in Mekong Delta Plan.

- *Conveyance Corridors*
  - Corridor linking Mekong - Tonle Sap
  - Corridor towards Svay Rieng
  - Relief corridor to Gulf of Thailand

- *Irrigation Schemes*
  - Around 500,000 hectares of floodplain to be defined by Sectoral studies and locations to be decided

- *Move towards intensive agriculture with flood protection*

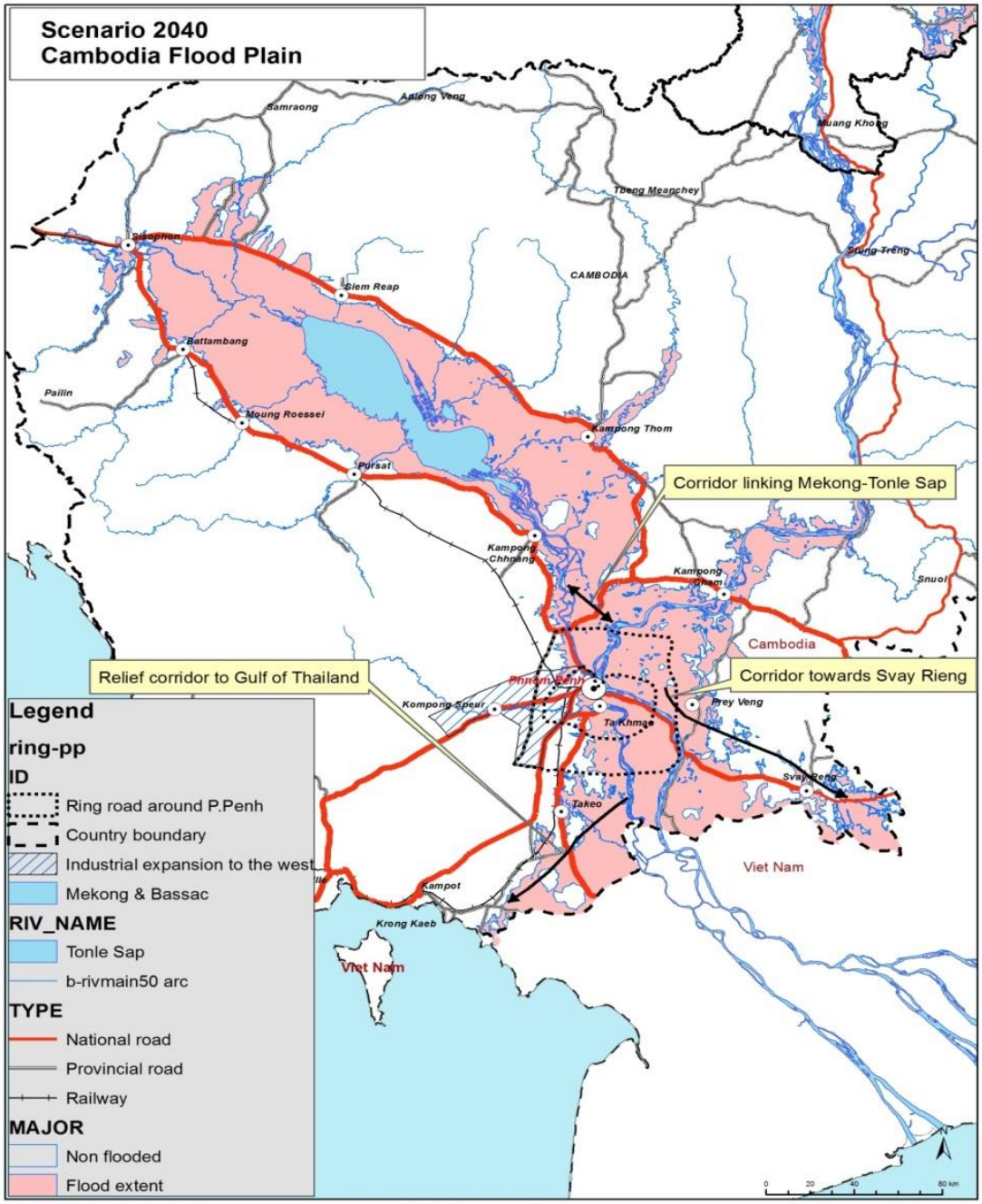


Figure 1: Scenario 2040 for Cambodian Floodplains

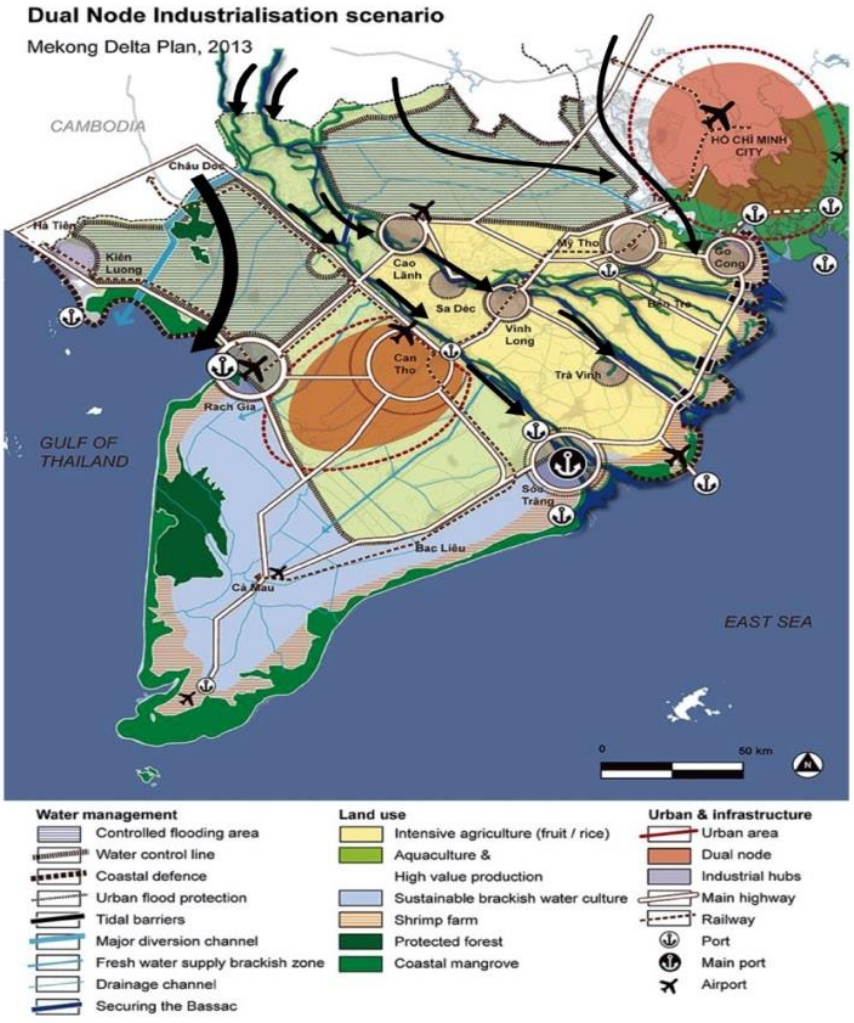


Figure 2: Scenario 2040 to be deducted from Mekong Delta Plan, 2013

Annex 3 – Flood Damages in Thailand (in USD)

Source: National Consultant Report of Initial Studies Task5a&6a

Year	Chiang Rai				Loei	Nongkhai					
	Mueang	Chiang Saen	Chiang Khong	Wiang Kaen	Chiang Khan	Mueang	Tha Bo	Phon Pi Sai	Sang Khom	Rattana Wapee	Pho Tak
2002	424,843.21	207,584.86	171,727.81	172,774.22	525,298.75	-	11,161.73	-	-	-	-
2003	250,058.39	103,497.93	92,414.45	61,061.44	33,616.42	94,822.33	103,062.10	52,010.22	77,292.96	32,706.24	-
2004	51,873.11	44,309.89	20,758.18	24,956.61	-	11,994.07	13,012.20	6,282.61	8,070.54	3,923.53	3,451.71
2005	-	92,774.47	-	-	161,982.83	-	-	-	-	-	-
2006	15,829.74	14,775.13	66,963.29	29,236.33	-	-	-	-	-	-	-
2007	34,893.26	21,579.00	30,448.13	-	-	-	-	-	504,592.68	-	294,414.95
2008	31,771.72	106,405.30	134,879.96	224,799.93	-	189,383.45	188,256.87	813,821.12	193,405.99	279,455.98	186,898.60
2009	163,153.74	245,812.59	311,593.44	330,833.46	-	301,586.42	299,792.40	1,295,981.26	307,992.17	445,023.75	297,629.39
2010	475,084.31	15,961.17	20,232.45	21,481.77	-	-	-	-	-	-	-
2011	233,157.56	-	-	-	-	-	-	-	-	-	-
2012	-	-	-	-	-	-	-	-	-	-	-
2013	42,089.82	7,809.47	-	-	-	-	-	-	-	-	-
2014	-	-	-	-	-	-	-	-	-	-	-

Year	Bung Kal				Nakhon Phanom						
	Mueang	Pak Kad	Bung Khong Loang	Bung Kla	Na Tom	Ban Paeng	Na Wa	Sri Song Khram	Tha U-Thane	Mueng	That Phanom
2002	-	-	-	-	523,612.86	484,374.75	1,009,159.59	357,849.60	106,734.01	83,457.16	49,623.18
2003	-	-	-	-	-	-	-	-	-	-	-
2004	-	-	-	-	75,813.45	62,083.59	168,863.10	59,185.64	20,784.75	13,384.69	8,641.69
2005	-	-	-	-	229,415.66	222,211.04	506,219.32	629,087.83	54,581.98	43,159.00	35,271.90
2006	-	-	-	-	37,158.90	35,786.69	64,208.33	78,761.15	5,389.07	4,410.92	3,731.54
2007	50,820.97	-	38,057.27	-	-	-	-	-	-	-	-
2008	574,503.48	304,508.26	184,413.81	75,214.46	345,923.93	513,804.12	737,931.66	5,998,141.65	612,573.57	472,116.18	422,760.06
2009	611,574.25	314,979.57	190,755.35	77,800.91	393,891.38	585,050.63	840,256.76	6,829,872.46	697,515.92	537,582.04	481,381.97
2010	-	-	-	-	-	-	-	-	-	-	-
2011	477,027.91	276,627.41	167,528.82	68,327.79	345,930.86	513,814.41	737,946.44	5,998,261.84	612,585.85	472,125.64	422,768.54
2012	-	-	-	-	-	-	-	-	-	-	-
2013	-	325,655.10	-	65,078.96	-	-	-	-	-	-	-
2014	-	-	-	-	-	-	-	-	-	-	-

Year	Muk Da Han	Amnat Charoen	Ubon Ratcha Thani						
	Mueang	Chanuman	Khem Rat	Na Tan	Po Sai	Sri Mueang Mai	Khong Chiam	Sirinthon	Boon Tharik
2002	4,650.72	-	2,285,828.56	1,765,692.11	1,589,964.68	1,162,679.84	1,822,733.18	1,649,563.65	2,032,248.09
2003	-	18,389.13	86,283.99	43,534.48	10,951.04	3,852.61	44,184.61	13,243.34	45,484.86
2004	-	32,902.99	85,175.28	39,749.29	111,753.44	3,923.53	47,976.28	13,235.69	45,666.86
2005	-	126,730.47	-	-	-	-	-	-	-
2006	-	-	-	-	-	695,184.98	92,757.87	87,653.75	574,283.26
2007	19,048.89	-	-	-	-	681,762.95	13,094.66	84,389.69	574,481.32
2008	331,205.23	-	104,932.71	47,537.69	152,198.54	53,037.80	56,844.95	19,812.37	70,467.28
2009	357,036.97	-	114,197.25	51,734.81	165,636.21	57,720.53	61,863.81	21,561.61	76,688.87
2010	-	-	-	-	-	-	-	-	-
2011	261,303.22	-	83,577.08	37,862.95	121,223.50	42,243.69	45,276.02	15,780.21	56,125.98
2012	-	-	-	-	-	-	-	-	-
2013	-	-	-	-	-	-	-	-	-
2014	-	-	-	-	-	-	-	-	-

REFERENCE EXCHANGE RATE (Source: Bank of Thailand)

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
43.0041	41.5303	40.2699	40.2697	37.9286	34.5637	33.3630	34.3351	31.7270	30.4944	31.0848	30.7319	32.4841

Summary of damage cost per year

Year	Damage in THB	Damage in USD
2002	707,054,600	16,441,563
2003	48,443,706	1,166,467
2004	39,374,810	977,773
2005	84,624,137	2,101,435
2006	68,504,018	1,806,131
2007	81,570,130	2,347,584
2008	453,504,069	13,427,007
2009	570,680,659	16,466,500
2010	16,902,867	532,760
2011	341,085,555	10,989,496
2012	0	0
2013	13,541,500	440,633
2014	0	0

Annex 4 – Flood Damage cost in Lao PDR (in USD)

Source: National Consultant Report of Initial Studies Task5a&6a

No.	Provinces/Districts	Damage cost in US Dollars							
		2007	2008	2009	2010	2011	2012	2013	2014
1	**Luangprabang province**								
1.1.	Luangprabang district	-	192,934.87	-	-	-			-
2	**Vientiane province**	-	-	-	-	-			-
2.1.	Thoulakhom	-	-	-	-	-			-
2.2.	Sanakham	-	-	-	-	-			-
3	**Vientiane Capital**	-	27,088,410.52	-	-	-			-
3.1.	Pakngum	-	-	-	-	-			-
3.2.	Xaythany	-	-	-	-	-			-
3.3.	Naxaythong	-	-	-	-	-			-
3.4.	Sangthong	-	-	-	-	-			-
3.5.	Sikhothabang	-	-	-	-	-			-
3.6.	Chanthabouly	-	-	-	-	-			-
3.7.	Xaysetha	-	-	-	-	-			-
3.8.	Hadxayfong	-	-	-	-	-			-
4	**Borikhamxay**	-	-	-	-	-			-
4.1.	Pakkading	-	-	-	-	-			-
4.2.	Pakxanh	-	-	-	-	-			-
4.3.	Thaphabat	-	-	-	-	-			-
5	**Khammouane**	-	-	-	-	-			-
5.1.	Nongbok	532,298.97	-	-	-	-			-
5.2.	Thakhek	-	-	-	-	-			-
5.3.	Hinboun	-	-	-	-	-			-
6	**Savannakhet**	-	-	-	-	-			-
6.1.	Xaybuly	644,717.71	337,868.33	-	8,115.94	6,489,905.51			552,343.36
6.2.	Khanhabouly	-	-	-	-	-			-
6.3.	Songkhone	2,797,095.81	-	-	-	-			-
7	**Saravane**	-	-	-	-	-			-
7.1.	Khongxedone	-	-	-	-	-			-
7.2.	Lakhonepheng	-	-	-	-	-			-
8	**Champasak**	-	-	-	-	-			-
8.1.	Sanasamboun	-	-	33,988.19	-	-			-
8.2.	Pakse	-	10,952.77	-	-	-			-
8.3.	Pathoumphone	-	56,412.67	-	-	-			-
8.4.	Khong	-	-	12,052.55	-	-			-
8.5.	Phonthong	-	-	-	-	-			-
8.6.	Champasak	-	41,455.66	80,028.93	-	-			-
8.7.	Sukuman	-	-	-	-	-			-
8.8.	Moonlapamok	-	80,202.57	-	-	-			-
	Total	3,974,112.49	27,808,237.40	126,069.66	8,115.94	6,489,905.51	-	-	552,343.36