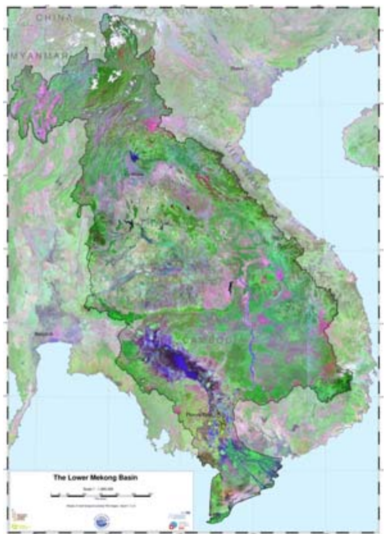
THE MEKONG RIVER COMMISSION SECRETARIAT

Final Report



The Flood Management and Mitigation Programme, Component 2: Structural Measures & Flood Proofing in the Lower Mekong Basin

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HASKONING NEDERLAND B.V.

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SUMMARY

The project

The Component 2 of the Mekong River Commission (MRC) Flood Management and Mitigation (FMMP) program aims at

- the reduction of the vulnerability of people living in the Lower Mekong Basin (LMB) to the negative impacts of floods and
- the establishment of sustainable flood risk management capacity in the MRC, MRCs, National Mekong Committees (NMCs) and national line agencies.

This Component 2 attempts to achieve these goals by formulating answers to the following questions:

- What are actually the flood risks in the LMB?
- How can these risks best be managed?
- What structural and flood proofing measures can best be applied for the reduction of the flood risks?

While answering the last question the Component 2 looks for bankable projects for being included in the Basin Development Plan (BDP).

During the Stage 1 Implementation phase the efforts concentrated on a number of focal areas spread over the LMB which were selected in the Inception Phase. These focal areas are characterised by the different types of flooding and flood risks that occur in the LMB. Answers to the above questions for these areas are meant to be used in the formulation of the strategic directions for flood risk management in the BDP sub-areas in the following Stage 2 of this component.

Methodologies and practices used in the search for socio-economic and environmentally viable strategic directions for these focal areas are the basis for the respective best practice guidelines for Integrated Flood Risk Management (IFRM) in the LMB that will result from this Component 2.

The Component 2 involves also a programme of capacity building and training which was implemented in Stages 1 and 2 with courses on the basic concepts of IFRM in the four riparian countries and on the Best Practice Guidelines.

The focal areas

The selected focal areas refer to:

In Thailand:

- Lower Nam Mae Kok, regarding flood risk management at Chiang Rai (flash tributary floods) and near the confluence with the Mekong River (combined floods).

In Lao PDR:

- Bokeo province, regarding management of erosion risk of the Mekong River bank.
- Lower Se Bang Fai basin, regarding flood risk management in the area prone to combined floods.

In Cambodia:

- Kratie province, regarding erosion risk management along the Mekong River in this province.

- Right Bank Bassac River, regarding flood risk management in the floodplains south of Phnom Penh Municipality (delta flood).
- Left Bank Mekong River, regarding flood risk management south of the National Road No 1 (delta flood).

In Vietnam:
- Upper Se San basin, regarding flood risk management in the upper mountainous catchment (flash flood).
- Plain of Reeds (POR), regarding flood risk management in deep flooded areas (Delta flood) east of the Mekong River.
- Long Xuyen Quadrangle (LXQ), regarding flood risk management in the deep flooded zones (delta flood) west of the Bassac River.

The four Delta focal areas in Cambodia and Vietnam compose two transboundary areas, one east of the Mekong River and the other west of the Bassac River.

Flood risks in the focal areas.

A proper assessment of actual flood risks is the keystone for flood risk management. A methodology was developed for flood risk assessments in the focal areas, based on a comprehensive analysis of the hydrological and flood hazards and an in-depth assessment of the flood vulnerability in a number of sample districts in these areas.

The assessment of hydrological hazards (peak discharges and volumes for different return periods) has proven to be possible with accuracy acceptable for risk assessment. The methodology applied is in principle applicable basin wide. The conversion of hydrological hazards into flood hazards (flooding depth and duration for different return periods) has proven to be more problematic. Limited topographical information and modelling quality or availability hamper accurate flood hazard assessments. The derived flood hazards and flood maps for the focal areas are, therefore, to be considered with due care. The flood hazard assessment for the Lower Nam Mae Kok has been delayed until the completion of the hydraulic model for that area.

Flood vulnerability assessments have been made for a number of sample districts in the focal areas. These assessments have allowed for the estimate of indirect damages due to flooding in addition to the, generally known, direct damages. Moreover, damage curves could be estimated providing the relation between flood damages and inundation depth and time of flooding in a certain area. In Stage 2, these flood damage assessments were extended to cover now also the Nam Mae Kok basin and especially all the districts in the Mekong Delta.

A GIS based tool has been developed that allows for the calculation of flood risks by combining flood maps and other available GIS data sets with the derived damage curves. This tool is, in principle applicable basin wide, provided that flood maps are produced and adequate GIS data sets are available.

Also the risk assessments produced for the focal areas are to be considered with due care in view of the restricted reliability of the available data and modelling results. The approach, however, is sound and the results can be used for a first evaluation of the impact of flood risk management measures on the flood risks.

Results of the flood risk assessments show, not surprisingly, that the actual risks in unprotected flood plain areas, both in the Delta and in areas prone to combined flooding, are relatively low. Actual land use is tuned to the prevailing flood conditions and traditional coping mechanisms are in place to reduce the vulnerability considerably. In protected areas, though, like in the

Vietnamese Delta, the risks are significantly higher. This is due to the much higher potential damages as a result of a more intensive land use and infrastructure development.

Flood risks in the flash flood area in the upper Se San are related to fatalities rather than to tangible damages. These latter damages are caused by landslides rather than by direct flood impacts. It is anticipated that the flood risk assessment in the Chiang Rai focal area will give a completely different flood risk picture for flash flood conditions, however, tis exercise vcould not be completed due to issues with the hydraulic model that could not be resolved in the timeframe of FMMP-C2.

Strategic directions for flood risk management in the focal areas

Considering a variety of flood risk management options and on the basis of a first evaluation of the impacts on risk reduction and potential loss of flood benefits, strategic directions for flood risk management have been formulated for the focal areas.

The development of strategic directions for flood risk management in the unprotected flood plains in Cambodia and Lao PDR is closely related with the envisaged land use scenarios. Current land use in these areas is merely restricted to single rice cropping in the absence of adequate structural measures for flood management and irrigation. "Living with flood" is the leading concept. The risk under the present land use conditions is relatively low and substantial investment in structural protection works will be difficult to justify. If present cropping patterns are sustained, the focus should be on vulnerability reduction by flood proofing of settlements and infrastructure and, for instance, the use and/or development of less vulnerable rice varieties. However, if future land use – on the basis of providing certain levels of flood protection – changes considerably, then the feasibility of the flood protection measures changes substantially as can be seen from the IFRM Plan for the West Bassac area prepared as a Demonstration Project under FMMP-C2. In that case, the IFRM Plan has turned into an IWRM Plan that turns out to be feasible.

If, however, agricultural development is envisaged in these unprotected floodplains then such developments would create increased risks in the absence of adequate flood protection measures. Polder development would then be an obvious approach. Such development should go together with the provision of irrigation facilities. The loss of environmental benefits, especially fisheries related benefits, will play a crucial role in the planning and design of such polder schemes.

The focal areas in the Mekong Delta cannot be considered in isolation from the entire Delta. Flood management options at Delta level that aim at the reduction of the flood hazards for the entire Delta are very limited. Such options would have to consider the reduction of the flood discharges and volumes that enter the Delta or the creation of diversion and/or retention options in the Delta. Upstream retention as a flood mitigating measure for the Delta is not considered a realistic option.

The only substantial retention option within the Delta area is related to the use of the storage capacity of the Tonle Sap Great Lake. Preliminary investigations show that an uncontrolled diversion of early flood water (July-August) to the Great Lake has a very limited impact on the flood hydrograph in the Delta. A controlled diversion of early flood waters could, however, delay the early flooding downstream of Phnom Penh by a couple of weeks on the average. Such diversion, though, provides no risk reduction for infrastructure and housing in the floodplains, since this type of damage is driven by the peak flood. A diversion scheme for flood risk management can be supplemented with works that regulate the outflow of the Tonle Sap Great Lake and the adjacent floodplains. Such regulation would provide additional benefits since it improves the low flow conditions in the Delta. Such comprehensive regulation scheme aiming at an integrated water resources management in the Delta is beyond the scope of this FMMP-C2.

Flood management at regional level within the Delta is the approach that is being followed in the Vietnamese part of the Delta. This approach refers to the different regions in the Delta with different levels of flooding (deep, shallow) and distinct boundary conditions requiring different flood control solutions. This regional approach is also suggested for the Cambodian part of the Delta. The development of cross boundary strategic directions is not considered appropriate, in view of the great difference between the development level and pace at the two sides of the border. Emphasis is to be given to the potential impacts that the separate regional strategic directions may have on neighbouring regions, rather than to try to come to common strategic directions.

The Vietnamese long term planning for the deep flooded focal areas in the Mekong Delta is essentially based on the "living with floods" concept and the management of floods to allow for a safe production of double rice Winter-Spring and Summer-Autumn crops, while human settlements and essential infrastructure will be flood proof throughout the year. The corresponding flood management infrastructure allows, though, for a management of the floods also beyond the early July-August floods. It will be the operation of this infrastructure that determines when and which area is allowed to be flooded.

For the Cambodian deep flooded areas in the Delta it is suggested to provide protection against the early floods only, allowing the save harvest of a second crop. Human settlements and essential infrastructure are to be safeguarded also during the main floods, though. The shallow flooded areas in the Cambodian Delta focal areas could be provided with full protection.

It is recommended not to make (parts of) the area completely flood free. A system of controlled flooding should be designed, which reduces the damages, but at the same time conserves the benefits of the flooding as much as possible. Special attention should be given to the remaining natural areas, they are not only threatened by changes in the flooding regime, but also, and probably even more so, by encroachment of local people.

The relatively low flood related damages (besides the human fatalities) and limited development potentials do not justify substantial investments in sub-basin wide structural measures for flood hazard reduction in the flash flood area of the Se San Basin upstream of Kontum. Flood proofing of infrastructure, though seems a sound measure that could reduce substantially the existing flood risks in the area, including human fatalities. It is recommended to incorporate flood risk assessments and flood proofing measures in the socio-economic development and poverty reduction initiatives in these areas.

Transboundary impacts

Transboundary impacts related to above outlined flood risk management approaches in the focal areas are essentially restricted to the transboundary focal areas in the Mekong Delta.

The transboundary impacts in these areas have been derived from model simulations of several flood risk management scenarios on both sides of the border. The results indicate that the proposed developments in Cambodia have marginal impacts on the flood risks in Vietnam or may even be beneficial for the POR. The negative impacts will rise when the protected areas and/or the protection levels increase.

On the other hand, if the management of the floods on the Vietnamese side of the border goes beyond the early flood only, then there will be substantial negative impact on the flood risk in Cambodia.

The transboundary impacts in both directions result essentially from the loss of storage capacity during the different stages of the floods Retention options to compensate for lost storage capacity are hardly available. It is therefore suggested that compensating measures are sought in the diversion of floodwaters in the border zone towards the Gulf of Thailand and/or the Vam Co River.

Best Practice Guidelines

In the course of the project it became apparent that an adequate flood risk assessment is the basis for any further step in the flood risk management process. For that reason it was concluded that the guidelines for flood risk assessment should have a key position in the set of guidelines.

The full set of Best Practice Guidelines (BPG) has been structured as follows:
Best Practice Guideline for Flood Risk Assessment, including:

- Flood hazard assessment;
- Flood damage assessment, and
- Flood risk assessment

Best Practice Guidelines for IFRM Planning and Impact Evaluation, including:

- selection and use of soft measures to manage flood risks;
- selection of an appropriate mix of hard and soft flood risk management measures;
- socio-economic and environmental evaluation of flood risk management measures.

Best Practice Guidelines for the development and design of structural measures and flood proofing, including:

- flood proofing buildings and infrastructure in urban and rural areas;
- use, design, construction, maintenance and operation of structural flood mitigation works and floodplain infrastructure;
- control and repair of riverbank erosion.

Best Practice Guidelines for IFRM for BDP.

The BPG for IFRM planning and impact evaluation focuses on the evaluation of the impacts of flood risk management measures on the environment, including existing and planned socio-economic conditions and developments. The focus of the IFRM guidelines for BDP is, on the contrary, on the impact that socio-economic developments may have on flood risk.

The Best Practice Guidelines for Integrated Flood Risk Management have been developed to provide policy-makers, managers and Flood Management and Mitigation (FMM) professionals in MRC and national line agencies with a common knowledge base to apply in:

- policy formulation;
- strategy and plan development;
- project design and evaluation for flood risk management in the LMB.

Each member country of the LMB has its own policy and legal frameworks that will guide or regulate the planning, evaluation and implementation of flood risk management plans and measures. The BPGs do not attempt to summarize or replace these national guidelines, nor are they intended as a recipe for carrying out planning or project design for flood risk management in the LMB. Rather the BPGs provide an information resource and additional tools to be adapted according to each country and project context.

Priority investment (ProDIP) and Demonstration projects.

In an intensive consultation process all riparian countries nominated a number of flood risk management projects for being included in the Project Development and Implementation Plan (ProDIP). The consultant has added to these lists a number of projects that emerged from the development of the strategic directions for the focal areas. A first evaluation of these long-lists of projects was carried out by the consultants. In this evaluation the impact on risk reduction and on flood benefits were the key criteria. These evaluation results were discussed with the respective NMCs with the objective to arrive at short lists of the preferred 12 projects for Cambodia and Vietnam each, and 6 projects for Lao PDR and Thailand each.

The results of these discussions were presented in the draft Stage 1 Evaluation Report and endorsed in the Regional Stage 1 Workshop of 25 September, 2008.

On the basis of the shortlists of project for ProDIP and considering the objectives of the Demonstration projects, the consultant made a selection of projects that comply with these objectives. These 36 projects have been further investigated in Stage 2 and put together in the ProDIP that could be integrated in the project portfolio of the BDP.

The following recommended Demonstration projects were also endorsed in the Regional Stage 1 Workshop.

Flood Risk Assessment Lower Nam Mae Kok Basin

The results of the socio-economic surveys have been used for the elaboration of damage curves for the urban and rural districts in the Province.
It was the intention to produce flood hazard and risk maps with the help of hydraulic model, however this appeared not to be feasible.

IFRM plans for Lower Se Bang Fai in Lao PDR and the West Bassac Region in Cambodia:

The strategic directions as formulated under Stage 1 have been translated into an IFRM plans. For this planning exercise input of BDP was provided for the formulation of land use and water resources development scenarios in these areas.
The plan consists of a number of sub projects that have been formulated.

Flood protection criteria in the Mekong Delta in Vietnam

This demonstration project focused primarily on the methodology for the development of design criteria for diking schemes for flood protection in the Vietnamese part of the delta. The link between design criteria, flood risk and risk acceptance has been formulated. For areas with known flood risks it has been shown for different protection criteria what the economic impact is and what the residual risk.

Joint project for transboundary flood risk mitigation in the border zone between Vietnam and Cambodia.

Assessment of the impact of existing flood risk management plans on both sides of the border on the flood risks in the Vietnamese and Cambodian part of the Mekong Delta.
Due to serious delays in the availability of the improived hydraulic model for the delta, the identification of measures in the border zone for mitigating negative impacts on flood risk in the neighbouring country has not been possible in the timeframe and resources available under FMMP-C2.

Consultation and capacity building

National consultations and working group meetings were held in Stage 1 and Stage 2 regarding:

- the focal areas, with provincial and district authorities and relevant line agencies;
- the preparation of the list of projects to be nominated by the riparian countries;
- the strategic directions for the focal areas and the selection of projects for ProDIP;
- Best practice guidelines;
- the demonstration projects.

Additionally, a bi-lateral consultation was held with Cambodia and Vietnam on the strategic direction for flood risk management in the transboundary focal areas.

The FMMP-C2 training program was implemented during Stage 1 with the training course 'Introduction IFRM concepts and planning in the LMB. Training continued during Stage 2 with week-long regional and bi-national courses on the Best Practice Guidelines, i) Flood Risk Assessment, ii) IFRM Planning and Impact Evaluation, and iii) Structural Measures and Flood Proofing.

In total about 200 participants participated in the training courses and received a certificate. In general there was sufficient and good participation, both with regard to quantity and quality. Participants from all four countries expressed their high appreciation about the content and the delivery of the training courses.

CONTENTS

Abbreviations and Acronyms

ADB	Asian Development Bank
BDP	Basin Development Plan Program
DEM	Digital Elevation Model
DSF	Decision Support Framework
DTM	Digital Terrain Model
DWR	Department of Water Resources in Thailand
EIA	Environmental Impact Assessment
FMM	Flood Management and Mitigation
FFMP	Flood Management and Mitigation Program
FMMP-C1	Component 1 of the MRC FMMP: Flood Warning and Preparedness
FMMP-C2	Component 2 of the MRC FMMP: Structural Measures and Flood Proofing
FMMP-C3	Component 3 of MRC FMMP: Mediation of Trans-boundary Flood Issues
FMMP-C4	Component 4 of the MRC FMMP: Flood Emergency Management Strengthening
FMMP-C5	Component 5 of the MRC FMMP: Land Management
FRM	Flood Risk Management
GEV	Generalised Extreme value
GIS	Geographic Information System
IFRM	Integrated Flood Risk Management
IKMP	Information and Knowledge Management Program of the MRC
IWRM	Integrated Water Resources Management
KOICA	Korea International Cooperation Agency
LMB	Lower Mekong Basin
MRC	Mekong River Commission
MRCS	Mekong River Commission Secretariat
NGO	Non Government Organisation
NMC	National Mekong Committee
POR	Plain of Reed
PR	Provincial Road
ProDIP	Project Development and Implementation Plan
RNE	Royal Netherlands Embassy
TCEV	Two Component Extreme Value
TOR	Terms of Reference
WUP	Water Utilization Program of MRC
WUP-A	WUP Basin Modelling and Knowledge Base Project
WWF	World Wildlife Fund
1D / 2D / 3D	One Dimensional / Two Dimensional / Three Dimensional

IFRM Glossary

Damage curve	The functional relation between inundation characteristics (depth, duration, flow velocity) and damage for a certain category of elements at risk.
Direct damage	All harm which relates to the immediate physical contact of flood water to people, property and the environment. This includes, for example, damage to buildings, economic assets, loss of standing crops and livestock, loss of human life, immediate health impacts and loss of ecological goods.
Exposure	The people, assets and activities that are threatened by a flood hazard.
Flood control	A structural intervention to reduce the flood hazard.
Flood damage	Damage to people, property and the environment caused by a flood. This damage refers to direct as well as indirect damage.
Flood damage risk (= Flood risk)	The combination or product of the probability of the flood hazard and the possible damage that it may cause. This risk can also be expressed as the *average annual possible damage*.
Flood hazard	A flood that *potentially may* result in damage. A hazard does not necessarily lead to damage.
Flood hazard map	Map with the predicted or documented extent / depth / velocity of flooding with an indication of the flood probability.
Flood proofing	A process for preventing or reducing flood damages to infrastructural works, buildings and/or the contents of buildings located in flood hazard areas.
Flood risk management	Comprehensive activity involving risk analysis, and identification and implementation of risk mitigation measures.
Flood risk management measures	Actions that are taken to reduce the probability of flooding or the possible damages due to flooding or both.
Flood risk map	Map with the predicted extent of different levels / classes of *average annual possible damage.*
Hydrological hazard	A hydrological event (discharge) that may result in flooding.
Indirect damage	All damage which relate to the disruption of economic activity and services due to flooding.
Integrated flood risk management	The approach to Flood Risk Management that embraces the full chain of a meteorological hazard leading to flood damages and considers combinations of structural and non structural solutions to reduce that damage.
Meteorological hazard	A meteorological event (storm) that may result in a hydrological hazard and, eventually, in flooding

Resilience	The ability of a system / community / society to cope with the damaging effect of floods
Susceptibility	The opposite of resilience, that is to say the **inability** of a system / community / society to cope with the damaging effect of floods
Vulnerability	The potential damage that flooding may cause to people, property and the environment

1 INTRODUCTION

1.1 Guide to the reporting structure of the Flood Management and Mitigation Programme - Component 2, Structural Measures and Flood Proofing

Component 2 on Structural Measures and Flood Proofing of the Mekong River Commission's Flood Management and Mitigation Programme was implemented from September 2007 till January 2010 under a consultancy services contract between MRCS and Royal Haskoning in association with Deltares and Unesco-IHE. The Implementation was in three stages, an Inception Phase, and two Implementation Stages. During each stage a series of outputs was delivered and discussed with the MRC, the National Mekong Committees and line agencies of the four MRC member countries. A part of Component 2 - on 'Roads and Floods' - was implemented by the Delft Cluster under a separate contract with MRC. Component 2 prepared five Demonstration Projects which have been reported separate from the main products.

The consultancy services contract for Component 2 specifies in general terms that, in addition to a Final Report, four main products are to be delivered. Hence, the reports produced at the end of Component 2 are structured as follows:

Volume 1 **Final Report**

Volume 2 **Characteristics of Flooding in the Lower Mekong Basin**
Volume 2A *Hydrological and Flood Hazards in the Lower Mekong Basin;*
Volume 2B *Hydrological and Flood Hazards in Focal Areas;*
Volume 2C *Flood Damages, Benefits and Flood Risk in Focal Areas;*
Volume 2D *Strategic Directions for Integrated Flood Risk Management in Focal Areas.*

Volume 3 **Best Practice Guidelines for Integrated Flood Risk Management**
Volume 3A *Best Practice Guidelines for Flood Risk Assessment;*
Volume 3B *Best Practice Guidelines for Integrated Flood Risk Management Planning and Impact Evaluation;*
Volume 3C *Best Practice Guidelines for Structural Measures and Flood Proofing;*
Volume 3D *Best Practice Guidelines for Integrated Flood Risk Management in Basin Development Planning;*
Volume 3E *Best Practice Guidelines for the Integrated Planning and Design of Economically Sound and Environmentally Friendly Roads in the Mekong Floodplains of Cambodia and Vietnam*[1]*.*

Volume 4 **Project development and Implementation Plan**

Volume 5 **Capacity Building and Training Plan**

Demonstration Projects
Volume 6A *Flood Risk Assessment in the Nam Mae Kok Basin, Thailand;*
Volume 6B *Integrated Flood Risk Management Plan for the Lower Xe Bangfai Basin, Lao PDR;*
Volume 6C *Integrated Flood Risk Management Plan for the West Bassac Area, Cambodia;*
Volume 6D *Flood Protection Criteria for the Mekong Delta, Vietnam;*
Volume 6E *Flood Risk Management in the Border Zone between Cambodia and Vietnam.*

Volume 6E *Flood Risk Management in the Border Zone between Cambodia and Vietnam*

The underlying report is **Volume 1** of the above series.

[1] Developed by the Delft Cluster

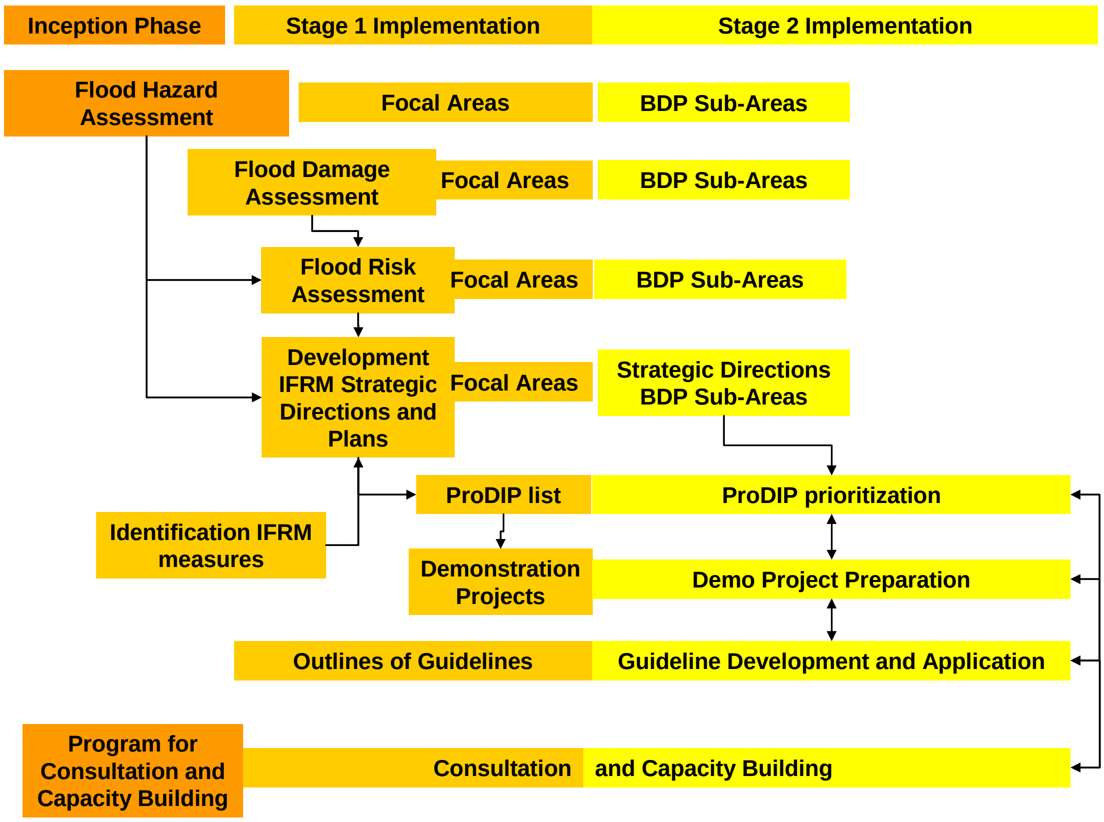
1.2 The Stage 2 Implementation Phase

The FMMP Component 2, Structural Measures and Flood Proofing, has been implemented in three steps, i.e. the Inception Phase and the Stages 1 and 2 of the Implementation Phase. The Inception Phase was initiated by the end of September 2007 and concluded in accordance with the Terms of Reference (ToR) with a Regional Workshop in Ho Chi Minh City by the end of January 2008, hence 4 months after project initiation. The original TOR envisage the Stage 1 Implementation Phase to be carried out in a period of 6 months, leaving 12 months for the Stage 2 Implementation Phase.

The core of Stage 1 has been in the preparation of strategic directions for flood risk management in the selected focal areas on the basis of flood risk assessments for those areas. In the slipstream of this activity, projects were identified for the FMM ProDIP and for Demonstration Projects. Also the outlines for the IFRM set of guidelines were prepared and the capacity building program initiated.

In the course of the implementation of the Stage 1, it became apparent that an effective execution of the entire Implementation Phase would require a better balance between the two stages of that Phase. It was agreed to split up the 18 months implementation phase into a 7 months Stage 1 and an 11 months Stage 2. Consequently, the Stage 1 covered the period February 2008 - August 2008. Stage 1 was concluded with the Stage 1 Evaluation report and the Stage 1 Regional Workshop held in Ho Chi Minh City on 25 September 2008.

The scope of the Stage 2 Implementation Phase, which was agreed during the mentioned Regional Stage 1 Workshop, is shown in the following figure:



Stage 2 started effectively on 5 January 2009 and will be concluded with the Draft Final Report (early January 2010) and a Regional Workshop to be held in Vientiane on 1 and 2 February 2010, to be followed by the Final Report scheduled to be submitted by the end of February 2010.

Stage 2 essentially followed the work plan set out at the end of Stage 2, however, the work plan had to be adjusted several times due to serious delays and issues with the hydraulic modelling tools.

Stage 2 focussed on i) the development of the set of Best Practice Guidelines, ii) the implementation of five Demonstration Projects, iii) the provision of training and capacity building especially in relation to the guidelines and the demonstration projects, and iv) the development of the Project Development and Implementation Plan (ProDIP). The development of the guidelines and the demonstration projects went in parallel in order to benefit from the experiences gained in the application of draft guidelines in project preparation.

During Stage 2, a number of comprehensive Technical Notes on specific subjects in the Demonstration Projects and drafts of the Best Practice Guidelines have been produced and circulated and discussed with the Working Groups established to guide the implementation of the Demonstration Projects, consisting of members of the NMCs and concerned Line Agencies.

1.3 Reporting requirements

The TOR of the FMMP Component 2 calls for a (Draft) Final Report at the end of the consultancy services assignment but does not specify specific reporting requirements other than that in addition to the (Draft) Final Report four main products are top be delivered as follows:
1. Characteristics of Flooding in the Lower Mekong Basin;
2. Best Practice Guidelines;
3. ProDIP and Demonstration Projects, and
4. Capacity Building and Training Plan.

Following agreement reached during contract negotiations for the consultancy services, the Demonstration Projects are not part of the four main products due to their country specific nature and purpose.

The reporting structure that evolved from the above requirements is presented in Section 1.1.

During Stage 2 implementation the second and third Semi-Annual Progress reports and a Mid-Term Report were produced. These reports addressed essentially the progress made in administrative terms.

The Stage 2 Draft Final Report will be finalised upon the incorporation of the observations, comments and conclusions of the national consultation meetings to be held in the second half of January 20010 and the regional workshop regarding this draft report scheduled for the beginning of February 2010.

1.4 Structure of this Stage 2 (Draft) Final Report.

This (Draft) Final Report constitutes a compilation of the results of the respective activities that were carried out during this implementation stages as illustrated above. The compilation is made on the basis of the Technical Reports that are reported in 16 separate Volumes (see Section 1.1). The 16 Volumes provide detailed descriptions of the Stage 1 and Stage 2 activities and outputs.

In line with the approach that is followed in the preparation of the strategic directions for flood risk management in the focal areas, this report and the corresponding Volumes, start with the presentation of methodology and results of the flood hazards assessments in the focal areas in Chapter 2, followed in Chapter 3 by the methodology and results of the flood damage and risk assessments in the same areas.

Based on these assessments, options for flood risk management in these areas are identified in Chapter 4 and strategic directions formulated.

Methodologies applied and lessons learned during the Stage 1 planning exercises in the focal areas have been laid down in Best Practice Guidelines for i) Flood Risk Assessment, ii) IFRM Planning and Impact Evaluation, iii) Development and Design of Structural Measures and Flood Proofing and iv) the IFRM guidelines for BDP; these are briefly described in Chapter 5.

The planning exercises in the focal areas have also generated a number of projects that qualify for ProDIP and or Demonstration projects in addition to projects that have been nominated by the riparian countries. The project possibilities and the proposal for the lists of projects for ProDIP and Demonstration Projects as reported under Stage 1 has been finalized and is summarized in Chapter 6 which also presents the summaries of the five Demonstration Projects that have been prepared during Stage 2.

Chapter 7 reports about the GIS based flood data database and Chapter 8 about the consultation and capacity building program that was implemented during the Stage 2.

In Appendix 1, the relation is presented between the 16 Volumes that come with this (Draft) Final Report and the deliverables as called for in the TOR.

2 FLOOD HAZARDS IN THE FOCAL AREAS

2.1 Flood hazard assessments: methodology and approach

Flood hazards (probability of high water levels) result from hydrological hazards (probability of high discharges), which are determined by the meteorological boundary conditions and the drainage characteristics of the watershed. To transform hydrological hazards into flood hazards the discharge hydrograph is to be translated into water levels, water depths and duration. In view of the latter apart from peak discharges the flood volume also plays a role as this affects the duration of flooding.

The procedure to be used for flood hazard assessment for selected return periods depends on the type of flood and the location of occurrence. The following types of floods are distinguished:
1. Tributary floods;
2. Mainstream floods,;
3. Combined floods;
4. Floods in the Cambodian Flood Plain;
5. Flood in the Mekong Delta.

Tributary floods
Tributary floods, which occur in the steep sloped upper reaches of the basins are flash floods due to intense rainfall after a long rainy period forcing the catchment to respond quickly to the rainfall. Flash floods are short lived (few hours), rise and fall rapidly and the flow velocities are very high. Further downstream flashiness reduces due to damping and differences in the timing of the contributions of tributaries. Out of the backwater reach of the Mekong the tributary flood hazard is determined by extreme river discharge and the downstream river conveyance capacity.

Mainstream floods
Mainstream floods are caused by high water levels on the Mekong as a result of extreme river flows in combination with limitations in the downstream conveyance capacity of the Mekong river and flood plain.

Combined floods
Combined floods are floods that occur in the downstream sections of the tributaries, where the flood level is determined by the combination of tributary flow and the water levels in the Mekong, backing up the tributary levels and impeding the drainage. Also, when the levels in the Mekong are high, backwater flowing into the tributaries may occur. The character of these floods is not flashy; they may stay for weeks. In view of the shallow areas along the Mekong downstream of Vientiane a large number of tributaries in their lower reaches face this type of flooding.

Floods in the Cambodian Flood Plain
The flood in the Cambodian flood plain describes the conveyance and storage of the flood in the Mekong and its flood plain downstream of Kratie to Phnom Penh, inclusive of the flooding around Tonle Sap Lake and the inflow to and outflow from the lake via the Tonle Sap River. Important aspects here are the spill levels of the rivers, the flood plain conveyance in relation with the road infrastructure and existence and dimensions of embankments.

Floods in the Mekong Delta
The flood in the Mekong Delta deals with the conveyance of floodwater via the Mekong and Bassac Rivers and their flood plains, including the use of colmatage canals to divert and control the flow from and to the rivers. In the delta the levels rise slowly due to the storage in Tonle Sap Lake and in the Mekong flood plains. Flooding here is recognized as essential for soil fertility,

biodiversity and aquaculture. At the same time, it hampers use of agricultural land for maximum output. The flood levels in the Mekong Delta in its downstream part are essentially the result of upstream and lateral inflow, net rainfall in the delta and downstream water levels at sea.

Focal Areas have been selected to develop IFRM strategic directions. In the selection of the Focal Areas the type of floods has been one of the key selection criteria. The following focal areas have been selected by the National Mekong River Committees for application of IFRM:

1. Focal Area 1: Nam Mae Kok at Chiang Rai and at river mouth: representative for risk assessment of tributary and combined floods;
2. Focal Area 2: Bokeo Province along Mekong River: flood hazards for river bank erosion;
3. Focal Area 3: Se Bang Fai from Highway Bridge 13S to Mekong River: representative for risk assessment in case of combined floods;
4. Focal Area 4: Kontum Province in upper Se San basin: representative for risk assessment in case of flash tributary floods;
5. Focal Area 5: Kratie Province: hydraulic design conditions for river bank protection near the city of Kratie
6. Focal Area 6: Mekong Delta: representative for risk assessment in case of delta flooding in the deep flooded Takeo and Prey Veng areas in Cambodia and in the Long Xuyen Quadrangle and POR in Vietnam.

In this chapter the hydrological and flood hazard assessment method are discussed as well as the results of the computations for the focal areas.

2.2 Focal Area 1: Nam Mae Kok

2.2.1 Method

Focal Area 1 comprises the Nam Mae Kok basin from Chiang Rai and surrounding some 75 km from the river mouth to its confluence with the Mekong at Sop Kok at rkm 2356, just downstream of Chiang Saen. The basin covers an area of 10,730 km^2 of which some 31% lays in Myanmar. Mayor tributaries are the Nam Mae Fang and the Nam Mae Lao, which latter drains immediately downstream of Chiang Rai. The basin is mountainous on the divides with elevations up to 2,000 m. The valleys of the Fang, the Lao and the Kok rivers from Chiang Rai to the mouth are flat and flood prone. The basin is densely forested in the upper areas with agricultural development in the lower reaches.
The flood hazard is determined for tributary floods around Chiang Rai and combined floods near the river mouth. In Annex 1 a detailed elaboration is presented on the applied procedures for the hazard assessment of the two types of floods. A summary is given below.

During the mayor flood of 2006 the lower Nam Mae Lao and a small creek named Nam Mae Korn were flooded, see Figure 2.1.

Flood hazard assessment for tributary flood
The procedure to derive the flood hazard for the Chiang Rai region is as follows:

1. The hydrological hazard is derived from a univariate extreme value distribution fit to the observed distribution of annual maximum discharges for the following locations:
   a) Nam Mae Kok at station Chiang Rai;
   b) Nam Mae Lao at station Ban Tha Sai, and
   c) Nam Mae Kok downstream Chiang Rai by combining the flows observed at the stations Chiang Rai and Ban Tha Sai
2. Flood levels are subsequently to be derived from a transformation of the hydrological hazard (i.e. peak discharges of selected return periods) using a hydraulic model of river and flood plain. The model is run for design hydrographs scaled to the required peak discharge for damage assessment related to flood depth and duration. The design hydrographs are

determined by scaling of the 20 largest flood hydrographs relative to the peak value in a window of 30 days around the peak.

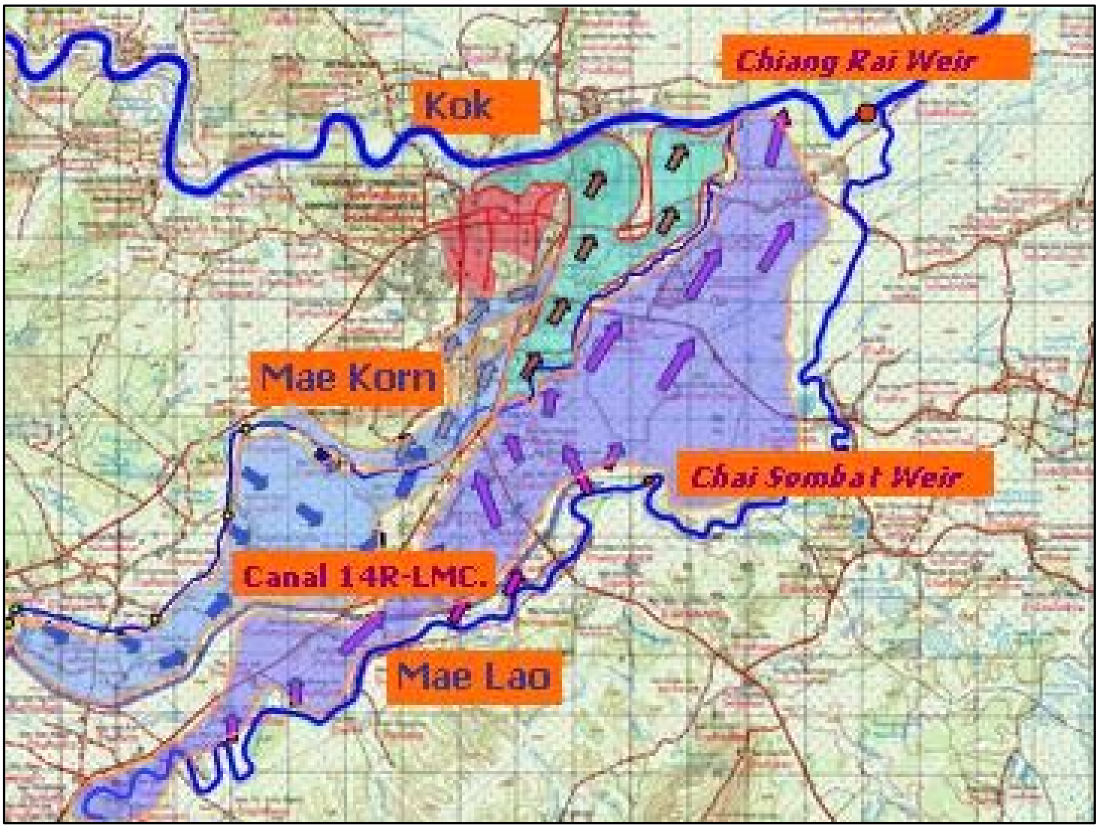


Figure 2.1. Flooding in Chiang Rai Province near the city of Chiang Rai.

Flood hazard assessment for combined floods

The water levels in the Nam Mae Kok in its lowest 25 km are affected by backwater from the Mekong. Here the Nam Mae Kok discharge as well as the water level in the Mekong determines the maximum water level. To determine the flood hazard of combined floods use is made of the Monte Carlo sampling technique to derive exceedance probabilities of water levels. The procedure uses three variables, representing the main causes for high water levels in the downstream part of the Nam Mae Kok:

- The maximum discharge in the Mekong river at Chiang Saen;
- The total volume of the flow in the Mekong river at Chiang Saen;
- The maximum discharge in the Nam Mae Kok near the river mouth.

The first two variables determine the downstream water level in the Mekong.

For each of the three random variables, samples are taken from their respective probability distribution functions. This procedure is repeated *N* times (with *N* sufficiently large) to obtain *N* combinations of possible realisations of the three random variables.

For each combination/year the hydraulic model is applied to derive the relevant hydraulic features like maximum water level at a number of locations in the Nam Mae Kok. Formally, this means that the hydraulic model should be run *N* times, but since *N* is generally quite large (10,000 in this case) that would require too much computation time. Instead, the model is run for 150 different combinations of the three random variables that basically cover the whole spectre of possible outcomes. The results of the 150 simulations are stored in a database.

Results of the *N* Monte Carlo runs are then determined by interpolation of the results of the 150 simulations. Since 3 random variables are involved, the interpolation is 3-dimensional. The next step is to derive the probability of exceedance of threshold values of the damage/maximum water level from the number of successes out of N. Repeating this procedure for a range of threshold values provides a relation between damage/maximum water level on one hand and exceedance probability on the other hand. The procedure is applied separately for each location in the area in which one is interested, as the relation between the three random variables on one hand and the resulting maximum water level or damage on the other hand may vary significantly from one location to the other.

2.2.2 Results

Data validation

A point of concern in the Kok basin is the quality of the hydrological data. Though the discharge series are sufficiently long for extreme value analysis, the base of these data is questionable. The applied stage-discharge relations for the stations on Nam Mae Kok and tributaries varied strongly from year to year.

Hydrological hazard

The hydrological hazard expressed as extreme discharge for selected return periods have been determined for the Nam Mae Kok at Chiang Rai, the Nam Mae Lao at Ban Tha Sai and the Nam Mae Kok downstream of the Lao confluence.

The peak discharges for selected return periods in the Nam Mae Kok at Chiang Rai, Nam Mae Lao at Ban Tha Sai and the Nam Mae Kok downstream of the Nam Mae Lao confluence are presented in Table 2.1.

Table 2.1 Peak-discharges in m^3/s for distinct return periods in the Nam Mae Kok and Nam Mae Lao around Chiang Rai according to Generalised Extreme Value (GEV)-distribution

Return Period (years)	Nam Mae Kok Chiang Rai u/s	Nam Mae Lao Ban Tha Sai	Nam Mae Kok Chiang Rai d/s
	1969-2005	1972-2002	1969-2005
2	540	180	723
5	694	215	898
10	790	232	989
25	903	247	1080
50	982	256	1135
100	1057	263	1181

Analysis shows that the annual peak discharges on the Nam Mae Kok at Chiang Rai and the Nam Mae Lao at Ban Tha Sai do generally not occur at the same time. This feature is to be included in the selection of the boundary conditions for flood hazard assessment with the hydraulic model; when peak values are applied to one branch a representative discharge is to be selected for the other, commensurate with history.

Neither the peak discharges nor the annual flood volumes in the Mekong versus the Nam Mae Kok show significant correlation. Furthermore, the annual maximum discharges on the Mekong occur on average about two weeks earlier than the annual peaks on the Nam Mae Kok.

Flood hazard

TNMC developed a hydraulic model of the Nam Mae Kok for flood and drought studies. The existing 1D model is based on ISIS-software. The model is considered to be unsuited for reliable flood mapping. Improvements and extensions are scheduled but have not yet materialized. Therefore, the transformation of extreme discharge hydrographs to flood levels could not yet be established. Design hydrographs have been developed for flood hazard computations around Chiang Rai city. An example is shown in Figure 2.2.

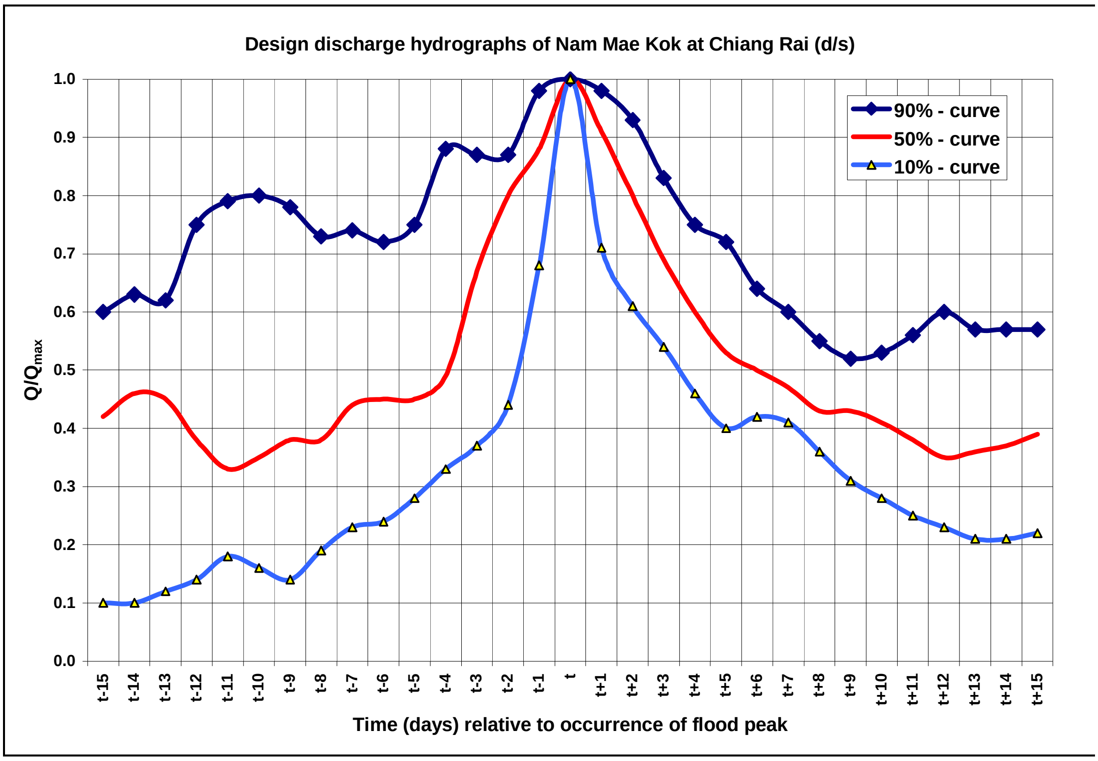


Figure 2.2 10%, 50% and 90% design hydrographs of Nam Mae Kok at Chiang Rai downstream Lao junction .

The boundary conditions of the hydraulic model will include:

1. for flood hazard assessment around Chiang Rai:
   a) Nam Mae Kok <u>upstream</u> Lao confluence: design hydrograph on Nam Mae Kok with related hydrograph on Nam Mae Lao/Nam Mae Korn;
   b) Nam Mae Kok <u>downstream</u> of Chiang Rai: design hydrograph is sum of Chiang Rai and Ban Tha Sai;
   c) Nam Mae Lao/Nam Mae Korn upstream of confluence: design hydrograph on Nam Mae Lao (Korn derived from Lao) with related hydrograph on Nam Mae Kok;
2. for flood hazard assessment near Nam Mae Kok mouth: selection of combination of water level hydrographs on Mekong at Sop Kok and discharge hydrographs of Nam Mae Kok for input to Monte Carlo technique.

2.3 Focal Area 2: Flood hazard for Mekong River bank erosion in Bokeo Province

2.3.1 Method

Focal Area 2 comprises river bank protection works along the Mekong River Bokeo Province selected by the LNMC. This includes the following locations along the river (chainage according to hydrographic atlas of MRC):

- Ban Thon Peung at rkm 2367-2369;
- Ban Don Savan at rkm 2364;
- Ban Kouan at rkm 2359;
- Ban Simouangngam at rkm 2349;
- Ban Bokeo at rkm 2314.

The location of the river bank protection sites is presented in Figure 2.3.

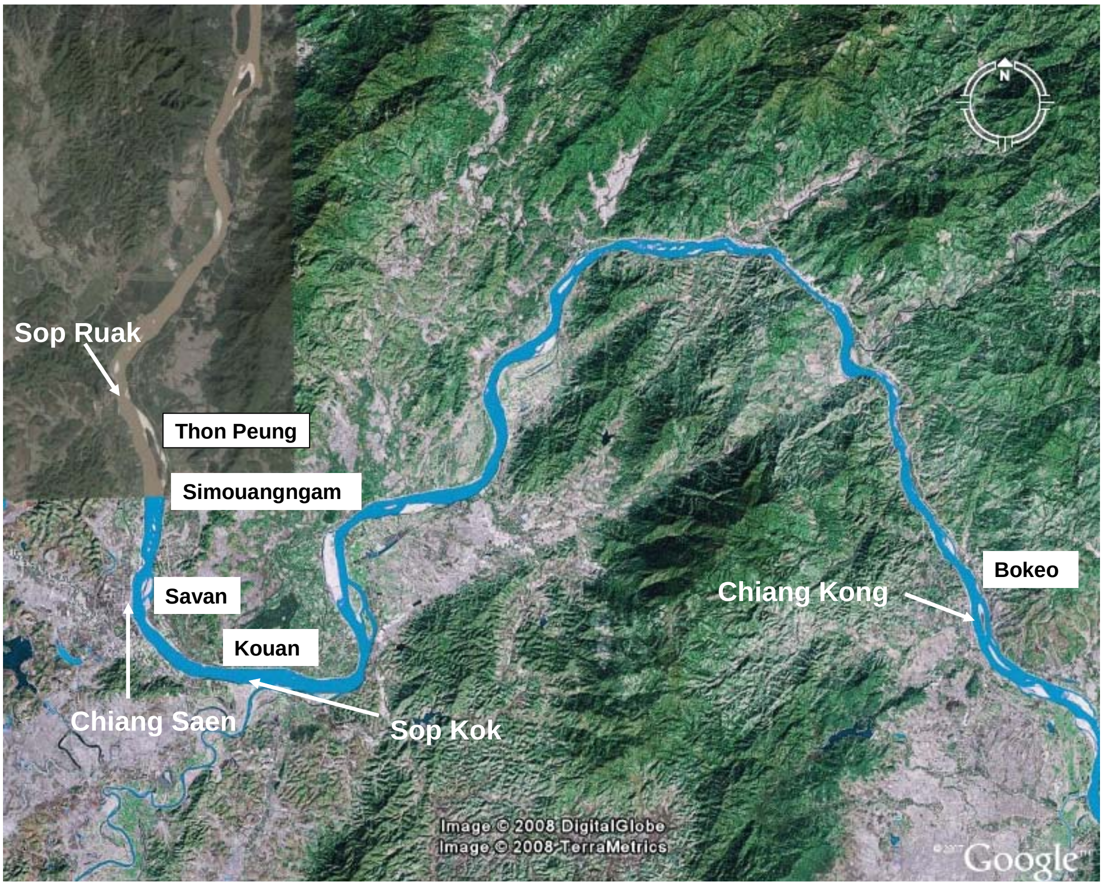


Figure 2.3 Location of water level gauging stations around Bokeo

The following hydrological information is required to support the hydraulic design of the protection:

- Water levels including maximum high water level, the 95% not-exceeded water level, the median water level, the 5% not-exceeded water level, the minimum water level and the rate of rise and of fall of the water level;
- Flow velocities;
- Rate of rise and fall of the water level.

In the Mekong reach of Focal Area 2 the required water levels are obtained from observations made at the following hydrometric stations (see Figure 2.3): Sop Ruak (rkm 2370.4), Chiang Saen (rkm 2364), Sop Kok (rkm 2359), and Chiang Kong (rkm 2313). The required water levels for the gauging locations are obtained from the average duration curves. By linear interpolation between the stations, the required levels at the selected river bank protection locations are obtained. Representative values for the rate of rise and of fall of the water level in m/day are computed from the time derivative of the hydrograph of station Chiang Saen.

Flow velocities should basically be obtained from 2D or 3D hydraulic models for detailed assessment of bank erosion. At this stage however average values are considered to be sufficient. These are computed for the maximum water level from the discharge at Chiang Saen upstream of Sop Kok augmented with the inflows to the Mekong from the Nam Mae Kok and Nam Mae Ing for the day of the maximum water further downstream. Combining the discharge with the cross-sectional areas available under the maximum water levels in the cross-sections from the Hydrographic Atlas of the Mekong the cross-sectional averaged flow velocity is obtained.

2.3.2 Results

The design water levels at the critical river stretches are obtained from the values at the stations by linear interpolation. The levels are presented in Table 2.2 and shown in Figure 2.4. The rates of rise are generally less than 1.5 m/day and less than 1 m/day for the fall. Occasionally, rises above 2 m/day have been observed.

The cross-section averaged flow velocities range from 1.8 to 2.5 m/s in the section Ban Thon Teung and from 1.7 to 2.0 m/s for the downstream sections.

Table 2.2 Design water levels at bank protection sections in Bokeo Province

Location	Location (Rkm)	Min (masl)	5%-level (masl	50%-level (masl)	95%-level (masl)	Max (masl)
Ban Thon Peung	**2369**	359.51	360.07	361.61	365.64	369.54
	2368	359.07	359.67	361.25	365.29	369.28
	2367	358.63	359.26	360.88	364.93	369.03
Ban Don Savan	**2364**	357.31	358.04	359.77	363.86	368.27
Ban Kouan	**2359**	356.08	356.68	358.37	362.69	368.02
Ban Simouangngam	**2349**	353.06	353.66	355.31	359.83	365.31
Ban Bokeo	**2314**	342.49	343.08	344.60	349.80	355.80

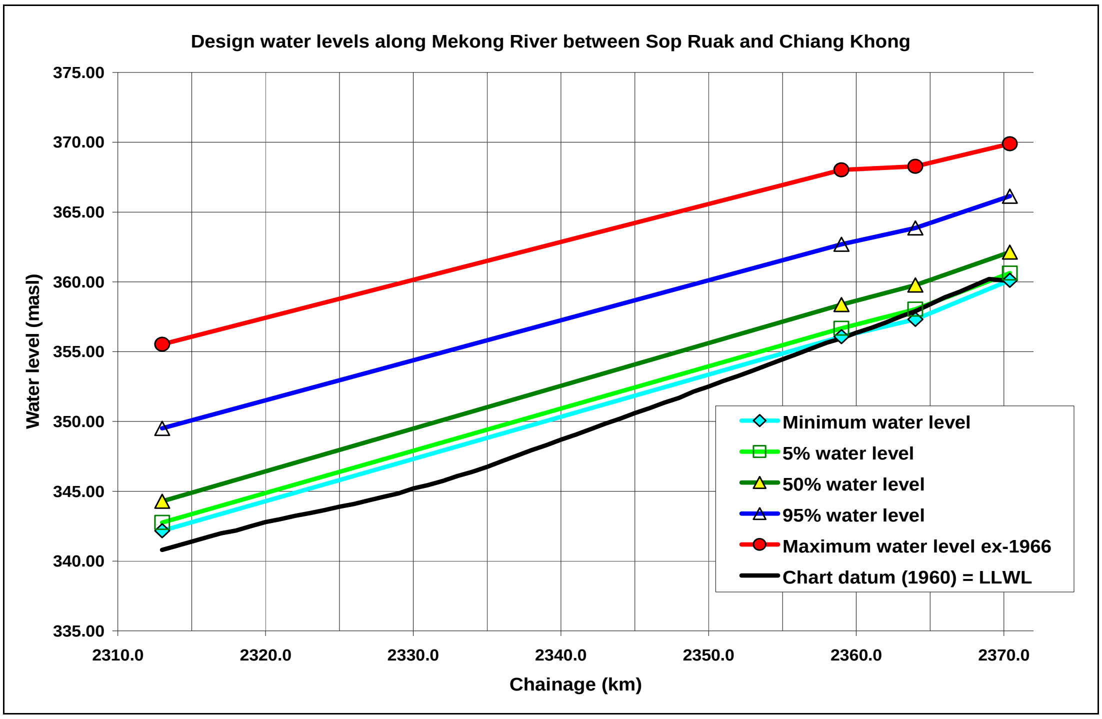


Figure 2.4 Design water levels in Bokeo Province on Mekong river

2.4 Focal Area 3: Se Bang Fai

2.4.1 Method

The Se Bang Fai basin has been selected by the LNMC as Focal Area for Integrated Flood Risk Management in Lao PDR. The Se Bang Fai basin covers an area of 10,240 km^2. The river takes its rise in the Annamite mountain range and it debouches into the Mekong opposite of That Phanom at rkm 1,166. The Focal Area concerns the lower Se Bang Fai river and flood plain from Se Bang Fai Highway Bridge to the river mouth. Whereas the upper basin is steep, below Mahaxai the river slopes are small and this reach is almost entirely affected by backwater from the Mekong. Hence floods on the lower Se Bang Fai are classified as combined floods. Flood extent around Nong Bok is shown in Figure 2.5

Satelite Photo of Flood Extents on Sept 17, 2000 in Xe BangFai

Figure 2.5 Extent of flooding along Lower Se Bang Fai and Mekong in the year 2000

The procedure applied to assess the flood hazard due to combined floods uses the Monte Carlo sampling technique to derive exceedance probabilities of water levels and damages. The procedure uses three random variables, representing the main causes for high water levels in the downstream part of the Se Bang Fai catchment:

- The maximum discharge in the Mekong river at That Phanom;
- The total volume of the flow in the Mekong river at That Phanom;
- The total volume of the flow in the Se Bang Fai river at Mahaxai, including the diversion from Nam Theun.

The method is similar to the one described in Sub-section 2.2.1 for the lower Nam Mae Kok reach near the Mekong. The samples in the Monte Carlo procedure are taken from a database containing the results of hydraulic model simulations of a limited number of combinations of boundary conditions. For the Nam Mae Kok 150 combinations were mentioned. There, a large number was required as the Kok and Mekong flood volumes and peaks are not correlated. For the Se Bang Fai a reduced number of 90 is sufficient in view of the significant correlation between Se Bang Fai and Mekong flood volumes and peaks, limiting the degrees of freedom in selecting historical years. For the hydraulic modelling the Mekong flood volumes and peaks at That Phanom (actually the flow data of Savannakhet have been used) are translated into water levels.

The ISIS 1D hydraulic model of the lower Se Bang Fai developed by the LNMC and MRC has been applied for the simulations. Verification of the calibration for Se Bang Fai Highway Bridge for the years 1995-2000 shows that the model generally underestimates the water levels with about 6 dm. It follows that the model results are suitable for demonstration purposes but not for design.

Summing up, the flood hazard assessment for the lower Se Bang Fai involves the following steps:

1. assessment of the hydrological hazard in the lower Se Bang Fai;
2. development of a hydraulic model of the river and flood plain to translate water levels and discharges into flood levels;
3. selection of 90 combinations of Mekong and Se Bang Fai floods;
4. running of the hydraulic model for 90 combinations of inflows (Mahaxai and lateral inflow) and downstream water levels (That Phanom);
5. application of Monte Carlo technique to simulations;
6. determination of flooding extent, depth and duration;
7. repeat the Steps 2, 4, 5 and 6 for each development alternative.

2.4.2 Results

Hydrological hazard

The frequency distributions of annual maximum discharge and flood volumes at the boundaries of the Focal Area are displayed in Table 2.3.

Table 2.3 Peak-discharge and flood volumes (June-November) for distinct return periods in the Se Bang Fai at Mahaxai and the Mekong at Savannakhet

Return periods (years)	Se Bang Fai at Mahaxai		Mekong at Savannakhet	
	Peak discharge (m^3/s)	Flood Volume (MCM)	Peak discharge (m^3/s)	Flood Volume (MCM)
2	1,757	6,916	28,623	220,577
5	2,177	9,045	32,950	250,532
10	2,398	10,188	35,220	264,469
25	2,626	11,386	37,550	277,351
50	2,765	12,126	38,961	284,374
100	2,881	12,755	40,139	289,752

In addition, relations between peak discharges and flood volumes have been established to arrive at 90 realistic combinations of peak flows and flood volumes for the Mekong and the Se Bang Fai in the selection of boundary conditions for the hydraulic model.

Flood hazard

The flood hazard along the lower Se Bang Fai has been assessed with the Monte Carlo procedure for the following cases:

1. no embankments along the Se Bang Fai (Case 1);
2. embankments along the left bank (Case 2);
3. embankments along the left and right banks (Case 3).

The water levels derived for the Se Bang Fai without embankments along the lower river are shown in Figure 2.6 for the river and for the flood plain in Figure 2.8. The flood extent in the flood plain follows from a comparison of the water levels with the Digital Elevation Model (DEM). Compared to Figure 2.5 it appears that the flood extent around Nong Bok is fairly well simulated, but immediately west of the Highway strongly underestimated.

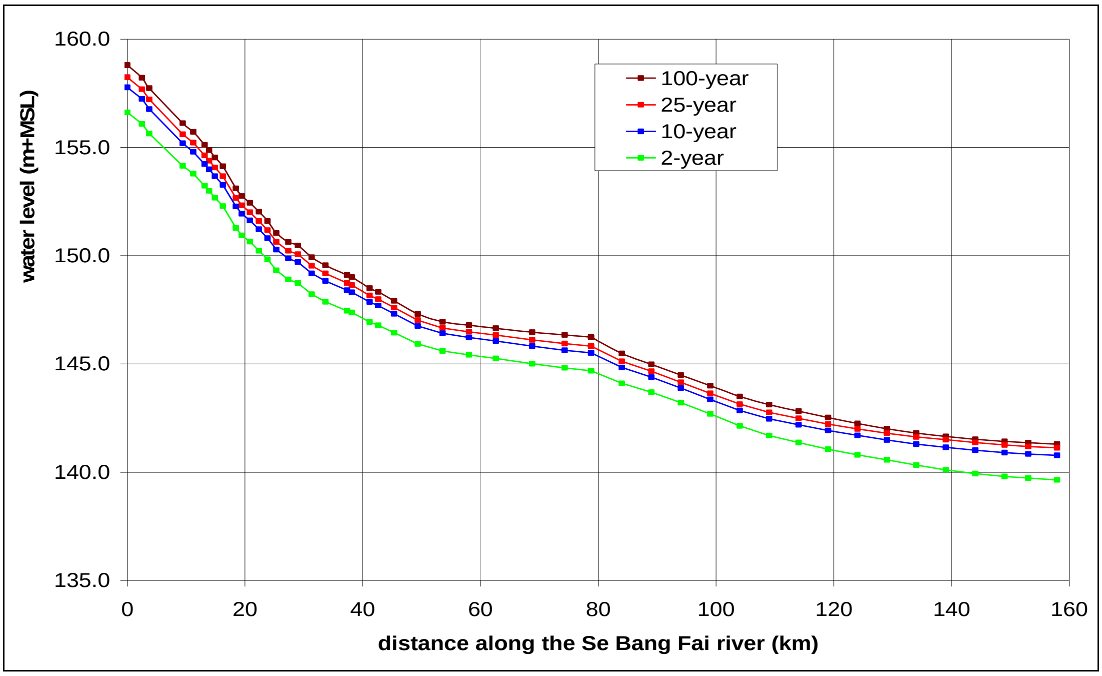


Figure 2.6 Computed 2, 10, 25 and 100-year flood level along the Se Bang Fai river for the case with no embankments.

The results for the cases 2 and 3 with embankments along the left and along both sides of the river (see Figure 2.7) are presented in Figure 2.9, showing the effect of these developments on the 100-year water levels along the river. It is observed that full embanking of the Se Bang Fai downstream of the Highway Bridge will increase the water levels locally with more than 1 m.

Another option that has been proposed is the construction of a bypass canal "Xelat" from the Se Bang Fai at Sokbo to the Mekong at Bungsan Nua upstream of That Phanom, see Figure 2.10. It involves an 8 km long canal with bed width of 200 m at an elevation of 138 masl. The effect of this bypass canal has been investigated with an extended hydraulic model including also the reach of the Mekong from Thakek to That Phanom. Simulations for the years 1995-2000 indicated that the bypass conveyed up to 500 to 1000 m^3/s, lowering the maximum water levels along the rivers near the off-take with about 0.5 to 1.0 m. Similar values are found for the flood plains with substantially reduced flood duration.

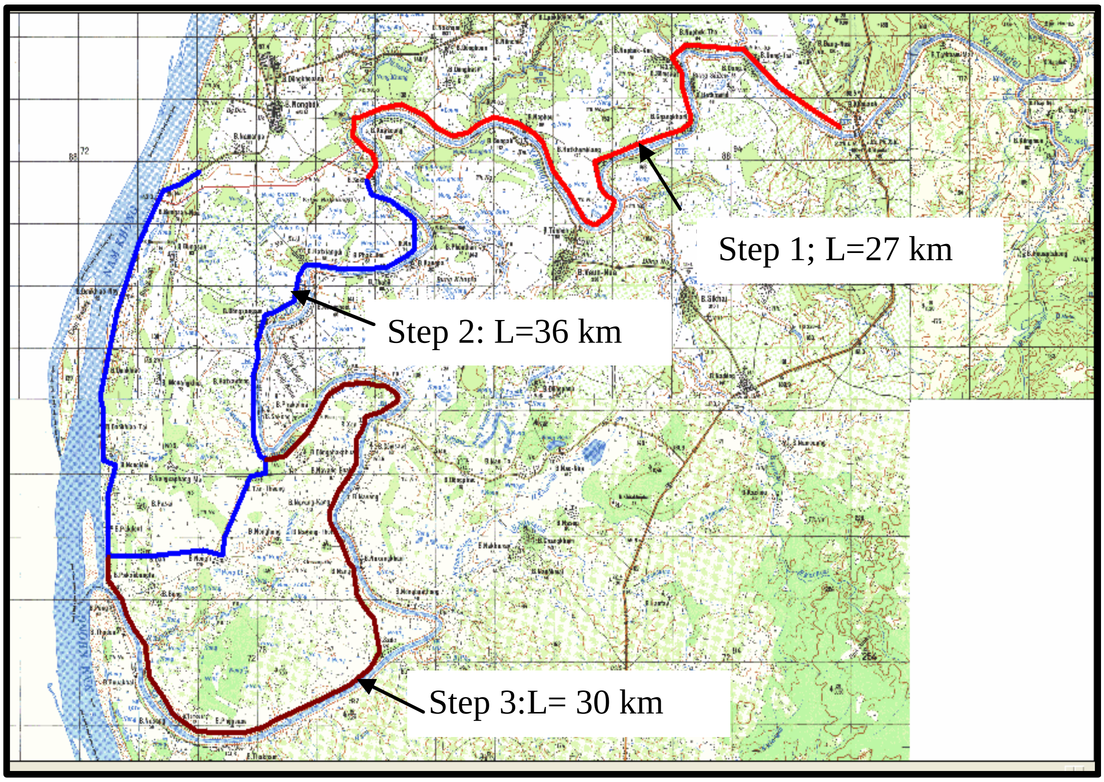


Figure 2.7 Construction of dikes along the right bank of the Se Bang Fai downstream of Highway Bridge

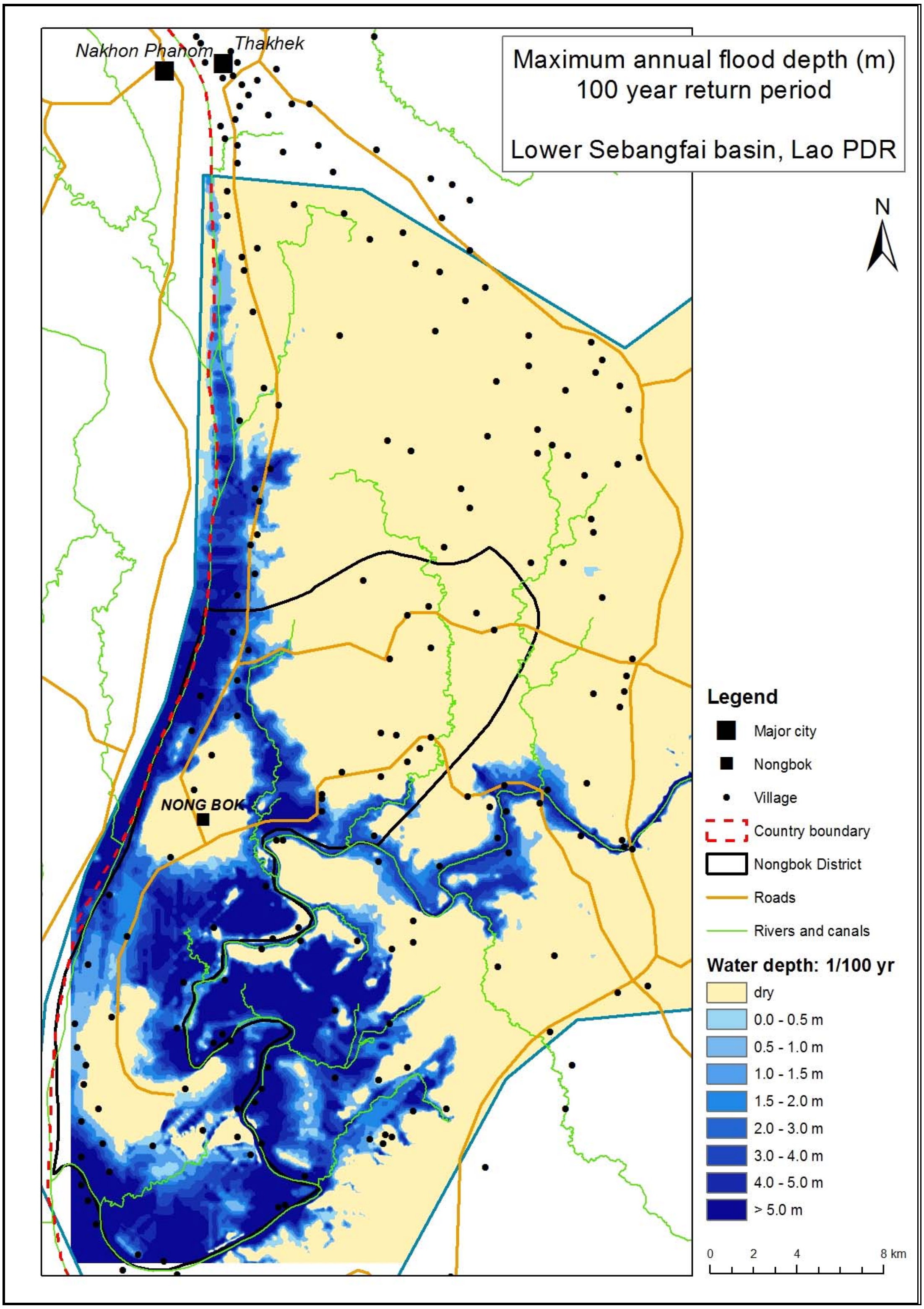


Figure 2.8 Flood depth and extent map lower Se Bang Fai, Case 1: Base case for T=100 years return period

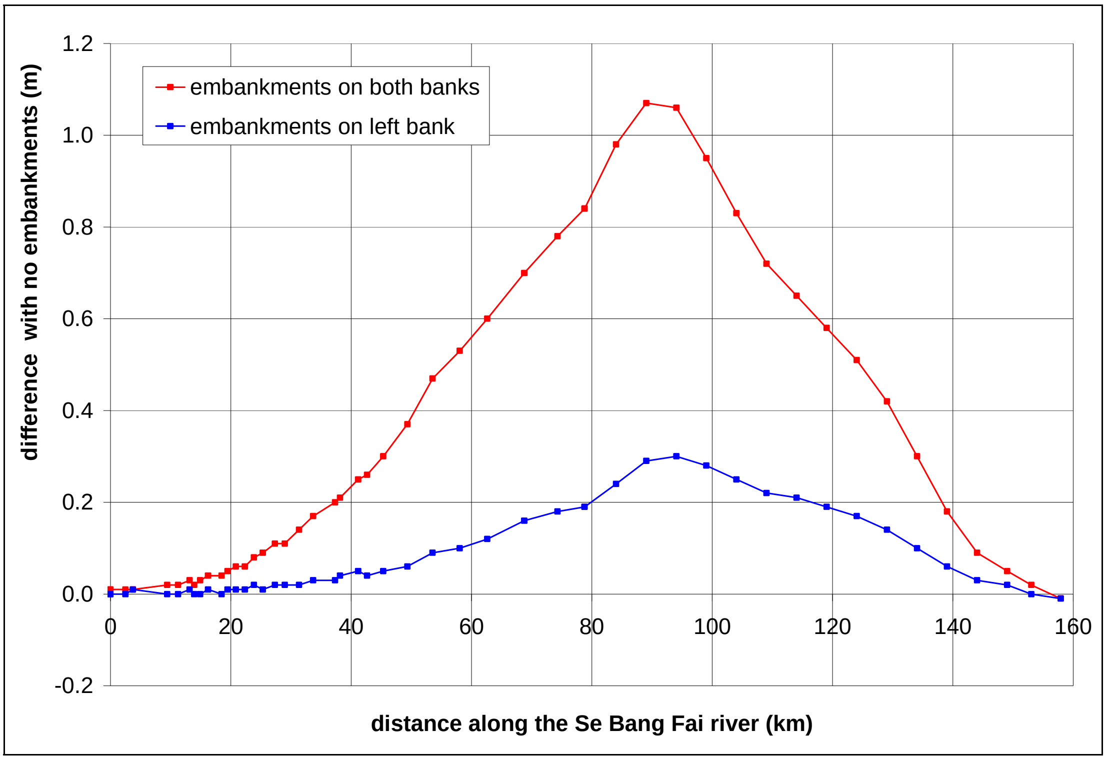


Figure 2.9 Differences in the computed 100-year flood level along the Se Bang Fai river for Cases 2 and 3 relative to case 1, the Base Case.

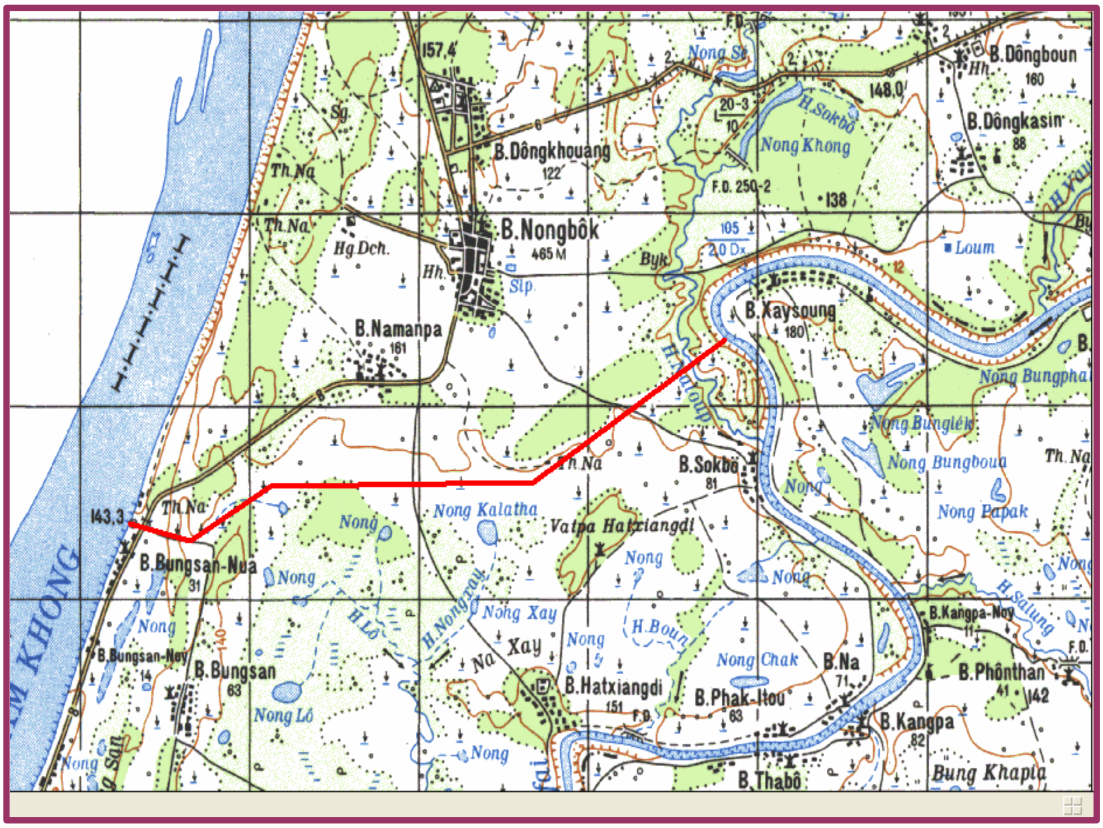


Figure 2.10 Canal “Xelat” from Sokbo to Bungsan Nua

2.5 Focal Area 4: Upper Se San

2.5.1 Method

VNMC has proposed the Upper Se San in Kontum Province as Focal Area for flood risk assessment due to flash floods. The headwaters of the Se San are formed by the Dak Bla and Krong Po Ko rivers, which join some 15 km downstream of the city of Kontum. Hydrographs of the Dak Bla at Kontum clearly show that floods on this river can be very flashy, see e.g. the flood of 1996 as shown in Figure 2.12. From the Field Visit Consultants undertook to Kontum on 22 February, 2008, it was learned that the flooding problems are not around the city but rather in the uplands. Little data is available for these areas.

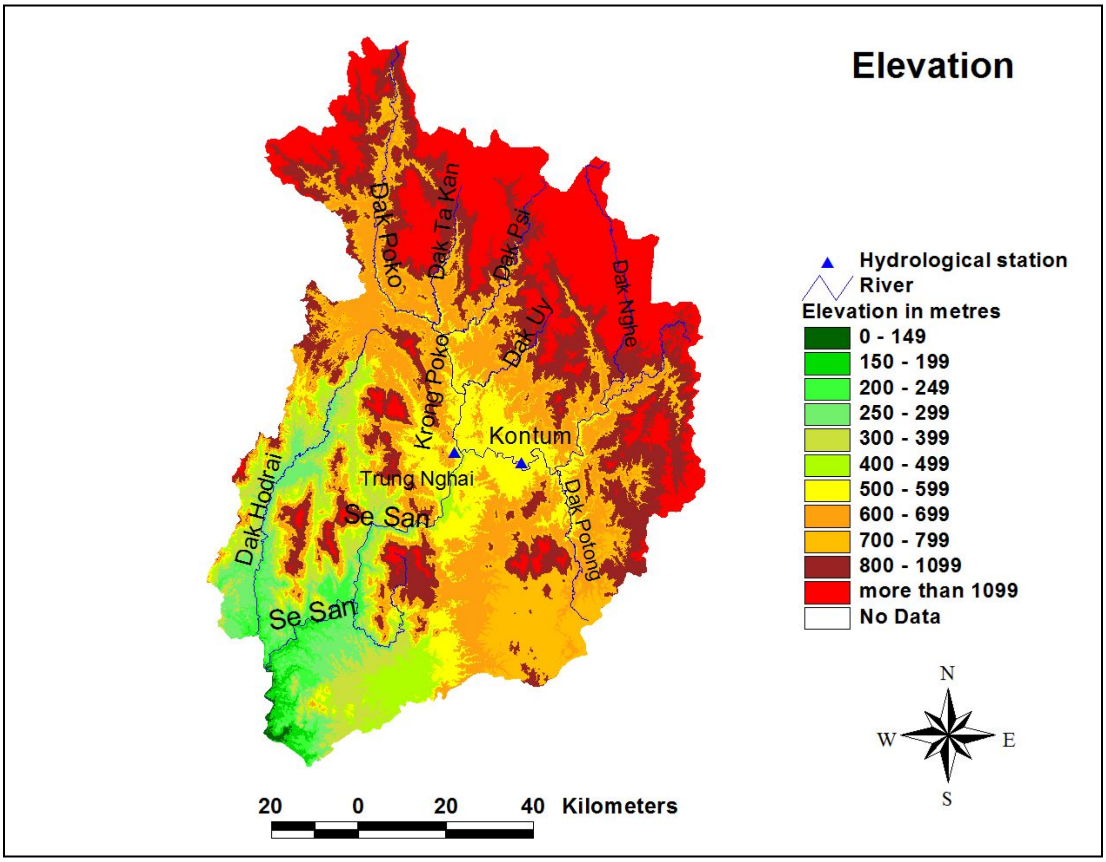


Figure 2.11 Elevation map of Upper Se San River Basin

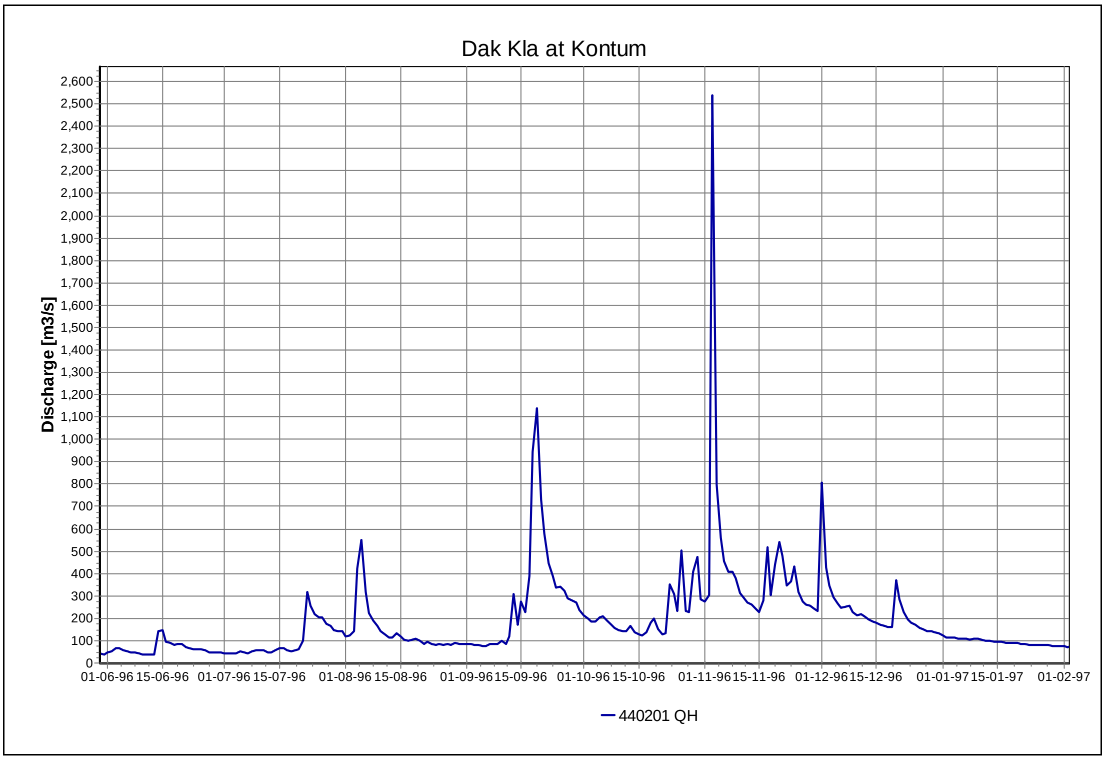


Figure 2.12 Discharge hydrograph of the Dak Bla at Kontum, year 1996

Flash floods are short lived, typically in the order of hours, rise and fall rapidly and the flow velocities are very high. The hydrological monitoring infrastructure in the LMB is such that only a limited number of basins are equipped with rainfall and water level recorders. For most locations only daily rainfall is available. These conditions have to be taken into account when flood hazard assessment procedures are developed. The following procedures are proposed:

1. Flood hazard derived from rainfall extremes
2. Flood hazard derived from observed flows
3. Flood hazard determined from regional flood statistics

When using rainfall extremes for the assessment of the flood hazard the following main steps are involved:

1. Determination of design rainstorms for different return periods: development of intensity-duration-frequency curves and subsequently using incremental intensities to arrive at a design storm;
2. Transformation of design rainstorms into design hydrographs: comprising estimation of excess rainfall and transformation of this excess storm into a design hydrograph by means of the Unit Hydrograph concept.;
3. Transformation of design hydrographs into design levels with the help of a mathematical model.

In case discharge series of sufficient length (≥ 15 years) is available then the procedure outlined for the hazard assessment for the city of Chiang Rai for tributary floods (see Sub-section 2.2.1) is also applicable.

Adamson (2007) proposed the use of a regional approach. It involves the creation of a regional sample of annual maximum flood peaks by pooling the individual annual maximum values scaled to their individual mean annual flood value. Subsequently, a Two Component Extreme Value (TCEV) distribution is fit to the observed frequency distribution of pooled values. And finally a regional relationship between the mean annual maximum flood discharge and one or more basin/climate characteristics is developed for use of the method in ungauged areas.

2.5.2 Results

In the absence of actual location data a 2-hour design hyetograph for basins in the Upper Se San has been developed starting off from daily rainfall of Pleiku. First an EV1 distribution function is fitted to the observed annual maximum daily rainfall values. Next, with the Rainfall-Ratio method these statistics are transformed to extreme values for shorter durations, to complete the intensity-duration-frequency curves, see Figure 2.13. Then incremental intensities are derived sorted around the peak value (derived from the storm advancement coefficient) to get the design hyetograph as presented in Figure 2.14. The last procedure is repeated for selected return periods.

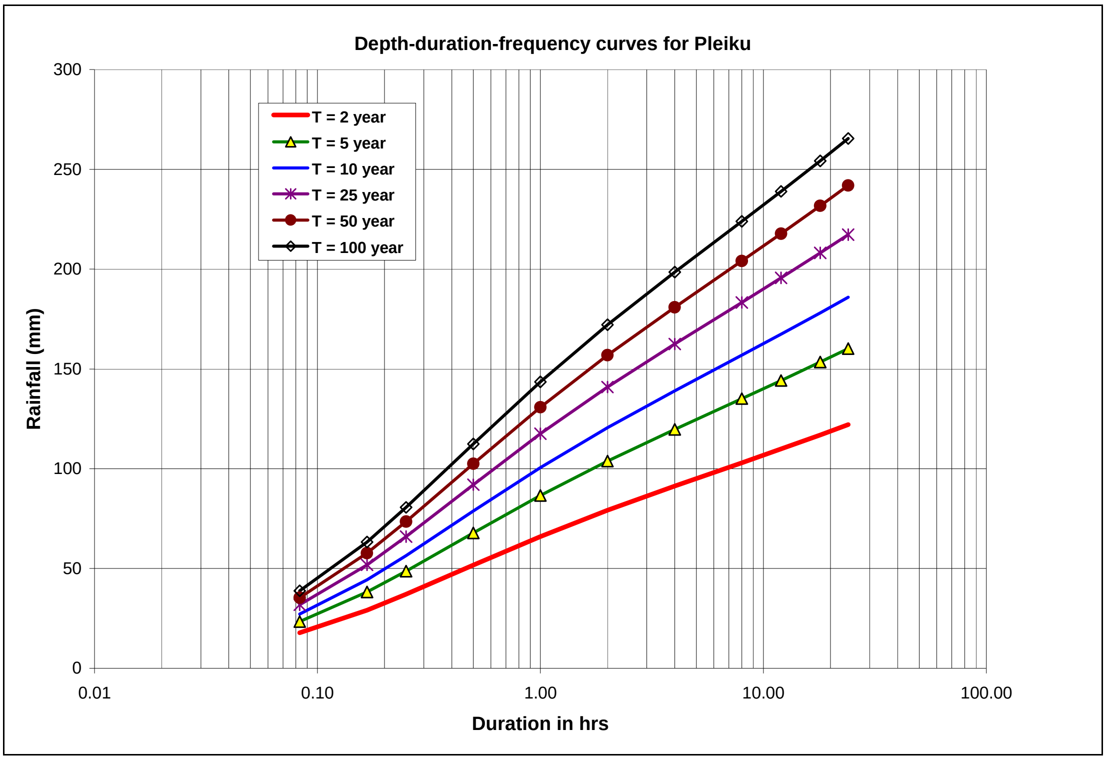


Figure 2.13 Depth-duration-frequency curves for Pleiku using Phnom Penh RR-values

Subsequently, rainfall losses are determined based on e.g. the Curve Number Method and the excess hyetographs are transformed into design hydrographs by a unit hydrograph. For this the Clark Method is recommended as it allows for incorporation of relevant physical features of the basin and of the runoff of excess rainfall. These design hydrographs are finally transformed into flood levels using a hydraulic model of the river reach of concern.

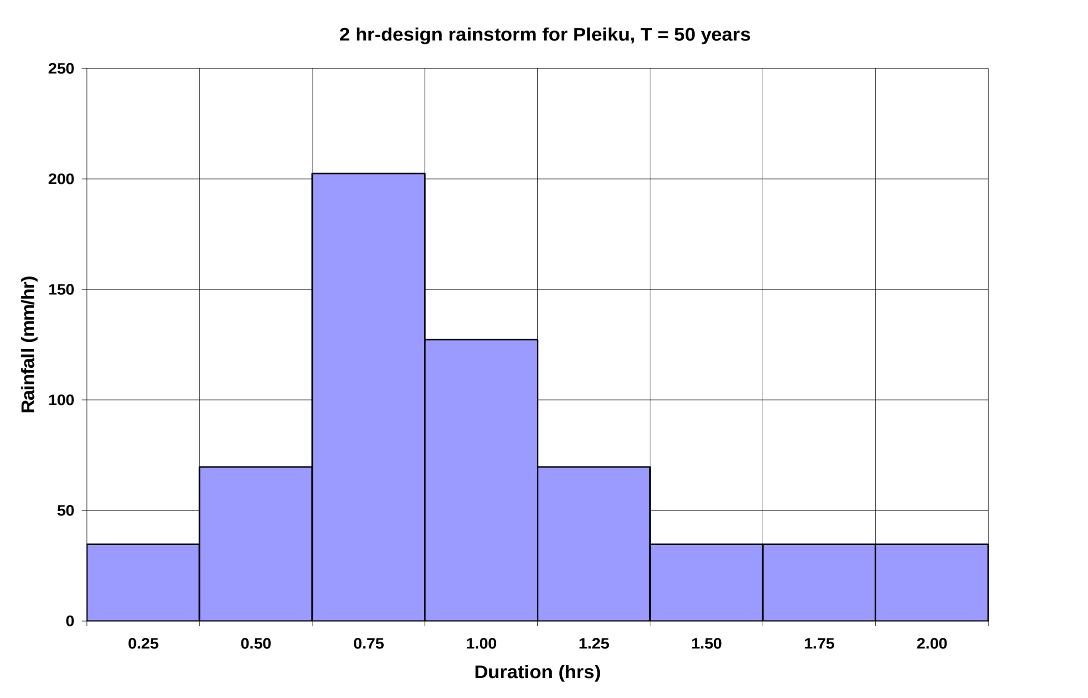


Figure 2.14 2 hour-design rainstorm for Pleiku, Return Period = 50 years

2.6 Focal Area 5: Kratie

2.6.1 Method

The CNMC has selected Kratie Province along the Mekong River as Focal Area for river training works to protect the river banks. This includes the following locations along the river around Kratie (see Figure 2.15):

1. Pu. Sambok at rkm 573.4
2. Pum Thmar Krae Kroam at rkm 568.7
3. Pum Peam Te at rkm 557.2

The type of information that is required for the hydraulic design of the river bank protections is similar to the requirements specified for Bokeo to which reference is made (see Sub-section 2.3.1). In this case the basic hydrological data on levels are obtained from station Kratie. The transformation of the required water levels at Kratie to levels at the above locations is by linear interpolation and extrapolation based on the water level slope between Kratie and Kampong Cham.

Preliminary estimates of the average flow velocities for the highest stages at the locations are determined from the ratio of the discharge at Kratie and the cross-sectional area obtained from the hydrographic map of the Mekong.

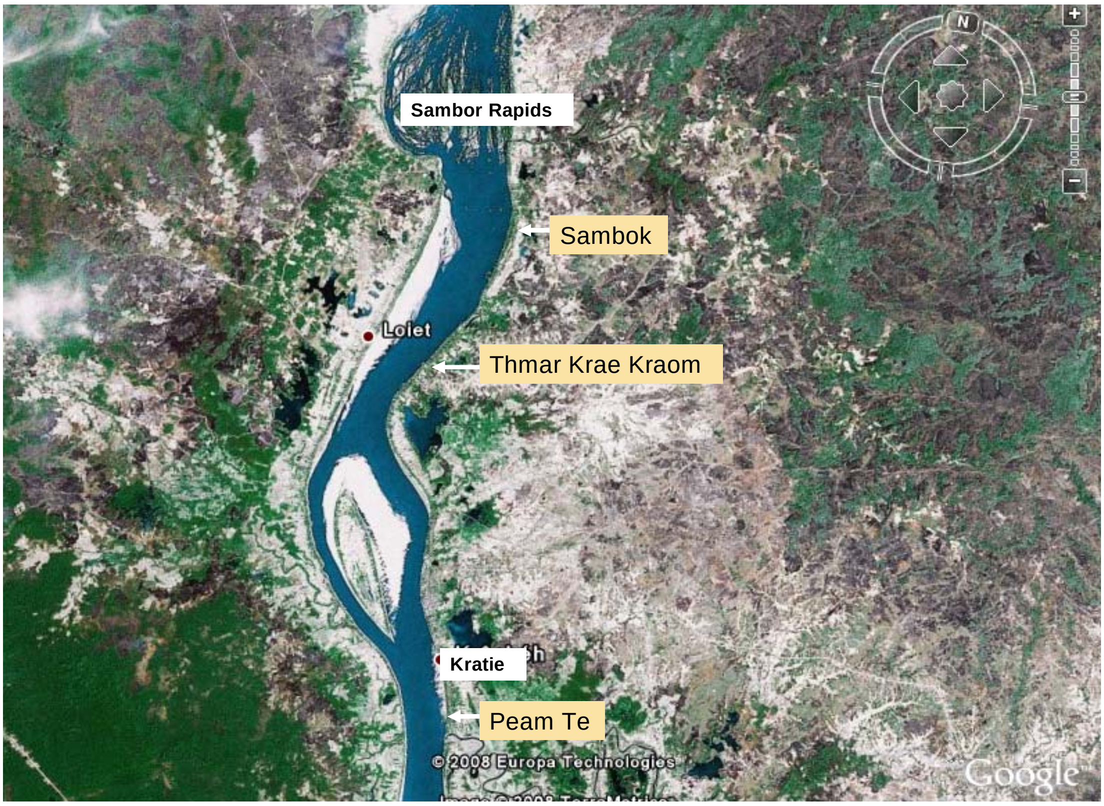


Figure 2.15 Layout of bank protection sites on Mekong near Kratie

2.6.2 Results

The design water levels as defined in Sub-section 2.3.1 have been derived from the average duration curve of the homogenized water levels at Kratie. The values are displayed in Table 2.4 and Figure 2.16.

Table 2.4 Design water levels around Kratie

Erosion sites/Gauging station	Location (Rkm)	Design water levels (masl)				
		MinWL	SLWL	MWL	AHWL	MHWL
Sambok	573.4	5.84	6.86	10.24	21.93	24.66
TK Kroam	568.7	5.63	6.65	10.00	21.60	24.33
Kratie	560.3	5.25	6.27	9.58	21.01	23.74
Peam Te	557.2	5.11	6.13	9.43	20.79	23.52

The average flow velocities in the reaches appear to vary from 3.3 to 4.7 m/s. These are unrealistically high values, probably due to wrong referencing of the bathymetry to the Chart Datum. To properly estimate the flow velocities in this case the use of 2D or 3D models is recommended.

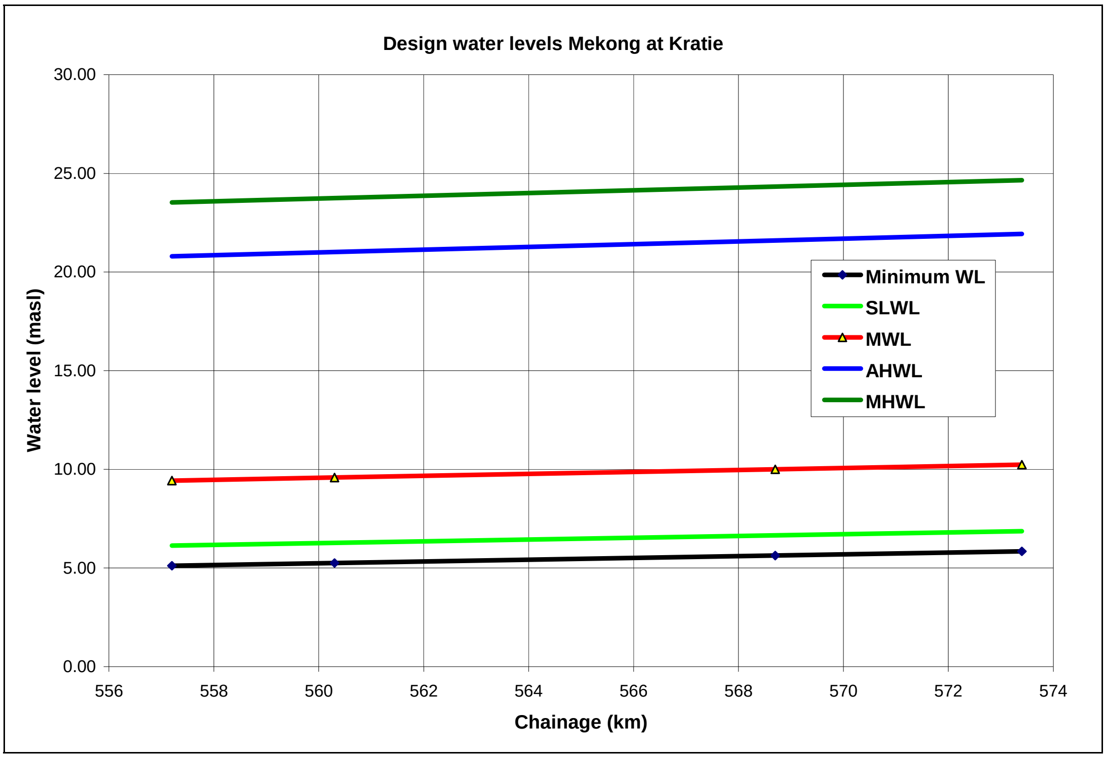


Figure 2.16 Design water levels around Kratie

2.7 Focal Area 6: Mekong Delta

2.7.1 Method

In the Mekong Delta four Focal Areas have been selected by the CNMC and the VNMC. These are deep flooded along the border between Cambodia and Vietnam. These include:

1. Takeo, west of Bassac in Cambodia;
2. Prey Veng, east of Mekong in Cambodia;
3. Long Xuyen Quadrangle, west of Bassac in Vietnam;
4. POR, east of Mekong in Vietnam

The floods in the Mekong Delta are classified as a special type of flood in the LMB due to their special external and internal boundary conditions and the delta's unique hydraulic infrastructure. The flood levels in the Mekong Delta in its downstream part are essentially the result of upstream and lateral inflow, local net rainfall and downstream water levels at sea. The flood in the Mekong Delta is conveyed via the Mekong and Bassac Rivers and via their flood plains, including the colmatage canal system which diverts and controls the flow from and to the River. In the delta the river regime is modified by the temporary storage in Tonle Sap Lake and in the Mekong flood plains, creating slowly rising and falling water levels.

For the Mekong Delta downstream of Kratie for flood hazard assessment use is made of the fact that a relatively long historical discharge series at the upstream boundary (Kratie or equivalently Stung Treng) is available. Furthermore, long representative series for the tributary inflow further downstream and to the Tonle Sap Lake have been created, preserving the serial and cross-correlation with the Mekong flow. The series, which cover the period 1910-2006, are used as boundary conditions for a hydrodynamic model (based on the ISIS-modelling package) to derive a 97-year series of water levels in the flood-prone areas. Further input to the model is formed by local rainfall, evaporation, water use and the year 2000 tidal conditions at the Gulf of

Thailand and the South China Sea. The relevant statistics including the probabilities of flooding and related damages for return periods from 2 to 100 years can be derived directly from the series of water levels and depths computed with the model. From the model results for each year maximum water levels and flood damages are derived for all model nodes to estimate the exceedance probabilities.

The hydraulic model of the Mekong Delta is based on the ISIS modelling system for the simulation of unsteady flow in channel networks. The system was introduced to the MRC under the WUP-A programme and now serves as part of the Decision Support Framework.(DSF). The model covers the Mekong Basin from Kratie to the South China Sea, including the Tonle Sap Lake and Floodplain, the Cambodian floodplains and the Vietnamese Mekong Delta. Recently, this model has been recalibrated, but it was concluded, that further improvements are needed before it can be used as a reliable instrument in the study of flood management scenarios. Consultants concluded that the current model will be acceptable for demonstration purposes to study the selected focal areas in the border area between Cambodia and Vietnam. For a final analysis the ISIS model has to be further improved. For the simulation of effect of structural measures to change the nature of the floods in the project areas, adaptations in the model schematization are required. Particularly the Cambodian part of the delta requires a denser network. It is emphasised, therefore, that the results presented in the following sections are to be judged with due care.

2.7.2 Results

For the management of floods and related risks in the Focal Areas in the Mekong Delta the following development scenarios have been considered:

[1] Base Case
The existing condition of land use and flood control levels in Cambodia and Vietnam.

[2] Scenario Cam0: flood protection in Cambodia
This scenario comprises of early flood protection and full flood protection in Cambodia according to recommendation in Stage 1, while no development in Vietnam is assumed. The protection in Cambodia is as follows:

- Takeo
  - Zones 1 and 3: full protection
  - Zone 2: early flood protection
- Prey Veng
  - Zone 1: early flood protection
  - Zones 2 and 3: 1: 10 year flood protection (+free board)
  - Zone 4: no protection.

Early flood protection is defined as follows: based on the model simulation of the base case the annual maximum water level of the early flood season, which ends on August 1, is derived for the series of 97 years (1910-2006). Subsequently, the water level with a return period of 10 years, h1Aug; 10, is derived from this series. So h1Aug; 10, is the water level that is exceeded on average once in every 10 early flood seasons (1 May – 1 August). Early flood protection means that the crest height of the dikes are raised to the level of h1Aug; 10. This means the probability of flooding in the early flood season is equal to 1/10 (10%).

[3] Scenario Vna flood protection in Vietnam, variant a
This scenario comprises of early flood protection and full flood protection in Vietnam.

- Long Xuyen Quidrangle
  - enlargement of canals,
  - no sluices along Bassac,
  - rubber dams open on the 15th of August
- Trans Bassac: full protection as at present
- Plain of Reeds: Canal enlargement

[4] Scenario Vnd flood protection in Vietnam, variant d
This scenario comprises of full flood protection in the largest part of the Mekong Delta in Vietnam. It is explicitly noted that this scenario is not in accordance with the current policy of Vietnam for flood protection of the delta. However, it provides an outlook in the far future, say 2060 in case that the socio-economic situation might have changed so much that full flood protection would be an option.

[5] Scenario Cam0Vna: flood protection in Cambodia and Vietnam
This is the combination of scenarios Cam0 and Vna

[6] Scenario diversion:
This is the scenario in which a Diversion to the Great Lake is built for early flood control.

The results are summarised below. The results for the development scenarios are compared with the Base Case for selected locations in the Focal Areas and along the rivers (see Figure 2.17), to assess the effect of the measures. Also, the effect of sea level rise is analysed.

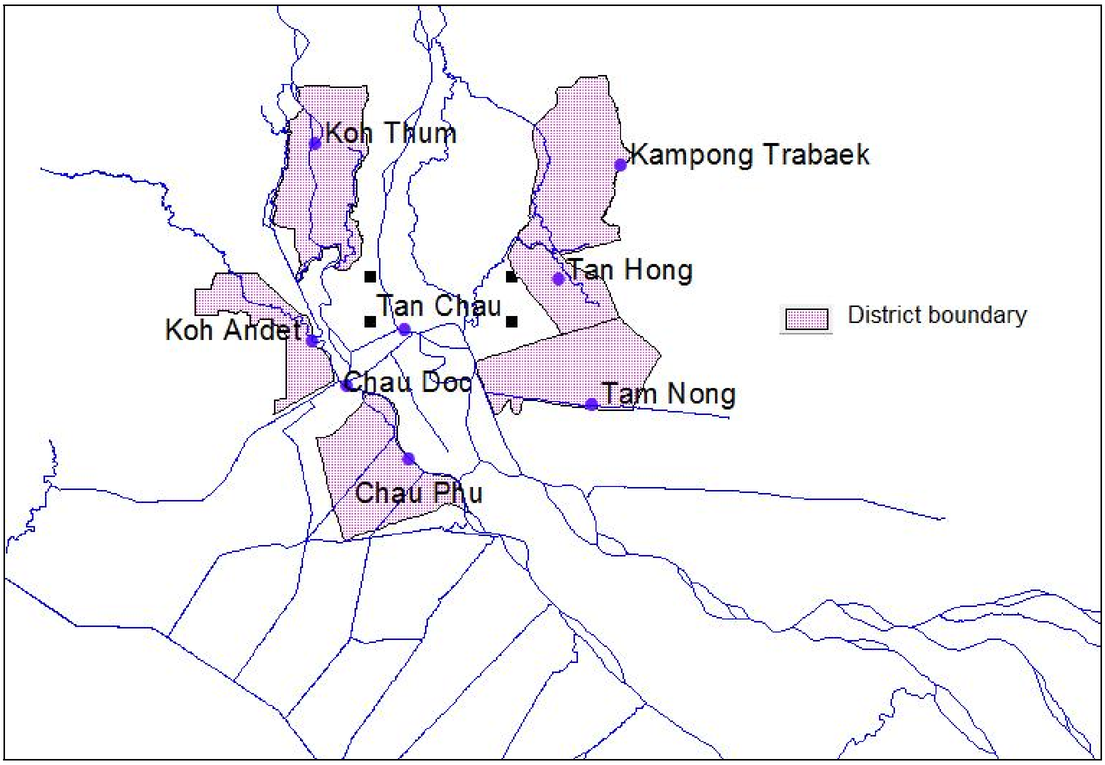


Figure 2.17 Selected locations for flood damage assessment.

Base Case

For the Base Case the hydraulic model was run for the 97 historical flood seasons (May to December) of upstream and tributary inflow from 1910 to 2006. Per year the annual maximum water levels were abstracted and subjected to a frequency analysis per node. The water levels for 2, 5, 10, 25 and 100 years were subsequently compared with ground elevation to determine flood depth and extent. The results for the 100 years return period are shown in Figure 2.18. By comparing these maps with land use, basic information for damage assessment is obtained. Instead of selecting the maximum water levels per year one can also select other characteristics for specific seasons as the full details of the hydrographs of 97 years are available in the database for any location in the model, including also flow velocities.

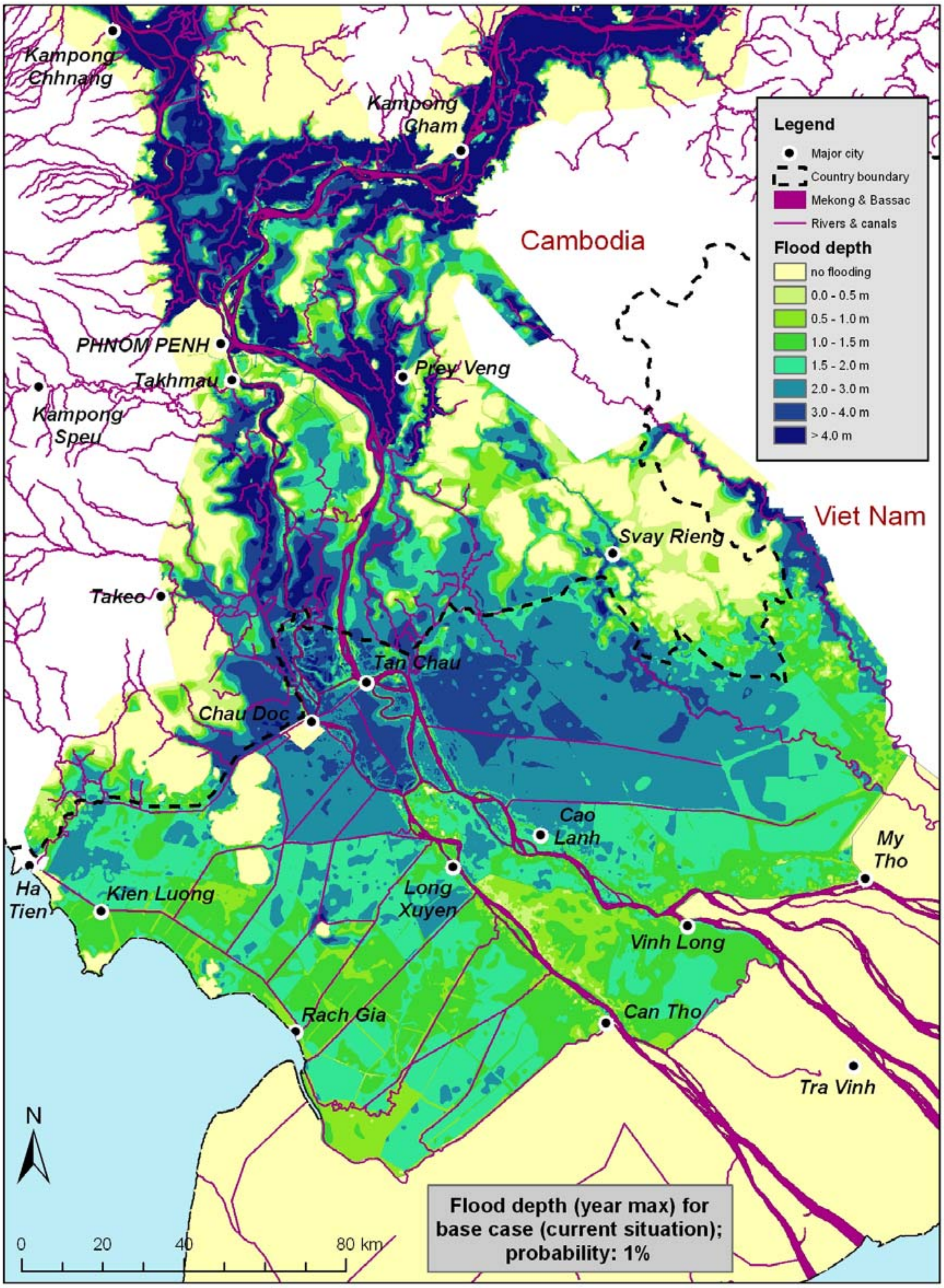


Figure 2.18 100 year flood map for entire Mekong Delta.

Development scenarios

Instead of running the hydraulic model for the above scenarios for the full 97 flood seasons, only 11 selected years (1918, 1923, 1927, 1929, 1939, 1940, 1971, 1994, 1996, 2000 and 2001) were simulated in order to save valuable computation time. The years were selected in such a way that they represent the range from moderate to extreme years in terms of Mekong flows and, consequently, flood depths.

Results for scenario [2] – Cam0

The water levels with probability of exceedance of 50%, 20%, 10%, 4%, 2% and 1% for this scenario are compared with the corresponding water levels for the base case. Figure 2.19 and Figure 2.20 show the differences with the base case for the 25 locations in Cambodia and 34 locations in Vietnam respectively. As can be seen there is no consistent pattern. For 16 out of 25 locations in Cambodia the water level decreases as a result of the measures of scenario Cam0, for 8 locations the water levels increases and for one location (Preah Sdech) both increases and decreases are observed. Of the 34 Vietnamese locations, 11 show an increase in water levels, 13 show a decrease in water levels and 10 show hardly any change at all. So for some locations the annual expected damages will increase as a result of the measures of scenario Cam0 and for some locations the water levels will decrease. This has been quantified in Volume 6E.

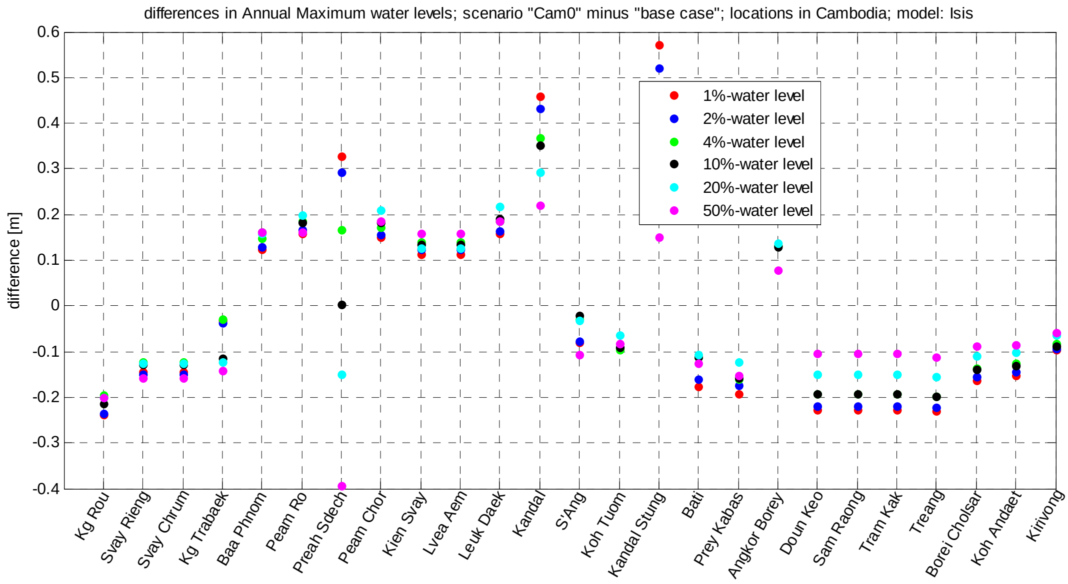


Figure 2.19 Change in the p-percent annual maximum water level (p=1, 2, 4, 10, 20 and 50) for 25 locations in **Cambodia**; comparison of scenario **Cam0** with the base case. Positive values indicate an increase in water level.

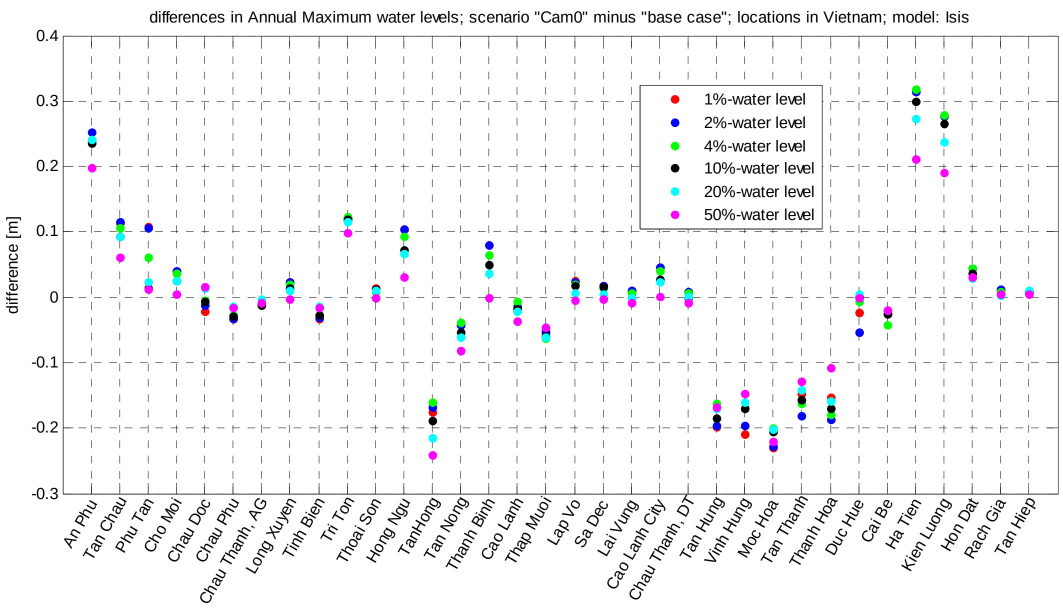


Figure 2.20 Change in the p-percent annual maximum water level (p=1, 2, 4, 10, 20 and 50) for 34 locations in **Vietnam**; comparison of scenario **Cam0** with the base case. Positive values indicate an increase in water level.

Results for Scenario [3] – Vna

Figure 2.21 and Figure 2.22 show the differences in water levels between scenario Vna and base case for the 25 locations in Cambodia and 34 locations in Vietnam respectively. Again, for some locations the water levels increase as a result of the measures of scenario Vna, while for other locations the water levels decrease. All Cambodian locations show an increase in water level.

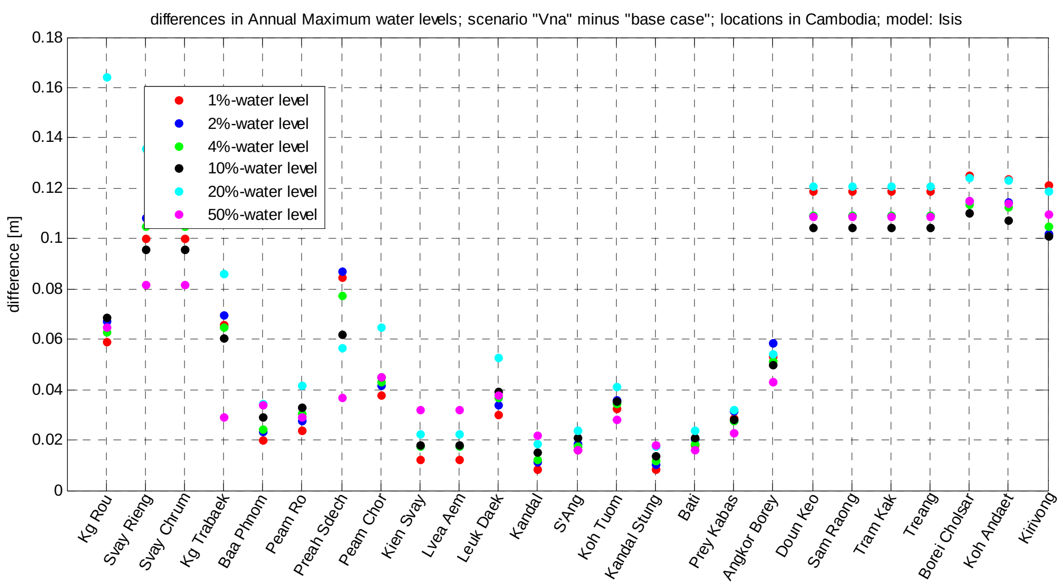


Figure 2.21 Change in the p-percent annual maximum water level (p=1, 2, 4, 10, 20 and 50) for 25 locations in **Cambodia**; comparison of scenario **Vna** with the base case. Positive values indicate an increase in water level.

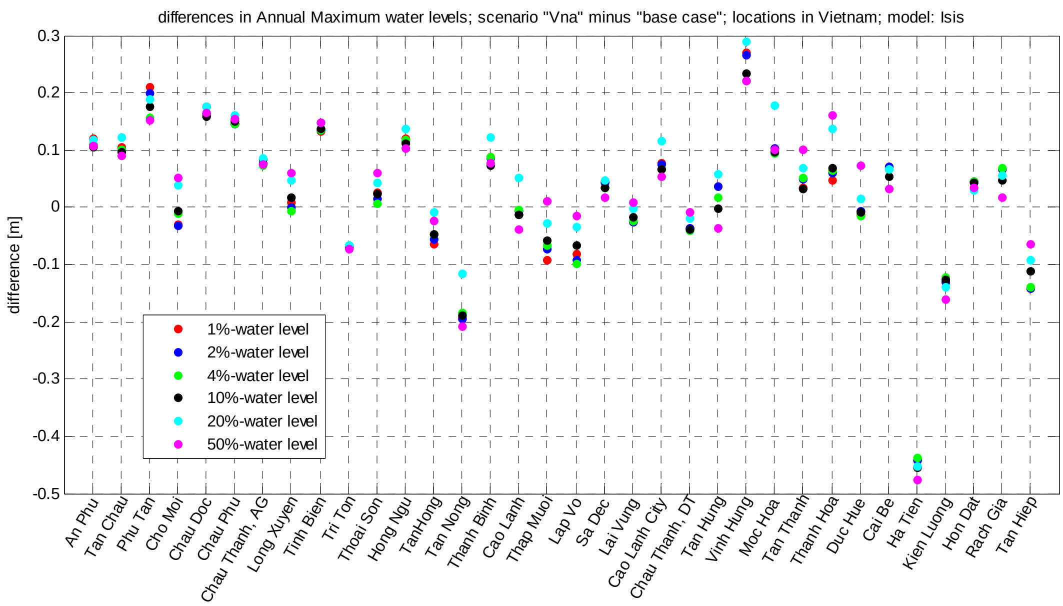


Figure 2.22 Change in the p-percent annual maximum water level (p=1, 2, 4, 10, 20 and 50) for 34 locations in **Vietnam**; comparison of scenario **Vna** with the base case. Positive values indicate an increase in water level.

Results for Scenario [4] – Vnd

Figure 2.23 and Figure 2.24 show the differences in water levels between scenario Vnd and base case for the 25 locations in Cambodia and 34 locations in Vietnam respectively. Again, for all locations in Cambodia the water levels increase as a result of the measures of scenario Vnd. For locations in Vietnam the effects of changes are mixed.

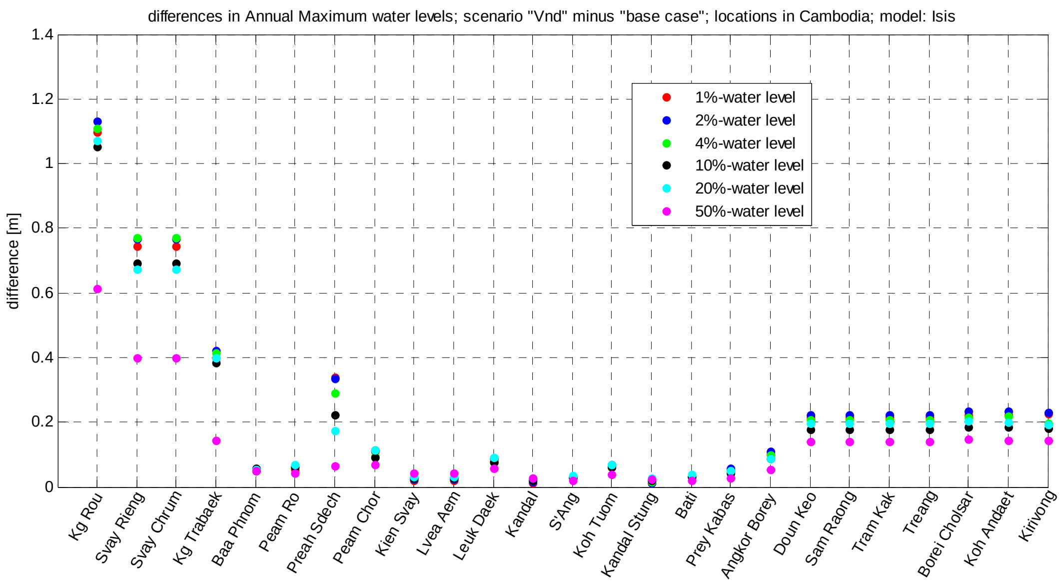


Figure 2.23 Change in the p-percent annual maximum water level (p=1, 2, 4, 10, 20 and 50) for 25 locations in **Cambodia**; comparison of scenario **Vnd** with the base case. Positive values indicate an increase in water level.

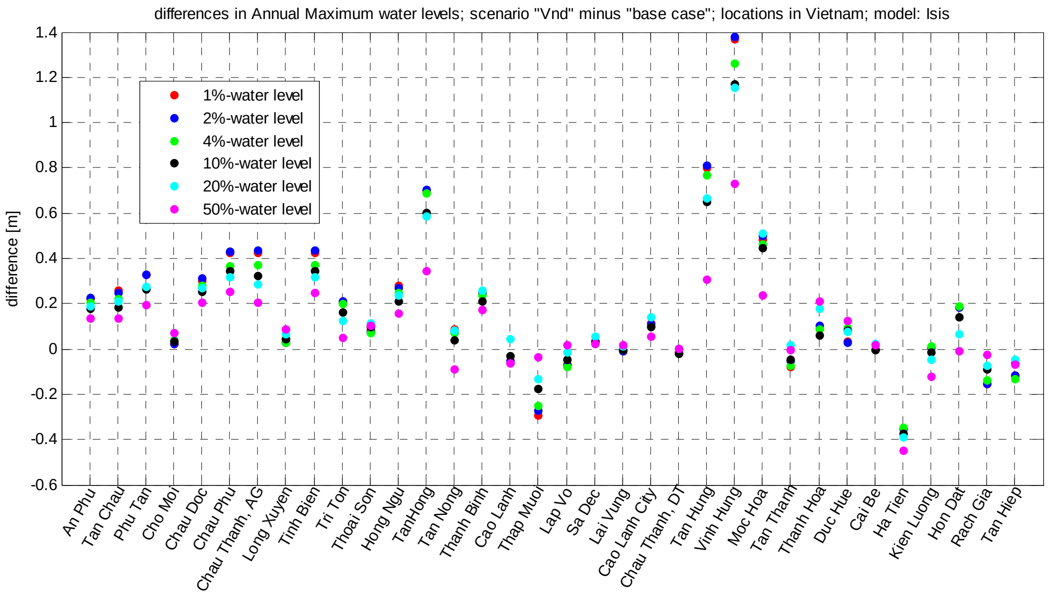


Figure 2.24 Change in the p-percent annual maximum water level (p=1, 2, 4, 10, 20 and 50) for 34 locations in **Vietnam**; comparison of scenario **Vnd** with the base case. Positive values indicate an increase in water level.

Results for Scenario [5] – Cam0Vna

Figure 2.25 and Figure 2.26 show the differences in water levels between scenario Cam0Vna and base case for the 25 locations in Cambodia and 34 locations in Vietnam respectively. Again, for some locations the water levels increase as a result of the measures of scenario Cam0Vna, while for other locations the water levels decrease.

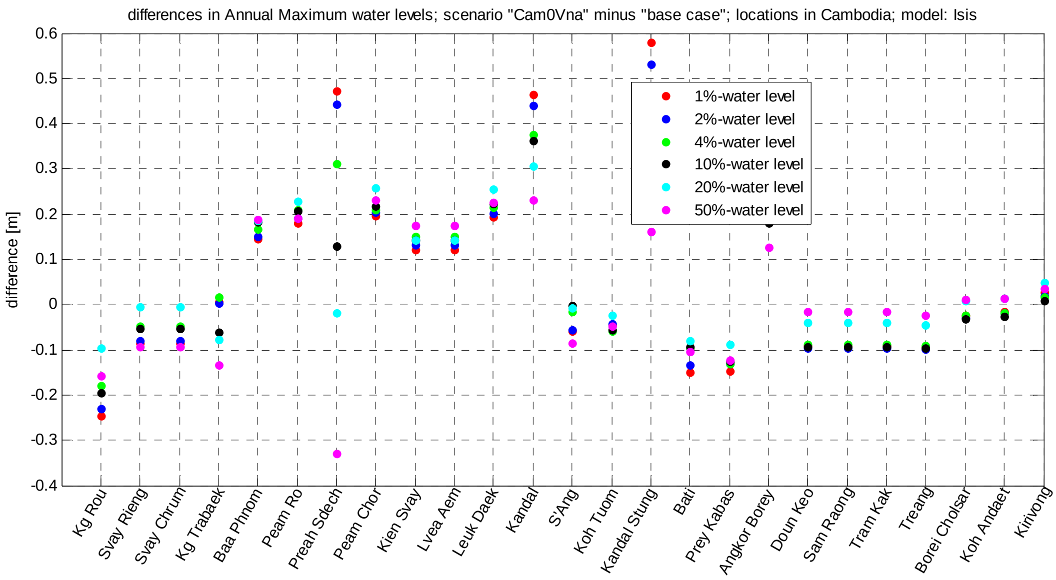


Figure 2.25 Change in the p-percent annual maximum water level (p=1, 2, 4, 10, 20 and 50) for 25 locations in **Cambodia**; comparison of scenario **Cam0Vna** with the base case. Positive values indicate an increase in water level.

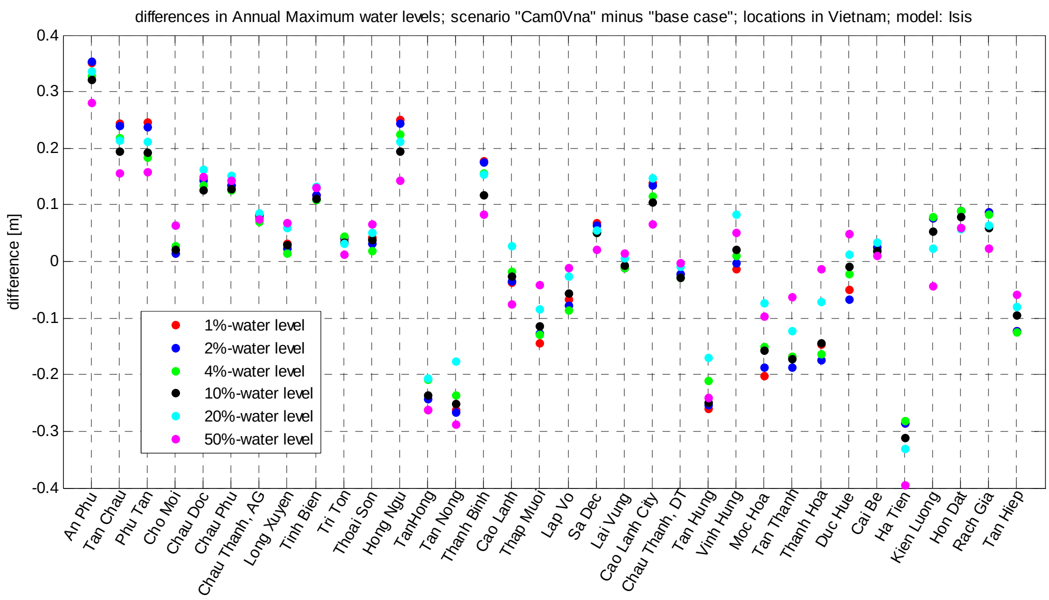


Figure 2.26 Change in the p-percent annual maximum water level (p=1, 2, 4, 10, 20 and 50) for 34 locations in **Vietnam**; comparison of scenario **Cam0Vna** with the base case. Positive values indicate an increase in water level.

Scenario [6] – flood diversion to the Great Lake

In Cambodia the paddy is harvested before 1 August each year according to the crop calendar. In Vietnam the crop is harvested before the third week of August. When floods occur before the date of harvest it will create damage to the crop. Hence, if the floods can be limited till after the date of harvest up to the capacity of the Mekong and Bassac downstream of Phnom Penh, then benefits are generated for the farmers. In Scenario_4 this is achieved by diversion of flood water to the Tonle Sap for early flood control. Additional benefits of such option is generated for fish farming in the Lake as the Great Lake level will be higher than normal. Furthermore, if the outflow from the Lake is controlled the water availability for the dry season increases, which provides options to reduce salinity problems in the delta.

The effectiveness of flow diversion to Tonle Sap from midway Kampong Cham-Phnom Penh to the Lake has been investigated for two variants:

1. a fully controlled diversion, and
2. an uncontrolled diversion.

For this a water balance model of the Mekong between Kampong Cham and Phnom Penh has been developed, including Tonle sap River and Lake and a diversion canal from the Mekong to the Lake, see Figure 2.27. In the controlled mode, the diversion is operated such that the flow downstream of Phnom Penh does not exceed the capacity of the rivers Mekong and Bassac, set to 30,000 m3/s. Limits are further set to the diversion capacity, and Tonle Sap River capacity (10,000 m3/s) and Great Lake volume (85.86 BCM i.e. equivalent to a Lake level of 11.0 masl). The model is run for the 97 historical flood seasons, see Chapter 4.

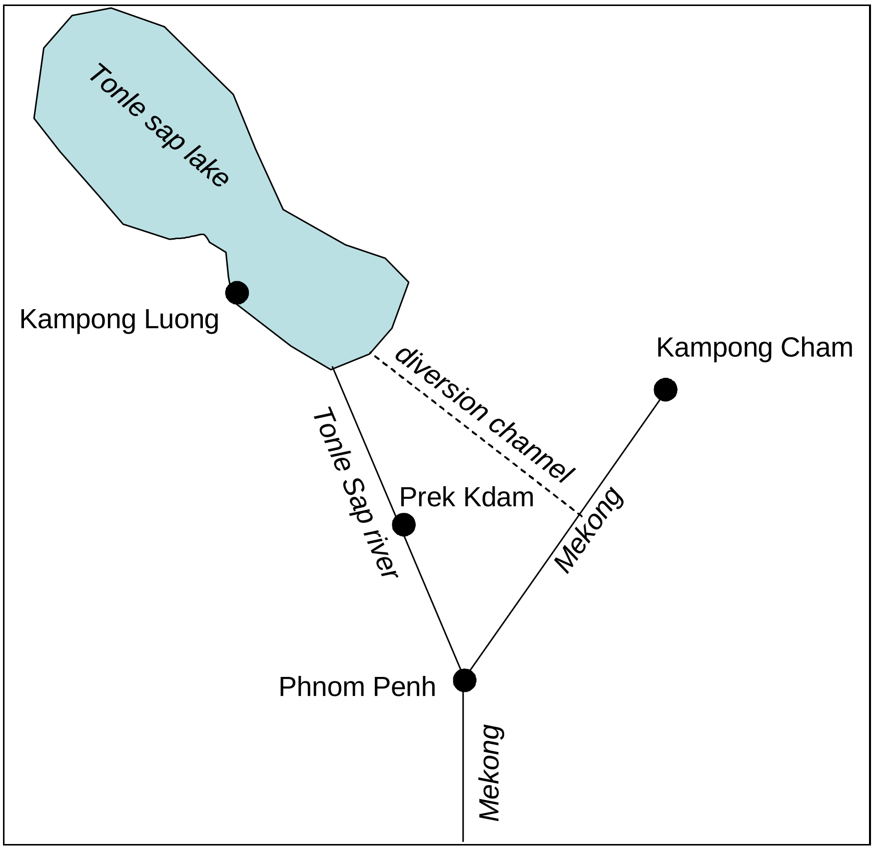


Figure 2.27 Structure of water balance model of Mekong and Tonle Sap

Controlled diversion

For the controlled diversion the effectiveness of the measure for different diversion capacities can be read from Figure 2.28.

The graph shows that under present conditions the number of days that flooding takes place downstream of Phnom Penh before 1 August is about 3 days on average each year. This would reduce to 1 day with a diversion canal with a capacity of 20,000 m^3/s. before the third week of August on average during 16 days flooding occurs, whereas with a diversion canal of the same capacity this would reduce to about 5. Figure 2.29 shows the mean wet surface area of the lake for different values of the flow capacity of the diversion channel. It shows the area increases with increasing capacity. Generally, an increase in the wet surface area has a positive effect on the fish population.

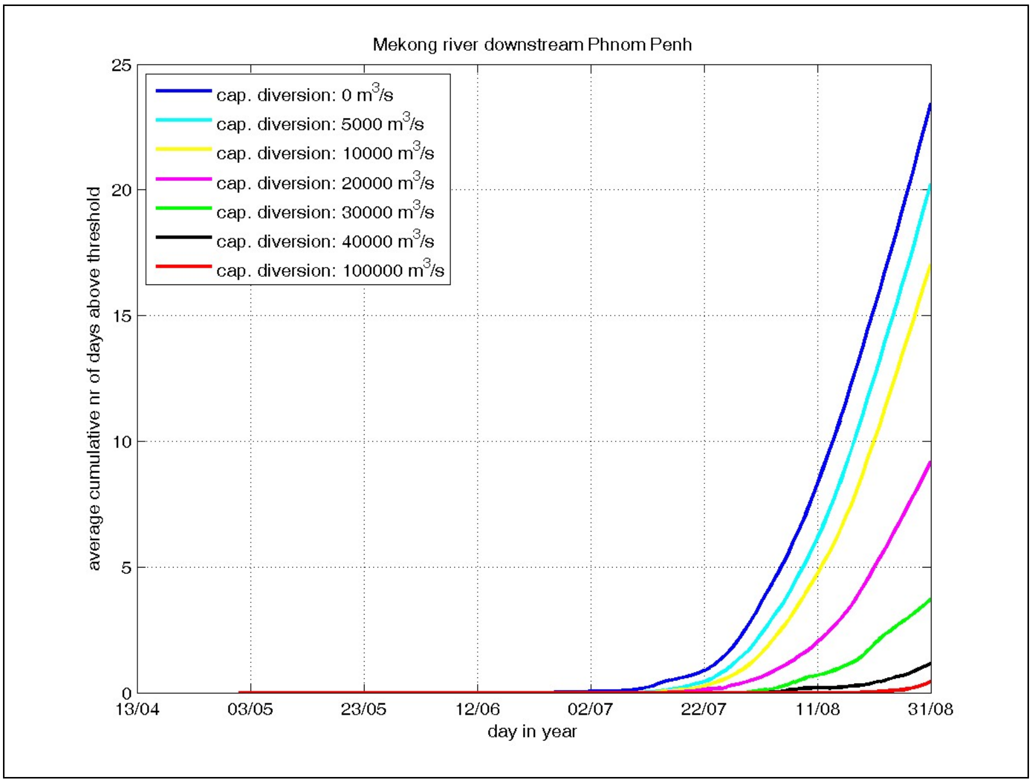


Figure 2.28 Average cumulative number of days (up to the date shown on the horizontal axis) in the simulated period 1910-2006 during which the flow downstream of Phnom Penh exceeded 30,000 m^3/s; depending on the available flow capacity of the diversion channel

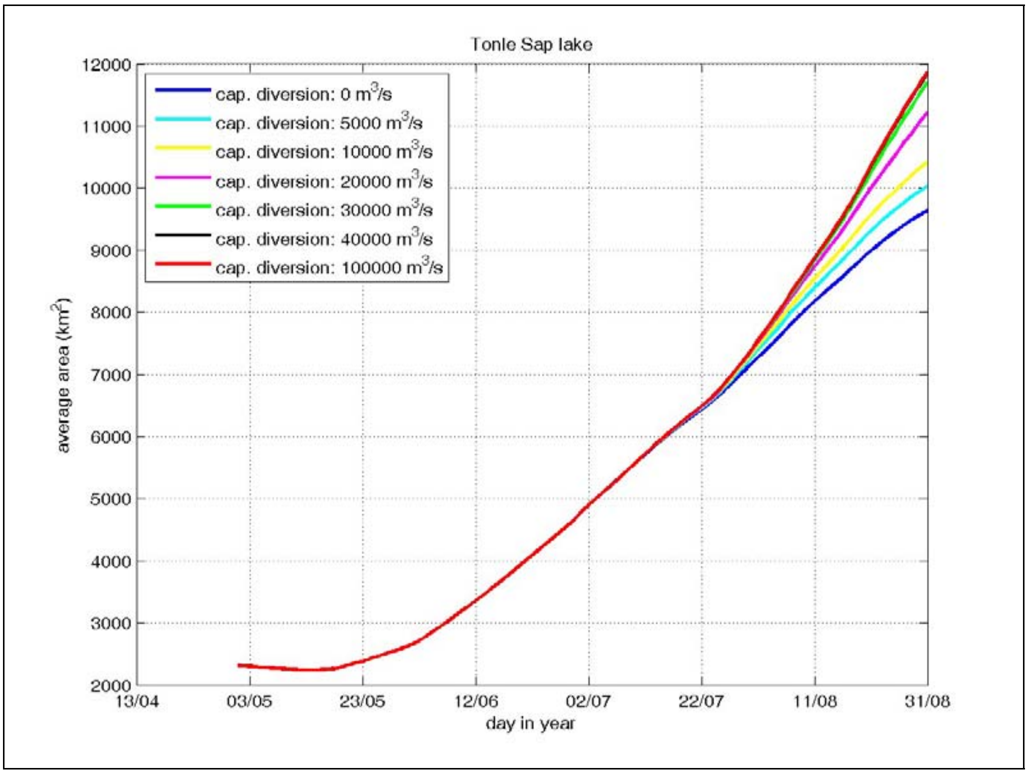


Figure 2.29 Mean wet surface area of the lake for different values of the flow capacity of the diversion.

Uncontrolled diversion

For the uncontrolled diversion a 2,500 m wide diversion canal is assumed with a weir at the off-take having a fixed level of 8.0 masl. The effectiveness of this measure seems to be limited as is observed from Figure 2.30 at first glance. However, this is mainly due to the fact that this option cannot control the flow downstream of Phnom Penh not to exceed exactly 30,000 m^3/s. The flood volume, though, will reduce substantially.

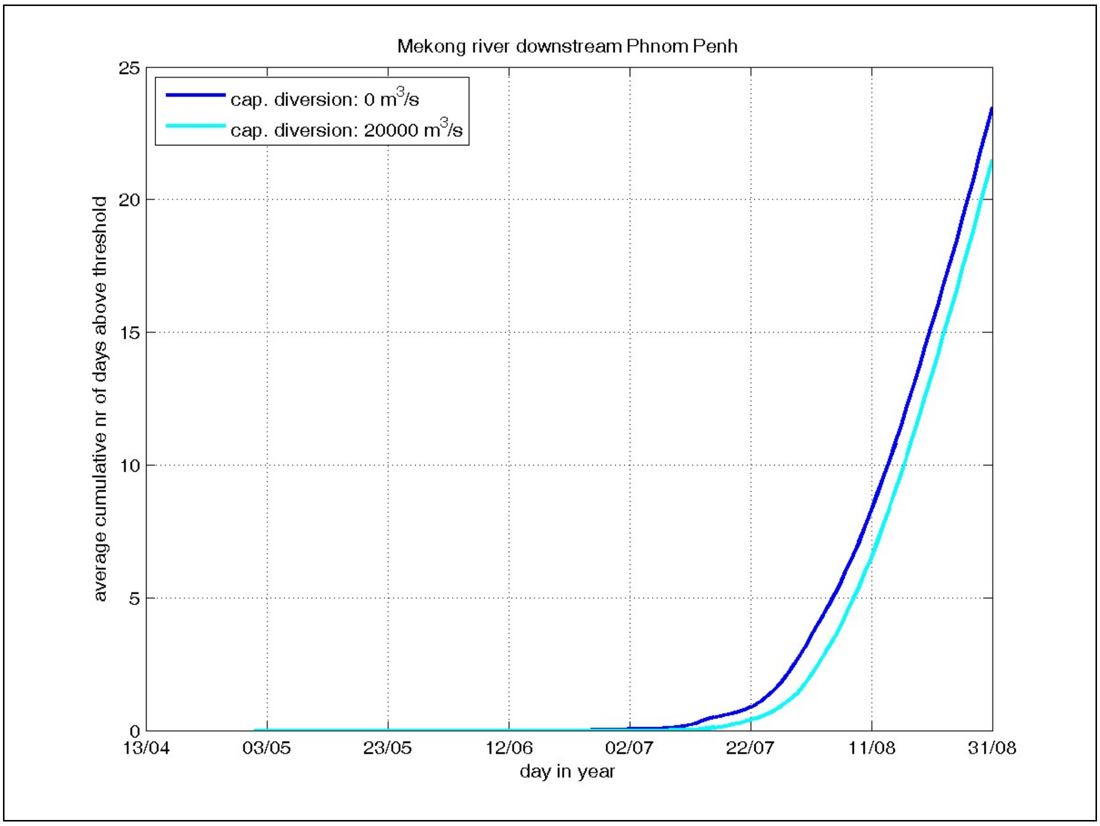


Figure 2.30 Average cumulative number of days (up to the date shown on the horizontal axis) in the simulated period 1910-2006 during which the flow downstream of Phnom Penh exceeded 30,000 m^3/s; depending on the available flow capacity of the diversion channel.

So the benefit of the uncontrolled channel can be found in the volume of water that fills the flood plain. This volume will be reduced each year the water flows into the diversion channel. For each year in the simulation period 1910-2006 the volume above the threshold of 30,000 m^3/s was derived. Figure 2.31 and Figure 2.32 show the frequency distributions of these volumes as derived on August 1st and August 21st each year. It shows that especially at August 1 there is a large percentage-wise reduction of flood volume, indicating that the diversion channel prevents significant areas of farmland from flooding before the end of the growing season.

An unregulated diversion canal diverting Mekong water into the Lake from an off-take at Khchau village was implemented. It turned out the maximum flood water levels are only slightly reduced by this Scenario, as its function has finished before the peak passes. The reduction on the early flood levels is somewhat larger but still very limited. By blocking the early return flow from the Tonle Sap the diversion channel option can be made more effective.

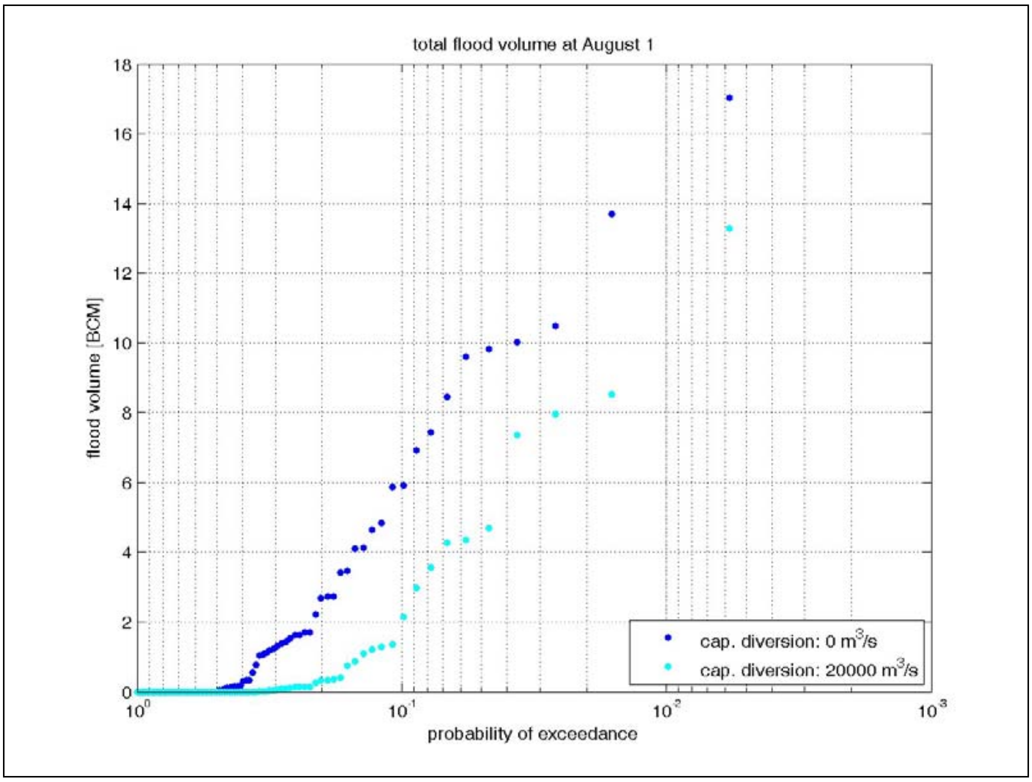


Figure 2.31 Frequency distribution of the total volume above a threshold of 30,000 m^3/s in the Mekong downstream of Phnom Penh until August 1, depending on the available flow capacity of the diversion channel.

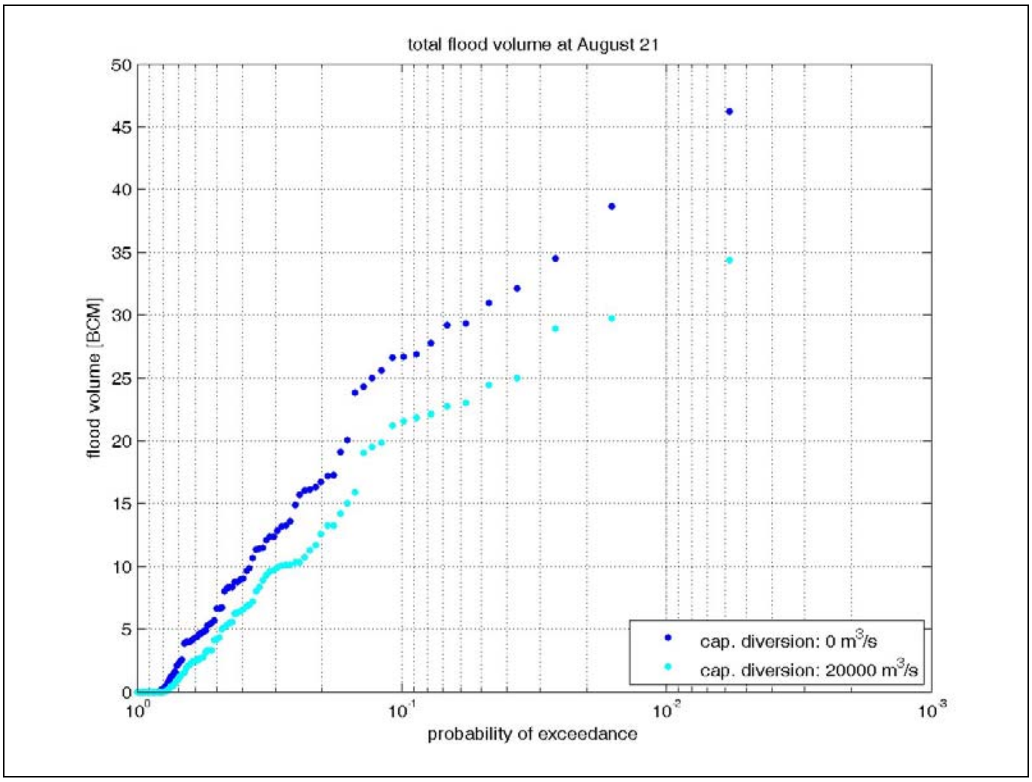


Figure 2.32 Frequency distribution of the total volume above a threshold of 30,000 m^3/s in the Mekong downstream of Phnom Penh until August 21, depending on the available flow capacity of the diversion channel.

Final remarks and recommendations

The use of the hydraulic model of the Mekong Delta ran for 97 historical flood seasons forms an excellent base for flood hazard assessment in the Mekong Delta to arrive at flood levels and related parameters of selected return periods. Since serial and cross-correlations between the influencing variables is fully taken into account use of complicated multi-variate distribution functions is avoided.

Based on the analyses it is strongly recommended to improve on the computational tools available at the MRC. The recalibration of the Mekong Delta hydraulic model is to be undertaken with priority including an extension of the computational network in the Focal Areas in Cambodia. Prior to the recalibration, during the 2010 flood season concurrent current meter and ADCP discharge measurements have to be made at Kratie to resolve in-homogeneities in the inflow series of the Mekong Delta.

The analysis of effects of the development alternatives are recommended to be repeated with the hydraulic model using the updated schematisation of the Focal Areas in Cambodia. Then also controlled diversion of flood water to the Tonle Sap, including an outflow control structure in the Tonle Sap River, to maximise the benefits of extra storage of water within the basin is recommended to be evaluated.

Finally, reference is made to the conclusions and recommendations given in the Appendices 6 to 11 of Volume 2B.

3 FLOOD DAMAGES AND FLOOD RISKS IN THE FOCAL AREAS

3.1 Flood damage assessments: methodology and approach

A proper assessment of the flood damage risks is essential before strategies, plans and projects can be developed for managing these risks. In the assessment of the risks the following steps are made:

1. flood hazard is assessed in terms of water levels, inundation depths and inundated areas as presented in the previous chapter;
2. Potential flood damages (vulnerability) for the areas prone to flooding are identified and quantified in monetary terms;
3. The flood hazard is combined with the potential damage that may result from such a hazard to arrive at the flood damage risk.

The grand total of damages caused by a flood in a certain area is the total of direct damages plus the total of indirect damages and minus the total flood benefits. Direct damages are primarily from:

- *Loss of life and injuries:* Number of people killed, missing and injured by the flood; treatment costs for the injured persons;
- *Damages to properties* in the targeted areas such as houses, schools, offices, commercial & industrial buildings and installations, hydraulic works, energy, transportation and other infrastructures and supplies/assets of individuals and businesses. These damages depend on the magnitude and duration of the flood. The damages to properties are the costs of replacement or restoration of an affected structure and inventories;
- *Crop damages* depend on the depth, timing and duration of a flood. The bigger the flood, the more submerged cultivated area sustains bigger losses. However, if flood occurs after harvesting, there would be no crop damage at all;
- *Livestock and agricultural equipment* depends on the magnitude and duration of the flood. The damages to livestock are the costs of livestock lost or the loss of income due to a distress sale. The damages to agricultural equipment/tools are the cost of replacement or restoration of these assets.

Indirect damages, among others, are from:

- *Costs of illness* of humans and livestock related to poor environmental conditions and increased water-born diseases. These costs including additional cost of health care that families and individuals spend more compared to condition of ‘no flood’; and additional expenditures from local government for disease prevention and treatment and for sanitation control during the flood;
- *Income losses* due to disruption of economic activities and/or services by the flood for (i) individuals, landless labourers, families and enterprises; (ii) large commercial and industry enterprises that have been partly or fully closed down for some period of time during high flood water level;
- *Higher costs of living* due to temporary relocation, purchase food that otherwise would be available from the family farm, lack of basic supply as save water and electricity, additional cost for transportation and daily activities;
- *Costs of temporary relocation and rescue* are the cost that local government agencies and Non Government Organisations (NGOs) incur before, during and after the flood to support affected people living during the flood and recovering at after the flood;
- *Cost of prevention measures* are incurred by individuals, households, enterprises and institutions before and during the flood;
- *Costs of cleaning and sanitation* after the flood are mainly labour mobilization by individuals, households, enterprises and institutions to clean their houses and buildings.
- *Other costs* include the negative impacts of flooding on tourism revenue, loss of income or revenue for people or enterprises outside the target areas, loss in social stability, problems

in income distribution and confidence of people in the Government and other forward and backward economic linkages are omitted from the study as no data are available or could be collected on these issues.

Benefits of flooding are primarily from:

- *Fishery:* Flood water provides habitat for fish (breeding grounds and nursing and growing environment). Natural fish is an important resource for people living in the LMB. The quantity of natural fish would be reduced in case of a low flood level; it depends on the magnitude, timing and duration of flood, but the best indicator is the flooded area;
- *Agricultural production:* Flood water (i) brings sedimentation for the flood plain; (ii) :flushes toxic substances from the cultivated soil; (iii) flushes acids from acid sulphate soil areas; (iv) kills the rats and pests; (iv) speeds up the process of plant residue disintegration; (v) improves soil structure; and (vi) provides soil fertility. This impact could be measured by net benefit from agricultural production after a year with a high flood as compared with a year with a normal flood;
- *Bio-diversity conservation:* Flooding plays an important role in maintaining bio-diversity values for Mekong River Basin, especially in the wetlands in the LMB. There are a few studies on these positive impacts, but their values in monetary-terms are not available.

A data collection and processing methodology was designed that could be expected to yield the required data for the focal areas, given the availability of secondary data, time and budget constraints.

Primary and secondary data have been collected from local (Provincial and District) officials, households and businesses, to establish an inventory of flood vulnerability characteristics and direct and indirect flood damages.

Focus group discussions with people living and working in the project areas have been held to provide insight into a range of relevant issues such as the benefits of flooding, traditional coping mechanisms and community resilience.

Surveys have been held to collect and/or validate existing information on direct damages for an agreed reference flood; and, to the extent possible, and to document and quantify indirect damages associated with the reference flood event. For this purpose the 2006 flood was selected as this flood can be considered an ‘average flood’ and as this year was considered recent enough for respondents to remember with an acceptable level of accuracy. During the Household and Business interviews respondents have been asked to also estimate damages in case the flood water would have reached higher levels than in 2006. During the meeting with Provincial and District authorities flood damages have been collected for as many years as were available in their records.

The sources of data on direct and indirect damages included interviews with the following groups:

Provincial and District officials: Review and validation of existing data on casualties and direct damages caused by historic flood/erosion events. This is an extensive listing in kind and in monetary terms of damages occurred in the recent past. Damage categories included educational facilities, healthcare facilities and assets, road and transport facilities, irrigation facilities, water supply & sanitation infrastructure, power facilities, and communication infrastructure.

Households: collection of data of individual households in the envisaged project areas for a particular reference year in which significant flooding/erosion occurred (2006). Data collection included household characteristics, characteristics of the recent flood(s), losses to residential structures, hypothetical damages to the residential structures in the case the inundation depth would have been higher, agricultural assets/incomes, crop losses, livestock losses, fish/shrimp losses, other HH income sources (e.g., home-based businesses, hired labour) and health impacts.

<u>Local businesses</u> (non home-based): collection of data of individual businesses in the envisaged project areas for a particular reference year in which significant flooding/erosion occurred (2006). Data collection included business data, characteristics of the recent flood(s), direct and indirect damages to business structures, equipment and inventory, impact on revenues and employment, and expenditures for flood protection.

In addition, the field work in each study area included:

<u>Baseline flood vulnerability data collection</u>: In consultation with local district and/or commune officials and existing databases, data were assembled to document key aspects of flood and erosion vulnerability including population composition and growth, number of households, household assets, economic activities, poverty incidence, land ownership, land use and cropping patterns, fisheries production, animal husbandry, types of structures and infrastructure. In addition, the baseline captured data on business activities, educational facilities and assets, healthcare facilities and assets, road and transport facilities, irrigation facilities, water supply & sanitation infrastructure, power facilities, and communication infrastructure. This data is to be incorporated into the flood data database, as well as being used in the formulation of flood risk management strategies.

<u>Focus groups on community resilience</u>: The survey team facilitated focus groups with local leadership, community/mass organizations and men and women living in the study area who represent different economic activities and wealth. The groups are used to collect qualitative information on the beneficial and detrimental effects of floods and erosion. A guide for these discussions had been prepared to ensure that the various groups follow the same pattern and that results could be compared and analysed. The focus group discussions covered issues such as the history of flooding in the area, their perception of 'good' and 'bad' floods, benefits of floods for paddy cultivation and fishing, traditional coping mechanisms and strengths and weaknesses of community preparedness and resilience to flooding.

For each of the above mentioned approaches a survey tool was developed. The tools consist of questionnaires for the first three approaches and a guideline for the focus group discussions. For focal areas where bank erosion is the issue, a revised methodology has been developed to collect data at district level for each relevant river bank section; no household or business interviews and no focus group discussions were held there. The set of tools consists of:

- Questionnaires for Provincial & District Inventory of direct flood damages/bank erosion;
- Questionnaires for District Flood vulnerability/bank erosion baseline database;
- Questionnaires for District flood events/bank erosion;
- Questionnaires for District Indirect flood/bank erosion costs;
- Guide for Focal Group discussion;
- Household questionnaire;
- Business questionnaire;
- National Report outline.

These tools have been translated into the local languages as required and spreadsheets for questionnaire analysis were prepared and were provided to the survey team, along with a guideline to prepare a national report.

As indirect damages are usually not recorded by District or Provincial authorities, the results of the surveys have been used to develop factors that are used to increase the values of the direct damages to include also the indirect ones for the categories Infrastructure & Relief and Housing. For the Agricultural category no indirect damages are estimated, as they are not regarded as substantial.

To make monetary flood damage data pertaining to various years comparable, they have been corrected for inflation by using country-specific deflation factors derived for the national consumer price indices. To make damage values comparable between MRC-member countries, they have been converted into US$.

For the above mentioned categories the (Provincial and) District-level historical direct & indirect flood damage data have been used in combination with the maximum flood levels of the respective years to arrive at District and category specific damage curves. An optimization procedure has been used to express the flood damage through a damage 'curve' consisting of two linear sections: one for low floods causing no or limited damage and one for high floods causing substantial damage. An example of such damage curve is shown in Figure 3.1.

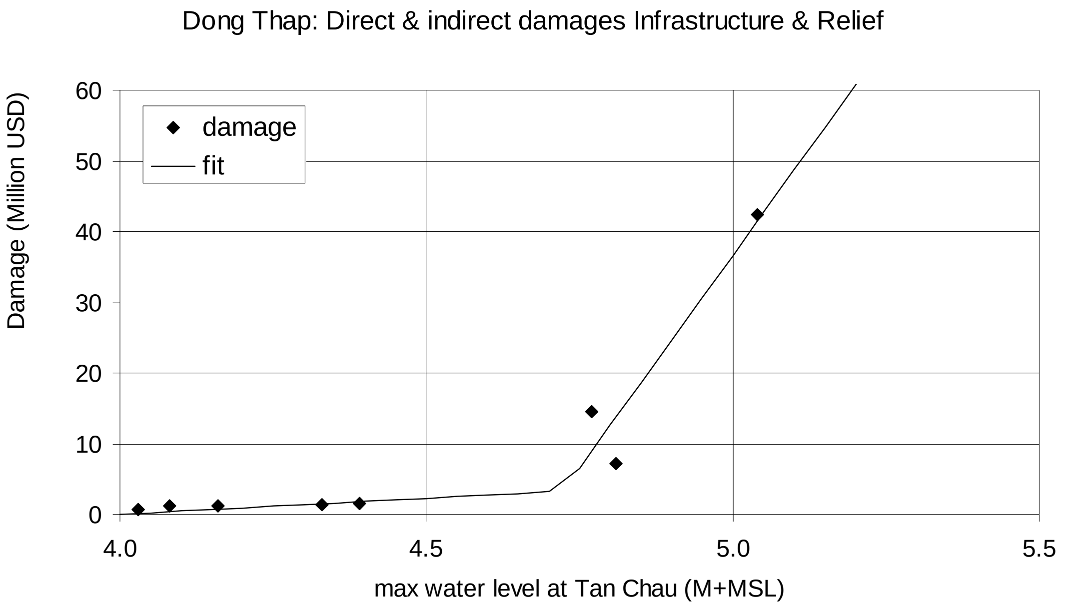


Figure 3.1 Province damage curve Dong Thap.

For the full set of damage curves for all Districts in the Focal Areas and for all three damage categories reference is made to Annex 2.

3.2 Flood risk assessments: methodology and approach

There are basically two approaches for flood risk assessment: a top-down and a bottom-up one. In the top-down approach historical damage data for an (administrative) area are used to assess the flood damage risk in that area by combining them with the historic flood levels that caused the damage. In the bottom-up approach inundation-damage relationships are developed on a per unit (ha, house) basis, and the flood damage risk is assessed by applying the per unit risk to the number of units in the concerned area and the probability of the area being flooded. In this study both approaches have been followed for damages to Housing and Agriculture; for Infrastructure & Relief only the top-down approach could be applied.

For policy purposes, District-level flood risks can be calculated for the distinguished flood risk categories. These annual flood damages are then used to identify the districts with the highest damage. These would be the districts for which flood mitigation measures would have to be developed on a priority basis.

This value of total flood damages can be used to make a rough estimate of the costs of flood mitigating measures that could be justified in case these damages would be mitigated. Additional benefits that would be created would have to be added, flood benefits that would be lost would have to be deducted.

3.3 Lower Se Bang Fai basin

This Focal is for the most part covered by the Nongbok District. The risk assessment for this focal area has, therefore, been focused on this district. This assessment is presented in more detail in Annex 2.

The direct damages caused by flooding in the Nongbok district were collected from district and provincial authorities for the period 1996-2006. The indirect damages for Housing were derived from the Household and Business surveys. These rates were 227% of the direct damages for household and 67% for businesses, resulting in a weighted average of 216%. This is much larger than in other areas, but is so because the damage to houses is rather small as the houses are built on stilts and are located on sandy ridges; the indirect costs relate largely to temporary relocation.

Indirect damages for Infrastructure & Relief for 2006 were collected from relevant departments in the Nongbok District. The total indirect costs in 2006 were US$ 125,098, mainly from irrigation, education and health departments. Other departments reported no indirect costs related to the 2006 flood. Direct flood damage in 2006 for Infrastructure & Relief was US$ 319,562. The indirect/direct rate was estimated as 39%. These indirect-direct rates were used to adjust the direct damages reported by local government for the years 1996-2006.

To make the damage data of the various years comparable with each other and with data of other MRC-member countries, the data have been converted to the 2007 price level and have been converted to US$.

There was no information on house damages in the district flood inventory during 1996-2006. From the Household survey in Nongbok district, it showed that 10 out of 70 households had to fix the house after the 2006 flood for an average amount of 312,500 Kip (37 US$) per affected house. From the Focus Group Discussions it emerged that most villages are located on high ground and many houses are built on poles of 2.5-3 m above ground level. Therefore flood damage to Housing is not significant.

According to the 2006 statistics, there were 7,593 households in Nongbok district and it was estimated that 14% of these households suffered from damages to the foundation and/or floor of their house. The total estimated flood direct damages in 2006 for housing would be 339 million Kip (US$ 39,879 equivalent).

The district flood damage data have been related to the annual maximum water levels in the flood plain on the right bank of the Se Bang Fai river (ISIS-point sp70d) for the categories Infrastructure & Relief and Housing, as the flood damages in these categories are expected to mainly depend on the maximum level of flooding.

The flood damages to Agriculture (mainly paddy cultivation) depend very much on the timing of the flood. There are two main seasons of paddy: (1) Wet season paddy is planted in June and harvested in November; and (2) Dry season paddy is planted in December and harvested in April where irrigation water is available during the dry season. Flood damage to Agriculture is mainly for the wet season paddy. Unlike agriculture in the Lower Mekong in Vietnam, where the early flood would affect the paddy, in Nongbok Agriculture is affected by the main flood. Therefore the maximum flood water level has been used also for the analysis of agricultural damages.

Damage curves for the three damages categories for Nongbok District were prepared and used to estimate the damages for the return periods of 2, 10, 25 and 100 years. The resulting combined Damage Probability curve is presented in Figure 3.2.

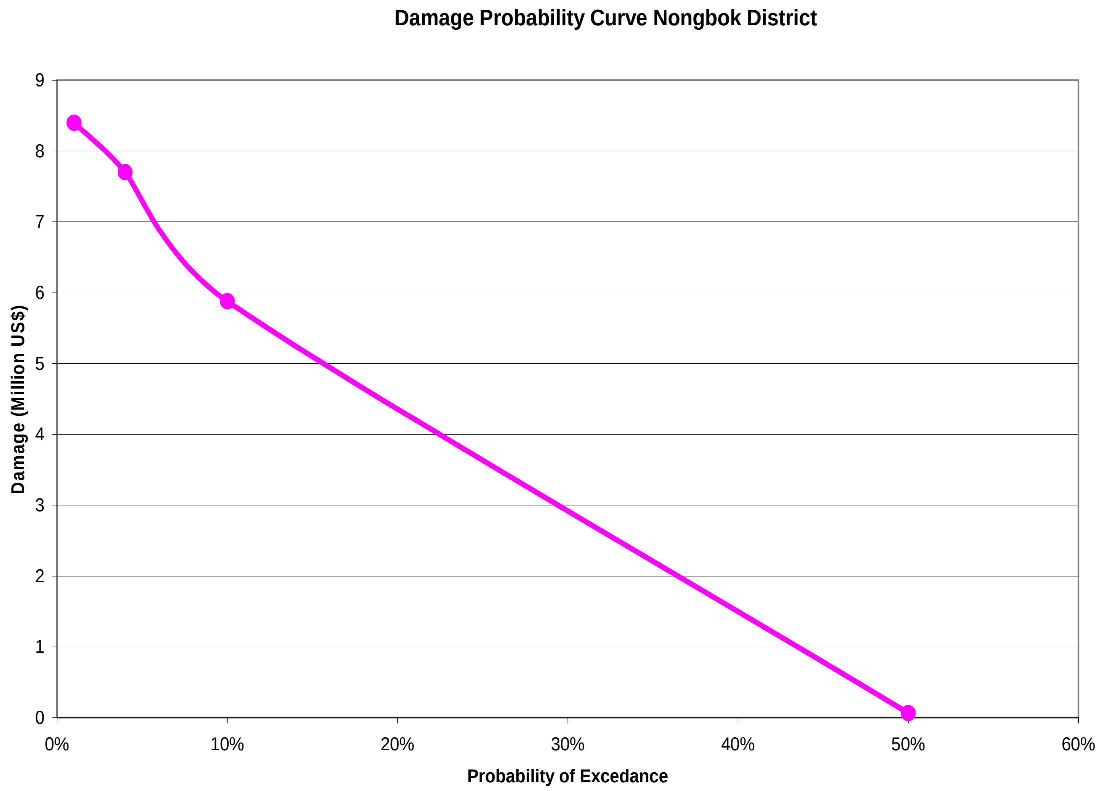


Figure 3.2 Damage probability curve for Nongbok district.

Potential damage reduction by flood control measures in focal areas can be identified by the area under the damage probability curve up to the proposed probability of control (say controlling flood at 10% probability or 1 in ten year return period). For the purpose of flood control measure analysis, the potential damage reduction by levels of control of 1%, 4%, 10% and 50% probability were derived in focal areas, See Table 3.1. The annual flood damages reduction would be about 1.19 million US$ for the district under flood control measures at 10% probability.

Table 3.1 Risk Reduction by Flood Control Measures

District	Population (person)	Land (ha)	Paddy (ha)	1% (M US$/yr)	4% (M US$/yr)	10% (M US$/yr)	50% (M US$/yr)
Nongbok	41,103	31,300	12,800	1.84	1.60	1.19	0.003

The risk reductions mentioned in Table 3.1 are established for the current situation of land-use and assume that the measures eliminate flooding up to the mentioned probabilities. This would be the case for flood protection dykes. Other measures, like flood diversions, would change the Damage Probability curve itself, and hence the effects could not be established in this way. In the case proposed flood control measure provides additional opportunity to increase cropping intensity in agriculture, then the net benefits from cultivation of the additional crop of about 400 US$/ha could be taken into account in cost and benefit analysis.

The two Focus Group Discussion reports show that there are no benefits from the flooding to Agriculture in terms of sedimentation and soil fertility, acidity leaching and pest control to the land. Most of households, however, are engaged in capture fisheries in the rivers and paddy fields. 70-80% household are fishing for sale, the remaining households only fish for their daily consumption. The duration of fishing is reported as 10-20 days. The benefit from capture fisheries per household are US$ 150-3,200 for average flood and US$ 290-6,400 for big flood.

3.4 Cambodian Mekong Delta

This Focal Areas comprise the Right Bank Bassac River south of Phnom Penh Municipality (Koh Andet & Koh Thum Districts) and the Left Bank Mekong River south of the National Road No 1 (Kampong Trabaek District). The flood risk presented in this Section is treated in more detail in Annex 2.

The direct damages of flood in the 3 selected districts were collected from district and provincial authorities from 2000-2007.

The indirect damages were derived from household and business survey and indirect damages by the flood collected from relevant departments in the selected districts. The weighted average indirect-direct ratio for household and business was estimated as 68% for the whole 3 districts.

From the secondary data collection at district level, indirect and direct flood damage data for the districts Koh Andaet, Koh Thum, and Kampong Trabaek in the 2006 flood year were estimated. These data provide an overall indirect-direct ratio for the Infrastructure & Relief category. The overall ratio was estimated at 19%.

These indirect-direct ratios were used to convert the direct damages as reported for the provincial level for the years 2000-2007 into total damages by adding 68% for the Housing category and 19% for the Infrastructure & Relief category. To make the damage data of the various years comparable with each other and with data of other MRC-member countries, the data have been converted to the 2007 price level and have been converted to US$.

The district flood damage data have been related to the annual maximum water levels at the district towns. The annual maximum flood levels for the categories Infrastructure & Relief and Housing as the flood damages in these categories are expected to mainly depend on the maximum level of flooding.

In the Cambodian part of the Mekong Delta there are two main seasons of paddy: (1) Wet season paddy which is planted in shallow flooded areas in May and harvested in November; and (2) Dry season paddy planted in November and harvested in April. Flood damage to agriculture is mainly for the wet season paddy in the 3 surveyed districts. In the absence of August-flood protection as practised in Vietnam, the flood damages to agriculture (mainly paddy cultivation) depends more on the maximum annual level of the flood than on its timing. Therefore, also for Agriculture the maximum annual flood level has been used to analyse the flood damages.

The district damage curves above were used to estimate the damages for the three categories for all the years between 1910 and 2006. The results are presented graphically in Figure 3.3.

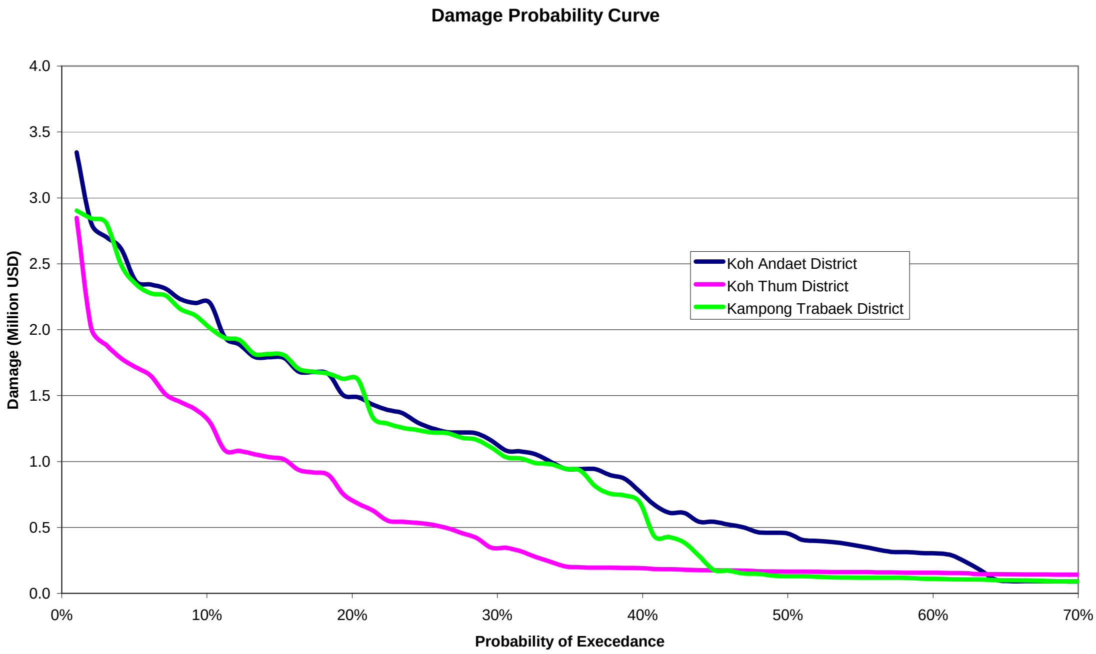


Figure 3.3 Damage probability curves for Cambodian districts.

Potential damages reduction by flood control measures in focal areas can be identified by the area under the damage probability curve up to the proposed probability of control (say controlling flood at 10% probability or 1 in ten year return period).

The damage-probability curves for the three selected districts were established as presented in the previous section. For the purpose of flood control measure analysis, the potential damages reduction by control levels of 1%, 4%, 10%, and 50% probability were derived in focal areas.

At the same level of protection, potential damage reduction would be almost the same for the three selected districts. The annual flood damages reduction would be about half a million US$ for each district under flood control measures at 10% probability. See Table 3.2.

Table 3.2 Risk Reduction by Flood Control Measures

District	Population	Land	Paddy	1%	4%	10%	50%
	(person)	(ha)	(ha)	(M US$/yr)	(M US$/yr)	(M US$/yr)	(M US$/yr)
Koh Andaet	50,716	24,749	24,186	0.77	0.68	0.54	0.07
Koh Thum	150,517	47,860	15,157	0.42	0.35	0.26	0.06
Kampong Trabaek	125,638	31,549	31,355	0.69	0.60	0.46	0.04

The risk reductions are established for the current situation of land-use and assume that the measures eliminate flooding up to the mentioned probabilities. This would be the case for flood protection dykes. Other measures, like flood diversions, would change the Damage Probability curve itself, and hence the effects could not be established in this way. In case the proposed flood control measure provide additional opportunities to increase the cropping intensity in agriculture, then the net benefit from cultivation of the additional crop of about 500 US$/ha could be taken into account in the cost and benefit analysis.

There is a high development opportunity for the Cambodian Mekong Delta as the cropping intensity is still low. Flood control measures in combination with irrigation and drainage facilities could change all paddy land from 1 crop to 2 crops, as in the deep flooded areas in the Vietnamese Mekong Delta, and to 3 crops in the shallow flooded areas.

In the Focus Group Discussion in the six surveyed communes farmers mentioned that floods have significant benefits for crop cultivation. After a big flood, the crop yield would be 1.5-2 ton higher than after a normal flood. The application of fertilizers and pesticides, however, is almost the same. Flood benefits for agriculture would be 0.62-0.93 million Riel/ha (about 150-230 US$/ha).

Depending on the district, 30-100% of families in the deep flooded area are fishing during flood the season. Duration for fishing is reported as 2-3 months in five communes; in the Preak Thmey commune fishing lasts for 7 months. The benefit of flood for capture fisheries of people in deep flooded areas are 0.32 – 3.78 million Riel/fishing household (about 80 – 945 US$) in most communes and much higher in the Preak Thmey commune as they also fish outside the flood season.

3.5 Vietnamese Mekong Delta

This Focal Area comprises the deep flooded parts of the Long Xuyen Quadrangle (An Giang Province) on the Right Bank of the Bassac River (Chau Phu District) and parts of the POR (Dong Thap Province) on the Left Bank of the Mekong River (Tan Hong & Tam Nong Districts). The flood risk for the Vietnamese part of the Mekong Delta has been analysed both at Provincial and at District level. Details are presented in Annex 2.

3.5.1 Provincial level

For the Vietnamese provinces Dong Thap (POR) and An Giang (Long Xuyen Quadrangle) in the deeply flooded areas bordering Cambodia, a dataset was obtained at provincial level covering direct damages for the period 2000-2007. To make the damage data of the various years comparable with each other and with data of other MRC-member countries, the data have been converted to the 2007 price level and have been converted to USD.

From the Household and Business surveys for the districts Chau Phu (An Giang province) and Tam Nong and Tan Hong (Dong Thap province) a relation between direct and indirect damages was derived for 2006. For the Businesses only an average relation could be calculated, as the sample was rather small. This relation was used to convert the direct damages as reported for the provincial level for the years 2000-2007 into total damages for the Housing category by adding 64%.

From the survey of district level indirect flood damage data for the districts Chau Phu, Tam Nong and Tan Hong a relation between direct and indirect damages for the Infrastructure & Relief category was derived for 2006. This relation was used to add 30% to the direct damages as reported for the provincial level for the years 2000-2007 to obtain the total damages for this category.

The provincial flood damage data have been related to the annual maximum water levels at Chau Doc (Bassac river) for An Giang and at Tan Chau (Mekong river) for Dong Thap for the categories Housing and Infrastructure & Relief, as the flood damages in these categories are expected to mainly depend on the maximum level of flooding. However, comparing the flood damages for 2001 and 2002, it appears that the damages in 2002 are considerably lower than in 2001, although the height, timing and duration of these two floods were very similar. It could be that in 2001 there was more wind creating higher waves, resulting in larger damages. It could also be that people and governments learned from the 2001 flood to take more precautions to avoid damages in 2002. This was confirmed by the participants in the relevant focal group discussions carried out as part of the project surveys.

The flood damages in the Vietnamese part of the Mekong Delta to agriculture (mainly paddy cultivation) depend very much on the timing of the flood. Dong Thap and An Giang provinces have two dominant crops per year except for some small areas were three rice crops are planted under full flood protection. Summer-Autumn Paddy is planted during March-April and it is harvested during July to mid of August. Winter-Spring Paddy is planted during November-December and it is harvested during February-March.

The deep-flooded areas in the POR and the Long Xuyen Quadrangle are all fitted with flood protection dykes that have been designed to protect agricultural land in normal years against floods till the end of August, allowing safe harvesting of the Summer-Autumn crop. In case the flood comes early, this crop is damaged. Therefore the agricultural damages have been related to the highest flood levels at Chau Doc and Tan Chau before 1 August.

All damages have been sorted and the totals are plotted in the Figure 3.4, showing the relation between total damage and probability in the two Vietnamese deeply flooded provinces. The curves clearly show that Dong Thap is more at risk than An Giang.

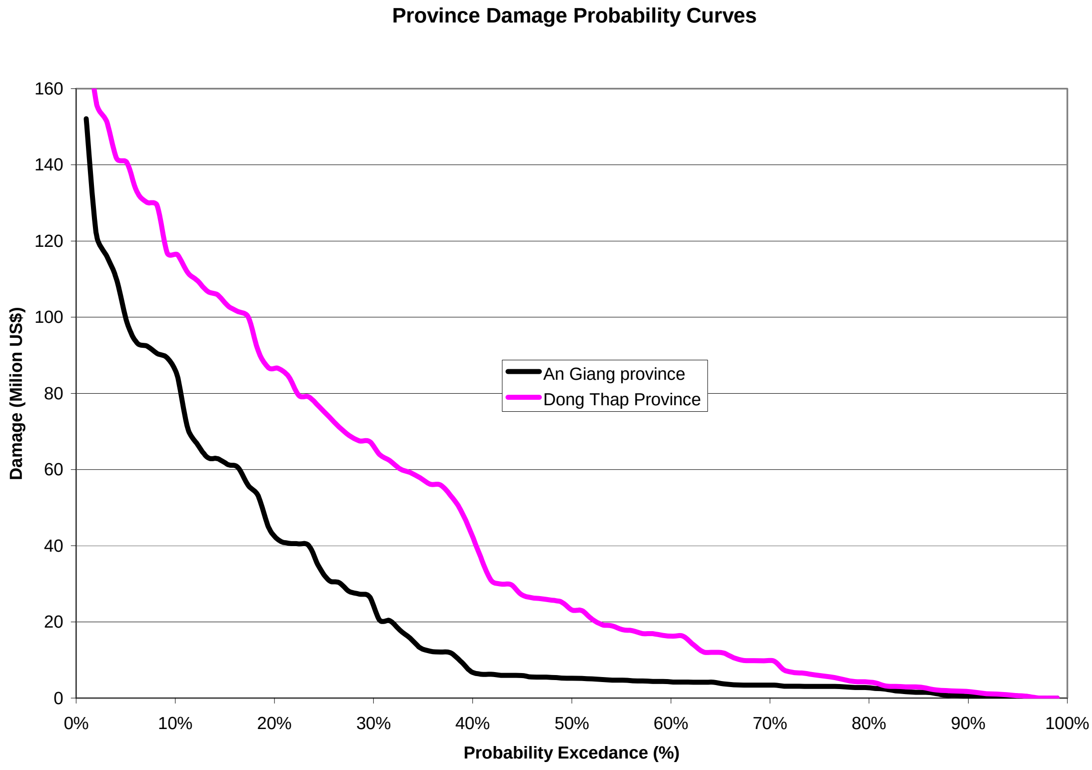


Figure 3.4 Damage probability curves for Vietnamese provinces.

3.5.2 District level

The direct flood damages for selected districts Chau Phu District (An Giang Province), Tan Hong and Tam Nong Districts (Dong Thap Province) were obtained at provincial level, covering the period 2000-2007.

From the Household and Business surveys and district indirect flood damage data for the 3 selected districts, a relation between direct and indirect damages was derived for 2006. The weighted average ratio between indirect and direct damages is 64% for the Housing category and 30% for Infrastructure & Relief. These weighted ratios are applied for estimating the total damages (direct and indirect) for Housing and Infrastructure for 3 districts. The corresponding maximum water levels were generated by the MRC-Mekong Delta hydrological model (ISIS). To make damage data of different years comparable, a deflation factor has been used, based on the Consumer Price Index.

The district damage curves above were used to estimate the damages for the three categories for all the years between 1910 and 2006. The results are presented in Figure 3.5.

The highest risk is found in Tam Nong District, where annual flood water is deeper than other area. It is followed by Tan Hong District. Lower risk is found in Chau Phu in Long Xuyen Quadrangle where there is an early flood protection control structure (Tha La–Tra Su Rubber dams and embankment) is in place to allow the safe harvesting of Summer-Autumn Paddy by mid-August. Generally it can be seen that for floods with a return period of 2 years or less (probability of exceedance more than 50%), the flood risk is rather small. Serious damage occurs at floods with a return period of 10 years and above (probability of exceedance less than 10%).

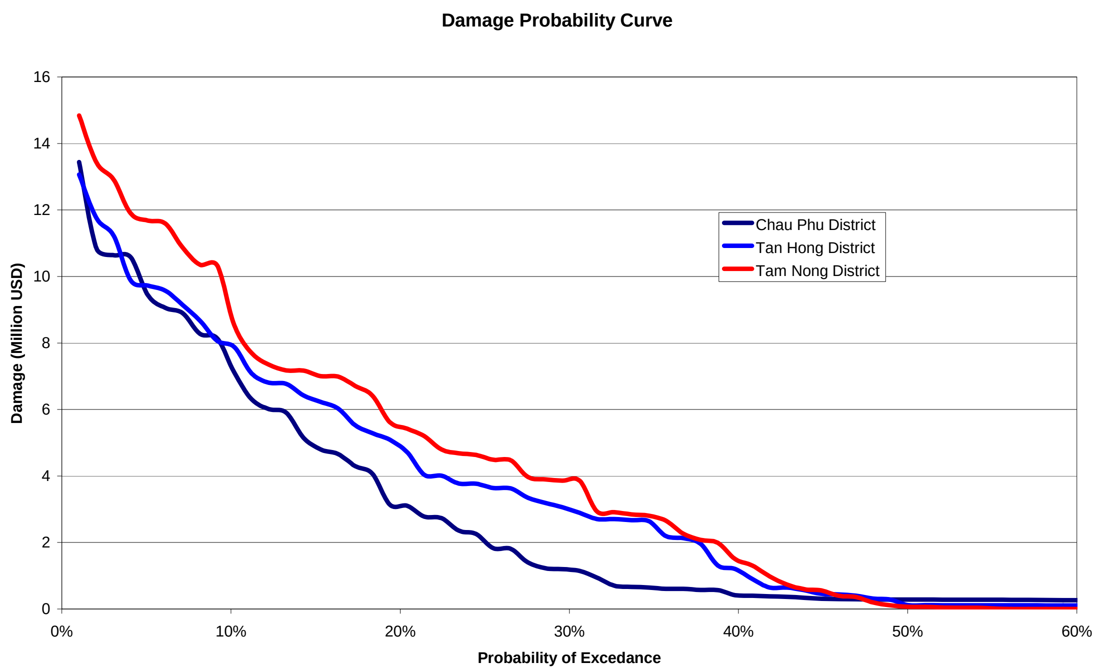


Figure 3.5 Damage probability curves for Vietnamese districts.

Risk reduction by flood control measures in the focal areas can be identified by the area under the damage probability curve up to the proposed probability of control (say controlling flood at 10% probability or 1 in ten year return period).

The damage-probability curves for the three selected districts and the whole Dong Thap and An Giang provinces were established as presented in the previous sections. For the purpose of flood control measure analysis, the risk reduction by levels of control of 1%, 4%, 10% and 50% probability were derived in focal areas, See Table 3.1. The annual flood damages reduction would be about 1.19 million US$ for the district under flood control measures at 10% probability.

At the same level of protection, risk reduction would be high in Dong Thap province compared to An Giang province. At the district level, the risk reduction would be high in Tam Nong district. It is followed by Tan Hong District and Chau Phu District. See Table 3.3. A map showing the flood risk for the three risk categories is presented in Annex 4, Appendix B.

Table 3.3 Risk Reduction by Flood Control Measures

	Population	Land	Paddy	1%	4%	10%	50%
	(person)	(ha)	(ha)	(M US$/yr)	(M US$/yr)	(M US$/yr)	(M US$/yr)
Districts							
Chau Phu	250,567	43,431	38,656	1.85	1.50	0.94	0.11
Tan Hong	86,137	31,115	24,869	2.27	1.90	1.34	0.04
Tam Nong	99,047	47,426	32,615	2.61	2.19	1.51	0.01
Provinces							
An Giang	2,231,000	340,000	238,500	22.99	19.01	13.16	1.35
Dong Thap	1,667,840	304,268	223,859	43.79	38.84	30.76	4.15

The risk reductions mentioned in Table 3.3 are established for the current (2006) situation of land-use and assume that the measures eliminate flooding up to the mentioned probabilities. This would be the case for flood protection dykes. Other measures, like flood diversions, would change the Damage Probability curve itself, and hence the effects could not be established in this way. In case the proposed flood control measures would provide opportunities to increase the cropping intensity in agriculture, then the benefit from cultivation of the additional crop should be taken into account in the cost-benefit analysis of the measures. This may be the case for the Long Xuyen Quadrangle and the POR. Existing agriculture in these areas is double paddy cropping. If flood control measures could provide full flood control for these areas, a triple cropping system could be implemented. The additional paddy crop could have net benefits of about 900 US$/ha.

In the six Focus Group Discussions held in focal areas, farmers mentioned that floods have significant benefit for crop cultivation. After a big flood, application of fertilizers and pesticides to Winter-Spring Paddy (November-March) is less than in a normal flood year by total value of 2-3 million VND per ha (about 100-200 US$/ha) but the yield is higher by 0.5-1.0 ton/ha. Flood benefits for agriculture would be 3-5 million VND/ha (about 200-300 US$/ha).

All most all families in the deep flooded area are fishing during the flood season. Duration for fishing varies between focal area, short duration for Long Xuyen Quadrangle (20-45 days) and longer duration for the POR (30-120 days) depending on the duration of the flood. The benefit of flood for capture fisheries of people in deep flooded areas are 1-5 million VND/household (about 100-300 US$/household) in normal flood years and about 2-12 million VND/household in big flood years.

3.6 Bank protection in Kratie and Bokeo

Two river bank erosion focal areas were selected for study by FMMP-2 namely: Kratie in Cambodia and Bokeo in Lao PDR. Socio-economic data collection for the erosion in the focal areas consisted of (i) District vulnerability and flood events; (ii) Direct damages caused by erosion; and (iii) Indirect damages caused by erosion. No Household or Business surveys were undertaken and no Focus Group Discussions were held in these two focal areas. Details of these Districts are provided in Annex 2.

3.6.1 Kratie district

There were six communes in Kratie District under the investigation: Sambok, Thma Krae, Krakor, Kratie, Roka Kandal, and Bos Leav. Socio-economic data collection from these communes included: the base line in 2006 for population, land & structure, business, education, health, road, irrigation, electricity, water supply and communication. The indirect erosion damages in 2006 by the above sectors were collected from the local authorities. There seemed not to have been significant erosion damages in 2006. Site visits in July 2008 could also not confirm the existence of significant river erosion. The noticed gully erosion of the Mekong banks was generally caused by drainage water from the roads running parallel to the river.

The indirect cost spent by local authorities was investigated. Total indirect cost in 2006 among six communes in Kratie district were 14.94 Mil Riel (US$ 3,735) of which 10.0 Mil Riel in Roca Kandal, 2.54 Mil Riel in Bosleav, and 2.4 Mil Riel in Krakor. The high indirect cost has been found in the irrigation sector where farmers had to pay extra cost to overcome irrigation disruption.

3.6.2 Bokeo Province

The data collection was carried out for Houayxai and Tom Pheung districts in Bokeo Province. Total direct erosion losses from 1997-2007 was 47,606 Mill Kip (5.6 Mil US$) in Ton Pheung district and 835 Mil Kip (98,300 US$) in Houayxai district. Indirect cost spent by local departments were investigated, there was no indirect cost that they spent in 2006.

3.7 Environmental risks of flooding in the Focal Areas

In Annex 2 the environmental risks of flooding are discussed in general terms and only qualitative assessments could be made for the Focal Areas, because detailed information on potential sources of pollution and environmental conditions in these areas is not available at this stage of the project. The present assessment of the environmental/health risk of flooding was made on the basis of information gathered during the household surveys and focal group discussions.

3.7.1 Right Bank Bassac, Cambodia

From the focal group discussions it became clear that main environmental problem related to flooding is the deterioration of the water quality, mainly in years with a 'bad' flood, that is a flood that starts early and lasts long. The water is reported to be stagnant for a long period in such years and to develop a bad smell and colour. Since a large proportion (over 30%) of the population is dependent on surface water as a source for domestic use, frequent occurrence of skin diseases, rashes and diarrhoea is reported. During 'good' flood years, the water keeps flowing and stays clear, and there are no health problems.

In the Koh Andet District, where the survey was carried out, there are no water treatment facilities and no sewerage systems. Less than 10% of the households have their own toilet/latrine and most of the people defecate in the fields. During a flood these human wastes, together with animal wastes, affect the water quality, as does the decay of flooded plans and crop residues and 'freshly added' human and animal wastes.

No industrial enterprises are located in the District, but there are 4 hard ware shops and 28 garages/repair shops and 83 food processing enterprises. Flooding of the garages/repair shops may result in pollution with hydrocarbons.

Fertiliser and pesticide use in the district is relatively low, even more so in the wet season than in the dry season. The risk of pollution of the flood water with fertilisers/ pesticides is therefore assumed to be low. During prolonged flooding, perennial trees and fruit trees are reported to become damaged.

3.7.2 Left Bank Mekong, Cambodia

The situation in the Focal Area on the left bank of the Mekong River is very much comparable with the situation on the right bank of the Bassac. The focal groups reported very comparably on environmental risks: also in this region, the Kampong Trabaek District, the main environmental problem related to flooding is the deterioration of the water quality in years with a 'bad' flood, starting early and lasting long. The water develops a bad smell and colour. A large proportion (some 25%) of the population is dependent on surface water for domestic use. As a consequence health problems occur frequently in the flood season. Illnesses reported are: skin diseases, rashes, diarrhoea, cholera, typhoid, and dengue fever. During 'good' flood years there are no health problems.

Less than 8% of the households in the Kampong Trabaek have their own toilet/latrine and people defecate in the fields. During a flood these human wastes, together with animal wastes affect the water quality, as does the decay of flooded plants and crop residues and 'freshly added' human and animal wastes.

No industrial enterprises are located in the District, but there are 61 garages/repair shops and 37 food processing enterprises. Hydrocarbon pollution may result from flooding of garages/workshops.

Also in this Focal Area fertiliser and pesticide use is low and the risk of pollution of the flood water with fertilisers /pesticides is therefore considered to be low. Damage to vegetation, fruit trees and other perennial trees, is reported to occur during prolonged flooding.

3.7.3 Bank Protection Kratie, Cambodia

In the Kratie Focal Area no focal group discussions were held, whereas the information collected during the household surveys, carried out in 6 communes (Sambok, Thma Krae, Krakor, Kratie, Rka Kandal and Bos Laev) in the Kratie District, only provided limited information.

A field visit to the area learned that the bank erosion of the Mekong River in the Kratie area does not pose any environmental risks. On the banks directly along the river no industrial enterprises are located and there no storage facilities containing potentially polluting materials are under threat.

Flooding in the Kratie area has a completely different character than flooding in the Cambodian Delta. Flood duration is short, about one week and waters are not stagnant. Industrial development in the area is limited and any pollutant that might end up in the floodwaters will be diluted to harmless concentrations due to the sheer magnitude of the flood volume.

3.7.4 Bank Protection Bokeo, Lao PDR

In the Bokeo Focal Area there is only a bank erosion problem, flooding is not an issue. There are garages/workshops (34), gas filling stations (4) and 3 ice production factories located in the 2 affected districts, Tonpheung and Houayxay. Non of these enterprises is located on the banks directly along the river, nor are storage facilities containing potentially polluting materials.

Since the river discharges in flood period are very high, any pollutant that might end up in the floodwaters will be diluted to harmless concentrations.

3.7.5 Se Bang Fai Flood Protection, Lao PDR

Participants in the Focal Group discussions in the Nongbok District in the Se Bang Fai Focal Area did not specifically mention poor water quality as the main environmental risk of flooding, as did people in the Cambodian Delta. However, health problems, like eye sores, dysentery, dengue fever, malaria and skin diseases, emerging after the flooding, when people start to work on the contaminated fields were specifically mentioned. This contamination with pathogens is related to the spread of human and animal wastes during the flood, when sanitary conditions are very poor. During the flood, poor water quality is not a problem, since people have enough stock of fresh rain water for household use. This is related to the fact that floods in the Se Bang Fai area do not last very long, 30 to 45 days at most.

No industrial enterprises are located in the District, but there are 26 garages/repair shops and 4 registered fuel stations. Flooding of the garages/repair shops and fuel stations could result in pollution with hydrocarbons.

Fertiliser use in the district is limited, and pesticide use is reported to be almost zero. Stocks of agrochemicals are brought to safe places before the flood arrives and for the period 1996 to 2006 no flood damages to fertiliser stocks have been reported. The risk of pollution of the flood water with fertilisers/ pesticides is therefore assumed to be low.

Overflowing of fish ponds is reported to occur frequently. This potentially results in the spread of exotic fish species over the flood plain and river system.

3.7.6 West bank Bassac (Long Xuyen Quadrangle), Vietnam

Household surveys in the Chau Phu District of the An Giang Province indicate that the water quality may become poor during flooding, more so during normal and small floods than during big floods. Again this is related to poor sanitation conditions in the area: human and animal wastes pollute the flood water. Although a large proportion of the population depends on river and canal water during the flood (70% in the Dao Huu Canh Commune and 32% in the Vinh Thanh Trung Commune) health impacts of the pollution are limited. This is to be attributed to the fact that Public Health Preventive Centers provide medicines, water filters and water treatment chemicals. Public places like kindergartens, schools and markets are disinfected (sprayed) after the flood recedes. Nevertheless, diarrhoea and dengue are reported to occur frequently. The poor part of the population is hit harder due to lack of awareness and money to pay for adequate provisions.

No info is available on garages, workshops, etc. in the area that could form potential sources of pollution. It is reported that businesses in the area have all raised foundations above the year 2000 flood level. The risk of spreading of pollutants with the flood water is therefore considered limited.

3.7.7 Left Bank Mekong (POR), Vietnam

The situation on the Left Bank of the Mekong is very much comparable with the situation on the Right Bank of the Bassac. Household surveys in four communes in the Tan Hong District of the Dong Thap Province indicate that the environmental risks of flooding are limited. Also in this area, poor water quality is the main problem, resulting in incidence of diseases. Mentioned are: intestinal, skin and respiration problems. Between 70 and 15% of the population in the four communes depend on river and canal water during the flood season. Medicines, water filters and purification chemicals (Cloramin B) are provided by health workers, and spraying is applied to disinfect public places and residential areas after the flood.

All industries, shops and other businesses in the area are located on raised areas, above the year 2000 flood level. Household stocks are stored on higher floors before the flood arrives. Consequently, the environmental risk of pollutants being spread by the flood water is considered limited.

3.8 Social dimensions of flooding

The annual floods in the LMB affect households, social groups and communities in different ways. In part, this is a function of the timing, depth, duration and other characteristics of the flood events. Other, very important aspects of how people are able to deal with floods are the social, demographic, economic and livelihood characteristics of the flood-affected people and communities themselves, as well as factors such as the facilities, services and institutional support that are available to them. These characteristics serve to define the social dimensions of flooding in terms of the strengths (resilience) and weaknesses (vulnerability) of individuals, households, social groups and communities.

In the focal areas identified for the FMMP-C2, a program of social surveys and focus groups was conducted involving district authorities, samples of households and businesses and other stakeholders. The program had two purposes: to collect data and information (i) to estimated direct and indirect flood damages and (ii) to gain a better understanding of the social dimensions of flooding. This information on social dimensions has been used to provide a preliminary assessment of how households and communities in the focal areas are resilient – or vulnerable – to the impacts of annual floods. This includes discussions of how people perceive good and bad floods, the range of traditional coping measures and other strategies that people use to reduce flood-related risks and the level of flood preparedness and capacity to deal with flood emergencies and recovery. This section summarizes some of the key issues of the social dimensions of flooding, while Annex 2 provides a more detailed report of the results of the social surveys and focus groups in each of 5 focal areas.

Social surveys and focus groups were conducted in portions of the 5 focal areas including (i) Se Bang Fai in Khammouane Province, Lao PDR, (ii) West Bassac in the provinces of Takeo and Kandal, Cambodia, (iii) East Mekong in Prey Veng Province, Cambodia, (iv) POR, Dong Than Province, Viet Nam and (v) Long Xuyen Quadrangle (LXQ), An Giang Province, Viet Nam. In each focal area, work was carried out in 1-2 districts; in each district, 2 communes or village clusters were selected as the target areas. The selection of these target areas was made in consultation with local authorities, with the objective of choosing areas that represented different flood conditions, e.g., deep-flooded areas versus shallow-flooded areas, areas along natural riverbank levees versus the main floodplain area, etc.

3.8.1 What constitutes good and bad floods?

There is a general consensus among people living in the LMB about the key characteristics of good and bad floods:

1. Flooding is an essential aspect of the rice cultivation and related livelihoods that dominate the LMB. A good flood is one that rises slowly, recedes quickly and, most importantly, is timed to provide the required amount of water needed for the wet-season rice crop.
2. In addition to fertilizing the soil through alluvial deposits, a good flood will also cleanse rice land. Flood waters are important means to kill off rats and other pests that threaten the rice crop, and to leach acidity (in acid sulphate soils as in the POR) and other contaminants from the soil.
3. Floods bring fish and create opportunities for households to supplement their diets during the flood season, as well as having a chance to make money through the sale of fish (or fish products such as prahoc). Fishing is often the key (or only) economic activity in households and communities that do not plant rice or other crops during the main flood season.
4. In simplest terms, a bad flood is one that comes at the wrong time, is too deep and/or lasts too long; a bad flood is out of sync with the needs of rice cultivation and increases the risks of damage to or loss of the rice crop.
5. In general, a bad flood is one that comes too early, before the early rice crop can be harvested; or, that persists for too long, delaying the planting of a recession rice crop. Another variant noted in Cambodia is the flood that is not high enough and/or that comprises a series of too-small peaks that are not timed with the needs of the rice crop (e.g., transplanting rice). This latter may be considered an aspect of the increasing incidence of (and concerns surrounding) drought conditions in the LMB.
6. Bad floods are often accompanied by high winds and waves that increase the exposure of people, particularly children, to the risks of drowning and/or curtail fishing and water transport activities. As noted, fishing is an important economic activity during the flood season and water transport is often the only means of travel.
7. Water quality deteriorates during floods, particularly when water stagnates. Contaminated drinking water, inadequate sanitation and washing clothes and bathing in floodwaters increase the risks of a range of diseases and health problems.

3.8.2 Community and household characteristics

Throughout the focal areas, there is a high degree of ethnic homogeneity. In Cambodia and Viet Nam, the populations belong predominantly to the main national ethnic group. In Lao PDR, most people living in the focal area belong to ethnic groups that are similar and constitute dominant groups in the country. On the other hand, except in Viet Nam, there are high levels of poverty in the focal areas, the proportion of children is very high and, in some instances, there are high proportions of female-headed households. The social dimensions of flooding related to these community and household characteristics include:

1. High levels of social, cultural and linguistic homogeneity support effective social and community networks that will increase the resilience of people and communities to deal with the impacts of flooding.
2. Poverty, however, is a key indicator of vulnerability to flood impacts. Poor people tend to live in housing of inferior quality located in more flood-prone areas; this means they may experience greater damages and losses due to flooding relative to the resource that they have. Poor people have lower cash incomes and are more dependent on financial assistance and loans that they may have difficulty to repay, creating a cycle of indebtedness. They are more at risk of having to sell off land and other capital assets as a means to pay for food, medical costs and other expenses that occur because of the flood, with a risk of becoming landless or being unable to invest in rebuilding their agricultural livelihoods. And, they tend to have lower education and job skills that would enable them to move temporarily or permanently to other types of work and sources of income.
3. Poverty tends to be higher among female-headed households (compared with households headed by men), making them more vulnerable to the adverse impacts of flooding. For example, if there is a lack of adult male labour it will be harder for these households to rebuild; female household heads may be more likely to sell land and assets to meet needs during floods.
4. A high proportion of children tend to increase risks and vulnerability in the event of flooding. Children are more often at risk of physical injury and drowning during floods. They may be more susceptible to becoming sick, for instance, if there is no safe drinking water or proper sanitation. If flood damages schools, children’s education can be disrupted; also their parents may not have money for school fees, books or clothes because of other flood-related expenses. Moreover, a high dependency ratio places extra burdens on parents and other adults to provide for children’s needs for food, shelter, health care, etc.

3.8.3 Land uses and tenure

Throughout the focal areas, the dominant land use is rice paddy and other productive land (upland crop land, plantation land, forest and wetlands). In general, this constitutes at least 90% of the territory of the surveyed districts. Areas developed for residential, commercial, institutional, industrial or other urban purposes are small. Landlessness is relatively low, as reported by district authorities in the focal areas; in general, the proportion of households without productive land is less than 5%. However, there are relatively few households that have full formal title to the land they occupy and use. In Lao PDR and Cambodia, there are not yet complete systems of registered land title, although most occupants are recognized as having some rights. In Viet Nam, in general, the Government has implemented a system of allocating and issuing land use right certificates (LURC) for agricultural land and, to a lesser degree, for residential land. However, in the 2 focal areas, there are high proportions of households (20-35%) that do not have LURC for their productive land or, in Chau Phu, for their residential land. Some of the social consequences in the context of flooding include:

1. The reliance of livelihoods on agricultural land increases the direct and indirect costs of flooding. Household expenditures for food and other basic needs will increase if people are unable to cultivate paddy or vegetables in riverbank gardens; incomes decrease from the loss of cash crops.
2. The lack of secure land tenure is a major risk factor for many households in Cambodia. They lack collateral to obtain loans to rehabilitate property damaged during a flood, finance agricultural inputs or meet other household needs (e.g., health care).
3. People without productive land are at risk during a flood because, in most instances, they work as agricultural labour on other people's land. They lose this source of income if land is inundated for extended periods and/or the rice crop is damaged or destroyed. As they are generally poor, they have few alternative resources to meet basic or flood-induced needs (e.g., health care).

3.8.4 Housing, other structures and household assets

The vast majority of principal structures in the focal areas are houses, accounting for 80-98% of main structures. In Viet Nam, commercial structures may account for 10-15%, but elsewhere they are less than 5% of main structures. There are very few, if any, industrial or institutional structures. Housing tends, in general, to be semi-permanent or temporary construction; small proportions of permanent house structures are larger and more valuable. Other types of structures include a range of construction types. Among a range of households assets, one of the most important in the context of flooding is boat ownership which, based on district data, varies considerably across the focal areas. In all focal areas, households and communities employ a range of traditional and more modern strategies to reduce the risk to housing, shops and other structures, such as:

1. Traditional wood houses are raised on concrete and wood poles in Lao PDR, Cambodia and, to a lesser extent, in Viet Nam. The height of houses may be just above flood levels or, often, a full story above ground.
2. Elsewhere, people will choose housing sites on higher ground and/or away from rivers and stream. They may also use earth or rubble to create a raised foundation or platform on which to build their houses. The resulting depressions are often used to develop fish ponds.
3. Many communities have designated safe areas that can be used by households to relocate temporarily. In general, however, these are not used by households except during a severe flood.
4. In contrast, the Government in Viet Nam has instituted a program of permanent relocation of households in the Mekong floodplain to flood-free areas that have been established.
5. Shops and markets are often located on naturally higher ground, in designated safe areas or along road and other embankments, offering greater protection from flood waters. In other areas, owners will strengthen the foundations to protect the structures against flood waters.
6. Prior to the onset of floods, people will do a number of things to protect their houses, shops and possessions, including: investing in strengthening and bracing their houses to make them more resistant to flood waters, moving household possessions to a higher level or other safer place within the house and moving business inventory and equipment to a high level or safer place.
7. Government agencies, the Red Cross and NGOs are involved in initiatives throughout focal areas to flood proof schools, clinics and other institutional structures, for example, by raising them above flood levels.

The detailed assessment of the social vulnerability of communities related to their housing and other assets varies across the focal areas, but the following generalizations may be made:

1. Traditional coping measures such as siting houses on high ground and building them on stilts and government strategies to create flood-free zones significantly decrease the vulnerability of many households to damages caused by flooding.
2. Poor people, however, tend to live in housing that is constructed of poor-quality materials (bamboo mats, thatch, found materials, etc.); their houses are also generally located on the ground, in low-lying and flood-prone areas. They are extremely vulnerable to their houses being damaged or swept away by flood waters. Although the monetary value of these houses is low, the ability of poor households to rebuild structures and replace damaged possessions is much more limited than wealthier households.
3. Throughout the focal areas, households also own a variety of small, temporary structures that are used to store rice and as animal shelters, outdoor kitchens and latrines and for other purposes. These structures are highly vulnerable to damage by flood waters, resulting in the loss of assets and resources for households related to their livelihoods (e.g., raising livestock) and living conditions (e.g., latrines).
4. Communities where there are households that own boats, particularly small boats that can navigate flooded areas, have a degree of resilience during floods that is not available to other communities/households. Households have a means of transport that can be used to catch fish, access markets and get to health care and other services. Their communities benefit from the availability of craft to respond to emergencies, reach isolated households, etc.
5. Communities with flood-proofed institutional structures are better prepared to deal with floods than other communities. These structures provide alternatives for temporary shelter of people, for example, during a bad flood. They also increase the availability of health care, education and other services to the community.

3.8.5 Occupations, economic activities and rural livelihoods

The majority of people living in focal areas are engaged in rice cultivation. In general, people in Lao PDR and Cambodia grow one, rainfed rice crop per year; in some areas, supplemental irrigation is provided by small-scale irrigation systems. In Viet Nam, rice cultivation is irrigated and people grow at least 2 crops per year. In general, households have an average of 2.1-2.5 ha of paddy land, although the average in the East Mekong focal area (Cambodia) is only 1.6 ha. Many FG participants suggested that 2 ha is the area required for household self-sufficiency. However, poor households (living in temporary structures) generally have 30%-40% less productive land than wealthier households (living in permanent structures). Moreover, in Lao PDR and Cambodia, crops yields are very low compared with Viet Nam. As a consequence, households use more than half of their crops to meet basic household needs; the remainder is sold primarily to repay loans for agricultural inputs, leaving households with low net cash incomes. In Viet Nam, in contrast, crops yields are very high and approximately 85-90% of the crop is sold.

Most rural households also grow a variety of other crops and vegetables. In Lao PDR, for example, women cultivate riverbank gardens to grow crops for household needs and to sell in markets. In areas of higher ground such as along natural river levees, the cultivation of cash crops and tree plantations is the major agricultural activity and source of household income. Throughout the focal areas, small numbers of households fish as a main source of income, including fish and/or shrimp ponds, fish cages and capture fishery. Most households raise small and large livestock. Larger animals are kept as draft animals and to provide a financial security net for households; pigs, chickens and ducks are raised for household consumption and, particularly in the case of pigs, to sell to generate cash income.

A number of coping mechanisms are employed by farmers to reduce their risks to flooding (and drought). These strategies vary in different focal areas due to the flood conditions and types of land, but the following summarizes the approaches used:

1. Early crops are planted, for example, in Viet Nam, using short-duration varieties that can be harvested before the normal annual flood arrives. Farmers take extra measures such as pumping water out of their paddy to ensure that they can plant by certain dates that increase the likelihood of a successful crop.
2. Wet season rice crops, such as in Lao PDR and Cambodia, use rice varieties that grow tall and have heavy stalks to resist flood damage during the growing season. They are often planted only in the upland areas that are shallow-flood areas. Farmers also adjust dates for sowing and transplanting rice, depending on rain conditions; and, if there are favourable conditions, they may plant an additional, short-duration crop later in the wet season.
3. A recession crop is grown throughout all focal areas. It benefits from conditions when flood waters recede and, in some areas, irrigation.
4. Increasingly farmers are switching from wet season crops to cultivating rice only in the dry season. This is true particularly in Lao PDR and Cambodia and reflects farmers' responses to the damages caused by major floods and, increasingly, drought conditions, as well as the higher yields that are common for the recession crop.
5. There is a general intensification and diversification of cash cropping (field crops, vegetables, fruits, etc.) that is occurring in higher areas within focal areas, particularly along natural levees. These areas have lower risks of major flooding and the annual floods contribute to depositing silt and cleansing and increasing the capacity of soils. In many instances, there are roads that provide good transport and access to urban and other markets. Sometimes these markets are international, for example, people in Se Bang Fai selling in Thailand and people in Viet Nam selling in Cambodia.
6. Whereas people are reluctant to move their households to safe areas except in major floods, they will frequently move their animals to protect them from injury and, in some cases, because the safe areas provide alternative grazing areas. In the period leading up to the annual floods, households will spend time cutting grass and making other preparations to ensure animal feed during the flood.
7. Catching fish is a major activity during the flood; in areas where there is no wet season rice crop (e.g., in lowland areas in the West Bassac focal area), it is often the only economic activity during this period. Households with fish ponds will protect them with embankments, netting and other means, to minimize the risks of fish escape from flooded ponds.
8. Prior to the flood season, households will store rice, water and other essentials to meet household needs during the flood season. In Viet Nam, if the summer-autumn rice harvest is successful, people generally have sufficient rice to last for the next 6 month, thus reducing or eliminating the risk of food shortages. In Lao PDR and Cambodia, however, many households experience food shortages of 1-2 months during a normal flood season and for up to 6-8 months if there is a bad flood.

In a normal – or good – flood, these coping mechanisms result in a good degree of resilience to flood impacts. As noted, the annual flood is an integral component of the rice cultivation that sustains rural livelihoods in the LMB. Households and the communities they form rely on the flood to fertilize their paddy fields, bring water to sustain growth of the crop and the extra fish to supplement their diets and generate some cash income. However, households can easily become vulnerable to bad flood conditions and/or to the cumulative impacts of successive years of flood impacts; the following summarizes conditions in focal areas in Lao PDR and Cambodia:

1. In bad flood years, the early and/or wet season crops may be damaged or lost. Moreover, the planting of the recession crop may be delayed. Crop yields are reduced and, in many areas, there is increased risk of food shortages.
2. Households often borrow from family, friends and NGOs to have enough money to buy food. They also borrow to purchase inputs for their rice crops. Therefore, much of the crop

is sold while still in the field or at harvest (when prices are low) because the proceeds are required to repay these loans.

3. The opportunities for fishing become critical, for example, in lowland areas where there is little or no wet season rice crop. Poor households that do not own a boat are particularly vulnerable. All fishers are vulnerable if, during a bad flood, there are high winds and waves that make fishing dangerous or impossible.
4. Due to the lack of food and money, poor people in particular increasingly rely on “free” sources of food and income such as fishing, catching crabs and snails, collection of wild vegetables, etc. This may be possible during a normal flood season if people have access to boats or other means to access natural resource areas, but it becomes difficult or impossible during bad flood seasons.
5. Some households faced with food shortages will reduce the number of meals from three to two per day; women are more likely to go without food in order to feed their husbands and children. This has adverse consequences for the general health of women as well as their vulnerability to disease.
6. Distress sales of land and animals often occur when households lose rice crops and require money for food, medical or other expenses. A common cause of people becoming landless is the sale of land to pay for medical expenses. People will often sell animals prior to a flood (at significantly reduced prices) if they are worried they cannot protect their animals, find grass to feed them or pay for animal feed during the flood.
7. Many households must rely increasingly on selling their labour and other non-agricultural activities to supplement their incomes. This includes men and women who migrate, for example, to cities looking for work. In some parts of the LMB, families are permanently migrating to other parts of their country because they cannot sustain their livelihoods.
8. The most vulnerable groups include a) women who head households because they lack male labour, b) landless people who rely on working as agricultural labour, c) poor households and d) households headed by elderly and disabled people who do not have young people in their households to support them.
9. The cumulative impacts of flood losses are evident when there very bad floods (e.g., the 2000/2001 floods) or several above-normal floods within several years. Poor households in particular may have difficulty to recover from a single flood event – rebuilding housing, obtaining money to plant a new crop, repairing or replacing damaged assets, etc. A cycle of indebtedness is established with people repaying cash and in-kind loans often at high interest rates. As a result, they are more vulnerable in subsequent years even to the impacts of normal flooding.

In the focal areas in Viet Nam, there is a higher degree of resilience to flooding. This is due primarily to the initiatives taken by government to construct embankments to protect rice fields, relocate households to flood-free areas and raise roads above 2000 flood levels. Focus group participants indicate that there are significantly lower flood risks in the region as a result of these measures, assuming that a major flood does not exceed the events that occurred in 2000.

3.8.6 Electricity, water & sanitation and health services

The availability of grid electricity is high in focal areas in Lao PDR and Viet Nam (80-98% of households connected) and very low in Cambodia (generally below 10%). Piped water supply is also variable: in Lao PDR and Cambodia, the proportion of households with access to piped water supply is 0-20%; in Viet Nam, the proportions range from 20-50%. There is little if any sewered wastewater collection; in Lao PDR and Cambodia, only wealthier households have a latrine. Throughout the focal areas, in general there are high ratios of population to available health care facilities. The implications for social vulnerability to flooding include:

1. The majority of households rely on water sources that are potentially unsafe and often contaminated during floods. Relatively few households are reported to boil water; moreover, during floods this is often not possible due to a lack of firewood. A common strategy is to collect rainwater and store it in containers that are raised above the flood levels.
2. Poor sanitation in combination with unsafe water are major causes of the widespread incidence of diarrhea and dysentery during floods. Stagnant water breeds mosquitoes and increases the risks of malaria and other water-borne diseases. Bathing and washing in flood waters increases the incidence of skin and eye infections. Vulnerability to these diseases is mentioned by FG participants as a major consequence of floods.
3. Inadequate, inaccessible and often ill-equipped health care facilities are a major source of the vulnerability of households and communities when injury and illness occur during or following floods. Due to the lack of adequate health care and/or the need to travel to obtain health care, there is a higher risk of extraordinary health care costs that strain (or exceed) the resources of households, particularly poor households. This may lead to distress sales and permanent loss of land and other valuable assets: in Cambodia, distress sales of land to meet medical costs are a common cause of households becoming landless.
4. In the absence of health care facilities and services, many people rely on self-medication, buying drugs from petty traders who have little or no medical knowledge and/or going to traditional healers (and monks) for help and advice.
5. The impacts are greatest on children and women. Children are easily injured or get sick because they play in and drink unsafe flood waters. Women are most likely to forego meals if the household is experiencing food shortages, thus reducing their overall health status. They are also unable to obtain reproductive health services during flood periods.

3.8.7 Flood warning, emergency response and recovery

In Lao PDR and Cambodia, there are little if any organized strategies or plans for flood warning, emergency response and recovery. Although national, provincial and local government authorities provide some resources, people living in these areas rely heavily on the Red Cross, international NGOs such as CARE and other non-governmental organizations. This compares with Viet Nam where the different levels of government in collaboration with the Red Cross and CARE are well-organized with specific plans and well-defined roles and responsibilities. Even in Viet Nam as elsewhere, however, FG participants indicated that a major weakness of existing systems is a lack of financial and technical resources.

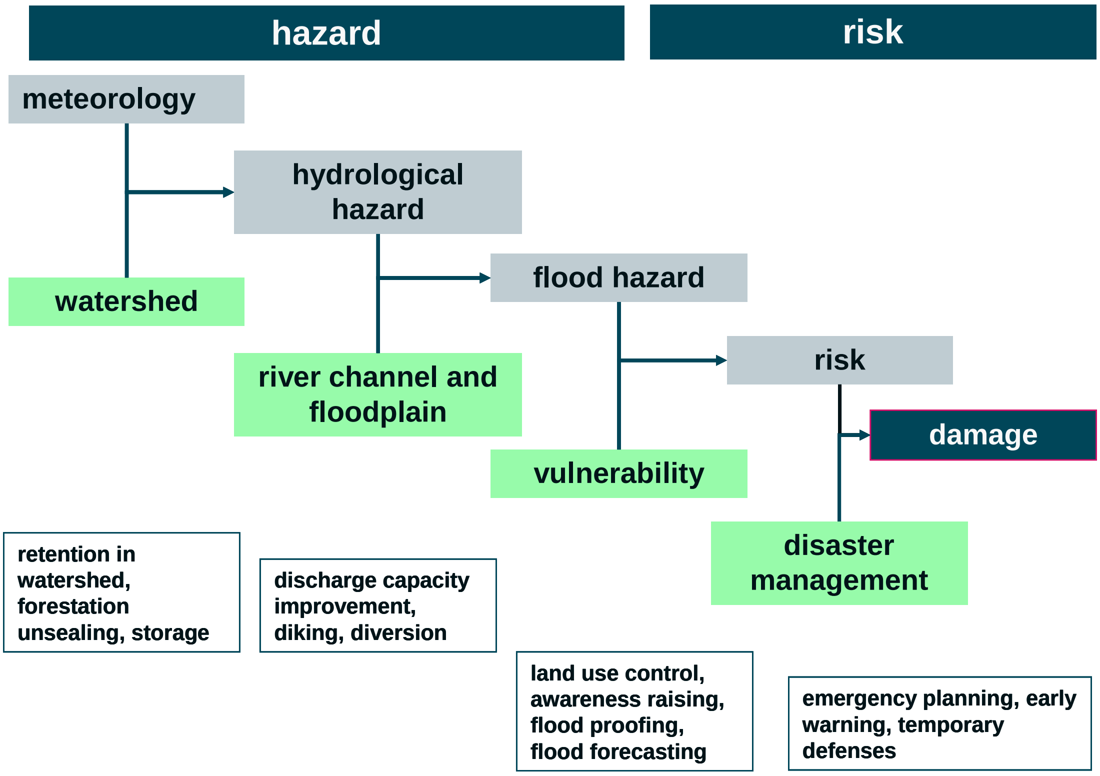
Flood preparedness is recognized as a major factor in increasing the resilience of households and communities to deal with floods. Therefore, ongoing initiatives – programs and specific projects – to help governments and communities to prepare flood warning systems and develop plans for emergency response and recovery although with training and capacity building will have a positive impact on strengthening the social dimensions of dealing with floods.

4 FLOOD RISK MANAGEMENT IN THE FOCAL AREAS

4.1 Integrated Flood Risk Management (IFRM): methodology and approach

4.1.1 IFRM concept

The concept of IFRM as used in the FMMP C2 is illustrated as follows:



It refers to the management of flood risk and the reduction of the damage in the full chain of events and circumstances that starts from a meteorological hazard all the way down to the occurrence of the eventual damage.

Flood risk management aims at the reduction of flood risks, whereas the reduction of the eventual damage when flooding is imminent is referred to as "disaster management".

This IFRM concept is used to find the most cost-effective measure (or combination of measures) to bring flood risks down to an acceptable level. The assessment of the "acceptability" of the residual risk, however, is not part of the approach.

The IFRM concept can also be used to find the most cost-effective measure (or combination of measures) to keep the flood risk at an acceptable level in case the flood risks increase as a consequence of changed land use (for instance the number of crops per year or the construction of public or industrial assets in flood prone areas) or of changed flood hazards (for instance sea level rise)

The IFRM approach provides the decision maker with the information about the most cost-effective way to reduce the flood risk to a certain level. It is up to the decision maker to make an assessment which level of risk is tolerated by society. From a purely economic point of view risks are tolerated as long as the costs for reducing these risks are higher then the actual risk reduction. It becomes more complicated, though, when intangible damages are at stake, especially loss of life. In such cases it is more appropriate to set targets rather then defining criteria. (For instance a target could be set to reduce flood risk to the extent that within a certain period of time, say 10 years, the number of fatalities is reduced by, say, 50%).

It is obvious that the application of the IFRM concept is only meaningful when there is sufficient understanding of the actual or future flood risks.

4.1.2 Flood risk management measures and impact evaluation

In the preparation of strategic directions for flood risk management a first assessment of the suitability of the different types of measures for certain types of flooding (see Chapter 2) and certain damage categories (see Chapter 3) is to be made. The following types of measures are considered:

1. Structural measures aiming at the reduction of the flood hazard, i.e.
    a. creation of storage and/or retention capacity, including small scale retention at field level, reservoirs and river floodplain restoration;
    b. improvement discharge capacity by river and/or diversion works;
    c. diking and/or polder schemes.

2. Structural measures aiming at the reduction of the flood vulnerability, i.e.
    a. flood proofing of buildings and infrastructure.

3. Non structural measures aiming at the reduction of flood hazards, i.e.
    a. watershed management;
    b. forestation;
    c. unsealing.

4. Non-structural measures aiming at the reduction of the flood vulnerability, i.e.
    a. land use control;
    b. awareness raising;
    c. flood forecasting.

5. Disaster management measures aiming at the reduction of the damages once flooding is imminent, i.e.
    a. early warning;
    b. emergency planning;
    c. temporary defences.

   A first evaluation of the appropriateness of the different measures has been made on the basis of an estimation of:
   1. impact of the measure on risk reduction;
   2. impact on the loss of flood benefits;
   3. related costs.

4.1.3 Focal areas

At the end of the Inception Phase of the FMMP-C2 a number of focal areas were selected for which strategic directions for flood risk management were to be developed during the Stage 1 Implementation Phase.

The focal areas that were selected for this planning exercise are:
1. The lower Nam Kok basin in Thailand;
2. The lower Se Bang Fai basin in the Lao PDR;
3. The Upper Se San basin in Vietnam
4. The transboundary Mekong Delta area on the right bank of the Bassac
5. The transboundary Mekong Delta area on the left bank of the Mekong.

Two other focal areas (Bokeo in Lao PDR and Kratie in Cambodia) refer to areas where bank protection is the main issue, rather than flooding.

For the formulation of the strategic directions for flood risk management in the above mentioned focal areas the following approach was developed:
1. Assessment of the flood risks for the actual situation;
2. Formulation of flood risk management measures;
3. Estimates of impacts of the flood risk management measures.

For the assessment of the flood risks in these areas reference is made to the Annex 2. From that Annex it is learned that during the Stage 1 Implementation phase the risk assessment could only be made for the Mekong Delta focal areas and the lower Se Bang Fai area. The risk assessments for the Nam Kok basin has been delayed in expectation of the socio-economic surveys and the flood hazard assessment (with the help of the ISIS model) to be implemented at the beginning of the next stage of the implementation phase. For the upper Se San basin it was found that the target area (Kontum) is barely at risk and that flood risk reduction should focus on vulnerability reduction in areas upstream of Kontum rather than on structural measures to reduce the flood hazards at the town of Kontum.

It is noted that the *acceptability* of the assessed flood risks in the focal areas has not been evaluated. Such evaluation would require an extensive consultation and political decision making process, especially when it comes to the assessment of the acceptability of the risk of loss of live and other intangible consequences of the floods. Such consultation and decision making process cannot be carried out in the framework of the FMMP-C2.

What has been achieved, though, is to illustrate to what extent flood risks can be reduced and whether the measures that are required to achieve the risk reduction can be justified from a socio-economic and environmental point of view.

Structural flood risk reduction measures aiming at flood protection may create benefits that go beyond the reduction of the existing flood risk. Such measures may allow for a more attractive land use than the actual one, generating more potential benefits. It is deemed essential to keep these potential developments in mind when evaluating the socio-economic impacts of flood risk reduction measures.

It is not the intention to asses under the FMMP-C2 the most attractive land use in the flood prone focal areas. For the socio-economic evaluation, though, of the flood risk management measures, assumptions are made regarding potential land use in the areas once protected against floods. These land use scenarios are indicative only and should be re-evaluated in the framework of integrated land and water resources management in the respective areas.

4.2 Strategic directions for flood risk management in the lower Se Bang Fai focal area

4.2.1 Flood risks and benefits

The Se Bang Fai floodplain, downstream of the crossing with Road 13, experiences flooding problems during the rainy season nearly every year. The risk in the Nongbok district, which covers most of the lower Se Bang Fai floodplains, has been estimated at some USD 1.8 million per year under the actual land use conditions. Extrapolating the results of the Nongbok district to the flood prone area downstream of the national Road 13, it is estimated that the flood risk in the lower Se Bang Fai area is of the order of USD 2-3 million per year. 90% if this risk is related to agricultural damages.

Results from focus group discussions held in focal areas showed that benefits from natural fishing is mainly from river and creeks. Farmers in the studied area said that there are no flooding benefit to agriculture in terms of sedimentation and soil fertility, acidity leaching and pest control to the land.

4.2.2 Flood risk management options

The reduction of the flood risk can be achieved by either the reduction of the flood hazard with the help of structural measures, the reduction of the vulnerability or a combination of both.

The flood risk in the lower Se Bang Fai is mostly due to agricultural damages. Reduction of vulnerability is therefore most effective if the vulnerability of the agricultural production is reduced. This can be done by adapting the cropping pattern to the flood regime and/or the introduction of more flood resistant crops. It is assumed that the actual cropping pattern is already optimally adjusted to the flood regime (traditional coping mechanism) and that further vulnerability reduction is to be sought in the use and/or development of less vulnerable varieties.

The reduction of the flood hazard in the lower Se Bang Fai area can in principle be achieved by:

1. The creation of flood retention capacity in or upstream of the flood prone area. Such measure allows for the reduction of the Se Bang Fai peak discharges and, consequently of the peak water levels in the river and adjacent floodplains.
2. The creation of additional discharge capacity of the river system. Such measure will reduce the peak water levels. The discharge capacity can be increased by deepening and or widening of the river itself or by creating additional capacity in a diversion and/or by-pass channel.
3. The construction of diking schemes that protect selected areas against high water levels.
4. The construction of gates that prevent Mekong waters to enter the Se Bang Fai floodplains.
5. The improvement of the drainage system in the flood plains, allowing for a reduction of the duration of the flooding. Further reduction of the duration of flooding can be obtained by the installation of gated structures at the locations where the (natural) drainage system of the flood plains drains into the Se Bang Fai or the Mekong river.

Regarding the creation of flood retention capacity upstream of the flood prone area, a project idea was identified concerning the construction of a flood storage reservoir in the Se Bang Fai at the confluence with the Xe Noy, just upstream of the Road 13 crossing, combined with construction of a flood gate in the Se Bang Fai mouth. This option has been discarded for reasons of far-reaching resettlement needs of the implementation of such option.

Under the actual conditions the floodplains have their own natural retention capacity. The creation / reservation of retention capacity in the flood prone area is, therefore, only relevant in combination with the implementation of diking schemes. In that case, part of the flood plain can be protected while another part is reserved for the retention of flood waters.

For the creation of additional discharge capacity, reference is made to previous studies on the flood diversion channel "Xelat" from Banne Sokbo to Banne. A flood diversion option is cost wise much more attractive than increasing the discharge capacity of the river channel itself.

Diking schemes for flood protection can be considered at several levels, from the so-called mini-polders to a full protection of the flood plains on both sides of the river downstream of the NR 13. Mini-polders refer to the protection of isolated areas in the order of 1,000 ha each. For the right bank of the lower Sebanfai (Nongbok) plans have been developed for polders from 3,000 ha to almost 10,000 ha.

At the Nongbok district level, ideas have developed that focus on drainage improvement rather than on flood protection. A number of 23 schemes have been identified for widening and deepening (natural) drains to be provided with gates at the confluence with Se Bang Fai or Mekong. These schemes try to achieve a reduction of the inundation time of flooded area to 15 days or less. Some of the schemes already exist but need rehabilitation and/or improvement.

4.2.3 Impacts of structural flood risk management options

Flood risk reduction

The flood risk in the Nongbok district was estimated with the help of the results of the existing ISIS model, which has a number of shortcomings as explained in the Annex 1. The risk assessment was done for the situation in which both sides of the lower Se Bang Fai (Nongbok and Savannakhet) are unprotected. Flood protection (protection level: 10%) would reduce the flood risk in the Nongbok district by 0.99 million USD per year, or about 55% of the actual risk.
However, protection of the Nongbok floodplains would create a loss of natural fish in this area in the order of 0.1 million USD per year.

Environmental impacts

Reduced flooding in the Se Bang Fai floodplain will have a number of significant environmental impacts. The area is at present a fairly important wetland area, which sustains a high biodiversity of flora and fauna, mainly water birds and fish. Reduction of the flooding will affect the dry season refuge habitats, small lakes, ponds and marshes, which are important for the survival of floodplain fish. From an environmental point of view complete flood protection, keeping the floods out, does not seem to be a good idea. A flood protection system that would allow flooding of the area during the main flood period of the Mekong River would sustain the precious wetland ecology and the fisheries potential.

4.2.4 Strategic directions

Land use scenarios.

The Se Bang Fai plain is one of the 4 main rice production areas in central Lao. Success or failure of lowland rice is closely linked to the natural flood cycle and every year part of the crop is damage by the flood. Yields are highest, 2.0 - 2.8 ton/ha, in areas that are not flooded very long.

The development of a strategic direction for flood risk management in the lower Se Bang Fai area is closely related with the envisaged land use scenarios. The risk under the present land use conditions is relatively low, essentially because the actual cropping patterns are fully tuned to the natural flood cycle. Nevertheless, the risk under the actual conditions is still almost USD 2 million per year in the Nongbok district alone.

A strategic direction for flood risk management could aim at:
1. risk reduction under the present land use conditions;
2. flood protection measures that aim at a more intensive land use.

Reduction of the actual flood risk

If no substantial development of the agricultural sector in the lower Se Bang Fai flood plain is envisaged, the reduction of flood risk in this area should focus on the reduction of the actual flood damage in this sector. Based on the risk assessment that was made for the Nongbok district it can be derived that the agricultural flood risk in the lower Se Bang Fai floodplain is of the order of USD 150 per year per hectare. A protection of this area against floods lower than the 1 in 10 year flood would reduce the risk with some USD 100 per year per hectare. This risk reduction does not justify substantial investments in large scale diking schemes.

It is anticipated that substantial reduction of the existing risk can be achieved by reduction of the duration of flooding. The option of drainage improvement in combination with gating of the Se Bang Fai tributaries could be an attractive option to achieve this goal.

The diversion option will reduce the peak levels along the Se Bang Fai downstream of the diversion canal. It will have no impact on the Mekong back waters. Further analysis of this option is required to assess its impacts on the agricultural risk. It is anticipated though that the cost of such measure is prohibitive as compared to the benefits (risk reduction)

A mini-polder might be attractive if it protects an area where the actual land use would justify such investment. Further analysis is required to assess whether such area exist in the lower Se Bang Fai flood plain.

Flood protection for agricultural development.

If agricultural development is envisaged in the lower Se Bang Fai floodplains then such developments would create increased risks in the absence of flood protection measures. It will consequently become more attractive to invest in flood protection schemes. Polder development, with or without a diversion scheme, would then be the obvious approach.

It is anticipated that the loss of environmental benefits, especially fisheries related benefits, will play a crucial role in the planning and design of polder schemes in the lower Se Bang Fai area.

4.3 Strategic directions for flood risk management in the upper Se San focal area

4.3.1 Flood damages and risks

The upper Se San focal area corresponds essentially with the Kon Tum province in Vietnam. Reported flood damages in this province over the period 2001 - 2005 are of the order of 0.9 million USD per year (in 2007 a damage of 1.9 million USD was reported). These damages are direct damages only. About half of the damage is related to irrigation and transport infrastructure, while the other half is related to households and agriculture.

Kontum town does not suffer from inundation, except under extreme flood conditions. Some damage was reported in the year 1996, which was an exceptional year (estimated probability of less than 0.02%). Despite the fact that Kontum is relatively safe for flooding, its location on the bank of the Dak Bla tributary makes bank protection necessary to avoid damages due to erosion. Information on erosion damages is not available.

Most flood related damages in the in the province occur reportedly in the area upstream of Kon Tum town. Most disaster related damage is due to land slides and not the direct impacts of floods. However, fatalities are essentially related to floods.

4.3.2 Flood risk management options

Flood risk management in the province focuses essentially on the reduction of the vulnerability of the people and infrastructure. Structural works to reduce the flood hazards upstream of Kon Tum town are not envisaged.

4.3.3 Strategic direction

The Steering Committee for Flood Storm Control of the People's Committee of Kontum Province has stipulated that a long term plan for flood risk management needs to be developed to minimise the losses and that replaces the existing reactive approach. In line with this recommendation CBDRM activities are initiated in which the communal Committee for Flood and Storm Control members together with villages' representatives develop plans for "Safer Communities".

The relatively low flood related damages (besides the human fatalities) and limited development potentials do not justify substantial investments in sub-basin wide structural measures for flood hazard reduction. Flood proofing of infrastructure, though seems a sound measure that could reduce substantially the existing flood risks in the area, including human fatalities.

It is recommended to incorporate flood risk assessments and flood proofing measures in the socio-economic development and poverty reduction initiatives in these areas. Guidelines for such incorporation will be developed under this FMMP-C2. (Guidelines for risk assessments, IFRM guidelines for basin planning and guidelines for flood proofing).

4.4 The Mekong Delta transboundary area

4.4.1 Flood management levels

The focal areas in Mekong Delta cannot be considered in isolation from the entire Delta. For the management of floods and the related risks in the Mekong Delta the following basic options have been looked into:

1. Flood management by structural measures at the Delta level. This option looks into the possibility to make use of the storage capacity of the Tonle Sap to reduce flood risks in the Mekong Delta.
2. Flood management by structural measures at a regional level. In the Delta focal areas the following regions are distinguished:
    a. Floodplains on the right bank of the Bassac River in Cambodia and south of the Phnom Penh Municipality.
    b. Floodplains on the left bank of the Mekong River in Cambodia and south of the National Road No. 1.
    c. Deep flooded plains on right bank of the Bassac River in the Long Xuyen Quadrangle in Vietnam.
    d. Deep flooded plains on the left bank of the Mekong River in the POR in Vietnam.
3. Flood risk management at a sub-regional or local level. This option considers flood risk management at tertiary level and the protection and/or flood proofing of human settlements and infrastructure in the Delta focal areas.

Flood management options at Delta level that aim at the reduction of the flood hazards Delta wide are very limited. Such options would have to consider the reduction of the flood discharges and volumes that enter the Delta or the creation of diversion and/or retention options in the Delta. Upstream retention as a flood mitigating measure for the delta is not considered a realistic option.

The option of Delta wide diversion schemes have been investigated in the Flood Control Planning for Development of the Mekong Delta (Basin-wide, 2007). Results of these studies show that different diversion options have regional impacts only and none of them have Delta wide impacts.

The only substantial retention option within the Delta area is related to the use of the storage capacity of the Tonle Sap Great Lake. Preliminary investigations show that an uncontrolled diversion of early flood water (July-August) to the Great Lake has a very limited impact on the flood hydrograph in the Delta. A controlled diversion of early flood waters could, however, delay the early flooding downstream of Phnom Penh by some three weeks on the average. (See Appendix 11 to Annex 1). Such diversion, though, provides no risk reduction for infrastructure and housing in the floodplains, since the flood damage to these structures is driven by peak of flood. A diversion scheme for flood risk management can be supplemented with works that regulate the outflow of the Tonle Sap lake and the adjacent floodplains. Such regulation would provide additional benefits since it improves the low flow conditions in the delta. Such comprehensive regulation scheme aiming at an integrated water resources management in the Delta is beyond the scope of this FMMP-C2.

Flood management at regional level is the approach that is being followed in the Vietnamese part of the delta. This approach was suggested in the Mekong Delta Master Plan and is being applied ever since. This approach refers to the different regions in the Delta with different levels of flooding (deep, shallow) and distinct boundary conditions requiring different flood control solutions.

This regional approach is also suggested for the Cambodian part of the Delta. The development of cross boundary strategic directions is not considered appropriate, in view of the great difference between the development level and pace at the two sides of the border. Emphasis is to be given to the potential impacts that the separate regional strategic directions may have on neighbouring regions, rather than to try to come to common strategic directions.

The sub-regional flood risk management refers to:
1. The "flood proofing" of settlements and infrastructure within the regions.
2. Differentiation of flood protection levels within regional protection schemes.
3. The zoning of regional protection schemes.

The flood proofing of settlements and infrastructure is essentially part of the "living with floods" approach in the focal areas.

Regional protection schemes have in principle a regional protection level. It is possible though to differentiate within a region the protection levels without loosening the living with flood principle. In general such differentiation would require different dike levels for different land uses, or more regulation works.

Sub-regional flood risk management could be attractive from a financing and/or implementation point of view. Zoning of regional schemes allows for a phased implementation and also for a differentiation of protection levels.

For the flood risk management in the Delta focal areas also other measures than structural ones can be taken. In the framework of the Integrated Flood Risk Management other relevant measures for flood risk reduction refer to: (i) land use / crop planning, (ii) awareness raising and (iii) early warning. These measures aim at the reduction of the vulnerability. For the focal areas in the Mekong Delta it is assumed that these soft measures are already in place. When land use changes occur as a result of structural flood protection measures, then the need for enhancement of the soft measures should be assessed.

4.5 Strategic directions for flood risk management in West of Bassac region in Cambodia (Takeo)

4.5.1 Flood risks and benefits

The West of Bassac region is located on the provinces of Kandal and Takeo along the west side of the Bassac. This area has an extension of 2,113 km^2. In this area two districts have been surveyed for damage and risk assessment. The following risks have been estimated for these districts (see Annex 2 for the details).

Cambodia	Koh Andet District	USD 0.7 mln per year
	Koh Thom District	USD 0.7 mln per year

Further analysis is needed to assess the flood damage risk at the level of the focal area. From the flood hazard maps it is preliminary estimated that the flood risk is of the order of some USD 3 million per year. About half of this risk corresponds to agricultural risks.

Floods also have positive impacts on the social economy such as natural fishing and soil fertility. Results from focus group discussions held in focal areas showed that benefits from natural fishing for people living in deeply flooded area would vary from 80-945 US$/household. Farmers also mentioned that floods have significant benefit for crop cultivation. After big a flood, Winter-Spring Paddy (Planting in November and harvesting in March) has a higher yield than normal flood years by 1.5-2.0 ton/ha. It would result in flood benefit for agriculture of about 150-230 US$/ha after a big flood. Assuming big flood frequency of one third, the annual flood benefit for agriculture would be 50-77 US$/ha.

4.5.2 Structural flood risk management options

Three flood risk management zones were identified based on present flood conditions, existing road and flood embankments, human settlements and land use. Subsequently, the type of structural components required for each area have been identified and preliminarily designed.
The three zones and their structural components are presented in Figure 4.1:

Zone 1

The zone 1 is located in the Kandal Province and is part of the Bassac flood plain. Road National 21 (RN21) is constructed as a road/flood embankment aligned along the west bank of the Bassac. The RN21 was designed as flood free road. Along the RN 21 there a large number of connections to colmatage canals linking the Bassac with the flood plain in the western side of the Bassac. The flood plain drains in the direction of the Prek Ambel river. The zone 1 has a total area of 208.6 km^2 and could be developed as flood free zone. In order to make the zone 1 flood free, the following structural measures are planned:

Zone 2

The zone 2 has a total extension of 1,311.4 km^2. The northern east corner of this area is located in the Kandal Province and the rest of the area is located in Takeo province. This area is deep flooded during the high flood season. This zone could be protected against early floods to secure early rice crop (May-July).

Figure 4. 1 Options for flood protection in Takeo area.

Zone 3

The zone is entirely located in Takeo Province and has a total extension of 593.0 km^2. This zone is a shallow flood area that is not inundated under early flood conditions with probability more than 10%. This area could be given protection against high floods to make more intensive land use possible, provided that irrigation is available.

4.5.3 Impacts of structural flood risk management options

Flood risk reduction

In case early flood protection is provided to the deep flooded areas and year around protection to the shallow flooded areas[2] the risk reduction has been estimated at 0.430 M US$/year in Koh Andet, this corresponds with some 55% of the actual risk. This estimated risk reduction is mainly related to the reduction of the agricultural risk in the shallow flooded area.

The benefits of the protection of the deep flooded areas against the early floods come from a second crop that can be planted once also irrigation water will be available. According to 2006 statistics, the dry season paddy area was 10,800 ha in Koh Andet district, 13,000 ha in Koh Thom district. It is anticipated that the second paddy crop in these focal areas would be the same as dry season crop. Assuming that the net benefits from paddy is 500 US$/ha, it would result in 5.4 M US$/year in Koh Andet district, 6.5 M US$/year in Koh Thom district.

Transboundary impacts

The flood risk management options that consider protection of agricultural areas go automatically together with the reduction of the storage of flood waters in these areas until the design level of protection works have been reached. This reduction of floodplain storage results in the increase of the river discharges at and downstream of the protected area and, consequently in the increase of the river water levels.

Runs with the ISIS model have been made to simulate the impact of the protection works in Cambodia on the water levels in the downstream area in Vietnam. The results of these simulations are shown and described in the Appendix 6 of Annex 1. It has to be taken into account that the model allows for a relative assessment of these impacts only. That is to say that the presented absolute values are to be given due care. More accurate modelling is required to assess the absolute values of these impacts and the eventual impacts on the flood risks in Vietnam.

From the modelling results it is learned that the protection works in Cambodia have a marginal (<0.1m) impact on the early flood levels in Long Xuyen Quadrangle. The impact on the maximum flood levels in the LXQ is negligible. However, due to the embankments in Cambodia, the maximum water level in focal areas of Vietnam being lower than the actual ones. It would result in reduction of risk for Vietnam at 0.1 million US$/year in Chau Phu district.

In the Bassac river, though, the maximum flood levels may increase 1-3 decimetres at Chau Doc and about 1 decimetre under early flood conditions.

Environmental impacts

Protection against the early flood, which means delaying of the flood and shortening of the flood period, may have a number of environmental impacts. Most significant are probably the impacts on the inland fisheries and the wetland vegetation and associated fauna.

Prolongation of the dry period may result in lower survival rates of ‘Black fish’ and so a reduced restocking during the flood season. Also ‘White fish’ migration into the floodplain might be effected, because the timing of the flooding may not coincide anymore with the presence of fish fry and larvae in the flood water. A deterioration of floodplain ecosystems like riparian forests and flooded grasslands could result in reduced food availability for the fish.

[2] protection levels are set at 10%, that is to say that protection is given for 9 out 10 years on the average

Natural vegetation could deteriorate because delayed flooding will lead to a further desiccation of the floodplain at the end of the dry season. Important ecosystems/habitats like riparian forests, seasonally flooded grasslands and marshes may be affected, resulting in a change in species composition. As a result they may lose their importance as a habitat for a large number of (rare and endangered) species of fish and water birds. Of special conservation importance is the Boeung Prek Lapouv wetland. It is important that measures are designed that this wetland will be provided with sufficient water year round, and further drainage of the area should not be allowed.

4.5.4 Strategic directions

Land use scenarios

In the Cambodian West of Bassac region "living with flood" is the leading concept. Land use is merely restricted to single rice cropping in the absence of adequate structural measures for flood management and irrigation. The formulation of a strategic direction for flood risk management in the deep flooded areas is based on the living with flood concept in combination with the following land use scenarios:

1. single cropping in the deep flooded area (actual land use)
2. double cropping in the deep flooded area
3. double or triple cropping in the shallow flooded areas

The direct relation between the different land use scenarios and flood risk management strategies is as follows:

- Single cropping can be done without protection of the agricultural land. Structural measures can be restricted to protection and/or flood proofing of human settlements and public infrastructure.

- Double cropping in the deep flooded areas requires flood management to secure that sufficient flood free time is available between two floods. In practice, this comes down to early flood protection of the agricultural land and/or adequate drainage of flooded areas after the flood. Additional protection and/or flood proofing will be required for infrastructure and human settlements.

- Double or triple cropping in the shallow flooded areas requires a full protection of these areas. A differentiation of the protection levels in these areas is to be considered, in which human settlements and essential infrastructure is provided with a higher level of protection then the agricultural areas.

Flood management strategic directions

The existing flood risks in the West of Bassac area do not justify substantial investments in flood protection works to reduce agriculture related risks. In case no further agricultural development in this area is envisaged, flood risk management measures should focus on the reduction of flood risks related to business, housing and infrastructure. These risks can be reduced by:
- early warning
- relocation of houses and businesses
- flood proofing and/or protection of residential areas and infrastructure.

An early warning system for the inhabitants of the flood prone areas is already in place. Relocation of houses and or business may be considered if the related costs are less than flood proofing and/or protection. This is not likely to be the case. For that reason it is suggested to focus on flood proofing and protection of the objects that are at risk in the flood prone areas.

Agricultural development can be strived at in the shallow flooded areas (zones 1 and 3), the deep flooded area (zone 2) or in both. A socio-economic evaluation is required to determine the most attractive approach and/or phasing for such development.

Flood risks in the shallow flooded areas are related to the peak flood levels rather than to early floods. Risk reduction measures in these areas should therefore aim at protection against the main flood. The level of protection of the agricultural lands is to be derived from a socio-economic evaluation. It is anticipated that a 10% protection level will be adequate (this means that flooding is accepted once in the ten years on the average). For the residential and business areas and the infrastructure within these protected zones a higher level of protection may be more appropriate, for instance 4 or 5%.

(It is noted that living in a protected zone may bring additional risks. Flooding of a protected zone may be caused by a dike breach. A dike breach creates more hazardous conditions than normal flooding. Early warning is often not possible and high flow velocities may locally occur.)

Agricultural development in the deep flooded area requires protection against early floods in order to have sufficient time available for the safe harvesting of a second crop. This protection can be provided in different ways:

- by providing protection to the early flood level only (once this level is exceeded the protection works will be overflown and the protected area will inundate automatically;
- by providing controllable protection works that allow the flooding to take place when suitable (This type of protection is practiced in the deep flooded areas in Vietnam)

It is suggested to follow the first (less costly) approach. In a later stage of development of the area it can than be considered to upgrade the protection works to "flood management" works.

Protection of the deep flooded areas against early floods is supposed to go together with protection and/or flood proofing of residential and business areas and essential infrastructure for not only the early but also the main flood.

Mitigation of transboundary effects

The preliminary results show that the early flood protection in the West of Bassac area in Cambodia may have marginal impacts, if any, on the flood risk in Vietnam. More detailed modelling is required to make a more accurate assessment. In case the increase, if any, of the flood risks in Vietnam is not considered acceptable, mitigating measures are to be found that compensate for the loss of storage during the early floods. It is suggested to investigate the possibility to compensate for this loss by providing additional discharge capacity of flood waters in the border area towards the Gulf of Thailand (West China Sea).

4.6 Strategic directions for flood risk management in East of Mekong region in Cambodia (Prey Veng)

4.6.1 Flood risks and benefits

The flood risk in this region has been estimated for the Kampong Trabek District only (see Annex 2). This risk has been estimated at 0.7 million USD per year. Flood hazards in this district are less severe than those in the districts Preah Sdach and Peam Chor that are located between Kampong Trabek and the Mekong. Further analysis is needed to assess the flood damage risk at the level of the focal area. From the flood hazard map it is preliminary estimated that the flood risk in this region is of the order of some USD 2 mln per year. Over 60 % of this risk is related to agricultural damage.

Flood damage to agriculture is mainly for the wet season paddy in the surveyed district. In the absence of August-flood protection as practised in Vietnam, the flood damages to agriculture (mainly paddy cultivation) depends more on the maximum annual level of the flood than on its timing.

Flood benefits are similar to those described for the Takeo area in section 4.5.1.

4.6.2 Structural flood risk management options

To the south of the RN1, the flood plain is drained by the two major rivers the Stung Slot and the Prek Kampong Trabek. Flood water expands to both sides of these two rivers in their respective flood plains, Low lying area (elevation 3-4m amsl) extends from the flood plain of the two rivers further south leaving the middle part with higher elevation (above 5.0m amsl) where is concentrating settlement of subsistence rice farmers communities. Towards the Cambodian/Viet Nam border, low lying areas practically join together to form a vast deep flooded area.

Four flood risk management zones were identified based on present flood conditions, existing road and flood embankments, human settlements and land use. Subsequently, the type of structural components required for each area have been identified and preliminarily designed.
The four zones and their structural components are presented in Figure 4.2

Zone 1.

This deep flooded area between the Mekong and the Stung Slot river has an extension of 364.91 km^2 that would be protected against early floods until the 1^{st} of August. After end of July the area would be left flooded until November-December.

Zone 2 and 3.

These zones have an extension of respectively 408.64 km^2 and 242.08 km^2 and are considered as shallow flooded areas that would be protected against the 1:10 years high flood.

Zone 4. This deep flooded zone would remain unprotected.

4.6.3 Impacts of structural flood risk management options

Flood risk reduction

In case early flood protection is provided to the deep flooded areas and year around protection to the shallow flooded areas[3] the risk reduction has been estimated at 0.5 million US$/year in Kampong Trabaek, or about two third of the actual risk. This estimated risk reduction is mainly related to the reduction of the agricultural risk in the shallow flooded area.

The benefits of the protection of the deep flooded areas against the early floods come from a second crop that can be planted once also irrigation water will be available. According to 2006 statistics, the dry season paddy area was 6,900 ha in Kampong Trabek district. It is expected that the second paddy crop in these focal areas would be the same as dry season crop. Assuming that the net benefits from paddy is 500 US$/ha, it would result in 3.45 M US$/year in Kampong Trabaek district.

Transboundary impacts

The reduction of floodplain storage results in the increase of the river discharges at and downstream of the protected area and, consequently in the increase of the river water levels.

From the modelling results it is learned that the protection works in the Prey Veng area south of National Road no 1 in Cambodia tend to have a positive impact on the flood risks in the POR in Vietnam. This is due to the fact that the protection works in Cambodia block, partially, the actual floodplain flow on the left bank flood plains of the Mekong. This holds for both the early flood and the peak flood. This would result in reduction of risk for Vietnam of 1.4 million US$/year in Tan Hong district, and 0.5 million US$/year in Tam Nong district.

In the Bassac river, though, the maximum flood levels may increase 1-3 decimetres at Chau Doc and about 1 decimetre under early flood conditions.

Environmental impacts

Sensitive and valuable ecosystems that are encountered in this region, such as seasonally-inundated riparian forests; seasonal wetlands, including marshes, small pools and pools; and seasonally inundated grasslands are essentially the same as those for the West of Bassac area described in section 4.5.3..No officially protected areas are located in the project area.

The potential environmental impacts of flood risk management in this area correspond, therefore, with those described in section 4.5.3.

[3] protection levels are set at 10%, that is to say that protection is given for 9 out 10 years on the average

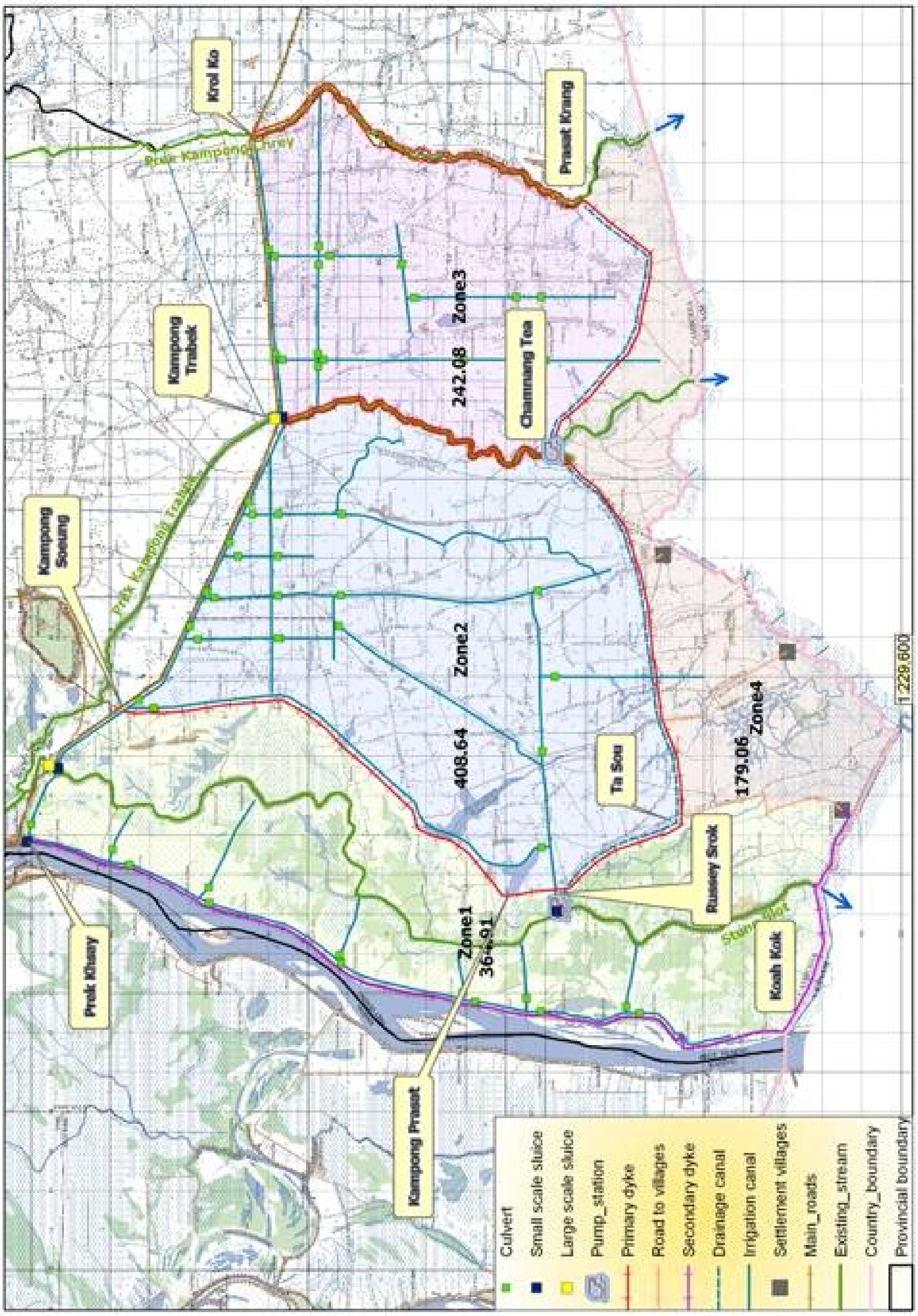


Figure 4.2 Options for flood protection East of Mekong region in Cambodia

4.6.4 Strategic directions

Land use scenarios

Also in the Cambodian East of Mekong region "living with flood" is the leading concept. Land use is merely restricted to single rice cropping in the absence of adequate structural measures for flood management and irrigation. The formulation of a strategic direction for flood risk management in the deep flooded areas is based on the living with flood concept in combination with the same land use scenarios and corresponding flood protection strategies as presented in section 4.5.4. i.e.

Flood management strategic directions

For the flood management in East of Mekong area the same strategic direction is proposed as for the West of Bassac area described in section 4.5.4. An essential difference, though, would be to keep a substantial zone unprotected near the Vietnamese border. Flood protection in this area is closely related to the operation of the flood management infrastructure in Vietnam and flood management, if any, in this area is to be done jointly with Vietnam.

Mitigation of transboundary effects

The preliminary results show that the flood protection in the East of Mekong area in Cambodia would have positive impacts on the flood risk in the POR in Vietnam. More detailed modelling is required to make a more accurate assessment.

A slight increase in the flood water levels in the Mekong is anticipated though. This increase could be compensated for by creating additional discharge capacity in the border zone, either towards the Vam Co river, the Gulf of Thailand or both.

4.7 Strategic directions for flood risk management in the West of Bassac area in Vietnam (LXQ)

4.7.1 Flood risks and benefits

For the estimate of the flood risks in the LXQ reference is made to the Annex 2. The average annual damage in the An Giang Province alone has been estimated at some 23 million USD per year. The flood risk in the surveyed Chau Phu District has been assessed at 1.9 million USD per year. It is noted that a substantial part of the risk in the An Giang province is related to bank erosion. This phenomenon is not reflected in the flood risk of the Chau Phu district.

Further analysis is needed to assess the flood damage risk at the level of the focal area. From the flood hazard maps it is preliminary estimated that the flood risk in the Vietnamese part of the focal area (Long Xuyen Quadrangle) could be two times the flood risk of An Giang Province only.

It is noted that under the present land use and flood protection conditions the risk related to agriculture is relatively low as compared to the total risk. The share of agricultural risk is only 1% of the total risk. By far most of the risk (about 85%) is related to infrastructure and relief.

It is moreover noted that under average flood conditions hardly any damage occurs and that most risk is related to extreme flood conditions. Apparently, adequate protection is already in place for the lower floods.

Results from focus group discussions held in the Vietnamese focal areas showed that: benefits from natural fishing for people living in deeply flooded area vary from 100-300 US$/household in normal flood years and from 120-750 US$/household in big flood years.

Farmers also mentioned that floods have significant benefit for crop cultivation. After a big flood, application of fertilizers and pesticides to Winter-Spring Paddy (Planting in November and harvesting in March) is less than in a normal flood year, and the yield is higher by 0.5-1.0 ton/ha. It would result in flood benefit for agriculture of about 200-300 US$/ha after a big flood. Assuming big flood frequency of one third, the annual flood benefit for agriculture would be 60-100 US$/ha.

4.7.2 Structural flood risk management options

The transboundary focal areas correspond with the so-called deep inundation areas. The Vietnamese long term planning for these areas is essentially based on the "living with floods" concept and management of floods to allow for a safe production of double rice Winter-Spring and Summer-Autumn crops.

The following objectives have been formulated by Vietnam for the flood management in the deep inundation areas:

1. Agriculture: Double rice cultivation of winter-spring and summer-autumn has to be produced reliably and stably ; it is recommended not to encourage to produce the third crop season; fruit trees are to be reasonably developed in favourable areas; creating favourable condition for changing crop seasons; develop agriculture mechanization.
2. Transportation:
   a. National roads, inter-provincial roads and provincial roads (PR): roads are reliable and safely constructed over flood level of 1961 for transportation during the whole flood season.
   b. District roads: constructed according to probability of road scales of non-inundated with low and medium floods and inundated with high foods
   c. Rural roads: will be constructed over water levels of low, medium and high floods of the early and late season. These roads might be inundated by large floods. Although having favourable condition, construction of higher roads should not be done because of blocking flood ways causing increases of water levels and longer inundation.
3. Navigation lines:
   a. Inter-province lines should be operating fully in the flood season; hence it has to have ship-transfer facilities in case of flood control works block free passage of the waterway;
   b. Inner-region: Full transport only in inner-region is needed hence ship transfer facilities are not needed.

4. Residential areas:
   a. Towns and inhabitant centres , schools, infirmaries have to be ensured of no inundation in the flood season, including high floods
   b. Inhabited lines along large roads and big canals have to be ensured not to be inundated in the flood season
   c. Scattered inhabitant areas need to be protected in the flood season

The structural measures that have been identified to realize above mentioned objectives are shown in the figure 4.3 and refer to:

1. Control floods from the border to the Long Xuyen Quadrant and drain floods to the Gulf of Thailand
2. Build up flood drainage construction to the Gulf of Thailand
3. Build up salinity prevention construction, and keep fresh water in the coastal areas of the Gulf of Thailand
4. Build up flood control construction from the Bassac river to the Long Xuyen Quadrant.

These structural measures allow in principle not only for a protection against early floods but also for full control of floods that are lower than the design flood of the works.

4.7.3 Impacts of structural flood risk management options

Flood risk reduction.

If the flood risk management works as described above would be operated to provide full protection to the LXQ, then most of the flood risks, apart from the bank erosion, would be eliminated. This would give a risk reduction of some USD 1.9 million/year for the Chau Phu District only.

If these works, however, would be operated to protect the LXQ against the early floods only (until half of August) then only the very minor agricultural risk would be eliminated.

Full protection would enable a third paddy crop. It is assumed that additional 70% of paddy land could be used for a third crop. Net benefit of additional paddy would be at the rate of 900 US$/ha, resulting in expected additional benefit from cultivation of third paddy as USD 24 million in the Chau Phu district. ,

Full flood protection in LXQ would reduce natural fish on paddy field at the rate of 30-40 US$/ha. Taken into account the remaining flooded paddy area, the fish loss would be some USD 1.3 million/year in Chau Phu district.

Full flood protection would create the loss of benefits related to sediments, leaching and pest control to an estimated amount of some USD 2.6 million/year for Chau Phu district.

Transboundary impacts

The flood risk management options that are described in the previous section allow for the management of not only the early floods, but also the floods arriving after August. Operation of the flood management infrastructure beyond the early flood (or half of August) will create increased water levels in the rivers both downstream and upstream of the protected area. In principle the flood management infrastructure could be kept closed until after the passage of the flood peak. In that case, the peak levels upstream of the protected area will increase and affect directly the flood risk in Cambodia.

The results of (ISIS) model simulations indicate that full flood control for the Focal Areas Long Xuyen Quadrangle and POR would aggravate the flooding conditions in Cambodia: from 1.5 to 1.7 m in Prey Veng to 0.5 to 0.8 m in Takeo. Corresponding increment of risk have been calculated at some USD 1 million US$/year in Koh Andet district and USD 0.3 MU US$/year in Koh Thom district. It is repeated again that these calculations are based on ISIS simulation results, and should be considered with due care.

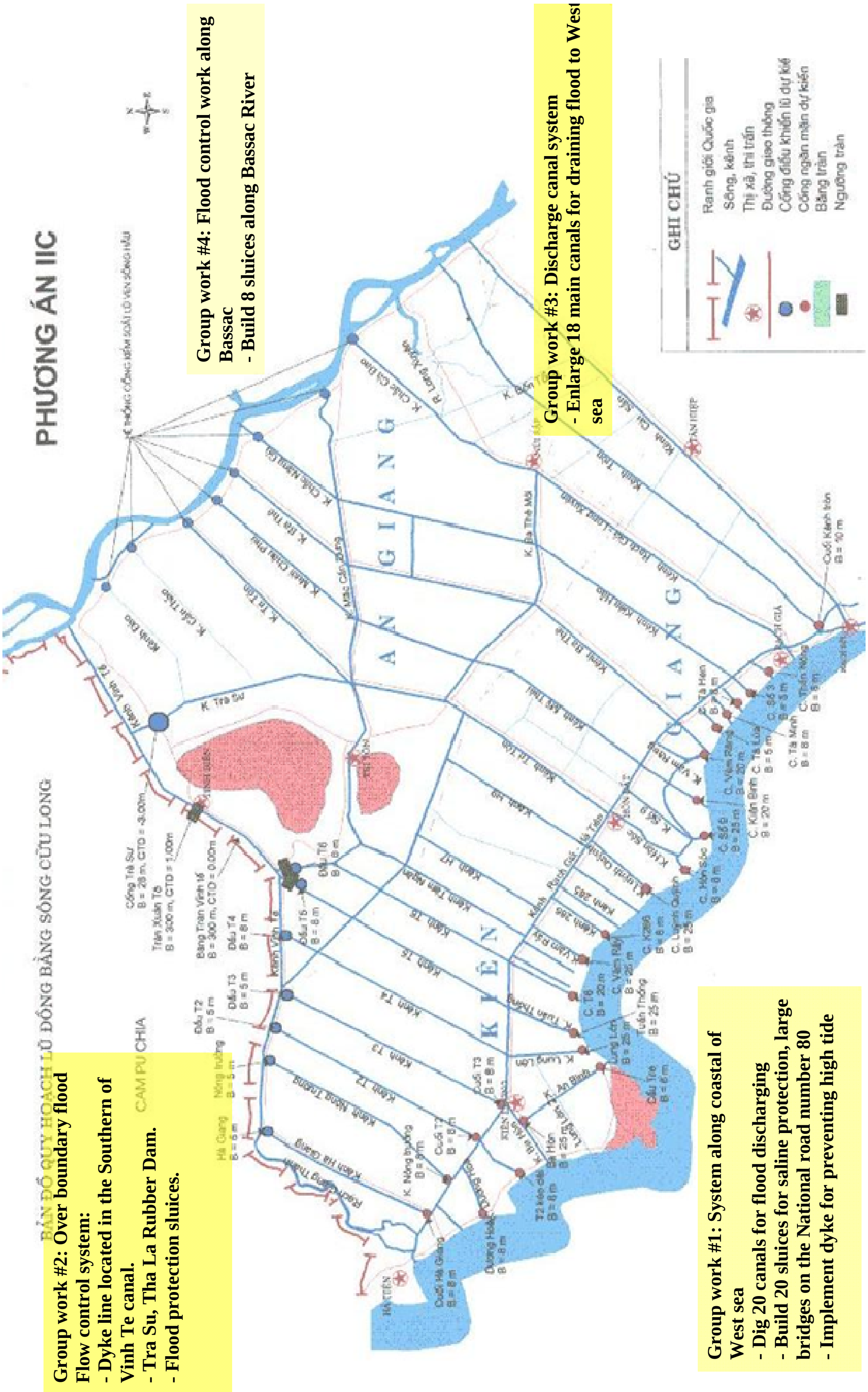


Figure 4.3 Flood management options Long Xuyen Quadrangle

Environmental impacts

Reduced flooding in the Vietnamese Delta will have a number of significant environmental impacts. Probably most important is the negative impact on inland fisheries. Reduction of access to the floodplain for migratory fish and reduction of the area where the fish can spawn and feed, will reduce the possibilities of rural people to be engaged in fisheries as a means to improve household nutritional conditions and household income.

Also important is the very likely further decline of the few remaining natural areas (seasonally flooded grasslands and Melaleuca swamps). These areas are important habitats for a large variety of flora and fauna species, among which a number of rare and endangered species.

Finally, a number of environmental benefits of flooding will be lost. Important are the decreased supply of fertilizing sediments, the reduced flushing of acid and toxic materials from the soil and the reduced sanitation of the area (pest control). Also the reduced flushing and diluting of polluted water at the end of the dry season will result in deteriorating water quality conditions.

It is recommended not to make (parts of) the area completely flood free. A system of controlled flooding should be designed, which reduces the damages, but at the same time conserves the benefits of the flooding as much as possible. Special attention should be given to the remaining natural areas, they are not only threatened by changes in the flooding regime, but also, and probably even more so, by encroachment of local people.

4.7.4 Strategic directions

Flood management strategic directions

Strategic directions for flood risk management in the LXQ are clearly defined in the long term flood control planning 1998, as approved by the Vietnamese Government in 1999. Objectives and guiding principles for the flood management in the Long Xuyen Quadrangle have been mentioned above.

Mitigation of transboundary impacts

From the model simulations as described in Annex 1 it is clear that any flood management that goes beyond the early flood (half of August) protection, will have impact on the flood hazard and eventually the flood risk in Cambodia.

Retention options to compensate for lost storage capacity are hardly available in the Vietnamese part of the Mekong Delta. It is therefore suggested that compensating measures are sought in the diversion of floodwaters just upstream of the protected LXQ area towards the South China Sea (Gulf of Thailand).

4.8 Strategic directions for flood risk management in the east of Mekong area in Vietnam (POR)

4.8.1 Flood risks and benefits

The average annual damage in the Dong Thap Province alone has been estimated at some USD 44 million per year. Further analysis is needed to assess the flood damage risk at the level of the focal area.

The share of agricultural risk is some 10% of the total risk. Most of the risk (about 55%) is related to infrastructure and relief, and one third is related to housing. It is clear that Dong Thap is more at risk than the An Giang. Also under moderate flood conditions the damage can be substantial (some USD 20 million during the average flood up to some USD 90 million under the once in 5 year flood).

The flood risk in the surveyed Tan Hong and Tam Nong districts has been assessed at respectively USD 2.2 million and USD 2.5 million per year. It is noted that a substantial part of the risk in the Dong Thap province is related to bank erosion. This phenomenon is not reflected in the flood risk of the surveyed districts.

Flood benefits on the POR are similar to those described in section 4.7.1.

4.8.2 Structural flood risk management options

Similar to the approach for the LXQ, the strategy proposed to achieve the flood control objectives for the POR relies on isolating areas from flood waters using dikes, and utilizing embankment systems at different scales and levels to control the transport of flood waters. The corresponding technical options aim at:

1. Influence and control flooding using the principle of "living with floods"; and distributing flood flow in the most efficient way.
2. Reduce flood pressure to the POR central area by improving flood drainage capacity at Tu Thuong and at low parts of Mekong and Vam Co rivers.
3. Control early flood, for harvesting summer – autumn crop and accelerate drainage for winter - spring crop; concurrently increase horizontal flow to improve sediment accretion from Mekong river.
4. Improve drainage canal system for reducing depth, duration of inundation; increasing dry season discharge for irrigation and impeding salinity intrusion.
5. Use advantages and disadvantages of tidal excursion to enhance effectiveness of drainage and irrigation measures.
6. Control flooding and redistribute flood flow by reasonable operation regime of flood-control works.
7. Raise crest levels for residential areas and road networks.
8. Dig new canals and enlarge existing canal system to help reduce depth and duration of inundation, particularly to accelerate flood drainage for early seeding Winter – Spring crop.

The structural measures that have been identified to realize above mentioned objectives are shown in the figure 4.4 and refer to:

1. Definite frame of canal systems (main, primary, secondary) to ensure they meet the needs of integrated use.
2. Tan Thanh - Lo Gach flood control line includes; dyke, sluices, overflows. This system has function of controlling over flow from inundated area of Cambodia and diverting flood discharge to Mekong and Vam Co rivers. It is operated primarily to protect against flooding in August.
3. Flood drainage work group at Tu Thuong including road-overflow. Its function is to reduce flood pressure for POR central area.
4. Sluices located along upstream reaches of the Mekong River within Vietnamese territory (from Hong Ngu to An Phong – My Hoa canal). These sluices have the function of reducing early flooding from Mekong and increasing discharge to remote area of the POR during the dry season.
5. Sluices located along downstream reaches of the Mekong River (from My Tho to Cai Be). These sluices are operated by tidal energy and can improve not only drainage but irrigation capacities also.
6. Sluice and navigation lock Vam Co, built at the confluence of two Vam Co rivers with automatic operation controlled by the energy of tide.

4.8.3 Impacts of structural flood risk management options

Flood risk reduction

If the flood risk management works as described above would be operated to provide full protection to the POR, then most of the flood risks, apart from the bank erosion, would be eliminated. This would give a risk reduction of some USD 2.2 and USD 2.5 million/year for respectively the Tan Hong and Tam Nong districts.

If these works, however, would be operated to protect the POR against the early floods only (until half of August) then only the agricultural risk would be largely eliminated in the surveyed districts. These risk reductions are estimated at USD 0.2 million for Tan Hong and USD 0.4 million for Tam Nong

Full protection would enable a third paddy crop. Under the same assumption as for the LXQ this would result in expected additional benefit from cultivation of third paddy at USD 16 million in the Tan Hong and USD 21 million in Tam Nong district.

Full flood protection in POR would reduce natural fish on paddy field at the rate of 30-40 US$/ha. Taken into account the remaining flooded paddy area, the fish loss would be some USD 0.8 million/year in Tan Hong and USD 1.1 million in Tam Nong district.

Loss of other flood benefits would be an estimated amount of some USD 1.6 million/year for Tan Hong and USD 2.3 million for Tam Nong district.

Transboundary impacts

As is the case for the regional LXQ flood protection scheme, also the POR scheme allows for the management of not only the early floods, but also the floods arriving after August. Operation of the flood management infrastructure beyond the early flood (or half of August) will create increased water levels in the rivers both downstream and upstream of the protected area. Moreover, the blockage of the floodplain flow will affect directly the floodplain flood levels upstream of this blockage.

In principle the flood management infrastructure could be kept closed until after the passage of the flood peak. In that case, the peak levels upstream of the protected area will increase and affect directly the flood risk in Cambodia.

Runs with the ISIS model have been made to simulate the impact of the scenario in which flood water will enter neither Long Xuyen Quadrangle nor the POR unless the management decides for controlled inlet.

The results of these runs indicate that full flood control for the Focal Areas Long Xuyen Quadrangle and POR would aggravate the flooding conditions in Cambodia: from 1.5 to 1.7 m in Prey Veng. These results do not take into account though the mitigating impact of the planned Tu Thuong flood release works.

Corresponding increment of risk have been calculated at some USD 1.4 million US$/year in Kampong Trabek district. It is repeated again that these calculations are based on ISIS simulation results, and should be considered with due care.

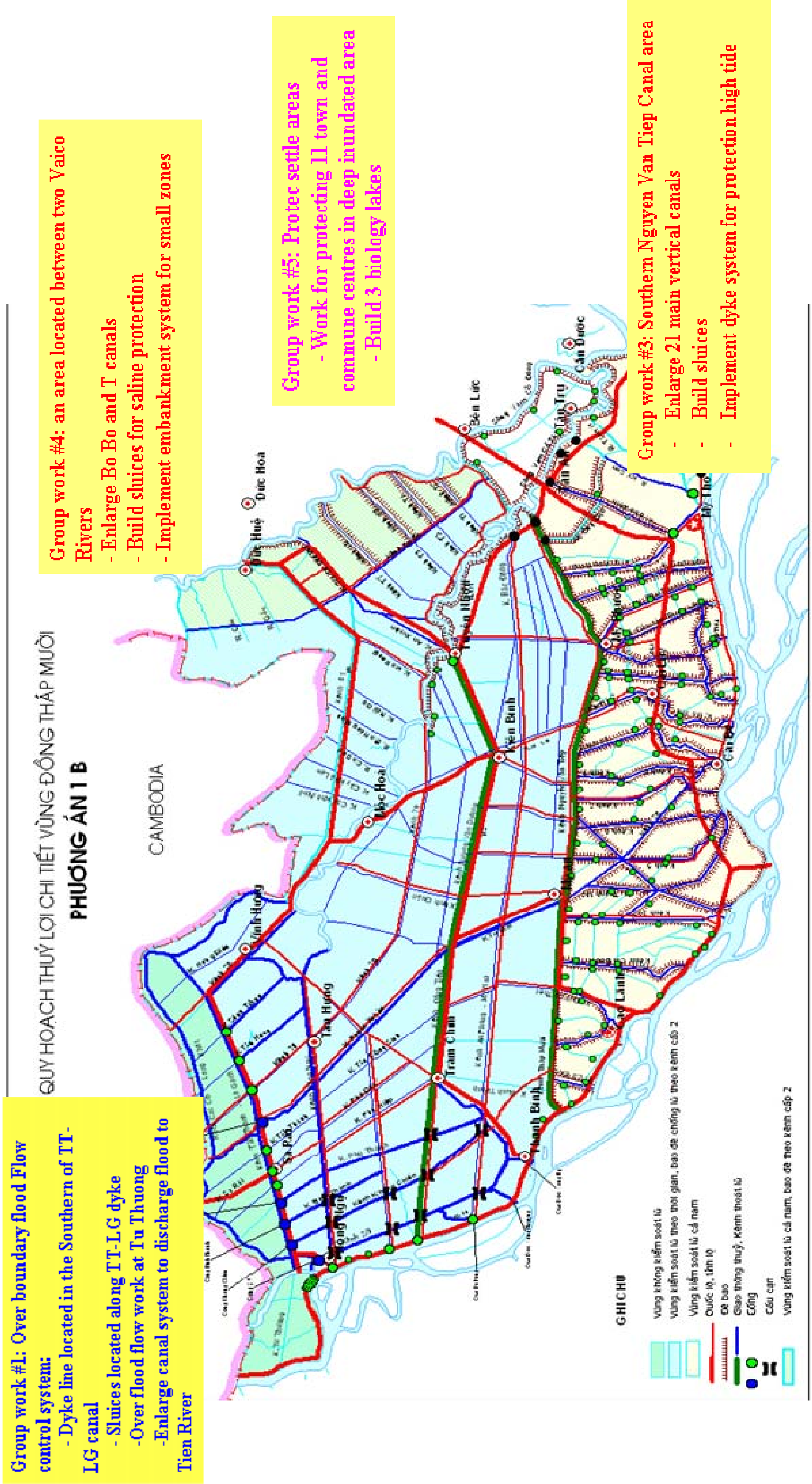


Figure 4.4 Flood management options POR

Environmental impacts

The potential environmental impacts of implementation of 'full protection' of the POR are very similar to those described in the previous sections regarding the Long Xuyen Quadrangle. It has to be remarked that full protection only means that floods can be kept out of the area completely, but that this will probably not be the case. Controlled flooding of certain areas during certain parts of the year will be allowed, possibly in a rotational scheme.

In the POR Focal Area there are two protected areas. Tram Chim National Park and the Lang Sen Wetland Reserve. Tram Chim is a low-lying wetland with seasonally inundated grasslands and natural Melaleuca forests, an abundance of freshwater fish, and consequently many birds.

BirdLife International ranked Tram Chim National Park as one of the most important sites for conservation in the Mekong Delta. The park receives international recognition as seasonal habitat for the globally endangered Sarus Crane. It is also an important breeding site for water birds.

Lang Sen is another remnant of the original wetland landscape of the POR and covers an area of some 5,030 ha, among which 1,500 ha is swampland providing habitats for a variety of wetland fauna and fish.

The above described protected areas are depending on regular flooding for their survival. Reduced or no flooding will reduce their ecological importance significantly.

Also here it is strongly recommended not to make (parts of) the area completely flood free. A system of controlled flooding should be designed, which reduces the damages, but at the same time conserves the benefits of the flooding as much as possible. Special attention should be given to the remaining natural areas, they are not only threatened by changes in the flooding regime, but also, and probably even more so, by encroachment of local people.

4.8.4 Strategic directions

Flood management strategic directions

Strategic directions for flood risk management in the POR are clearly defined in the long term flood control planning 1998, as approved by the Vietnamese Government in 1999 (Decision No 144/1999/QD-TTg) and the Master Plan Study on water Works of the Mekong Delta as approved by the Vietnamese Government in 2006 (Decision No 84/2006/QD-TTg. Objectives and guiding principles for the flood management in the POR have been mentioned above.

Mitigation of transboundary impacts

From the model simulations as described in Annex 1 it is clear that any flood management that goes beyond the early flood (half of August) protection, will have impact on the flood hazard and eventually the flood risk in Cambodia. Especially the protection of the Vietnamese POR has substantial impact on the flood hazards in the East of Mekong flood plains in Cambodia.

Retention options to compensate for lost storage capacity are hardly available in the Vietnamese part of the Mekong Delta. Consequently, additional discharge capacity is to be provided at and downstream of the border area to mitigate the cross-boundary impacts. Such additional capacity could be provided in the direction of the Mekong River (KOICA, alternative), towards the Vai Co River or towards the Gulf of Thailand.

Transboundary impacts do not only refer to the impact of risk reduction in Vietnam on the flood risks in Cambodia, but also the other way around, as described in the previous chapters related to the flood risk management in Cambodia. It is therefore recommended to investigate the options of diversion in the border zone between Cambodia and Vietnam.

4.9 Strategic directions for Mekong erosion management in Bokeo province, Lao PDR.

4.9.1 Erosion damages and risks

A socio-economic survey was carried out in the Houayxai and Ton Pheung districts in Bokeo Province to collect data regarding (i) district vulnerability and flood events; (ii) direct damages caused by erosion; and (iii) indirect damages caused by erosion.

Total direct erosion losses from 1997-2007 were assessed at USD 5.6 million in Ton Pheung district and USD 0.1 million in Houayxai district. Details are presented in Annex 2. Indirect costs spent by local departments were investigated. There were no indirect costs reported for 2006.

In the Bokeo Focal Area there is a bank erosion problem only, flooding is not an issue. Environmental damages due to bank erosion in these districts were not found. None of the enterprises or storage facilities containing potentially polluting materials is located on the banks. .Since the river discharges in flood period are very high, any pollutant that might end up in the floodwaters will be diluted to harmless concentrations.

4.9.2 Need for joint approach for erosion management

In the Bokeo stretch (Figure 4.5), the Mekong River has a variable width and it is geologically controlled almost along the whole length and local geology and related rock outcrops are very important. In the Upper Mekong reach the floodplain is only marginally developed, and often the river reaches the flood plain levels only during extreme floods.

Figure 4.5 Alignment of the Mekong river in Bokeo Province, controlled by geology, from the Golden Triangle to Chiang Khong District in Thailand

Like many other rivers, the Mekong erodes its banks at many locations. Erosion along the Mekong in the Bokeo stretch has not reached alarming proportions but the considerations on: (i) international border, (ii) sustained socio-economic development of the region, (iii) flood and protection of existing infrastructure and cultural heritage could require prompt attention at critical locations along the waterfront.

The problems, which, until now, have prevented a systematic and strategic approach to erosion management in particular in Lao PDR are of a morphological, economic and technical nature. The increase in population, the investment in infrastructure in towns and rural areas (irrigation and drainage projects), the river training works already carried out in the recent past for various as well as cost-effective improved techniques (JMREMP) in arresting bank erosion, are all reasons for formulating a project with a broader view into the technical and socio- economic feasibility of protection works against bank erosion.

Between Lao-PDR and Thailand, river Bank Protection (RBP) demonstration projects along the Mekong River main objectives are twofold: (i) to prevent the erosion along the international border between Lao-PDR and Thailand and (ii) to prevent bank erosion that affects urban and semi-urban areas, transport and flood infrastructure from damage during floods that will also likely may increase regional flooding.

4.9.3 Objectives

Technically and economically feasible river bank management, short-term protection works and river training works on a sustainable scale for a major river like Mekong cannot, in general, be successfully developed unless they are incorporated within an integrated overall strategic program.

Accordingly, when designing river bank erosion protection measures it is agreed that they should fit into a coherent plan (river training) to harness in optimum way the river system with the possibility of new concepts being applied in recent projects or innovative different concepts in combination with temporary protection works at key locations.

The overall objective of the joint project is to provide a framework in which the technical, economic, social, environmental and other effects of various alternatives for river training works of the Mekong river along sub-areas 1L and 2T, can be assessed and evaluated at different levels of detail. The joint project will moreover, provide a systematic approach of the river training works in regard of their various aspects as design criteria, construction, sequence of implementation, monitoring and maintenance, and the institutional and organizational management requirements related to these aspects.

4.9.4 Main components of the joint project:

In order to strategically address the erosion problems and formulate cost effective bank protection projects, in sub-areas 1L & 2T requires answering the following questions: Where, When and What to protect and How.

- WHERE is related to threat in short-time by currents or waves;
- WHEN is a matter of morphological predictions of river channels, making good use of low river stages and the urgency to stop the threat;
- WHAT, is a matter of economics and strategic considerations;
- HOW to protect which is first a technical problem to be solved.

The approach of the joint bank protection study focuses on the engineering analysis of all reasonable options and strategies for protecting the river banks against erosion, with special emphasis on floods, environmental, social and political considerations. The main components of the joint project can be summarized as follows:

(1) River training component. Consisting of:

- Division of main river system into different stretches
- Review of earlier studies
- Selection of most stable river planform for each of the different river stretches.
- Interaction with other projects (navigation) and effect of developments upstream,
- identify the influences of bank materials and changes in the planform on the rate of bank erosion,
- Develop bank erosion prediction methods using satellite images. The potential of such prediction methods for erosion monitoring and vulnerability assessment has been recognized,
- Preparing erosion hazard maps,
- Development of short-term (up to 5 years) and medium term strategy (5-15 years), for river bank protection, based also on socio-economic and environmental impacts and economic analysis,
- Review of recent bank erosion protection experiences in Thailand and Laos
- Study of failures and successes with river bank protection works in Thailand and Laos and elsewhere and recommendations on best practice related to type of protection works
- Development of strategy for implementing river bank erosion works and how to reach most stable river planform
- Recommendations for "learning by doing"

(2) Environmental impact component. Consisting of:

- Study of base-line conditions along the river in sub-areas 1L and 2T
- Morphological impact study of proposed strategies on the alignment of the river banks
- Environmental impact study of proposed strategy and alternative approaches (when needed)

(3) Economic analysis component, consisting of:

- C/B analysis of proposed river bank erosion strategy(ies)
- Economic analysis to help formulating short-term and medium-term strategy(ies)

(4) Institutional component, consisting of:

- Advise on present setting of river bank erosion management units in Laos and Thailand,
- Advice on future institutional needs in relevant agencies,
- Training of professional staff responsible for river bank erosion works in the countries' Line Agencies, and
- Advice on monitoring and maintenance (how, who?)

4.10 Strategic directions for Mekong erosion management in Kratie, Cambodia.

The Mekong River flows over about 140 km long across Kratie province. The erosion of the left bank occurs over 6 km from Sambok at km 572 to Ph Thmar Krae Kraon and Ph Russei Cha (km 566) and over 15 km from Kratie (km 572) to Prek Te (km 557).

Figure 4.6 Focal area Kratie Province. Sub-area 8C

A socio-economic survey was carried out in six communes in Kratie District. Data collection from these communes included: the base line in 2006 for population, land & structure, business, education, health, road, irrigation, electricity, water supply and communication. The indirect erosion damages in 2006 by the above sectors were collected from the local authorities. There seemed not to have been significant erosion damages in 2006. Site visits in July 2008 could also not confirm the existence of significant river erosion. The noticed gully erosion of the Mekong banks was generally caused by drainage water from the roads running parallel to the river.

The indirect cost spent by local authorities was investigated. Total indirect cost in 2006 among six communes in Kratie district were some USD 4 thousand. Most indirect cost has been found in the irrigation sector where farmers had to pay extra cost to overcome irrigation disruption.

A field visit to the area learned that the bank erosion of the Mekong River in the Kratie area does not pose any environmental risks. On the banks directly along the river no industrial enterprises are located and there no storage facilities containing potentially polluting materials are under threat. Flooding in the Kratie area has a completely different character than flooding in the Cambodian Delta. Flood duration is short, about one week and waters are not stagnant. Industrial development in the area is limited and any pollutant that might end up in the floodwaters will be diluted to harmless concentrations due to the sheer magnitude of the flood volume.

For the erosion management in this area essentially the same approach is suggested as presented for the Bokeo area in the previous section.

4.11 Strategic directions for IFRM in the LMB Sub-areas

The TOR calls for the development of strategic directions for IFRM in the 10 LMB Sub-areas. During the Inception Phase and the following implementation stages of FMMP-C2, an essential choice was made to develop strategic directions for IFRM for the various types of natural river floods and flooding that occur in the LMB. Hence, on the basis of the comprehensive analysis of the hydrological and flood hazards in the 10 Sub-areas of the LMB (see Volume 2A), focal areas were selected for further investigations into the IFRM strategic directions by type of floods and flooding. These have been presented in the above Sections of this Chapter and in the Volumes 2B, 2C and 2D.

As such, the studies for the focal areas provide samples of methodologies that can be applied in developing IFRM strategic directions for areas that experience similar types of flooding in the LMB Sub-areas. The LMB Sub-areas are shown in the figure below.

Focal Areas were selected to develop IFRM strategic directions. In the selection of the Focal Areas the type of floods has been one of the key selection criteria.

The following focal areas have been selected for application of IFRM; the LMB Sub-areas that could experience similar type of flooding have been included as well:

- Focal Area 1: Nam Mae Kok at Chiang Rai and at river mouth: representative for risk assessment of tributary and combined floods; this sample area is relevant to all Sub-areas with the exception of Sub-area 10V.
- Focal Area 2: Bokeo Province along Mekong River: flood hazards for river bank erosion; this sample area is relevant to all Sub-areas with the exception of Sub-areas 5, 7 and 9 since these the Mekong is not flowing trough (or forms a border between) these areas. However, river bank erosion may also occur at the banks of the large tributaries, like the Mun River.
- Focal Area 3: Se Bang Fai from Highway Bridge 13S to Mekong River: representative for risk assessment in case of combined floods; this sample area is relevant to all Sub-areas with the exception of Sub-area 10V.
- Focal Area 4: Kontum Province in upper Se San basin: representative for risk assessment in case of flash tributary floods; this sample area is relevant to all Sub-areas with the exception of Sub-area 10.
- Focal Area 5: Kratie Province: hydraulic design conditions for river bank protection near the city of Kratie; this sample area is of similar nature as the Bokeo focal area (see above)
- Focal Area 6: Mekong Delta: representative for risk assessment in case of delta flooding in the deep flooded Takeo and Prey Veng areas in Cambodia and in the Long Xuyen Quadrangle and POR in Vietnam. This sample area is representative for the LMB Sub-area 10 and to the southern part of Sub-area 9.

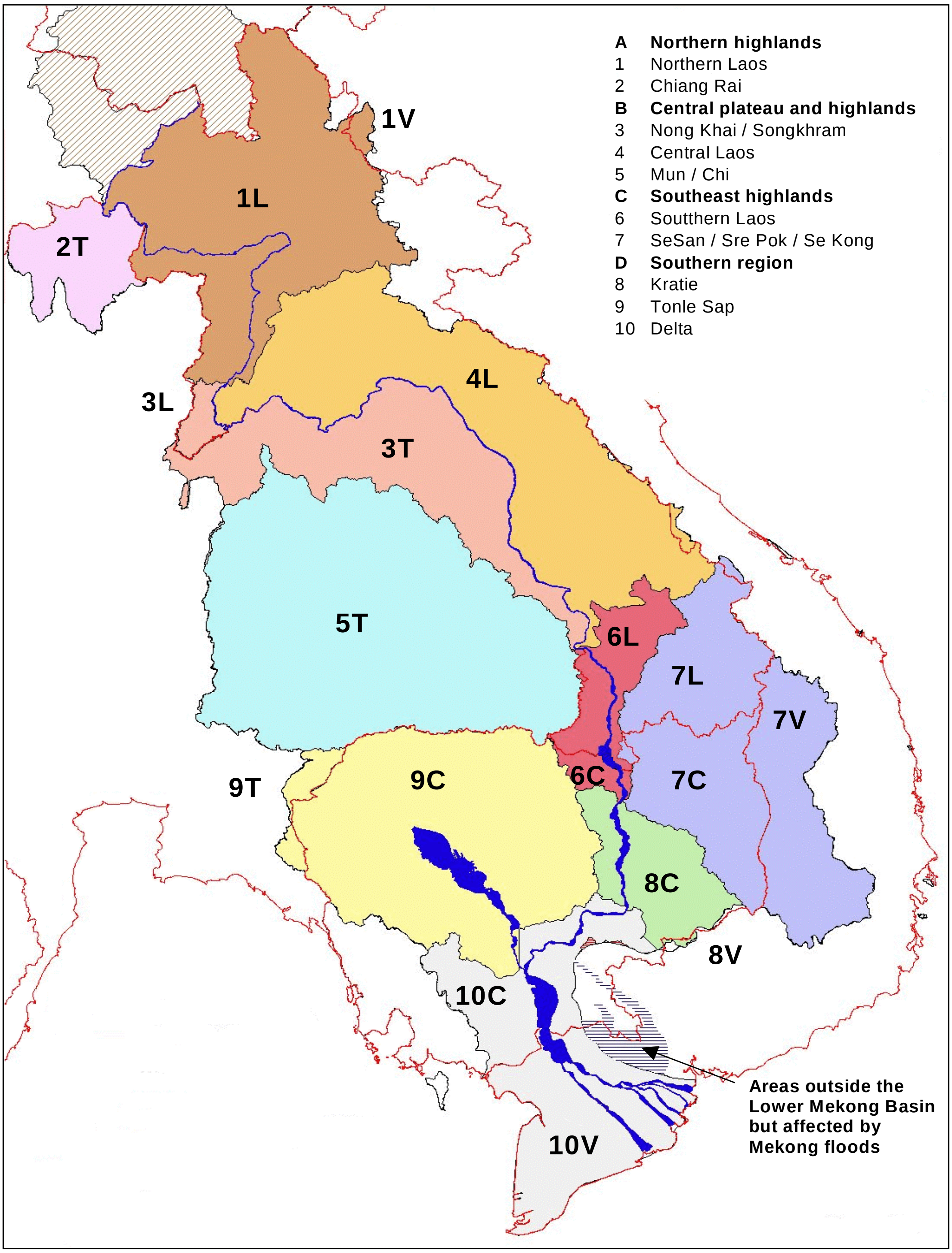


Figure 4.1 Overview of sub-areas in the Lower Mekong Basin.

5 GUIDELINES

5.1 General

The TOR call for the preparation of a set of nine best practice guidelines, viz.:

Best Practice Guideline
Best practice Guidelines for the Selection and Use of Soft Measures to Manage Flood Risk
Best Practice Guidelines for Flood Proofing Buildings and Infrastructure in Urban and Rural Areas
Best Practice Guidelines for the Use, Design, Construction, Maintenance and Operations of Structural Flood Mitigation Works and Flood Plain Infrastructure
Best Practice Guidelines for the Selection of an Appropriate Mix of ‘Hard’ and ‘Soft’ Flood Risk Management Measures
Best Practice Guidelines to Assess and Manage the Environmental Impacts of Structural Flood Mitigation Works and Floodplain Infrastructure
Best Practice Guidelines to Assess the Socio-Economic and Other Costs of Flooding
Best Practice Guidelines to Assess the Socio-Economic and Other Benefits of Flooding
Best Practice Guidelines to Control and Repair Riverbank Erosion
Best Practice Guidelines for the BDP

In the inception phase it was concluded that these guidelines can be grouped with regard to their field of application into i) guidelines that are to be used in the process of IFRM planning, including guidelines for flood risk assessment, ii) guidelines that are to be used in the assessment of the impacts of IFRM measures, iii) guidelines that are to be used in the development and design of projects of structural measures for flood risk management, and iv) guidelines to be used by BDP in the Integrated Water Resources Management (IWRM) based basin planning.

In the course of the Stage 1 it became apparent that an adequate flood risk assessment is the basis for any further step in the flood risk management process. For that reason it was concluded that the guidelines for flood risk assessment should have a key position in the set of guidelines. During national consultation meetings the outlines of this specific guidelines were presented in Stage 1.

These Best Practice Guidelines (BPG) for Integrated Flood Risk Management are being developed to provide policy-makers, managers and FMM professionals in MRC and national line agencies with a common knowledge base to apply in:

- policy formulation,
- strategy and plan development and
- project design and evaluation for flood risk management in the LMB.

Each member country of the LMB has its own policy and legal frameworks that will guide or regulate the planning, evaluation and implementation of flood risk management plans and measures.

The BPGs do not attempt to summarize or replace these national guidelines, nor are they intended as a recipe for carrying out planning or project design for flood risk management in the LMB. Rather the BPGs provide an information resource/tool to be adapted according to each country and project context.

During the Stage 1 of FMMP C2, the outlines were prepared for these BPG's. In principle these outlines were meant to indicate how these BPG's would be structured and what the contents would be. The guidelines have been developed during Stage 2. The TOR call for the application of the BPG's in the ranking of projects for ProDIP and in the elaboration of the Demonstration Projects during Stage 2.

5.2 Best Practice Guideline for Flood Risk Assessment

5.2.1 Use of the Best Practice Guideline for Flood Risk Assessment

The BPG for Flood Risk Assessment consists, in accordance with the IFRM concept, of three elements (practices):

- practices for the assessment of flood hazards
- practices for the assessment of flood damages and
- practices for flood risk assessment.

The BPG on Flood Risk Assessment is presented in Volume 3A.

Who should use the guideline and what is the main use for which the BPG is being prepared?

Firstly, there is the group of policy makers that will participate in the development of the flood risk management strategies at national and/or regional level.

Secondly, there are the regional and/or basin planners that should be aware of the impact of development scenarios on flood risks and that should take flood risk management as an essential component of Integrated Water Resources Management. (For this group also the IFRM BPG for Basin Development Planning (BDP) is being prepared.

Thirdly, there is the group that will participate in the preparation of flood risk management related projects, structural or non-structural. The guideline can be used to generate field level flood benefits and costs that can be used as an input for project analysis. This project analysis itself is treated in the Best Practice Guidelines for IFRM Planning and Impact

Last but not least there is the group that will participate in multilateral dialogues regarding transboundary flood risk related impacts.

5.2.2 Background on development of the Best Practice Guideline for Flood Risk Assessment

The BPG has been prepared on the basis of:

- a review of other guidelines or best practice documents in the field of flood risk assessments;
- a review of existing guidelines in the LMB countries regarding damage assessments;
- experience gained during the flood risk assessments made for the LMB focal areas during the Stage 1 of the FMMP-C2.

In the Stage 1 of the FMMP-C2 a damage data collection and processing methodology was designed that yielded the required data for the LMB focal areas, given the availability of secondary data, time and budget constraints. The methodology was evaluated by the survey teams that did the secondary and primary data collection for workability and by the consultants as for providing the required information. Both concluded that the method was workable and suitable in the local context of the MRC-member countries and that the damage data could be used for processing into flood risks. For details on the FMMP-C2 damage data collection, reference is made to the Volume 2C.

In Stage 1 also flood hazards were assessed comprehensively for the focal areas with different types of flooding in the LMB. Methodologies applied in these assessments will be the basis for the guideline for hazard assessment. Volume 2B gives the details and results of the methodologies applied for the assessment of the flood hazards in the LMB focal areas. In Stage 2 this was advanced for the areas covered by the Demonstration Projects, notably for the Nam Mae Kok basin and the Mekong Delta (West Bassac IFRM Plan and FRM in the border zone between Cambodia and Vietnam)

5.2.3 Practices for flood hazard assessments

This part of the BPG for flood risk assessments describes in detail the steps and procedures to be used for flood hazard assessment. A classification of floods is used as applied by the MRC for the LMB, including:

- Tributary floods including also flash floods
- Main stream floods
- Combined floods
- Flood in Cambodian flood plain
- Floods in the Mekong Delta

A description is given of the flood types and an overview is presented of the occurrence of the type of floods in the LMB per BDP-sub-area. The guideline gives for each type of flood:

An overview of the flood characteristics. The available methods for assessment of the hazard of the floods will be described in relation with the location in the catchment and the data and modelling tools available. The steps to be taken are presented.

Data requirement. An outline is given of the types of data that is required for assessment of the flood hazard, including spatial and time oriented data.

Data collection and storage. An overview is given of the sources of data and agencies to be consulted to obtain the required information. The structure of the database to be developed for the various stages of hazard assessment will be presented

Field visit. A detailed programme for the field visit is given with a checklist of points that need attention, including the monitoring system layout, operation and maintenance, hydraulic infrastructure and its operation in times of floods.

Data validation and processing. Thorough validation of the spatial and time oriented data is necessary to make a reliable assessment of the flood hazard. Efficient validation procedures are described for each type of data, including correction and completion techniques. Procedures to deal with unsteady flow and backwater effects in discharge ratings are presented. Test are described to assess the homogeneity of the data and checks on outliers. Special attention is given to changes in land use on flow statistics.

Hydrological hazard The appropriate statistical hydrological hazard assessment procedures are dealt with for each type of flooding.

Flood hazard assessment The hydrological hazard in terms of peak flow statistics and associated hydrographs is transformed into water levels by means of a hydraulic model of the concerned river reach. Model requirements, schematization, calibration and selection of boundary conditions, and application to discharge extremes with flood waves are discussed.

5.2.4 Practices for flood damage assessment

This part of the BPG describes in detail the steps and procedures to be used for flood damage assessment for different damage categories. The grand total of damages caused by a flood in a certain area is the total of direct damages plus the total of indirect damages and minus the total flood benefits.

Different damage categories refer to:
- Loss of life
- Household related damages
- Direct damages
- Indirect damages
- Public and industrial infrastructure and services related damages
- Direct damages
- Indirect damages
- Agricultural damages

Levels of assessment. The level of detail required for the different uses of the flood risk assessment are explained. Distinction is made between:
- strategy development and planning, for which the provincial or district level is considered the appropriate level,
- project preparation, for which commune /village level is considered more appropriate

Data collection, review and validation. Secondary and primary data collection at various levels and different damage categories is described, together with the data collection tools as developed and tested under the FMMP-C2 project. Also review and validation methods for existing data are described.

Analysis of flood surveys. Description of methodology is given to give adequate monetary values to the series of collected damage data, such as deflation factors, economic development and improvements in the level of flood protection

Description of methodology to develop factors that link indirect damages to direct damages. Such factors can than be applied to increase the values of the direct damages to include also the indirect ones.

5.2.5 Practices for flood risk assessments

Damage curves. Distinction is made between the different levels of risk assessments, that is to say,
- risk assessments for IFRM strategy development and planning, and
- GIS based risk assessment for IFRM project preparation.

The first level is suggested to be done at "district" level, making use of "district" damage data. For IFRM project preparation a more detailed level of geo-referenced damage information is needed.

For the two different levels of risk assessment the methodology is presented for the preparation of damage curves. These curves will provide the relation between the damage related to the three damage categories and:
- inundation depth in different times of the year;
- duration of the inundation

For a quick "district" damage assessment the "district" damage curve could provide the relation between the "district" damages and a representative flood level in the respective district.

Inundation maps. The procedure is described to generate inundation (depth) maps for different flooding probabilities on the basis of ISIS model results or other methods as referred to under practices for hazard assessment. The suggested flood probabilities are: 50%, 25%, 10%, 4%, 2% and 1%

Damage probability curves and flood risk mapping.
The procedure is described to link the damage curves to the inundation depth in the GIS environment and to generate for the different damage categories the damages that correspond to the different flood probabilities.

The procedure is described to generate damage probability curves that form the basis of the risk assessment.

The procedure is described to generate flood risk maps, including categorization and classification (level of severity) of the risks.

Use of damage probability curves and flood risk results. "District" risk maps are used to identify the districts with the highest damage. These would be the districts for which flood mitigation measures would have to be developed on a priority basis.

The methodology is described to use the damage probability curve and flood risk results to make an estimate of the costs of flood risk management measures that could be justified.

5.3 Best Practice Guideline for IFRM Planning and Impact Evaluation.

5.3.1 Use of the Best Practice Guideline for IFRM Planning and Impact Evaluation.

This BPG is meant to provide guidance in the process of the preparation of IFRM strategic directions and plans. The BPG on IFRM Planning and Impact Evaluation is presented in Volume 3B.

Strategic directions refer to the type of measures that are most attractive to manage the risks and reduce the damages in a certain area, whereas IFRM plans present the most attractive set of specific measures for flood risk management in a certain area.

The start of any IFRM planning exercise should be an adequate risk assessment (see section 5.2). After this risk assessment the following steps are distinguished:
- the identification of possible measures for risk reduction;
- the consultation and participation of stakeholders;
- the evaluation of environmental impacts;
- the evaluation of social impacts;
- the evaluation of the economic impacts.

In the guidelines, the practices referring to each of these steps are described. It proposes an approach to the identification of IFRM measures and the assessment of social, economic and environmental impacts of structural flood mitigation measures in the LMB. It also summarizes the various ways to involve the general public and other stakeholders in the planning, design and implementation of these measures

The Guidelines will be relevant for planners and project managers in MRC, the National Mekong Commissions and line agencies when doing:
- Formulation of strategic directions for flood risk management;
- Planning and prioritisation of potential structural flood mitigation measures;
- Screening and preparation of structural flood mitigation projects;
- Designing projects and monitoring their implementation.

The Guidelines will be applicable to the assessment of social-economic and environmental impacts of structural measures for flood risk reduction only. The socio-economic and environmental impacts of non-structural flood risk management measures are not dealt with.

5.3.2 Background on the development of the BPG

This Guideline is based on a review of social, economic and environmental impact assessments methods from the MRC (Basin Development Plan Programme), and on standards for impact assessments required by MRC-member states and major donor agencies.

Also the lessons learned in the process of the formulation of strategic directions for the focal areas in the Stage 1 Implementation Phase of the FMMP-C2 have been used in the preparation of this outline.

Practices as presented in this BPG have been tested and further elaborated in the FMMP-C2 demonstration projects during Stage 2.

5.3.3 Practices for identification of IFRM measures

This part of the guideline refers to the basic IFRM concept and explains how to come to an adequate mix of different flood risk management measures (hard and soft) considering:

Types of flooding. The type of flooding is an important factor in the assessment of the appropriateness of different types of measures. The BPG provides the considerations regarding the effectiveness of measures for the following types of floods:

- Tributary floods,
- Mainstream floods,
- Combined floods,
- Floods in the Cambodian Flood Plain, and
- Flood in the Mekong Delta.
- The category of damage that is at stake.

5.3.4 Practices for stakeholder participation

Public participation improves the effectiveness of flood management measures by assessing and integrating the needs and concerns of those vulnerable to flood damage into project design and outcomes. As flooding brings benefits and potential damage, the advantage of structural flood protection measures can only be assessed in interaction with communities living in flood affected areas.

Therefore, a public participation strategy must be developed early in the project planning to clarify what communities will be consulted about, when and how. The public is necessarily involved at some stage when an infrastructure is constructed in their area.

The guideline describes the forms of public participation that are considered relevant for the preparation of flood risk management projects.

Public participation for project preparation should build on the existing mechanisms of public consultation and, where possible, reinforce the role of local government or local elected councils as the convenor of public forums in their jurisdiction. Public participation processes also involves consulting with community-based organizations and other civil society groups that represent members or more vulnerable groups.

Forms of Public Participation

Public participation has various stages depending on the type of project and level of engagement that is feasible at each stage of the project cycle. The essential stages are:

- Stakeholder Analysis;
- Information Dissemination;
- Information Gathering;
- Consultation;
- Participation in decision-making;
- Public awareness on disaster risks and disaster preparedness;
- Community mobilization for operation and maintenance.

For the planning stage for IFRM the first five elements are of importance. Number 6 refers essentially to a soft flood risk management measure aiming at vulnerability reduction. The last element is of importance for the operation and maintenance stage. An overview of the first five stages is presented in the outline.

Stakeholder Analysis

A good stakeholder analysis will identify the people and groups that are directly or indirectly involved in or affected by the project, including groups that are supportive of and other groups that may oppose the project. Understanding these social issues is important to define strategies to gain support for and encourage participation in the project.

Information dissemination

Information dissemination can take a variety of forms throughout the project cycle and should aim to provide information that is understood and useful to the stakeholders. Thus, the knowledge gained in the stakeholder analysis should be used to design the information dissemination methods and the types of materials to be used.

Information Gathering

The next stage of public involvement is to examine how stakeholders are affected by a particular project or programme by developing a better understanding of their social, economic, cultural and political conditions. This stage is also referred to as the social impact assessment. The process for social impact assessment gathers information from the community using participatory techniques. The purpose and methods are described in detail in the practices for Social Evaluation.

Consultation and Participation in decision-making

Consultation goes beyond gathering and disseminating information and creates an opportunity for stakeholders to discuss and negotiate their needs and preferences. It is here that ideas and priorities from stakeholders can start to affect project design. This step is crucial in the sense that it creates the opportunities by which stakeholders can influence a final decision (the final stage). In consultation processes the inputs from participants are documented by project planners who then assess whether the expressed needs and preferences can be included in design and if so in what ways.

Stakeholder Participation Action Plan

The action plan for consultation and stakeholder participation will depend on the nature of the project. The starting point for any action plan is the stakeholder analysis which describes all the potential participants. The greater the stake of participants, and the less influence they have on the outcome through normal channels, the greater the need to engage them in a participation process.

5.3.5 Practices for environmental evaluation

In order to evaluate the socio- and environmental impact of any flood risk management measure in a meaningful way, broadly speaking, we have to know (i) which areas would be affected directly and indirectly by the measure, (ii) the present situation including expected autonomous developments in terms of socio-economic and environmental parameters, (iii) the nature and scope of the considered measure, and (iv) we need to have a fairly accurate idea of how the situation would be or develop in the affected area with the measure in terms of the same socio- and environmental parameters.

The outline describes the conceptual framework for Environmental Impact Assessments. Emphasis is put on:

Screening: the procedure used to determine the environmental assessment requirements of a proposed project.

Impact identification In the development of flood risk management plans, programs or measures four phases can be distinguished that each may lead to specific environmental and socio-economic impacts. They are:

- Project site selection;
- Project concept, planning and design;
- Project implementation, including construction; and
- Project management, operation and maintenance.

Site selection can have adverse environmental impacts due to change in the environmental characteristics of the site or area, impacts on livelihood, and the possible need to resettle people away from their current dwelling places. Inappropriate project concept, planning or design may result in undesirable environmental impacts due to changes in the hydraulic characteristics, including the flooding regime, of the site or area; environmental impacts on land, water, and air quality; and changes in the socio-economic viability of the project site or area. Regarding the impact identification special attention is given to the potential **loss of flood benefits** as a result of flood management measures.

A checklist has been prepared of environmental, social and economic parameters for flood risk management projects as presented in Volume 3B.

5.3.6 Practices for social evaluation

The purpose of the social evaluation of FRM measures is to define the strategies and specific measures that will:

- Enhance the social objectives of the project, for example, to reduce poverty;
- Ensure equitable benefits for different social groups;
- Promote local ownership for the FRM measures through stakeholder participation;
- Minimize and compensate adverse social impacts, particularly those that affect vulnerable groups; and,

Monitor the social outcomes and impacts to identify any needs for further measures.

As an integral part of the environmental, economic and social evaluation of a project to implement FRM measures, the social assessment encompasses following activities:

- Gather and analyze quantitative and qualitative data about different stakeholders, how they affect and/or are affected by the FRM measures and the resources and capacities they have to address potential benefits and adverse impacts;
- Facilitate a process to disseminate and exchange information between project proponents, beneficiaries and other stakeholders during preparation, implementation and monitoring of the project; and,
- Engage a participatory planning process to define project strategies that strengthen and take into consideration the socio-cultural and institutional contexts.

The two last items refer to the stakeholder participation, for which the guidelines are outlined in the section5.3.4.

This section of the guidelines outlines the principal methods and tools that are used for analysing how different stakeholders are affected by flood risk management measures. Emphasis is put on the preparation of:
- Socio-economic profiles;
- Assessment of land acquisition requirements and eventual compensation and resettlement needs;
- Institutional capacity assessment;
- Social management plan.

5.3.7 Practices for economic evaluation

The economic analysis of flood damage reduction and development projects should follow the international best practice for economic project analysis of comparing both benefits and costs on a 'With-project minus Without-project' basis, thereby including the autonomous developments (both positive and negative) of the Without-project situation and the flood damage reduction and development potential of the envisaged project intervention.

The project net benefits are described consisting of the following key components:
- Reduction of direct and indirect flood damages;
- Increase of net benefits resulting from the envisaged change in land use;
- Reduction of natural fish and soil fertility. The proposed protection measures may have negative impacts on natural fish due to reducing and/or eliminating flooding in the areas. These losses in natural fish and soil fertility due to the proposed control flooding measures would be taken into account in the economic analysis;
- Environmental and social costs and benefits.

The project costs are described consisting of the following key components:
- Cost of project structures which include all necessary infrastructure for controlling the flood;
- Cost for resettlement which includes compensation for land and structure acquisitions, rehabilitation of income for project affected peoples and other related social/community development;
- Externality costs. The proposed flood control measures may have negative impacts as flood water level raised for upstream and downstream the protected areas. These potential external economic losses would be evaluated;
- Annual operation & maintenance cost and replacement equipments.

Benefit-Cost analysis (BCA) is a process of comparing in common units all the gains and losses resulting from specific actions to determine which one provides the most economic value and the most efficient use of resources to the society. The fundamental principle in BCA is to compare effects that due to a development intervention from those that will occur without it. The analysis should follow the international best practice for economic project analysis which is available in economic text books and website of e.g. ADB. The above key economic principles should be kept in mind during evaluation of cost and benefit of the project.

5.4 Best Practice Guidelines for the development and design of structural and flood proofing measures

Three BPGs have been developed for guidelines related to the development and design of structural and flood proofing measures:

- BPG Flood proofing;
- BPG bank erosion control measures;
- BPG flood embankments/dikes.

The BPG on the Development and Design of Structural Measures and Flood Proofing is presented in Volume 3C.

5.4.1 Practices for flood proofing[4]

The purpose of the Guidelines is to offer a set of planning and design approaches to promote the integrated use of known engineering, structural measures, rather than to propose ready-made solutions which depend on the flooding site specific conditions of each particular area.

A checklist has been prepared of main issues to be addressed when developing and designing flood proofing measures. This checklist is to be examined by the relevant line agencies for assessing the need for modification or a supplement to existing guidelines in the riparian countries. The checklist refers to functional requirements, design criteria and general specifications of specific flood proofing measures.

5.4.2 Practices for bank erosion control

This guideline has not the intention to cover all river hydraulics, morphological, natural and technical related aspects, which might be envisaged during the investigation, and implementation of bank protection works. Instead, main issues regarding planning, design and typical structural solutions developed on basis of risk and experiences of constructed projects or within demonstration projects are considered.

Special consideration is given to Typical Structural Solutions (TSS) which can be designed less massive as compared to so-called “permanent works" to allow for a sustainable use of restricted funds (economic approach).

For introducing TSS, a categorization is required defining i) the range of expected impact loads ii) the importance of the protected area and risk. This is indispensable to prevent from overdesign, but also to exclude projects of extraordinary and national importance (i.e bridges, protection scheme around main urban centres, cultural heritage, etc.) from the simplified planning procedures as proposed for TSS. For this purpose the guidelines will include structure categories (SC), with increasing project relevance from SC1 to SC4 as follow:

- SC1 Minor measures and structures that can be coped by traditional means and/or ad-hoc measures.
- SC2/SC3 Erosion prevention within identified priority areas of valuable assets. Limited structural damages keeping the primary function may be tolerable, and adaptations to meet changing requirements are generally feasible.

[4] Flood proofing is a process for preventing or reducing flood damages to the infrastructure and/or to the contents and integrity of buildings located in flood hazard areas.

- SC4 Measures for objects of extra-ordinary importance and/or most severe and complex hydraulic and morphological conditions. Damages are not acceptable.

The guidelines also considers a simplification and standardization of the planning and implementation process as it is crucial to allow for timely completion of bank protection structures within a restricted construction window and despite possible sudden changes of the river course.

- SC2/SC3 Erosion prevention within identified priority areas of valuable assets. Limited structural damages keeping the primary function may be tolerable, and adaptations to meet changing requirements are generally feasible.
- SC4 Measures for objects of extra-ordinary importance and/or most severe and complex hydraulic and morphological conditions. Damages are not acceptable.

The guidelines will also consider a simplification and standardization of the planning and implementation process as it is crucial to allow for timely completion of bank protection structures within a restricted construction window and despite possible sudden changes of the river course.

A checklist has been prepared (see Annex 6B) that will form the backbone of this BPG.

5.4.3 Practices for flood embankments / dikes

This guideline has been developed to present basic principles used in design and construction of dikes and for the general guidance of design engineers. The guideline is not intended to replace existing national guidelines or the judgment of the experienced design engineer. The primary responsibility for proper dike design lies with the design engineer for the project.

The guidelines convey best engineering practices in a typical situation and detail the issues or problems which a hydraulic design engineer may need to resolve. In order for a dike to safely fulfil its intended function, the dike must also be constructed, operated and maintained properly. Supervision of construction or reconstruction of the dike by competent engineers is required to ensure that the dike will be built according to the approved plans. The guideline will address these issues as well.

It is recognized that the design of flood protection dikes varies according to design conditions/forces, foundation conditions, and construction materials. Design forces include height and duration of high water, flow velocities, debris, seepage, internal drainage, natural processes, etc. This guideline main purpose is to assist Line Agencies in further improvement of dike design and therefore will incorporate a number of technical requirements, including, but not limited to:

- The profile of the design flood;
- Freeboard for hydraulic and hydrologic uncertainty;
- Landside slope stability due to steady seepage;
- Waterside slope stability due to draw down;
- Surface erosion of slopes;
- Stream erosion of the waterside slopes;
- Seepage, uplift, and piping through or under the dike and structures;
- Internal drainage;
- Permanent access for inspection, maintenance, and monitoring;
- Practicality and economy of construction and dike maintenance, and;
- Structures in and through dikes.

There are also numerous limitations on dike design due to the nature of the design standard, uncertainty in the determination of the design conditions and forces, and ongoing changes experienced in natural systems that affect operation and maintenance requirements. Those aspects are addressed in the guidelines as well.

5.5 IFRM guideline for BDP

A framework for the development of Best Practice IFRM Guidelines for the BDP[5] was prepared in preparation of the FMMP-C2. The objective and purpose of the BDP Guidelines were stated as follows:

'The objective of the BDP Guidelines is 'to reduce the socio-economic costs of flooding in the Lower Mekong Basin, whilst preserving the environmental and other benefits of floods, through a better understanding of the management of flood risk and flood behaviour by MRC via the BDP and by national line agencies via national programs'.

The purpose of the BDP Guidelines 'is to ensure that the BD planning process identifies and addresses flood-related impacts and opportunities of potential development scenarios and development projects in a consistent fashion that is technically, socially, environmentally and financially responsible and effective'.

The role of these guidelines was intended to serve as a "screen" for all type of water related plans and projects emerging from the MRC programs to pass before being taken up in the (IWRM based) Basin Development Plan.

From the strict perspective of flood risk management, the function of the "screen" would be to assess to what extent mentioned plans and projects have an impact, negative or positive, on flood risks in the LMB. In this context, the IFRM guidelines for BDP are meant to guide the process of impact (on flood risk) assessment for each water related development sector. Consequently the IFRM guidelines will essentially consist of a checklist for each of these sectors of flood risk related issues that need to be addressed in the impact evaluation of sectoral strategies, plans and projects.

The outline BPG for IFRM planning and impact evaluation (as described in section 5.3) focuses on the evaluation of the impacts of flood risk management measures on the environment, including existing and planned socio-economic conditions and developments. The focus of these IFRM guidelines for BDP is, on the contrary, on the impact that socio-economic developments may have on flood risk.

The BPG for BDP is presented in Volume 3D.

These guidelines are intended to be used in connection with existing guidelines in the MRC and the different countries in the LMB for environmental impact assessments in other sectors. Not only water related but also transport infrastructure, forestry, urban and industrial development related sectors[6].

The IFRM BPG is intended to form an appendix to existing Environmental Impact Assessment (EIA) guidelines. The objectives of the outline BPG are to:

- Provide an overview of sectoral developments that may affect flood risks;,

[5] MRC, March 2007, Best Practice IFRM Guidelines for the BDP, Volume 1 Framework for Development of Guidelines.

[6] Guidelines for planning and design of roads in floodplains, developed under the Delft Cluster-IHE UNESCO-WWF project, will be incorporated in the Guidelines for BDP.

- Identify the flood risk related elements that must be included in an impact assessment of sectoral development policies, plans and projects.
- Provide methodologies and samples of flood risk evaluation of development policies, plans and projects.

6 PRIORITY INVESTMENT PROJECTS AND DEMONSTRATION PROJECTS

6.1 ProDIP, Project nomination, evaluation and ranking

6.1.1 Terms of Reference

The Terms of Reference of the FMMP C2 call for the preparation of a FMM Project Development and Implementation Plan (ProDIP) based on a limited number of Flood Management and Mitigation (FMM) projects nominated by the four riparian countries.

The ProDIP may additionally include non nominated FMM projects from the BDP project database and projects identified (and not nominated) in the course of the development of flood risk management plans under this project.

FMM projects are all type of projects that are related to flood management and mitigation and that aim at the reduction of flood risks in the LMB riparian countries, including bank protection projects along the Mekong main stream.

The Term of Reference also call for 4-6 demonstration projects to be selected from the list of projects that eventually will make up the ProDIP. The most important criterion in selecting these demonstration projects is their contribution to achieving the principal objectives of the FMMP-C2, that is to say, to the establishment of sustainable flood risk management capacity in the MRC, Mekong River Commission Secretariat (MRCS), NMCs and national line agencies. The extent to what a demonstration project will add to the capacity building has been assessed in relation with the extent to which the Best Practice Guidelines are to be used in the development of the projects.

6.1.2 Project nomination and short-listing procedures

The MRC Member States presented long lists of project ideas. These were compared with the FMM projects figuring in the BDP project database. A review was carried out of the FMM projects included in the BDP project database. In this review process, projects that are no longer considered for nomination and eventual inclusion in the ProDIP were eliminated.

An inventory was made of FMM Project Ideas that were not included in the BDP project data base but that are now considered by the respective line agencies for nomination and eventual inclusion in the ProDIP. The consultant developed in consultation with the relevant line agencies, Project Ideas in the framework of the IFRM studies in the focal areas. Regarding project ideas in the Mekong Delta area a special bi-lateral meeting was arranged on 26 June 2008 in Siem Reap between Vietnam and Cambodia in which strategic directions for flood risk management in that area was discussed.

The process of categorization of projects by type of measure, expected impacts of the projects, status of project preparation etc. that allowed for a ranking of the project has been presented in the Stage 1 Evaluation Report and its Annex 8.

The following criteria were considered of importance for the short-listing of projects for ProDIP:

1. Projects should aim at the reduction of considerable flood and/or erosion risks;
2. Projects should be effective regarding risk reduction.
3. Projects should preferably have already a certain level of project preparation in terms of availability of existing data, studies and evaluation tools (modelling).
4. Projects should have full stakeholder acceptance / ownership. They should, moreover, allow for public participation in the project preparation.

5. Projects should be potentially “bankable”, that is to say that they should be economically and financially viable.
6. Projects should potentially stand the social and environmental evaluations as required by the international financing agencies and donors.
7. Projects should match the development strategies and priorities of the respective member states with regard to poverty reduction.
8. Projects should be developed in an adequate institutional setting, that is to say that roles and responsibilities of the participating institutions are well defined.
9. Projects should fit in the Integrated Flood Risk Management strategies, if any, in the respective BDP Sub-areas.
10. Projects should fit in the Integrated Water Resources Management concept, if any, of the respective BDP Sub-areas.
11. Projects should be appealing, that is to say that the potential results should lead to the implementation of similar projects elsewhere in the LMB.

During Stage 2, the shortlisted projects have been investigated further and with assistance from the NMCs and Line Agencies the Project development Sheets have been prepared in the format as provided by the BDP. In some cases, projects that were shortlisted in Stage 1 had to be replaced by other projects, for example when it happened that a shortlisted project was already being implemented in 2009.

The following sections present the lists of projects retained in the shortlist for each Member Country, their prioritization and preliminary implementation plan.
The full ProDIP report is presented in Volume 4.

6.2 Shortlist of selected projects for ProDIP

6.2.1 Shortlist of projects for ProDIP Cambodia

The selected FMM projects for the Project Development Implementation Plan (ProDIP) for Cambodia are shown in the following table.

Table 6.1 Shortlist of selected projects for Cambodia.

	Description/ Name
1	IFRM Plan Preparation for Takeo – West Bassac
2	Flood Protection Deep-flooded Area (Zone 2) - West Bassac
3	Flood Protection Five Polders (Zone 1) – West Bassac
4	Flood Proofing Settlements and Infrastructure (Zone 2) – West Bassac
5	Flood Protection/ Proofing Anchor Borey in West Bassac
6	Flood Protection Shallow-flooded Area (Zone 3) – West Bassac
7	Flood Risk Mitigation/ Diversion in the Border Areas Between Cambodia and Vietnam
8	IFRM Plan Preparation East of Mekong (Prey Veng), East Mekong
9	IFRM Plan Preparation Stung Sreng
10	Flood Risk Management Options Tonle Sap Great Lake
11	Land Zoning Flood Proofing Peam Ro
12	Capacity Building Disaster Management

6.2.2 Shortlist of projects for ProDIP Lao PDR

The selected FMM projects for the ProDIP for Lao PDR are shown in the following table.

Table 6.2 Shortlist of selected projects for Lao PDR.

	Description/ Name
1	Capacity Building in Flood-prone Area of Champasack
2	IFRM Plan in Lower Xe Bangfai River Basin
3	Landuse Planning in Sebanghien Flood-prone Area
4	Joint Bank Protection Study – Bokeo
5	Establishment of National Flood Forecasting and Warning Centre
6	Study on Flash Floods in Luangnamtha Province

6.2.3 Shortlist of selected projects for ProDIP Thailand

The selected FMM projects for the ProDIP for Thailand are shown in the following table.

Table 6.3 Shortlist of selected projects for Thailand.

	Description/ Name
1	Preparation of IFRM Plan for the Lower Kok River Basin
2	Study on flash floods in the Kok River Basin
3	Capacity Building on Flood Risk Management in Chiang Rai Province
4	Landuse Planning for Flood-prone Areas in Chiang Rai Province
5	Flood Proofing of Key Infrastructure in selected areas in Chiang Rai Province
6	Joint Bank Protection Study – Bokeo

6.2.4 Shortlist of selected projects for ProDIP Vietnam

The selected FMM projects for the ProDIP for Vietnam are shown in the following table.

Table 6.4 Shortlist of selected projects for Vietnam.

	Description/ Name
1	Design Criteria for Flood Protection
2	Flood Risk Mitigation/ Diversion in the Border Area Between Cambodia & Vietnam
3	Development of Flood Control Structures along Tu Thuong Canal
4	Rotation Flood Control Embankment in Deep-flooded area of the POR area.
5	Flood Control Sluice Gates along Tien River
6	Flood Control For Fruit Tree Area in the Southern Nguyen Van Tiep Canal
7	Enlarge Main Canals in the POR
8	Flood Control Sluice Gates along Hau River
9	Rotation Flood Control Embankment in Deep-flooded area of the LXQ area.
10	Enlarge Main Canals in the LXQ
11	Riverbank Protection Works in Dong Thap, Tien Giang, Ben Tre, An Giang, Can Tho and Vinh Long Provinces
12	Integration of Flood Risk Reduction in the Implementation of P135, with emphasis on Flood Proofing of Infrastructure and housing in Kon Tum Province

6.3 Project description sheets

In developing the ProDIP further, Project Description Sheets (PDS) have been prepared for each of the nominated 36 ProDIP projects. Basically, the PDS constitutes a collation of information on each project. In general, information contained in the PDS includes:

- Project description and its strategic importance;
- Development and project objectives and key indicators;
- Project outputs;
- Principal beneficiaries;
- Outline of the key features/ scope of works for the project;
- Proposed institutional/ implementing arrangements;
- Expected timing of implementation of activities;
- Estimated costs and proposed financing arrangement;
- Key risks and assumptions that could affect the implementation of the project and desired outcomes.

Thus, the PDS can be regarded as a “stand-alone” document that provides vital information at a glance on each of the selected ProDIP projects. It should be noted that the PDS also forms part of MRC’s Project Portfolio, which is currently being assembled for the Basin Development Plan. The Project Portfolio contains information on projects that are regarded as strategically important in achieving sustainable and efficient development of the basin under the IWRM-based Basin Development Strategy that developers, planners and government agencies can use to attract financing sources for investments. The format of the PDS has been provided by BDP.

Information contained on the PDS was compiled from available data/ information and from information provided by the Programme Coordinators/ NMC’s in the four countries. It has not been possible to provide all the information required to complete fully the PDS, because some of the ProDIPs are only “concept ideas” at this stage. This particularly relates to project costs, institutional and financing arrangements and timing schedule for implementation.

The PDS prepared for the 36 ProDIP projects are contained in Volume 4.

6.4 Prioritisation of the ProDIP projects for the LMB countries

6.4.1 <u>General</u>

It became necessary to prioritise the shortlisted FMM projects for each country as some projects required urgent attention and need to be implemented as early as possible, while others that are less urgent can be implemented at a later stage.

In view of the above, the Consultant has provided an assessment of the relative importance of each ProDIP project in each of the riparian countries. The ranking was purely based on the perceived importance of the individual project in terms of expected reduction in flood risk, anticipated socio-economic benefits on the vulnerable people living in the flood-prone areas, and sustainability of the proposed schemes.

In prioritising the projects it appeared that some of them had the same level of importance. In such cases, the projects were equally ranked. However, there is a need for proper sequencing of projects that have been equally ranked or are linked in such a way that implementation of one could affect the outcome of the other and hence the overall success of the proposed flood mitigation measures.

Table 6.5 to Table 6.8 in the following sections show the prioritisation by the Consultant of the ProDIP projects for each country.

6.4.2 Cambodia ProDIP prioritisation

The prioritised list for the selected 12 FMM projects for the ProDIP for Cambodia is shown in the following table.

Table 6.5 Prioritisation of ProDIP for Cambodia.

Project	Rank	Comments/ Reasons
IFRM Plan Preparation for Takeo – West Bassac	1	Very High priority; Demonstration project
Flood Protection Deep-flooded Area (Zone 2) - West Bassac	2	High priority; Demonstration project
Flood Protection Four Polders (Zone 1) – West Bassac	2	High priority; Demonstration project
Flood Proofing Settlements and Infrastructure (Zone 2) – West Bassac	3	Medium priority; only after the implementation of infrastructure projects
Flood Protection/ Proofing Angkor Borey – West Bassac	4	Medium - Low priority; might be considered by other line agencies
Flood Protection Shallow-flooded Area (Zone 3) – West Bassac	2	High priority; as related to lower flood damage
Flood Risk Mitigation/ Diversion in the Border Areas Between Cambodia and Vietnam	4	Based on Vietnam's ranking of medium priority; to reduce flood risk in the border areas of Cambodia and Vietnam
IFRM Plan Preparation East of Mekong (Prey Veng), East Mekong	2	High priority; could be taken up by the current Work Bank project on trans-boundary project between Vietnam-Cambodia
IFRM Plan Preparation Stung Treng	4	Low priority; could be a component of an existing project
Flood Risk Management Options Tonle Sap Great Lake	4	Low priority; should be linked to a specific project in the area.
Land Zoning Flood Proofing Peam Ro	4	Low priority; should be part of the comprehensive IFRM in East Mekong region.
Capacity Building Disaster Management	5	Low priority; should be taken care of by the FMMP-C4.

6.4.3 Lao PDR ProDIP prioritisation

The prioritised list of the selected 6 FMM projects for the ProDIP for Lao PDR is shown in the following table.

Table 6.6 Prioritisation of ProDIP for Lao PDR.

Project	Rank	Comments/ Reasons
Capacity Building in Flood-prone Area of Champasack	4	Low priority;
IFRM Plan in Lower Xe Bangfai River Basin	1	Very high priority; Demonstration Project
Landuse Planning in Sebanghien Flood-prone Area	5	Very low priority;
Joint Bank Protection Study – Bokeo	2	High priority; riverbank erosion is considered a major problem in the area.
Establishment of National Flood Forecasting and Warning Centre	3	Medium priority; current practice in flood warning requires improvement
Study on Flash Floods in Luangnamtha Province	3	Medium priority

6.4.4 Thailand ProDIP prioritisation

The prioritised list of the selected 6 FMM projects for the ProDIP for Thailand is shown in the following table.

Table 6.7 Prioritisation of ProDIP for Thailand.

Project	Rank	Comments/ Reasons
Preparation of IFRM Plan for the Lower Kok River Basin	1	Very high priority.
Study on flash floods in the Kok River Basin	1	Very high priority; could also be part of the IFRM Plan for Lower Kok River Basin
Capacity Building on Flood Risk Management in Chiang Rai Province	3	Medium priority
Landuse Planning for Flood-prone Areas in Chiang Rai Province	2	High priority; could be part of the IFRM Plan for Lower Kok River Basin
Flood Proofing of Key Infrastructure in selected areas in Chiang Rai Province	4	Low priority; could be part of the IFRM Plan for Lower Kok River Basin
Joint Bank Protection Study – Bokeo	2	High priority.

6.4.5 Vietnam ProDIP prioritisation

The prioritised list of the selected 12 FMM projects for the ProDIP for Vietnam is shown in the following table.

Table 6.8 Prioritisation of ProDIP for Vietnam.

Project	Rank	Comments/ Reasons
Design Criteria for Flood Protection	2	High priority; as there is the need to improve the existing design approach for flood protection.
Flood Risk Mitigation/ Diversion in the Border Area Between Cambodia & Vietnam	4	Medium priority; reduce flood risk in the border areas of Cambodia and Vietnam.
Development of Flood Control Structures along Tu Thuong Canal	7	Low priority; as only the Tu Thuong section is to be considered.
Rotation Flood Control Embankment in Deep-flooded area of the POR area.	5	Low priority; enable cultivation of 3 crops per year.
Flood Control Sluice Gates along Tien River	6	Low priority; will not have significant impact on flood risk reduction
Flood Control For Fruit Tree Area in the Southern Nguyen Van Tiep Canal	4	Medium priority; protection of fruit crops
Enlarge Main Canals in the POR	3	High priority; need to increase drainage capacity of canals in the POR and border areas
Flood Control Sluice Gates along Hau River	6	Low priority; Will not have significant impact on flood risk reduction
Rotation Flood Control Embankment in Deep-flooded area of the LXQ area.	5	Low priority; enable cultivation of 3 crops per year.
Enlarge Main Canals in the LXQ	3	High priority; need to increase drainage capacity of canals in the POR and border areas
Riverbank Protection Works in Dong Thap, Tien Giang, Ben Tre, An Giang, Can Tho and Vinh Long Provinces	1	Very high priority; as there is risk to the loss of life in some areas, such as Vinh Long, Tau Chau and Houg Ngu.
Integration of Flood Risk Reduction in the Implementation of P135, with emphasis on Flood Proofing of Infrastructure and housing in Kon Tum Province.	1	Very high priority; more vulnerable people (ethnic and poor) are affected

6.5 Tentative implementation plans/ schedules

Tentative plans for the implementation of the various ProDIPs for each country have been prepared and these are shown on Figure 6.1 to Figure 6.4. The durations shown on the bar charts include, where applicable, periods for study/ investigations, preliminary and detailed engineering designs and construction. The Project Description Sheet column refers to the PDS-sheet numbers in the Appendices.

It is emphasised that the proposed implementation plans are tentative only, and as such are expected to be revised at a later stage by the individual countries based on availability of funding and other implementation arrangements.

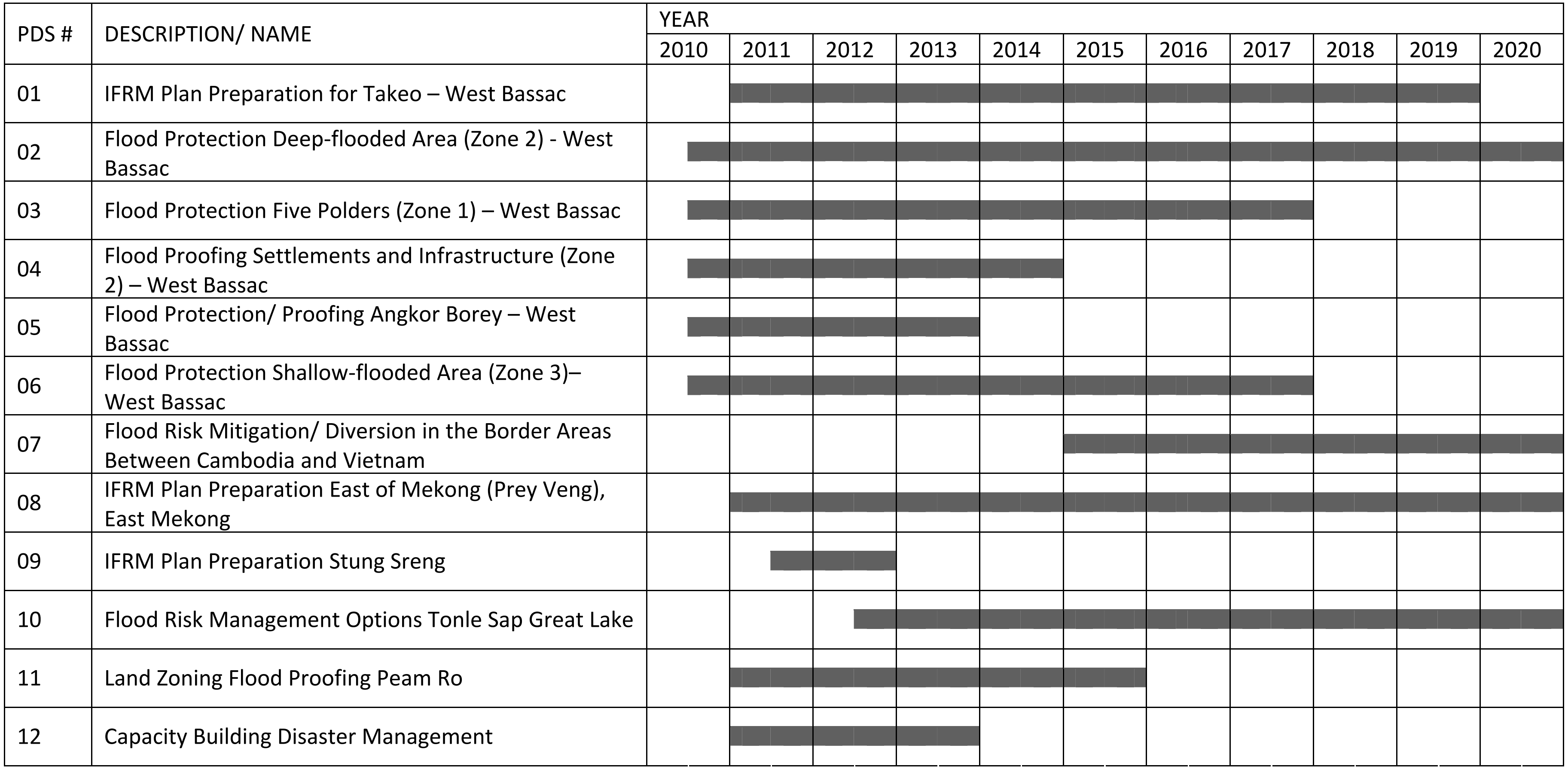


Figure 6.1 Cambodia projects implementation plan.

PDS #	DESCRIPTION/ NAME	YEAR										
		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
01	Capacity Building in Flood-prone Area of Champasack											
02	IFRM Plan in Lower Xe Bangfai River Basin											
03	Landuse Planning in Sebanghien Flood-prone Area											
04	Joint Bank Protection Study – Bokeo											
05	Establishment of National Flood Forecasting and Warning Centre											
06	Study on Flash Floods in Luangnamtha Province											

Figure 6.2 Lao PDR projects implementation plan.

PDS #	DESCRIPTION/ NAME	YEAR										
		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
01	Preparation of IFRM Plan for the Lower Kok River Basin											
02	Study on flash floods in the Kok River Basin											
03	Capacity Building on Flood Risk Management in Chiang Rai Province											
04	Landuse Planning for Flood-prone Areas in Chiang Rai Province											
05	Flood Proofing of Key Infrastructure in selected areas in Chiang Rai Province											
06	Joint Bank Protection Study – Bokeo											

Figure 6.3 Thailand projects implementation plan.

PDS #	DESCRIPTION/ NAME	YEAR										
		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
01	Design Criteria for Flood Protection											
02	Flood Risk Mitigation/ Diversion in the Border Area Between Cambodia & Vietnam											
03	Development of Flood Control Structures along Tu Thuong Canal											
04	Rotation Flood Control Embankment in Deep-flooded area of the POR area											
05	Flood Control Sluice Gates along Tien River											
06	Flood Control For Fruit Tree Area in the Southern Nguyen Van Tiep Canal											
07	Enlarge Main Canals in the POR											
08	Flood Control Sluice Gates along Hau River											
09	Rotation Flood Control Embankment in Deep-flooded area of the LXQ area											
10	Enlarge Main Canals in the LXQ											
11	Riverbank Protection Works in Dong Thap, Tien Giang, Ben Tre, An Giang, Can Tho and Vinh Long Provinces											
12	Integration of Flood Risk Reduction in the Implementation of P135, with emphasis on Flood Proofing of Infrastructure and housing in Kon Tum											

Figure 6.4 Vietnam projects implementation plan.

6.6 Demonstration Projects

6.6.1 Criteria for project selection

During the Inception Phase the following considerations were presented and agreed regarding the selection of Demonstration Projects (in addition to the criteria that were applied for ProDIP projects):

1. Address the different types of flooding that occur in the LMB, i.e.:
   - Flash Floods in Mekong tributaries;
   - Main Stream Flooding upstream;
   - Delta flooding;
   - Combined Main Stream and Tributary Flooding at the confluences.

2. Demonstration projects should be distributed geographically as to reflect the specific requirements of the different member countries and the different BDP Sub-areas.

3. Demonstration project should involve a variety of different structural flood risk management and flood proofing measures.

4. Demonstration should require the application of the Guidelines that are being developed in the FMMP-C2. These guidelines refer to:
   - Guidelines for flood risk assessment;
   - Guidelines for IFRM planning and impact evaluation;
   - Guidelines for the development and design of structural measures and flood proofing;
   - IFRM guidelines for BDP.

6.6.2 Selected Demonstration Projects

Selection of proposed demonstration projects was based on the criteria indicated above and with the purpose to find a balanced selection of plans and measures amongst the demonstration projects. Another important consideration was the development of the Best Practice Guidelines which follow the IFRM planning process, while application and fine-tuning of these guidelines was envisaged in the preparation of the demonstration projects and the prioritization of the ProDIP.

Based on the aforementioned considerations and after consultation during the Stage 1 Regional Workshop , the following selection was made:

Demonstration projects Cambodia	
Sl.	Description
1.	IFRM plan preparation for Takeo. This project requires BDP input for the "socio-economic evaluation and prioritization of investment projects in Focal Area 1 - West Bassac"
2	Joint project for transboundary flood risk mitigation in border zone between Cambodia/Vietnam

Demonstration project Lao PDR	
Sl.	Description
1.	IFRM plan in Lower Se Bang Fai River Basin

Demonstration project Thailand	
Sl.	Description
1.	Flood risk assessment Lower Nam Mae Kok basin

Demonstration projects Vietnam	
Sl.	Description
1.	Criteria for flood protection in the Mekong Delta
2	Joint project for transboundary flood risk mitigation in border zone between Cambodia/Vietnam

The following Sections present the findings and results of the five Demonstration Projects.

6.6.3 Flood Risk Assessment in the Nam Mae Kok basin

The Demonstration Project aimed to assist Thailand in ***Flood Risk Assessment*** in the Nam Mae Kok basin in Chieng Rai province in Thailand. The project is presented in Volume 6A.

Based on the analyses presented in the report the following conclusions can be drawn.
Flood prone area in the Nam Mae Kok basin comprise:

- Valley of Nam Mae Fang,
- Chiang Rai Province, and
- Mouth of Nam Mae Kok.

Floods in the upper reaches of the tributaries are flashy. Flashiness decreases further downstream in the Chiang Rai region. In the lower 20-25 km of the Nam Mae Kok near the mouth the flood levels are affected by backwater from the Mekong.

Extreme value distributions of peak flows and the possible range of flood volumes can be used for assessment of the hydrological hazard in the Chiang Rai region regarding peak levels and flood duration. A bivariate distribution for the river mouth.

Data availability and validation

Water level and discharge series of sufficient length are available to asses the hydrological hazard in the Chiang Rai region and near the Nam Mae Kok mouth.

Validation of hydrological data does not appear to be common practice according to sources at the data collecting agencies.

The applied stage-discharge relations for the stations on Nam Mae Kok and tributaries varied strongly from year to year. The number of discharge measurement taken each year suggest that the changes are due to morphological developments in the station controls. Some re-settings of gauges to different gauge zeros seem to have occurred, but have not been recorded.

Whereas the rainfall records are mutually consistent, the discharge series are not. Distinct changes in the records are apparent in the series of Ban Pang Na Kham in the period 1988-1994, whereas the series of Ban Mae Phaeng is inconsistent with the area adjusted sum of the Kok and Lao flows for almost its entire record.

As a consequence of the Ban Mae Phaeng inconsistency, the SWAT based lateral inflows are overestimated by a factor 2.3.

Hydrological characteristics

Annual rainfall in the Kok basin is largest towards the river mouth (1,700 mm) with lower values of 1,300 to 1,400 mm in the upper reaches of the Nam Mae Kok and the Nam Mae Fang. Rainfall is highest in the months July-September

Evaporation peaks in April-May. Annual totals vary from 1,300 to 1,500 mm. It exceeds rainfall in the period November – April.

The annual average flow volume of the Nam Mae Kok at mouth is about 5.24 BCM. Runoff of Nam Mae Kok at Chiang Rai per unit area is twice the runoff of the Nam Mae Lao. At Chiang Rai the runoff is highest in the months August and September, whereas in Nam Mae Lao September is the month with the largest flow volume.
The regime of the Nam Mae Kok is a few weeks in spate relative to the Mekong regime.

Hydrological hazard

The hydrological hazard expressed as extreme discharge for selected return periods with a full range of flood volumes have been determined for the Nam Mae Kok at Ban Pong Na Kham, the Nam Mae Lao at Ban Pong Pu Fuang and the Nam Mae Kok downstream of the Loa confluence. Generally, the GEV fits best to the data, but due to the limited data length the EV1 is not rejected as an alternative.

The annual discharge peaks on the Nam Mae Kok at Ban Pong Na Kham and the Nam Mae Lao at Ban Pong Pu Fuang do generally not occur at the same time. This should be included in the selected boundary conditions for flood hazard assessment with the hydraulic model.

EV1 and GEV distributions fit well to the marginal distributions of observed annual maximum flood peaks and annual flood volumes in the Mekong at Chiang Saen.

The bivariate distribution of annual flood peaks and flood volumes in the Mekong at Chiang Saen can be described by regression equations and GEV-distributions for the regression residuals.

The observed distribution of annual flood volumes in the Nam Mae Kok is well described by an EV-1-distribution.

The bivariate distribution of annual flood peaks and flood volumes in the Nam Mae Kok at mouth can be described by regression equations and GEV-distributions for the regression residuals.

Neither the peak discharges nor the annual flood volumes in the Mekong versus the Nam Mae Kok show significant correlation.

The annual maximum discharges on the Mekong occur on average about two weeks earlier than the annual peaks on the Nam Mae Kok.

Flood hazard

The flooding around Chiang Rai city is complex and its extent is preferably modelled with a 1D2D hydraulic model.

The existing hydraulic model of the Nam Mae Kok needs to be adjusted in the cross-sections particularly for the Lao and recalibrated using appropriate lateral inflows for reliable flood hazard assessment.

A full range of hydrographs (flood peaks and related range of flood volumes) have been developed for flood hazard computations around Chiang Rai city.

Some 150 combinations of water level hydrographs for the Mekong at Sop Kok and discharge hydrographs of the Nam Mae Kok at mouth will be required for flood simulation near the river mouth as input to the Monte Carlo technique to establish the flood maps of required return periods.

Flood damages have been assessed through a data collection and social surveys in 12 communes. Results show that damages have decreased considerably over the past years, likely as a result of the flood control measures that have been implemented in the area at Chiang Rai, but it is also possible that lower floods occurred in the past years. A proper risk assessment could not be established due to issues with the hydraulic model that makes it unsuitable for simulations at this point in time. Flood damage probability curves are presented but should be interpreted with gat caution because these are indicative only, due to lack of hydraulic simulation results.

However, the methodologies to arrive at flood risk assessment have been presented in the report and are based on the Best Practice Guidelines for Flood Risk Assessment (Volume3A).

6.6.4 Integrated Flood Risk Management Plan for the Lower Xe Bangfai basin, Lao PDR

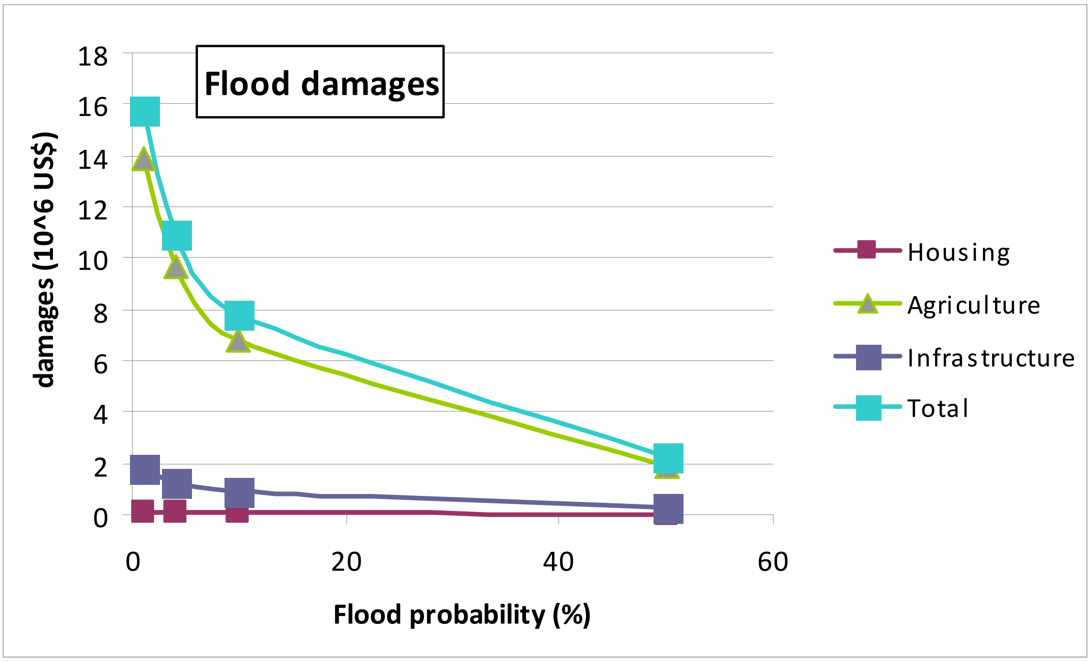
The Demonstration Project aimed to assist Lao PDR in formulating an Integrated Flood Risk Management Plan for the Lower Xe Banfgai area in central Lao. The project is presented in Volume 6B.

Flood Hazard

The flood hazard has been assessed with the ISIS Xe Bangfai model, using the most up to date data on the physical representation of the existing infrastructure and boundary conditions for discharges, local rainfall, water use etc. Flood hazard has been analyzed with historical time series of discharges in the Mekong and the Xe Bangfai River. Since flooding is affected by backwater from the Mekong, multi-variate statistical analysis was applied to determine the combined effect of flows in the two rivers on water levels in the floodplains. The bed level of the Mekong changes as a result of changes in sediment transport and causes considerable variation in water levels. The flood hazard assessment therefore was also carried out with 0.75 m higher and 0.75 m lower levels in the Mekong. Flood hazard maps have been produced for various exceedance frequencies of flow in the rivers for the current conditions and for a number of flood protection scenarios.

Flood Damages

The flood damages have been assessed through analysis of official flood damage data as is being inventoried by Nongbok district[7]. The data has been categorized in three groups, damages to i) a wide range of public services facilities, referred to as "Infrastructure", ii) domestic properties referred to as "Housing", and ii) "Agriculture", comprising also losses in aquaculture. Flood damages have first been translated into flood damage curves, relating damages to (maximum) water levels based on eight years of available damage data. The simulated water level series were then subjected to the flood damage functions to produce the flood damage probability curves for each of the three damage categories (and the total). Damages are essentially in agriculture (88%) and Infrastructure (11%), damages to Housing are negligible showing that people are adapted to living with the flood.



Flood Risk

[7] For reasons of limited resources and time, field surveys and analysis were carried out mainly in Nongbok district under the assumption that the socio-economic conditions in the other districts are similar, and that extrapolation to the left bank flood prone areas is possible.

Through integration of the flood damage probability curves, the annual flood risks have been determined for a series of probabilities of exceedance. For example the risk at a 1% probability of exceedance of water levels, amounts to about US$ 3 mln in total. This means that by protecting this area against floods up to the level of 1% probability of exceedance, on average US$ 3 mln per year will be saved through reduction in flood damages.

Flood Risk in Nongbok District (US$ mln/year)

		Flood Risk (mln US$/year)		
P(%)	T(year)	I	H	A
1%	100	0.36	0.01	2.58
2%	50	0.34	0.01	2.46
5%	20	0.30	0.01	2.14
10%	10	0.25	0.01	1.74
25%	4	0.14	0.00	0.94
50%	2	0.08	0.00	0.47

Integrated Flood Risk Management Strategy

The main objective of the plan is to reduce the flood risks. This can be achieved by either reducing the flood hazard with the help of structural measures or by reducing the vulnerability or a combination of both.

Reduction of flood hazard

The reduction of the flood hazard can in principle be achieved by:

1. Creation of flood retention capacity in or upstream of the flood prone area reducing peak discharges and peak water levels in the river and floodplains.
2. Creation of additional discharge capacity of the river system reducing the peak water levels. This can be achieved by deepening and or widening of the river itself or by creating additional capacity in a diversion and/or by-pass canal.
3. Construction of embankment schemes that protect areas against high water levels.
4. Construction of gates that prevent floods to enter the Xe Bangfai floodplains.
5. Improvement of the drainage system in the flood plains reducing the duration of flooding. Further reduction of the duration of flooding can be obtained by the installation or rehabilitation of gates and or pump stations at the locations where the drainage system discharges into the Xe Bangfai or the Mekong River.

Regarding the creation of flood retention capacity, a project idea was identified concerning the construction of a storage reservoir in the Xe Bangfai at the confluence with the Xe Noy, just upstream of the Road 13 crossing, combined with construction of a flood gate in the Xe Bangfai mouth. This option has been discarded for reasons of far-reaching resettlement needs, impact on environment and costs.

The floodplains have their own natural retention capacity. The creation, reservation and/or enhancement of retention capacity in the flood prone area is, therefore, only relevant in combination with the implementation of embankments. In that case, part of the flood plain can be protected while another part is reserved for the retention of flood waters. The proportion between the 2, ‘how much is to be protected?’ versus ‘how much must be reserved for retention?’, is a political choice that ought to be agreed amongst the different stakeholders. The retained flood water might be appreciated as water for irrigation in the dry seasons.

For the creation of additional discharge capacity, reference is made to previous studies on the flood diversion canal ‘Xelat’ from Banne Sokbo to Banne. A flood diversion option is thought to be cost wise much more attractive than increasing the discharge capacity of the river channel itself. The diversion option will reduce the peak levels along the Xe Bangfai upstream and downstream of the diversion canal off-take point.

Nongbok district developed ideas that focus on drainage improvement rather than on flood protection. A number of 23 schemes have been identified for widening and deepening of natural drains to be provided with gates at the confluence with Xe Bangfai or Mekong. These schemes try to achieve a reduction of the inundation time of flooded area to 15 days or less.

Reduction of flood risks

The strategic direction for flood risk management is closely related with the envisaged future land use scenarios. The risk under the present land use conditions is relatively high: though the actual cropping patterns are tuned to the flood cycle the total risk under the actual conditions is still in the order of US$ 3 mln per year in the Nongbok district alone. Assuming similar socio-economic conditions prevail in the left bank floodplains, the total risk amounts to over US$ 6 mln per year

Reduction of flood vulnerability

The flood risk in the lower Xe Bangfai area is mostly due to damages to the wet season crop. Vulnerability reduction is therefore most effective if the vulnerability of the agricultural production is reduced. This can be done by adapting the cropping pattern to the flood regime and/or the introduction of more flood resistant crops. It is most likely that the actual cropping pattern is already optimally adjusted to the flood regime (traditional coping mechanism) and that further vulnerability reduction is to be sought in the use and/or development of less vulnerable varieties.

Selected strategy

It is anticipated that substantial reduction of the existing risk can be achieved by reduction of the duration of flooding. Hence, flooding would not be eliminated completely in order to preserve the important wetland areas and fisheries benefits. Controlled flooding can be used in that approach.

The option of embankments along the river banks and controlled flooding with drainage improvement in combination with gating of the small Xe Bangfai tributaries can be attractive to achieve this goal.

Flood protection for agricultural development

Khammouane and Savannakhet provinces have expressed desire to develop the agricultural sector in the lower Xe Bangfai floodplains by having a larger irrigated area. However, irrigation schemes are at present used for about 50% of the areas, these small schemes are located on the river levees and are not seriously affected by flooding. Though there is a potential for new irrigation schemes, the focus should first be on the rehabilitation of the existing schemes so that these can be used to their full extent.

The proposed plan

After an initial environmental examination and stakeholder consultation in Nongbok district and evaluation of a number of options for embankments with or without a diversion canal, the proposed IFRM plan should best consist of the following elements:

- Construction of flood protection embankments on both banks of the Xe Bangfai River downstream of the road crossing, designed to protect the areas up to frequencies of exceedance of river discharges of 1% (1 : 100 year), total length of 127 km;
- Rehabilitation or upgrading of 20 sluice gates at the confluences of the natural drains with the Xe Bangfai, allowing for controlled flooding of the wetlands and improved internal drainage;
- Construction of eight drainage pump stations;
- Establishment of water management bodies with representatives of all relevant stakeholders that will be responsible for the management of the systems and for monitoring the socio-economic and environmental impacts of the plan.

The costs of the plan[8] have been estimated at US$ 34.3 mln. With the flood risk reduction benefits of US$ 6.1 mln per year, the economic internal rate of return is estimated at 20%.

Plan implementation is estimated to take five years.

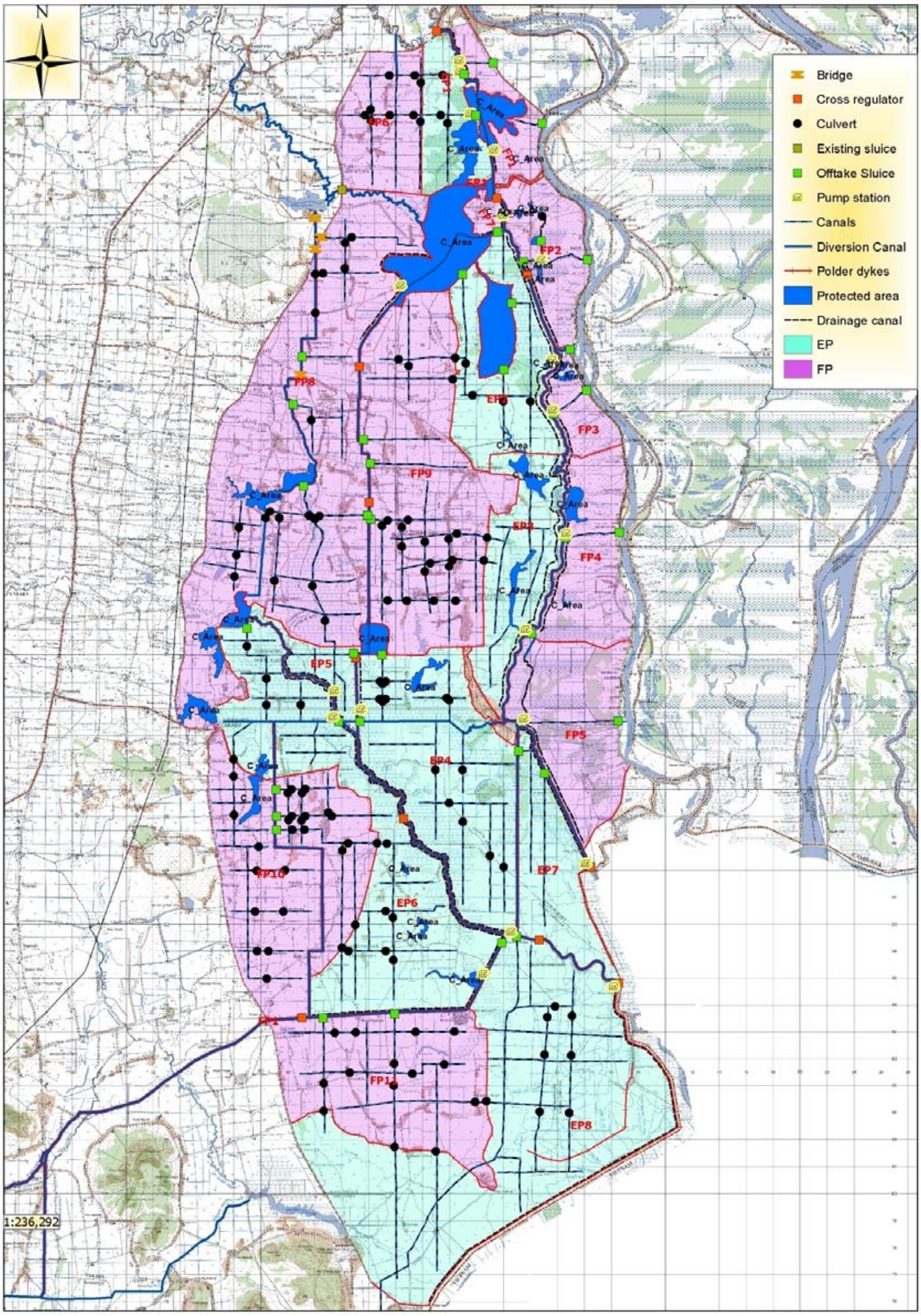
The option with a diversion canal (and embankments) would have an optimal bottom width of 125 m and a depth of more than 4 m. However, the option with a diversion canal turns out to be US$ 4.2 mln more costly and yields a 1.6 percentage-points lower internal rate of return. The diversion canal option should however not yet be discarded completely on these grounds because it would also reduce flood levels upstream of the bridge for which the additional benefits could not be estimated at this stage.

The plan could be sub-divided into a number of projects at provincial or district level and be divided in phases. For project preparation and implementation the embankments could best be split-up in two sections in both provinces (four sections in total). In order to achieve coherence in project preparation, the gates and pumping stations should be an integral part of the embankment projects.

6.6.5 Integrated Flood Risk Management Plan for the West Bassac area, Cambodia

The Demonstration Project aimed to assist Cambodia in formulating an ***Integrated Flood Risk Management Plan for the West Bassac area*** in the south-western part of the country; the area is located in Kandal and Takeo provinces. The project is presented in Volume 6C.

[8] excluding the rehabilitation of 15 gates that will be undertaken by the NTPC.



The West Bassac IFRM Plan area.

Integrated Flood Risk Management Strategy

Three flood risk management zones were identified based on present flood conditions, existing road and flood embankments, human settlements and land use. Subsequently, the type of structural components required for each area has been identified and preliminarily designed.

The formulated scenario is based on the concept of living with flood and to take maximum advantage from flood and to reduce risk by avoiding the maximum flood period for agricultural activities in deep flooded areas. Due to the low level of infrastructure development in the area, flood risk reduction alone could not justify large investment for flood protection. On the other hand it would lead to an optimum use of the land use potential of the area by increasing the crop intensification and diversification. The West Bassac area can be sub-divided into three management zones

Zone 1

This zone is delimited to the east by the RN21, a flood free road built on existing river levees along the Bassac River. The RN21 runs from Phnom Penh to the Cambodian-Vietnamese border at Chhrey Thom. To the west, zone 1 is partly delimited by the existing left embankment and the planned embankment of the flood plain main drain. Currently some 90 colmatage canals divert a large amount of the Bassac flood water across this zones extending 2 to 5 km into the flood plain conveying and storing water through and in the flood plain. Behind the Bassac levees (RN 21), land elevation is about 3.5 to 4.0 m sloping towards the flood plain.

Major population settlement is concentrated along the RN21 road embankment and parts of the Preik Ambel embankment and a few higher road embankments around Sa'ang town. Land use intensification and diversification potential of this area is amongst the highest in the part of the Mekong delta in Cambodia.

Currently only a few of the existing colmatage canals are gated providing water control capability. A small portion of this zone has been developed to be a polder (pilot stage). Under existing conditions, the "Chamcar" occupies higher ground near to the RN21 and the area near to the flood plain main drain is generally used for rice flood recession crop. With steady improvement of the road embankment of the left bank of the Preik Ambel, the area tends to develop itself as a series of polders. This can only be successful with a comprehensive integrated plan combining integrated flood risk management and integrated water resources development taking the whole flood plain into consideration.

It is proposed to conceive zone 1 as an area with full flood protection but with the benefits from flooding. This means that the infrastructural design and management should allow controlled flooding for re-supply of sediment and sanitation of farm conditions. Zone 1 will be sub-divided into five large polders using the flood free RN21 as a protection dike from the Bassac.

On the western side the embankments of the flood plain main drainage channel function as flood protection dikes. The number of colmatage canals will be reduced to only one per polder connecting between the Bassac and the flood plain main drain. Remaining colmatage canals will be closed but will be maintained and improved for drainage and irrigation water supply to each part of each polder. Existing lateral irrigation/drainage canals of each polder will be improved. Each polder will be equipped with a pumping station equipped with a reversible pump installed at the lowest part of the polder serving both for drainage and irrigation water supply.

The deep flooded area has limited settlement space, the right bank of the flood plain main drain will be raised to a flood free level with a series of flood proof causeways of 100 m long at an interval of every 2km for flood passage with design crest above 10 year return period of July maximum water level. The crest of the embankment of the flood plain main drain on the left bank is designed for a 100 years annual maximum return period flood.

The flood plain main drain will be dredged and improved for navigation with rural port facilities at Angkor Borei, head of Preik Ambel and Sa'ang. The hydraulic simulation model will be used for determination of appropriate canal dimensions following the Best Practice Guideline for Structural Measures for Integrated Flood Risk Management.

The Preik Ambel is affected by tide, the operation of the diversion/drainage canal and the related water control infrastructure shall be the main focus during the operation phase to optimize the operation cost. The water management shall be the task of a specialized qualified government line agency. It is expected that water use communities will be established for the management of each polder. Farmer will use their own pumps to irrigate their field from the existing network of colmatage canals.

The design of Integrated Flood Risk Management and Integrated Water Resources Management in Zone 1 has been based on existing and new infrastructure and local condition specific to each polder. The approach used is based on the maximum use of benefit from flooding which would rely mainly on the management capability and flexibility rather than on a full control by protecting against maximum design flood and assure timely drainage for different sets of crop calendars.

Zone 2

The deep flooded area zone 2 is a large flood storage and conveyance area of 85,000 ha covering almost ¼ of the total provincial area extending from the Ta Khmao town to Phnom Den at the Cambodian-Vietnamese border, delimited to the east by the zone 1 and to the west by the non flooded and shallow flooded area zone 3. Almost all the surface runoff and rainfall in the province including the Mekong flood water are stored and conveyed in and through this area. Land elevation of this zone varies between somewhat less that 2.0m to 5.0m with some small hill and higher ground around S'ang district and Angkor Borei constituting as a natural screen hindering hydrological regime and alluvial deposition in the northern and southern part of the zone 2.

A number of natural drainage channels, river branches and canals run into and through this zone: They supply this zone with the Mekong flood water and surface runoff from the western catchments and drain it across the Cambodian-Vietnamese border.

This zone is mainly occupied by flood recession rice area, waste land, flooded forest, protected areas for Cyrus Crane (Preik Lopeou, 9,000 ha) and deep lakes.

Fishery known to be one of the major natural resources of this zone has declined rapidly due to poor management and systematic destruction of habitat (encroachment of flooded forest and overfishing), the number of commercial fishing lot has dropped from 21 to 8 only now for the benefit of fishery community. Remaining commercial fishing lots are mainly concentrating around Angkor Borei area. Current total provincial average fish catch is about 10,700 t/year giving average consumption of only 13 kg/person/year which is very low as compared to national average 30kg per person per year. Aquaculture has a potential for development with improvement of water resource management.

In contrast to deep and prolonged flooding of this area, flood recession cultivation from water course suffers from shortage of water for supplementary irrigation due to insufficient and inadequate irrigation system. Only a limited number of reservoirs (flood water storage) can supply water for irrigation. Limited number of farms located near to the river and canals are able to produce two crops per year making use of tidal effect (recession crop and fully irrigated dry season crop). Most existing irrigation/drainage canals in the zone are silted up quickly due to lack of maintenance.

Due to prolonged flood period only a few population settlement were established in this zone in some small villages along the higher levees of the Takeo River and Moat Chruok canal as well as on spots of higher ground.

Based on the concept of living with flood and the above strategic direction for the Cambodian Mekong delta part, it is proposed to conceive for the protection of the zone 2 only against the early flood and for agriculture development only with consideration on the ecological balance in this zone.

Critical requirement for IFRM structural planning and IWRM in this zone are:

- the capacity for timely drainage of excess flood recession water for field preparation for recession crop (November-March);
- protect early crop (May-July) from early flooding and local excess rainfall;
- provide source of water for supplementary irrigation with least pumping cost
- provide adequate transport infrastructures for easy access to cropping areas
- propose a conservation area for ecological balance
- propose new and improved settlement scheme for effective economic development of the area.

For supplementary irrigation, the source of water will be existing and new reservoir, the flood plain main drain, the Stung Takeo, the Takeo canal, the proposed canal linking the Boeung Chhoeung Luong with the Takeo flood plain and canal storage regulated according to tidal conditions. For the most southern part, south of Takeo Canal, existing main irrigation will be used as main irrigation canal.

Zone 3

The zone 3 extends along the RN 2 to the east and consisting of non-flooded and shallow flooded areas. Soil of this area is dominated by grey leached soil type on ancient alluvium terrace extending from the western foot hill until the north of Preik Ambel in northwest southeast direction with different characteristics from north to south, in north and northwest area at an elevation more than10 m, terrace with high content of sand and fine gravel, towards the south in terrace at elevation between 6 and 7m, consisting of silt and clay mineral, and interface with recent sediment of the Mekong system at elevation between 2 and 5m. In the shallow flooded area different type of recent alluvium soil stretches across the Bassac/Stung Takeo flood plain littoral in thin layer from Bati until Angkor Borei. The part of the shallow flooded area is affected by regular Mekong flood in spite the advantage of being closer to the water source. Existing flood protection dike system is not operational.

Zone 3 is the most populated area of the West Bassac area with large population concentration along RN2 and rural roads. With population increase, land plots are increasingly dispersed and smaller and risks of agricultural drought are also increasing due to change in local hydrological conditions caused by extensive irrigation canals network but most of them functions as drainage canals instead due to lack of appropriate source of water and water control structures, surface runoff is drained rapidly into the flood plain leaving the field dry. Erratic rainfall regime (early, mid season or late season droughts) is another limiting factor for agricultural development of this area.

Major water source for supplementary irrigation of this area is non reliable depending on small western sub catchments and the Tonle Bati Lake which depend on the Preik Thnot flow regime. There is no storage reservoir in the Preik Thnot basin.

Potential for crop intensification and diversification is rather limited as compared to zone 1 and zone 2. Many farmers are now looking to expand their cultivated land into the zone 2 causing increasing number of land encroachment in protected areas in this zone damaging fishery resources of the region. Transportation and public facilities are extremely poor between the zone 3 and zone 2. Crop intensification need intensify capital and labour intensive such as weeding, pest management, water control etc. this can be optimized only when accessibility and travel distance and security are optimally met. There is a need for joint and integrated planning between the two zones especially for the establishment of new settlement areas and their accessibility.

The integrated flood risk management and integrated water resource management of the zone 3 is focusing on:

- securing full wet season crop in non flooded area by providing access to reliable and affordable water source for supplementary irrigation water;
- Reduce risk of flood damage from western catchment by diverting excess surface water from the cultivated area;
- Providing full flood protection of shallow flooded area along the Bassac flood plain;
- building and strengthening capacity in integrated water resource management to achieve optimum operation of structures for flood risk and water resource management.

Future agricultural development

Future without plan

According to the commune database 2007, agriculture in the area had a low cropping intensity of 90% of total potential land (176,830ha) for agriculture. The cultivated crops were 158,576ha of which 79,378ha of cultivated dry season rice, 74,632ha of cultivated wet season rice, 788ha cultivated upland rice, and 3,770ha cultivated non-rice crops. There were 87% cultivated dry season rice being irrigated by different water sources: pond/lake, well, river/stream, and canal/reservoir. Supplementary irrigation for rice in wet season covered 12% of the cultivated area.

The land very suitable for agriculture, however main constrain for agricultural development in the area is availability of water in dry season and flooding. Crop field elevation is varied from 6 to 8m above MSL and water level in Bassac river in dry season in an order of 2 m, pumping irrigation would be required for the area from canal distribution net-work to the field. Possibility for gravity irrigation is limited except from some existing natural lake/pond.

There would certainly be a small-scale irrigation scheme development in future without the plan. However, It is expected that an irrigated area from new irrigation schemes would be balanced the deteriorated rate of existing irrigation schemes. With this assumption, it is expected that future without plan would be more or less the same as existing agriculture.

Future with the plan

The plan provides irrigation facilities (canal, regulators, pumping stations), and flood control measures (ring dykes, compartment dykes, sluice-gates) for early flood protection in July to ensure the double cropping system in the deep flooded area and year around full flood protection for zone 1 and Zone 3 (shallow flooded area).

The first crop in the area would be planting in November-December and harvesting in March-April which is fully irrigated in dry season. The second crop would be planting in March-April and harvesting in June-July when early flood arrives in the area. The early flood protection (embankments and gates) would ensure the second crop safely harvested. Irrigation is also needed during April-June when no rain or insufficient rain compared to crop requirement. The third crop in full flood protection areas would be planted in August and harvested in November. This crop season would be rain-fed with provision of flood protection and local rain drainage.

For the purpose of a preliminary assessment on economic feasible for flood control measures and irrigation development, it is assumed that:

1. Agricultural land in future with the plan would be reduced by 5% compared to future without plan for infrastructure development (canal systems, embankments, rural roads and on-farm development, etc)
2. Cultivated crops would cover at a maximum rate of 90% land availability;
3. Zone 1: In dry season crops planted mainly non-rice crops. In wet season 50% of area planted by rice and the remains for non-rice crops. There would be 10,000ha (48% of the area) that the third non-rice crop could be planted;
4. Zone 2: Crops are mainly rice for dry and wet seasons. There would be two crops per year. Triple crop land in the area would not be possible.
5. Zone 3: “Lowland” would be planted wet and dry rice crops (two crops/year). “Highland” would be planted wet and dry non-rice crops (two crops/year). There would be about 20,000ha (27% of the area) in the low land that third crop of non-rice could be planted.

With the above assumption, it is expected that:

- Cultivated dry season rice would be about 110,000ha with full irrigation of which more than 65,000ha in zone 2 and 45,000ha in zone 3. There would be no dry season rice in zone 1, since zone 1 in the dry season would be covered totally by non-rice crops;
- Cultivated wet season rice would be nearly 120,000ha with supplementary irrigation, of which about 9,000ha in zone 1, 65,000ha in zone 2, and 45,000ha in zone 3;
- There would be no upland rice in future with plan, this land would be convert into non-rice crop area;
- Cultivated non-rice crops would be mainly covered by red corn in wet and dry seasons for animal feeds, there would be some other potential non-rice crops such as green bean, soy bean and peanut for domestic consumption. Total cultivated area of non-rice crops would be about 102,000ha of which 38,000ha in zone 1, 900ha in zone 2, and 63,000ha in zone 3.

Overall cropping intensity in 2007 and future *without* plan conditions was 90%, of which 95% in Zone 2, 90% in Zone 3 and 73% in Zone 1. With the plan it is expected that cropping intensity would be 228%, 180%, and 207% in zone 1, zone 2, and zone 3 respectively.

Even with full flood protection in zone 1 and zone 3 the expansion of third crop in the area would be limited due to limitation of irrigation water in dry season. It is noted that there would be significant needs for agricultural extension services in the plan area for supporting farmers in cultivation techniques, new crop varieties, proper application of fertilizers & pesticides, and marketing. Short-term credit would also be provided to farmer to cover their physical inputs required during crop cultivation.

Flood Risk

Flood Hazard

The flood hazard has been assessed with the ISIS Mekong Delta model, using the most up to date data on the physical representation of the infrastructure and boundary conditions for discharges, local rainfall, water use etc. Flood hazard has been analyzed with historical time series of discharges in the Mekong River. Flood hazard maps have been produced for various exceedance frequencies of flow in the rivers for the current conditions and for a number of flood protection scenarios for the whole Mekong Delta.

Flood Damages

The flood damages have been assessed through analysis of official flood damage data as was inventoried for all districts. The data has been categorized in three groups, damages to i) a wide range of public services facilities, referred to as "Infrastructure", ii) domestic properties referred to as "Housing", and ii) "Agriculture", comprising also losses in aquaculture. Flood damages have first been translated into flood damage curves, relating damages to (maximum) water levels based on seven years of available damage data. The simulated water level series were then subjected to the flood damage functions to produce the flood damage probability curves for each of the three damage categories (and the total).

Flood Risk

Through integration of the flood damage probability curves, the annual flood risks have been determined for a series of probabilities of exceedance. The protection levels that were taken in the design of the IFRM Plan lead to an annual risk reduction of 1.56 mln through reduction in flood damages. Flood risk is highest in agriculture (59%); and Infrastructure and housing (41%), damages to housing is relatively minor showing that people are adapted to living with the flood.

IFRM Plan cost estimate and feasibility

The costs of the plan have been estimated at US$ 301 mln, with US$ 75 mln for Zone 1, US$ 85 mln for Zone 2 and US$ 141 mln for Zone 1.

With the annual benefits of US$ 75 mln from agricultural development, annual flood risk reduction of US$ 1.6 mln. and taking into account losses in fisheries resulting from reduced water body areas, and reduced soil fertility from reduction in silt supply, the net present value amounts to US$ 75 mln; the economic internal rate of return is estimated at 16%.

Plan implementation is estimated to take nine years.

The plan could be sub-divided into a number of projects at national, provincial or district level and be divided in phases.

6.6.6 Flood Protectiion Criteria for the Mekong Delta, Vietnam

The Demonstration Project aimed to assist Vietnam in formulating flood protection criteria for the Vietnamese part of the Mekong Delta. Since, the Mekong Delta covers a vast area, the analysis was carried out for six representative districts representing different levels of flooding and also different types of land use. The project is presented in Volume 6D.

Flood Hazard

The flood hazard has been assessed with the VRSAP model, using the most up to date data on the physical representation of the existing infrastructure and boundary conditions for discharges, local rainfall, water use etc. Flood hazard has been analyzed with a historical time series of 97 years of discharges in the Mekong River at Kratie.

Flood Damages

The flood damages have been assessed through analysis of official flood damage data as is being inventoried by the districts in the Mekong Delta. The data has been categorized in three groups, damages to i) a wide range of public services facilities, referred to as Infrastructure, ii) domestic properties referred to as Housing, and ii) Agriculture, comprising also losses in aquaculture.

Flood damages have first been translated into flood damage curves (for eight years of available data), the simulated historical discharge series were then subjected to the flood damage functions to produce the flood damage probability curves for each of the three damage categories (and the total)

Flood Risk

Through integration of the flood damage probability curves, the annual flood risks have been determined for a series of frequencies of exceedance, for example the risk at a 1% probability of exceedance of river (system) discharges, translated into water levels, is as follows:

Flood Risk in six out of 34 districts in the Mekong Delta USD/year

District	Total	Infrastructure	House	Agriculture	I	H	A
Chau Phu	514	394	117	3	77%	23%	1%
Long Xuyen	758	656	92	10	87%	12%	1%
Tam Nong	1,056	481	433	143	46%	41%	14%
Tan Hong	933	433	408	92	46%	44%	10%
Sa Dec	420	114	204	101	27%	49%	24%
Cai Be	1,935	417	346	1,173	22%	18%	61%

Actual Level of Flood Protection

From the damage probability curves, the currently prevailing level of flood protection can be derived for each category of damages:

Actual Flood Protection Levels im the Mekong Delta in Vietnam

	Frequency				Return period			
Ditrict	Combined	I	H	A	Combined	I	H	A
Tam Nong	30%	25%	35%	12%	3.3	4.0	2.9	8.3
Tan Hong	25%	25%	35%	13%	4.0	4.0	2.9	7.7
Chau Phu	25%	24%	32%	8%	4.0	4.2	3.1	12.5
Long Xuyen	10%	10%	23%	10%	10.0	10.0	4.3	10.0
Sa Dec	30%	25%	27%	37%	3.3	4.0	3.7	2.7
Cai Be	20%	12%	30%	18%	5.0	8.3	3.3	5.6

The order of magnitude of the actual flood protection in the deep flooded areas in the part of the Mekong Delta in Vietnam is about 25% (1 in 4 years) for infrastructure and housing and some 10% (1 in 10 years) for agricultural land.

For the shallow flood area the protection levels vary, Long Xuyen being located in between the deep and shallow flooded area having a 10% (1 in 10 year) degree of protection while for Sa Dec and Cai Be this is not more than 30 to 20% (3 to 5 year), whereas in these two districts the protection level for agricultural land is less than half of that in the deep flooded area.

What would be the optimal level of flood protection?

Through a preliminary engineering analysis of what would be required in terms of civil engineering works to increase flood protection levels for a series of flood exceedance frequencies, the optimum level of protection can be derived through an economic cost / benefit analysis.

The results of that cost / benefit analysis show very clearly:

For the deep flooded areas, it appears that there is no economic ground whatsoever justifying for aiming at higher flood protection levels for land that is used for double cropping of paddy. This finding confirms that **the GoVN policy for that area (at least as far as it is related to land used for agriculture) to provide only for early August flood protection, is confirmed as the right approach and should be continued for many years to come, possibly for decades to come .** These ddeepp flooded areas are already protected against early flooding at on average an exceedance frequency of 10%. Costs for works that provide higher protection levels with regard to agricultural production outweigh by far the benefits that could be obtained by such measures.

On the other hand, the analysis also shows that in the deep flood-prone areas (Plain of Reeds, Long Xuyen Quadrangle) providing for an enhanced flood protection level at community or village level is economically highly beneficial. It would enhance living conditions of the population in these - at times – deeply flooded areas. Their businesses, the district governmental administration and all kinds of district public services as for example education and pubic health services are affected by high flood events, as has been expressed in the damage functions.

The findings also demonstrate that providing higher than the existing flood protection in urban areas such as Long Xuyen and Sa Dec also turns out to be very negative.

6.6.7 Flood Risk Mitigation in the Boredr Zomne between Cambodia and Vietnam

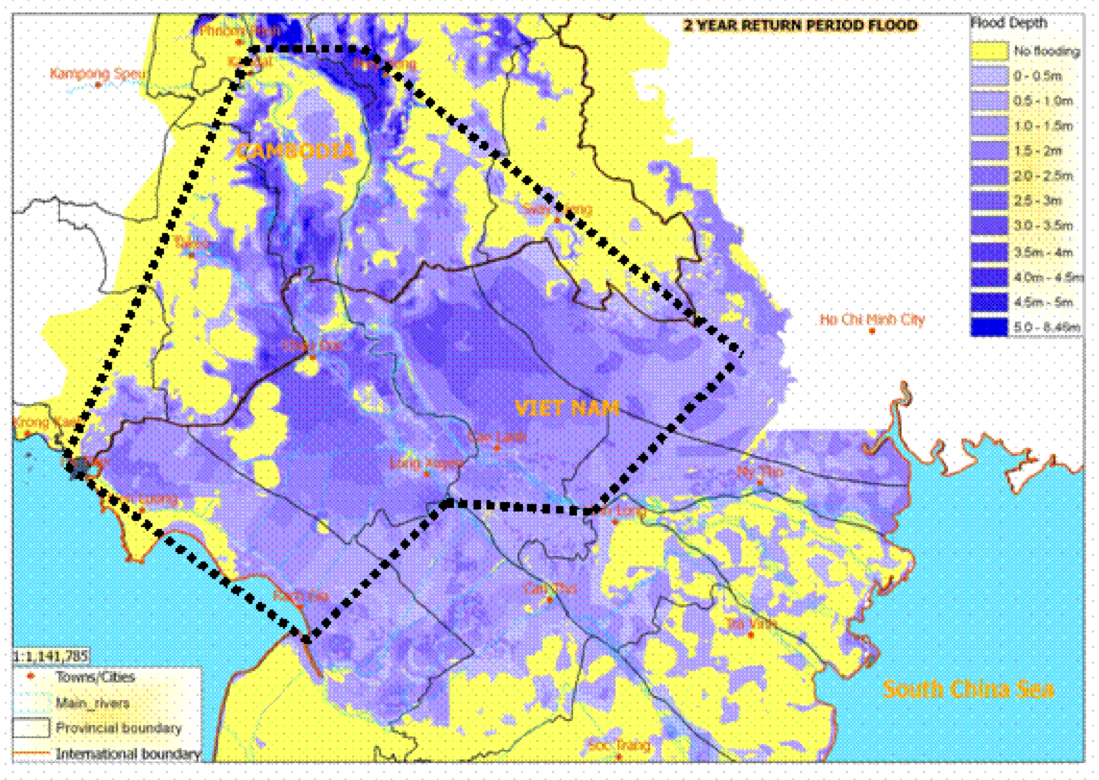
The Demonstration Project aimed at assisting Cambodia and Vietnam to develop a "Joint Project for flood risk mitigation / diversion in the border area between Cambodia and Vietnam". The project is presented in Volume 6E.

Area concerned

The project area should in principle include the areas where impacts are envisaged of existing plans for flood risk management in the Mekong Delta. For the present project, only existing flood risk management plans are considered in the following areas:

1. In Vietnam:
   a. Long Xuyen Quadrangle (LXQ)
   b. Area between Bassac and Mekong north of the Vam Nao
   c. Plain of Reeds (POR) north of the Nguyen Van Tiep Canal

2. In Cambodia:
   a. Floodplains on the West Bassac (WB)
   b. Floodplains between Bassac and Mekong
   c. Floodplains on the left bank of the Mekong and south of the NR #1, also refered to as East Mekong.



Flood damages

Direct flood damages data were collected from provincial and/or district departments from annual reports. It covers damages for housing and properties, crops, aquaculture, infrastructure (roads, irrigation, power and water supply, schools, industry and commercial centres, public service utilities etc.), and emergency rescue and relief. The flood direct damages were grouped into 3 main categories as housing, infrastructure, and agriculture. From the damage probability analysis the following total expected damages at various probabilities of exceedance have been obtained:

		Expected Damage, Total (USD 1,000)					
Region	Area (ha)	1%	2%	4%	10%	20%	50%
West Bassac	408,875	24,087	22,794	20,318	13,684	5,167	922
Trans Bassac CBD	145,592	9,904	9,330	8,233	5,319	1,902	747
East Mekong	320,604	30,285	28,326	24,659	15,406	5,234	1,240
Total Cambdia	**875,071**	**64,276**	**60,451**	**53,210**	**34,410**	**12,303**	**2,909**
PoR	560,144	158,965	146,840	126,157	77,947	28,764	3,072
Trans Bassac VN	185,325	83,332	77,442	66,174	36,128	6,145	550
LXQ	494,485	85,306	78,724	66,304	34,152	2,154	55
Total Vietnam	**1,239,955**	**327,604**	**303,006**	**258,635**	**148,227**	**37,063**	**3,678**
Total;	**2,115,026**	**486,569**	**449,846**	**384,792**	**226,174**	**65,827**	**6,750**

Flood risk, differences between scenarios and base case

For the management of floods and related risks in the Mekong Delta the following flood protection development scenarios have been considered:

[1] Base Case

The existing condition of land use and flood control levels in Cambodia and Vietnam.

[2] Scenario Cam0: flood protection in Cambodia

This scenario comprises of early flood protection and full flood protection in Cambodia according to recommendation of FMMP-C2 in Stage 1, while no further development in Vietnam is assumed. The protection in Cambodia is as follows:

Takeo (West Bassac)
- Zones 1 and 3: full protection
- Zone 2: early flood protection

Prey Veng (East Mekong)
- Zone 1: early flood protection
- Zones 2 and 3: 1: 10 year flood protection (+free board)
- Zone 4: no protection.

[3] Scenario VNa flood protection in Vietnam, variant a

This scenario comprises of early flood protection and full flood protection in Vietnam, in accordance with the approved plan for flood protection in the Mekong Delta..

Long Xuyen Quidrangle: early flood protection by:
- enlargement of canals,
- rubber dams open on the 1st of August

Trans Bassac: full protection
Plain of Reeds: early flood protection Canal enlargement

[4] Scenario Cam0VNa: flood protection in Cambodia and Vietnam

This is the combination of scenarios Cam0 and VNa

In this demonstration project, the impact of such scenarios on both sides of the border have been investigated, therefore it is of interest to look at differences in both flood hazard and risk. The flood hazard difference of a scenario compared to the base cas can be expressed in terms of the difference in flood depth., The difference in risk have been calculated:

Difference in Risk between Scenarios Base Case and Cam0

	Cam0: Risk Total (USD 1,000 per year)					
Area	1%	2%	4%	10%	20%	50%
West Bassac	6	(8)	(53)	(375)	(934)	(1,491)
Trans Bassac CBD	7	13	25	54	83	82
East Mekong	36	63	44	(179)	(333)	(442)
Total Cambdia	**49**	**69**	**17**	**(500)**	**(1,184)**	**(1,851)**
Plain of Reeds	(105)	(274)	(646)	(1,783)	(3,193)	(3,765)
Trans Bassac VN	223	436	827	1,789	2,872	3,732
Long Xuyen Quadrangle	233	461	896	2,071	3,656	5,128
Total Vietnam	**351**	**623**	**1,078**	**2,078**	**3,335**	**5,096**

Difference in Risk between Scenarios Base Case and VNa

	VNa: Risk Total (USD 1,000 per year)					
Area	1%	2%	4%	10%	20%	50%
West Bassac	39	76	142	299	478	696
Trans Bassac CBD	10	19	33	55	61	65
East Mekong	47	87	150	251	312	395
Total Cambdia	**96**	**181**	**326**	**605**	**851**	**1,156**
Plain of Reeds	145	333	724	1,929	(2,248)	(4,777)
Trans Bassac VN	16	(403)	(1,133)	(2,719)	(3,738)	(3,807)
Long Xuyen Quadrangle	11	(48)	(153)	(417)	(1,921)	(2,010)
Total Vietnam	**172**	**(117)**	**(562)**	**(1,207)**	**(7,907)**	**(10,594)**

Difference in Risk between Scenarios Base Case and Cam0VNa

	Cam0VNa: Risk Total (USD 1,000 per year)					
Area	1%	2%	4%	10%	20%	50%
West Bassac	37	45	38	(224)	(742)	(1,296)
Trans Bassac CBD	10	20	39	88	148	174
East Mekong	53	99	111	(35)	(85)	(155)
Total Cambdia	**100**	**164**	**188**	**(170)**	**(678)**	**(1,277)**
Plain of Reeds	(109)	(172)	(269)	(432)	(4,487)	(6,940)
Trans Bassac VN	203	(102)	(609)	(1,605)	(1,861)	(714)
Long Xuyen Quadrangle	195	314	547	1,194	(310)	(400)
Total Vietnam	**289**	**40**	**(331)**	**(844)**	**(6,658)**	**(8,054)**

The conclusions are that in case of developments in Cambodia alone, the risk in Cambodia reduces. *This is obviously only true for the higher, since protection measures would have been provided up to a certain level - 1% for full flood protection and 10% for early protection in the deep flooded areas. The effect of measures increases the water levels in the system which causes that the risk increases for the lower probabilities of exceedance.* Risk increases in Vietnam, especially the Trans Bassac and LXQ suffering higher risk, the PoR would see lower risk due to the effect of the full protection of part of the East Mekong Region.

Scenario VNa, development of flood protection in Vietnam alone would have an opposite impact, risk increases in Cambodia, while total risk in Vietnam decreases as a result of the protection measures.

The combined scenario Cam0VNa, results in lower risk in both countries with the exception of LXQ, which is apart from the main Mekong and Bassac rivers, more or less the only flood passage way to the sea.

Flood risk mitigation

The countries have expressed that increased flood risks can be mitigated by enlarging existing canals, and are not considering large scale new canals in view of land acquisition issues. The most effective measure is the widening of the canals in the LXQ due to the shortest distance to the sea. Such projects are already underway.

It can be concluded that the risk reduces considerably. Further studies in engineering design are required to find optimal solutions for increasing the discharge capacity, especially in the LXQ.

It was the intention of this Demonstration Project to do such investigations. However, issues with the ISIS LMB model caused the model to become available in the beginning of October 2009.

The flood hazard assessment, damage probability assessment, risk assessment and all mapping work followed and were completed by mid December.

Unfortunately, no more time is available to do the technical analysis into flood risk mitigation measures.

The present Flood Risk Analysis however, provides a good understanding of the impacts of measures of each country on the other and in their combination. It stands to reason that gradually over time, existing plans and new projects will be implemented at both sides of the border. Hence, this document provides the insights in impacts of measures on risk at both sides of the border and can be helpful in mutual understanding (common ground) and if it stands to reason, in negotiations in how to resolve negative impacts of actions by one country on the other country.

7 FLOOD DATA DATABASES

7.1 Introduction

The FMMP Component 2 involved the collection, processing and analysis of various sets of flood-related data on the Lower Mekong Basin from Cambodia, Thailand, Lao PDR and Vietnam. The data were collected with two main goals:

1. To determine the flood hazards in the LMB;
2. To determine the flood damages (and benefits) in the LMB.

Based on these data sets the further project goals (all related to flood damage mitigation and flood benefit enhancement) could be elaborated. The data sets cover both general information and flood-specific information: on hydrology/ climate, hydraulics, socio-economics, landuse, housing and infrastructure. The sections below give background information on the data sets: contents, formats, storage, access etc. MRC base data sets are not described below; only when these were processed for project purposes and included in the databases of the project.

7.2 Data types

Several levels of data can be distinguished. Primary data are collected by the investigator conducting the research. Secondary data, by contrast, is data collected by someone other than the user. In the FMMP-C2 project both types have been collected.

Primary data:	The data collected on damages/ benefits and socio-economy through surveys/ interviews.
Secondary data:	Hydrological/ meteorological data, data collected on damages/ benefits and socio-economy through government and non-government institutions in the four countries, and data already available at the MRC.

In the category *secondary data* various subsequent (processed) data sets can be distinguished, e.g. the hydraulic simulation results.

7.3 Data sets: contents and metadata

7.3.1 Flood hazard data

Hydrological data:	Water level Streamflow (calculated discharge) Stage-discharge (measured flow) Type and location of hydrological stations Water use/ demand (mainly agriculture)
Meteorological data:	Rainfall Evapo(transpi)ration Type and location of meteorological stations

The hydraulic model ISIS simulates water levels (m) and flows (m^3/s) for the LMB for the years 1910-2006 using the following data (see also Section 7.4):

1. Mekong flow (Q) at Stung Treng (since 1910), from the MRC's HYMOS database, updated by the FMMP-C2 project;
2. Flows (Q) of the tributaries to Tonle Sap (Great Lake), adapted from previous MRC project IBFM2 results;

3. Flows (Q) of a few tributaries to the Mekong, from MRC's Decision Support Framework (DSF);
4. Rainfall and evaporation, from MRC's DSF (1985-2001) and the Department of Meteorology (DOM Cambodia; 2002-2006);
5. LMB water levels from MRC's DSF;
6. Water demands (mainly agriculture) from the IQQM model in MRC's DSF.

Details on the collected hydrological and meteorological data are given in the description of the 'sub-areas' in this report. Also the mentioned models/ databases give more details on the data.

With the ISIS water level simulation data flood hazard maps have been created for various flood return periods in the LMB: of the current (baseline) situation as well as of several flood mitigation scenarios. In addition 'difference maps' were produced, showing the water level difference between the baseline situation and a scenario, and between two scenarios.

The maps were produced with a Geographic Information System (GIS), and ISIS nodes' names, the nodes' coordinates, the nodes' water levels and a Digital Elevation Model (DTM) were used as input. The outputs are flood depth maps and flood difference maps for various flooding frequencies.

Details on the mapping can be found in the Best Practise Guidelines for Flood Risk Assessment.

7.3.2 Flood damage (and benefit) data

Flood damage data is collected annually by various administrations: at province, district and commune level. Also flood levels are measured by governmental agencies. These data have been retrieved in Stage 1 of the FMMP.

Primary and secondary data have also been collected at households and businesses in order to establish an inventory of flood vulnerability characteristics and direct and indirect flood damages.

Surveys have been held to collect and/or validate the governmental information on *direct damages* for an agreed reference flood (2006), and to document and quantify *indirect damages* associated with the reference flood event.

The data collected on direct and indirect damages were:

Provincial and District officials:

Review and validation of existing data on casualties and direct damages caused by historic flood/ erosion events. Damage categories included educational facilities, healthcare facilities and assets, road and transport facilities, irrigation facilities, water supply & sanitation infrastructure, power facilities, and communication infrastructure.

Households:

Collection of data of individual households in the envisaged project areas for a particular reference year (2006). Data collection included household characteristics, characteristics of the recent flood(s), losses to residential structures, hypothetical damages to the residential structures in the case the inundation depth would have been higher, agricultural assets/ incomes, crop losses, livestock losses, fish/shrimp losses, other household income sources (e.g. home-based businesses, hired labour) and health impacts.

Local businesses (non home-based):

Collection of data of individual businesses in the envisaged project areas for a particular reference year (2006). Data collection included business data, characteristics of the recent flood(s), direct and indirect damages to business structures, equipment and inventory, impact on revenues and employment, and expenditures for flood protection.

In addition, field data collection, mainly using standardised questionnaires, included:

Baseline flood vulnerability data collection

Data were assembled to document key aspects of flood and erosion vulnerability including: population composition and growth, number of households, household assets, economic activities, poverty incidence, land ownership, land use and cropping patterns, fisheries production, animal husbandry, types of structures and infrastructure. In addition, the baseline captured data on business activities, educational facilities and assets, healthcare facilities and assets, road and transport facilities, irrigation facilities, water supply & sanitation infrastructure, power facilities, and communication infrastructure.

Focus groups on community resilience

The survey team facilitated focus groups with local leadership, community/ mass organizations, and people who represent different economic activities and wealth in the study area. The groups were used to collect qualitative information on the beneficial and detrimental effects of floods and erosion. The focus group discussions covered issues as the history of flooding in the area, their perception of ‘good’ and ‘bad’ floods, benefits of floods for paddy cultivation and fishing, traditional coping mechanisms and strengths and weaknesses of community preparedness and resilience to flooding.

The data from the surveys, interviews, group discussions, field observations, combined with the data in the governmental damage reports, were the basis for the damage functions and damage-probability curves. The Best Practise Guidelines for Flood Risk Assessment contain more details on the flood damage and benefit data collection, and how these data have been used to obtain the damage functions and damage-probability curves.

The flood damages and risks were calculated for 25 districts in Cambodia and 34 districts in Vietnam based on the above-described data. These figures have been presented on district maps with the GIS. Details of this mapping can be found in the Best Practise Guidelines for Flood Risk Assessment.

7.4 Data sets: used programmes and formats

For the data storage and processing various software programmes have been used, each with its particular data format. The following table gives an overview of the software and the associated data.

The MRC has user licenses for HYMOS, ISIS, ArcGIS and the Microsoft Office programmes (Access, Excel, Word). VRSAP (‘Vietnam River System And Plains’) is developed and owned by the Southern Institute for Water Resources and Planning in Vietnam. Basic text editors, image editors/ viewers and Adobe Reader are freely available through Internet.

Table 7.1 The used data sets and the associated programmes.

Programme type	*Programme*	*Content: type, format*[2]	*Content: information*
Hydrological database	HYMOS	Data, metadata (his, xml)	Hydrology, meteorology
Hydraulic model[1]	ISIS, VRSAP	Data, methods (dat/ ASCII, …)	Water infrastructure schematisation and their relationships
Geographic Information System	ArcGIS	Maps, data (shp, adf)	Hydrology, landuse, DTM, population.
Relational database	MS Access	Data (mdb)	Water levels, hydraulic parameters
Spreadsheet	MS Excel	Data, methods, formulas, graphs (xls)	Socio-economy, damages, risks
Basic text editor	any (ASCII) text editor	Hydraulic model input/ output (csv)	Hydraulics/ hydrologic/ meteo data, DTM, infrastructure parameters
Advanced text editor/ viewer	MS Word, Adobe Reader	Reports, guidelines (doc, pdf)	All subjects covered by FMMP-C2
Image editor/ viewer	Any image editor/ viewer	Photos, images (jpg, tif, bmp)	Flood hazards, flood damages, hydrology, landuse, socio-economy, population, flora/ fauna etc.

1) Excluding input and output data
2) Main format(s); formats of associated files not mentioned

HYMOS

HYMOS is the information system for water resources management. It covers data storage and processing for analysis, planning, design and operation of water management systems. HYMOS is time series oriented with facilities for spatial data analysis. The programme features database management, time series storage and analysis, and several tools: for storage and processing of flow measurements, stage-discharge measurements and rainfall-runoff simulation. The MRC uses HYMOS: for its content, see the MRC's HYMOS documentation.

ISIS

For the flood hazard assessment of the LMB the hydraulic models ISIS and VRSAP were used.

ISIS was introduced to the MRC under the WUP-A programme and is now part of the Decision Support Framework (DSF). It simulates one-dimensional unsteady flows in channel networks (including reservoirs). The schematisation covers the Mekong Basin from Kratie to the South China Sea, including the Tonle Sap Lake and Floodplain, the Cambodian floodplains and the Vietnamese Mekong Delta.

In FMMP-C2 ISIS is used to compute flood levels for several return periods between 2 to 100 years with the duration and time of occurrence of the flood, based on 97 years of historical floods from 1910 to 2006. Several flood protection scenarios in Cambodia and Vietnam have been simulated. The resulting water levels have been used for the analysis of mitigation measures. The boundary input data for ISIS are (see also Section 7.3.1):

- mainstream Mekong inflow at Kratie (Stung Treng),
- tributary inflow to Tonle Sap Lake,
- tributary inflow to Mekong,
- rainfall,
- evaporation,
- water use, and
- downstream boundary condition at Gulf of Thailand and South China Sea.

VRSAP

VRSAP is an acronym of 'Vietnam River Systems and Plains', a program for mathematical modelling of one-dimensional hydrodynamic motion and transport dispersion of mixed substances (salinity, acidity, bio-chemical materials, etc.). An algorithm of implicit finite difference scheme to solve one-dimensional Saint-Venant equations and advection dispersion equation is applied for a complex network of rivers, canals, and sewers. Basis on a one-dimensional problem in an open-channel system, the program has been improved to simulate overland flow by assuming a quasi-two-dimensional scheme and flow under pressure in a filled sewer. The model covers, like ISIS, the Mekong Delta.

Two input files are needed for VRSAP: 1) a file with hydrological data (water level, discharge, and salinity at the boundaries and under initial conditions), 2) a file with topographic data (structure and hydraulic elements of the water system).

The hydrological data are:

- water level at stations corresponding to boundary nodes (upstream sites, river mouths or any internal nodes),
- discharge (in/outflow, constant or varying in time) at boundary segments,
- salinity at boundary nodes, and
- rainfall at several stations.

Topographic data comprise of geometric information on each segment of the river/ canal/ sewer and each parcel of the plain. Each segment is defined by a section ended by two nodes. Water level and salinity at nodes are computed while flow is considered at the ends of each segment.

Output data including water level, salinity at selected nodes and flow at two ends of selected segments can be generated in tabular format and linked to the graphic software and GIS.

Besides the simulation of the existing condition, the effects of different water control alternatives or variations in water resources such as water extraction, canal excavation, building hydraulic structures, changes in natural flow etc. can be predicted by changing topographic and hydrological data in the model.

ArcGIS

A Geographic Information System can combine databases with maps, as long as the data have a spatial component. The GIS used in the project (and within the MRC) is from ESRI: ArcGIS. This software consists of various modules, depending on the data type (vector, raster) and type of processing or analysis. Being the worldwide standard in GIS, details on this programme can be found on Internet (i.e. www.esri.com).

The FMMP-C2 uses ISIS and VRSAP node-related flood hazard data and district-related flood damage (benefit) data. As these data sets have a spatial component, spatial analysis and mapping is an obvious step. The MRC uses ArcGIS and employs several GIS specialists. Elaborate data sets are available on the MRC network.

7.5 Data storage and access

Below an overview is shown of the data directories (folders) that will be handed over to the MRC. The data will be supplied 1) on DVDs, 2) on an external hard disk, and 3) copied onto the MRC FMMP storage servers, the path of the data (\\bdc\haskoning&Delft) and (\\bdc\Haskoning&Delft_01). The folders/ subfolders contain the following information:

- **GIS**
  - *BackgroundInfo*
    Info on ArcGIS ('con' function), methods (interpolation, flood / damage/ risk mapping) and input data (available topo maps for Lao PDR and Cambodia) and the GIS ToR for FMMP-C2.
  - *Basin*
    Selection of relevant original MRC FMMP GIS data sets, LandSat images of the LMB, newly (FMMP-C2) created base layers to be used with flood/ damage/ risk mapping, and flood damage files for Cambodia applying the 'relative damage assessment' method.
  - *Basin_Nov2009*
    Contains the final version of the FMMP-C2 GIS/ Access/ Excel files with ISIS and VRSAP node/ reservoir info, water levels and water depths for the baseline (current situation) modelling and the scenarios, plus maps on water depth differences (between baseline/ scenarios). Abbreviations used in the file names: WL = water level, WD = water depth, 1A = max up to 1 August, ym = max year, 002 = return period (yr).
  - *Cambodia*
    Specific Cambodia files applying the 'relative damage assessment' method, the digital Atlas of Cambodia (source: MRC), JICA GIS data on Cambodia (source: MRC), and flood mitigation measures options for Cambodia.
  - *DeltaFocal_2009*
    Flood/ damage/ risk data, zoning and mitigation measure options on six focal areas in the Cambodian-Vietnamese delta. Most of the hydraulic model info and flood/ damage/ risk data has been superseded by the info in *Basin_Nov2009*.
  - *Hatfield_SatFlood*
    Satellite image-based flood extent maps by Hatfield for floods in 1999, 2000, 2005 and 2006 (source: MRC). Used for verification of GIS interpolation results.
  - *ISIS*
    ISIS files (Nov. 2009) with water levels, nodes/ reservoir positions and relationships between nodes, used for the flood mapping.
  - *Laos*
    Nongbok District (Se Bang Fai) data for flood/ damage/ risk mapping.
  - *Map1_5mill*
    Map of the Mekong Basin at a scale of 1:5,000,000 (source: MRC).
  - *MRC_StandardMaps*
    Series of maps produced by the MRC with key data (population, socio-economy, landuse, hydrology, flooding) on the LMB (source: MRC).
  - *ReportFMMP_C2_CharAndFloodLMB*
    Data and maps for the FMMP-C2 report "Character and Nature of Flooding in the Lower Mekong Basin".
  - *Thailand*
    Delineation of the project's focal area in Thailand: Nam Mae Kok (Chiang Rai). No further maps were created for this area.

- *Topo50*
  A few topo maps of Phnom Penh and Se Bang Fai at a scale of 1:50,000 (source: MRC).
- *Vietnam*
  Delineation of the project's focal areas in Vietnam. Base data and flood/ damage/ risk maps of these areas are located in the subfolders *Basin*, *Basin_Nov2009* and *DeltaFocal_2009*.

- **HydraulicModel_ISIS**
  - *Delta*
    Contains the ISIS model/ schematisation/ boundary files and the water level files (CSV-format) for the current situation (baseline) and the various flood mitigation scenarios in the Mekong Delta (Cam = Cambodia, Vn = Vietnam).
  - *ISIS_previous*
    Initial testing of the ISIS model (in particular sensitivity).
  - *NamMaeKok*
    As in *Delta*, but for Nam Mae Kok (Thailand). Results in this basin were not satisfactory.
  - *SeBangFai*
    As in *Delta*, but for Se Bang Fai (Lao PDR).

- **HydroMeteo**
  - *Bathymetry*
    Mekong and Bassac bathymetric GIS data.
  - *Delta_Feb2008*
    Water level (stage) and rainfall data for the delta, mainly from MRC's DSF (Decision Support Framework).
  - *HYMOS_Databases*
    The MRC HYMOS database has been used for hydrological/ hydraulic analysis. For Thailand new data were added.
  - *NamMaeKok*
    Studies on modelling of the Nam Mae Kok basin. The actual modelling was done with ISIS, but with unsatisfactorily results. These can be found in folder *HydraulicModel_ISIS*.
  - *NamTheun2_Jan2008*
    Data related to hydro-dam construction upstream of the Se Bang Fai and its impacts on the hydrology of the Se Bang Fai.
  - *SeBangFai_Jan2008*
    Old version of the ISIS schematisation on Se Bang Fai. Superseded by the files in the folder *HydraulicModel_ISIS*.
  - *TonleSap*
    Tonle Sap tributary/ inflow data, mainly from DHI and MRC's DSF (Decision Support Framework).
  - *Yearbook*
    MRC hydrology yearbooks for the years 1999-2000 and 2001-2002, using the Tideda software (source: library MRC).

- **SocioEconomy**
  - *CropBudgets*
    Crop budget spreadsheets for Cambodia and Vietnam, used for damage calculations.
  - *FieldSurveys_PrimaryData*
    Data related to flood damages collected through interviews, questionnaires and focus group meetings in the field: Lao PDR, Thailand, Cambodia and Vietnam.
  - *FloodDamages_SecondaryData*
    Flood damage data collected at government agencies (in particular at district level) in the four LMB countries.

- *SocioEconomy_SecondaryData*
  Socio-economic (vulnerability) data collected at government agencies (in particular at district level) in the four LMB countries.

8 CONSULTATION AND CAPACITY BUILDING IN STAGE 1

8.1 Consultations

8.1.1 Focal area consultations

Upon the conclusion of the Inception Phase during the Regional Inception Workshop in Ho Chi Minh City on 17-18 January 2008 and the final selection of the Focal Areas, consultations were started in the four countries with the relevant provincial and district authorities in the focal areas and relevant line agencies from January to March 2008.

8.1.2 Bi-lateral focal area consultation

Two of the focal areas refer to the deep flooded cross-boundary areas in the Mekong Delta, i.e.:

- the area west of the Bassac River, including the Takeo Province in Cambodia and the Long Xuyen Quadrangle in Vietnam;
- the area east of the Mekong River, including Prey Veng Province south of the National Road 1 in Cambodia and the POR in Vietnam.

For the development of the IFRM strategic directions and plans for these focal areas a bi-lateral consultation meeting with Cambodia and Vietnam was held on 26 June in Siem Reap with the purpose:

- To present to the preliminary results of the flood risk assessment in the two focal areas,.
- To present options for structural measures to reduce the flood risks in these areas;
- To consult the two countries about the strategic directions for flood risk management in these trans-boundary areas.

8.1.3 ProDIP and Demonstration Projects consultations

In May 2008 the activities for the preparation of the lists of projects for ProDIP was initiated with explanatory meetings in the four countries. These meetings were held in the slipstream of the introductory course on IFRM in order to make sure that the projects to be nominated by the countries would fit in the IFRM concept.

Upon the submission of long lists of nominated projects and the initial evaluation by the consultant, a second round of consultation meetings were held in the four countries aiming at the selection of projects for ProDIP and the eventual selection of demonstration projects. These meetings were held in Lao PDR in July and early August 2008.

The results of the ProDIP consultations are presented in Chapter 6 and Volume 4.

ProDIP and Demonstration project consultations continued during Stage 2 in 15 Working Group meetings for the Demonstration Projects; these meetings were intended to present intermediate results obtained in the preparation of the projects and to get feed back and guidance from the Working Groups.

8.1.4 Guideline consultations

In Stage 2, use was made of the Working Group meetings for the Demonstration Projects to present and discuss the drafts of the best practice guidelines.

8.2 Training courses

During Stage 1, a training course was held on ‘Introduction IFRM concepts and planning in the LMB’.

During Stage 2, four one week training courses were held on the Best Practice Guidelines ‘Flood Risk Assessment’, ‘IFRM Planning and Impact Evaluation (two bi-national courses)’, and ‘Structural Measures and Flood Proofing’.

Volume 5 presents the outlines of the training courses held and the evaluation by the participants from the four Member Countries; overall the participants highly appreciated the courses.

Appendix 1

Relation between deliverables as per the Terms of Reference and the (Draft) Final Report and its associated Volumes

Output Number	Details of Deliverables	Stage 2	Volume of the Draft Final Report
11 Description of the Character and Nature of Flooding in the Mekong River and its Tributaries	Best Practice IFRM Guidelines for BDP	Procedures for the evaluation of impacts of basin scenarios and plans on flood risk	Volume 3D
	A report documenting available flood data for the LMB	Reporting on additional data collection for focal areas	Volume 2A
	Digitised Paper Maps	na	Available maps of MRCS used throughout tall Volumes
	A 'Flood Data' Database	Hydrological data focal areas Damage data focal areas Socio-economic data focal areas Results of socio-economic surveys in focal areas Environmental characteristics focal areas Flood control structures in focal areas	Volumes 2A, 2B, 2C and 2D
	A report describing the Character and Nature of Flooding in the LMB	Update of working document included in Appendix 1 of the Inception Report, based on additional data collection for focal areas	Volume 2A
	A report presenting the results of frequency and socio-economic impact analyses of recent floods in the LMB	Update of analysis of frequencies incorporated in Appendix 1 of the Inception Report, based on additional data collection for focal areas	Volumes 2C and 2D
	A report describing and quantifying the environmental, social, economic and other benefits of floods	Baseline description focal areas for assessment of potential negative impacts of flood risk management	Volume 2D
	Best Practice Guidelines to Assess the Environmental, Socio-economic and Other Benefits of Floods	Guidelines for Impact Assessments of flood risk management measures	Volume 3B

Output Number	Details of Deliverables	Stage 2	Volume of the Draft Final Report
12 Socio-Economic Surveys of Flood-Affected Communities	A report describing the design, implementation and results of socio-economic surveys of flood-affected communities	Report on results socio-economic surveys in focal areas	Volumes 2C and 2D
	Representative flood-damage curves for different land uses in urban and rural areas (direct damages)	Report on flood damage curves for focal areas	Volume 2C
	Representative estimates of indirect damages and clean-up costs in urban and rural areas	Report on results socio-economic surveys in focal areas	Volume 2C
	A report describing the socio-economic benefits of flood-proofing urban and rural buildings and infrastructure and other 'soft flood risk management measures		Volume 3C
	A report describing the effectiveness of traditional flood-coping mechanisms at the community level	Report on results socio-economic surveys in focal areas	Volume 2D
	A report describing the socio-economic vulnerability of flood-affected communities	Report on results socio-economic surveys in focal areas	Volume 2D
	Best Practice Guidelines for the Selection and Use of 'Soft' Measures to Manage Flood Risk	Guidelines for IFRM planning Procedures for evaluation IFRM measures	Volume 3C
	Best Practice Guidelines for Flood-Proofing Buildings and Infrastructure in Urban and Rural Areas	Guideline prepared	Volume 3C
	Best Practice Guidelines to Assess the Socio-Economic Costs of Flooding	Outline guidelines for flood damage (vulnerability) assessment	Volume 2A

Output Number	Details of Deliverables	Stage 2	Volume of the Draft Final Report
13 Guidelines for the Use and Impact Assessment of 'Hard' Flood Mitigation Measures And Floodplain Infrastructure	A report describing how the activities and results of the Delft Cluster-IHE/UNESCO-WWF project will be integrated into the outputs of Component 2	Guidelines prepared by Delft Cluster, integrated in the FMMP-C2 Final Report	Volume 3E
	A report describing the results of the review of national practices regarding the use, design, construction, operation and maintenance of structural flood mitigation works and floodplain infrastructure		Volume 3C
	A report describing the nature and significance of the impacts of structural flood mitigation works and floodplain infrastructure on mainstream, tributary and floodplain flooding behaviour	Results hydraulic evaluation IFRM options focal areas	Volumes 2A, 2B and 3C
	A report describing the nature and significance of the environmental and ecological impacts of structural flood mitigation works and floodplain infrastructure	Results environmental evaluation IFRM options focal areas	Volume 2D, and Volumes 6B and 6C
	Best Practice Guidelines for the Use, Design, Construction, Maintenance and Operation of Structural Flood Mitigation Works and *flood management related* Floodplain Infrastructure	Guideline prepared	Volume 3C
	Best Practice Guidelines to Assess and Manage the Environmental and Ecological Impacts of Structural Flood Mitigation Works and Floodplain Infrastructure	Guideline prepared	Volume 3B
	Best Practice Guidelines to Control and Repair Riverbank Erosion	Guideline prepared	Volume 3C

Output Number	Details of Deliverables	Stage 2	Volume of the Draft Final Report
14 Guidelines for the Combined Use of 'Hard' and 'Soft' Flood Risk Management Measures	A report describing national flood management strategies in the four riparian countries	Update of Inception Report description	Volume 2D
	A report describing the opportunities and constraints in MRC programs to better flood risk management in the LMB	Procedures for evaluation impacts of basin plans / scenarios on flood risk prepared	Volumes 2D and 3D
	Best Practice Guidelines for the Selection of an Appropriate Mix of 'Hard' and 'Soft' Flood Risk Management Measures	Guidelines for IFRM planning prepared	Volume 2B
15 A FMM Project Development and Implementation Plan for the LMB (ProDIP)	A report reviewing flood risk management problems and issues on a sub-area basis across the LMB	Review FRM problems and issues on Sub-Area basis	Volume 1
	A database for recording existing and planned structural flood mitigation works and floodplain infrastructure in the LMB	Re Deliverable 11d	Volume 2A
	An inventory (in the database) of existing and planned structural flood mitigation works and floodplain infrastructure		Volume 2A
	A prioritised ProDIP of FMM projects, both 'hard' and 'soft', with nationally nominated projects developed to the BDP PIN level	ProDIP prepared	Volume 4
	A report assessing the likely cumulative trans-boundary impacts on flooding behaviour of the ProDIP FMM Projects	Transboundary impacts of focal area IFRM strategies	Volume 6E
16 Demonstration Projects	Demonstration projects identified and further developed to appropriate levels towards project implementation	Demonstration projects prepared	Volumes 6A, 6B, 6C, 6D and 6E

Output Number	Details of Deliverables	Stage 2	Volume of the Draft Final Report
21 Improved Consultation and Consensus Building	A report on the coordination of Component 2 activities with other MRC programs (including the other components of the FMMP) and with national programs and activities		Inception Report
	A report describing the proposed program of national and regional consultation workshops	Stage 2 work plan	Stage 2 Work Plan, in Stage 1 Evaluation Report
	National and regional consultation workshops	As scheduled	Volume 4, 5, and 6
	A report assessing the need for, design and implementation of stakeholder workshops		Stage 2 Work Plan, in Stage 1 Evaluation Report
	Stakeholder workshops, if required		Volumes 6B an 6C
	A report assessing the need for, design and implementation of public awareness campaigns		No needs were identified
	Public awareness campaigns, if required		No needs were identified
22Training and Capacity Building Programs	A report assessing capacity building and training needs in the MRC and national line agencies		Inception Report
	A capacity building and training plan that addresses these needs, including training in the use of the various sets of guidelines developed under Component 2		Stage 2 Training Plan (Main Report), and Volume 5
	Capacity building and training programs delivered to MRC and national line agency staff in accordance with the training plan, emphasizing on-the-job training	Training on BPGs implemented	Volume 5
	A report assessing the need for training programs at regional training centres		Inception Report
	Regional training programs, if required		Volume 5
	A report assessing the need for formal in-country training programs to address specific aspects flood risk management		Inception Report
	In-country training programs, if required		Volumes 5 and 6