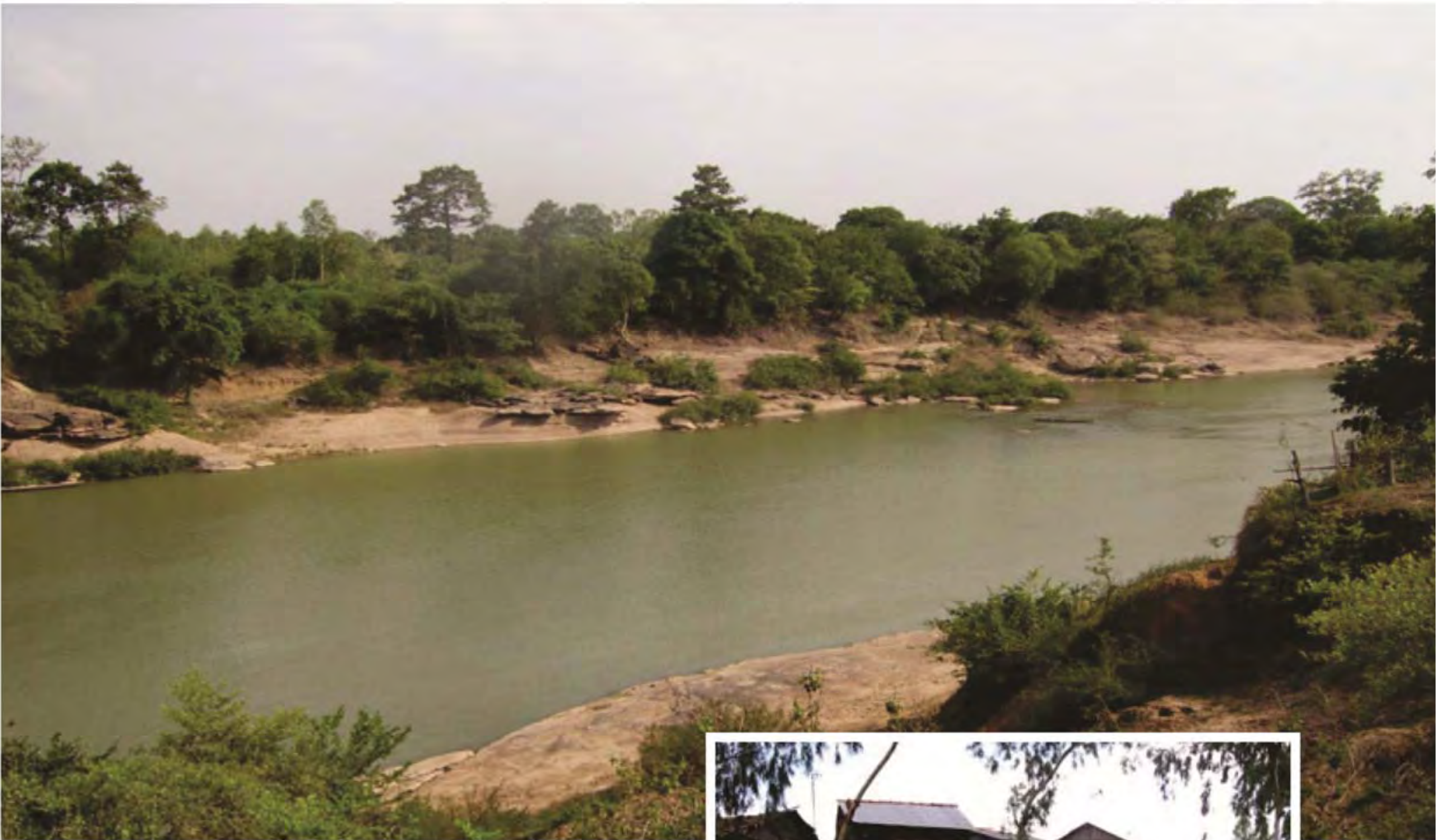
Integrated Flood Risk Management Plan for the Lower Xe Bang Fai area in Lao PDR



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

May 2010
Final Report, Volume 6B

Deltares
Enabling Delta Life — Delft Hydraulics

ROYAL HASKONING

UNESCO

Mekong River Commission

Flood Management and Mitigation Programme

Structural Measures and Flood Proofing in the Lower Mekong Basin

Integrated Flood Risk Management Plan for the Lower Xe Bang Fai area in Lao PDR

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Editors have applied, to the extent possible, the MRC standard for names of rivers, villages, districts and provinces. However some names in maps, figures and tables could not be timely adjusted as a result of the picture-format used by the authors.

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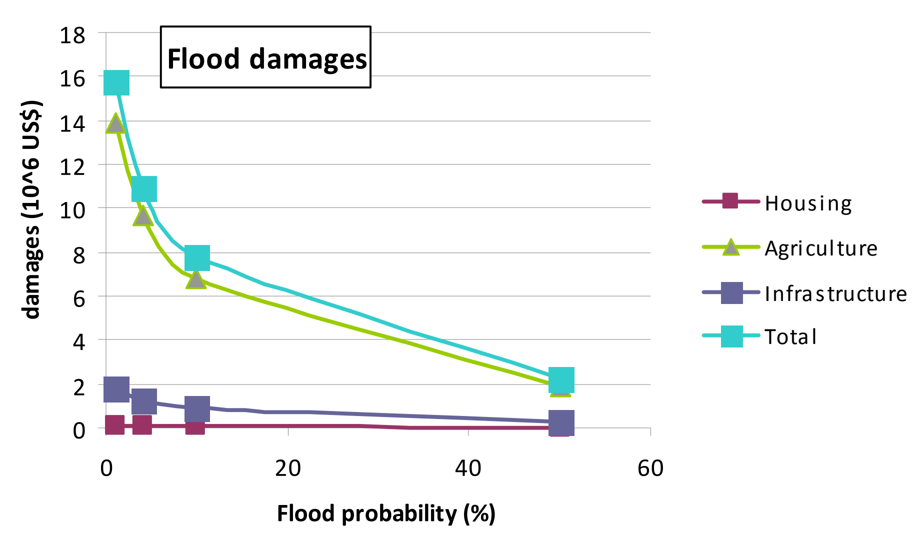
SUMMARY

This report presents the findings of the FMMP-C2 Demonstration Project that aims to assist Lao PDR in formulating an Integrated Flood Risk Management Plan for the Lower Xe Bang Fai area in central Lao PDR.

Flood Hazard
The flood hazard has been assessed with the ISIS Xe Bang Fai 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 analysed with historical time series of discharges in the Mekong and the Xe Bang Fai River. Since flooding is affected by backwater from the Mekong, multivariate 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 alterations 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[1]. The data has been categorised 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.

[1] 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.



Flood Risk
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 USD 3 mln in total. This means that by protecting this area against floods up to the level of 1% probability of exceedance, on average USD 3 mln per year will be saved through reduction in flood damages.

Flood Risk in Nongbok District (USD 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:
(i) 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.
(ii) 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.
(iii) Construction of embankment schemes that protect areas against high water levels.
(iv) Construction of gates that prevent floods to enter the Xe Bang Fai floodplains.
(v) Improvement of the drainage system in the floodplains 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 Bang Fai 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 Bang Fai at the confluence with the Xe Noy, just upstream of the National Road 13 South crossing, combined with construction of a flood gate in the Xe Bang Fai 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 floodplain can be protected while another part is reserved for the retention of flood waters. The proportion between the two, '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 floodwater might be appreciated as water for irrigation in the dry season.

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 Bang Fai 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 schemes (23) have been identified for widening and deepening of natural drains to be provided with gates at the confluence with Xe Bang Fai 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 USD 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 USD 6 mln per year.

Reduction of flood vulnerability
The flood risk in the Lower Xe Bang Fai 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 riverbanks and controlled flooding with drainage improvement in combination with gating of the small Xe Bang Fai tributaries can be effective 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 Bang Fai 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 consist of the following elements:

- Construction of flood protection embankments on both banks of the Xe Bang Fai 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 Bang Fai, 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[2] have been estimated at USD 34.3 mln. With the flood risk reduction benefits of USD 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 USD 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.

[2] excluding the rehabilitation of 15 gates that will be undertaken by the NTPC.

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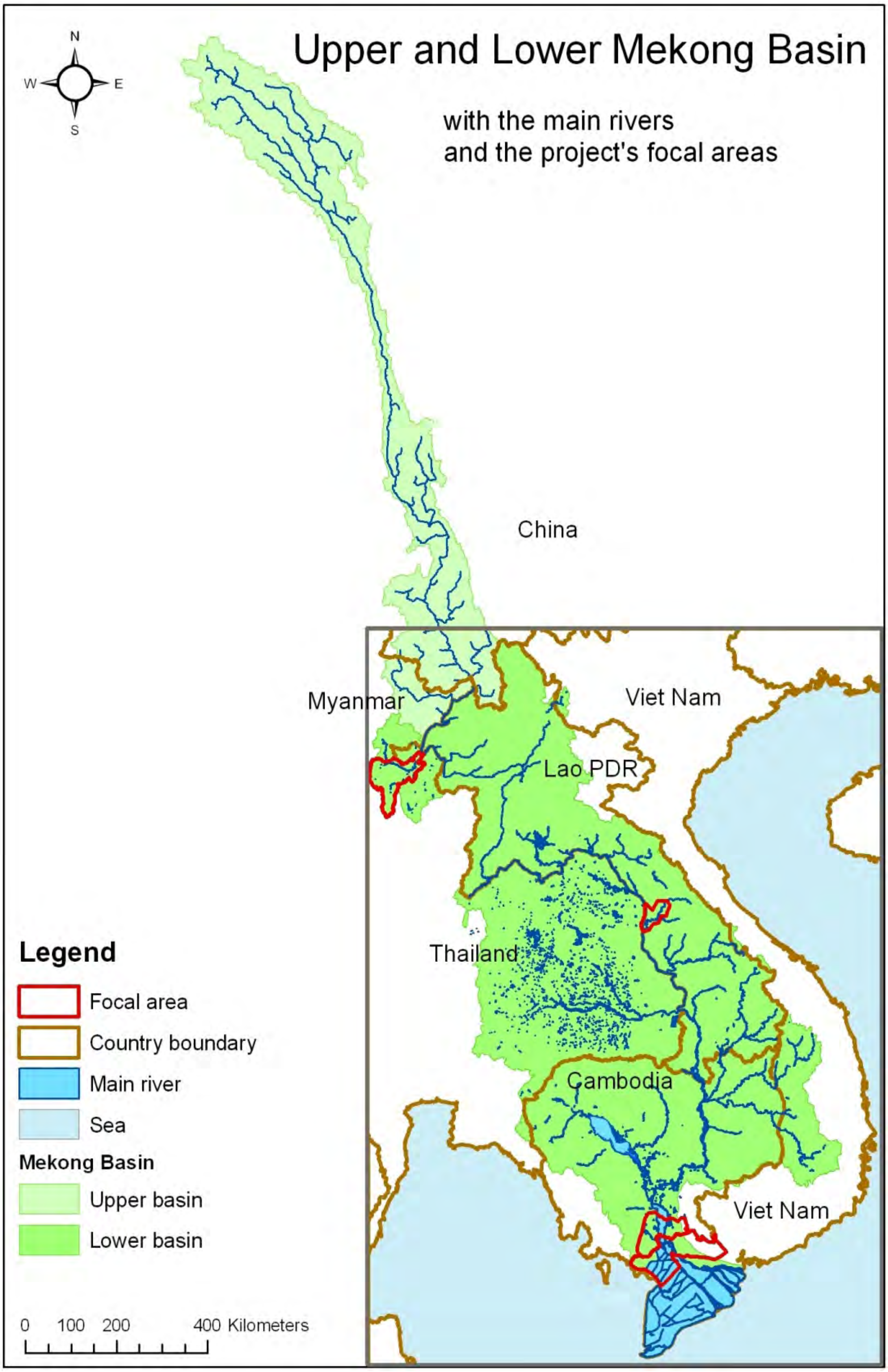

Upper and Lower Mekong Basin
with the main rivers
and the project's focal areas
N
W
E
S
China
Myanmar
Viet Nam
Lao PDR
Thailand
Cambodia
Viet Nam
Legend
Focal area
Country boundary
Main river
Sea
Mekong Basin
Upper basin
Lower basin
0 100 200 400 Kilometers

ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
amsl	Above Mean Sea Level
BDP	Basin Development Plan Programme (MRC)
BPI	Ban Pong Intertrade Co. Ltd., Thailand
DDMC	District Disaster Management Committee
DEM	Digital Elevation Model
DWR	Department of Water Resources of Thailand
EIRR	Economic Internal Rate of Return (economic term)
FG	Focal Group
FMMP	Flood Management and Mitigation Programme (MRC)
FMMP-C1	Component 1 of the MRC FMMP: Establishment of the Regional Flood Management and Mitigation Centre (RFMMC)
FMMP-C2	Component 2 of the MRC FMMP: Structural Measures and Flood Proofing
FMMP-C3	Component 3 of MRC FMMP: Enhancing Cooperation in Addressing Transboundary 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
IDW	Inverse Distance Weighting
IFRM	Integrated Flood Risk Management
IKMP	Information and Knowledge Management Programme (MRC)
ISIS	Hydrodynamic model used by MRCS
IWRM	Integrated Water Resources Management
KIP	Lao Kip, currency of Lao PDR
KSL	Khon Kaen Sugar Industry Plc., Thailand
LMB	Lower Mekong Basin
LNMC	Lao National Mekong Committee
LXBF	Lower Xe Bang Fai
NDMC/NDMO	National Disaster Management Commission/Office
MRC	Mekong River Commission
MRCS	Mekong River Commission Secretariat
NMC	National Mekong Committee
NPV	Net Present Value (economic term)
NR13S	National Road Nr 13 South
NTPC	Nam Theun 2 Power Company
TCEV	Two Component Extreme Value (statistical term)
TOR	Terms of Reference
USD	United States Dollar
UTM	Universal Transverse Mercator
VUDA	Vientiane Urban Drainage Administration
WUO	Water User Organization
XBF	Xe Bang Fai
1D/2D/3D	One Dimensional/Two Dimensional/Three Dimensional

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.

CHAPTER 1

INTRODUCTION

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 were 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.

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 Hazard in the Lower Mekong Basin;*
Volume 2B *Hydrological and Flood Hazard in Focal Areas;*
Volume 2C *Flood Damages, Benefits and Flood Risk in Focal Areas, and*
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, and*
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 Viet Nam*[3]*.*

Volume 4 **Project Development and Implementation Plan**

Volume 5 **Capacity Building and Training**

Volume 6 **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 Bang Fai 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, Viet Nam;*
Volume 6E *Flood Risk Management in the Border Zone between Cambodia and Viet Nam.*

The underlying report is **Volume 6B** of the above series.

[3] Developed by the Delft Cluster

The FMMP Component 2, Structural Measures and Flood Proofing, was developed in three steps: the Inception Phase and Stages 1 and 2 of the Implementation Phase. The Inception Phase began at the end of September 2007 and concluded in accordance with the Terms of Reference with a Regional Workshop in Ho Chi Minh City at the end of January 2008, only 4 months after project initiation. The original TOR envisaged the Stage 1 Implementation Phase to be carried out in a period of 6 months, leaving 12 months for the Stage 2 Implementation Phase. See for reference *Final Report*, Volume 1.

1.2 Background of the Demonstration Project

The immediate objectives of the *Flood Management and Mitigation Programme, Component 2: Structural Measures and Flood Proofing (FMMP-C2)* have been formulated as follows:

- to reduce the vulnerability of people living in the LMB to the negative impacts of floods; and
- to establish sustainable flood risk management capacity in the MRC, MRCS, NMC's and national line agencies.

The project has consequently a "learning by doing" character in which the preparation of concrete measures aiming at the reduction of people's suffering goes together with building capacity and preparing guidelines for sustainable flood risk management in the region. The dual project objective requires that in the preparation of the concrete measures all steps are followed that are crucial for a socio-economic and environmentally sound flood risk management. All these steps need to be well documented in support of the capacity building and the preparation of guidelines.

Integrated Flood Risk Management (IFRM) is defined here as applying the most effective mix of all possible measures, hard and soft, for the reduction of flood damage risk. The first step in the process to come to this most attractive package of measures is the proper assessment of flood risk. Secondly, possible measures for risk reduction are to be identified. The third step involves the evaluation of the effects and impacts of the different types of measures and to develop a strategy for flood risk management. These strategies will be developed at the level of the Sub-areas as defined under the MRC Basin Development Plan programme. In the fourth step, IFRM plans are to be developed on the basis of these strategies. Such plans include a specific set of measures and projects for the reduction of flood damage risk in a certain area. In the fifth step these measures and projects are prepared for implementation.

During Stage 1 of the *Flood Management and Mitigation Programme, Component 2: Structural Measures and Flood Proofing (FMMP-C2)* five Demonstration Projects had been formulated to i) demonstrate the application of Best Practice Guidelines that are being developed under FMMP-C2, and ii) to prepare bankable project proposals [Ref. 0]. The preparation of an Integrated Flood Risk Management Plan for the Lower Xe Bang Fai area in the Lao PDR is one of the selected demonstration projects (see Figure 1-1).

During Stage 1 of the FMMP-C2, a report was prepared on the Potential Development in the Xe Bang Fai area with the aim to investigate options for flood risk reduction and agricultural development. The options were based on plans that have been under preparation by the provincial authorities. Options consisted of flood protection embankments on the right bank of the river, on both sides of the river, and a diversion canal. Also a storage reservoir was considered for irrigation purposes. The alternatives developed constitute large scale structural measures for flood risk reduction.

In Stage 2 of FMMP-C2, the preparation of an Integrated Flood Risk Management Plan for the Lower Xe Bang Fai, took the earlier plans as a starting point and investigated the options further. The following main activities were implemented for the preparation of the IFRM Plan:

- Flood hazard assessment;
- Flood damage assessment;
- Flood risk assessment;
- Public participation planning;
- Stakeholder consultation;
- Initial environment examination;
- Agricultural development opportunities; and
- Economic analysis.

This report was prepared to have a comprehensive understanding of all the relevant aspects of the IFRM plan.

Figure 1-1 Location of the Lower Xe Bang Fai area in Lao PDR.

As IWRM is based on a collective vision and collective actions, this report was prepared to guide the technical development of the area in order to meet the collective vision of the local population. The latter is crucial to secure their willingness to further participate in the development of structural measures, as well as in the construction and the management of systems at a later stage.

1.3 Contents of the report

Chapter 2 describes the main characteristics of the Lower Xe Bang Fai area. Chapter 3 describes the impact of floods and flooding. Strategic directions for flood risk management are discussed in Chapter 4. The Lower Xe Bang Fai project for integrated flood risk management is elaborated in Chapter 5. The public participation in the project preparation is discussed in Chapter 6. The social impact of the project proposal is discussed in Chapter 7. The outcome of an initial environmental examination is presented in Chapter 8. Chapter 9 presents a cost benefit analysis. Chapter 10 discusses the required institutional development.

CHAPTER 2

PROJECT AREA

2 PROJECT AREA

2.1 Location

The Xe Bang Fai River originates in Boualapha District, before flowing into Mahaxai District. The river then flows through Xe Bang Fai District before entering the Lower Xe Bang Fai floodplains where it forms the southern border of Nongbok District, Khammouane Province, and the northern border of Xaybouli District, Savannakhet Province. It ends in the Mekong River.

The Lower Xe Bang Fai area is located in the MRC Basin Development Plan (BDP) Sub-area 4L (see Figure 1-1).

The project area comprises the flood-prone areas located along the Lower Xe Bang Fai River, downstream of the crossing with the National Road Nr 13 South (NR13S). To the west the area is bounded by the Mekong River and is part of the Khammouane Province. To the east, in Savannakhet Province, the NR13S forms the upstream boundary of the area.

The area covers the whole area of Nongbok District and some villages of the Xe Bang Fai District on the right bank of the river and part of the Xaybouli District on the left bank of the river (see Figure 2-1).

Figure 2-1 Location of the Lower Xe Bang Fai area.

Due to limited resources and available time, only part of the project area could be analysed, which was the Nongbok District, on the right bank of the Xe Bang Fai.

2.2 Population and living situation

2.2.1 Population

According to the Nongbok District statistics, the population in 2006 was about 41,000 people with 7,600 households. Average household size was 5.41 persons and the average annual population growth rate during the period of 2001-2006 was 0.49%.

Sex distribution was 49% for male and 51% for female in almost all age groups except the group more than 65 years old.

Ethnicity in Nongbok District is mainly Lao (71%) and it is followed by Phouthyai (25%), Mangkong (3%) and Kinh (1%). Most of the households are headed by males, occupying 95% of the total families in the district.

The communities are culturally and linguistically homogenous. This contributes to effective social and community networks that are important assets for the collective actions around flood planning and management.

Households in Nongbok have, on average, 5.4 persons (see Table 2-1). The majority (95%) are headed by men who slightly outnumber women in the district population. However, more than one-third of the population (35%) is under the age of 15 years. This high proportion of children in combination with elderly people living in the district results in an age dependency ratio of 0.71. This means that every working-age person in the district must produce enough to support his or her own needs plus 70% of the needs of another, dependent person.

The implications for social vulnerability include:

The large proportion of children in Nongbok tends to increase vulnerability to the impacts of flooding. Children are 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 during floods. If flooding damages schools, children's education will be disrupted. Moreover, the high dependency ratio places extra burdens on parents and other adults to provide for children's needs for food, shelter, etc.

Table 2-1 Household Characteristics.

Household Characteristics Xe Bang Fai Focal Area, Lao PDR			
Indicator		*Unit*	*District*
HH size (average)		Pers.	5.40
HH head	Male	%	95.00
	Female	%	5.00
Male/female ratio		Ratio	1.02
Children < 15 years		%	35.50
Dependency ratio		ratio	0.71

Source: District Flood Vulnerability, Database Lao PDR

2.2.2 Land use and tenure

Almost the entire territory of Nongbok District is land that contributes to the rural livelihoods of people living in the district. Cultivated land encompasses more than 45% of the district area and includes irrigated paddy (7%), rain fed paddy (34%) and other land such as upland crops land and residential gardens (6-7%). See Table 2-2. In addition, people rely on riverbanks, wetlands and forests to grow and/or harvest food crops, as well as for other productive uses such as building materials, medicines, etc.; together, these resources account for nearly 40% of the district area.

Table 2-2 Land use.

Indicator	***Unit***	***District***	***Unit***	***District***
District area	**%**	**100**	**ha**	**31,300**
Rice land – rain fed	%	33.7	ha	10,548
Rice land – irrigated (originally)	%	7.3	ha	2,285
Upland crop land	%	5.5	ha	1,722
Plantation land	%	0.3	ha	94
Rural residential (gardens)	%	1.6	ha	501
Urban land	%	0.4	ha	125
Lakes, ponds & wetlands	%	8.7	ha	2,723
Forest - dry Dipterocarpus	%	30.0	ha	9,390
Forest - non-productive	%	11.3	ha	3,537
Communal	%	1.2	ha	376

Source: District Flood Vulnerability Database, Lao PDR

Legal title to agricultural land in Lao PDR generally takes the form of a land certificate issued by local authorities. In Nongbok District, the ratio of land certificates to households is 0.95, meaning that nearly all households have secure tenure to their productive land. Landless households account for 1.7% of all people in the district. All households in the district also have a land certificate for their residential land. The issues of social vulnerability to the impacts of flooding include:

(i) The reliance of livelihoods on land and natural resources increases the direct and indirect costs of flooding. Household expenditures for food and other basic needs will increase if people are unable to cultivate vegetables in riverbank gardens or harvest forest or wetlands products they normally use for different purposes.

(ii) Secure land tenure as well as house ownership (see section below) provide households with collateral that will facilitate their ability to obtain loans and other assistance to rehabilitate property damaged during a flood or to meet other households needs (health care, new agricultural inputs, etc.). This is an important and positive point with regard to future development in a flood secure area, because it will allow access to micro-credit.

(iii) 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). In Nongbok, the needs of the small number of landless people may be effectively met through the strong family and social networks that exist.

2.2.3 Housing and other structures

Residential and separate commercial structures account for, respectively, 88% and 11% of the main structures in the district; however, many business activities are accommodated in spaces that are attached directly to residential structures. These types of structures are generally owned by their occupants. Industrial and institutional structures make up about 1% of the total (see Table 2-3).

Table 2-3 Structures, Nongbok District.

Indicator	***Unit***	***District***
Main structures – total	**No.**	**9,030**
Residential - % total	%	88.4
Permanent	*%*	*20.0*
Semi-permanent	*%*	*70.0*
Temporary	*%*	*10.0*
HH owns structure	*%*	*100.0*
Commercial - % total	%	10.6
Permanent	*%*	*20.6*
Semi-permanent	*%*	*79.4*
HH/business owns structure	*%*	*100.0*
Industrial - % total	%	0.2
Semi-permanent	*%*	*100.0*
Institution - % total	%	0.9
Permanent	*%*	*40.5*
Temporary	*%*	*59.5*

Source: District Flood Vulnerability Database, Lao PDR

Permanent structures made from brick and/or concrete account for 20% of these structures; 70% are semi-permanent construction, generally wood; and, the remainder are constructed of thatch, bamboo and other materials. Based on data provided by surveyed households, permanent and semi-permanent house structures tend to have similar areas and value (see Table 2-4).

Flood risks are a major factor in the location and design of housing in the focal area. In raised safe areas, people will construct one-story brick houses. However, in most areas, the traditional coping mechanisms include:

(i) Houses are raised 2.5-3 m on concrete poles to protect them against annual floods. The concrete poles have replaced wood poles that were traditionally used as they are more resistant to water logging.

(ii) Retail shops, repair garages/workshops and other commercial structures are generally not raised. However, the foundation will be made stronger to withstand potential damage from flood waters.

(iii) Within commercial structures, people frequently make provisions for temporary storage of inventory and equipment above the normal flood level that may occur within the structure. For commercial activities located in structures adjacent or attached to houses, the inventory and equipment will often be moved and stored within the raised house.

(iv) Other industries such as rice mills will often be located on higher ground within the community to provide protection during floods.

Table 2-4 Housing Area & Value, Nongbok District.

Housing Area & Value Nongbok District		% HH	Area m^2	Value KIP mln
Average			67	40.1
By house type	Permanent	84.3	66	39.8
	Semi-permanent	15.7	70	42.2

Source: Household surveys, Lao PDR

There are also numerous small agricultural structures such as rice huts and animal shelters (the number is nearly equal to the number of main structures). These are all temporary structures.

In terms of household assets, people in Nongbok rely on motorbikes as their principal means of transport; less than 1% of district households own a car or truck. Although the district is bounded by the Xe Bang Fai and Mekong rivers, only 2% of households own small boats (without motors); an even smaller proportion (0.5%) own larger, motorised boats. More than a third of households own a hand tractor, but very few if any households own other types of productive equipment such as mechanised tractors, water pumps, diesel generators, rice mills.

The implications for assessing the vulnerability of households to flood damages are as follows:

(i) The traditional house form reduces the risks of flood damages to people's housing. In most years in Nongbok, there are no flood-affected houses; even in the serious floods in 2001 and 2005, there were only 2-3 damaged houses.

(ii) The establishment of safe areas and/or the selection of locations of non-residential structures on higher ground help to minimise flood damages.

(iii) However, the low proportion of households that own small or larger boats will be reflected in the lack of access that many people have during floods to health care and other services outside their immediate village. The lack of boats may also constrain local emergency response activities.

2.2.4 Economic activities

Main occupations in the district are in agricultural production, fishery and working as hired labour in agriculture (68% of the population). 25% of the population works as hired labour in Thailand, particularly in factories (see Table 2-5). Very few people do business, trading or offer services. This indicates that the population is directly depending on its immediate environment.

Table 2-5 Economic activities, Nongbok District.

Indicator	*Unit*	*District*
Number of persons 18-60 yrs.	**No.**	**24,098**
Agriculture	%	63.5
Fishery	%	1.5
Agricultural labour	%	3.7
Construction labour	%	0.9
Other labour – Thailand	%	24.9
Business owner	%	1.9
Employee – private sector	%	0.8
Employee – government	%	2.8

Source: District Flood Vulnerability Database, Lao PDR

(i) Vulnerability to economic losses due to flooding is directly related to the proportion of people engaged in agricultural activities.

(ii) The incidence of working people who migrate to Thailand reflects better job prospects and wages that are available to people living in Nongbok, as well as possible constraints on economic activities in the district (e.g., lack of agricultural land, non-farm employment). The higher wages contribute to the low poverty levels in the district. At the same time, however, the absence of younger family members during a flood event may increase household vulnerability. In addition, a greater burden is place on women when adult men are absent from the household.

2.2.5 Access to electricity, water and sanitation

Only about 1,000 households in the district (14%) are actually connected to piped water in the district town, most families take water from a well and/or the river. During floods people rely on rainwater, or purchased water for washing and bathing.

There is no wastewater collection or treatment system in the district. There are 52% of total households having their own toilet/latrine, in most instances water-sealed. The remaining households have no facilities.

There is a high rate of households connected to national power grid (95%).
The implications for the assessment of social vulnerability to flooding include the following:

(i) Due to inadequate supplies of safe drinking water and, particularly, poor sanitation conditions (defecation in the open and in paddy fields), there is a high risk of diarrhoea and dysentery.
(ii) Bathing and washing clothes in flood waters increases the incidence of skin rashes and infections due to contamination of the water.

2.2.6 Access to health care

Floods in Nongbok are associated with a variety of health problems: diarrhoea and dysentery; malaria and dengue fever; colds; and, skin and eye infections.

In Nongbok District, the health care facilities include: 1 district hospital with 15 beds, 2 clinics and 10 dispensaries. The 2 clinics provide services for the 72 villages in the district, with a ratio of 3,797 households per clinic. There is one dispensary for each village cluster, or a district-wide ratio of 759 households per dispensary. Due to the lack of adequate medical facilities and the difficulties of travel during the flood season, many households rely on traditional herbal medicines to treat diarrhoea, dysentery and the various types of skin and eye infections. The implications for social vulnerability due to flooding include:

(i) The inadequate (and often ill-equipped) health care facilities are a major source of people's vulnerability when they are injured and/or become ill during or following the flood.
(ii) 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 the resources of households, particularly poor households.

2.3 Climate and meteorology

The rainy season in the area has duration of five months (May-September) and provides for 87% of total annual rainfall. The dry season lasts seven months (October-April); especially there is almost no rain in November-January (See Figure 2-2).

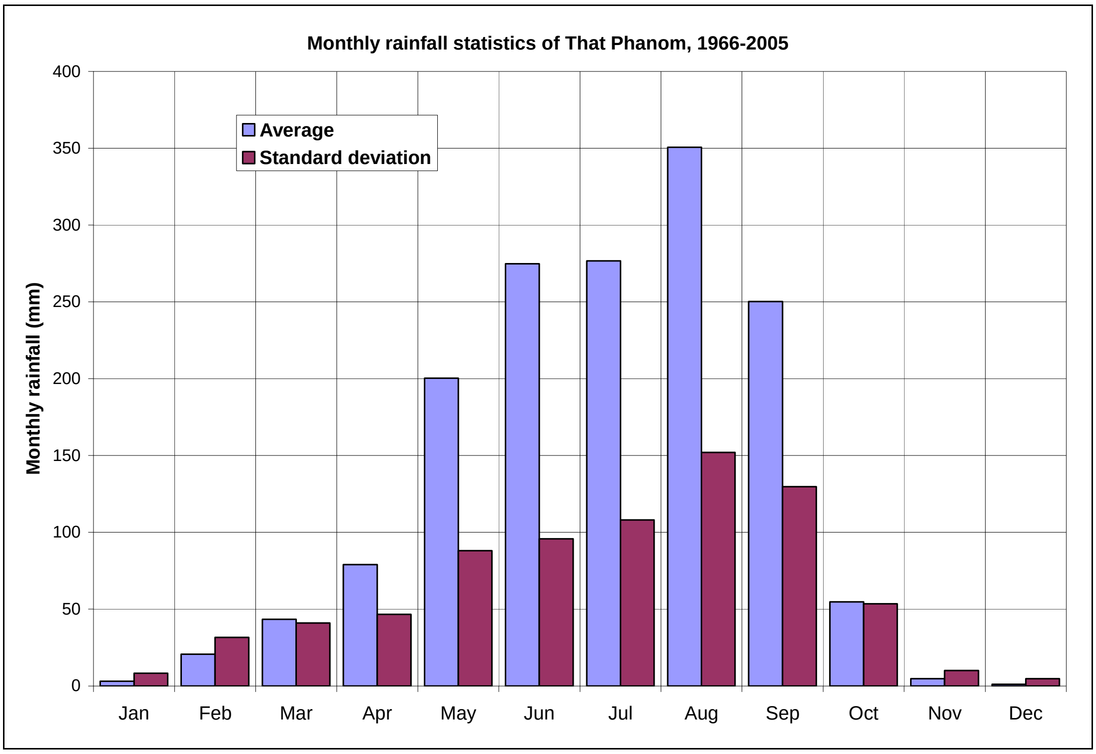


Figure 2-2 Monthly rainfall statistics of station That Phanom, period of 1966-2005.

2.4 Infrastructure

2.4.1 Roads

The road network in the project area is fairly dense with National Road Nr 13 South, connecting Thakhek with Savannakhet forming the eastern boundary of the project area. Most villages in the Nongbok District are accessible by road, both in the rainy and in the dry season. There are 81 roads with a total length of 287 km in the district. Of these roads, 71 (273 km) can be used in both seasons. There are five bridges in the district.

2.4.2 Flood management infrastructure

Flood protection of the area is still very limited and mainly consists of low level embankments on parts of the right and left banks of the river and partly along the Mekong. Most of the natural drains that connect to the Xe Bang Fai have been equipped with gates, in total there are 9 gate structures in Savannakhet and 11 in Khammouane. The gates are in urgent need of rehabilitation. Out of the 20 gates, 15 will be rehabilitated by the NTPC.

2.5 Navigation

The navigation on the Xe Bang Fai is inconvenient, only small volumes can be transported within fifty kilometres from the confluence with the Mekong River. In the wet season, the river is navigable for ships with a capacity up to 5 tonnes, in the dry season the capacity of the ships is limited to 0.2 ton.

Villagers report that their use of the Xe Bang Fai River for transportation during the dry season is less than in the past, and there are only a few regular passenger boat services operating in the lower section of the river.

The discharge of the Nam Theun 2 hydropower station to the Xe Bang Fai Basin will favourably contribute to navigation since the water level will increase.

2.6 Agriculture

Rice cropping and vegetables growing are the main agricultural activities in the project area. Agriculture is the area's largest sector of employment. Vegetables and other crops are grown by residents on the somewhat elevated Xe Bang Fai riverbanks, as well as in the floodplains around natural lakes as water recedes. Lowland wet rice is cultivated in the lower lying areas.

Nongbok District has 10,535 ha of wet season rice of which is 50% for staple rice and the remainder for commercial rice. The dry season rice was only 1,880 ha under irrigation and 1,230 ha of non-rice crops on riverbank slopes cultivated after rainy season using residual soil moisture and flood recession. The existing cropping intensity was 97%. There would be a potential for irrigation development in the area to increase cropped area in dry season.

In Xaybouly District, where irrigation exists, wet season rice was 8,617 ha and dry irrigated rice was 8,520 ha. Beside rice cultivation in a low land, there was 2,884 ha sugarcane on a highland, where flooding has no impact. The cropping intensity in the area was 165%. There would be no room for new irrigation development in the area except improving and/or modernising existing irrigation schemes. Table 2-6 presents an overview of the present land use. Appendix 3 presents a study on socio-economics and agriculture.

2.6.1 Rice cropping

The Xe Bang Fai plain is one of the four main rice production areas in central Lao PDR. Success or failure of lowland rice is closely link to the natural flood cycle and every year part of the crop is damaged by the flood. In the project area, there are two main types of rice production: rain-fed lowland (wet season from June till November) rice and irrigated lowland (dry season from December to April) rice.

The rainy season in the area maintains a duration of five months (May-September) occupying 87% of total annual rainfall. It plays an important role in wet season crop cultivation as cultivated area and cropping calendar. The dry season lasts seven months (October-April); while there is almost no rain in November-January (see section 2.2).

Wet season rice
The rain-fed rice requires sometimes supplemental irrigation water by a diversity of small-scale irrigation systems. In the wet season 10,535 ha are cropped with a yield of 4.3 tonnes/ha.

Rice is the staple food for all households. More than half of the rice production is required to meet basic household consumption needs. However, sale of surplus rice in Thai markets is an important source of income for households in this district.

Table 2-6 Agricultural land use, 2009.

Items	Nongbok	Xaybouly
Gross area	**31,300**	**NA**
Non-agricultural land	**17,150**	**NA**
Agricultural land	**14,150**	**14,500**
Cultivated crop area	**13,794**	**23,934**
Cropping intensity	**97%**	**165%**
I Wet season cultivated land	**10,684**	**11,772**
A. Cultivated rice	**10,535**	**8,617**
1. Staple Rice	5,268	8,617
2. Commercial rice	5,267	-
B. Cultivated non-rice	**149**	**3,155**
1. Chilli	-	9
2. Sweet corn	149	80
3. Sugarcane	-	2,884
4. Other crops	-	182
II Dry season cultivated land	**3,110**	**12,162**
A. Cultivated rice	**1,880**	**8,520**
1. Staple Rice	-	-
2. Commercial rice	1,880	8,520
B. Cultivated non-rice	**1,230**	**3,642**
1. Tobacco	35	112
2. Chilli	170	63
3. Sweet corn	53	94
4. Sugarcane	-	2,884
5. Other crops	746	489

Source: FMMP-C2: Secondary data collection, April-June 2009

In years of heavy flooding, such as during the rainy season of 2000, a large proportion of the cultivated area was damaged. Farmers report that rice production is very sensitive to flooding in the region (slightly higher or of longer duration than normal can make the difference between having a large or small harvest).

Dry season rice

In the dry season, the cultivated area is only 1,880 ha. It is irrigated by several small irrigation schemes. The average yield is 6.2 tons/ha for that period, much higher than in the wet season. Ideally the dry season paddy should provide supplementary rice to farmers, both for consumption and for sale on the local markets. However, the dry season cropping has not been as successful as envisaged. Most villagers see dry season rice cultivation as a potential supplement — not as a replacement — to the main rice crop grown during the rainy season.

The expansion of pump-based irrigation, and the economic rationale for this expansion, is increasingly problematic and questionable. This is partly due to:

(i) High water conveyance losses of the canal system;
(ii) Loss of value of the Lao currency, the kip, making imports of fuel and chemical fertiliser more expensive;
(iii) High price of electricity.

The market price for rice, however, remains relatively low. Installed about 10 years ago, all of the diesel-powered pumps along the Xe Bang Fai River are not in operation, most having been used for just a single season. The economics for the electric pumps are better but still marginal at best. Farmers are being told to repay the costs of these government-provided irrigation systems. This added expense is contributing to disillusionment and frustration felt by many farmers regarding dry season rice cultivation. This negative experience works against the setting-up of any collective action for flood management and development of the area in partnership with government representatives

Farmers have also encountered other major problems with dry season rice farming including pest infestation. Continued use of the electrical pumps appears to be dependent on large government subsidies and the strong encouragement of district officials. While local officials continue to report an expansion of the area of dry season rice farming, villagers report that in fact it is declining.

Even though the cash generation of dry season rice appears to be higher than the wet season rice, the farmers don't find it attractive to crop. The inputs appear to be much higher. The benefit is related to the input-output market prices. All in this results in a higher risk taking. The problem farmers might encounter could be the cash-flow for this more risky venture. This ought to be confirmed by more detailed investigations.

Although food security appears not to be an issue in the area, the Government has embarked on a major programme of irrigation development along the Xe Bang Fai; most villages along the Xe Bang Fai now have irrigation pumps. Originally there were 9 gated-sluices and 25 pumping stations in the district serving the command area of 1,750 ha.

The water to be discharged by the Nam Theun 2 dam provides an opportunity for increasing agricultural production during the dry season. A number of large irrigation schemes have been made and are being planned for the Xe Bang Fai area, but recent experiences are reason for caution.

2.6.2 Riverbank vegetables

Cultivation of vegetables is done mainly by women, and it is an important activity which provides food and income to the families. About 25% of villagers are involved in riverbank gardening in the Nongbok and Xaibouly districts in the Lower Xe Bang Fai Region. The average size of riverside crop fields is 0.15 ha/household.

Vegetables are grown in 2 periods: September-December and December-February. The first crops are onion, yam, water melon, long bean, cucumber etc. These are grown in the moist fertile soil on the riverbanks and tributary banks.

The second vegetables are planted down the riverbank as water recedes further. They are of shorter duration and must be harvested by February-March. Main crops are lettuce, garlic, chilli and eggplants.

2.6.3 Upland crops

Other upland crops and fruit trees represent a small proportion of agricultural activities in the district. Crops such as tobacco, corn and beans are grown where rice cannot be grown. According to 2009 statistics, there were 149 ha of corn cultivated in wet season and total 1,230 ha of non-rice crops cultivated in dry season. See Table 2-6.

Part of the production is sold on local markets and tobacco forms the largest single source of cash income. Tobacco is sold not only on the provincial markets, but also in Vientiane and across the border in Thailand. The choice and volume of these crops is determined by market demands in Lao PDR and in Thailand.

Use of agrochemicals and fertilisers

In 2003, the FAO conducted a case study on pesticide use in Lao PDR. The study found that pesticide use is relatively low compared to other countries of the region, and that active promotion of pesticides is not widespread. However, the study also found that pesticides are widely available, and that most of those for sale are highly toxic. Folidol, a class 1a pesticide, was found to be the most widely available and used pesticide, even though it is officially banned. It was also reported that a clear trend toward increasing use of pesticides is noted, particularly by farmers producing for urban markets. Although these farmers are aware of the dangers, they repeatedly stated that they know of no other way to meet the demands of the market, consumers and middlemen, other than to use more pesticides. The study concluded that merely not promoting pesticides is not enough, and that more concerted policies, strategies, and action are urgently needed.

In general, pest attack on rice crops is low in Lao PDR. Although there is a range of pests mentioned both by farmers, officials and in the literature, these are rarely of economic importance. Consequently pesticide use per unit area of rice is low. A recent survey indicated that in Savannakhet Province 50% of farmers sprayed rice one or more times per year, with 25% spraying once and 25% spraying more than once. In general pesticide use is higher in irrigated areas, partly to protect the extra investment in the dry season irrigated crop, but partly because double cropping leads to an increase in the number and intensity of pests attacking the crop. Rice diseases are rarely treated with chemicals (e.g. fungicides); weed control with herbicides is also very rare.

Pesticide use for vegetable growing is believed to be significant. The number of treatments applied is apparently not excessive, but every farmer treats his vegetables with insecticides. There has been no analysis of pesticide residues in fresh produce in Lao PDR, since there are no laboratory facilities for this.

Inorganic fertilisers are used predominately on the dry season rice crop, but increasingly also in the wet season. The type of usage varies according to the recommendations of extension workers and local availability. Farmers mentioned using an NPK 16-20-0 compound fertiliser to "prime" the land at around 200 – 350 kg/ha followed by Urea 46-0-0 at around 50 kg/ha. These fertilisers contain no K, making the rice susceptible to diseases such as brown spot disease in K deficient conditions. Farmers and officials in the Xe Bang Fai floodplain indicated that inorganic fertiliser use appears to follow no particular guidelines with respect to soil analyses or the analysis and usefulness of organic fertiliser. Some inorganic compound fertilisers appear to be used on the basis of availability from donors rather than on need. In the Xe Bang Fai, plain organic fertiliser, mainly manure, is used in combination with inorganic fertiliser at around 250 kg/ha; a relatively low rate, but beneficial if applied annually.

2.6.4 Crop benefits

Representative crop-budgets for the project area were collected in April-June 2009 under a framework of the FMMP-C2 activities. The standard crop-budget forms were developed and the Lao Consulting Groups carried out the data collection at the field.

Economic benefits of crops were derived from financial benefit by applying conversion factors[4] (CF) to remove transfer-payments (taxes, tariffs, and loan interest). The CF was 70% for

[4] ADB Bac Hung Hai irrigation improvement project, Vietnam. Royal Haskoning 2009 and consultant estimates.

unskilled labour, 80% for fertilisers, 200% for electricity tariff[5] applied for agriculture and irrigation; and 90% for other cost items as seed, mechanical equipment.
For a rain-fed crops, high economic net benefit was found in commercial rice (690 USD/ha) and it is followed by wet season cotton (407 USD/ha), wet staple rice and sugarcane (383-384 USD/ha).

For irrigated crops, high economic net benefit was found in commercial rice (936 USD/ha). It is followed by sugarcane (599 USD/ha), corn (522 USD/ha), and staple rice (504 USD/ha). They are summarised in Table 2-7 and details are in Appendix 3.

Table 2-7 Net benefit of selected crops.

No	Crops	Production (kg/ha)	Revenue (USD/ha)	Total Inputs (USD/ha)	Physical input (USD/ha)	Financial NB (USD/ha)	Economic NB (USD/ha)
1	Wet Rice	4,300	759	516	223	243	384
2	Dry Rice (irrigated)	6,200	1,094	721	416	373	504
3	Wet Cotton	1,500	618	280	178	338	407
4	Dry Cotton	800	329	178	112	151	192
5	Wet Commercial rice	4,500	1,059	509	217	550	690
6	Dry commercial rice irrigated)	6,500	1,529	726	421	803	936
7	Rain-fed Sugarcane	45,000	794	546	340	248	383
8	Irrigated Sugarcane	65,000	1,147	647	434	500	599
9	Irrigated Corn	8,000	941	525	321	416	522
10	Rain-fed Corn	5,000	588	475	273	113	238

Source: FMMP-C2: Survey data, April-June 2009

2.7 Fisheries

Next to rice cropping, fisheries is one of the most important livelihood activities in the Xe Bang Fai Basin, and many villagers devote much of their time and energy to fishing. Fishing activities in the mainstream Xe Bang Fai River are most prevalent in the dry season, while people generally fish in wetlands, streams and inundated rice fields during the rainy season.

There is a wide variety of fishing methods and fishing gear utilised by villagers in the Xe Bang Fai Basin including nylon monofilament gill nets, spears, hook and line, cast nets, scoop nets and many types of traps, but also explosives and, poisonous plants. Drift and gillnets are the most important gear in terms of the size of fish landings made by fisherman from the Xe Bang Fai.

Seasonal fish migrations between the Mekong and Xe Bang Fai rivers, and through the Xe Bang Fai River and its tributaries, are an important characteristic of the river basin and are essential to the fisheries and livelihood security of the communities living in the Xe Bang Fai Basin. The first major fish migration of the year commences at the beginning of the monsoon season. When the rains begin in May or early June, seasonal streams begin flowing, and the water level and flow volume of the Xe Bang Fai River begin to rise. At that time, according to villagers, a large number of fish species begin migrating up the Xe Bang Fai River from the Mekong River, while other fish species are believed to move from deep-water pools in the Xe Bang Fai River. At around the same time that fish move up the Xe Bang Fai River, they also begin to migrate up its larger tributaries.

[5] Electricity tariff for irrigation and agriculture was 295 Kip/kWh which is about half of average tariff applied for Industry and Government office.

After the fish migrations at the beginning of the rainy season have taken place, there is considerable fishing activity in wetlands for the duration of the rainy season, and no important fisheries in the large rivers during this time of the year. In October, as the rainy season ends, an important fishery based on migrating fishes of the cyprinid family takes place.

When the water recedes, many villagers make barrier traps (tone) at the edges of rice fields and on streams to catch fish, and in some cases large quantities of fish are caught. Fishing in oxbow lakes, natural depressions and streams is extremely important for people living in the Xe Bang Fai Basin, particularly for those communities situated away from the Xe Bang Fai River and other major rivers as it is only during this period that many of these fish can be caught in locations away from the major rivers.

Ethnic Lao villagers have a number of traditional practices for catching fish including the trapping of wild fish in ponds when flood waters recede (nong sa) and communal taking of fish in wetland areas (pha nong). These systems are dependent on the seasonal flood cycle of the Xe Bang Fai river system.

Wild capture fisheries are clearly one of the most important livelihood resources in the Xe Bang Fai Basin. While fisheries have always been important to local people, their relative importance to society may actually be increasing. In areas where rice production does not provide families with a supply of rice sufficient for an entire year, wild capture are their main means for getting rice — either through direct barter trade with other villages or through selling fish and using the money to buy rice.

After rice, fish is the most important item on the diet for all ethnic groups in the area. Fish are a significant component of the local economy. Fish traders from Khoua Xe (the trading centre at the NR13S Bridge crossing the Xe Bang Fai River) and other population centres travel to riverside villages to buy fish on a regular basis; some villages selling tens of kilograms or more per day. In some areas, villagers sell their own fish at district centres. Marketing patterns differ from place to place. The sale of fish in local markets adds considerably to the income of most households.

Besides fish, many other living aquatic resources are gathered from rivers and wetlands by villagers. These aquatic resources include shrimp, snails, earthworms (used for fish bait), frogs, crabs and aquatic insects. These resources are especially important in villages with a small area of wet rice fields or fields that are particularly vulnerable to flooding. While many non-fish living aquatic resources are utilised as food within individual households, some people realise substantial income from their sale. Women and children often play the major role in the collection of these resources. Table 2-8 presents the proportion of fish caught at various locations.

Table 2-8 Proportion of fish catch at different locations.

Location	***Proportion***
Xe Bang Fai River	54%
Xe Bang Fai Tributaries	3%
Paddy fields	14%
Other small bodies of water	10%
Back swamps and natural ponds	19%
Total	100%

Source: Nam Theun 2 Power Company, 2005b

Families in the lower reach of Xe Bang Fai catch on average 168 kg fish/HH/year, sufficient for daily consumption and the production of 2 - 8 jars (= 22 kg) of 'Padek' per HH/year. Padek, salted fermented fish, is the second staple food in Lao PDR, after rice. The remaining catch, on average 20% or some 35 kg/HH/year, is sold on the market. Anecdotal information suggests that production has declined over the last 10-15 years. Average fish size and the number of species caught have also declined. The reason for the decline is thought to be overfishing and use of small mesh monofilament gillnets.

Results from focus group discussions held in focal areas[6] showed in the Nongbok District 70-80% of the households fish for sale, and the remaining households only fish for their daily consumption. The duration of fishing is reported to be 10-20 days. According to the group discussion, benefits from natural fishing for people living flooded areas vary from 150-3,200 USD/household in normal flood years to USD 290-6,400 for big flood years. The fishing is mainly from river and creeks.

According to the MRC-Technical Paper[7] on fish yields, the data for typical yields of fish in paddy fields in Lao PDR is limited. However, it is reasonable to expect that the fish yield in Lao PDR would be lower than in the Cambodian and Vietnamese floodplains. The lower limits of natural fish in Cambodia and Viet Nam were 55-80 kg/ha. The floodplain in Xe Bang Fai is under rainy seasonal paddy from June-October, with much shorter flooding duration compared to floodplains in Cambodia and Viet Nam. It is estimated that the fish yield would be about 20 kg/ha, resulting in the value of 6 USD/ha.

2.8 Aquaculture

Aquaculture is rarely practiced in the Nongbok District, with less than 3% of households involved. Backyard ponds, rice field fish culture, and village swamp fish culture are the most important types of fish culture. Net cages are least important. No production estimates are available for aquaculture activity in the Project area.

One reason for the low level of aquaculture might be the relative abundance of fish within the river and adjacent wetlands. Lack of infrastructure and well-developed market systems or transport services are other valid explanations, as well as lack of knowledge about fish culturing techniques. However, aquaculture is becoming more common in the Lower Xe Bang Fai zone, in part due to population pressure and in part due to availability of irrigation waters which are also used in aquaculture.

Natural and man-made fish ponds are stocked in the late spring and early summer for harvests 9-10 months later. The yields vary from 0.5 tonnes/ha for 6,000 ha of natural ponds and 1.2 tonnes/ha for 3,000 ha of man-made ponds. During a field mission in 2009, a fishpond farm was visited exploiting 6 ponds of 10 by 4 m. A net return on investment of USD 100 per month was estimated.

2.9 Livestock and animal husbandry

In many villages, livestock is a major source of income. Water buffaloes, cows and pigs act as de facto 'banks' for many families; animals are raised and can be sold for cash during times of

[6] See Annex 2 of the Stage-1 Report for detailed analysis of the focal group discussions.
[7] MRC-Technical Paper, No. 16, October 2007: Consumption and the yield of fish and other aquatic animals from the Lower Mekong Basin.

particular need, such as during rice shortages or illness of a family member, or to pay the costs of weddings or funeral ceremonies.

Livestock are frequently to be found along, and in, the rivers of the basin. Along the Xe Bang Fai River, pigs forage for worms along the riverbanks, water buffaloes wallow in the river and eat large amounts of algae and other water plants, ducks swim and feed in the river, and chickens, goats and cows drink from the river and forage vegetation along its banks. These ‘free’ services provided by the Xe Bang Fai reduce the amount of resources that the owners of livestock would otherwise need to provide to these animals, reducing people’s workloads and making the raising of livestock an efficient economic activity.

In the Lower Xe Bang Fai area every household has on average 1 - 2 head of cattle, 0 - 1 pig and some 10 chicken. Buffalo are still an important source of draft power for land preparation, although power tillers are becoming more common, particularly in the larger and more prosperous villages.

2.10 Natural Environment

The seasonally inundated Lower Xe Bang Fai floodplain is a sensitive and valuable ecosystem. It consists of a mosaic of fresh water lakes, river ponds, rice paddy and fresh water marshes. As part of the middle Mekong fish migration system is an important habitat for fish species. One hundred and thirty-one species have been observed in the Xe Bang Fai, sixty-seven (67) of these in the Lower Xe Bang Fai. The Xe Bang Fai floodplain is also thought to be an important spawning area for different types of fish. The wetlands are also important as refuges for ‘Black fish’ in the dry season and as spawning and nursing areas for both ‘Black’ and ‘White fish’ in the flood season.

The main dry season fish habitat types in the Lower Xe Bang Fai River and floodplain are pools and slow water stretches in the river and swamps and stagnant pools on the floodplain. During the wet season, most of these habitats change completely and some are displaced to other areas. During these periods fish populations frequently use habitats that are not available during the dry season for spawning, incubation of eggs, and rearing of fry. In the Lower Xe Bang Fai Basin, flooded areas are important as nursery grounds and refuges for juvenile fish. Flood reduction will impact on the reproduction of different fish species, including the fish species migrating in the basin. By consequence, in addition to the reproduction rate and the fish biodiversity in the area, biodiversity in the rest of the basin might be impacted by the reduction of flood in the Xe Bang Fai floodplain.

The area around the Xe Bang Fai is also an important habitat for a distinctive guild of riverine bird species. Small islands and riverine sand-bars are formed by natural deposition during seasonal high river flow. They form a habitat for pioneer plant communities and breeding sites for water birds.

It is possibly the only wetland in the area that retained a significant proportion of its original vegetation. It is also the largest, about 3 km^2, and has open water at the end of the dry season.

Nearly 9% (2,726 ha) of the Nongbok District, the district covering most of the project area) consists of wetlands. Some 30% of the district (9,400 ha) is under forest.

No information is available on the fauna in the project area. However, it is known that the wetlands of the Lower Mekong Basin, and thus probably also the wetlands on the floodplains of the Xe Bang Fai, host several endangered species, out of which some 15 globally-threatened bird species, the Siamese Crocodile and the Chinese three-striped box turtle.

As an important spawning and nursing area in flood season, and as an important refuge for 'Black fishes' in dry season, as a habitat for different riverine water birds, as wetlands producing timber and non-timber products, the Lower Xe Bang Fai floodplains provide ecosystem services to the whole Mekong Basin population. Its ecological value is considerable. The question to how important it is, this is very difficult to quantify. The exact assessment of its value to the populations will be possible the day all these provided services to the communities will have been reduced or disappeared with the reduction or disappearance of the floods.

2.11 Other ecosystem services

River-based livelihoods involve a combination of many different linkages between people and their rivers. While rice fields, fisheries, livestock, and vegetable gardens are the most visible components of local livelihoods and economies, many other resources are perhaps less visible but no less important. Many of these less visible components of local livelihoods can only be appreciated and understood in the light of knowledge and experiences of local people living along, and with, the river. Together, aquatic and forest resources form the foundation of livelihood security for many of the people living in the Xe Bang Fai Basin.

2.12 Industry

There is no significant industry within the project area.

CHAPTER 3

FLOOD AND FLOODING

3 FLOODS AND FLOODING

3.1 Flood characteristics

The Xe Bang Fai takes its rise in the Annamite mountain range near to the border with Viet Nam west of Thakhek and joins the Mekong at rkm 1,166, opposite of the city of That Phanom in Thailand. The river drains an area of 10,240 km^2.

The upper basin is steep, but below Mahaxai the river slopes are small and the reach from 10 km downstream of Mahaxai to the mouth is affected by backwater from the Mekong (Figure 3-1). At Mahaxai the Xe Bang Fai drains an area of 4,520 km^2 or about 44% of the basin. At station Ban Xe Bang Fai or National Road Nr 13 South (NR13S) Bridge the upstream drainage area amounts to 8,560 km^2, which is 84% of the basin.

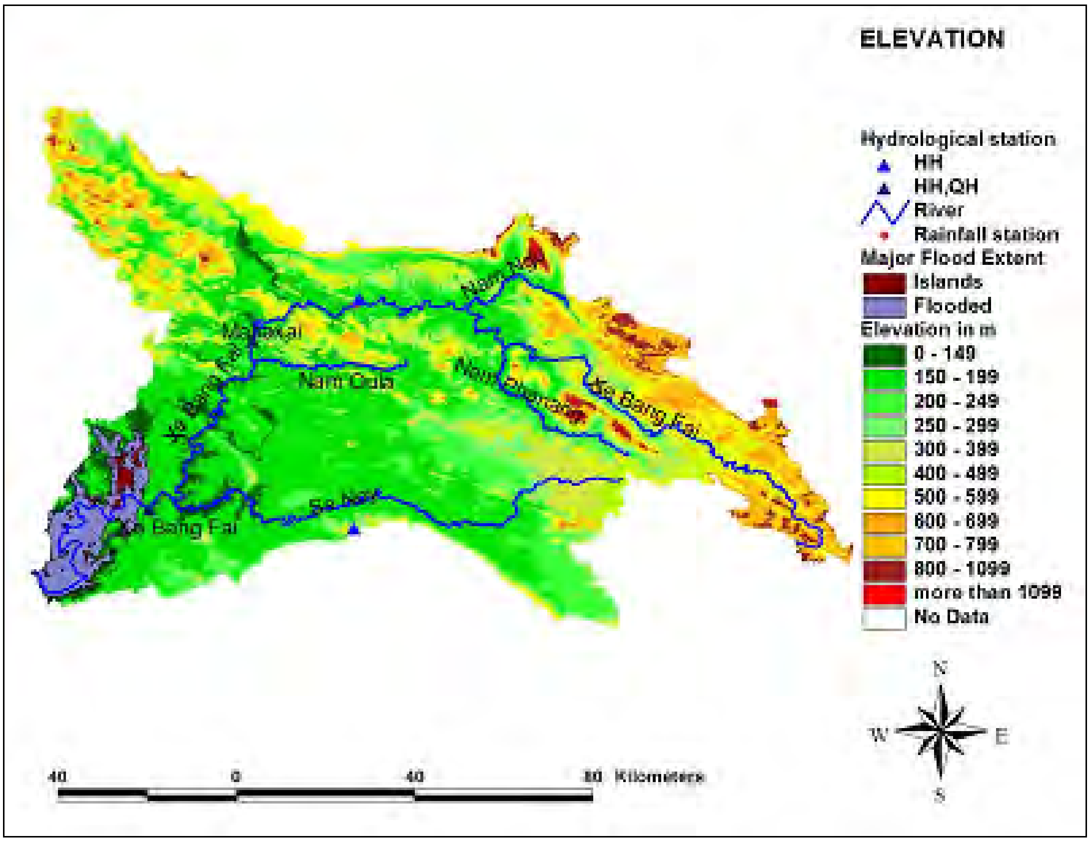


Figure 3-1 Elevation map of Xe Bang Fai Basin.

The drainage of the Xe Bang Fai Basin combined with backwater from the Mekong River cause flooding in the districts Thakhek, Nongbok, Xe Bang Fai and Mahaxai. The small area in Mahaxai District facing floods according to local information is located near Road Nr 1F between Mahaxai and Nam Oula, and is flooded each year for about one week.

Major flooding takes place between the Mekong and the NR13S (see Figure 3-2). Lowest areas in the plains are at 140 m amsl, whereas Nongbok Village is flood free at an elevation of 150 m amsl. Flooding here lasts several months, between July and mid-October.

The flood levels in the Lower Xe Bang Fai area are a function of three factors:

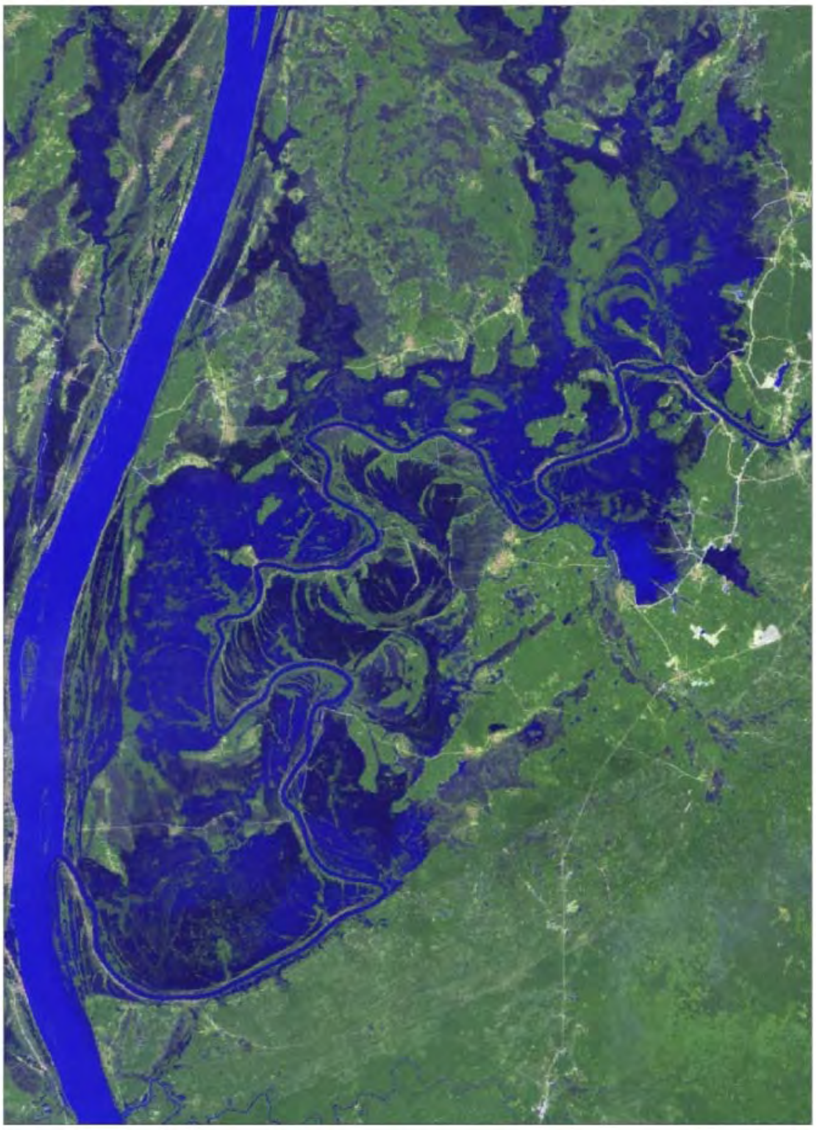
(i) The Xe Bang Fai river discharge;

(ii) The water levels in the Mekong; and
(iii) The drainage of local rainfall.

When the water surface in the Xe Bang Fai exceeds a certain level, usually late in the rainy season, backwater from high Mekong River discharges causes the flow in the river channel to be reversed, the Xe Bang Fai River can't discharge, the local plains can't drain their runoffs and flooding takes place through the tributaries and overtopping of the riverbanks.

The flood is characterised by sudden and rapid rise of the water level (5 to 7 days). Except for the period advent, no regular pattern has been identified in the rising of the flood, or in the predicted height of it.

Local farmers say that a high flood comes every 3 to 5 years and exceptionally high every 8 to 10 years. They say high floods can rise in some days and last for 2 to 3 weeks, inundating their fields with 2 to 4 meters of water.



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

Figure 3-2 Extend of flooding along Lower Xe Bang Fai and Mekong in year 2000.

In December 2009 the Nam Theun 2 Hydro-electric Project will begin operating. The Project will dam the Nam Theun near Ban Sop Hia in Khammouane Province and on an average 220 m^3/s will be diverted to the Xe Bang Fai (see Figure 3-4). The planned variation in the release from the Nam Theun 2 Hydroelectric project is between 315 and 60 m^3/s on weekdays, and a constant 60-75 m^3/s on Sundays. However, it is expected that this will not greatly affect the flooding pattern, since the reduced flows of the Nam Theun/Nam Kading into the Mekong River will result in a fall of about 15 cm of the Mekong water levels during flood events. This should allow for quicker drainage of the Lower Xe Bang Fai during times of flooding, and consequently partially offset the impact of the increased flows in this portion of the river.

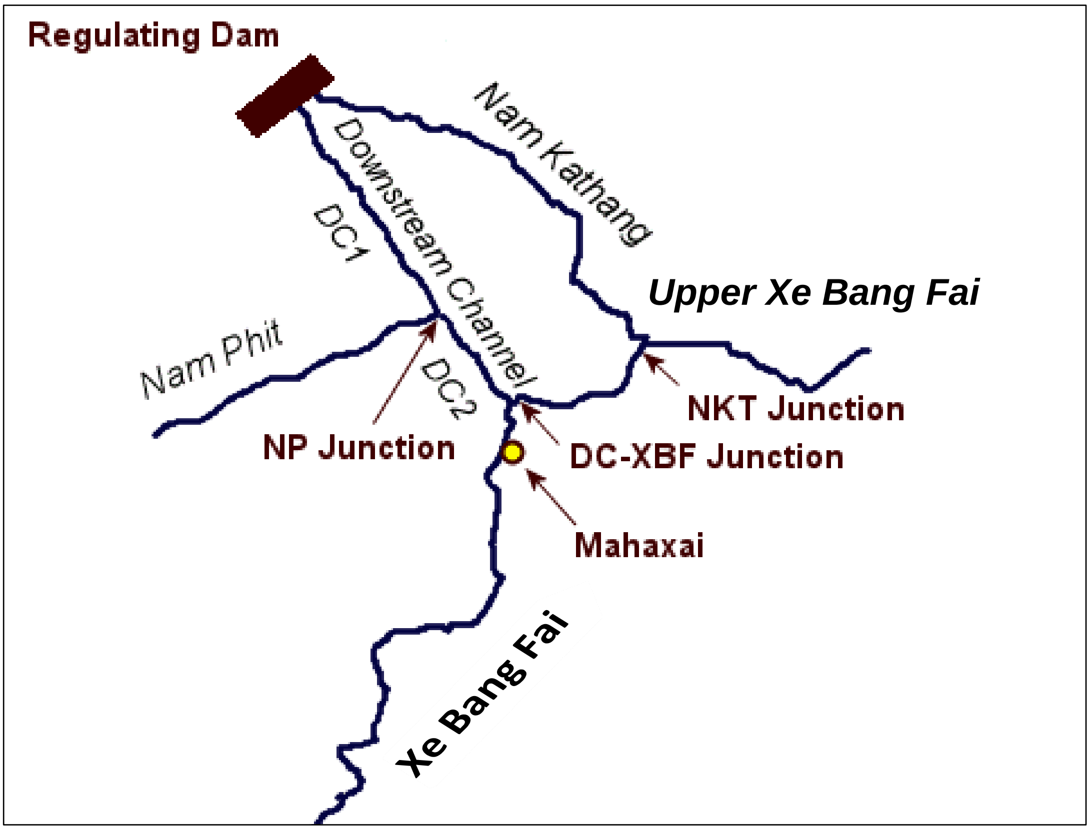


Figure 3-3 Schematic layout of trans-basin diversion from Nam Theun to Xe Bang Fai.

Figure 3-5 shows the longitudinal section of the Xe Bang Fai River downstream of Mahaxai, to the confluence with the Mekong River. The riverbed is shown in grey and the riverbanks in stripped lines. The red line shows the highest water level considering the 1 in 100 year flow in the Mekong and the 1 in 100 year flow in the Xe Bang Fai. For these exceptional floods, the water level in the river can be up to five meters higher than the riverbanks.

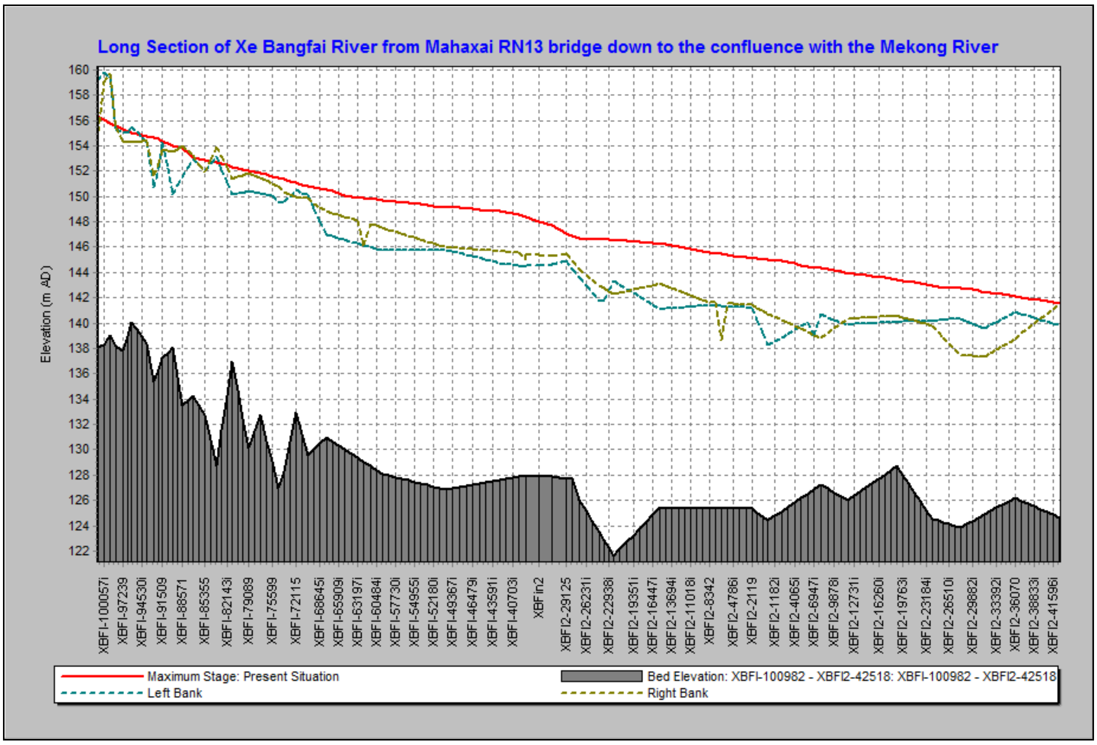


Figure 3-4 Long section of Xe Bang Fai River indicating the water level under extreme flood events, riverbed and bank elevations.

3.2 Social perception of flooding

Throughout communities in Nongbok, flooding is considered as the main hazard in the region. Floods are considered harmful. The damages caused by the flood are:

Agriculture: The flood is devastating to most of the cultivated corps. Only the trees can survive. The flood is damaging to the irrigation scheme infrastructure.

Livestock: Animals have to be moved to higher locations. Some, especially the smaller animals and poultry, are washed away. Fish is lost from the fish ponds. Herbivores can't be fed, since grazing area is missing.

Health: With the floods, all the latrines flow over and infect the water wells. This provokes waterborne diseases for humans and animals. Drinking water is gone. Sanitary conditions are poor.

Property: The flood damages houses and community buildings (schools, dispensaries, temples).

Environment: Some floods create such erosion to land on riverbanks. Erosion also occurs in paddies. Firewood for cooking can't be fetched.

Transportation: The flood damages the roads. Transport is very difficult in flooding periods.

A discussion amongst farmers exists whether the flood has an effect on sedimentation and soil fertility, and pest control to the land. Most of them say that the impact is beneficial. Little knowledge exists about the potential benefits of flood on agricultural production (such as pest control and restoring soil condition, flushing toxic soil components). It might actually be largely undervalued. The real beneficial impact of flood might be appreciated when the conditions of flood change with the proposed project. The latter might be a good reason to incorporate flexibility towards flood control in the infrastructure design.

It is also important to notice that with this perspective of potential loss due to the flood forces the population to avert risk to the maximum. This attitude of the local population has to be considered during public participation in the different stages of the project.

3.3 Community preparedness to flooding

During the flood season, people's activities focus on the following: planting and cultivating the wet season rice crop; fishing and fish cultivation; maintaining fences, embankments and ditches; preparing (and repairing) tools for the upcoming harvest; and, thatching mats used in house construction. The traditional coping mechanisms to protect livelihoods include:

(i) Prior to the onset of floods, people set aside at least a month's supply of rice, prepare containers to collect rainwater and collect firewood and other materials used as fuel for cooking.
(ii) Protect livestock by moving them to higher ground and collecting grass and rice straw to feed them during the period that they are unable to graze.
(iii) Protect fish ponds by using plastic screens to surround the pond and prevent fish from getting out.

The implications for an assessment of vulnerability to flood impacts include the following:

(i) In Nongbok, there is a significant slow-down in agricultural activities during the flood season. People who work as agricultural labourers will generally have little or no income during this period.
(ii) As mentioned previously, while there is an abundance of fish including in paddy fields, most people fish primarily to supplement household diets. The low rate of boat ownership and the low prices for fresh fish limit the opportunities to generate significant cash income from these activities.
(iii) However, according to FG participants, there are few if any problems with food shortages during most floods: Rice and fish are the main food for people during the flood. Here everyone has rice and everyone catches fish.
(iv) Individuals and traders with access to boats will buy food in market towns and resell it to neighbours and others who cannot access markets.
(v) The groups that are identified as vulnerable during floods include: elderly people; and, people without boats who are unable to fish or collect firewood.

In 2007, the District Disaster Management Committee (DDMC) for Nongbok prepared a flood preparedness programme with assistance from the MRC-ADPC-ECHOIII project. This programme includes:
(i) Investments such as the upgrading of roads, embankments and water gates (mentioned above).
(ii) Non-structural measures such as raising public awareness, establish village revolving funds, integrating disaster risk reduction into the school curriculum, land use planning, preparing flood risk maps and early warning systems, and
(iii) Identifying a budget plan with agency responsibilities for implementation of the programme.

Traditional methods of flood warning include markings on riverside trees, other markers on riverbanks and water levels at houses and other structures. These have been associated with staged actions such as relocating animals, removing possessions to upper levels of structures, stocking rice and water for one month, relocating children and the elderly and, finally, tying the house to nearby trees. The strengths of this system were that it was easy for people to learn and remember, and it could indicate rather precisely when different actions should be taken. However, when a tree is cut or a portion of the riverbank is eroded, important markers are lost.

In Nongbok, different strategies have been used to respond to floods although the success has not been high according to FG participants:

(i) In 1997 and 1999, the district provided bags for people to fill with sand and dirt to construct temporary embankments against floodwaters. The success was that there was a high level of participation and cooperation, but the floodwaters were too fast/high.

(ii) The Office of Social Welfare is responsible for emergency responses. The planning is done without consultation of people living in the area although they participate as much as possible in flood protection practice/drills. However, in a bad flood the waters rise too fast and too high.

There are been no formal flood recovery plans in the district (according to FG participants). The chief of each village cluster and village administration committees prepare and implement ad hoc plans with a small amount of assistance from the Office of Social Welfare. There is, however, a high level of participation and contribution of labour by villagers for recovery activities such as cleaning and repairing damaged houses, shops and businesses, community buildings and their equipment (schools, clinics, etc.) and damaged land.

3.4 Flood hazards

The flood levels in the Lower Xe Bang Fai are not only due to high river discharges but are also affected by high water levels in the Mekong at the river mouth at That Phanom. The floods in this region are therefore classified as combined floods. Appendix 1 presents the results in detail of the flood hazard assessment for Xe Bang Fai based on ISIS calculations. Figure 3-6 to Figure 3-9 present the flood hazards maps for the situation *without* embankments, which represents the present situation. Since 2002 embankments have been made on the left bank, but those have not been very effective because they do not fully protect the floodplain behind. The flood still reaches those areas.

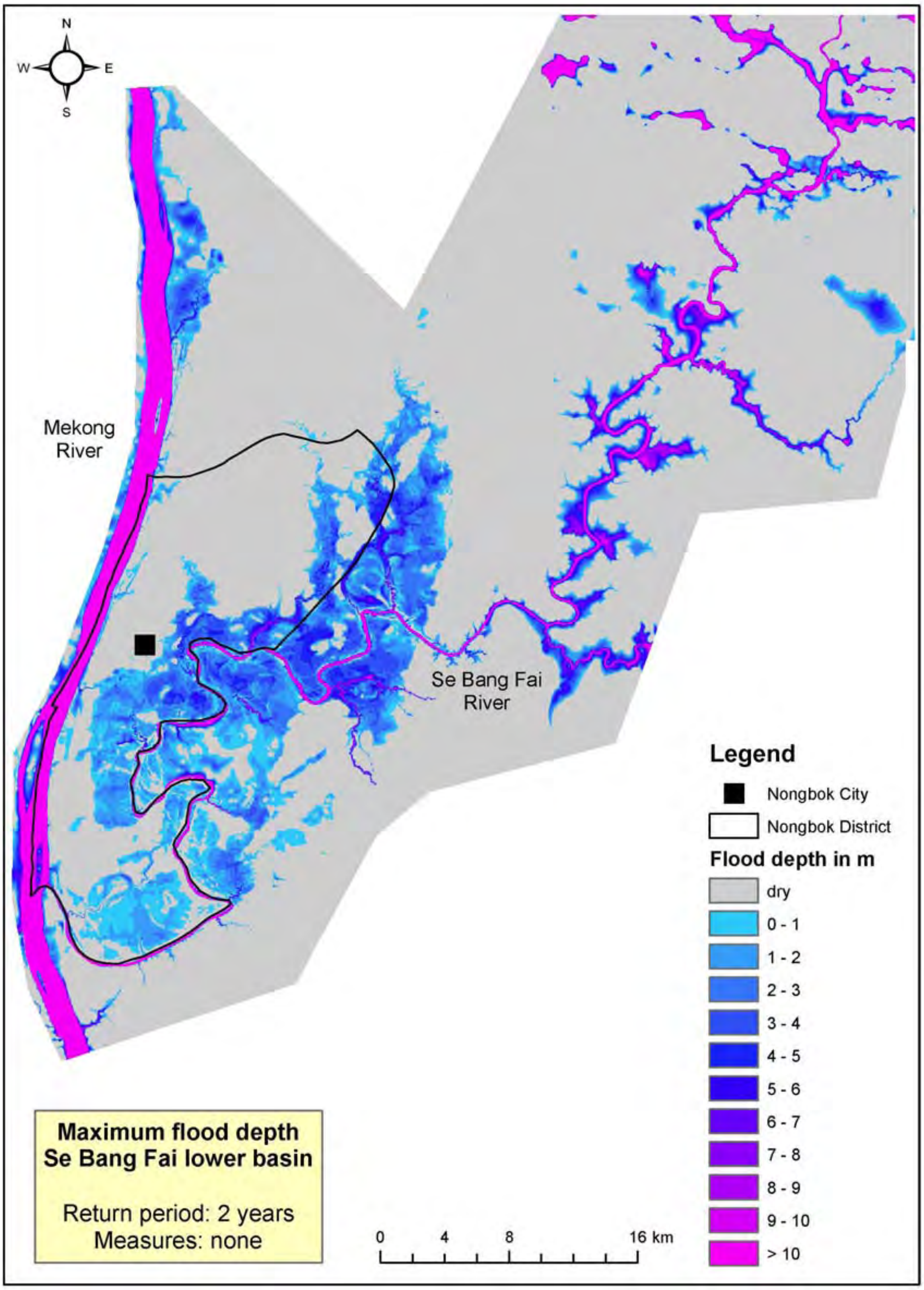


Figure 3-5 Flood depth and extent Lower Xe Bang Fai, T= 2 years.

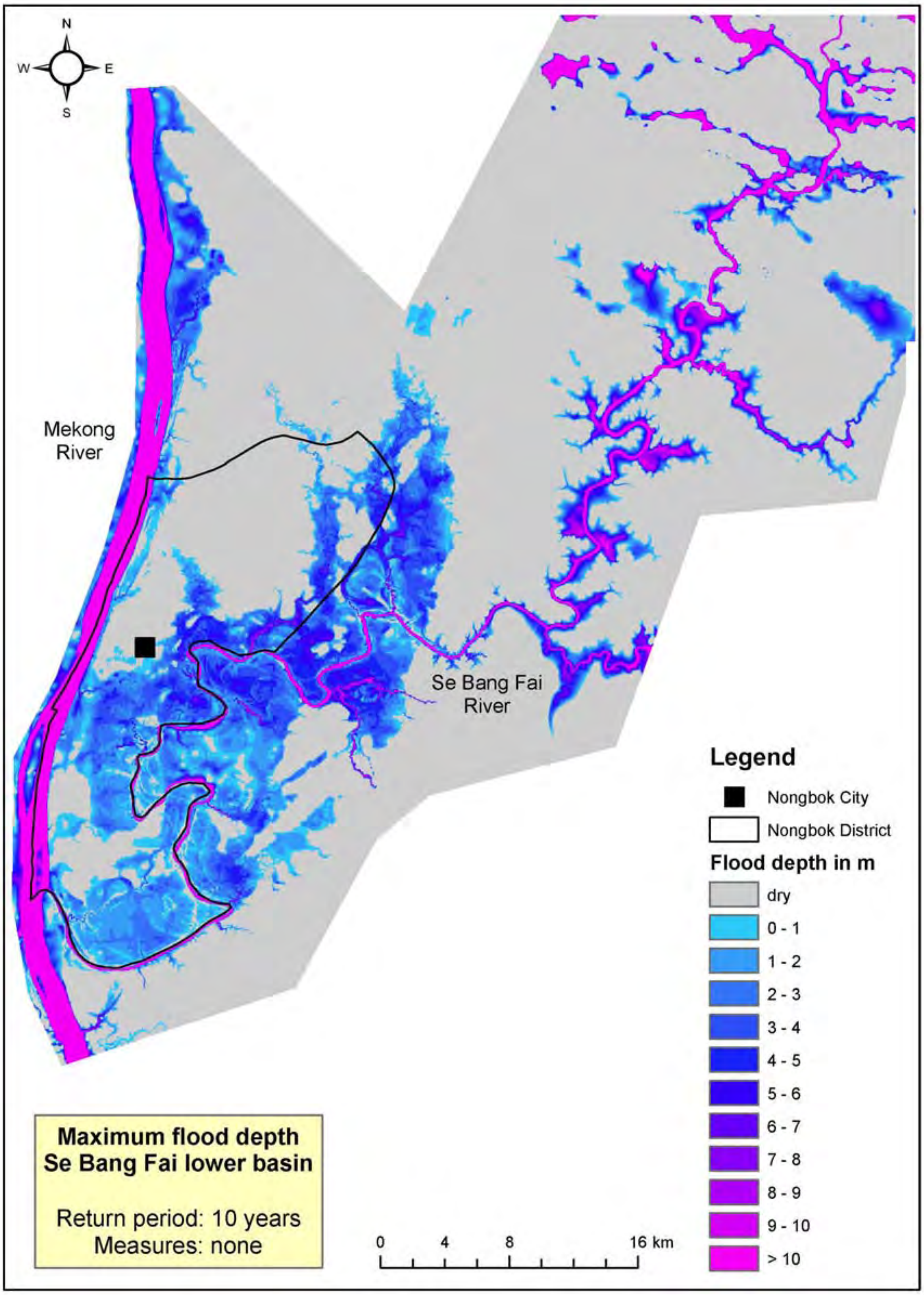


Figure 3-6 Flood depth and extent Lower Xe Bang Fai, T= 10 years.

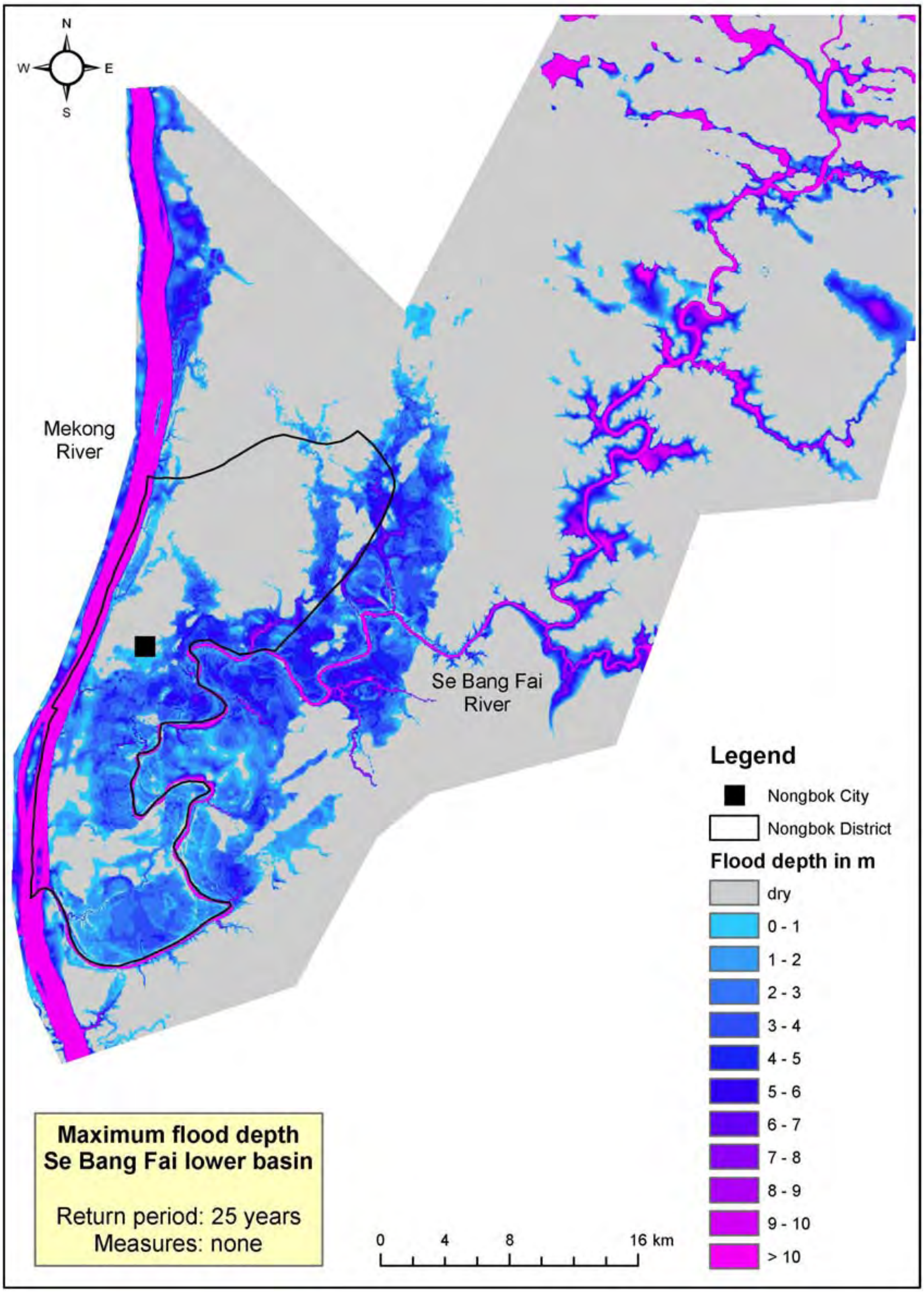


Figure 3-7 Flood depth and extent map Lower Xe Bang Fai, T= 25 years.

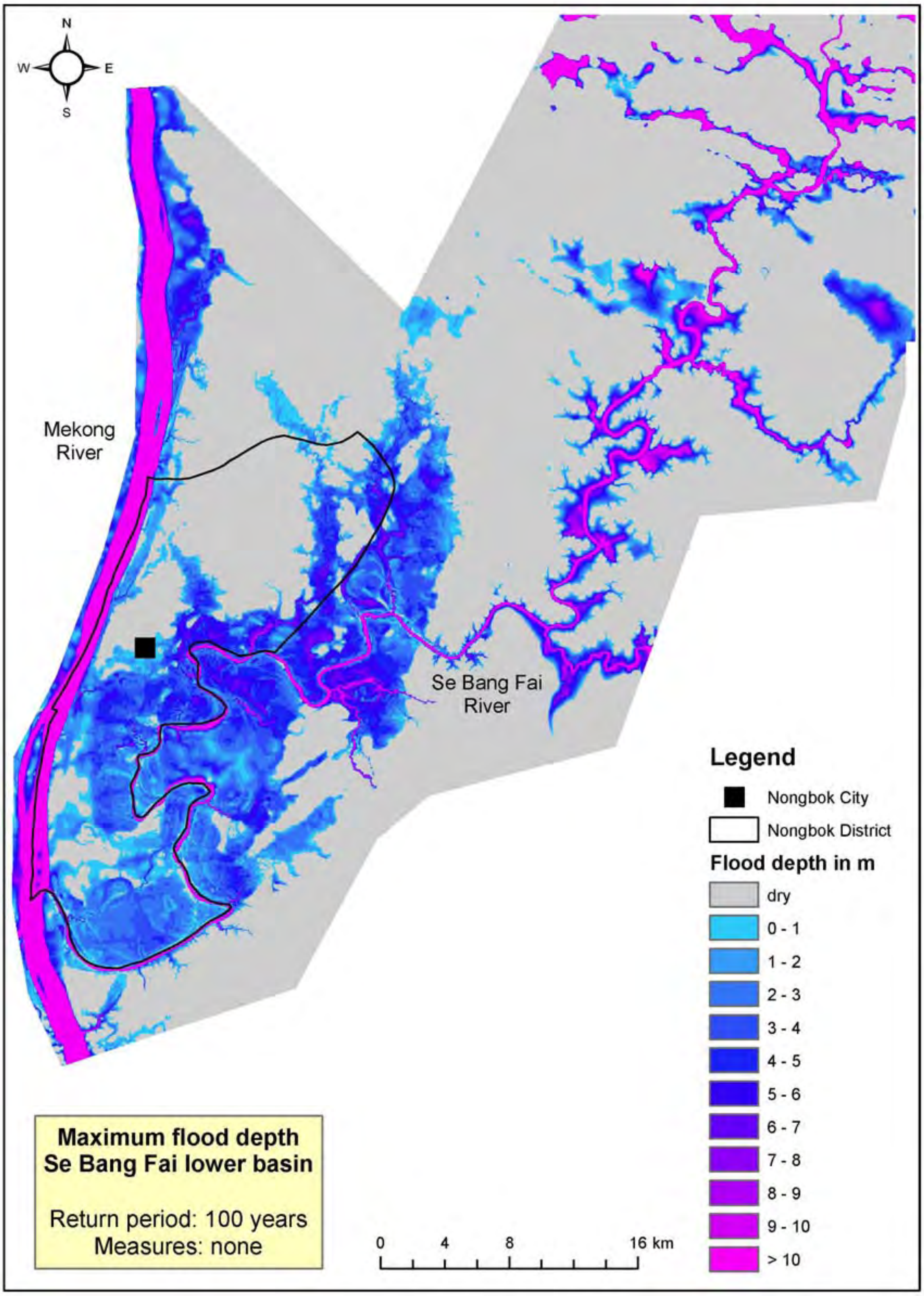


Figure 3-8 Flood depth and extent map Lower Xe Bang Fai, T= 100 years.

The flood prone areas in the Xe Bang Fai Basin are:

(i) Between the Mekong River and NR13S, north and south of the Xe Bang Fai River, creating extensive and long lasting flooding; and

(ii) Near NR01F (Ngommalad-Xetammoak) between Mahaxai and Nam Oula with flooding of one week duration per year on average.

3.5 Flood damages

The Best Practise Guidelines for Flood Risk Assessment in the Lower Mekong Basin' (Volume 3A) gives the methodology to produce maps of flood levels, flood depths, flood damages and flood risks with the ISIS model. These have been applied in stage 1 of the FMMP-C2 for Nongbok District. Following the absolute damages assessment approach for combined flooding (tributary and mainstream flooding), damage figures for certain flood return periods have been produced (see Table 3-1). The damages include the direct and indirect damages occurring with floods. Appendix 2 presents the flood damages and risk study in detail.

Table 3-1 Damages for housing, agriculture and infrastructure/ relief (USD mln).

Damage type	Damage 2 year r.p.	Damage 10 year r.p.	Damage 25 year r.p.	Damage 100 year r.p.
Housing	0.01	0.05	0.08	0.12
Agriculture	1.91	6.83	9.64	13.88
Infrastructure	0.28	0.89	1.24	1.77
Total	2.20	7.77	10.96	15.77

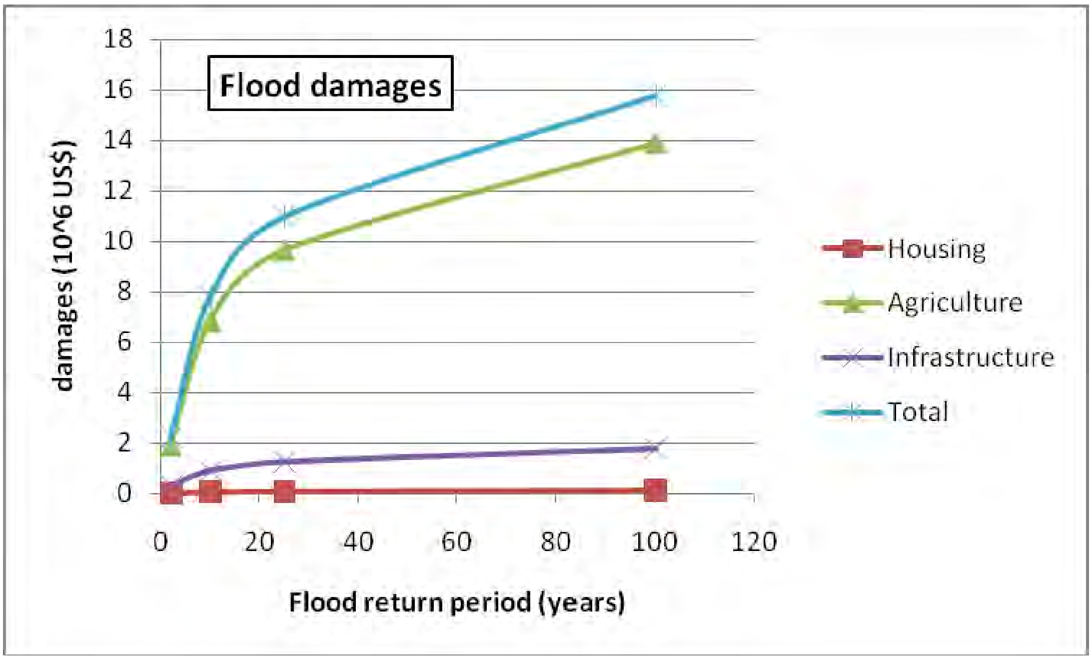


Figure 3-9 Flood damages for floods with different return periods.

3.6 Annual flood risk

From the return period and the damage as given by Table 3-1 the probability – damage curve has been produced (Figure 3-9). The expected damage or risk can be determined by calculating the area under the curve. For Nongbok District the expected annual risks are presented in Table 3-2.

Table 3-2 Annual risk, Nongbok District (USD mln per year).

Damage type	Risk
Housing	0.014
Agriculture	2.605
Infrastructure	0.362
Total	2.981

It is estimated that the flood risk in Nongbok District is of the order of USD 3 mln per year. 87% of this risk is related to agricultural damages. The agricultural damage is the wet season rice harvest loss. Appendix 2 presents the flood damage and risk assessment.

The idea was raised to integrate the development of the agricultural sector in the area by considering increasing the irrigation schemes in the area.

The fact that the villages are located on high ground and many houses are built on poles 2.5-3 m above ground explains the insignificant damages to houses by the flood.

Agriculture, the peoples' livelihood, is most at risk when compared to the housing and infrastructure. This explains the risk aversion attitude that can be noticed in the area. The local populations are to be considered risk managers. It is this attitude that is orienting their decisions.

3.7 Flood benefits

Apart from the negative impacts of flooding as mentioned above, floods also have positive impacts on the social economy such as natural fishing and soil fertility and pest control. Results from focus group discussions held in focal areas[8] showed that benefits from natural fishing for people living flooded areas vary from USD 150-3,200 per household in normal flood years to USD 290-6,400 for big flood years. The fishing is mainly from river and creeks.

According to an MRC-Technical Paper[9] on fish yields, the data for typical yields of fish in paddy fields in Lao PDR is limited. However, it is reasonable to expect that the fish yield in Lao PDR would be lower than in the Cambodian and Vietnamese floodplains. The lower limits of natural fish in Cambodia and Viet Nam were 55-80 kg/ha. The floodplain in Xe Bang Fai is under rainy seasonal paddy from June-October, with much shorter flooding duration compared to floodplains in Cambodia and Viet Nam. It is estimated that the fish yield would be about 20 kg/ha, resulting in the value of USD 6 per ha.

[8] See Annex 2 of the Stage-1 Report for detailed analysis of the focal group discussions.
[9] MRC-Technical Paper, No:16, October 2007:Consumption and the yield of fish and other aquatic animals from the Lower Mekong Basin.

CHAPTER 4

STRATEGIC DIRECTIONS FOR FLOOD RISK MANAGEMENT

4 STRATEGIC DIRECTIONS FOR FLOOD RISK MANAGEMENT

4.1 Introduction

The main objective of the proposed project is to reduce the flood risks. 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 Xe Bang Fai is mostly due to agricultural damages to the wet season crop. 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.

4.2 Reduction of flood hazard

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

(i) The creation of flood retention capacity in or upstream of the flood prone area. Such a measure allows for the reduction of the Xe Bang Fai peak discharges and, consequently of the peak water levels in the river and adjacent floodplains.

(ii) 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 canal.

(iii) The construction of embankments that protect selected areas against high water levels.

(iv) The construction of gates that prevent floods from entering the Xe Bang Fai floodplains.

(v) The improvement of the drainage system in the floodplains, 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 floodplains drains into the Xe 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 Xe Bang Fai at the confluence with the Xe Noy, just upstream of the NR13S Bridge crossing, combined with construction of a flood gate in the Xe Bang Fai mouth. This option has been discarded for reasons of far-reaching resettlement needs, impact on environment and high construction costs.

Under the actual conditions 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 construction of embankments. In that case, part of the floodplain can be protected while another part is reserved for the retention of flood waters. The proportion between the two, ‘how much is to be protected?’ versus ‘how much must be reserved for retention?’ is a political choice that ought to be agreed upon 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.

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

4.3 Reduction of flood risks

The development of a strategic direction for flood risk management in the Lower Xe 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 in the order of USD 3 mln per year in the Nongbok District alone.

Reduction of the actual flood risk
It is important to consider that the flood damages are mostly related to the loss of wet season agricultural production. Compared to the latter, the loss of housing is negligible (< 1%), and the loss to infrastructure represents only 12%. If no substantial development of the agricultural sector in the Lower Xe Bang Fai floodplain is envisaged, the reduction of flood risk in this area should focus on the reduction of the actual flood damage in this sector.

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 Xe Bang Fai tributaries could be an attractive option to achieve this goal.

The strategic direction for flood risk management is closely related to 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 USD 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 USD 6 mln per year

The diversion option will reduce the peak levels along the Xe Bang Fai downstream of the diversion canal. It will have no impact on the Mekong backwaters.

Flood protection for agricultural development
Khammouane and Savannakhet provinces have expressed desire to develop the agricultural sector in the floodplains. This would increase risks in the absence of flood protection measures. As such it makes it bankable to invest in flood protection schemes. Polder development, with or without a diversion scheme, is then the obvious approach.

It is advised to consider the loss of environmental benefits, especially fisheries related benefits, in the planning and design of polder schemes in the Lower Xe Bang Fai area in order to minimise them.

CHAPTER 5

THE LOWER XE BANG FAI PROJECT

5 THE LOWER XE BANG FAI PROJECT

5.1 Structural measures for flood management

Two proposals have been investigated. A first project proposal was formulated in Stage 1 of FMMP-C2 which focuses on the protection of the floodplains in Khammouane Province only. This proposal investigated three alternative measures for flood risk reduction.

A second project proposal has been forwarded jointly by the Khammouane and Savannakhet provinces. In that proposal both the right and the left bank floodplains would be protected.

5.2 Proposal 1

The project proposal considers only protection of the floodplains around Nongbok, on the right hand side of the river. For Khammouane Province the following alternative measures have been investigated:

(i) Step-wise construction of embankments along Xe Bang Fai and Mekong: a three-step construction of a 94 km long embankment along the right bank of Xe Bang Fai River and along the Mekong (See Figure 5-1).

(ii) Construction of embankments along Xe Bang Fai: one-step construction of a 63 km long embankment along the right bank of Xe Bang Fai River only from Nongbok to Danpakse (see Figure 5-2).

(iii) Construction of a bypass canal 'Xelat' from Sokbo to Bungsan Nua in Nongbok District to the Mekong. The bypass canal (see Figure 5-3) involves a 7 to 8 km long canal with bed width of 200 m at an invert level of 138 m amsl.

A combination is proposed because it is expected that the construction of a bypass canal 'Xelat' can reduce the cost of the embankments.

5.2.1 Alternative 1: Dyke construction in three phases

The construction of embankments along the Xe Bang Fai and the Mekong River will be carried out in 3 phases, see Figure 5-1.

Phase 1

In FMMP-C2, Stage 1, an embankment between Banne Nongbone in the Xe Bang Fai District and Banne Sokbo in the Nongbok District (27 km) will be constructed along the right bank of the Xe Bang Fai. Four new control gates have to be constructed in tributaries that discharge to the Xe Bang Fai in this river stretch. Besides, four pumping stations and a 3 km long drainage canal also have to be constructed. After completion of this phase 9,700 ha land and 26 villages would be protected against flooding.

Technical features:

- Crest width: 6 m
- Height of embankment: 3.5 - 4 m
- Crest elevation: 148 m – 145 m
- Side slope: not mentioned in proposal

See comments of the Consultant on the technical features as given in Section 5.3

Estimated total cost: USD 10.73 mln.

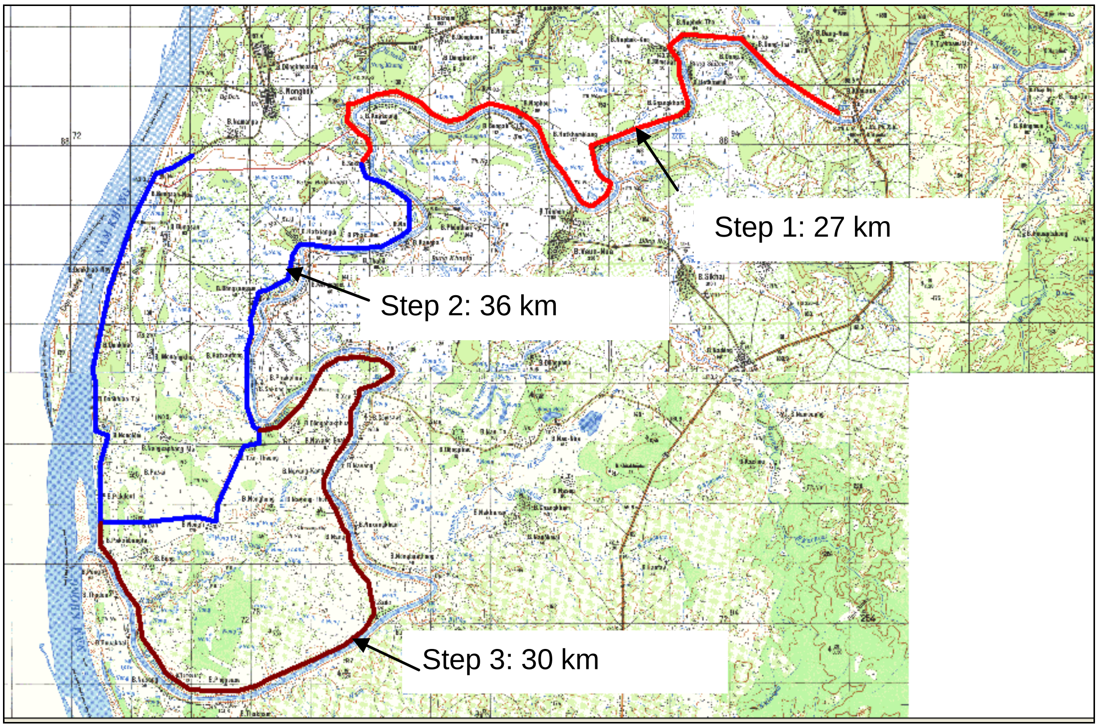


Figure 5-1 Alternative 1: embankment construction in 3 phases.

Phase 2

In Phase 2 the embankment will be extended over a length of 36 km from Banne Sokbo to Banne Bungsanetha. Four new control gates have to be constructed and 5 control gates have to be repaired next to the construction of 9 pumping stations and 5 km drainage canals. After Phase 2 an additional 4,000 ha and 17 villages will be flood proof.

Estimated additional total cost: USD 12.69 mln.

Phase 3

In Phase 3 another 30 km of embankment will be constructed between Banne Tantheung and Banne Dannepakse in Nongbok District. One control gate will be constructed and one gate will be repaired. In this phase 2 pumping stations and 3 km drainage canal also have to be constructed. Phase 3 will provide protection against flooding for an area of 3,000 ha including 13 villages.

Estimated additional total cost: USD 7.46 mln. Table 5-1 gives a summary of the works to be carried out.

Table 5-1 Summary of works and protection provided.

No	Project component	Phase 1	Phase 2	Phase 3	Total
1	Dike construction	27 km	36 km	30 km	93 km
2	Construction of new control gates	4	4	1	9
3	Repair of existing control gates	0	5	1	6
4	Construction of pumping stations	4	9	2	15
5	Construction of drainage canals	3 km	5 km	3 km	11 km
	Total cost (USD mln)	10.7	12.7	7.5	30.9
	Area protected	9,700 ha	4,000 ha	3,000 ha	16,700 ha
	Villages protected	26	17	13	56

5.2.2 Alternative 2: One step embankment construction

This alternative considers constructing a protection embankment only along the right bank of the Xe Bang Fai. The embankment runs between Banne Nongbone in the Xe Bang Fai District and Banne Danpakse in the Nongbok District and has a length of 65 km (See Figure 5-2). For this alternative 9 new control gates have to be constructed and six existing gates have to be repaired. At four locations drainage canals have to be constructed.

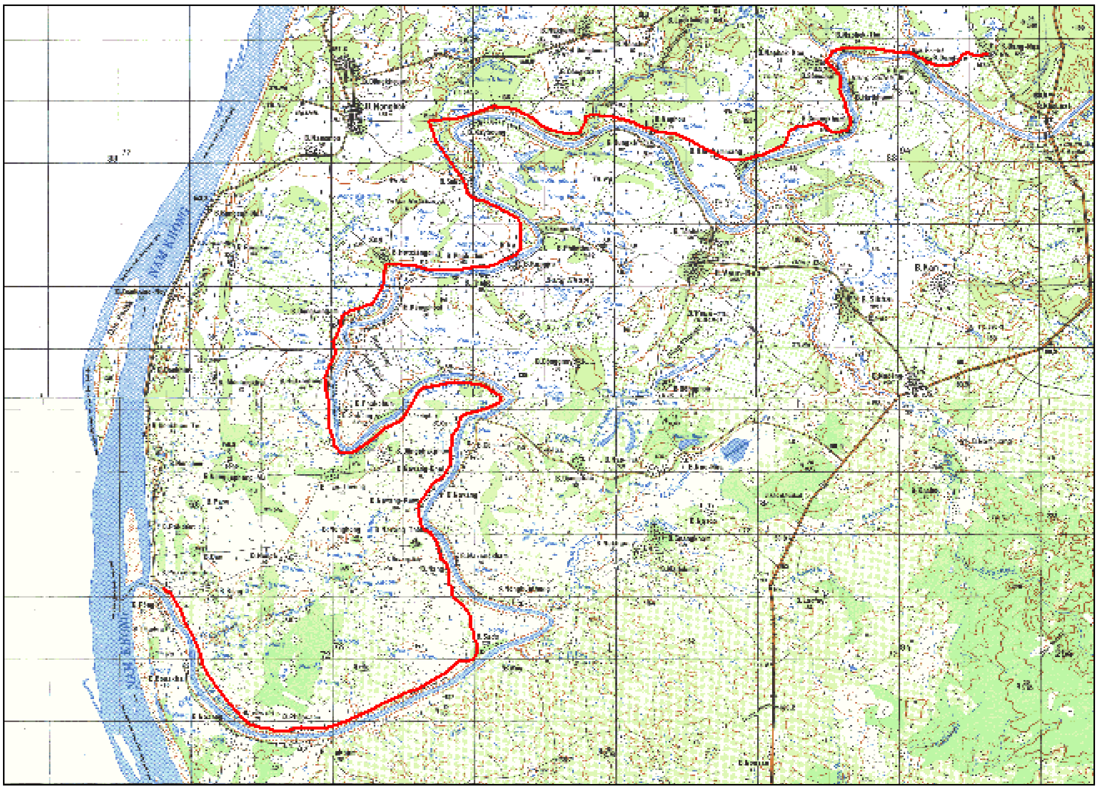


Figure 5-2 Alternative 2: One step embankment construction (right bank).

Technical features:

- Crest width: not mentioned in proposal, likely 6 m
- Height of embankment: not mentioned in proposal
- Crest elevation: not mentioned in proposal
- Side slope: not mentioned, likely 1.5

Table 5-2 Estimation cost for construction (USD).

No	Items	Total
1	Soil work	15,339,375
2	New control gate in 9 locations	4,500,000
3	Repair control gate in 6 points	600,000
4	Drainage canal construction in 4 points	20,000
Total		20,639,375

5.2.3 Alternative 3: Flood diversion canal

The construction of a diversion canal will reduce the peak levels of the Xe Bang Fai River but it will have no impact on the Mekong backwaters. This measure is to be considered in combination with embankment of the Xe Bang Fai. Embanking the Xe Bang Fai River solely would raise the water level in the river during flood season. In order to reduce this, a diversion canal has been proposed.

In addition to alternatives 1 or 2, a diversion canal with a bed width of 200 m and a length of about 8 km will be constructed to divert water from the Xe Bang Fai near Banne Sokbo (about 46.4 km upstream of the confluence with the Mekong River) to Banna Bungsan Nua along the Mekong.

Figure 5-2 presents a cross section of the diversion canal.

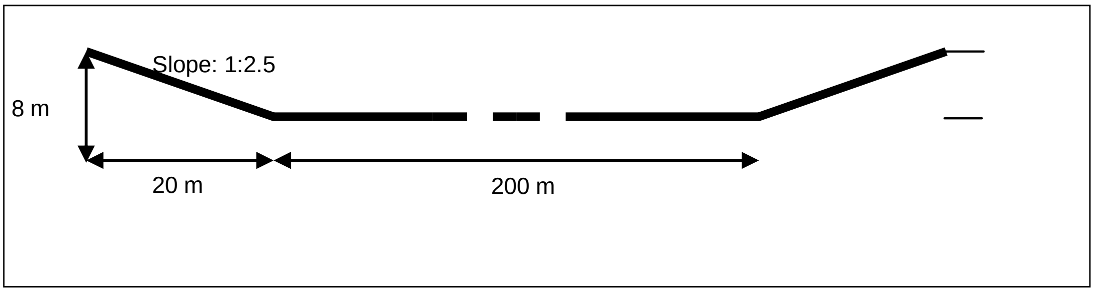


Figure 5-3 Cross section of diversion canal.

Two possible layouts for this so-called Xelat canal have been distinguished. See Figure 5-3. The bed elevation will be 138.0 m amsl.

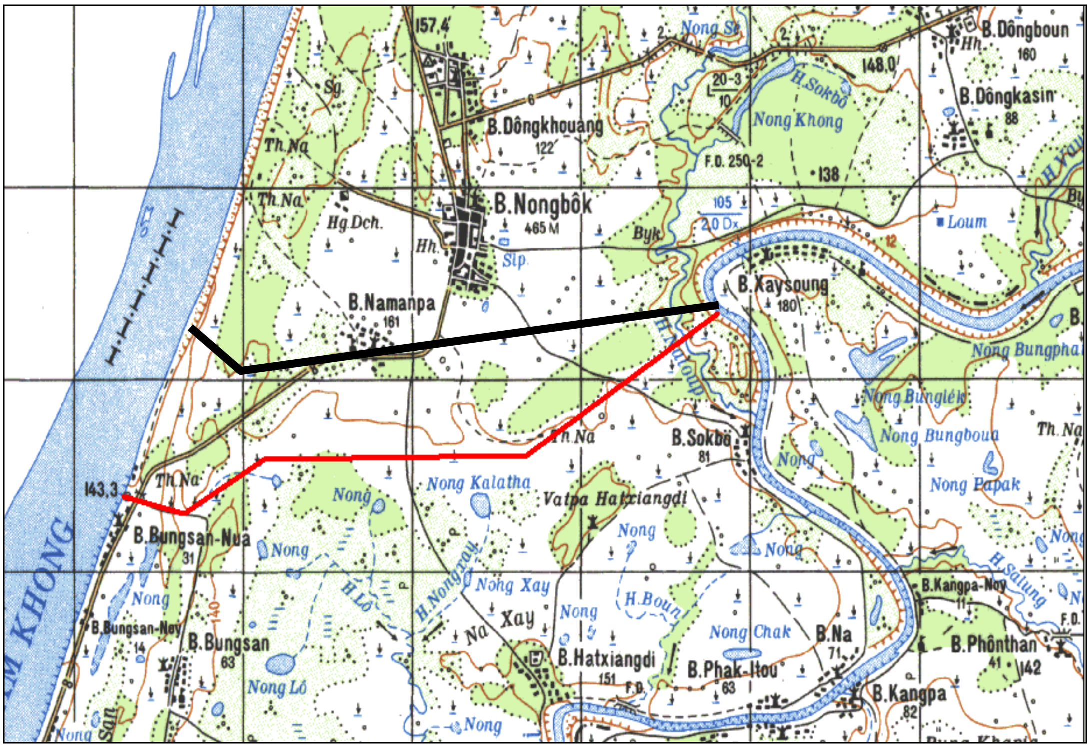


Figure 5-4 Proposed alternative layouts of the Xelat Diversion.

Estimated total cost: USD 9.59 mln.
The proposal describing the three alternatives doesn't mention any protection level for the design of the embankments, but it is understood that this was taken at 85%.

In the cost estimation, no land acquisition or relocation costs have been considered.

The most important factor speaking against the proposal and its alternatives is that only the right bank side of the river would be protected, the other side has already some low level of protection and the impact of proposal 1 would lead to increased flooding in Savannakhet, which is to be avoided. Proposal 2 remedies this shortcoming. Proposal 1 - and its alternatives - is not a serious option in the context of integrated flood risk management and is therefore not further considered in impact assessments.

5.3 Proposal 2

The second project proposal is a joint proposal coming for the Khammouane and Savannakhet Province administration, supported by the Department of Agriculture and Forestry.

The aim is to protect both the Savannakhet province and the Khammouane Province by building embankments on both the left and right bank of the Xe Bang Fai.

The construction plans are to be executed in 4 phases, as shown in Figure 5-4. The proposal also includes a reservoir, irrigation scheme and a mini hydropower station; these elements of the provincial proposal are not being considered in this IFRM Plan preparation since there is no relation to flood protection due to the very small catchment of that tributary.

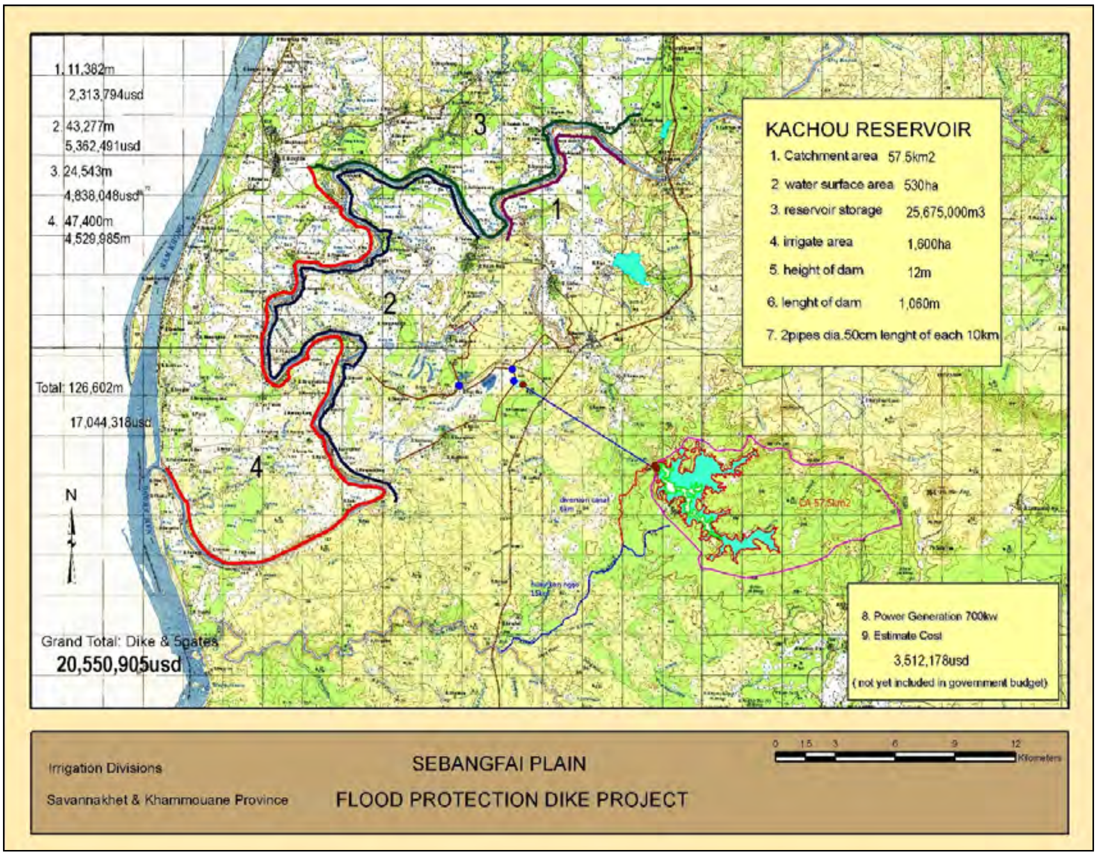


Figure 5-5 Proposal 2: embankments on the left and right bank of the Xe Bang Fai River.

The design has the following features:

- protection against floods having a 15% probability (1 in 6.7 years)
- Crest width: 6 m;
- Height of embankment: 3.5 – 4 m;
- Crest elevation: 148 m with a slope of 1:10,000;

- Side slope: 1:1.5;
- Freeboard: 0.60 m.

Estimated total cost for installation of 5 gates: USD 3.51 mln.
Estimated total cost for construction of 127 km embankments: USD 17 mln.
Estimated total cost: USD 20.6 mln.

The consultant has the following comments on the design features:

(i) It is not clear how design water levels have been determined.

(ii) The protection level of 15% is too low to achieve substantial flood risk reduction; the proposed design seems not to be economically feasible. The provinces take as benefits a value of USD 200 per ha of paddy land, but the benefit is to be derived from the risk reduction function at 15%.

(iii) Height of embankment follows from the bank elevations and the design water level and is more variable than the quoted range.

(iv) Side slopes are too steep for river embankments, the outer slope (land side should be designed based on the geotechnical characteristics of the earth material available in the area and seepage analysis.

(v) Freeboard is too small, for river embankments this is to be calculated taking into account, wave heights, wind set up, settlement of the embankment after construction, and a surcharge to cover a number of uncertainties in the calculation of the design water levels. These uncertainties are in the field of hydrology and hydraulics (short data time series available), analysis methodologies, quality of the ISIS schematisation, etc.

5.4 Impact of proposals on flood hazards

Flood maps have been produced for flood return periods of 2, 10, 25 and 100 years for the following cases have been determined including preparation of flood depth and flood extent maps:

(i) situation without embankments (see section 3.4);
(ii) situation with embankments along the left bank since 2002;
(iii) situation with embankments on both banks;
(iv) situation with diversion canal and no embankments;
(v) situation with diversion canal and embankments of left and right bank.

The flood hazard after implementation of various measures are best visualised by putting flood depth maps at a 1% frequency of exceedance next to each other. This is shown in Figure 5-5.

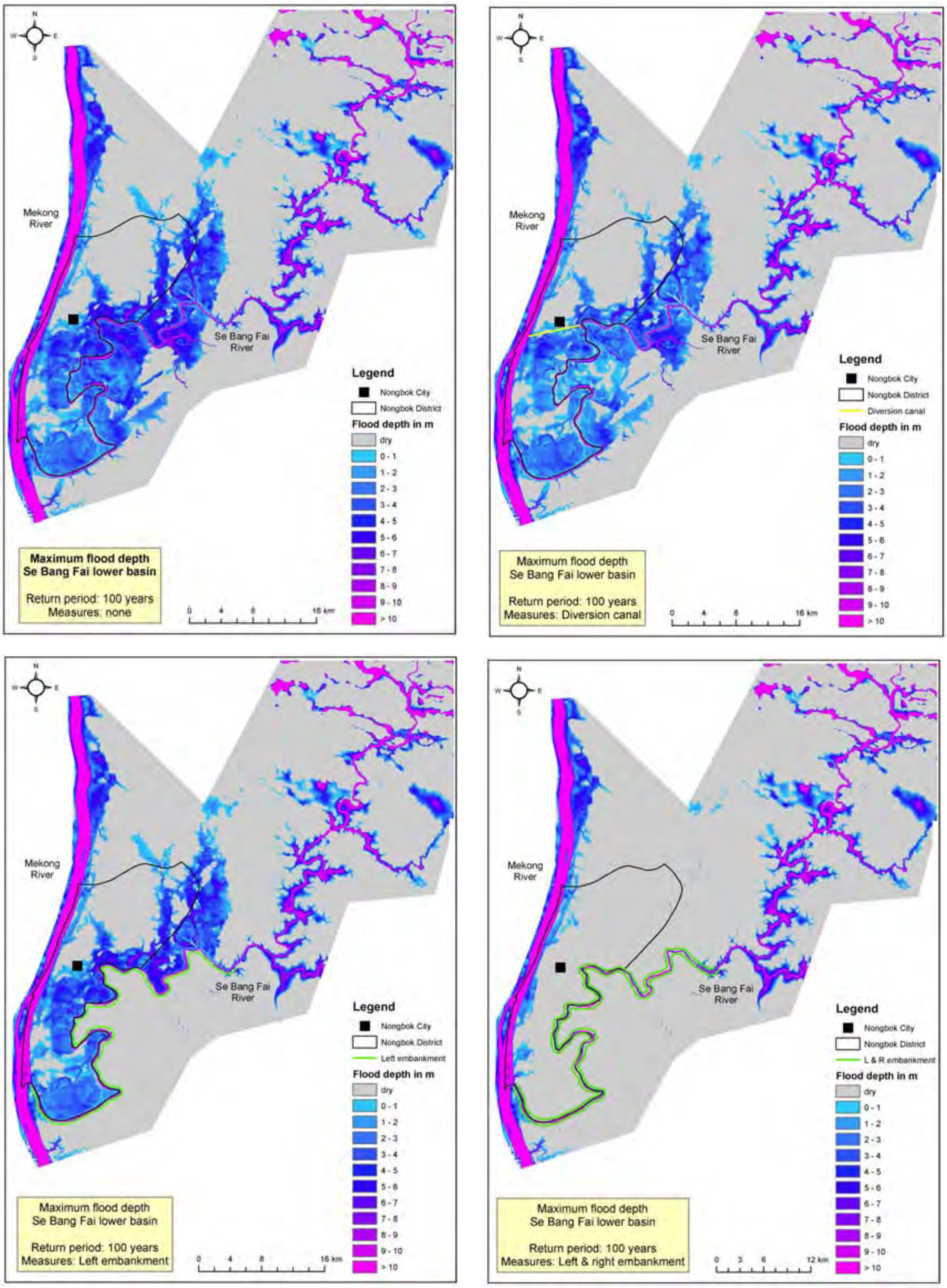


Figure 5-6 Flood depth in the LXBF area, for various measures, impact for a flood of 1%; case shown for a diversion canal is without embankments along the XBF, case of a diversion canal plus left and right side embankments is the same as for the both sides embankment case but with lower embankments.

Impact of embankments

The embankments protect the downstream floodplains but back up the water further upstream. The situation with only embankments on the left is profitable for the downstream floodplain locations on the left but disadvantageous for locations on the right.

Figure 5-6 shows the results for three simulated situations of the river:
(i) situation with no embankments;
(ii) situation with embankments along the left bank;
(iii) situation with embankments on both banks.

Figure 5-7 shows the mutual differences in 100-year water level between the three cases. From the figure, it can be seen that differences are negligible at both the upstream and downstream model boundary. For the upstream boundary this is because it is outside the backwater reach of the location where the embankments begin (at NR13S Bridge). At the downstream end differences are small because the flow in the Mekong dominates the water levels and therefore water levels are not influenced by the embankments along the Xe Bang Fai. Moving to the middle sections, differences are increasing, being at maximum around 70 kilometres from the river mouth. The embankments cause water to stay in the river and keep the floodplains dry. As a result, water levels in the river rise higher than in case of the situation with no embankments. For the 100-year water level the embankments cause a maximum rise in water level of 1.2 m.

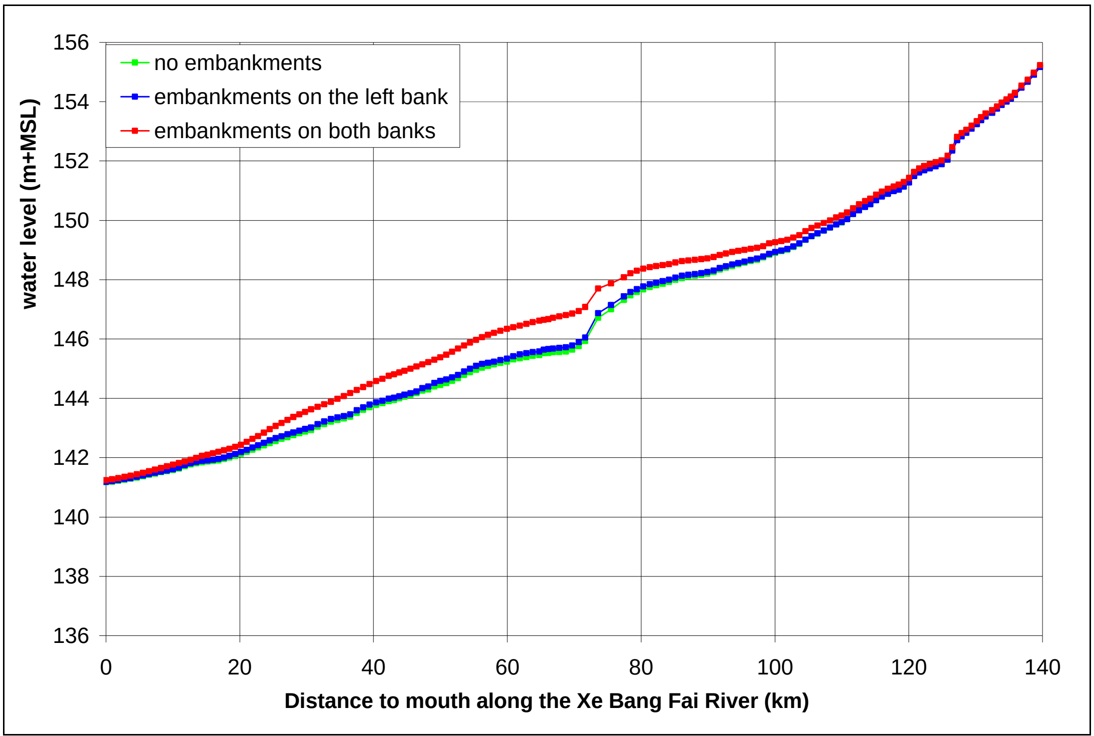


Figure 5-7 Computed 100-year flood level along the Xe Bang Fai River.

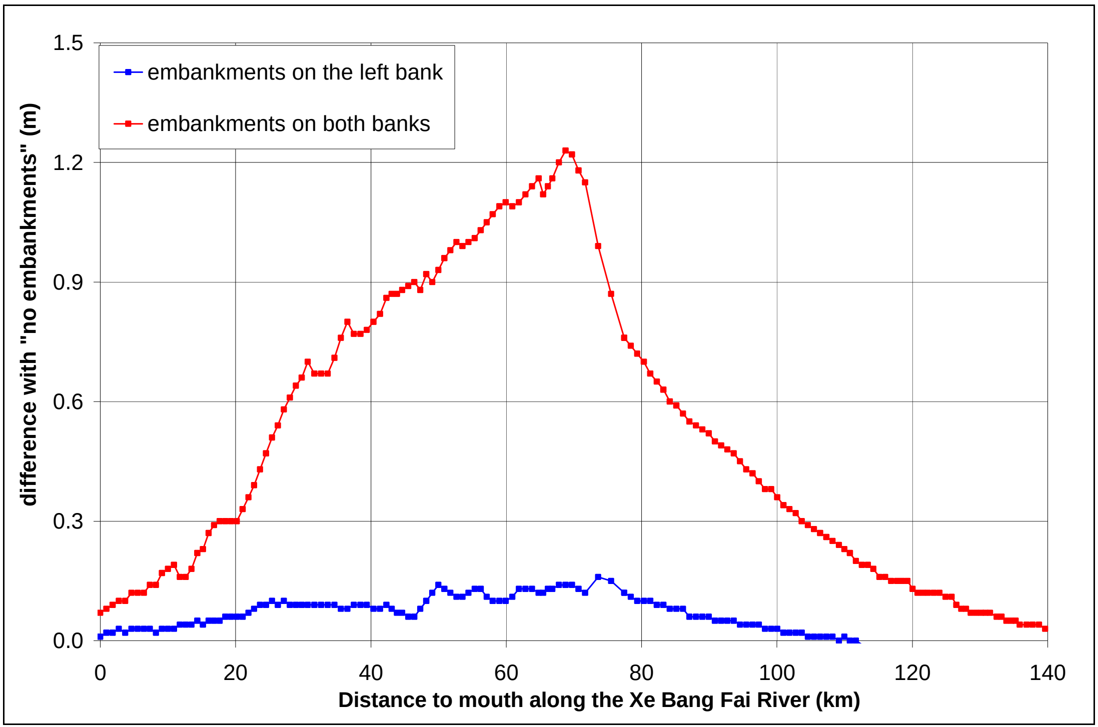


Figure 5-8 Differences in the computed 100-year flood level along the Xe Bang Fai.

Impact of diversion canal

The 100-year water levels have been derived for all locations along the lower reach of the Xe Bang Fai River, assuming the existence of the diversion canal.

Figure 5-9 compares the resulting 1 in 100-year water level with the reference situation in which no diversion canal is present (no embankments). Figure 5-10 shows the difference between the two cases. The diversion canal has a maximum reducing effect of almost 2 m on the 100-year water level in the river, approximately 50 km from the river mouth. The effect reduces to approximately zero at the upstream and downstream boundaries. For the 1 in 100-year water level a maximum reduction (near the off-take) of 1.83 m is observed.

The effects of a diversion canal from Xe Bang Fai to the Mekong to improve the drainage conditions have been investigated. A 200 m wide bypass with bed level at 138 m amsl conveyed for selected years up to 500 to 1000 m^3/s, lowering the maximum water levels along the rivers near the off-take with about 0.50 to 1.00 m. Similar values are found for the floodplains with substantially reduced flood duration. For the 1 in 100-year water level a maximum reduction (near the off-take) of 1.83 m is observed.

In order find the optimum dimensions of the diversion canal, we tested a series of canal dimensions starting with a bottom width of 100 m and invert of 140 m amsl increasing with steps of 25 m to 200 m and invert of 136 m amsl.

Figure 5-3 shows the results for probability of exceedance of 1% (1 in 100 years). These results were used to calculate earth work volumes for embankments and diversion canal options. Optimisation was done to find the optimum economic internal rate of the whole project; this is reached with a canal of 125 m wide and bottom level of 139 m amsl. However, without a diversion canal total costs are lower and a higher economic return on the investment is reached.

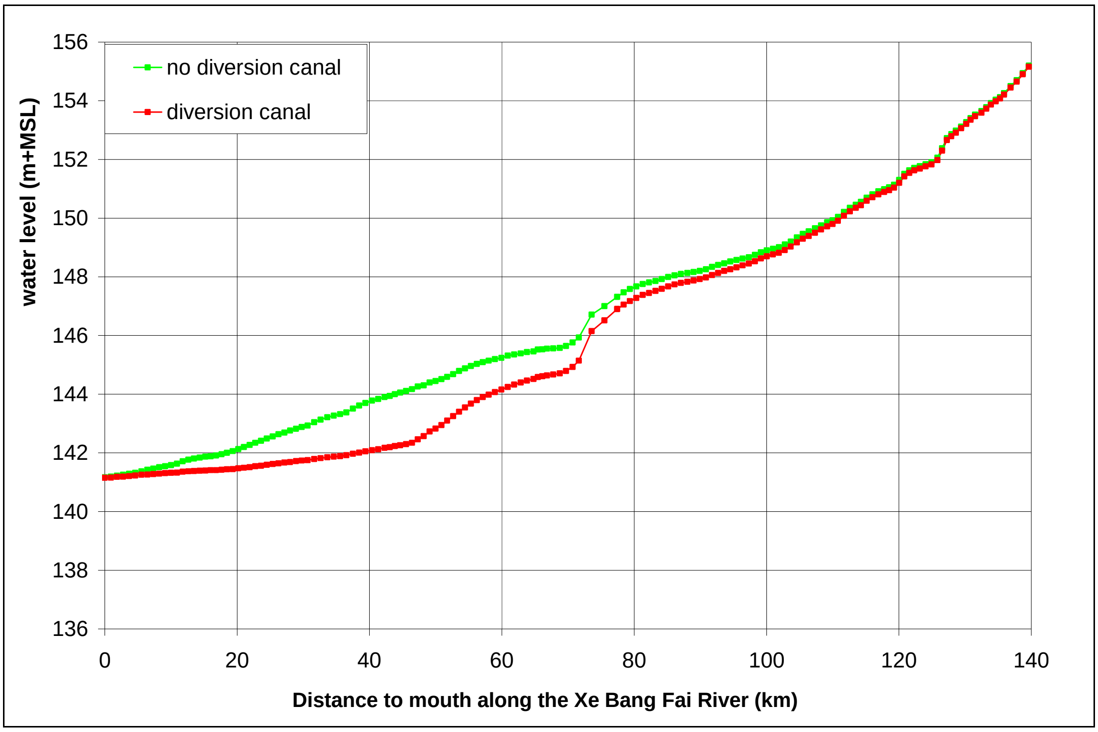


Figure 5-9 Computed 100-year flood level along the Xe Bang Fai River for the cases with a 200 m wide diversion canal and without a diversion canal.

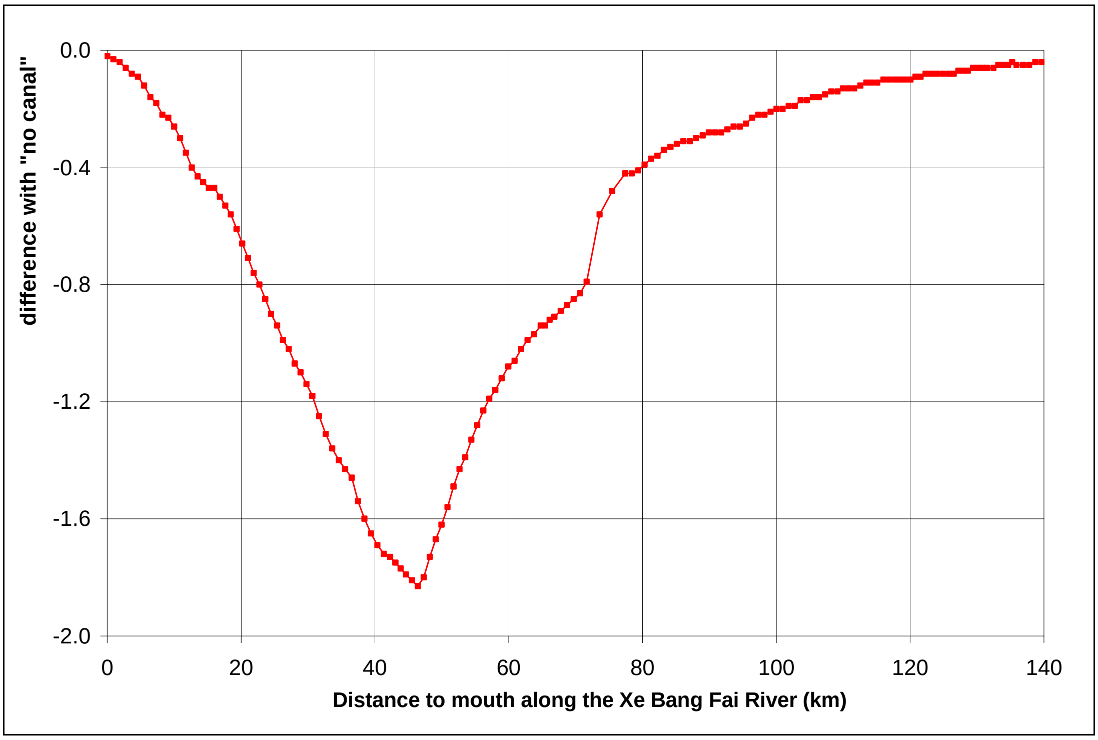


Figure 5-10 Differences in the computed 100-year flood levels along the Xe Bang Fai River for the cases with and without diversion canal of 200 m bottom width.

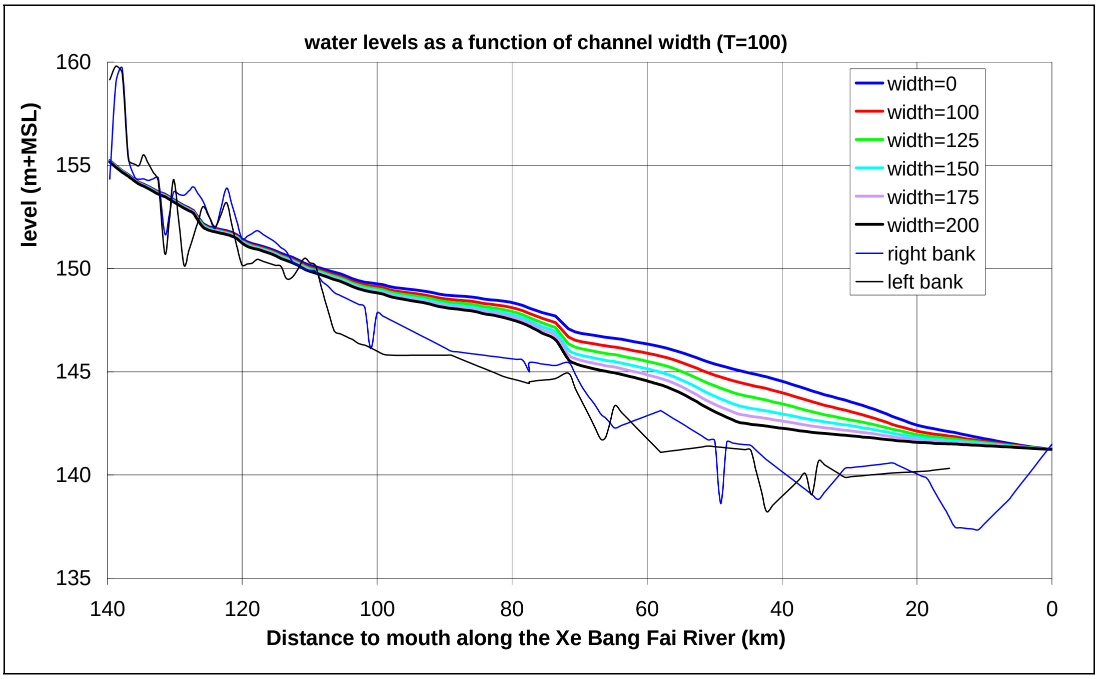


Figure 5-11 Water levels in the Xe Bang Fai with diversion canal of various width and without a diversion canal.

5.5 Future agricultural development

Irrigation development in the project area should be seen as an independent activity, as there is no linkage between the flood protection measures and irrigation in dry season. Future agricultural development is investigating potential increase cultivated crop area and/or land use change due to the project in a case of:

(i) Flood protection measures only; and
(ii) Flood protection combined with irrigation development.

In the economic analysis of the IFRM Plan, only the first scenario is taken into account.

Appendix 3 presents a study on socio-economics and agriculture.

5.5.1 Staple rice

The main rice season is rain fed, seeded in June and transplanted in July. It is harvested in October or November, depending on the lasting of the raining season. Due to the long raining season, and as harvesting of a majority of the crops are to take place in dry periods, a combination of 2 crops will for sure be possible with additional irrigation.

As mentioned earlier in this report, the first priority of local farmers is to provide enough rice to their household. As such and as already expressed by local farmers in public participation sessions, they want to carry on cropping common rice for household consumption in the flood-protected area. This is based on their experiences of farming in a flood prone area and it is part of their risk management strategies. After having secured food, the farmers will consider growing a second crop to generate cash.

At a later stage, when the farmers consider that rice as staple crop can be secured on smaller land surface or by buying it on the market, larger areas for cash crop production will become available.

The farmer's choice to grow a second particular crop will depend on a series of different parameters:

(i) The proposed cash production must be more productive than the usual sticky rice, in relation to the local limiting factor: labour. The farmer expects a higher earning per working day.

(ii) The market of that particular crop must be secured.

(iii) The higher return on investment will have to be demonstrated.

(iv) The required investments must remain within his resources and land exploitation capacities.

(v) The farmers must have acquired knowledge for growing that particular crop.

(vi) The farmer must have the required capacities to crop and many other parameters that only local farmers perceive as important based on their situation, experience and collective history.

Based on the existing agricultural experience in Lao PDR a number of crops can be envisaged. In terms of agricultural production, the top five crops in Lao PDR in order of importance are rice, vegetables and beans, sugarcane, starchy roots, and tobacco.

Since 1990, among these 5 leading crops, production of vegetables and beans has grown the fastest, followed by sugarcane. In the decade since 1990 rice production has increased 47.9%. Among agricultural products often produced as cash crops are: mung beans, soybeans, peanuts, tobacco, cotton, and sugarcane.

This chapter presumes some crops that might have market option in the Lower Xe Bang Fai project area. Commercial rice, long cotton and sugarcane have been identified as potential cash crop. The choice was made on the consultant's perception of possible market development, and on the existing Laotian cropping experience.

Considering the efforts of the World Health Organisation to control tobacco, (WHO Framework Convention on Tobacco Control FCTC), intensively growing tobacco in the Lower Xe Bang Fai area was not considered as an option in this assessment, even if it was raised during the Public Participation activities, and even if marketing opportunities exist in Savannakhet.

The cropping calendar in Table 5-3 provides an overview of the possible cropping combinations with the rainy season paddy rice grown from July till November.

5.5.2 Commercial rice

Cropping a commercial rice variety would take advantage of growing demand for rice to supply inputs for noodle production and brewing. A pilot programme has been launched in Khammouane Province to promote the cultivation of polished rice, following a study showing that the demand for high-quality products remains high.

Also called "Polished rice", commercial rice attracts a higher price compared to sticky rice, of which the country currently has a surplus. However, less than 20% of commercial rice used in Lao PDR factories is produced by local farmers, while the rest is imported[10].

[10] study done by Provincial Agriculture and Forestry Department and SNV (Netherlands Development Organisation)

In order to open up and create a market for commercial rice, the coordinated chain between farmers, rice purchasing agencies and financial institutions needs to be strengthened. Development of contract farming would as such be endeavoured.
During local field visits (July 2009), local farmers have expressed an interest in growing these commercial rice strains, because the study showed that growing commercial rice brings considerably more profit.

5.5.3 Sugarcane

A market opportunity for extensively produced sugarcane exists since Khon Kaen Sugar Industry Public Ltd (KSL) , Thailand's fifth largest sugar manufacturer, plans to invest up to Baht 300 mln (about USD 86,000) to establish an ethanol production plant in Lao PDR, expanding its investment in the country. The plant, scheduled to begin production in Savannakhet in 2010, is the second phase of the investment in Lao PDR for Khon Kaen Sugar Industry Plc.

A joint-venture agreement was signed with Ban Pong Intertrade Ltd (BPI) and the Laotian government to develop a 10,000 ha sugarcane plantation and sugar mill in Savannakhet province. KSL and BPI agreed to establish the Savannakhet Sugar Corporation to execute the project, which is worth around USD 11 mln. The company plans to produce 600,000 tons of sugarcane over the next four years, but additional sugarcane for KSL's mill will come from other Laotian plantations, operated by firms including Mitr Phol Co, Thailand's largest sugar business, which two years ago invested USD 22 mln in a 6,000 ha plantation. KSL will export most of its Laotian output to the EU with some going to local clients.

In Vientiane Municipality, sugarcane is mainly supplied to PakSap Sugar Factory. This is a small factory, but their demand for sugar cane is rising. They are still under their maximum processing limit. National wise, the government of Lao PDR imports sugar from Thailand. This means that, next to the huge KSL ethanol project, the national market for sugar remains an option.

The waste from sugarcane, bagasse, has also the potential to feed the energy production sector using biomass (Bouathep Malaykham, Ministry of Energy and Mines, Department of Electricity, Brief Report of Biomass in Lao PDR).

5.5.4 Cotton

Cotton is most commonly found as an intercrop in Lao PDR, with several hundred square metres of cultivation being sufficient to satisfy the weaving needs of one household. Local cotton varieties yield 200 - 800 kg of seed cotton/ha and have ginning outturns of between 20 and 33%. The short coarse fibres provide a rough-textured cloth for everyday use.

In the south of Lao PDR, farmers sow cotton as an off-season flood-plain crop. Where lowland rice is the major crop, the most common association is groundnut–cotton in order to have a smooth work schedule for farmers. It is not common practice to use organic fertilisers or to apply pest control for cropping cotton in Lao PDR.
Long fibre cotton has higher economic value than the local short fibre strains. Of all varieties tested in Lao PDR, only S 295 and SRI F4 (cultivated in Chad) and G 31 9-1 6 (Côte d'Ivoire) adapt well to Laotian ecosystems. But the Indian cotton variety G. Hirsutum (known as Kham Khao 1 in Lao PDR) - which is extremely hairy and behaves very well in the field-offers the best results (about 2,500 kg/ha of seed-cotton with intensive crop protection).

Lao PDR has the possibility of opening its rather restrictive national market towards Thailand, and perhaps Viet Nam, on condition that it develops production of the medium long fibre varieties demanded by cotton manufacturers.

The current socio-economic climate is favourable for the expansion of cotton cultivation. National and international markets appear to exist and farmers appear to be receptive.

A national coordination of the production appears to be essential to coordinate production input procurement, and purchase of smallholders' harvests. A rural cotton research base and a ginning unit presently exist in Savannakhet.

Aiming at the establishment of a sustainable cotton sector, a fair-trade approach might be considered, respecting labour and the environment. The international "fare-trade" market is growing.

5.5.5 Crop calendar

Most annual crops are planted during the rainy season, starting from June, and harvested in the dry season. Vegetables are mainly cultivated after the rainy season and/or the flood recession period taking advantage of soil moisture after the wet season. See Table 5-4.

Table 5-3 Possible farming calendar for the Lower Xe Bang Fai area.

	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
	6	7	8	9	10	11	12	1	2	3	4	5
INTENSIVE CASH CROP												
Rainy Seasonal Paddy rice	■	■	■	■	■	■						
Dry season irrigated paddy rice							■	■	■	■	■	
Suger cane	■	■	■	■	■	■	■	■	■	■	■	■
Rainy season cotton	■	■	■	■	■	■	■					
Dry season cotton							■	■	■	■	■	■
CROP FOR PERSONNAL CONSUMPTION or SMALL CASH												
Onion						■	■	■				
Green Onion						■	■	■	■	■	■	■
Chilly							■	■	■	■		
Corn						■	■	■	■	■	■	■
Dry seasonal tobacco						■	■	■	■			
Groundnut	■	■	■	■	■	■	■	■	■	■	■	■

5.5.6 Future without project

Promoting new crops requires sound thinking and progressive research in on-farm conditions. A new crop cannot be a sustainable answer, especially in term of risks for farmers, but must be considered into existing farming systems, always mixed between many plants and animals productions. Introducing a new cropping system is not so obvious. It is possible only if the farmers take it over. However, the local farmers are risk averting and presently not ready to reduce their staple food cropping, which is wet season rice. Presently, farmers perceive a land-use change as taking a risk.

In the project area, there exist several small scale irrigation schemes. In future without projects, some irrigation schemes may be improved to increase irrigated area. However, it is assumed that the area increased by new developments would counter balance the existing irrigation scheme deteriorated. Therefore, it is expected that future irrigated areas would be the same as current irrigated ones.

Future agricultural land use in case of without projects would be the same as current land use.

5.5.7 Future with flood protection project

It is expected that the proposed project would remove (i) annual flood damage to agriculture; (ii) flooding constraints on agricultural development in the area. It has a potential for expansion of cultivated area in the wet season and/or replacing short-duration crops by longer-duration ones which generate more benefit.

Under full flood protection for crops, it would be possible to change annual crops (rice, and non-rice crops into perennial crops such as sugarcane, if it is more profitable.

Financial and economic net benefit of crops presented in section 2-5 showed that commercial rice has a high return compared to other crops in the same cultivated conditions (rain-fed and/or irrigated). Expansion of commercial rice cultivation in the project area would not depend on flood protection measures, but depend on market and production contract between farmer and business. Replacing the rice with sugarcane is not economically justified, since the net benefit from rice (cultivated in wet season) is higher than that from sugarcane (cultivated year-round).

In general, flood protection measures can remove the potential flood damages but cannot increase cultivated crop area neither in the dry season nor in the wet season, since it is currently full crop cultivation already in the wet season. It is therefore that *agricultural land use in future with flood protection would likely be the same as the agricultural land use in future without project.*

5.5.8 Future with flood protection and irrigation project

As mentioned above, irrigation schemes have been developed for Xaybouly District. There are some small irrigation schemes in Nongbok with irrigated area of 1,880 ha out of 10,355 ha. The potential crop cultivation with new irrigation schemes would increase dry irrigated crop from existing low level to full level of 10,355 ha. Other non-rice crops such as vegetables, corn, beans etc. are assumed to be the same as the future without project. The cropping intensity in Nongbok District would be increased from 96% to 157%.

In short, future agriculture land use in Nongbok District under flood control and irrigation development would mainly change dry season rice from 1,880 to 10,535 ha. See Table 5-4. However, new irrigation development is independent of flood protection and needs to be justified on its own.

Table 5-4 Future agricultural land use.

Items	Future Without Project		Future With Project	
	Nongbok	Xaybouly	Nongbok	Xaybouly
Gross area	**31,300**	**NA**	**31,300**	**NA**
Non-agricultural land	**17,150**	**NA**	**17,150**	**NA**
Agricultural land	**14,150**	**14,500**	**14,150**	**14,500**
Cultivated crop area	**13,794**	**23,934**	**13,794**	**23,934**
Cropping intensity	**97%**	**165%**	**157%**	**165%**
I Wet season cultivated land	**10,684**	**11,772**	**10,684**	**11,772**
A. Cultivated rice	**10,535**	**8,617**	**10,535**	**8,617**
1. Staple Rice	5,268	8,617	5,268	8,617
2. Commercial rice	5,267	-	5,267	-
B. Cultivated non-rice	**149**	**3,155**	**149**	**3,155**
1. Chilli	-	9	-	9
2. Sweet corn	149	80	149	80
3. Sugarcane	-	2,884	-	2,884
4. Other crops	-	182	-	182
II Dry season cultivated land	**3,110**	**12,162**	**3,110**	**12,162**
A. Cultivated rice	**1,880**	**8,520**	**10,535**	**8,520**
1. Staple Rice	-	-	-	-
2. Commercial rice	1,880	8,520	10,535	8,520
B. Cultivated non-rice	**1,230**	**3,642**	**1,230**	**3,642**
1. Tobacco	35	112	35	112
2. Chilli	170	63	170	63
3. Sweet corn	53	94	53	94
4. Sugarcane	-	2,884	-	2,884
5. Other crops	746	489	746	489

Source: Consultant estimates

5.6 Preliminary engineering design

Preliminary engineering designs of the main components have been carried out; however no technical field surveys such as topographical surveys and geotechnical investigations have been undertaken. Available maps are outdated; riverbank longitudinal profiles have been derived from the river cross sections that appear in the ISIS XBF model.

The Consultant has adopted the preliminary design features as follows:

(i) Design water levels have been determined with the ISIS XBF model, for design purposes we selected the situation that both the Mekong and the Xe Bang Fai river discharges have a probability of exceedance of 1% (1 in 100 years); this selection is based on risk reduction grounds, costs for lower protection levels outweigh the then achievable benefits (with a likely exception for the 1 in 50 years flood events).

(ii) Crest levels of embankments follow from the riverbank elevations and the design water level plus freeboard.

(iii) Crest width of embankments has been set at 6.00 m.

(iv) Side slopes for river embankments and the possible diversion canal are taken at 1 : 2.25 (V/H) on average; the slopes should be designed based on the geotechnical characteristics of the earth material available in the area and stability analyse under design water level seepage conditions. The outer slope (river side) of the embankment would likely be in the order of 1 : 1.5 to 1 : 2 and the inner slope (land side) at 1 : 2.5 to 1 : 3.

(v) Freeboard for river embankments is to be calculated taking into account, wave heights, wind set up, settlement of the embankment after construction, and a surcharge to cover a number of uncertainties in the calculation of the design water levels. These uncertainties are in the field of hydrology and hydraulics (short data time series available), analysis methodologies, quality of the ISIS model etc. At this stage, we have opted for a freeboard of 1.00 m.

(vi) Fixation of both starting and ending points of a possible diversion canal with reinforced concrete sills and scour protection at both sides of the sill.

(vii) Borrow areas for soil required for embankments would be acquired under the project and would be either directly from strips of land along the embankment alignment or from elsewhere; from the community consultation that was undertaken it came out that the population prefers to lose as little of their land as possible, indicating that it would be advisable to seek borrow pits not along the alignments but elsewhere.

(viii) Borrow areas would be excavated to a depth of 3.00 m, which determines the borrow pit area to be expropriated for the project.

(ix) Land acquisition for river embankments and for the potential diversion canal has been calculated on the basis of the width of the embankments along the river plus 2.00 m for right of way and for the potential diversion canal a strip of 10.00 m between the canal section and the canal embankment wherever the canal is partly in fill.

(x) Relocation of people and property has to be avoided to the maximum extent by selecting alignments for embankments and the potential diversion canal in such a way that it does not lead to relocation of people or commercial properties; this seems a reasonable assumption since the area is not densely populated.

5.7 Cost estimate of works

The cost estimate of works that figure in the proposed IFRM Plan is based on the following assumptions:

(i) Compacted earth fill in embankments with earth coming from borrow areas at a maximum of 10km haulage distance from borrow pits is priced at USD 2.00 per m^3. This is based on a April 2009 Engineer's Estimate for a major road project in Lao PDR that established unit rates of work items in sufficient detail;

(ii) Earth excavation and disposal in depot is priced at USD 1.50 per m^3 (same source);

(iii) Rehabilitation or new construction of gates at USD 750,000 each;

(iv) Pump stations at USD 300,000 each;

(v) Feasibility study, including field surveys, at a price of USD 1.5 mln if no diversion canal needs to be investigated, otherwise USD 2 mln;

(vi) Surveys and designs of embankments and canal options at USD 1.050 per km;

(vii) Surveys and design of sluice gates and pump stations at 1.5% of the estimated investment cost;

(viii) Contingencies for as yet unknown or unquantifiable work items that will be necessary for example bridges and small but gated culverts, have been taken at 20% of total costs before contingencies.

Table 5-5 Cost estimates for works, without and with diversion canal options.

Item	rate	No canal	Diversion Canal				
			100m	125m	150m	175m	200m
Earth work (excav. and cc)	2	19.7	17.4	14.9	12.8	11.5	10.2
Earth work (excavation)	1.5	-	3.6	5.6	8.1	11.4	15.2
Sill and div. canal		-	2.0	2.3	2.5	2.8	3.0
Control gates and drains		3.8	3.8	3.8	3.8	3.8	3.8
Pumping stations		2.4	2.4	2.4	2.4	2.4	2.4
Feasibility Study	LS	1.5	2.0	2.0	2.0	2.0	2.0
Survey & Design (dykes)	1,050	0.1	0.1	0.1	0.1	0.1	0.1
Survey & Design (gates /drains)	1.50%	0.1	0.1	0.1	0.1	0.1	0.1
Land acquisition		1.0	1.1	1.0	1.0	0.9	0.9
Relocation costs	PM		-	-	-	-	-
Contingencies	20%	5.7	6.5	6.4	6.5	7.0	7.5
TOTAL		**34.3**	**38.8**	**38.6**	**39.3**	**41.9**	**45.2**

5.8 Project phasing

For the implementation of the plan it could be sub-divided in a number of projects at provincial or district level and in phases. For project preparation and implementation the embankments it would be best to 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.

CHAPTER 6

PUBLIC PARTICIPATION IN PROJECT PREPARATION

6 PUBLIC PARTICIPATION IN PROJECT PREPARATION

6.1 Public Participation strategy

The objectives of the Public Participation strategy in Stage 2 were to:

(i) Develop Public Participation Plan for the structural flood protection measures demonstration projects to ensure inputs from stakeholders are incorporated in the design and that any potential negative impact on stakeholders is minimised;

(ii) Prepare Best Practice Guidelines to help the facilitators in conducting Public consultation exercises;

(iii) Train staffs of NMC and Line Agencies in facilitating public participation during the implementation of the demonstration project.

6.2 Public Participation Plan

A Public Participation Plan for the Lower Xe Bang Fai Demonstration Project has been prepared (see Appendix 4). Internal and external stakeholders with an interest in the development of integrated flood risk management plans for the Lower Xe Bang Fai area were identified. The following key stakeholders from Line agencies, communities and other organisations were to be consulted:

1. Department of Irrigation;
2. Department of Hydrology & Meteorology;
3. Department of Water Resources;
4. National Disaster Management Office;
5. Lao National Mekong Committee;
6. Department of Land Use;
7. Water Resource and Environment Research Institute (Newly formed);
8. Department of Waterways;
9. National Disaster Management Committee;
10. Social Welfare Council, Thakek and Nongbok;
11. Community at Sok Boe and Hatsai Phong Village;
12. Water user association vice chief at Tan Theung Village.

6.3 Best practice guideline

A Best Practice Guideline for Integrated Flood Risk Management, Planning and Impact Evaluation was prepared [Ref. 5], which discusses the processes and methods involved in public participation and stakeholder consultation.

6.4 Training of NMC and Line Agencies in facilitating public participation

In Lower Xe Bang Fai, representatives from LNMC and district Line Agencies were trained to facilitate community consultation on getting feedback on structural measures for flood protection. A ‘community consultation facilitation guide’ was also prepared and translated into Lao language and the Line Agencies representatives were trained to facilitate community consultation (see Appendix 5).

6.5 Stakeholder consultation

The consultation was done in two days by four teams consisting of 3 to 4 members each from Line agencies. A total of 16 villages were selected, which accounts for 22% of the 72 villages in Nongbok District. The villages were selected based on their vulnerability characteristics. Since the villages on the levee are prone to flooding than villages in hinterland, 12 villages on the levee were selected and the other 4 villages selected were hinterland villages. The consultation helped in validating the assumption regarding benefits and concerns of the communities when the project is implemented.

The Line agencies representative from Nongbok District highlighted the following hazards and problems:
- flood is the main hazard as it damages crops, riverbanks, roads and irrigation infrastructure;
- the other important problems identified by the line agencies are marketing agricultural produce, especially rice and disease outbreak during the floods.

The preferred solution according to the line agencies representatives when the demonstration project can be implemented is:
(i) Increasing irrigation in the dry season in order to increase area under cultivation and provide economic benefit to the farmers, followed by:
(ii) Construction of flood protection embankment along the right bank of Lower Xe Bang Fai River together with adequate drainage and pumping.

If structural measures are not implemented due to lack of funding, the Line agencies representatives would want to see:
(i) Improvement in the existing irrigation infrastructure;
(ii) Improvement in access to credit for micro-enterprise development such as pig rearing; and
(iii) Encouragement for alternative crops like tobacco, vegetables apart from improved rice seeds and marketing support.

6.5.1 Feedback from line agencies

At this stage, the idea of the project is still abstract and hence a very detailed feedback cannot be expected. Despite this, people provided comprehensive feedback which demonstrates their understanding of the problem in the area and a feel for priorities.

The structural measures with flood protection embankments along the right bank of Xe Bang Fai River with flood control gates and drainage canals will make the area flood free and hence will protect the village assets like schools, offices, irrigation infrastructure apart from the houses, people and livestock. It will increase livestock grazing area and increase productivity of both livestock and crops as there will be reduction in diseases and better care and management will be possible.

On the negative side, the fear is that it might reduce the amount of fish and hence will affect people who depend on fishing for their livelihoods. Erosion to riverbank might increase as the water level in the Xe Bang Fai will increase because of the embankment and in the event of a big flood and breach of the embankment, it could cause heavy damage in the area. Some of these concerns could be addressed in the design of the embankment and drainage channel construction.

There could be loss of fertilisation effect of the floods, if the area is made completely flood free through polder development. Hence, appropriate agriculture development should be looked into that will protect and build on soil structure and fertility rather than destroying it due to intensive cultivation.

6.5.2 Feedback from communities

All groups in the 16 villages opted for the Alternative 2, which is construction of embankment along the right bank of Xe Bang Fai River with drainage and flood control gates.

In Xe Bang Fai, the attitude of the people is to reduce the existing risk and damage of flood and to have a modest improvement in livelihood opportunities:

(i) Dyke, flood control gates and irrigation system are very important for them to reduce exposure of flood to the agriculture areas.

(ii) Irrigation system maintenance will become easier and this will reduce the cost of electricity and irrigation.

(iii) Most of the villages are too close to the Xe Bang Fai River and hence they cannot be protected by an embankment, although women would prefer to protect the village as well. The men would want to protect the agriculture land and live with floods in the village for few weeks. However, women demand that all the families in the village have boats, medicine, and safe shelter to move to during the floods and remain disease free. They are not prepared to move as they are already on the higher ground.

(iv) Some villages like Dong Sangam can be protected by embankments and this option should be explored.

(v) Embankments around the village (small polder) option can be explored. In this case, the embankment should be higher than the embankment that protects agricultural land.

(vi) Land acquisition for embankment construction is a concern and they would prefer to be compensated with land rather than cash.

(vii) Impact on fishing and environment was not expressed clearly by the communities. They thought that the amount of fish might be reduced. They were aware of fish migration and breeding and that majority of it takes place in the ponds in the floodplains.

Since the embankment will not protect the village from flooding, as it will be built between the village and the agricultural land on the existing road, it will be important to integrate non-structural measures and create opportunities to increase the number of boats in the village for vulnerable groups to move to neighbouring village with their belongings.

They are ready to participate in the construction of embankment and some are also willing to contribute land if it is a small portion. They are also willing to contribute labour for the construction of the embankment.

CHAPTER 7

SOCIAL IMPACT

7 SOCIAL IMPACT

The different structural measures, as presented above have important impacts on the communities.

Land acquisition and resettlement
The embankments along the Xe Bang Fai, and partly the Mekong River, will be constructed or heightened. Because of their relatively elevated position, these riverbanks are the areas where population is concentrated. Land acquisition and resettlement are important issues in this case. During discussions with the communities, the local population expressed their preference to build the embankments on the location of the present roads. However, this option will entail land acquisition of a minimum 7 to 8 m per meter embankment. Construction of a diversion canal will entail additional land acquisition and resettlement, as well as loss of some agricultural area.

Human health and safety impacts
Overall the project will have a positive impact on human health and safety. People will be better protected against flooding. Floods will last shorter and food (rice) production, and so food security, will increase. This is not the case for the amount of fish available in the flood season, as this will be greatly reduced. Reduced flushing and dilution of polluted water at the end of the dry season may pose a threat to human health. Reduced flood risk will also reduce the contamination of wells, improving the sanitary conditions.

Construction activities are another threat to health and safety for a variety of reasons: emission of dust, fumes, noise and vibration from construction sites and access roads, increased traffic and workers accidents. Inflow of workers from other areas also increases the risk of a spread of HIV/AIDS.

Socio-economic development
With a reduced flood risk, the overall socio-economic environment and development is expected. Socio-economic development is expected based on the increased agricultural production and the trade of the products.

CHAPTER 8

INITIAL ENVIRONMENTAL EXAMINATION

8 INITIAL ENVIRONMENTAL EXAMINATION

Embankment schemes for flood risk management may have considerable impacts on the ecosystems of the floodplains. As described above they sustain the livelihood of the local populations. Appendix 6 presents the results of an initial environmental examination in detail. The potential environmental impacts of structural flood risk management measures can be summarised as follows:

Destruction of natural habitats, valuable resources

(i) Provision of full flood protection, keeping out the floods, will have a detrimental effect on the wetland habitats, the more so when combined with improved drainage. A large proportion of the wetlands will dry out and the floral species composition will change drastically. This will have a negative impact on the value of these ecosystems as a habitat for wetland dependent fish and birds; they will decrease greatly in numbers or disappear completely. When not flooded anymore, the function of the floodplain as a dry season refuge for 'Black fish' and a wet season fish spawning and nursing area (for both 'Black' and 'White fish') will be lost.

(ii) Indirect impacts of reduced flooding will also be considerable. Better protection of the area will increase the value of the land for agricultural production and hence will increase the pressure on the presently non-cultivated areas.

(iii) Other important habitats in the project area are pools and slow water stretches in the river. These are not expected to be affected by the project.

Loss of biodiversity, rare and endangered species

(i) Reduced flooding will have a significant negative impact on the biodiversity in the area, in number of species as well as in number species' representatives. Species composition of flora and fauna will change and the diversity and extent of water bodies and swamps in the floodplain will decrease.

(ii) A decrease in number or area of the floodplain lakes, or even a later arrival of the floodwater, results in drying out of the floodplain lakes and ponds or the development of very poor water quality conditions and ultimately in a loss of species like snakehead, mud perch, spiny eels, climbing perch, walking catfish, and gouramies.

(iii) The survival rate of 'Black fish' in the floodplain will decrease considerably and lateral migration to spawning and feeding areas in the floodplain will be impossible for 'White fish'.

Loss of environmental services

(i) Flooding and the related sustenance of wetlands are known to have a number of benefits, these benefits may disappear or decrease if flooding is prevented or diminished.

(ii) Reduced flooding will reduce the replenishment of groundwater and surface water bodies with flood water. This will affect the wetland ecology, but also the amount of surface and ground water available in the next season. Of importance is also that not only the available quantity will be affected, but also the quality of the water. Pollutant concentrations increase in the course of the dry season and flooding flushes these pollutants out or reduces the concentrations to harmless levels. Reduced flooding will result in a deterioration of the water quality in the area.

Impact on Fisheries

(i) As described before, reduced flooding of the floodplains will have a significant negative impact on fish stocks, both on the floodplain itself and in the river.

CHAPTER **9**

COST BENEFIT ANALYSIS

9 COST BENEFIT ANALYSIS

9.1 Project costs

The project cost estimate and the assumptions made are presented in Section 5.7 and are summarised in Table 9-1.

Table 9-1 Cost estimates for works, without and with diversion canal options.

Item	rate	No canal	Diversion Canal				
			100m	125m	150m	175m	200m
Earth work (excav. and cc)	2	19.7	17.4	14.9	12.8	11.5	10.2
Earth work (excavation)	1.5	-	3.6	5.6	8.1	11.4	15.2
Sill and div. canal		-	2.0	2.3	2.5	2.8	3.0
Control gates and drains		3.8	3.8	3.8	3.8	3.8	3.8
Pumping stations		2.4	2.4	2.4	2.4	2.4	2.4
Feasibility Study	LS	1.5	2.0	2.0	2.0	2.0	2.0
Survey & Design (dykes)	1,050	0.1	0.1	0.1	0.1	0.1	0.1
Survey & Design (gates /drains)	1.50%	0.1	0.1	0.1	0.1	0.1	0.1
Land acquisition		1.0	1.1	1.0	1.0	0.9	0.9
Relocation costs	PM		-	-	-	-	-
Contingencies	20%	5.7	6.5	6.4	6.5	7.0	7.5
TOTAL		**34.3**	**38.8**	**38.6**	**39.3**	**41.9**	**45.2**

9.2 Project benefits

9.2.1 Flood risk reduction

From the flood risk assessment (See section 3.6) for Nongbok District the flood risk for all the flood prone areas has been extrapolated, the resulting total flood risks are presented in Table 9-2.

Table 9-2 Flood risk in Nongbok District and total risk in the whole flood prone area.

Expected damage reduction (M USD/year) for Nongbok District				Expected damage reduction (M USD/year) for whole flood prone area				Total
P(%)	Infrastructure	Housing	Agriculture	P(%)	e	Housing	Agriculture	
1%	0.36	0.01	2.58	1%	0.75	0.03	5.36	6.14
4%	0.31	0.01	2.24.	4%	0.67	0.02	4.74	5.43
10%	0.25	0.01	1.74	10%	0.54	0.00	0.00	0.54
50%	0.08	0.00	0.47	50%	0.18	0.00	1.08	1.27

9.2.2 Agricultural benefits

There would be no incremental net benefit from crop cultivation due to the proposed IFRM Plan. Though development potential for irrigation systems exist, these would be independent of flood protection measures and should therefore be economically feasible on their own.

9.3 Reduction of flood benefits

9.3.1 Impact on fisheries

Under controlled-flood conditions, the natural fish production will be reduced. It is presently extremely difficult to quantify the impact of the structural measures on the natural fish production. Under full-flood protection it might be drastically reduced.

In order to mitigate the impact of floodplain reduction, institutional agreements on accepting controlled flooding in the area, water levels in the natural reservoirs, protected spawning zones and period could be negotiated and enforced.

The loss of fish production in the area could be compensated by intensive aquaculture.

9.3.2 Other ecosystem services and goods

Supply of other ecosystem service and goods, such as timber, might be reduced by the structural measures and the related flood reduction. For the time being no exhaustive identification of the different services and goods contributing directly or indirectly to the livelihoods of the communities living in the immediate or extended neighbourhood of the flood-plain ecosystems has taken place. Additionally, very little is known about the contribution to the community's cash and non-cash livelihood.

Table 9-3 Categories of ecosystem services and goods.

Supply services	**Regulation services**	**Cultural services**	**Support services**
Food; Water; Wood; Fibres; Medicinal resources.	Climate; Flood; Diseases; Water quality.	Spiritual (sacred springs and forests); Aesthetical; and Recreational benefits.	Soil formation; Pollination; and Nutrient cycle.

Supplementary research is required to make a conclusion on this issue and to propose mitigation actions. For example, very little is known about the impact of flood on diseases and pest control, on the soil formation, on the groundwater level and groundwater quality, and on sustaining the local biodiversity providing pollination services.

Qualitatively, one can expect that with the flood reduction and the related reduction of the ecosystems (in surface and in biodiversity), particular services and goods will diminish or even disappear (production of natural fibres such as long grasses and timber, access to natural medicinal healing products, diseases and pest control, soil formation).

The loss of these services and goods will have to be replaced by artificial measures that will have to be bought on the market.

9.3.3 Water supply and sanitation

Except for the district town, which has its water treatment and supply grid, the rural water users extract water from wells or straight from the river. This water is not treated before consumption.

The impact of a flood reduction on the ground water level and ground water quality is unknown.

The flood-reduction will reduce the overflow of the pit latrines. This will reduce the contamination of wells and the spread of diseases during flood periods

9.4 Economic analysis

First a cost benefit analysis was performed on the basis of annuities of flood risk reduction benefits and costs, this resulted in B/C ratios smaller than 1 for high probabilities of exceedance but larger than 1 for the lower probabilities of 1% and 2%.

We therefore have selected the 1 in 100 year protection level in a cash flow calculation with the following assumptions on the cost side:

- construction takes place in five years with a distribution of the investment of 10%, 25%, 30%, 25% and 10% respectively;
- annual O&M at 2.5% of investment;
- replacement of electromechanical equipment (pumps and gates) after 15 years;
- a Standard Conversion Factor of 0.85 to arrive at the economic price of the works (removing transfer payments like taxes, subsidies, land acquisition; and shadow prices);
- a discounting rate of 10% for the calculation of the Net Present Value (NPV) over a period of 30 years.

At the benefit side, we have assumed that 50% of the risk reduction is achieved after implementation of the first phase from year three and achieves its full potential in year five.

The resulting economic internal rate of return of the project amounts to 19.9%, the Net Present Value is estimated at USD 17.9 mln.

We have tested the economic feasibility of the inclusion of a diversion canal, to find optimum canal dimensions. We have varied the width of the canal, starting with a bottom width of 100 m and bottom level of 140 m amsl, in steps of 25 m up to a canal with 200 m bottom width and invert of 136 m amsl. This was simulated in the ISIS XBF model in all cases with embankments along the river. The economic optimum for the canal appears to be 125 m bottom width and invert of 139 m amsl. The total costs however would increase to USD 38.6 mln as compared to the situation without a diversion canal; the EIRR is calculated at 17.3%.

In view of the preliminary nature of the engineering of the works, the above figures rather present an order of magnitude; a feasibility study with field surveys etc, is needed to estimate the works more precisely and to confirm the economic analysis.

CHAPTER 10

INSTITUTIONAL DEVELOPMENT

10 INSTITUTIONAL DEVELOPMENT

10.1 Present situation

Appendix 7 presents the administrative levels in the water sector in Lao PDR. A description of their water related responsibilities is presented in Table 10-1.

Table 10-1 Lao PDR-Institutional Tasks, Responsibilities, Activities, Mandate.

Institution	Water-related responsibilities
Lao National Mekong Committee	• Advise the Lao representative to the MRC Council on all matters relating to activities within the Mekong River Basin that could affect Lao PDR interests; • review proposals prepared by Lao agencies in the light of the Mekong Agreement; • provide coordination between MRC and concerned ministries of Lao PDR Govt.
Water Resources and Environment Administration (WREA)	• Define policies and develop strategies for water resources; • research and investigations of water resources; • prepare plans for water resources development and conservation; • flood forecasting and warning; • manage direct and indirect water resource use; • collect and manage data and information about surface water, groundwater, and meteorology; • administer international collaboration, including that within the Mekong River Basin (hosts Lao PDR NMC); • Protection of natural resources and environmental quality from degradation; • water quality monitoring and pollution control, including monitoring wastewater discharges and issuing permits; • disseminate water-related information.
Water Resources Coordination Committee	• coordinate national water resources utilisation; • develop a new national water resources strategy; • drafting of River Basin Profiles; • advice on/general review of the Law on Water & Water Resources (LWRR) and the Decree on Implementation of the LWWR; • advise on the set-up of River Basin Organisations; • provide technical advice on relevant issues.
Ministry of Energy and Mines (MEM)	Water-related responsibilities include: • planning hydropower development; • administration of single-purpose schemes for hydro-power; • planning industrial water use.

Institution	Water-related responsibilities
Ministry of Public Works and Transport (MPWT), including - Dept. of Housing &Urban Planning - Roads Dept.; - Waterways Dept.;	Water-related responsibilities include: • urban drainage and sewerage systems; • partial role in flood management/bank protection works; • study, survey and construction of river works for navigation and water transport; • monitoring hydrography, hydrology and hydraulics along Mekong mainstream and major tributaries; • construction of roads, interaction roads and floods in floodplains and flood prone areas; • domestic water supply and urban sanitation.
Ministry of Agriculture and Forestry (MAF)	Water-related responsibilities include: • planning & implementation of irrigation, drainage and rural flood control; • develop policies and strategies for agriculture, forestry and fisheries related to the management of water resources; • watershed management; reforestation, manage forests; • fisheries-related impacts of regulation and other interventions.
Ministry of Finance (MoF)	MoF is responsible for the national budget and the Public Investment Programme. Water-related investments can be proposed by various ministries/departments, and MoF has the role of harmonising proposals, and matching them against the national investment priorities.
Ministry of Planning and Investment	National 5-year socio-economic development plans; overall national planning and coordination.
Ministry of Health	Health related issues of water resources development, water supply and sanitation; health related impacts of floods and other disasters.
National Land Management Authority	Responsible for land-use planning, land title registration and (urban) master planning. No flood mapping and/or flood risk management.
Ministry of Labour and Social Welfare/National Disaster Management Committee/Office (NDMC/NDMO)	• improve disaster/flood preparedness; • provide disaster/flood relief; • provide disaster/flood early warning; • emergency response planning; • collection of flood damage data/info; • increase public awareness; • centre for DM information & training.
Lao Red Cross	• provide disaster/flood preparedness; • provide disaster/flood relief; • provide disaster/flood early warning; • collection of flood damage data/info.
Municipalities, viz. Vientiane	Large municipalities are responsible for drainage and sewerage within their area of jurisdiction. Example: Vientiane Urban Drainage Administration (VUDA).
Development committees	Development committees at provincial, district and village levels have responsibility for socio-economic development initiatives. In some, water-related initiatives may be included, particularly with regard to water supply and sanitation.
Note: Some management and planning functions are made in collaboration between several agencies, each supplying expertise and data *All ministries are involved in awareness-building and HRD*	

Water Users Associations (WUA) have organised themselves around the irrigation schemes to manage the water input and the pumping stations. It appears that these institutions are too weak in terms of capacities at the moment because most of the stations are in poor working conditions.

In the area, wetlands and wetland fisheries are managed by communities to conserve these ecosystems, to maximise the productivity of the associated fisheries, and to ensure that all members of these communities share the benefits obtained from these management systems. These systems of community wetland and fisheries management in the floodplains of the Xe Bang Fai Basin are diverse. It should be noted that even within these systems there are various wetland microhabitats that are managed and used in different ways depending on environmental and social conditions. The full variety of management systems being utilised by communities in the Xe Bang Fai Basin cannot possibly be described here.

10.2 Development

10.2.1 Strategy and Policy setting

Before project conceptualisation, societal choices are to be defined, and trade-offs are to be negotiated amongst the different stakeholders, with the "two ends of the cable"-knowledge of decision impacts. To the consultants knowledge no clear societal choices translated in development policy strategy for the area have been formulated yet.

This report shows that there is still little known about the multiple assumed impacts of the infrastructural measures on environment and society. Much more research is required to identify the different interrelationships between the environment and the different communities in the Xe Bang Fai and in the Mekong Basin as a whole.

The proposals as they have been presented suppose societal choices to sacrifice in-land fish stock and other flood-dependant ecosystem services and goods for the benefits of agriculture. Local populations might not fully agree with this extreme approach. Negotiated intermediate, more creative solutions might need to be developed in order to achieve more win-win conditions. A win-win situation could be achieved by optimising not only agricultural land use, but also the existing inland water bodies. To do so, embanking the inland water bodies and the smaller rivers connecting them to the Xe Bang Fai and the Mekong could create inland water storage reservoirs for dry season irrigation and fisheries. This is a societal choice that could be made.

For the time being, one can conclude that the project results endeavoured by the 2 proposals have not yet been identified and quantified, mainly because of the weak and incomplete knowledge of the possible impacts of the project.

Participation of the local stakeholder in the decision making process and planning is one of the milestones in IWRM. The consultant can't conclude on the level of participation for the two proposals developed in this document.

10.2.2 Management of infrastructure

For risk reduction in the Lower Xe Bang Fai, two projects of creating polders in the area have been proposed in the past. Even if not explicitly mentioned in the proposals, the management of the structural measures suppose that the yearly flood will be controlled and avoided, with gates and pumping stations. This means that the situation will evolve from a naturally imposed and occurring flood, towards a flood-free situation, managed with a drainage system. Contradictory interests between land-users will most likely enter into conflict, which can escalate to important social conflicts.

As the flood will be controlled through structural measures, the following questions ought to be addressed:

- *"When should the water recession start?"*
- *"When will the yearly artificial drainage period start (with pumping stations)?"*
- *"What are acceptable water levels in the area?"*
- *"At which pace should the water recession occur?"*
- *"How will it be managed and financed?"*
- *"By whom?"*

These aspects stress the importance of an Integrated Management considering the different water-, land- and environment uses, and of the institutional development that ought to go hand-in-hand with the construction of the structural measures.

In order to get a feeling of the different benefits and losses caused by the structural measures, it is advised to simulate the different productions in the area under the new conditions, (different agricultural crops, fish, wood, etc.), together with the real stakeholders in functions of the different decisions taken regarding the flood occurrences and recessions. This will allow the local stakeholders to experience all benefits and losses.

It allows as well simulating particular institutional arrangement that can reduce certain impacts. Respecting agreements related to controlled-flooding, water inlet in natural reservoirs, protected spawning areas and periods and the use of adequate fishing gear with large-mesh, can for example reduce the loss of fish stock due to flood reduction.

IWRM supposes a participation and collaboration of different stakeholders to undertake collective actions, aiming at a collective goal. Therefore, trust, based on previous collaborative experiences between the different actors, is to be reinforced and consolidated. It is a partnership for a collective action that is to be established. The building of the partnership starts at the conceptualising stage. At this early stage it is important to identify for all the stakeholders what the costs and benefits are to them to participate in the collective action.

The consultant stresses this aspect because weak institutional experience in stakeholder participation is often a cause for the overestimation of the local stakeholders' buying-in and appropriation of the project. Participation of the local stakeholders is crucial for the project's sustainability.

From the existence of a local Water Users Association, presently managing the dying irrigation schemes, it appears that the project area already has experience in participative management. However, their institutional capacity appears to be insufficient. This is partially demonstrated by the non-sustainable exploitation and management of the existing irrigation schemes.

10.2.3 Agricultural extension services

As identified in different sections in this report, a qualitative extension service is a precondition for the successful land-use change to cropping commercial cash-crops.

Knowledge and capacity building will be required in:

1. Production practices such as pest control, nutrient management, water management;
2. Agriculture marketing and contract negotiation, including provision of market information, production planning, distribution and sale.

CHAPTER **11**

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APPENDICES

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1. Introduction

This Report deals with flood hazard assessment for combined floods in the Lower Xe Bang Fai. Combined floods refer to flooding in the downstream parts of tributaries in the vicinity of the Mekong caused by large discharges from the tributaries backed up by high water levels in the Mekong. The general procedure used in such cases is presented and its application to the Xe Bang Fai is discussed.

The set-up of this Report is as follows. The procedure for flood hazard assessment for combined floods is outlined in Chapter 2. A description of the Xe Bang Fai Basin, its hydraulic infrastructure, hydrological monitoring system and data availability is given in Chapter 3. The hydraulic model used for the simulation of the floods in the Xe Bang Fai Basin, the river and floodplain schematisation and applied boundary conditions are presented in Chapter 4. The hydrological hazard assessment is dealt with in Chapter 5, followed by the results of the simulations and of the flood hazard assessment in Chapter 6. Conclusions on the computations and analyses are drawn in Chapter 7 with recommendations on the application of this procedure for other areas.

2. Flood Hazard Assessment for Combined Floods

2.1 General

The procedure for flood hazard assessment in case of combined floods is discussed in this chapter. It deals with the creation of flood levels and flood extent of selected return periods as well as flooding depth and duration. Subsequently, flooding depth and duration are combined with land use information to determine the losses and benefits (social, environmental and economic) of the flooding, which is discussed in a separate volume.

2.2 Outline of procedure

The procedure applied to assess the flood hazard 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 Xe Bang Fai catchment:

- the maximum discharge in the Mekong River at Nakhon Phanom, near the Xe Bang Fai River mouth at That Phanom;
- the total volume of the flow in the Mekong River at Nakhon Phanom; and
- the total volume of the flow in the Xe Bang Fai River at Mahaxai.

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. This can be considered as a synthetic series of *N* years, where each sampled combination of random variables describes the main hydraulic features of the flood season in a single year.

For each combination/year the hydraulic model of the Lower Xe Bang Fai based on ISIS is applied to derive the relevant hydraulic features like maximum water level at a number of locations in the Xe Bang Fai area. Formally, this means that the hydraulic model should run *N* times, but since *N* is generally quite large (100,000 in this case) and would require such a long computation time that the procedure would become unpractical. Instead, the hydraulic model is run for 90 different combinations of the three random variables that basically cover the whole spectre of possible outcomes. The results of the 90 simulations are stored in a database. Results of the *N* Monte Carlo runs are then determined by interpolation of the results of the 90 simulations. Since 3 random variables are involved, the interpolation is 3-dimensional.

The procedure above results in relevant hydraulic features at a number of locations in the Xe Bang Fai area. Based on economic analysis it is also possible to estimate the damage for each simulated year. The next step is to derive the probability of exceedance of threshold values of the damage. For Monte Carlo techniques this is a relatively straightforward procedure. Suppose the threshold damage D^1 is exceeded in 100 out of N simulations, the estimated probability of exceedance of D^1 is equal to $100/N$. Similarly, if another threshold value $D^2>D^1$ is exceeded in 10 out of N simulations, the estimated probability of exceedance of D^2 is equal to $10/N$. Repeating this procedure for a range of threshold values provides a relation between damage on one hand and exceedance probability on the other hand. Figure 2-1 gives an example of what such a relation might look like.

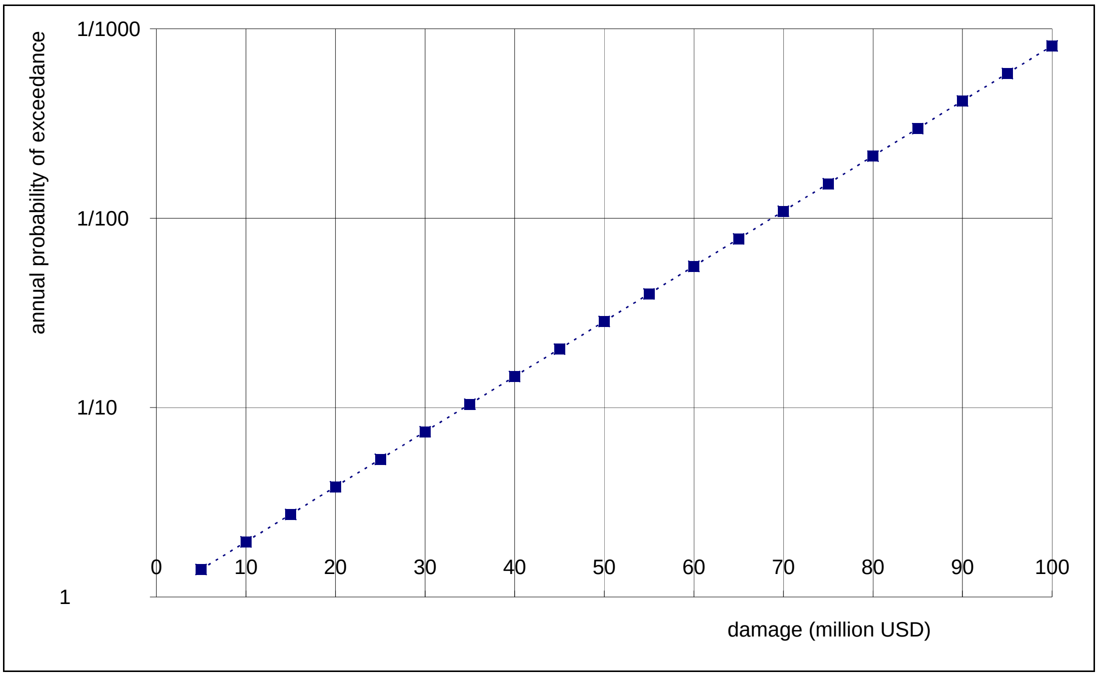


Figure 2-1 Hypothetic relation between damage and annual probability of exceedance.

The last step in the procedure is to derive the *T*-year flood event. Using damage as the criterion, the *T*-year flood event is defined as:

"The threshold damage D_T which has a probability of exceedance of p=1/T per year"

The availability of a relation as shown in Figure 2-1 enables the determination of the T–year flood, i.e. the *T*-year damage. For example the 100-year damage D_{100} can simply be derived by checking were the dotted line crosses the horizontal threshold of *p*=1/100. In the example of Figure 2-1 this occurs at around 70 million USD, so D_{100} = 70 million USD.

Notes:

- Instead of damages other criterions can also be defined to derive the *T*-year flood, such as the maximum water level. In that case one needs to derive a water level that has an annual exceedance probability of 1/*T*. The same procedure as above can be applied, i.e. exceedance probabilities for a range of threshold water levels which need to be derived.
- The procedure needs to be applied separately for each location in the area in which one is interested. This is because the relation between the three random variables on the one hand and the resulting maximum water level or damage on the other hand may vary significantly from one location to the other.

3. Basin Description

3.1 General

The Xe Bang Fai has been selected by LNMC as focal area for IFRM (Integrated Flood Risk management) in areas with combined floods, i.e. flood levels in tributaries affected by backwater from Mekong.

3.2 Basin description

The Xe Bang Fai takes its rise in the Annamite mountain range near to the border with Viet Nam west of Thakhek and joins the Mekong at rkm 1,166, opposite of the city of That Phanom in Thailand. The river drains an area of 10,240 km^2. On its rise it is joined by the Nam Phanang, Nam Hue with major tributary Nam In, Nam Gnom or Nam Kathang, and just upstream of Mahaxai by Nam Phit. Downstream of Mahaxai the river Nam Oula and finally the largest tributary Se Noy, with its headwaters Nam Meng and Se Bay, discharges to the river. The Se Noy drains upstream of station Ban Xe Bang Fai/National Road Nr 13 South (NR13S) Bridge. The upper basin is steep, but below Mahaxai the river slopes are small and the reach from 10 km downstream of Mahaxai to the mouth is affected by backwater from the Mekong (Figure 3-1 and Figure 3-2). The strongly meandering Xe Bang Fai near the confluence opposite That Phanom is shown in Figure 3-3.

At Mahaxai the Xe Bang Fai drains an area of 4,520 km^2 or about 44% of the basin. At station Ban Xe Bang Fai or NR13S Bridge the upstream drainage area amounts 8,560 km^2, which is 84% of the basin.

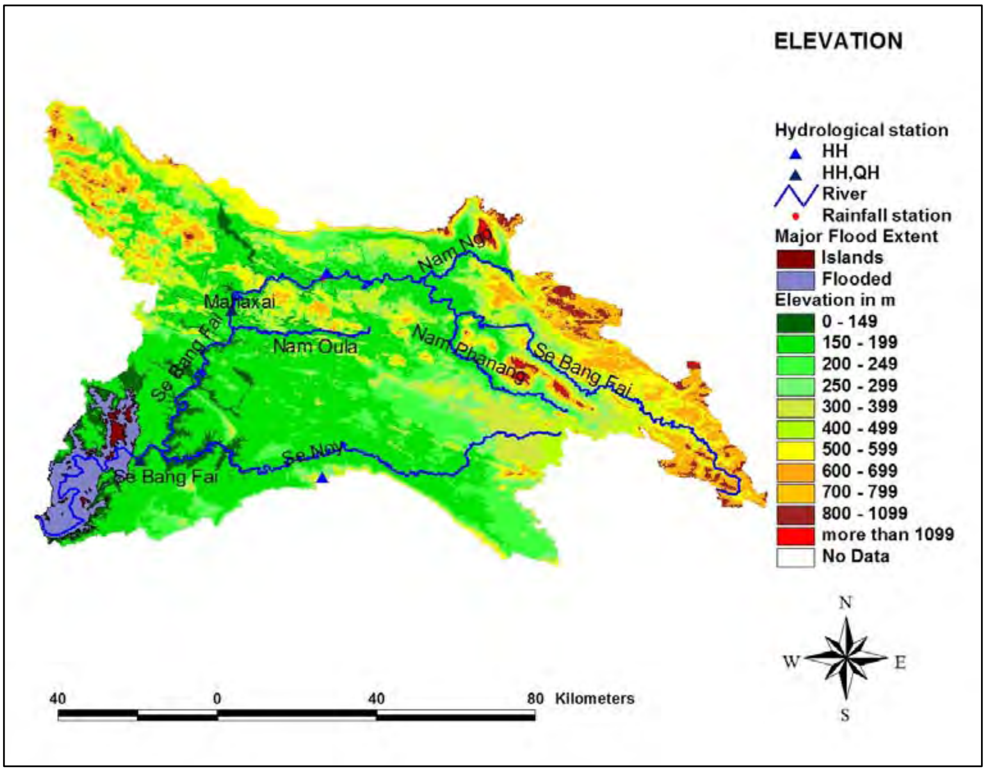


Figure 3-1 Elevation map of Xe Bang Fai Basin.

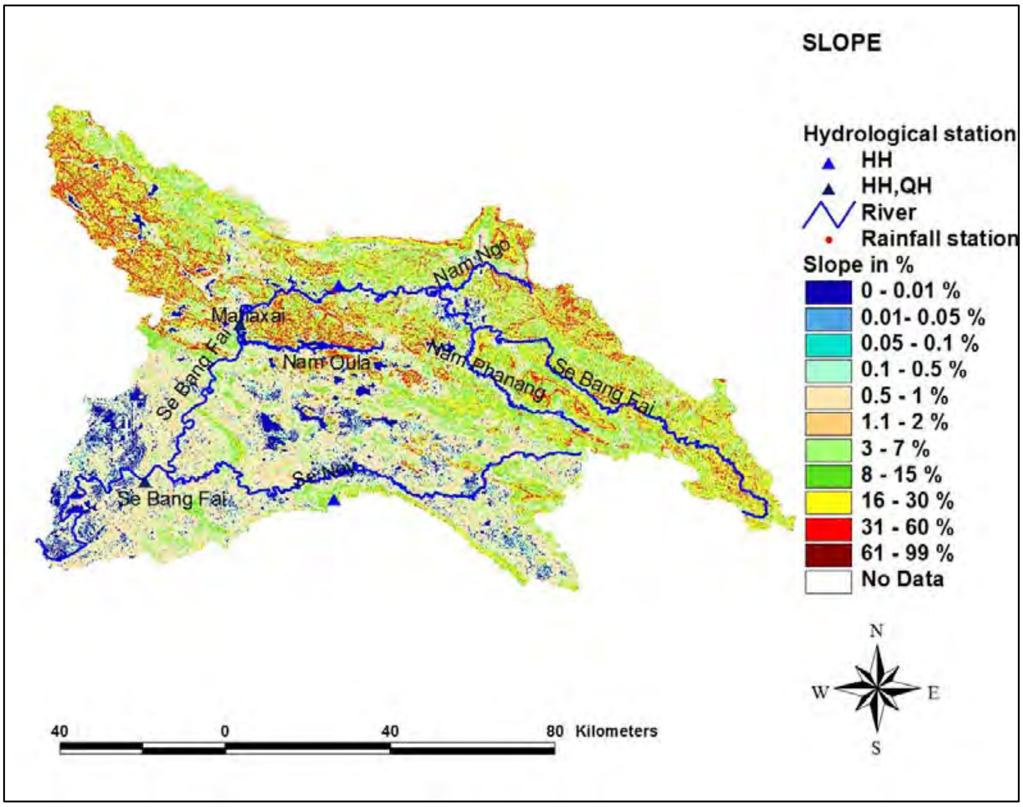


Figure 3-2 Xe Bang Fai slope map.

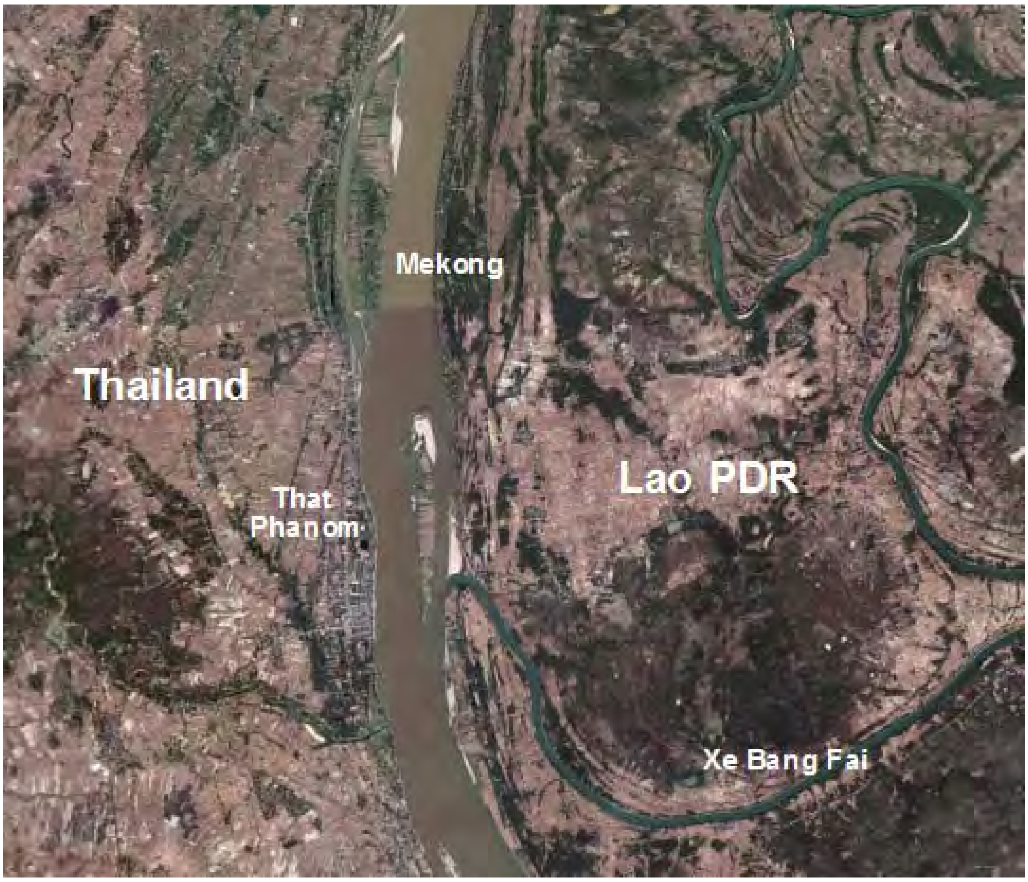


Figure 3-3 Confluence of Xe Bang Fai with Mekong opposite That Phanom.

In December 2009 the Nam Theun 2 Hydro-electric Project will be put in operation (ADB, 2004). The Project will dam the Nam Theun near Ban Sop Hia in Khammouane Province and its average annual flow of 220 m^3/s will be diverted to the Xe Bang Fai. The Nam Theun water will be stored in the Nakai reservoir with a total capacity of 3.91 BCM. Water from the reservoir will drop about 350 m through a tunnel to a power station located at the base of the Nakai escarpment. From here the water will flow into an 8 MCM regulating pond controlled by the Regulating Dam (see Figure 3-4). From this dam water flows towards the Xe Bang Fai mainly via a 27 km Downstream Channel, which lower tail combines with the Nam Pith, and a small part is discharged to the Nam Kathang at a rate equivalent to the current natural flow. The planned variation in the release from the Regulating Dam is between 315 and 60 m^3/s on weekdays and a constant 60-75 m^3/s on Sundays. As can be observed from Figure 3-4, the inflows from Nam Theun take place upstream of Mahaxai.

Figure 3-4 Schematic layout of trans-basin diversion from Nam Theun to Xe Bang Fai.

3.3 Problem description

Xe Bang Fai River and floodplains near the confluence with Mekong are shown in Figure 3-5 and Figure 3-6. Flooding takes place in the districts Thakhek, Nongbok, Xe Bang Fai and Mahaxai. Major flooding takes place between the Mekong and NR13S, north of Xe Bang Fai River (see Figure 3-7). Lowest areas are 140 m amsl, whereas Nongbok Village is flood free at an elevation of 150 m amsl. Flooding here lasts several months.

Figure 3-5 Xe Bang Fai at Nongbok, looking upstream; left bank is in Savannakhet Province.

Figure 3-6 Areas east of Nongbok severely flooded in wet season, with flood mark on concrete pile.

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

Figure 3-7 Extend of flooding along Lower Xe Bang Fai and Mekong in the year 2000.

Apart from the area along the Lower Xe Bang Fai there is also one smaller area in Mahaxai District facing floods according to local information. This area is located near Road 1F between Mahaxai and Nam Oula, and is flooded each year for about one week.

To reduce the flood risk in Savannakhet Province, i.e. along the left bank of Xe Bang Fai, flood protection in the form of a dike is already in place. For Khammouane Province (along the right bank of Xe Bang Fai) the following options are being studied:

1. Construction of mini-polders and construction of dykes along Xe Bang Fai and Mekong;
2. Construction of a bypass canal “Xelat” from Sokbo to Bungsan Nua in Nongbok District to the Mekong;
3. Construction of a regulating dam at the junction of the Se Noy with Xe Bang Fai.

For Option 1 a number of cases have been distinguished:

- Construction of mini-polders at 3 locations protecting in total 1,470 ha of land in Mahaxai and Se Bang Fai districts, involving dykes with a total length of 18.94 km (estimated cost USD 2.2 million);
- Step-wise construction of dykes along the Lower Xe Bang Fai and Mekong (estimated total cost USD 30.9 million) as follows (see Figure 3-8):
  - Step 1: 27 km long dyke with crest at 148.0 m from Nongbone to Sokbo, protecting 9,700 ha of land including 26 villages;
  - Step 2: 36 km long dyke with crest at 146.0 m from Sokbo to Bungsanetha, protecting 4,000 ha of land and 17 villages; and
  - Step 3: 30 km long dyke with crest at 145.7 m from Tantheung to Dannepakse, protecting 3,000 ha of land and 13 villages.
- One-step construction of a 65 km long dyke along the right bank of Xe Bang Fai River only from Nongbone to Danpakse (estimated cost USD 20.6 million) (see Figure 3-9).

The bypass canal of Option 2 (see
Figure 3-10) involves an 8 km long canal with bed width of 200 m at an elevation of 138 m amsl. The estimated cost is USD 9.6 million. Negative impacts of the option involve loss of 65 ha of land, no drainage when the Mekong levels exceed Xe Bang Fai and morphological effects in Xe Bang Fai.

The third option involves a 25 m high and 200 m long regulating dam with a reservoir capacity of 840 MCM operated at a level of 145 m amsl to provide irrigation water for 22,200 ha of land and flood protection to 92,910 ha along the right riverbank. The estimated cost of this option is USD 138.7 million. The reservoir will flood 18 villages, adds dam break risks and requires construction of dykes along the Xe Bang Fai and Mekong. As an alternative a 30 m high and 450 m long dam with a reservoir capacity of 1,500 MCM has been mentioned. Costs of this alternative will be much higher and so will be its impacts.

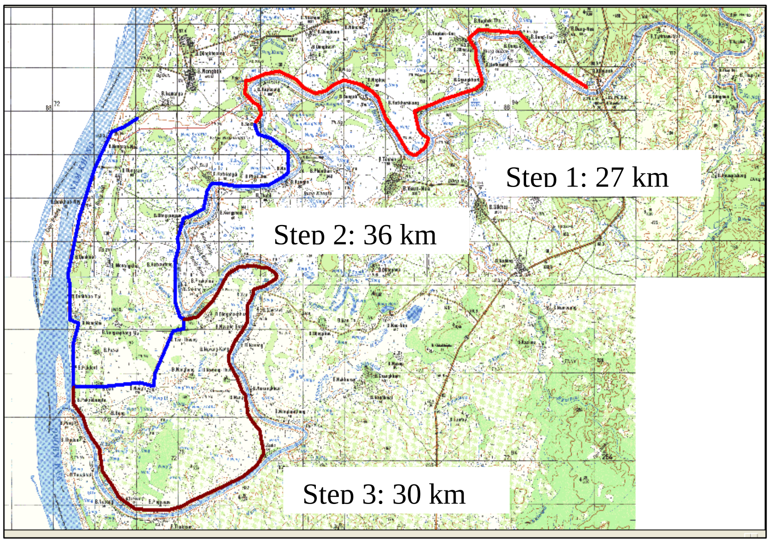


Figure 3-8 Step-wise construction of dykes along Lower Xe Bang Fai.

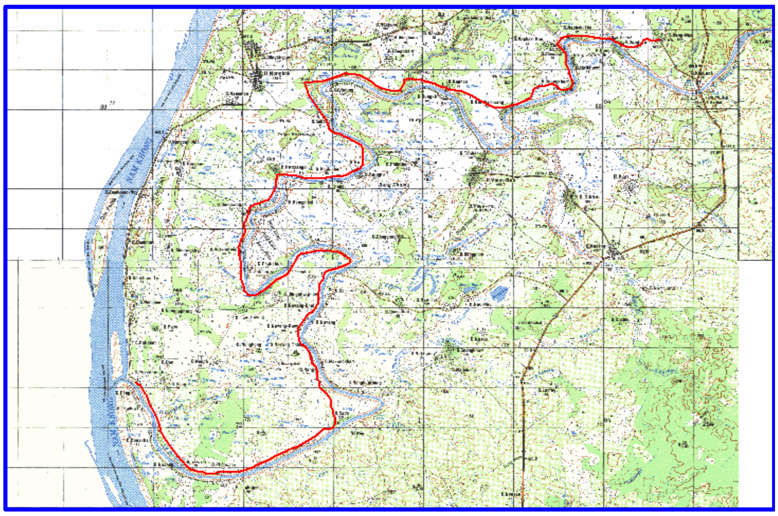


Figure 3-9 One-step construction of dyke along right bank of Xe Bang Fai.

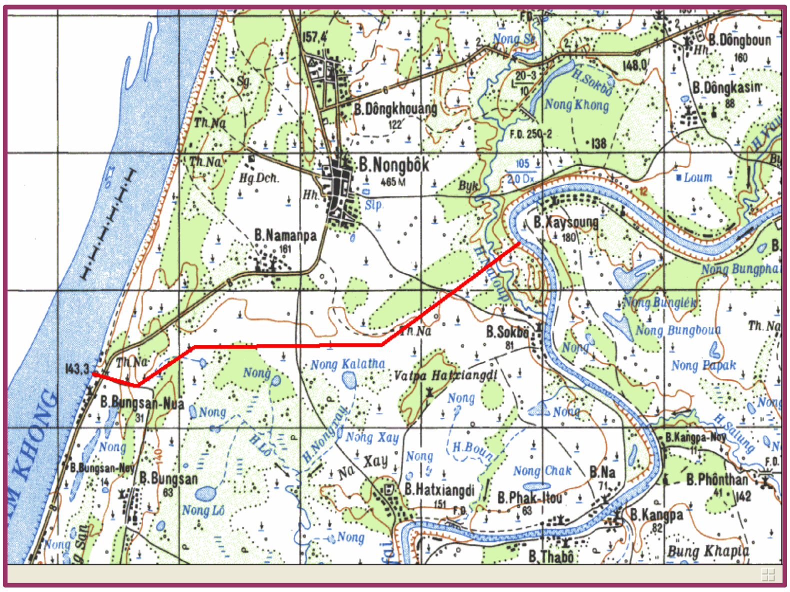


Figure 3-10 Canal “Xelat” from Sokbo to Bungsan Nua.

3.4 Hydrological network and data availability

The upper boundary of the Xe Bang Fai to be included in the hydraulic model should be outside the backwater reach of the Mekong. An estimate of the distance over which the effect of the Mekong River is felt on the flood levels in the Xe Bang Fai can be derived from a first order backwater calculation (see also Figure 3-11 for a definition sketch):

$$\Delta h_L \approx \Delta h_0 \exp\left(\frac{-3S_0 L}{h_e(1-Fr^2)}\right) \approx \Delta h_0 \exp\left(\frac{-3S_0 L}{h_e}\right) \quad for\ Fr << 1$$

$$also,\ with\ \lambda = \frac{h_e}{3S_0}: \quad \Delta h_L \approx \Delta h_0 \exp\left(-\frac{L}{\lambda}\right) \qquad (3.1)$$

$$because: \ln\left(\frac{\Delta h_L}{\Delta h_0}\right) \approx \frac{-3S_0 L}{h_e} = -\frac{L}{\lambda} \quad it\ follows:$$

$$at\ \Delta h_L = 5\%\ of\ \Delta h_0 \quad then \quad \ln\left(\frac{\Delta h_L}{\Delta h_0}\right) = -3, \quad so:$$

$$L_{5\%} \approx \frac{h_e}{S_0} = 3\lambda$$

with: Δh_0 = deviation from equilibrium depth at x=0
Δh_L = deviation from equilibrium depth at x = L
h_e = equilibrium depth
S_0 = bed slope
Fr = Froude number
λ = characteristic backwater length

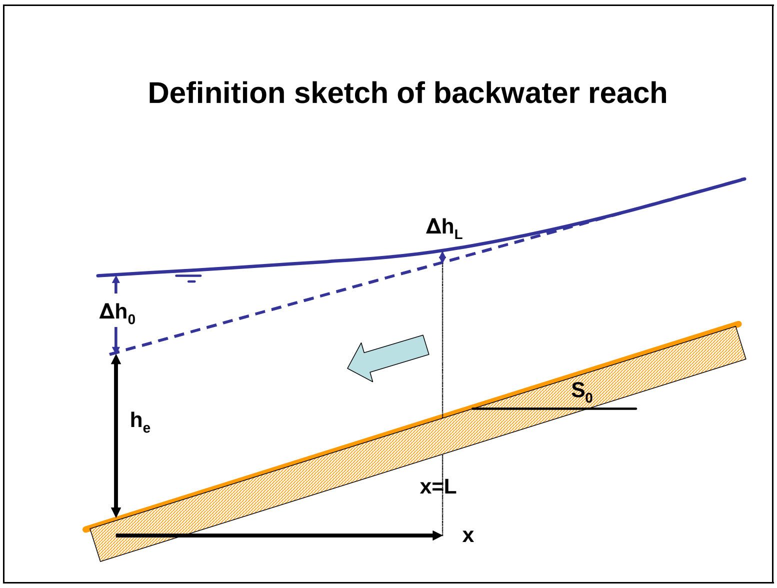


Figure 3-11 Definition sketch of extent of backwater reach.

So, backwater of the Mekong on the Xe Bang Fai will be felt over a distance of:

$$L_{5\%} \approx \frac{h_e}{S_0} = \frac{15}{1.1x10^{-4}} \approx 134km \qquad (3.2)$$

where the bed slope S_0 follows from the floodplain levels of 155.5 m amsl at Mahaxai and 139.5 m amsl along the Mekong at That Phanom, at a distance of about 143 km apart. The equilibrium depth h_e is taken as the maximum water level range at Mahaxai. It follows that the backwater effect from the Mekong exists till some 9 km d/s of Mahaxai. So, for simulation of the combined flooding in the Lower Xe Bang Fai, basically, only the basin downstream of Mahaxai is of interest. The boundary conditions for this area comprise:

- the flow in the Xe Bang Fai at Mahaxai;
- lateral inflow to and outflow from the Xe Bang Fai between Mahaxai and the river mouth;
- water level in the Mekong at the junction with the Xe Bang Fai.

The key station on the Xe Bang Fai at Mahaxai is shown in Figure 3-12. This station controls apart from the runoff from the Xe Bang Fai Basin, in future also the trans-basin diversion from Nam Theun 2 Hydro-electric Project, which discharges upstream of Mahaxai via the Nam Pith and Nam Kathang. The discharge record of Mahaxai started in 1988.

Figure 3-12 Location of gauging station on Xe Bang Fai at Mahaxai.

Regarding lateral inflow it is noted that no hydrometric stations are available on the tributaries Nam Oula and Se Noy downstream of Mahaxai. Only records from station Ban Xe Bang Fai at NR13S Bridge across the river is available. Basically, the lateral inflow can be derived from the discharge records at NR13S Bridge 13S and Mahaxai. But the water levels at NR13S Bridge at 71.6 km from the river mouth are (according to equation (3.2) affected by backwater from the Mekong. This complicates accurate assessment of the flow at the station and hence of the lateral inflow. Another way of deriving the lateral inflow and outflow downstream of Mahaxai would be through rainfall-runoff modelling provided that sufficient rainfall data is available.

The water level in the Mekong at the Xe Bang Fai junction is determined by the river discharge at the junction (That Phanom) and the conveyance capacity (with possible imposed water level conditions) downstream of the junction:

- The river discharge at the junction follows from the Mekong flow at Nakhon Phanom (Thailand) or Thakhek (Lao PDR) resp. 51 and 50 km upstream of the confluence and the runoff from the Xe Bang Fai. The combined flow (including also the runoff from the minor tributaries Nam Kam and Huai Bang Sai) is observed at Mukdahan (Thailand) and Savannakhet (Lao PDR) resp. 43 and 46 km downstream of the confluence. Flow series for Nakhon Phanom and Thakhek are available as from 1924 onward, whereas the discharge records of Mukdahan and Savannakhet started in 1923.
- The conveyance capacity of the Mekong downstream of the junction is determined by the river cross-section, bed slope and hydraulic roughness in the reach That Phanom-Mukdahan/Savannakhet and beyond, covering a reach of approximately 150 km.
- For That Phanom at the junction a water level record is available as of 1972.

The rainfall, climatic and hydrometric stations and their data availability are presented in Table 3-1. From the table it is observed that daily rainfall data is available for a number of stations in the nineties and in the last decade. Prior to that only for two stations records are available. It follows that insufficient data on rainfall is available to create reliable long series of lateral inflow. Evaporation data is available for three stations from FAO's Climwat database.

Table 3-1 Overview of rainfall, climatic and hydrometric stations in and around Lower Xe Bang Fai with data availability.

Variable	Stations	ID	Long	Lat	Availability
Rainfall	That Phanom	160403	104.7334	16.9500	1966-2005
	Phalan	160506	106.2333	16.7000	1991-94, 97, 01-06
	Thakhek	170404	104.8000	17.4167	1961-64, 80-92, 94-06
	Signo	170501	105.0500	17.8333	1987, 90-06
	Muong Mahaxai	170502	105.2020	17.4133	1989-06
	Ban Kouanpho	170505	105.4167	17.4833	1995, 97-98, 00-06
	Ban Xe Bang Fai	320101	104.9850	17.0720	2004-06
Evaporation	Seno-FAO	160502	105.0000	16.6667	From Climwat database
	Mukdahan-FAO	160401	104.7367	16.5400	From Climwat database
	Nakhon Phanom-FAO	170403	104.8034	17.3984	From Climwat database
Water level	Ban Xe Bang Fai (HB13)	320101	104.9850	17.0720	1988, 1992, 1994-2006
	Mahaxai	320107	105.2020	17.4133	1988-2006
	That Phanom (rkm 1166)	013105	104.7334	16.9500	1966-2005
	Nakhon Phanom (rkm 1217)	013101	104.8034	17.3984	1972-2005
	Thakhek (rkm 1216)	013102	104.8067	17.3933	1980-2006
	Keng Kabao (rkm 1151)	013301	104.7500	16.8133	1972-1999
	Mukdahan (rkm 1123)	013402	104.7367	16.5400	1960-2005
	Savannakhet (rkm 1126)	013401	104.7467	16.5617	1972-2006
Discharge	Ban Xe Bang Fai (HB13)	320101	104.9850	17.0720	1960-85, 88, 92, 94-04
	Mahaxai	320107	105.2020	17.4133	1988-2006
	Nakhon Phanom (rkm 1217)	013101	104.8034	17.3984	1924-2005
	Thakhek (rkm 1216)	013102	104.8067	17.3933	1924-2006
	Mukdahan (rkm 1123)	013402	104.7367	16.5400	1923-2005
	Savannakhet (rkm 1126)	013401	104.7467	16.5617	1923-2006

Table 3-2 Gauge zero levels of water level gauging stations in and around Xe Bang Fai.

Station	ID	River	rkm	GZ (m amsl)
Ban Xe Bang Fai (HB13)	320101	SBF	-	125.00
Mahaxai	320107	SBF	-	139.56
That Phanom (rkm 1166)	013105	Mekong	1166	127.94
Nakhon Phanom (rkm 1217)	013101	Mekong	1217	130.961
Thakhek (rkm 1216)	013102	Mekong	1216	129.629
Keng Kabao (rkm 1151)	013301	Mekong	1151	128.00
Mukdahan (rkm 1123)	013402	Mekong	1123	124.219
Savannakhet (rkm 1126)	013401	Mekong	1126	125.41

3.5 Hydrological characteristics

3.5.1 Rainfall

A long rainfall record in the neighbourhood of the Lower Xe Bang Fai is available for station That Phanom, opposite the junction of the Xe Bang Fai with the Mekong. The long-term annual rainfall for this station amounts to 1,560 mm, varying from 890 to 1,940 mm as can be observed from Table 3-3. About 87 % of the annual rainfall occurs during the South-West Monsoon from May to September, with highest rainfall on average in August, see also Figure 3-13. The annual rainfall, which is available for the years 1966-2005, does not show a distinct trend (Figure 3-14); the average rainfall during the period 1966-1987 of 1,578 mm compares well with that in the period 1988-2005 of 1,537 mm, the period for which also discharge data is available for the Xe Bang Fai at Mahaxai. Note that the average runoff depth at Mahaxai amounts about 1,650 mm per year. Compared to the rainfall value at That Phanom it indicates a strong orographic effect in the Xe Bang Fai rainfall from west to east.

Table 3-3 Monthly rainfall statistics and evaporation (ETo) in mm around Lower Xe Bang Fai.

Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average	3.1	20.7	43.4	79.1	200.3	274.8	276.6	350.6	250.3	54.7	4.8	1.2	1559.5
Stdev	8.3	31.6	40.9	46.7	88.1	95.8	108.1	151.9	129.8	53.5	10.0	4.7	267.9
Cv	2.69	1.53	0.94	0.59	0.44	0.35	0.39	0.43	0.52	0.98	2.11	3.96	0.17
Min	0.0	0.0	0.0	5.0	53.1	120.0	88.2	121.9	20.9	0.0	0.0	0.0	890.7
Max	31.3	161.7	150.9	226.4	377.1	516.8	542.8	758.8	538.1	257.9	58.3	27.6	1940.6
Evap.	122	122	156	162	150	124	127	120	112	129	128	121	1572

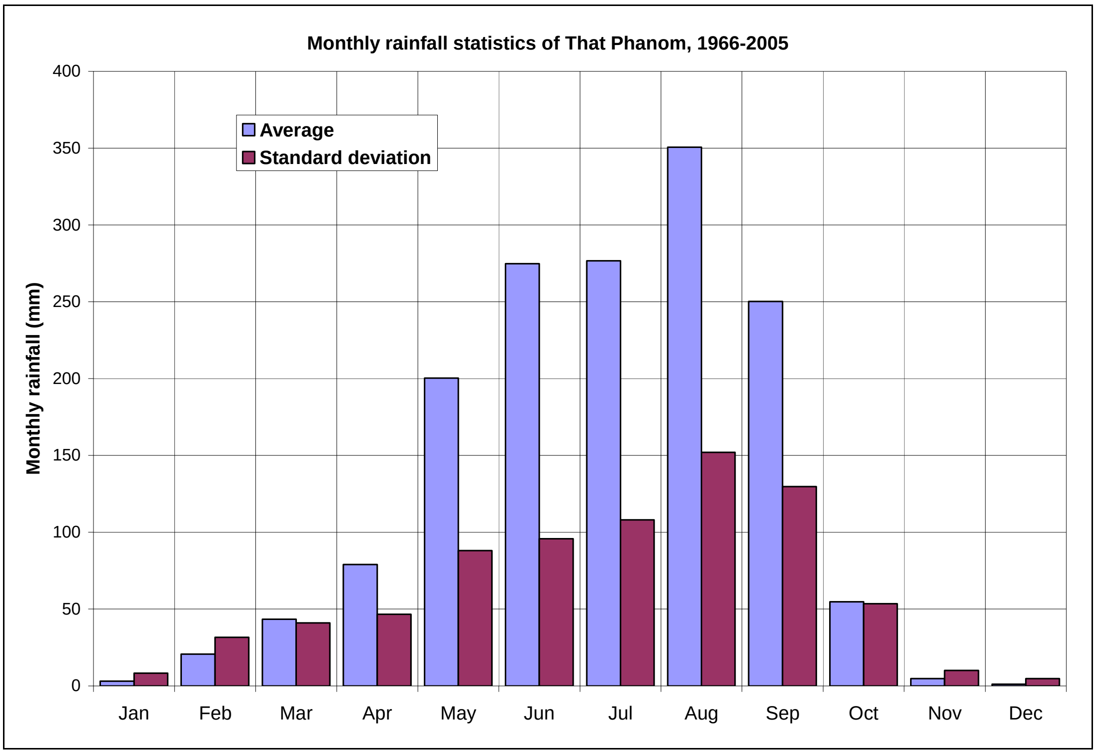


Figure 3-13 Monthly rainfall statistics of station That Phanom, period 1966-2005.

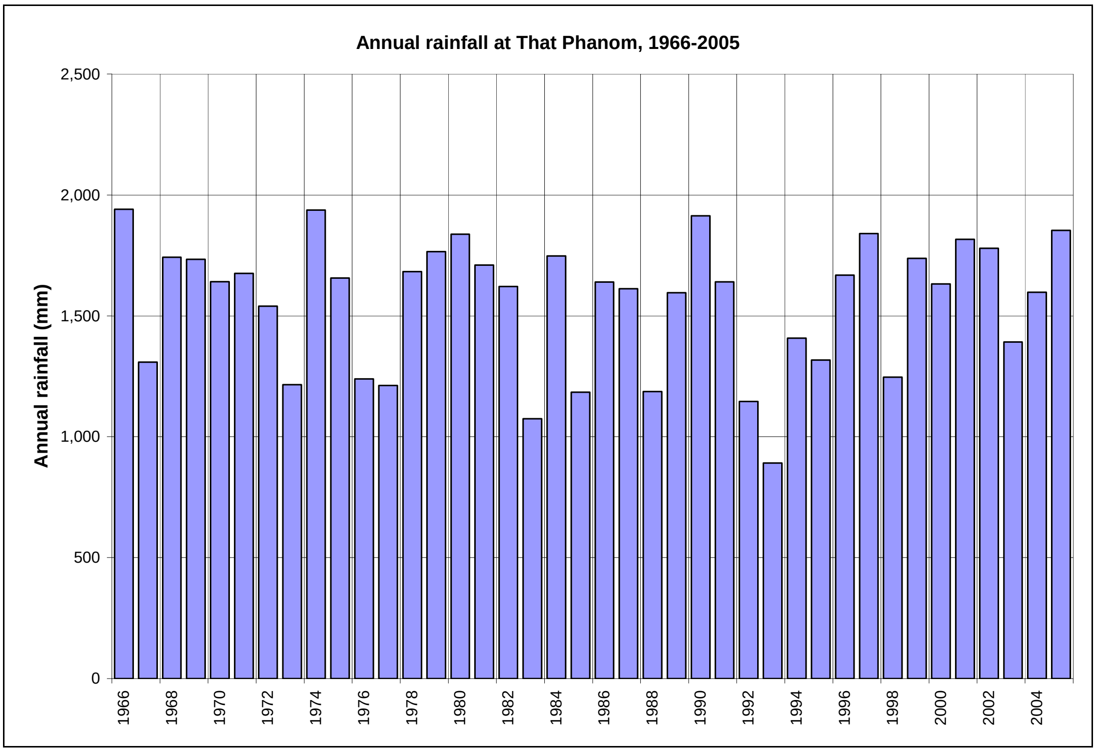


Figure 3-14 Annual rainfall at That Phanom, period 1966-2005.

3.5.2 Evaporation

Pan evaporation data is available for a few stations in the area, but the series showed unrealistic values for a number of years, and are therefore not presented. Below (Figure

3-15) monthly average daily reference evaporation rates (ETo) are shown for Seno/Savanakhet, Mukdahan and Nakhon Phanom, taken from the Climwat-database of FAO. During the flood season an average daily evaporation rate of about 4 mm/day or 120 mm per month is observed from the graph (see also Table 3-3). During these months the rainfall greatly exceeds the evaporation, whereas from October to April there is a water shortage as can be observed from Figure 3-16.

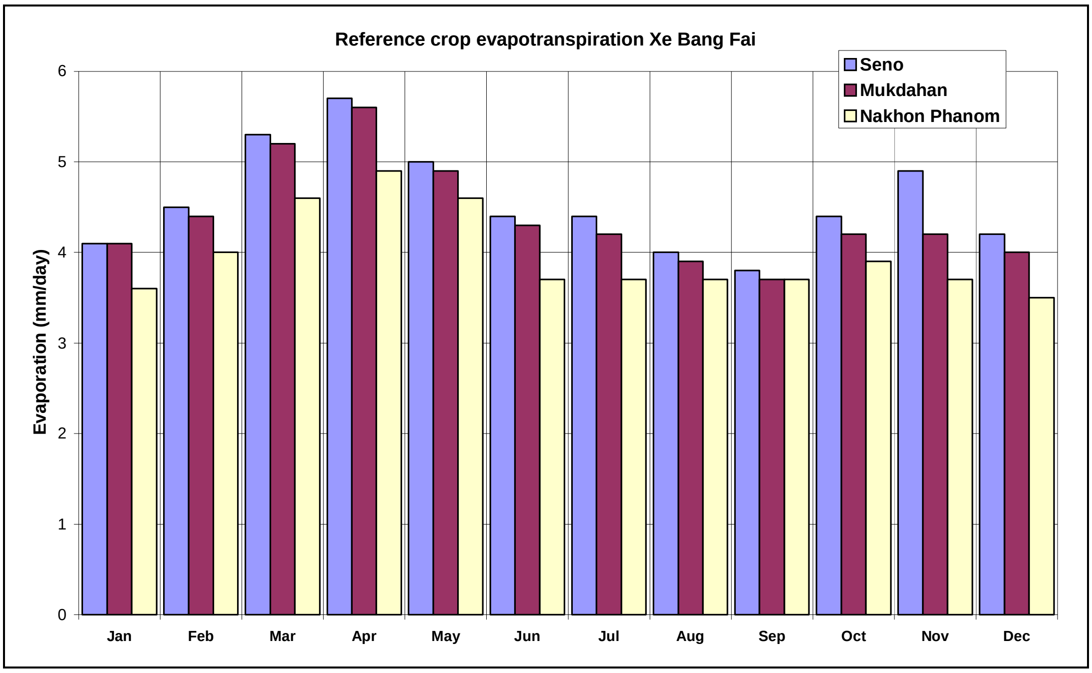


Figure 3-15 Monthly average daily evaporation (ETo) values for stations in the surrounding of the Lower Xe Bang Fai Basin.

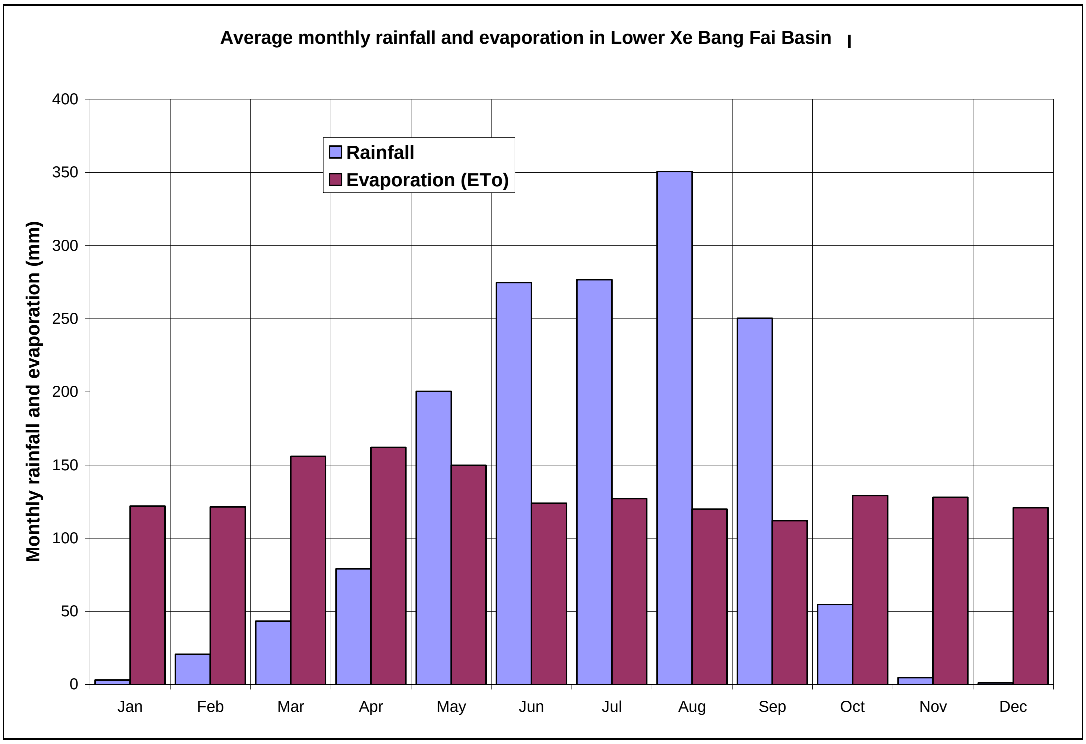


Figure 3-16 Average monthly rainfall and evaporation.

3.5.3 Runoff

The monthly flow statistics of the Xe Bang Fai at Mahaxai is presented in Table 3-4 and Figure 3-17. Note that the average annual runoff depth at Mahaxai is larger than the annual rainfall at mouth. The frequency curves and extremes of the daily discharges of the Xe Bang Fai at Mahaxai are presented in Figure 3-18. The curves indicate that in the period from July till early October high discharges can be expected on the Xe Bang Fai. The hydrograph of a single year shows distinct sharply rising and falling levels. From the frequency curves of the daily average water levels of the Mekong at That Phanom near the Xe Bang Fai River mouth (gauge zero = 127.94 m amsl and floodplain level 139.50 m amsl), shown in Figure 3-19, it is observed that these peaks are likely to coincide with high water levels on the Mekong.

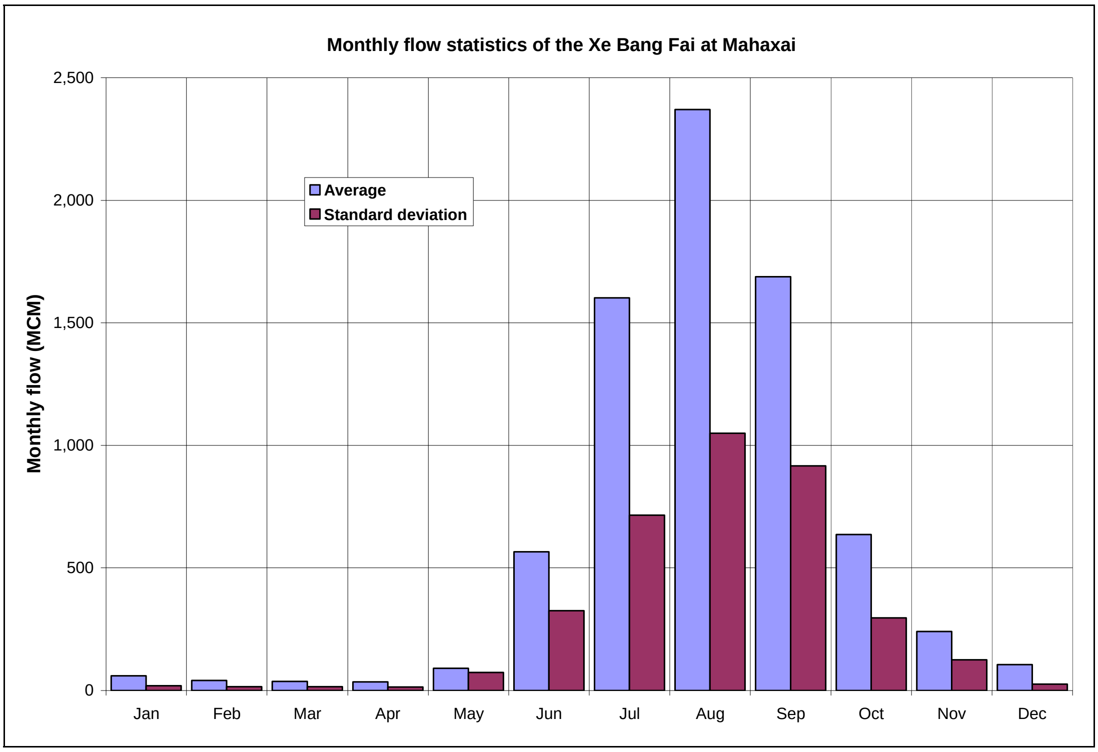


Figure 3-17 Monthly flow statistics of the Xe Bang Fai at Mahaxai.

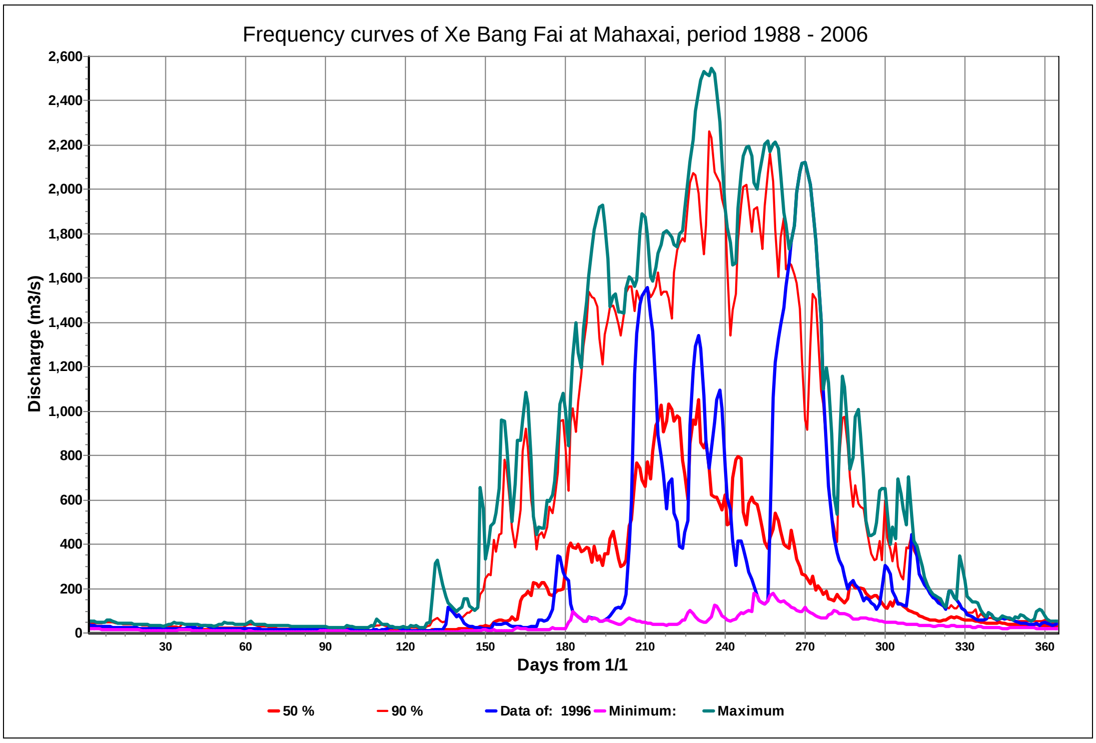


Figure 3-18 Frequency curves of daily average discharge of Xe Bang Fai at Mahaxai, period 1988-2006.

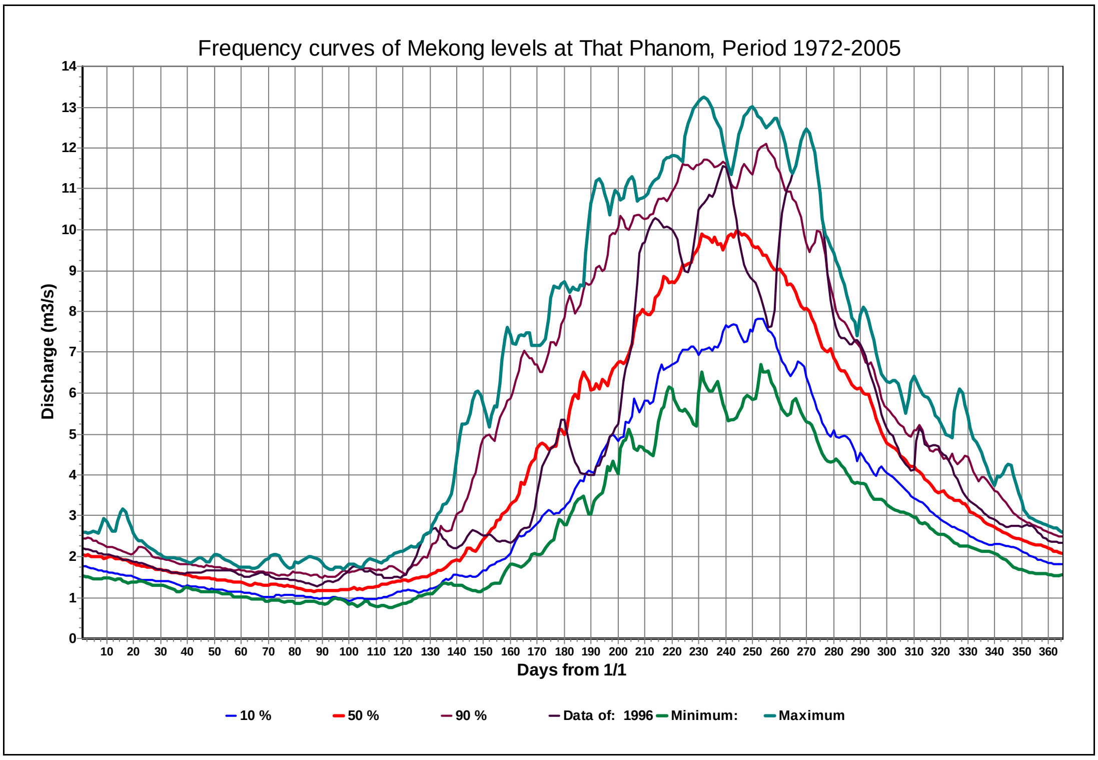


Figure 3-19 Frequency curves of daily average water levels of the Mekong at That Phanom, period 1972-2005.

Table 3-4 Monthly and annual statistics of runoff volume and depth of the Xe Bang Fai at Mahaxai.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean (MCM)	60.0	41.5	37.2	34.7	90.8	565.6	1601.4	2370.7	1687.9	635.9	240.5	105.8	7504.4
St.dev (MCM)	19.6	15.4	15.5	14.0	73.4	325.8	714.9	1049.1	916.0	296.2	125.2	26.0	2155.4
Mean (mm)	13.3	9.2	8.2	7.7	20.1	125.1	354.3	524.5	373.4	140.7	53.2	23.4	1653.1
St.dev (mm)	4.3	3.4	3.4	3.1	16.2	72.1	158.2	232.1	202.7	65.5	27.7	5.7	476.9

The statistics of the monthly flow of the Mekong at Nakhon Phanom and Mukdahan are presented in Table 3-5 and Figure 3-20. It is observed that, generally, the peak flows in the Mekong at these locations occur in August similar to the Xe Bang Fai. The lateral inflow to the Mekong between Nakhon Phanom and Mukdahan is seen to be relatively small; the annual flow of the Xe Bang Fai is only 3% of the annual total of the Mekong at Nakhon Phanom. Finally, in Figure 3-21 the frequency curves of the daily discharge at Nakhon Phanom are presented.

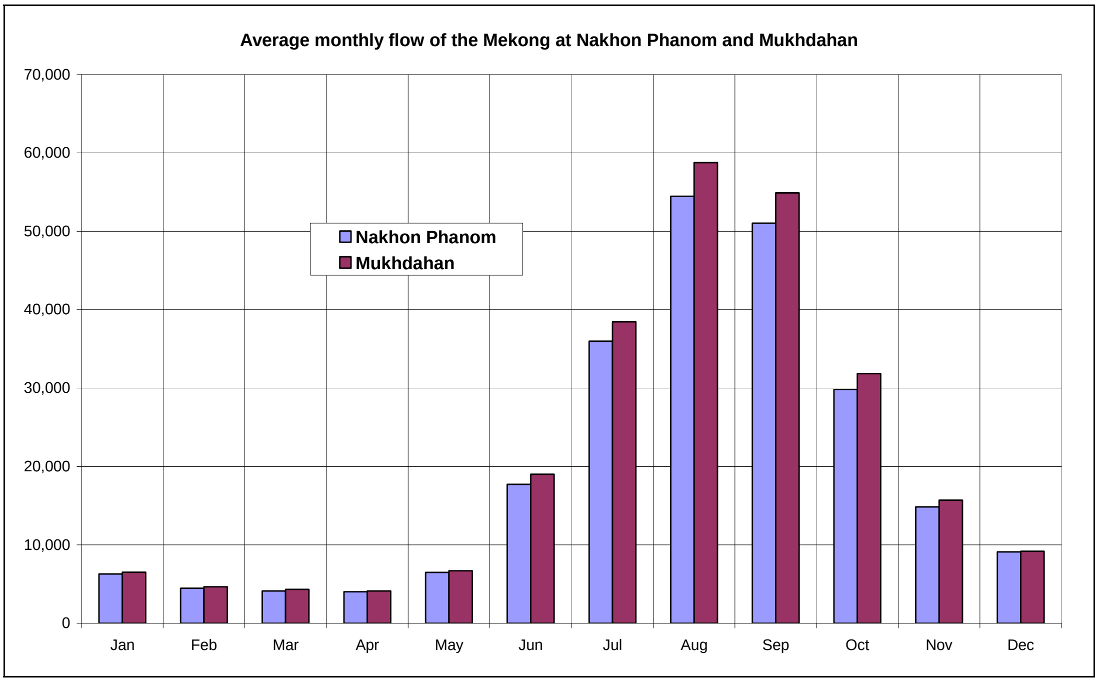


Figure 3-20 Average monthly flows in the Mekong at Nakhon Phanom and Mukdahan.

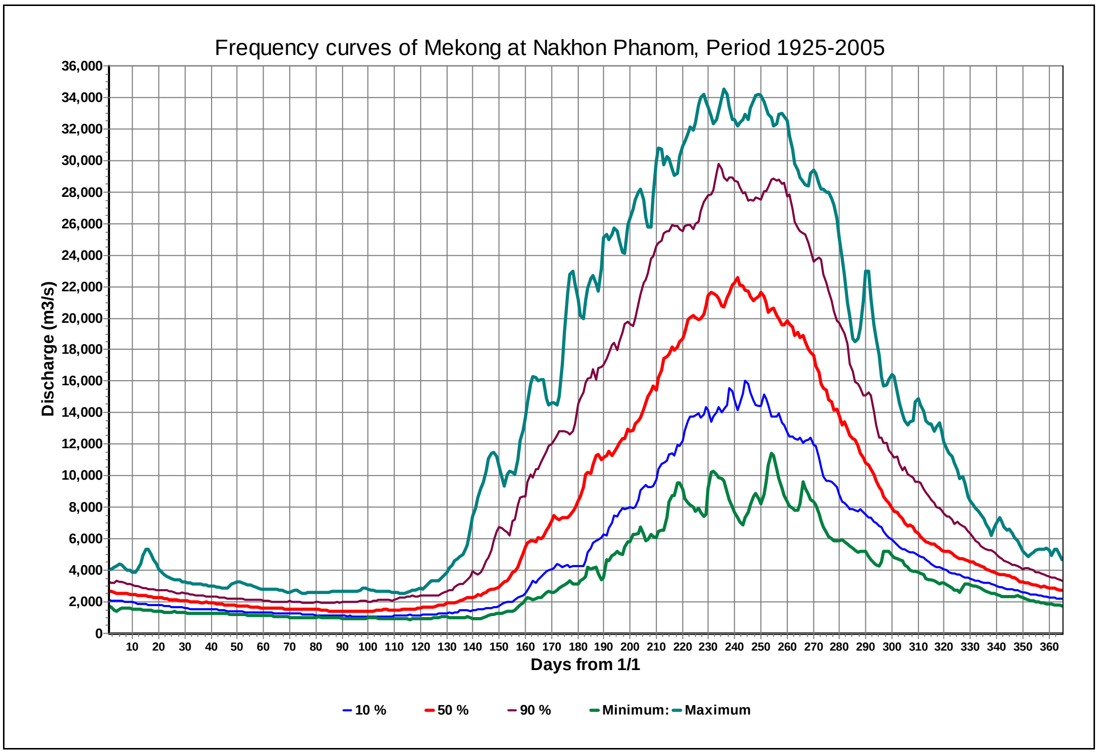


Figure 3-21 Frequency curves of daily average discharge of the Mekong at Nakhon Phanom, period 1925-2005.

Table 3-5 Monthly and annual statistics of the flow in the Mekong at Nakhon Phanom and Mukdahan.

N. Phanom	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean (MCM)	6,277	4,469	4,130	4,000	6,492	17,722	35,993	54,457	51,055	29,808	14,860	9,111	238,376
Stdev (MCM)	1,316	944	940	943	2,234	6,288	9,870	11,741	10,984	7,027	3,554	1,652	39,460
CV	0.21	0.21	0.23	0.24	0.34	0.35	0.27	0.22	0.22	0.24	0.24	0.18	0.17
Min	3,902	3,034	2,767	2,530	3,171	7,532	15,149	28,206	24,261	15,811	8,859	6,147	138,447
Max	10,864	7,371	7,106	6,729	17,503	33,849	62,865	81,324	70,290	45,702	27,322	13,504	340,084
Mukdahan	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean (MCM)	6,522	4,651	4,317	4,134	6,703	19,029	38,441	58,772	54,893	31,841	15,686	9,183	253,875
Stdev (MCM)	1,030	690	686	733	2,102	6,810	9,788	12,203	11,021	7,576	3,634	1,613	36,214
CV	0.16	0.15	0.16	0.18	0.31	0.36	0.25	0.21	0.20	0.24	0.23	0.18	0.14
Min (MCM)	4,162	3,300	2,844	2,608	3,166	7,296	19,718	33,006	29,129	15,058	8,948	5,700	165,954
Max (MCM)	10,679	7,120	6,717	6,278	15,077	39,782	64,697	88,261	81,363	51,088	30,285	12,652	330,576

4. Hydraulic Model

4.1 General

The flood levels in the Lower Xe Bang Fai are a function of the river discharge and the water levels in the Mekong. These flood levels are determined with a one-dimensional hydraulic model based on ISIS. This model has been developed by the LNMC and MRC. The schematisation of river and floodplain, applied boundary conditions and calibration is discussed in this chapter.

4.2 Schematisation

The hydraulic model of the Xe Bang Fai used for flood analysis in the Lower Xe Bang Fai comprises the Xe Bang Fai River from Mahaxai to the river mouth at That Phanom and the Mekong between Nakhon Phanom upstream and Mukdahan downstream of the confluence. The layout of the model is shown in Figure 4-1, with details in Figure 4-2. This model replaces the initial hydraulic model used for flood flow simulations and analysis during Stage 1 of FMMP-C2, which only covered the Xe Bang Fai downstream of Mahaxai.

Schematisation of Xe Bang Fai

The Xe Bang Fai branch of the new model covers the lower 157.953 km of the river from the mouth of the Nam Khatang, at 14.916 km upstream of Mahaxai, to the confluence with the Mekong at That Phanom. The river bathymetry is represented by 38 surveyed cross-sections. In addition, the mouth of the Xe Bang Fai tributary Se Noy, which discharges about 10 km upstream of station Ban Xe Bang Fai/NR13S Bridge, is included in the model with 3 surveyed cross-sections. The remaining tributaries are modelled as lateral inflow points. The longitudinal profile and characteristic cross-sections at Mahaxai and Ban Xe Bang Fai are shown in Figure 4-3 to Figure 4-5.

The floodplains along the Lower Xe Bang Fai are schematised by storage cells with a depth-volume relation. The storages are connected to the main stream via spillways/two way weirs. The schematisation of the storage cells has been derived from a digital elevation model (DEM), which in turn was based on topographic information in 1/10,000, 1/20,000 and 1/50,000 scale maps, updated by a sample survey in July 2008. The survey party consisted of the modelling teams of LNMC and MRC together with the irrigation engineer from the Dept. of Agriculture and Forestry of Khammouane Province. A high resolution DEM (15 x 15 m) was developed for the floodplain downstream of NR13S, reproduced from 1/1,000 scale maps. To include the latest information on the elevation of the levees and layout of the flood protection structures in the model for reliable simulation of the spill to the floodplain, the levees and structures on either side of the Lower Xe Bang Fai were surveyed in October 2008.

The hydraulic roughness in the Xe Bang Fai branch of the model, expressed as Manning-n, ranges from 0.05-0.07 in the upper part of the model near Mahaxai to 0.045-0.036 downstream of the Se Noy confluence, see Figure 4-6. In comparison to the initial model used in Stage 1 the roughness values in the lower part have substantially increased.

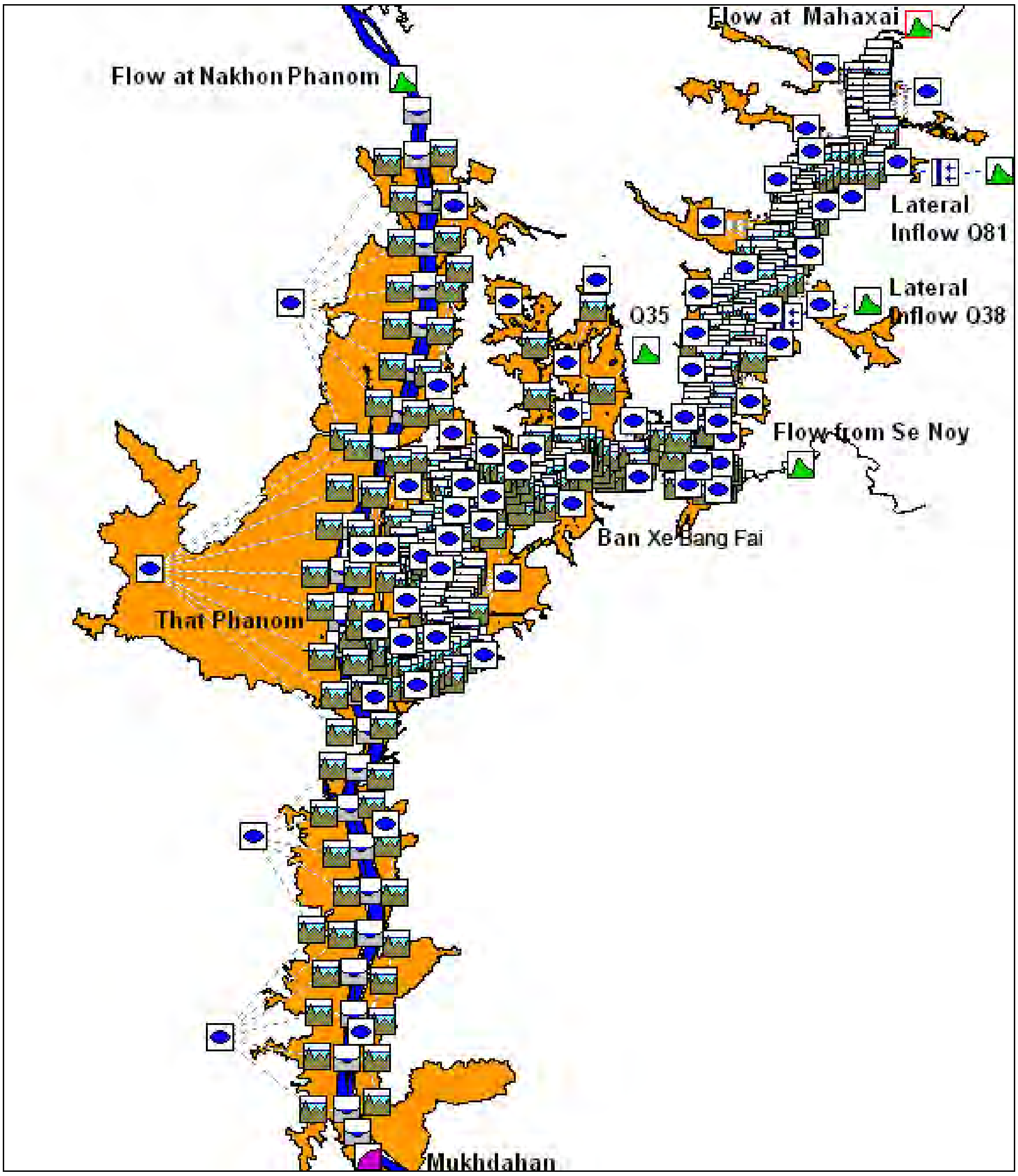


Figure 4-1 Schematisation of Xe Bang Fai in ISIS-hydraulic model.

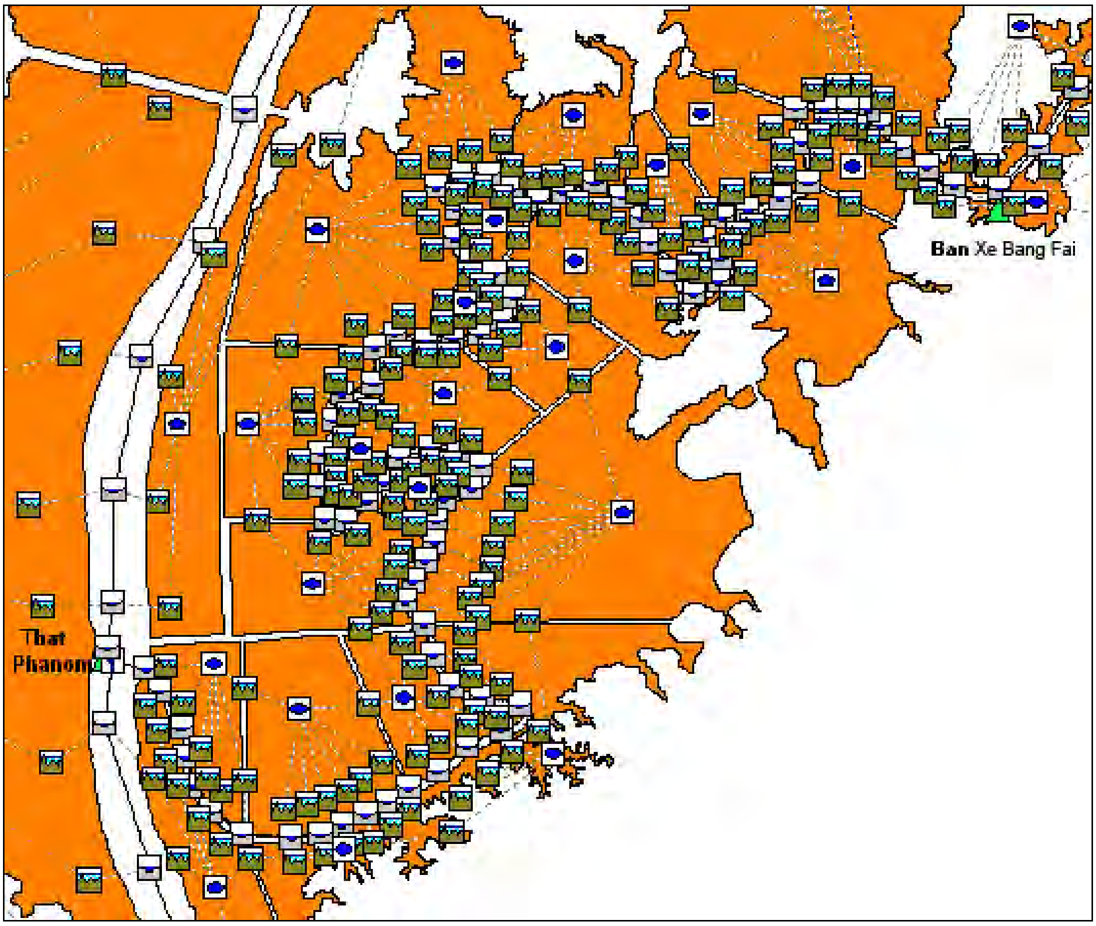


Figure 4-2 Detail of ISIS-hydraulic model of Xe Bang Fai near river mouth.

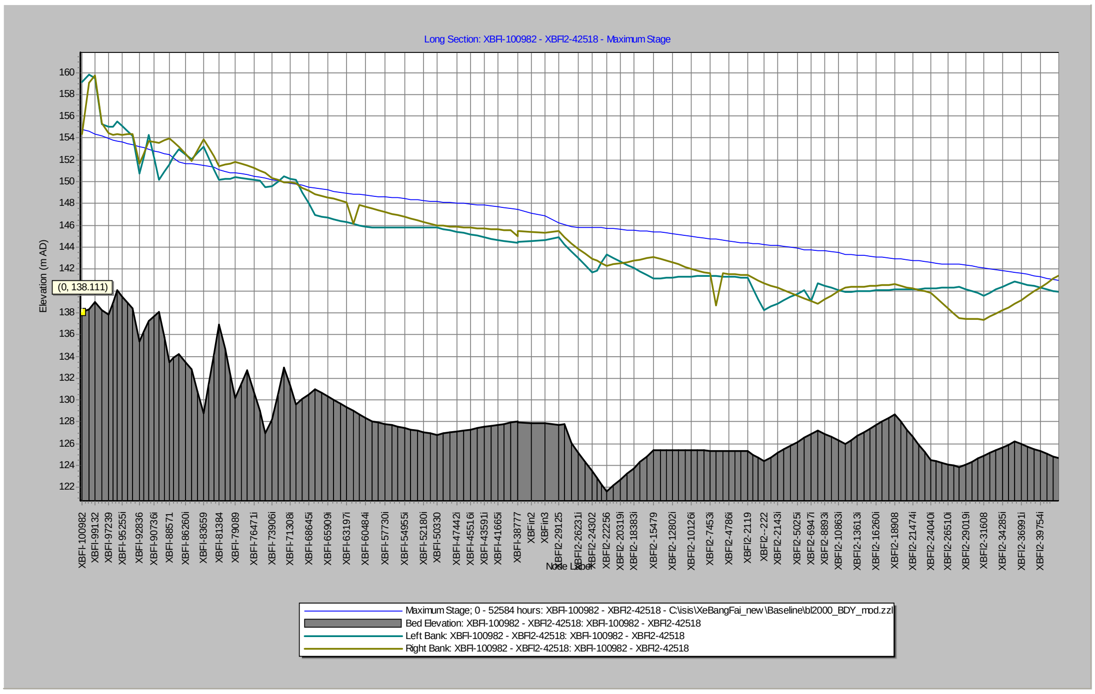


Figure 4-3 Longitudinal profile of Xe Bang Fai from 15 km u/s Mahaxai to river mouth.

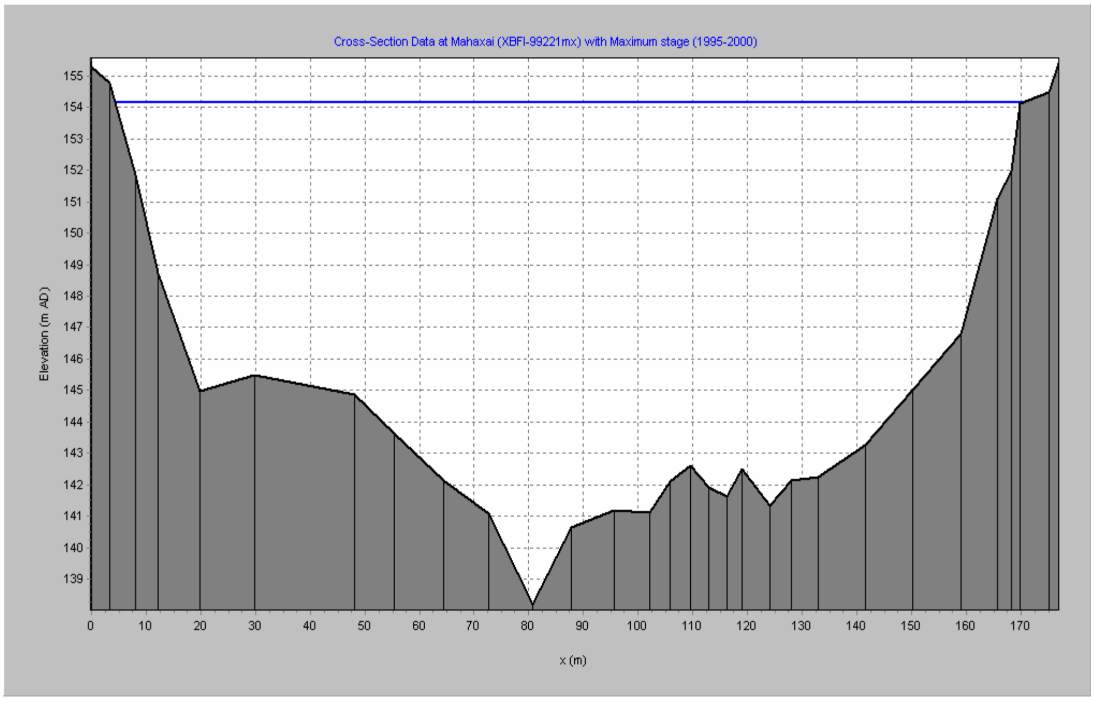


Figure 4-4 River cross-section at Mahaxai.

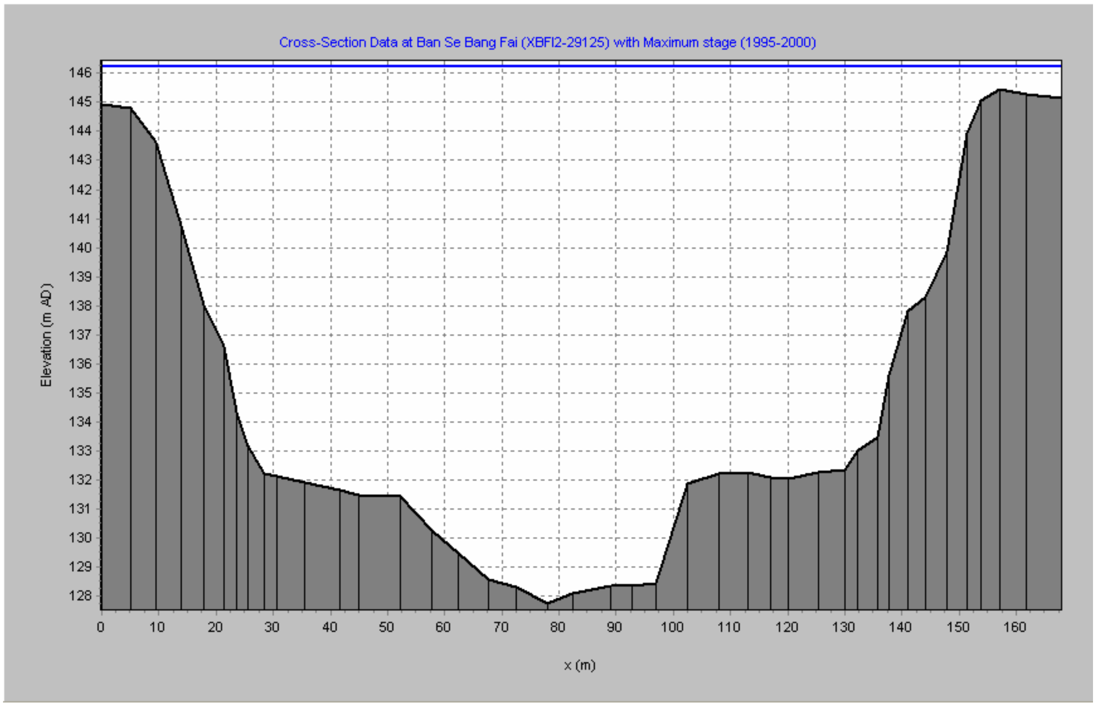


Figure 4-5 River cross-section at Ban Xe Bang Fai/National Road Nr 13 South Bridge.

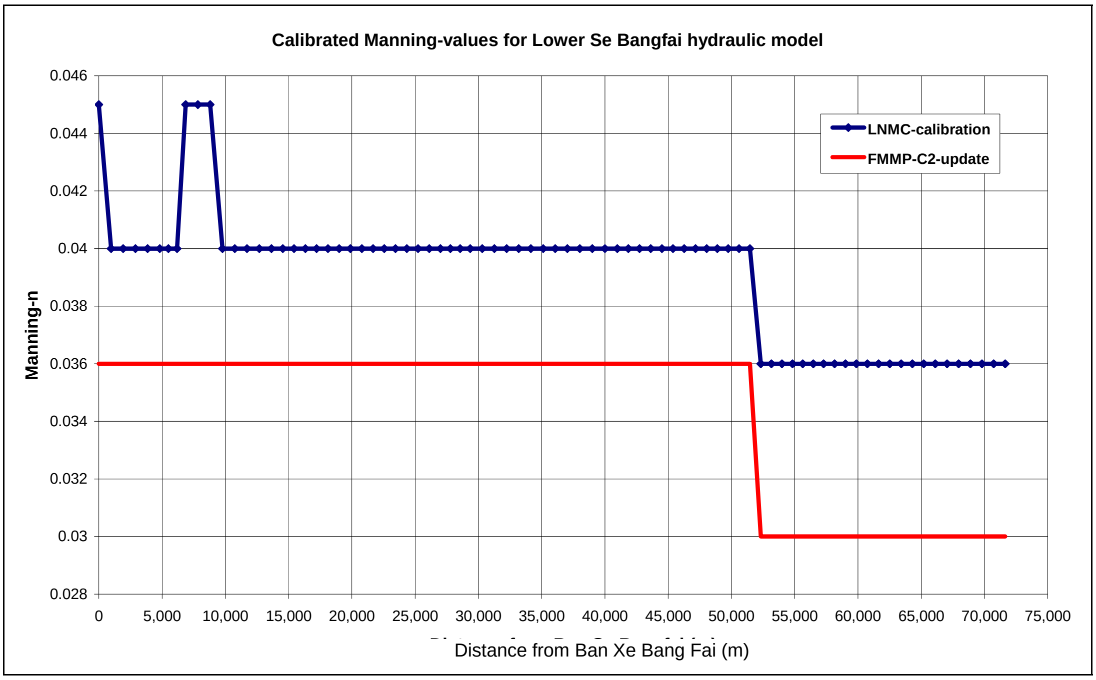


Figure 4-6 Hydraulic roughness of lower Xe Bang Fai River (Ban Xe Bang Fai-That Phanom) as calibrated by LNMC and updated by FMMP-C2.

Schematisation of Mekong

The Mekong reach between Nakhon Phanom and Mukdahan has been schematised by 25 cross-sections extracted from the ISIS-model derived from details presented in the Hydrographic Atlas of the Mekong River. A longitudinal profile of the river stretch is presented in Figure 4-7. In the schematisation at a number of locations a connection is established between the Mekong River and the floodplain adjacent to the Xe Bang Fai.

A constant Manning roughness of n = 0.032 is assumed for the Mekong branch of the hydraulic model.

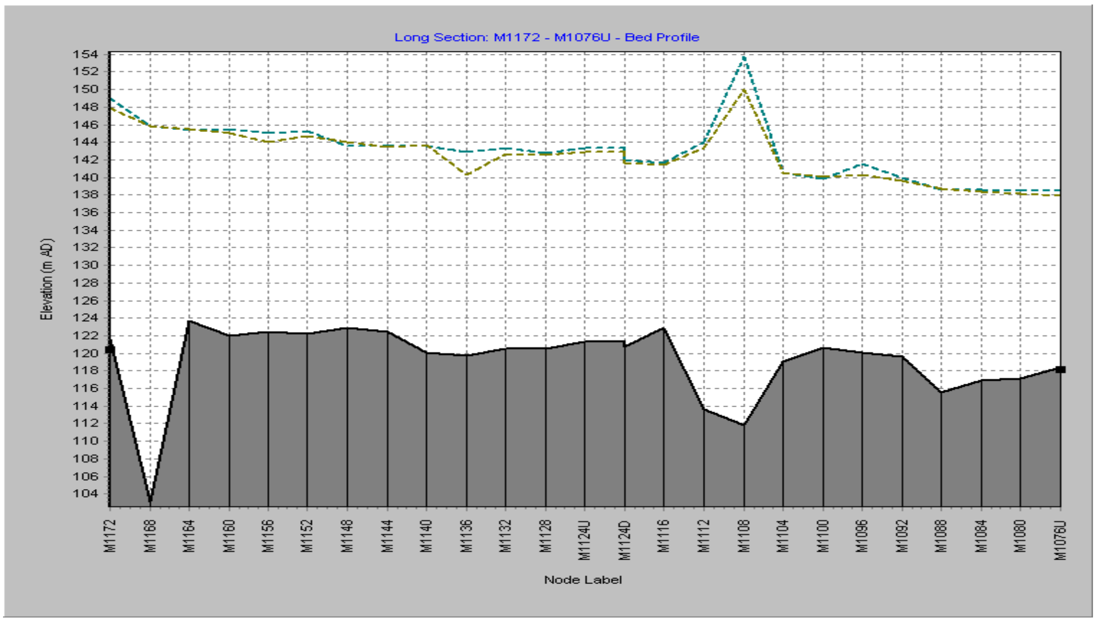


Figure 4-7 Longitudinal profile of Mekong from Nakhon Phanom to Mukdahan.

4.3 Boundary conditions

4.3.1 General

The following boundary conditions are used in the hydraulic model:

- for the Xe Bang Fai branch:
  - discharge at Mahaxai as upstream inflow;
  - lateral inflow (from Nam Oula, Se Noy, etc) schematised to concentrated inflows at the Se Noy confluence and the locations Q81 and Q38 upstream and location Q35 to floodplain around Ban Xe Bang Fai;
- for the Mekong branch:
  - discharge at Nakhon Phanom as upstream inflow;
  - downstream at Mukdahan a stage-discharge relation (for model calibration the observed water level at Mukdahan has been considered, but this is not feasible for flood hazard assessment).

The boundaries are discussed below.

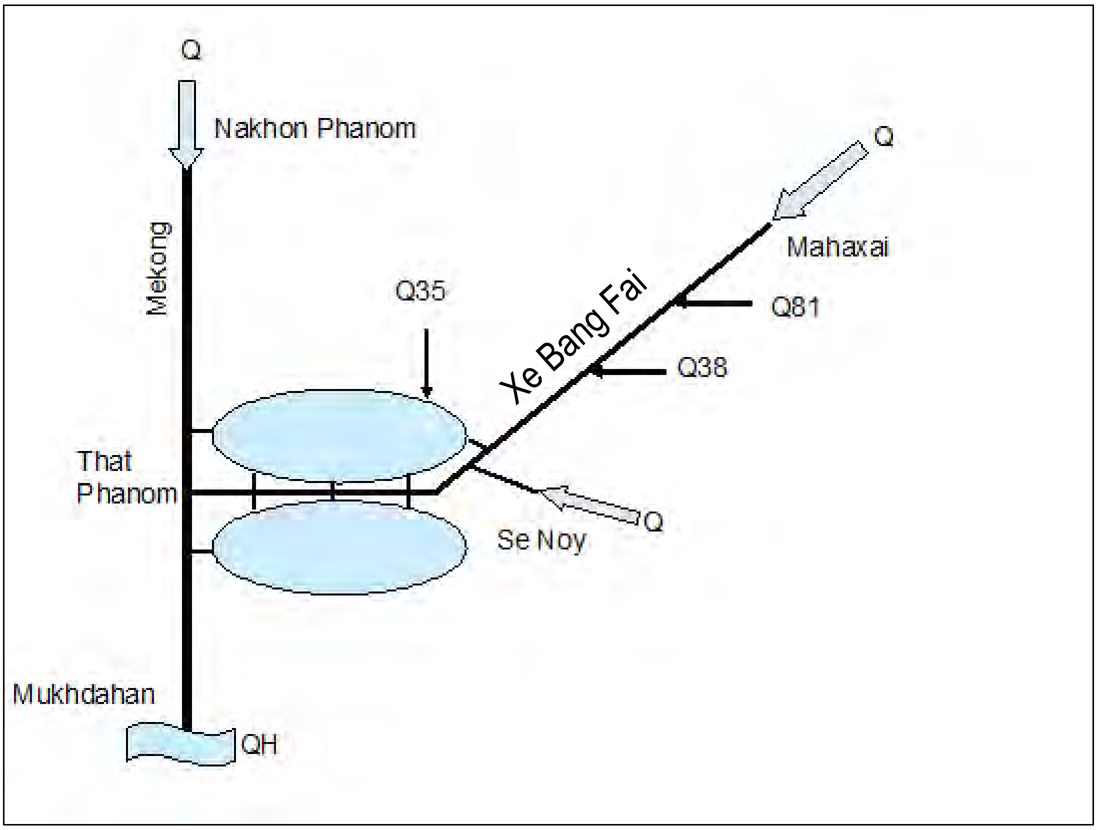


Figure 4-8 Schematic layout of boundary conditions in the hydraulic model of the Lower Xe Bang Fai.

4.3.2 Discharge at Mahaxai

The upstream discharge boundary is derived from the discharge record of the Xe Bang Fai at Mahaxai, which is available for the period 1988-2006. This series is based on the water level observations at station Mahaxai and regularly updated discharge rating curves. An example of a discharge rating for Mahaxai is shown in Figure 4-9. Though in some years there is substantial difference between the discharge observations and the rating curve used for the creation of discharge series, in general the applied discharge ratings match with the observations. From the applied curves it appears that the river downstream of Mahaxai is not stable. A shift of 1 to 2 m is observed from Figure 4-10 for fixed high discharges. It implies that regular adjustments to the bathymetry of the river in the hydraulic model would be required to match with the observed water levels at the station.

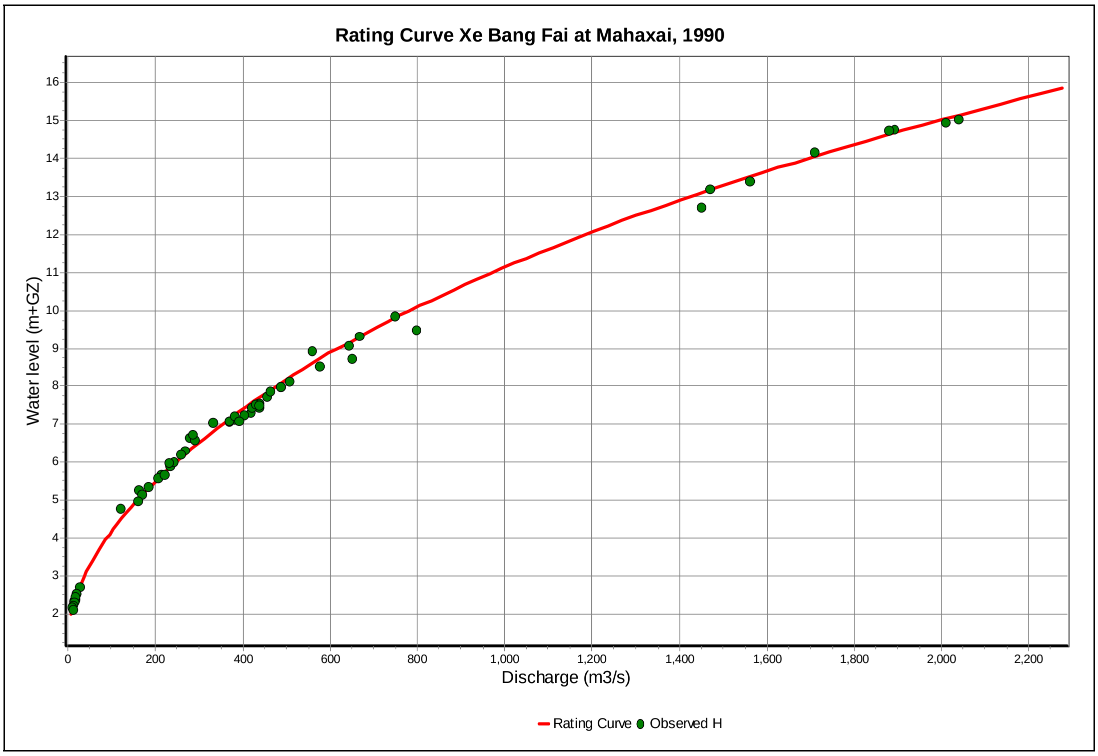


Figure 4-9 Discharge rating of the Xe Bang Fai at Mahaxai for the year 1990.

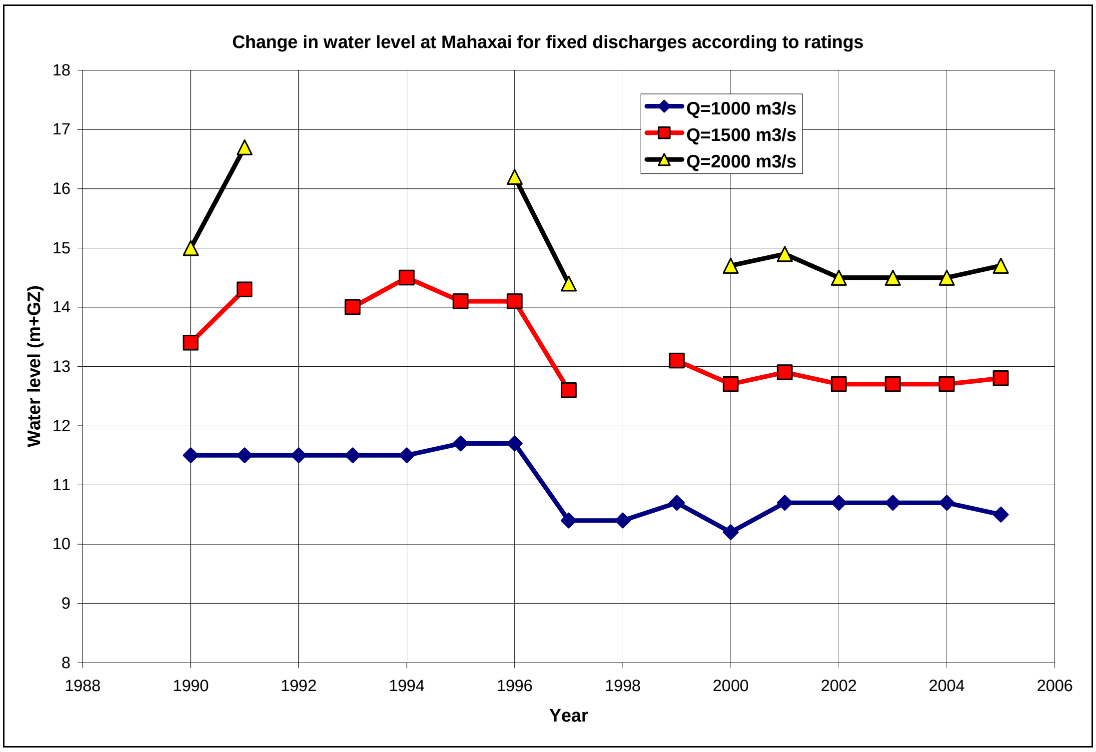


Figure 4-10 Water level at fixed discharge levels in the Xe Bang Fai at Mahaxai, period 1990-2005.

Hydrographs show rapid rise and fall, which leads to unsteady flow effects in the stage-discharge relationship. No such corrections seem to have been implemented in the past. Adjustment of the discharge measurements using the Jones correction when establishing the discharge rating curve, and application of this correction in the conversion of stages into discharge would improve the discharge series of the Xe Bang Fai at Mahaxai.

4.3.3 Lateral inflow

Beside a discharge record for Mahaxai, a long discharge series also exists for station Ban Xe Bang Fai. The difference between the series is the lateral inflow between the two locations. However, the discharge series of Ban Xe Bang Fai has not been correctly derived. A unique stage-discharge has been applied to the water levels at the station, whereas from a summary of the stage-discharge measurements at Ban Xe Bang Fai in Figure 4-11 it is immediately observed that the station is strongly affected by backwater from the Mekong (see also equation (3.2)). In view of the very mild bed slope of the river downstream of Ban Xe Bang Fai it is estimated that about 40% of the set up at the river mouth is still available at the site. A slope correction is required to adjust the flows, for which a twin gauge approach with the gauge reading at That Phanom as the second series is needed.

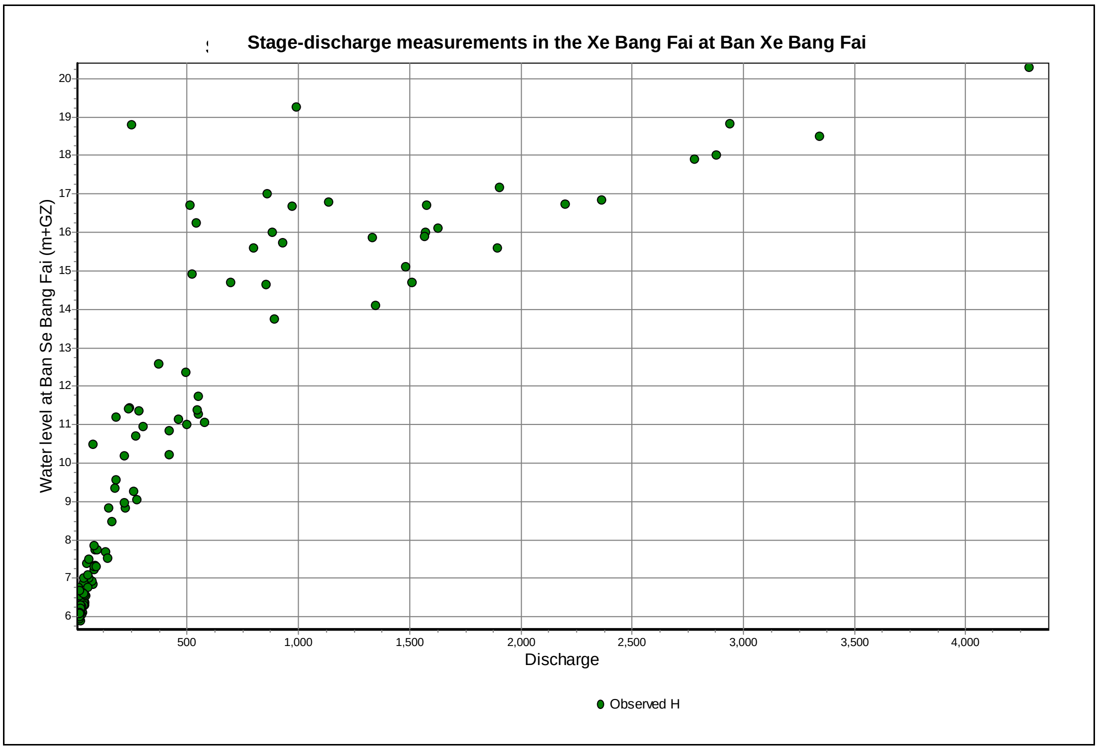


Figure 4-11 Backwater affected and backwater free stage-discharge measurements.

However, a simpler procedure has been applied, making use of a relation between the observed discharge at Ban Xe Bang Fai and the discharge on the same day at Mahaxai. A fairly unique relationship exists, particularly for the high discharges:

$$Q_{BSBF} = 0.838 Q_{Mahaxai}^{1.108} \quad (4.1)$$

with: Q_{BSBF} = discharge at Ban Xe Bang Fai
$Q_{Mahaxai}$ = discharge at Mahaxai
Qlat = lateral inflow between Mahaxai and Ban Xe Bang Fai

This relation is shown in Figure 4-12, and when corrected for the flow at Mahaxai it gives the lateral inflow to the river between Mahaxai and Ban Xe Bang Fai:

$$Q_{lat} = Q_{BSBF} - Q_{Mahaxai} = Q_{Mahaxai}(0.838 Q_{Mahaxai}^{0.108} - 1) \quad for: \quad Q_{Mahaxai} > 5.2\, m^3/s \quad (4.2)$$

where: Q_{lat} = lateral inflow between Mahaxai and Ban Xe Bang Fai.
The lateral inflow is seen from Figure 4-13 to increase gradually to about 90% of the discharge at Mahaxai, in case of extreme floods, commensurate with the respective drainage areas (44% of the total basin area lays upstream of Mahaxai and 40% between Mahaxai and Ban Xe Bang Fai), see Section 3.2. Downstream of Ban Xe Bang Fai net rainfall also contributes to inundation of the floodplain; it covers an area of some 16% of the total basin area.

The LNMC modelling team followed a different approach and extracted the lateral inflow from the existing SWAT rainfall-runoff model from Vientiane to Mukdahan. The lateral inflow was taken as the sum of the sub-basins 435, 438 and 439. Though it will be very difficult to get reliable runoff from the SWAT model for these sub-basins as hardly any rainfall station is available, they claim to have obtained an acceptable fit for the SWAT sub-basins upstream of Mahaxai, calibrated to the flow at Mahaxai, with an efficiency coefficient of 0.6 and a volume ratio of 99.5%. Equation (4.2) shows that the lateral inflow downstream of Mahaxai is indeed strongly correlated with the flow at the station.

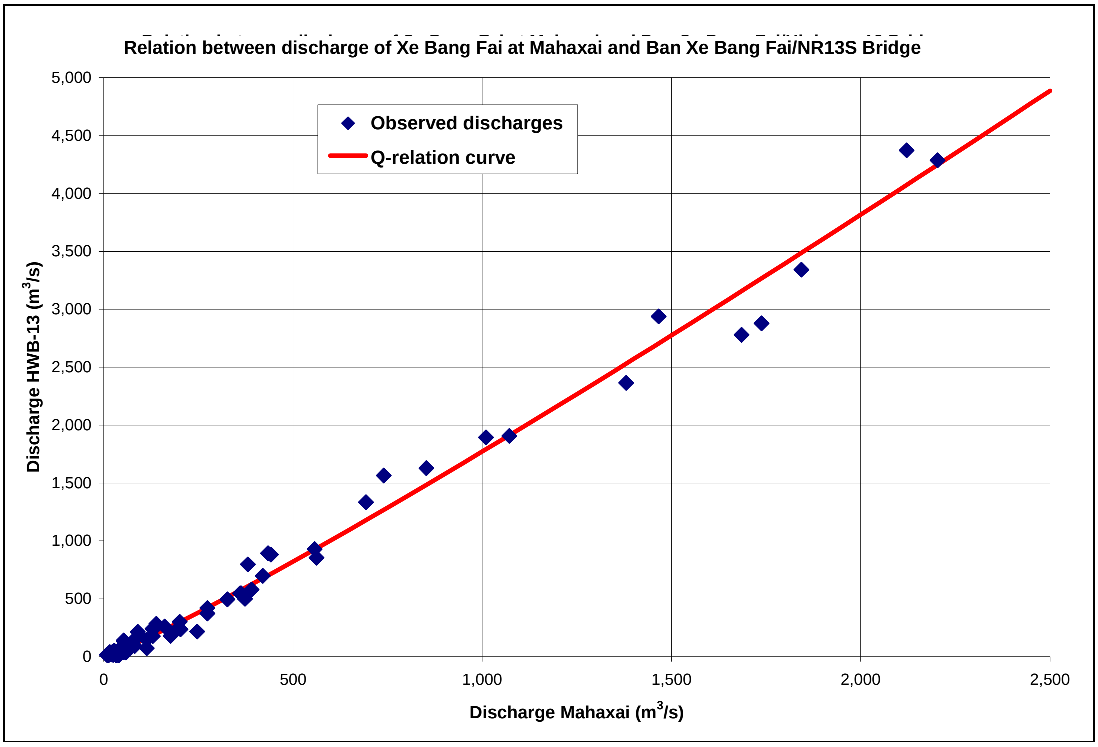


Figure 4-12 Discharge of Xe Bang Fai at Ban Se Bang Fai as function of discharge at Mahaxai.

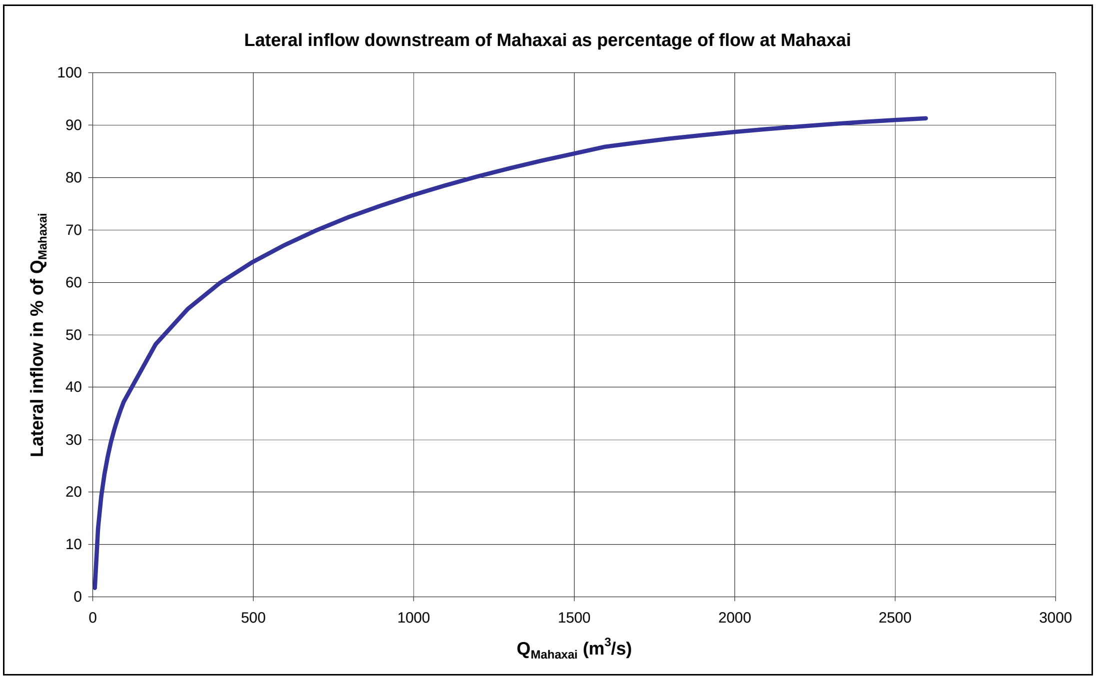


Figure 4-13 Lateral inflow between Mahaxai and Ban Xe Bang Fai as percentage of the discharge at Mahaxai.

4.3.4 Discharge at Nakhon Phanom

The discharge at Nakhon Phanom acts as upstream boundary for the Mekong branch. Discharge series as from 1924 onward are available for this location. A complete review of this series is not possible as water levels are only available for this station since 1972, whereas stage-discharge measurement data are available from 1962 onward. Hence, no information is present as to how the series prior to 1962, respectively 1972 has been created. From Figure 4-14 and Figure 4-15 it is observed that the discharge rating for Nakhon Phanom varies considerably, hinting at large scale morphological development in the control reach downstream of the station. Figure 4-15 shows maximum variations up to about 2.5 m for a fixed high discharge. It also shows that in the years without any stage-discharge measurement the previous discharge rating is continued to be applied, which may have, in view of the unstable river bed, serious consequences for the quality of the discharge series. To validate the relevant discharge characteristics of Nakhon Phanom (peak flow and flood volume) comparisons have been made with the same quantities at Mukdahan, downstream. In view of the larger total drainage area at Mukdahan and limited floodplain storage along the main river it is expected that both annual peak flow and flood volume (1 June- 30 November) will be larger at the downstream site. Figure 4-16 and Figure 4-17 show that generally the peak flows and flood volumes are consistent. Only in a limited number of years consistency is not attained. This is particularly so for the period 1976-1993 when no discharge ratings were available for Nakhon Phanom; at Mukdahan the availability is slightly better and shows variations where the Nakhon Phanom rating was kept constant. The inconsistencies are, however, not strong. From double mass analysis between the same stations for the same quantities as before also no serious anomalies were found as can be observed from Figure 4-18 and Figure 4-19. Hence, it is concluded that the series of flood peaks and flood volumes that can be obtained from the Nakhon Phanom discharge series are generally reliable, and form a solid basis for flood hazard assessment.

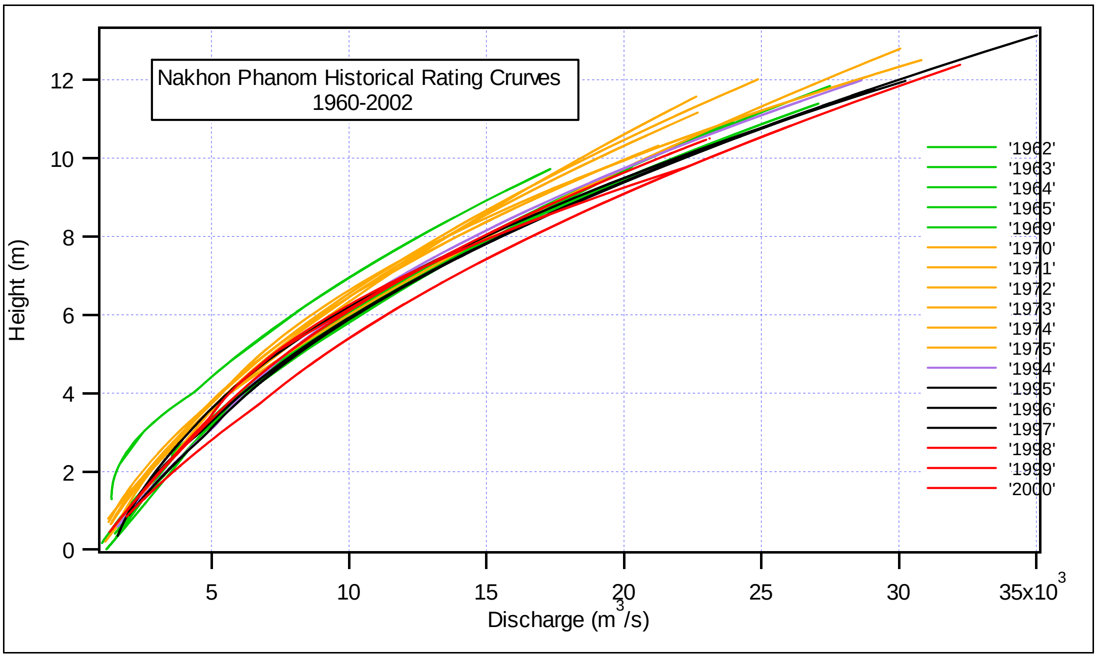


Figure 4-14 Stage-discharge relation of Mekong at Nakhon Phanom (MRC, 2002).

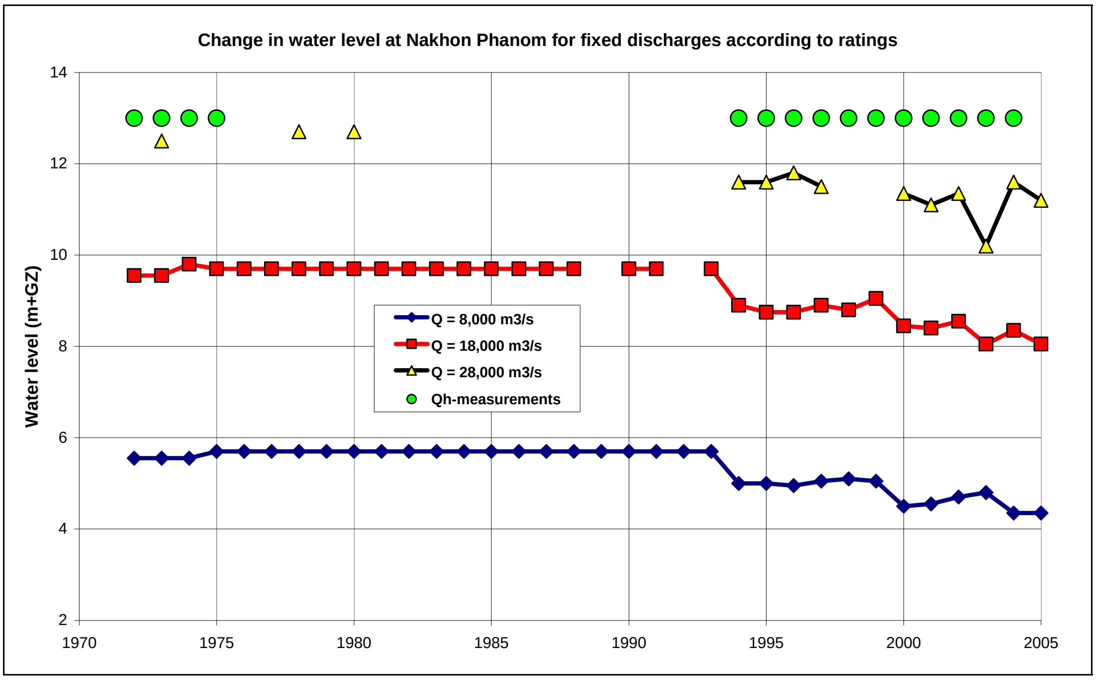


Figure 4-15 Change in water level at Nakhon Phanom for fixed Mekong discharges, period 1972-2005.

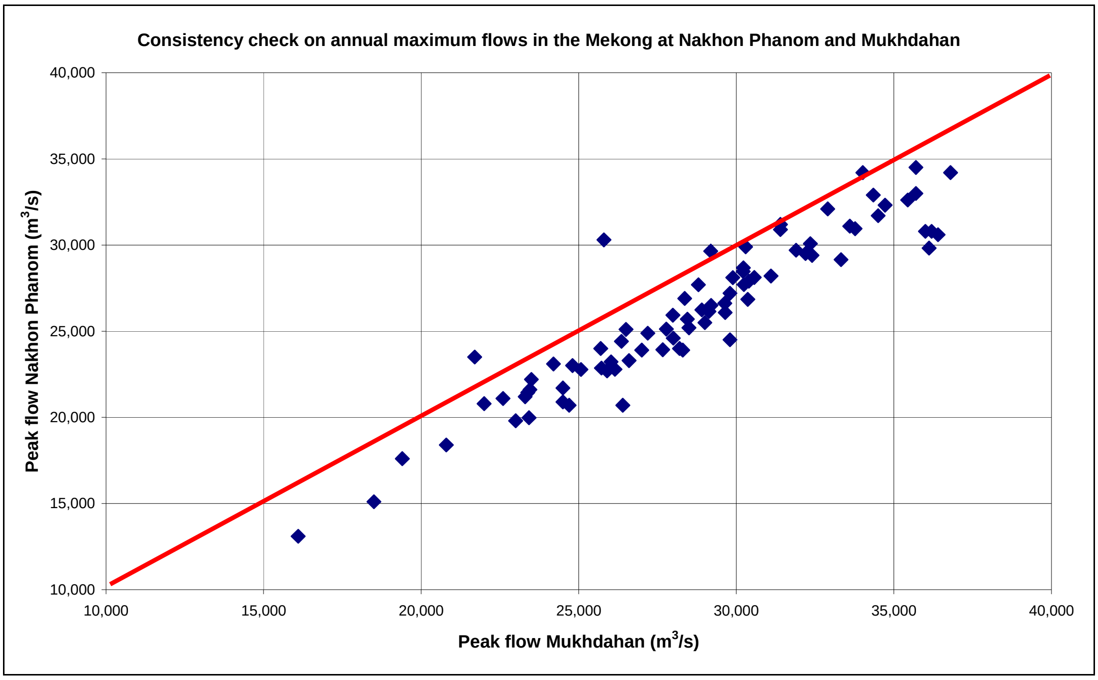


Figure 4-16 Comparison of annual peak flows at Nakhon Phanom with Mukdahan.

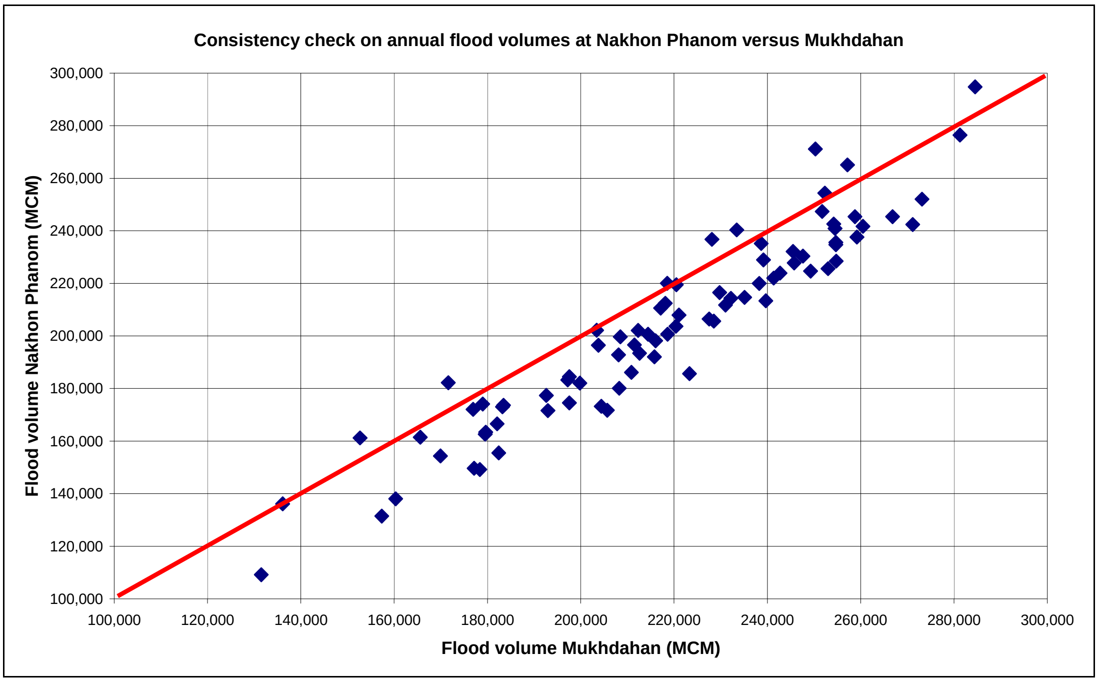


Figure 4-17 Comparison of annual flood volumes at Nakhon Phanom with Mukdahan.

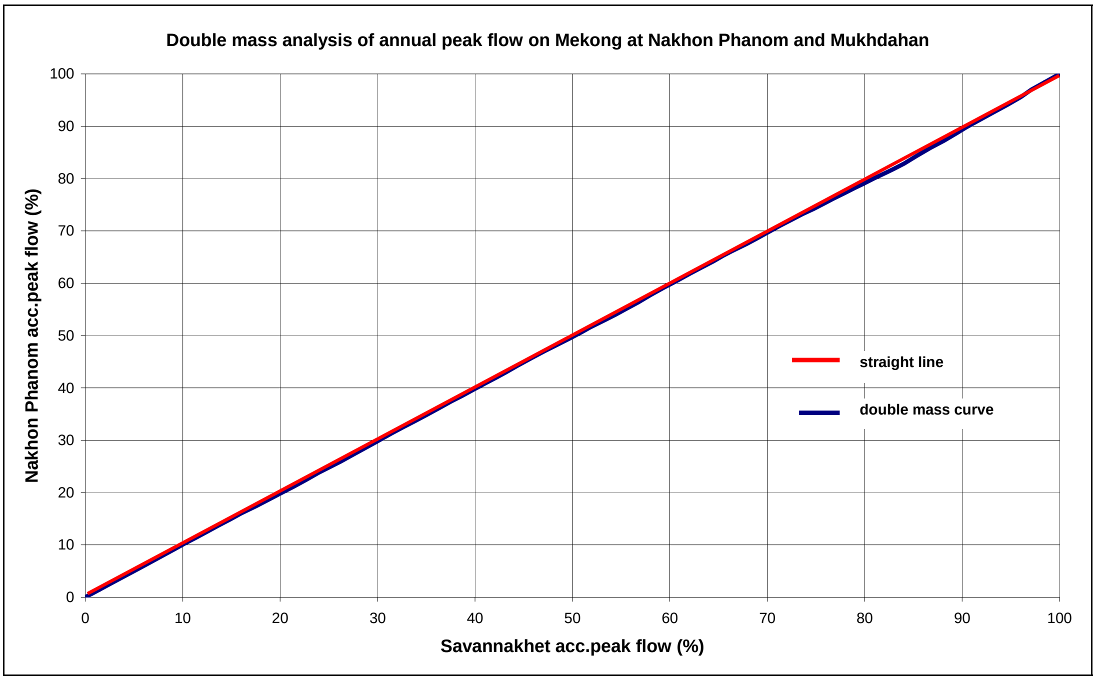


Figure 4-18 Double mass analysis of annual peak flows at Nakhon Phanom and Mukdahan.

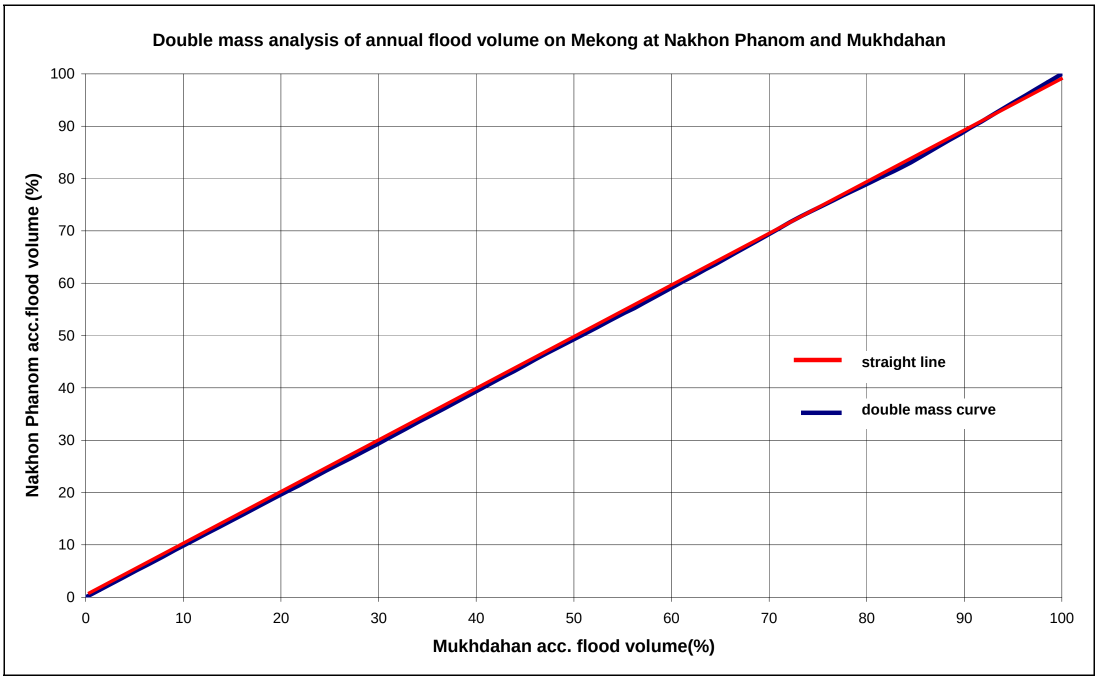


Figure 4-19 Double mass analysis of annual flood volumes at Nakhon Phanom and Mukdahan.

4.3.5 Stage-discharge relation at Mukdahan

At the downstream end of the model on the Mekong at Mukdahan a stage-discharge relation has to be imposed rather than a water level. Different from model calibration, applying a water level at that location for analysing development scenarios in the Lower Xe Bang Fai would not be correct as these developments may affect the discharge and hence the levels at Mukdahan, which in turn gives severe backwater effects on the water level at the Xe Bang Fai mouth at That Phanom; the characteristic backwater length for the Mekong at high flows for this reach is about 50 km, whereas the distance between Mukdahan and That Phanom is only 43 km. It follows that of a disturbance in the water level at Mukdahan still over 40% is left at That Phanom. Therefore a stage-discharge relation is imposed at this site for analysis of developments rather than a water level. Unfortunately, similar to the situation in Nakhon Phanom, the stage-discharge relation at Mukdahan varies from year to year as can be observed from Figure 4-20 and Figure 4-21. For the highest discharges the levels vary up to 1.5 m.

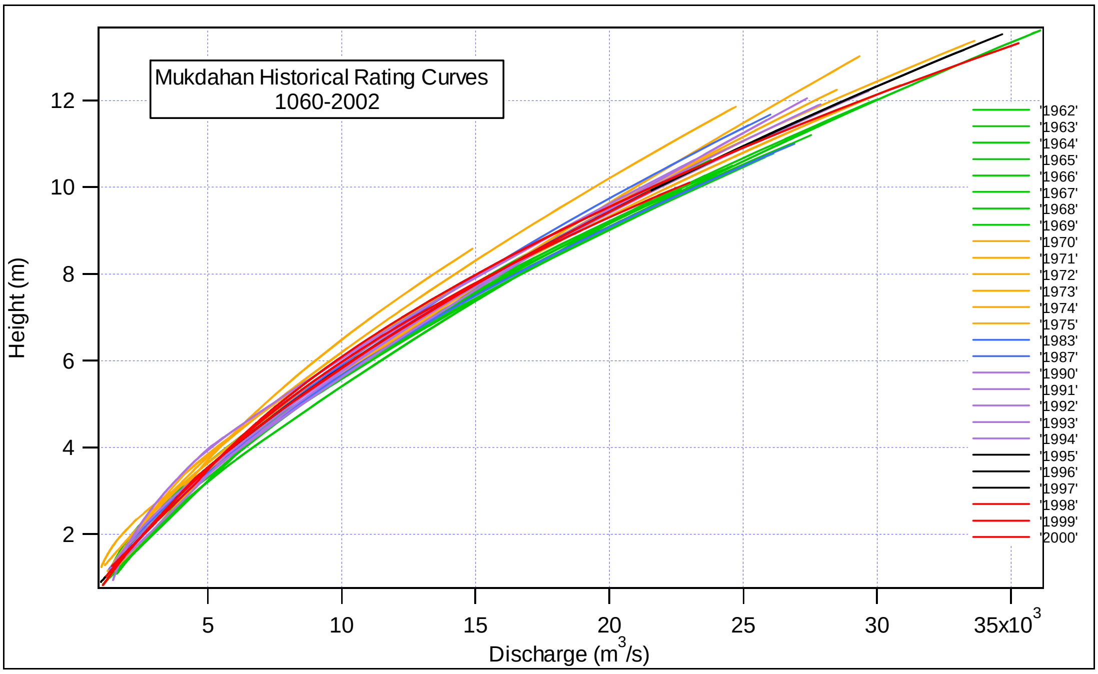


Figure 4-20 Stage-discharge relation of Mekong at Mukdahan (MRC, 2002).

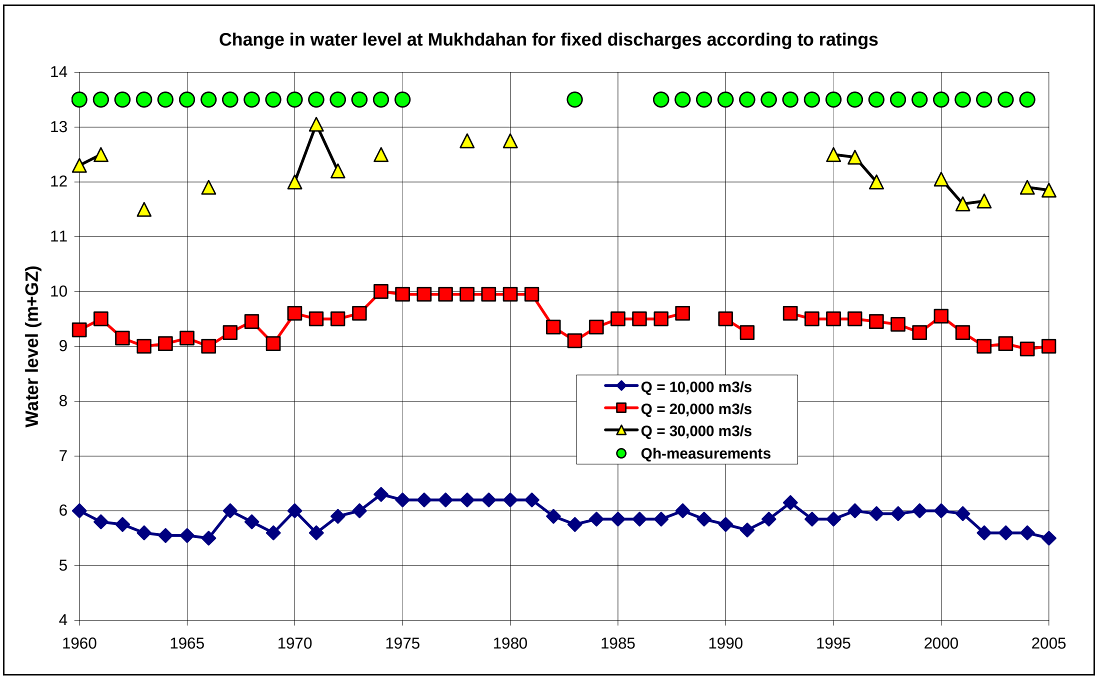


Figure 4-21 Change in water level at Mukdahan for fixed Mekong discharges, period 1960-2005.

The Mekong branch of the hydraulic model was calibrated for the year 2000 stage-discharge conditions, see Figure 4-22. From Figure 4-21 it is observed that this curve forms a middle position of historical discharge curves observed at Mukdahan. Hence, levels for high discharges at this location based on the year 2000 curve may be up to 0.75 m off, up and down. At Nakhon Phanom this variation was in the order of +/- 1.25 m, hence at That Phanom in between these locations a variation of about +/- 1.00 m is to be expected, relative to the year 2000 conditions of the river bed. Observed frequency distributions of water level changes relative to year 2000 for fixed high discharges at Nakhon Phanom and Mukdahan are presented in Figure 4-23. It is observed that these distributions are approximately uniform. This additional uncertainty has to be taken into account in the flood hazard assessment and derived levels. The changes in the ratings observed at Mukdahan appear to be fully uncorrelated with the peak flows and flood volume at Nakhon Phanom for all years with discharge measurement data. Hence, generated flows at the latter are not indicative for the type of change in the discharge rating at Mukdahan.

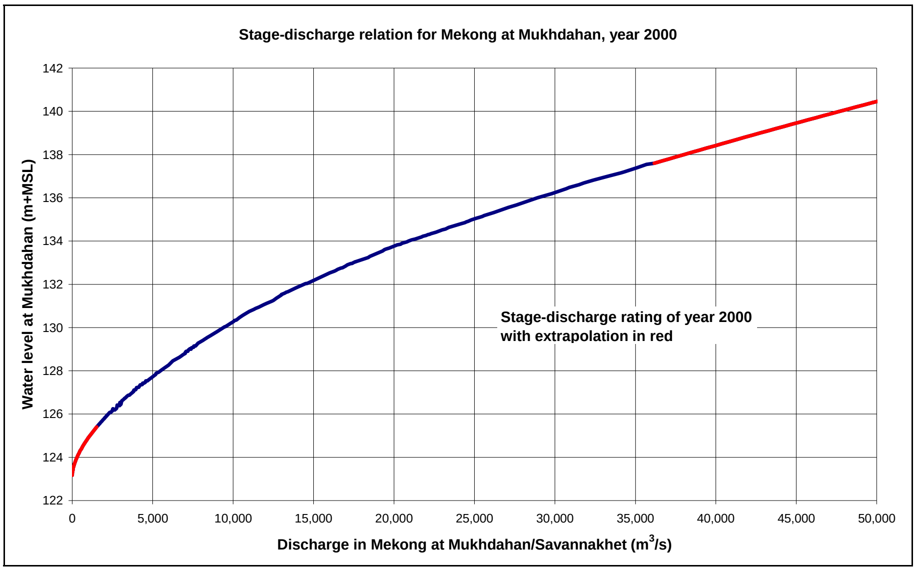


Figure 4-22 Assumed stage-discharge relation for Mukdahan in hydraulic model, year 2000.

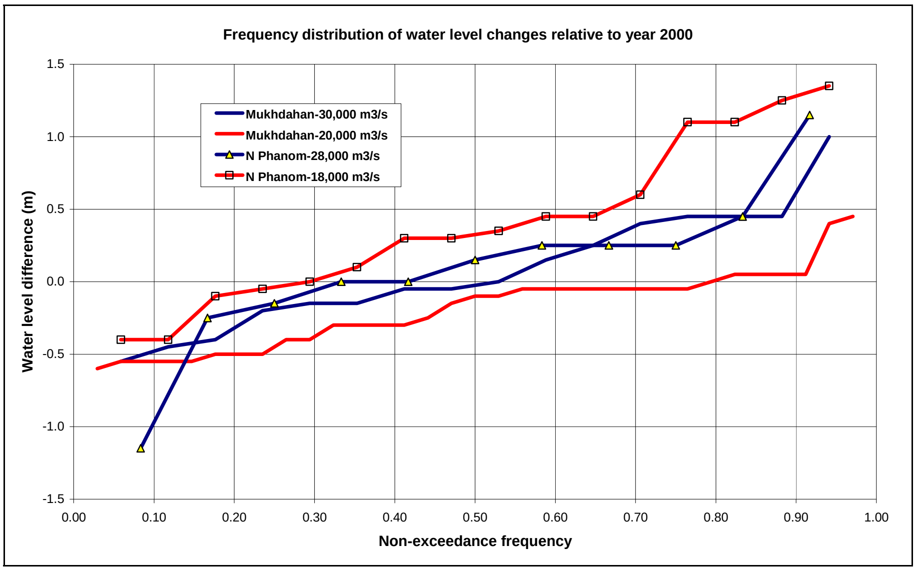


Figure 4-23 Frequency distribution of water level changes relative to year 2000 for fixed high discharges in Mekong at Nakhon Phanom and Mukdahan.

4.4 Model performance test

For the verification of the hydraulic model the gauge readings of Ban Xe Bang Fai and That Phanom of the period 1995-2000 have been used. The model delivered by LNMC with the consultant's boundary conditions (lateral inflow derived from the series at Mahaxai according to equation (4.2)) gave a biased result (on average too high values: average difference for h>140 m amsl = 0.76 m) as is observed from

Figure 4-24. To eliminate the bias the hydraulic roughness of the Xe Bang Fai downstream of Ban Xe Bang Fai has been changed (reduced) to the values displayed in Figure 4-6. The results are presented below.

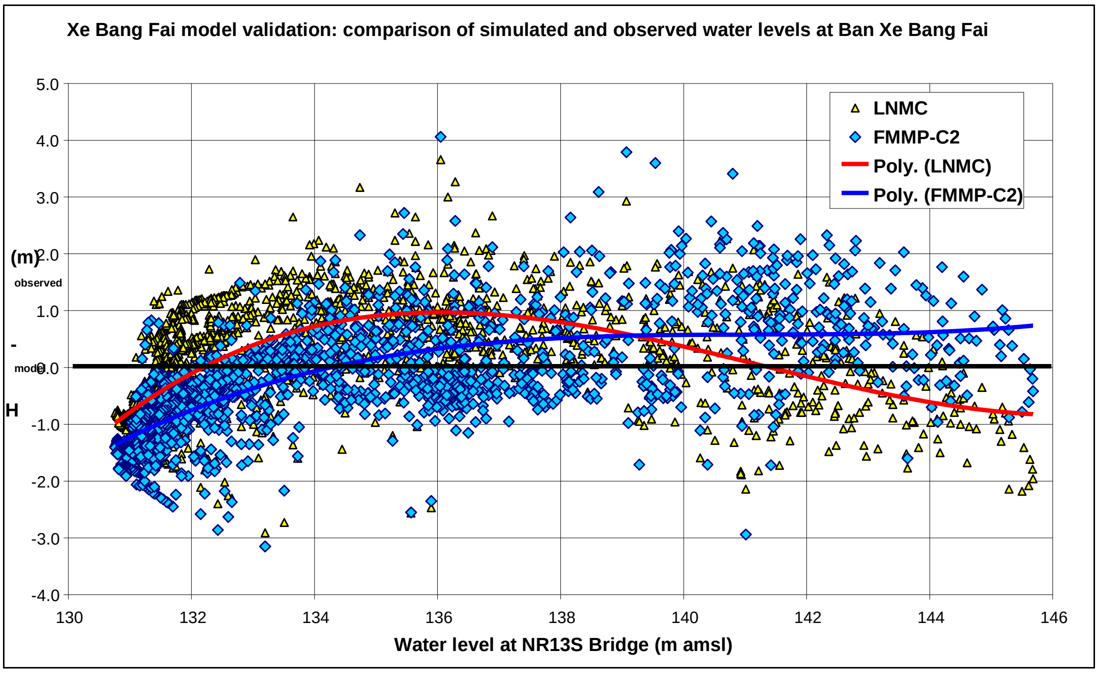


Figure 4-24 Error analysis of Xe Bang Fai hydraulic model calibration at Ban Xe Bang Fai, application of LNMC-calibration.

Verification on levels at That Phanom

The performance of the model with the adjusted hydraulic roughness has been tested on the computed water levels at Ban Xe Bang Fai for the period 1995-2000. The results are presented in Figure 4-25 to Figure 4-30, and an error analysis is presented in Figure 4-31.

From Figure 4-25 to Figure 4-30 it is observed that in general the shape of the hydrographs are closely reproduced by the model, indicating that the applied procedure for the lateral inflow is acceptable as far as the water level at National Road Nr 13 South Bridge is concerned. The suitability of the model for design can be judged from the differences between the observed and computed water levels at Xe Bang Fai Bridge. The results for the years 1995-2000 have been summarised in Figure 4-31. From the figure it is observed that the overall model performance is unbiased for water levels > 135 m amsl values. Individual values, however, may deviate +/- 1.5 m. These differences are partly due to small shifts in the quick rising and falling of the hydrograph and are due to inaccuracies in the supplied tributary discharge. In this respect it is noted that a very high accuracy is not to be expected because about 45% of the discharge at Ban Xe Bang Fai is estimated via an approximate regression equation from the flow difference between Ban Xe Bang Fai and Mahaxai and not from a discharge rating curve. The quality of the model to determine the inundation depth and extent in the flood is still uncertain as detailed information on the extent of the flooding phenomenon is not available. Hence, there remains doubt on the ability of the model to properly describe the interaction between river and floodplain. It is strongly advocated to use a 1D-2D model for the Lower Xe Bang Fai for appropriate simulation of the river-floodplain interaction. This also simplifies the model set-up and calibration.

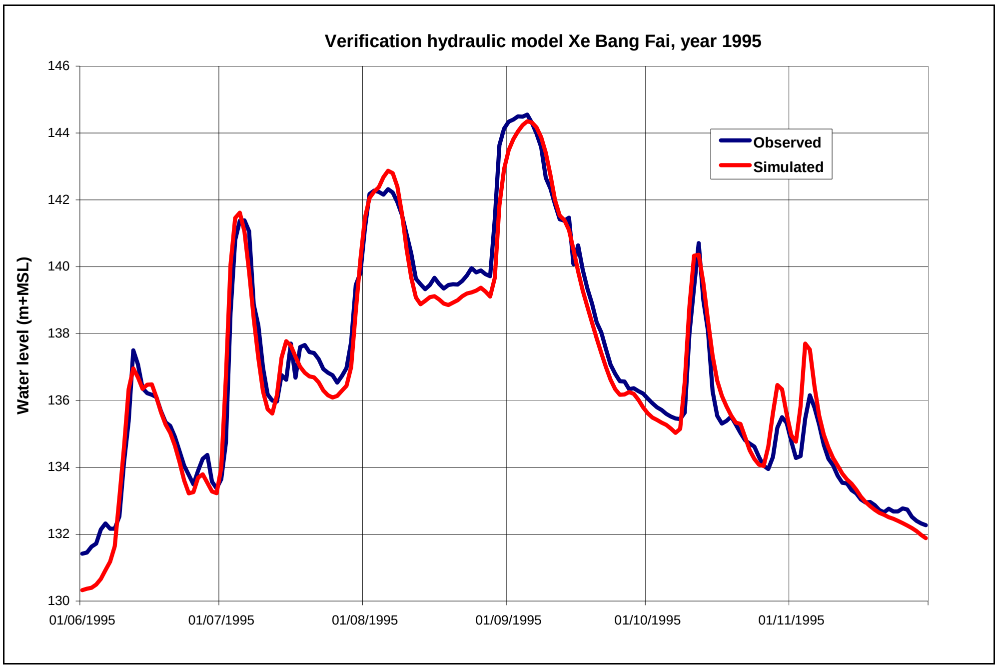


Figure 4-25 Model performance test, observed and simulated water level of 1995 at Ban Xe Bang Fai.

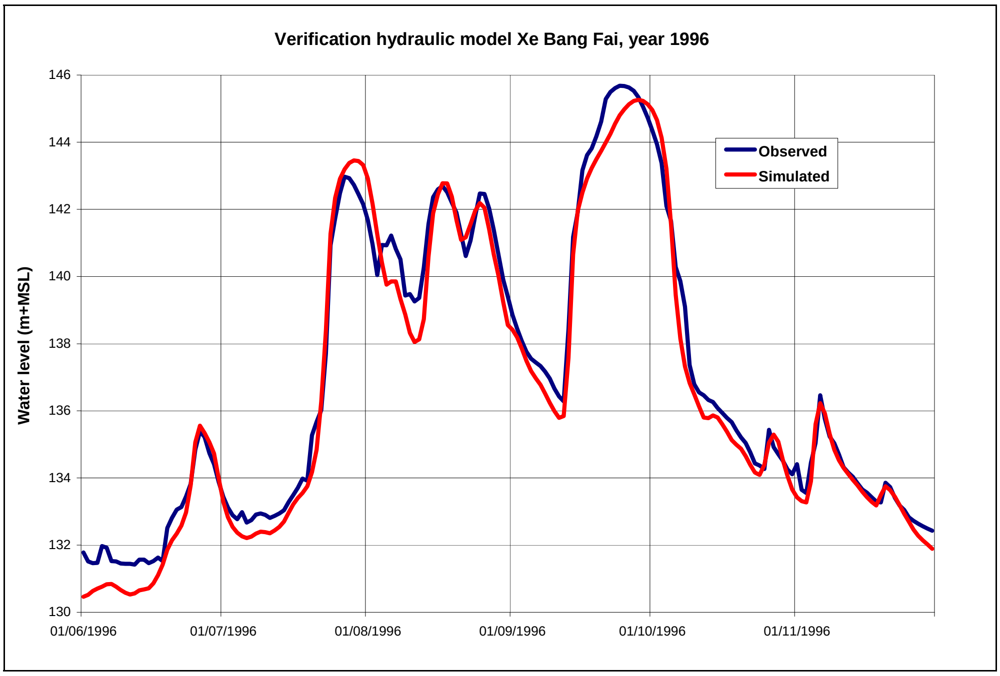


Figure 4-26 Model performance test, observed and simulated water level of 1996 at Ban Xe Bang Fai.

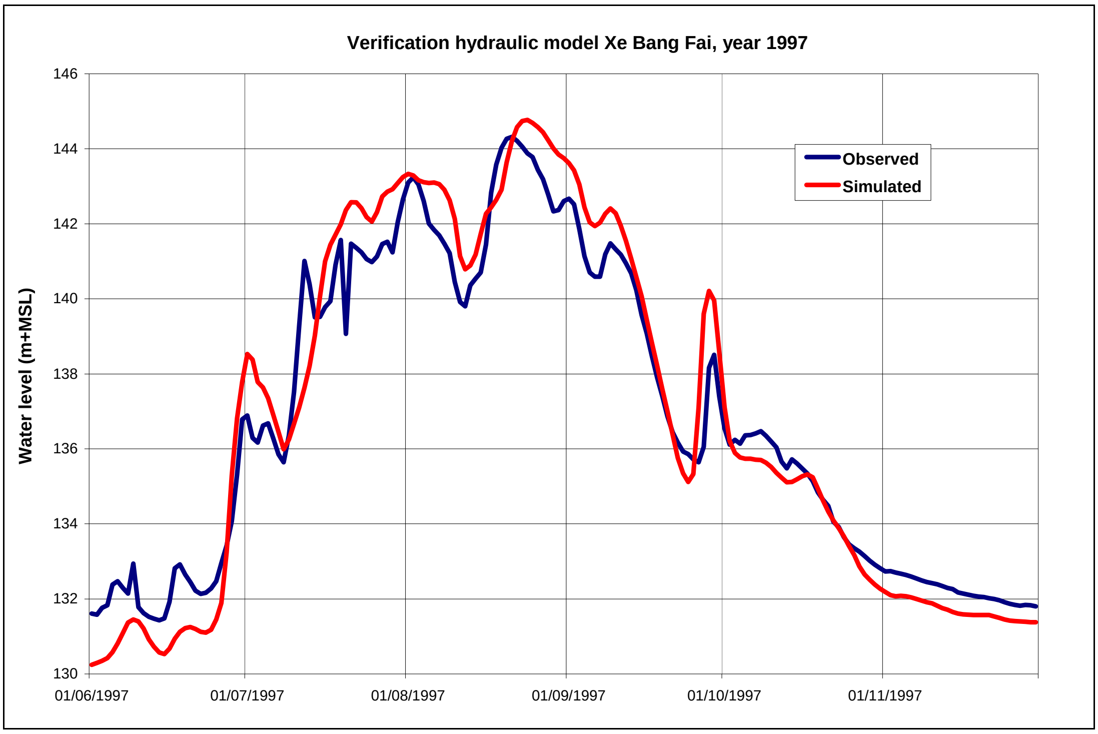


Figure 4-27 Model performance test, observed and simulated water level of 1997 at Ban Xe Bang Fai.

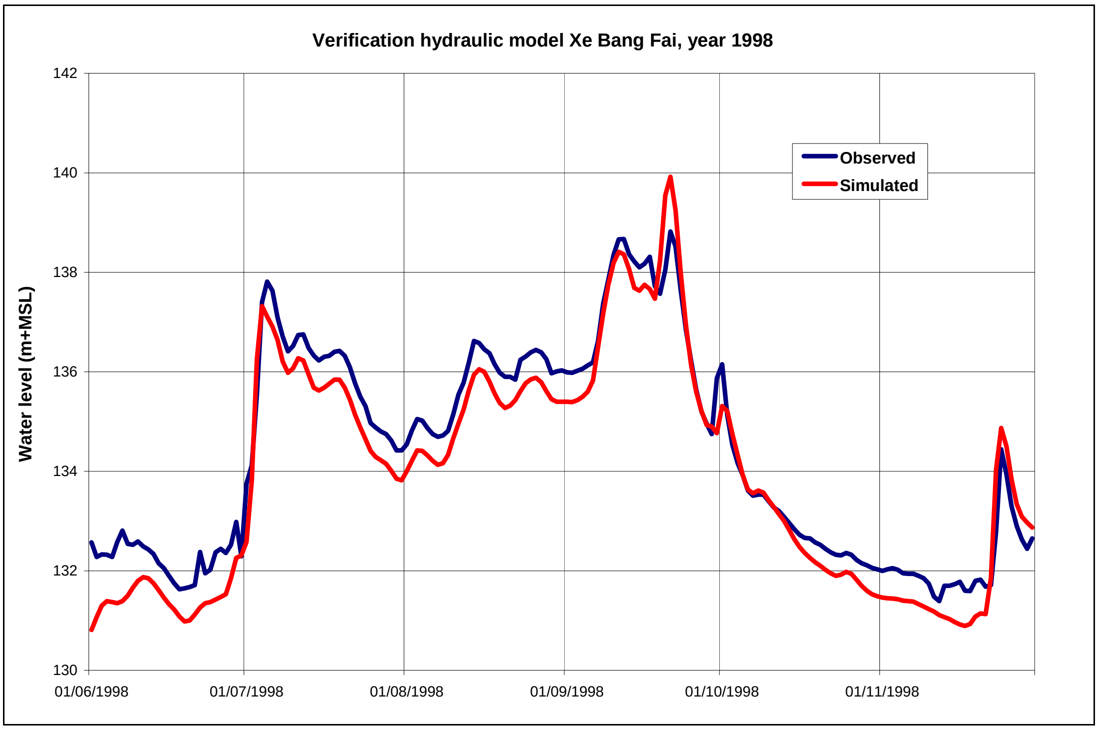


Figure 4-28 Model performance test, observed and simulated water level of 1998 at Ban Xe Bang Fai.

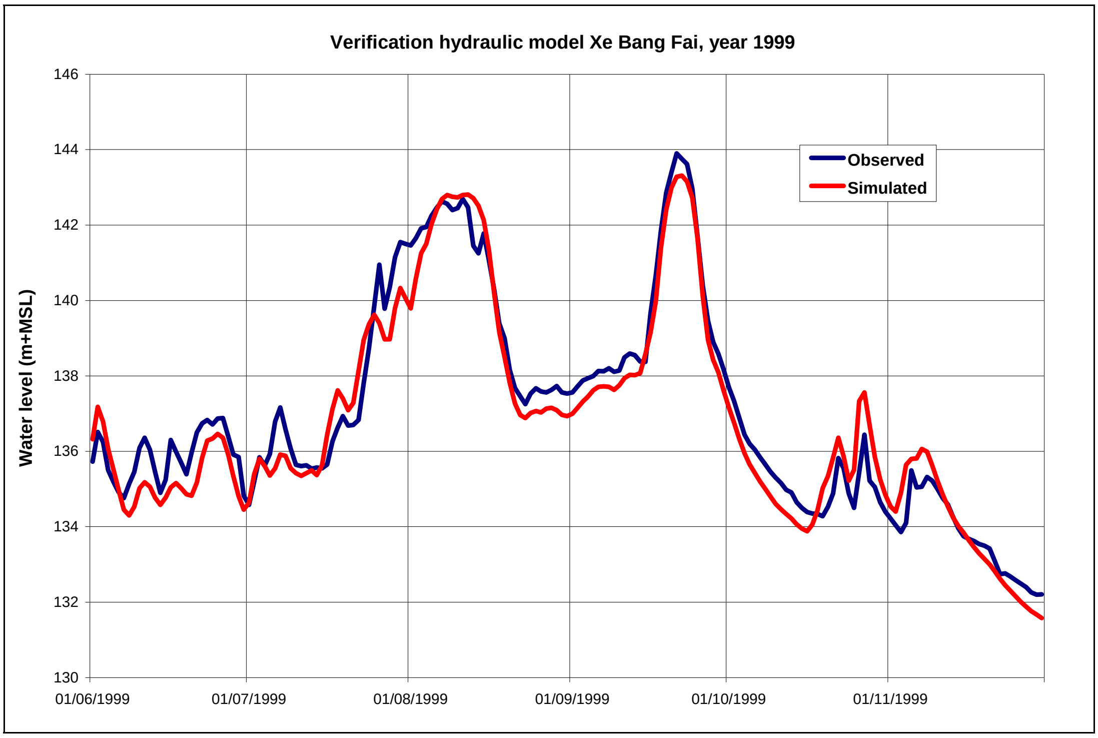


Figure 4-29 Model performance test, observed and simulated water level of 1999 at Ban Xe Bang Fai.

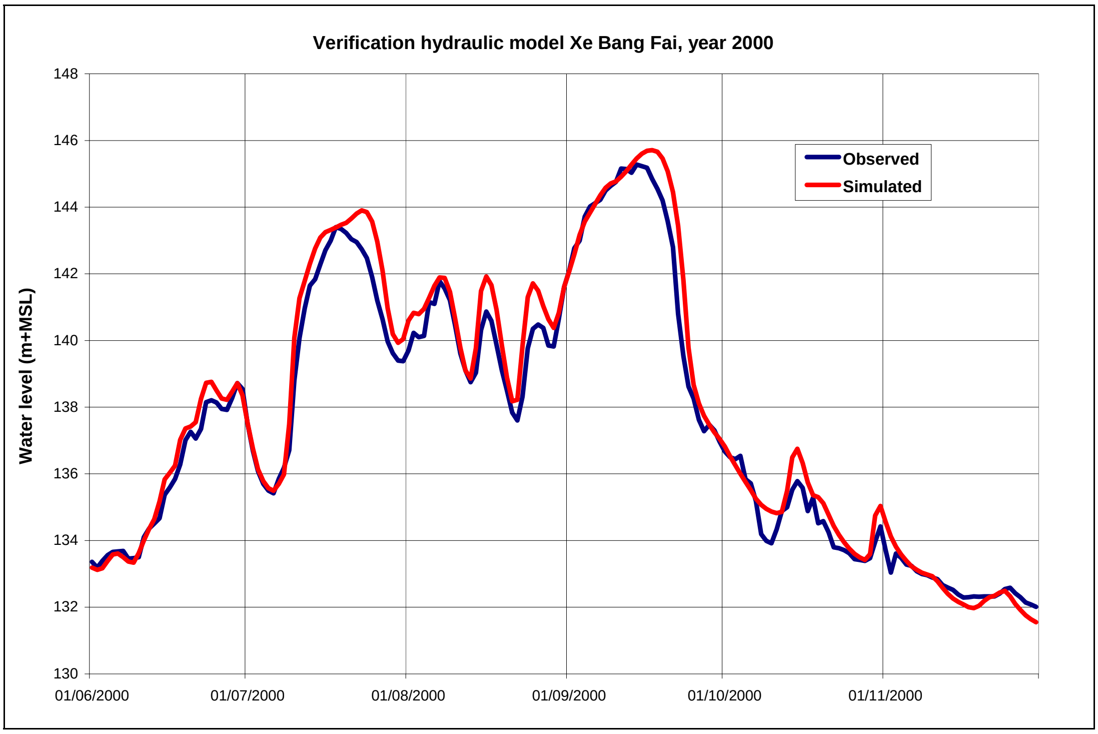


Figure 4-30 Model performance test, observed and simulated water level of 2000 at Ban Xe Bang Fai.

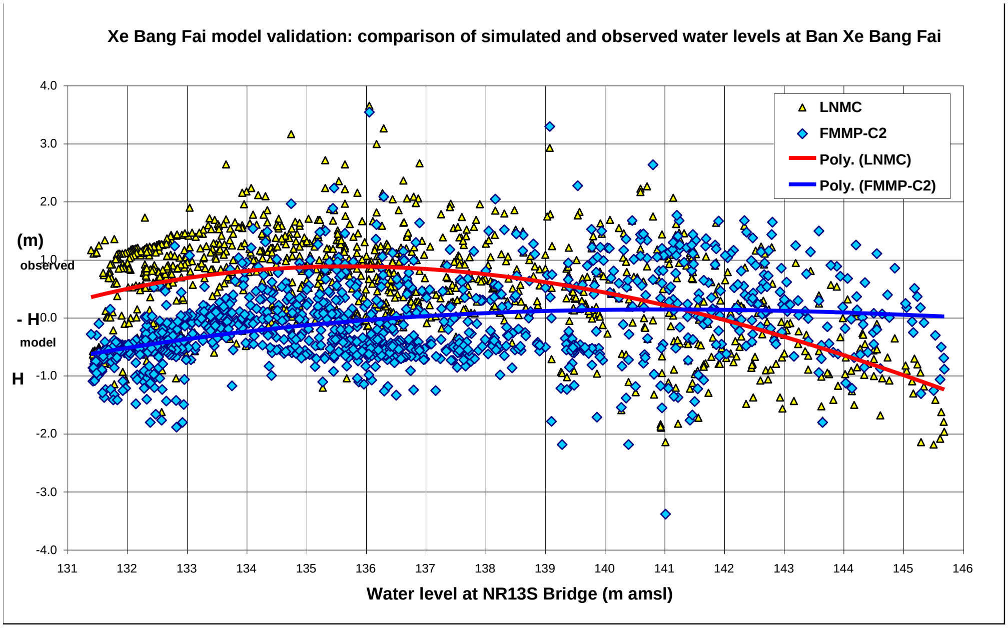


Figure 4-31 Error analysis of Xe Bang Fai hydraulic model calibration at Ban Xe Bang Fai.

Verification on levels at That Phanom

The computed water levels at That Phanom for the period 1995-2000 have been compared with observed ones as well. Some results are displayed in Figure 4-32 and Figure 4-33, whereas in Figure 4-34 an analysis is given of the model error. From the figures it is observed that a close match is obtained between model result and observations, with deviations generally less than 2 dm. This close match is to a large extent imposed by the water level boundary at Mukdahan, which gives strong backwater effect on the stage at That Phanom.

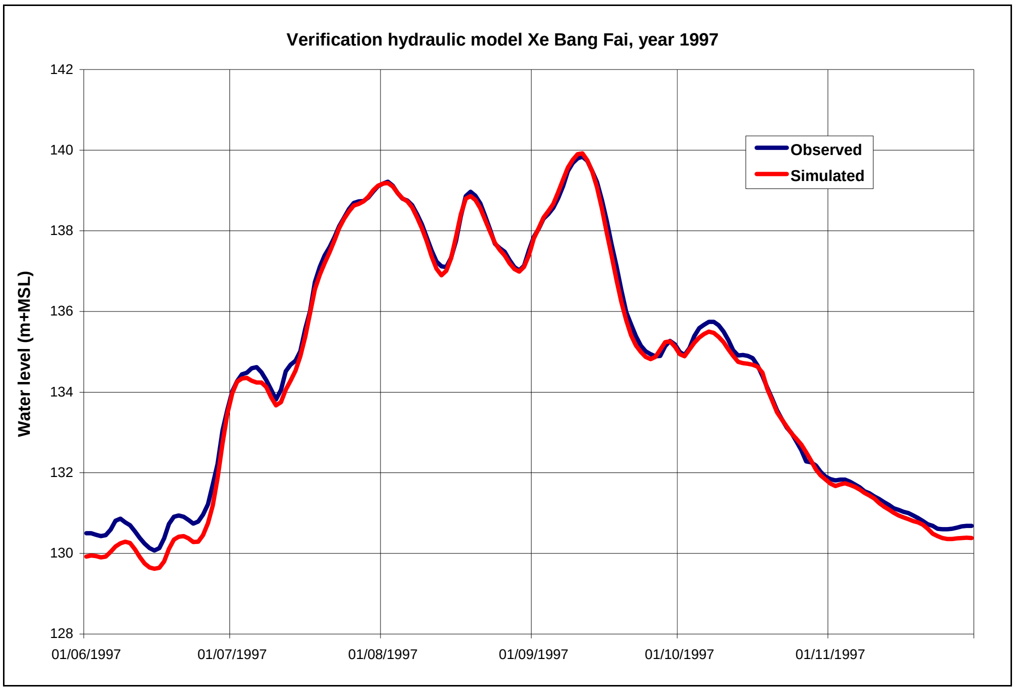


Figure 4-32 Model performance test, observed and simulated water level of 1997 at That Phanom.

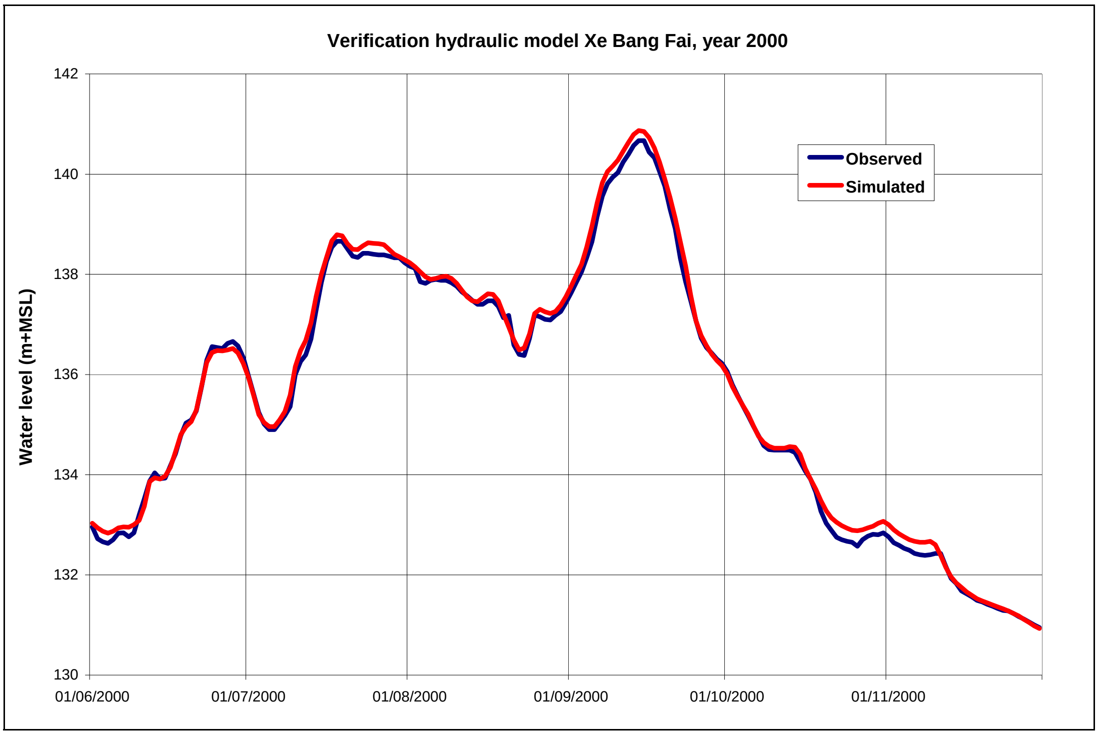


Figure 4-33 Model performance test, observed and simulated water level of 2000 at That Phanom.

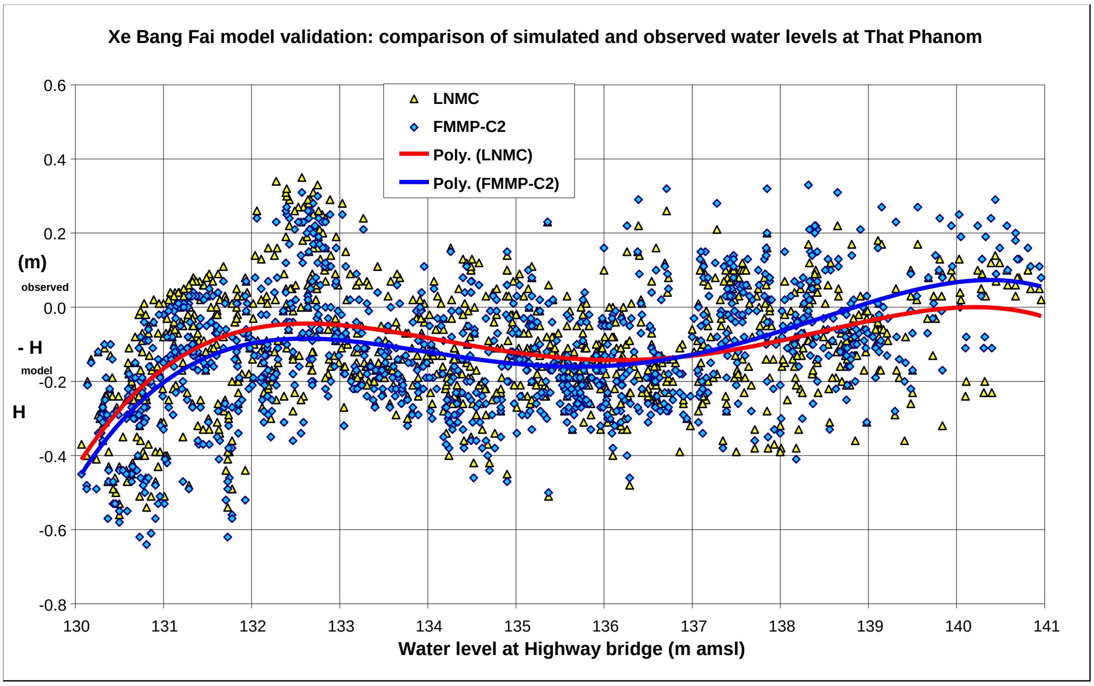


Figure 4-34 Error analysis of Xe Bang Fai hydraulic model calibration at That Phanom.

5. Hydrological Hazard Assessment

5.1 General

For flood hazard assessment the water levels in the Xe Bang Fai between Mahaxai and the river mouth opposite That Phanom for distinct return periods (T = 2, 10, 25 and 100 years) will have to be determined using the Monte Carlo procedure as discussed in Chapter 2. The hydrological boundary conditions needed for the application of the procedure are presented in this chapter including their interrelation.

5.2 Peak discharge and flood volume Xe Bang Fai at Mahaxai

Peak discharge

Annual peak discharges in the Xe Bang Fai at Mahaxai in the period 1988-2006 ranged from 834 m^3/s in 1998 to 2,548 m^3/s in 2005, see Figure 5-1. The peak mainly occurs in the months August and September and occasionally in late June or July, as can be observed from Figure 5-2. The General Extreme Value distribution fits well to the observed annual peak discharges at Mahaxai, as shown in Figure 5-3. This distribution has the form:

$$F(x) = \exp\left\{ -\left(1 - k\left(\frac{x-u}{\alpha} \right) \right)^{1/k} \right\} \qquad (5.1)$$

where: F(x) = GEV distribution function
k, α, u = parameters of the distribution

The parameters as determined by probability weighted moments and the discharge values for distinct return periods are summarised in Table 5-1.

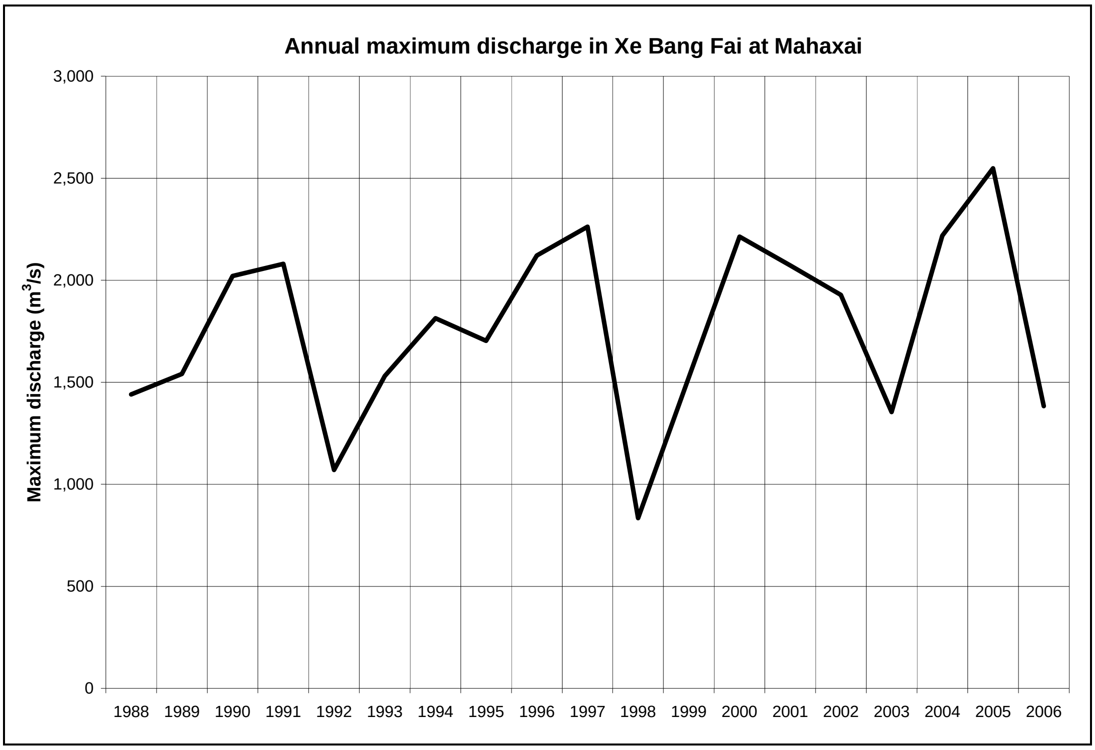


Figure 5-1 Annual maximum discharge in the Xe Bang Fai at Mahaxai, period 1988-2006.

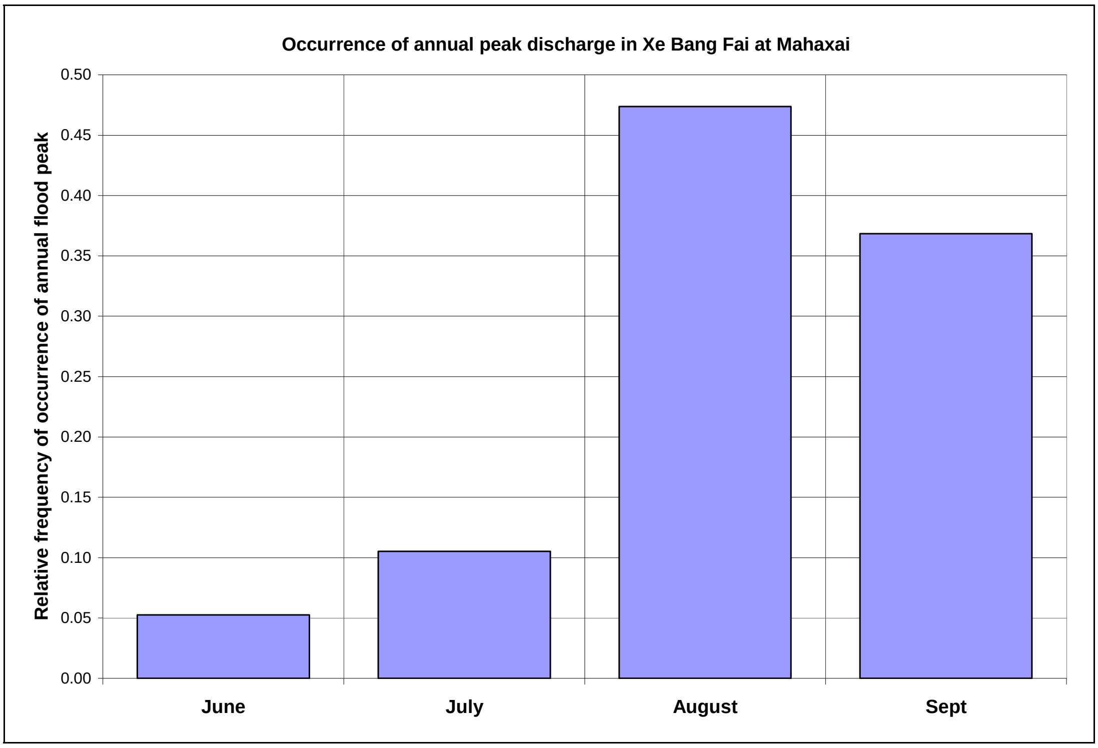


Figure 5-2 Occurrence of annual maximum discharge in the Xe Bang Fai at Mahaxai.

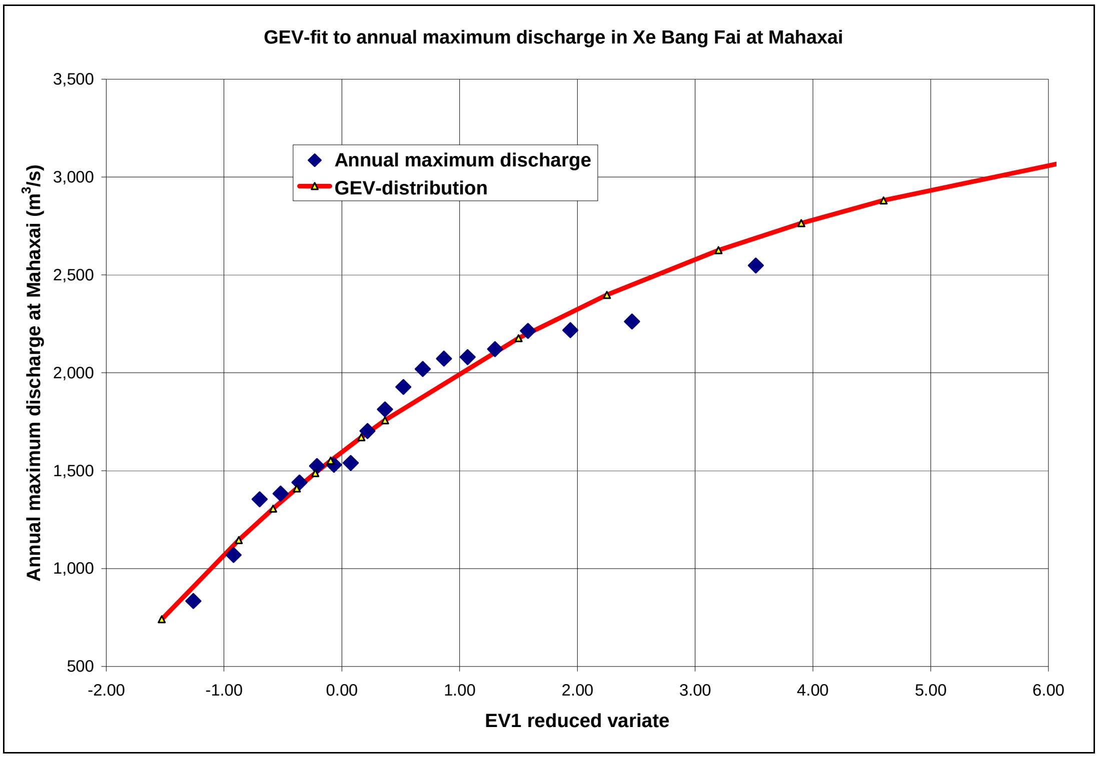


Figure 5-3 GEV-fit to annual maximum discharge in the Xe Bang Fai at Mahaxai.

Table 5-1 GEV-parameters, peak-discharge and flood volumes for distinct return periods in the Xe Bang Fai at Mahaxai.

Parameter	Peak discharge (m^3/s)	Flood Volume (MCM)
k	0.341	0.221
α	498	2,304
u	1,614	6,105
T (years)		
2	1,757	6,916
5	2,177	9,045
10	2,398	10,188
25	2,626	11,386
50	2,765	12,126
100	2,881	12,755

Flood volumes

Similarly, the GEV-distribution fits well with the distribution of annual flood volumes in the Xe Bang Fai, see Figure 5-4. The annual flood volume is defined here as the volume in MCM occurring in the fixed period from 1 June till 30 November. A fixed time is needed here for proper reproduction of the occurrence of inundations in view of assessment of damage to crops. The parameters of the GEV-distribution and flood volumes for distinct return periods are summarised in Table 5-1.

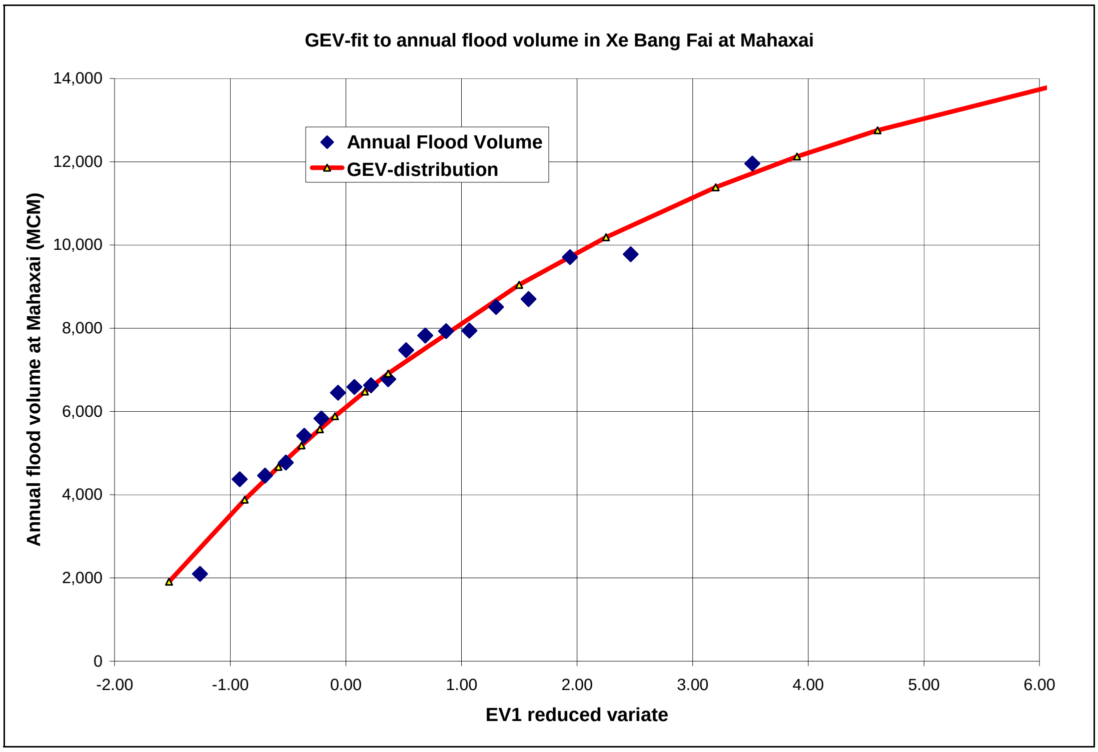


Figure 5-4 GEV-fit to annual flood volume in the Xe Bang Fai at Mahaxai.

Peak discharge – flood volume relation

For the flood hazard assessment with the Monte Carlo procedure for given flood volumes in the Mekong, representative flood volumes in the Xe Bang Fai will be selected. Reference is made to Sub-section 5.4 for the relationship. To improve the selection among historical floods on the Xe Bang Fai its concurrent realistic peak value has to be known. This can be obtained from the relationship between peak discharges and flood volumes.

The relationship between peak discharge and flood volumes at Mahaxai is presented in Figure 5-5. From this figure it is observed that a fairly close relationship exists between the annual peak-discharge and the flood volume in the Xe Bang Fai at Mahaxai:

$$Q_{peak,Mahaxai}(m^3/s) = 0.1734\,V_{FV,Mahaxai}(MCM) + 556 \quad (R^2 = 0.78) \qquad (5.2)$$

where: Q = peak discharge in (m^3/s) at Mahaxai
V = flood volume in (MCM) at Mahaxai

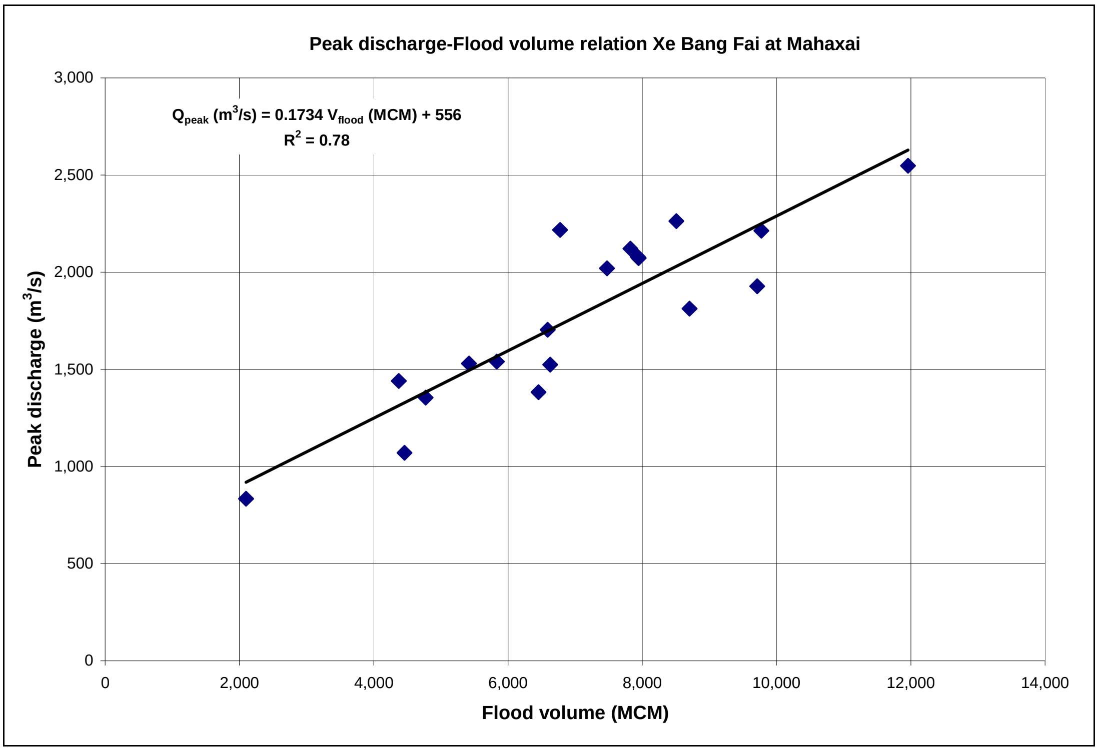


Figure 5-5 Relation between peak discharge and flood volume in the Xe Bang Fai at Mahaxai.

5.3 Peak discharge and flood volume Mekong at Nakhon Phanom

Marginal distributions of peak discharge and flood volume

Statistics of the discharge series of Nakhon Phanom on the Mekong are the key to the formulation of the Mekong boundary in the Monte Carlo procedure as is explained in Chapter 6. The statistics of the peak-flow and annual flood volume (from 1 June to 30 November) at Nakhon Phanom are discussed below. The annual maximum discharge in the Mekong at Nakhon Phanom is presented in Figure 5-6. The long-term average annual peak flow amounts 26,049 m3/s with a standard deviation of 4,486 m3/s. The observed frequency distribution is well fitted by a GEV-distribution as shown in Figure 5-7. The distribution parameters and the peak flows for distinct return periods are presented in Table 5-2.

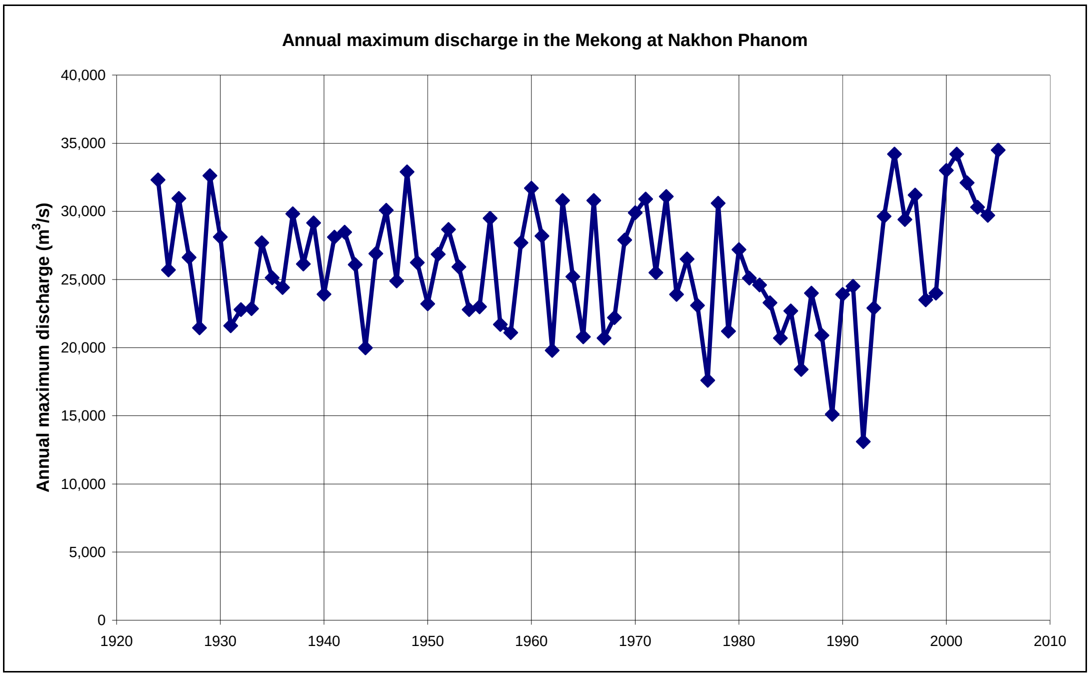


Figure 5-6 Annual maximum discharge in the Mekong at Nakhon Phanom, period 1924-2005.

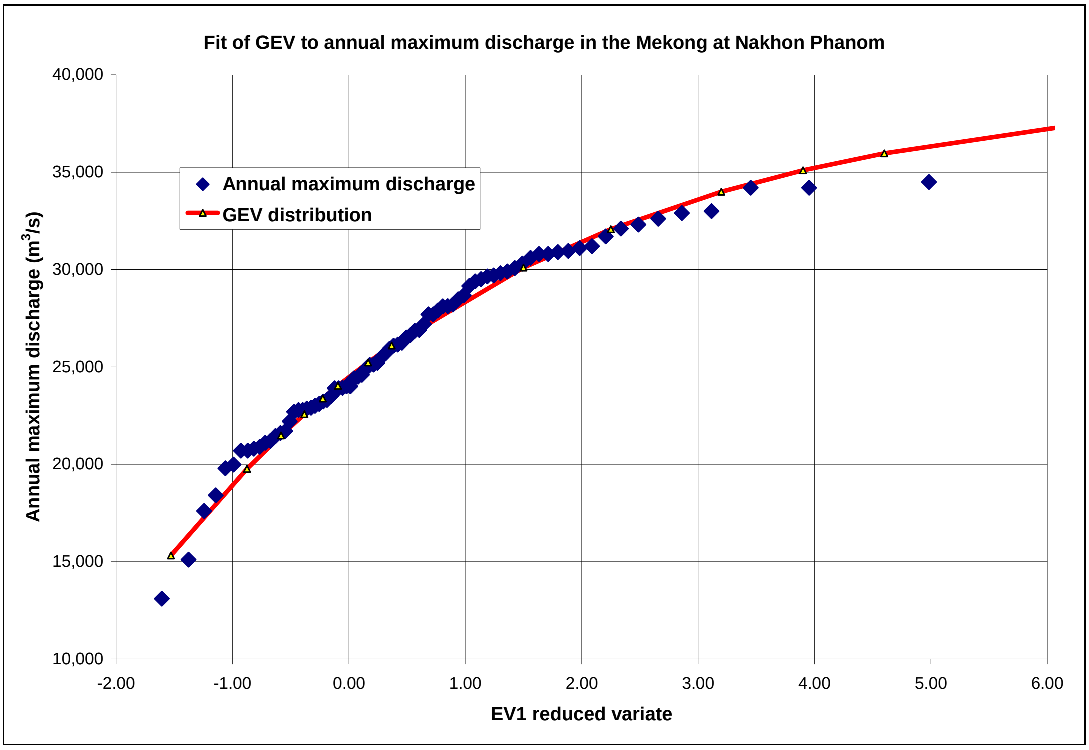


Figure 5-7 GEV-fit to marginal distribution of annual maximum discharge in the Mekong at Nakhon Phanom

The annual flood volumes, defined here as the flow volume between 1 June and 30 November, is displayed in Figure 5-8. Note that the recent years have been extremely voluminous. Like for the annual peak values, the GEV-distribution fits to the annual flood volumes. Distribution parameters and values for selected return periods are shown in Figure 5-9 and Table 5-2. An excellent fit is observed from the graph. The average flood volume amounts 203,895 MCM; the standard deviation is 35,952 MCM.

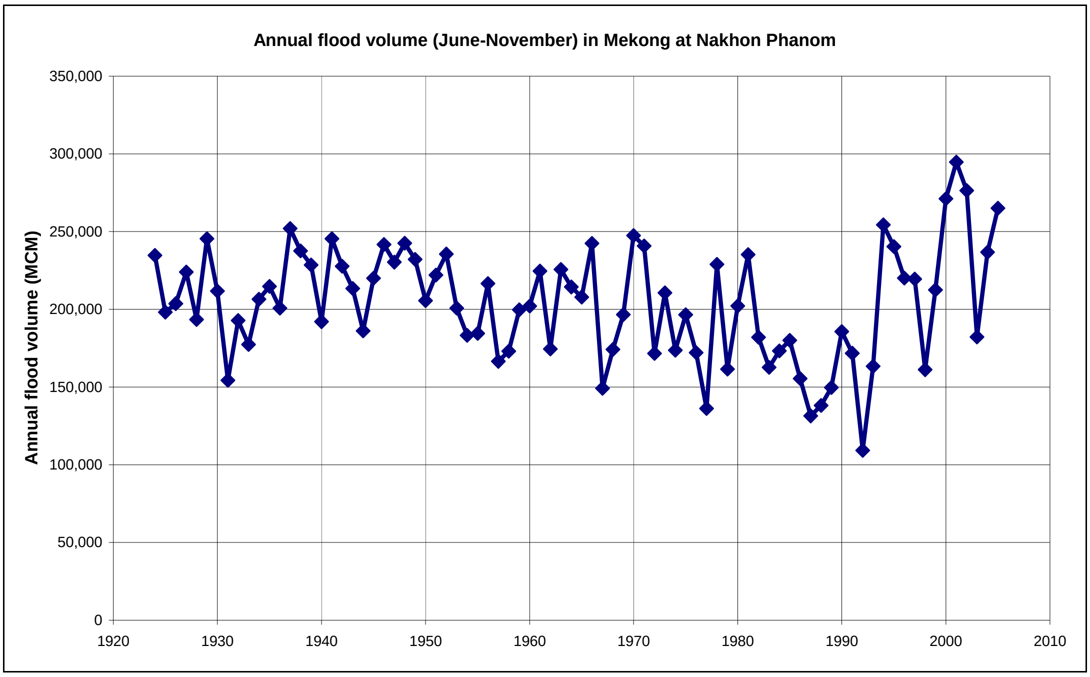


Figure 5-8 Annual flood volume (June-November) in Mekong at Nakhon Phanom, period 1924-2005.

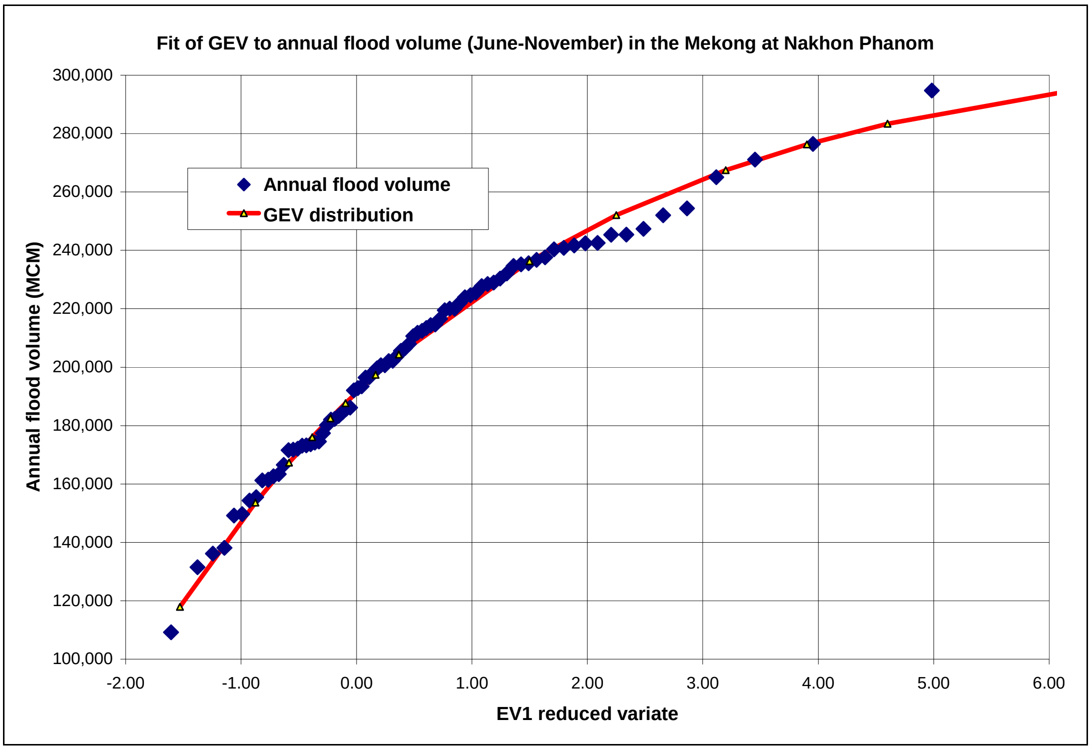


Figure 5-9 GEV-fit to marginal distribution of annual flood volume (June-November) in the Mekong at Nakhon Phanom.

Table 5-2 GEV-parameters, peak-discharge and flood volumes (June-November) for distinct return periods in the Mekong at Nakhon Phanom.

Parameter	Peak discharge (m^3/s)	Flood Volume (MCM)
k	0.309	0.309
α	4,685	37,515
u	24,475	191,288
T (years)		
2	26,098	204,288
5	30,097	236,318
10	32,070	252,123
25	33,989	267,502
50	35,090	276,328
100	35,970	283,382

Bivariate distribution of peak discharge and flood volume

The bivariate extreme value distribution of flood peaks and flood volumes has been described by Adamson et al. (1999). The joint probability can be generated by the Gibbs sampler Monte Carlo procedure. This technique requires that annual flood peaks (X) and annual flood volumes (Y) are regressed against each other:

$$X = a_{x,y} + b_{x,y}Y \qquad Y = a_{y,x} + b_{y,x}X \tag{5.3}$$

and the GEV distributions are used to model the residuals of flood peaks and flood volumes with parameters respectively (u_x, α_x,,k_x) and(u_y, α_y,,k_y). The Gibbs procedure then reads the uniformly distributed random numbers R and the generated values marked with #:

$$X_j^{\#} = a_{x,y} + b_{x,y}Y_j^{\#} + u_x + \frac{\alpha_x}{k_x}\left\{1-(-\ln(R_1))^{k_x}\right\} \qquad Y_{j+1}^{\#} = a_{y,x} + b_{y,x}X_j^{\#} + u_y + \frac{\alpha_y}{k_y}\left\{1-(-\ln(R_2))^{k_y}\right\} \tag{5.4}$$

The relation between flood volume and peak flow and vice versa is depicted in Figure 5-10, with the coefficients of the equations (5.3) presented in Table 5-3.

Table 5-3 Regression parameters and parameters of GEV distributions of regression residuals for the peak flows and flood volumes of the Mekong at Nakhon Phanom.

Regression	Regression parameters		GEV parameters of regression residuals		
Peak on volume	$a_{y,x}$=4,902	$b_{y,x}$=0.1037	u_y= -973.7	α_y= 2,332	k_y=0.1944
Volume on peak	$a_{x,y}$=30,353	$b_{x,y}$=6.6622	u_x=-6,738	α_x=19,951	k_x=0.3063

The GEV-fit to the residual peak discharges and flood volumes is presented in Figure 5-11 and Figure 5-12. The parameters are shown in Table 5-3.

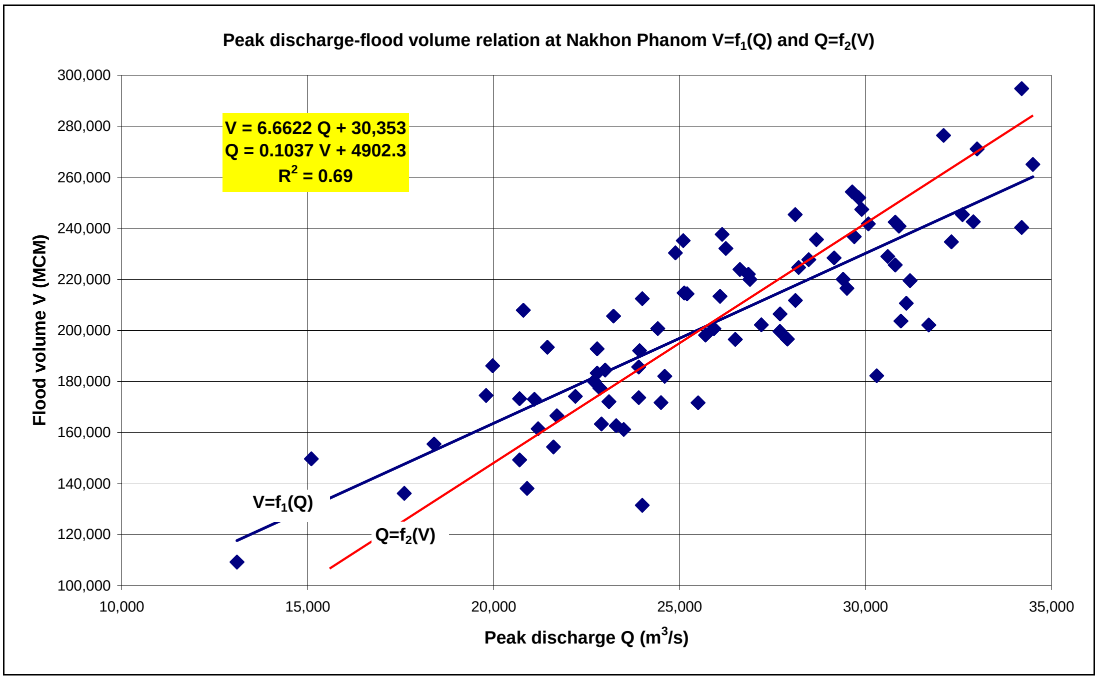


Figure 5-10 Flood volume – peak discharge relations for the Mekong at Nakhon Phanom.

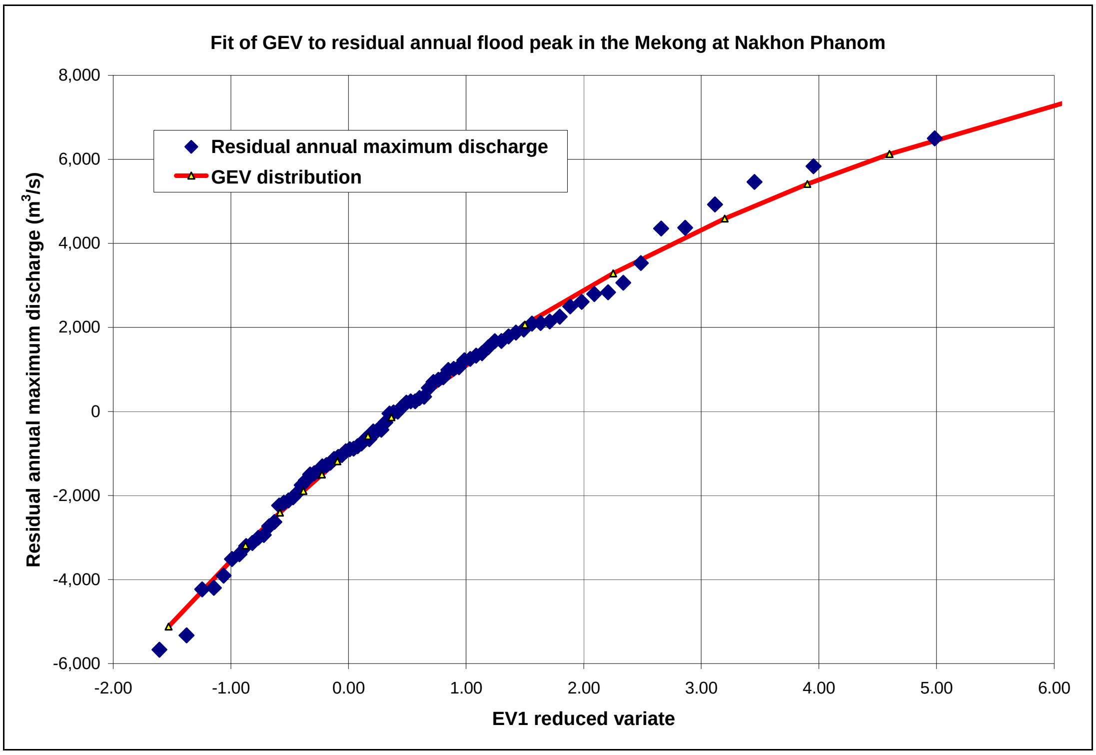


Figure 5-11 GEV-fit to residual annual peak discharge, Mekong at Nakhon Phanom.

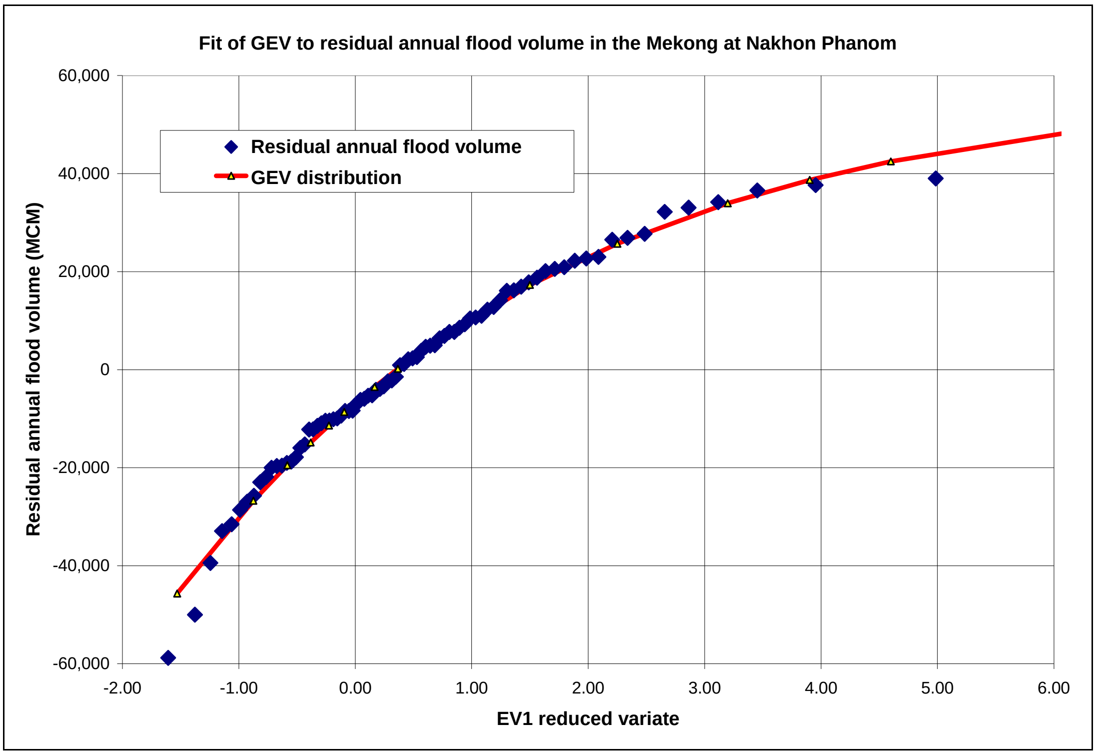


Figure 5-12 GEV-fit to residual flood volume, Mekong at Nakhon Phanom.

5.4 Xe Bang Fai-Mekong correlation

Another aspect that is of importance in selecting samples for the Monte Carlo procedure is the correlation between flood volumes on the Xe Bang Fai and on the Mekong and between discharge peaks on both rivers.

The flood volume in the Xe Bang Fai is correlated with the flood volume in the Mekong, as shown in Figure 5-13. The relation between the flood volumes is given by:

$$V_{Mahaxai}(MCM) = 0.0335\,V_{NakhonPhanom}(MCM) + 52.8 \quad (R^2 = 0.58) \qquad (5.5)$$

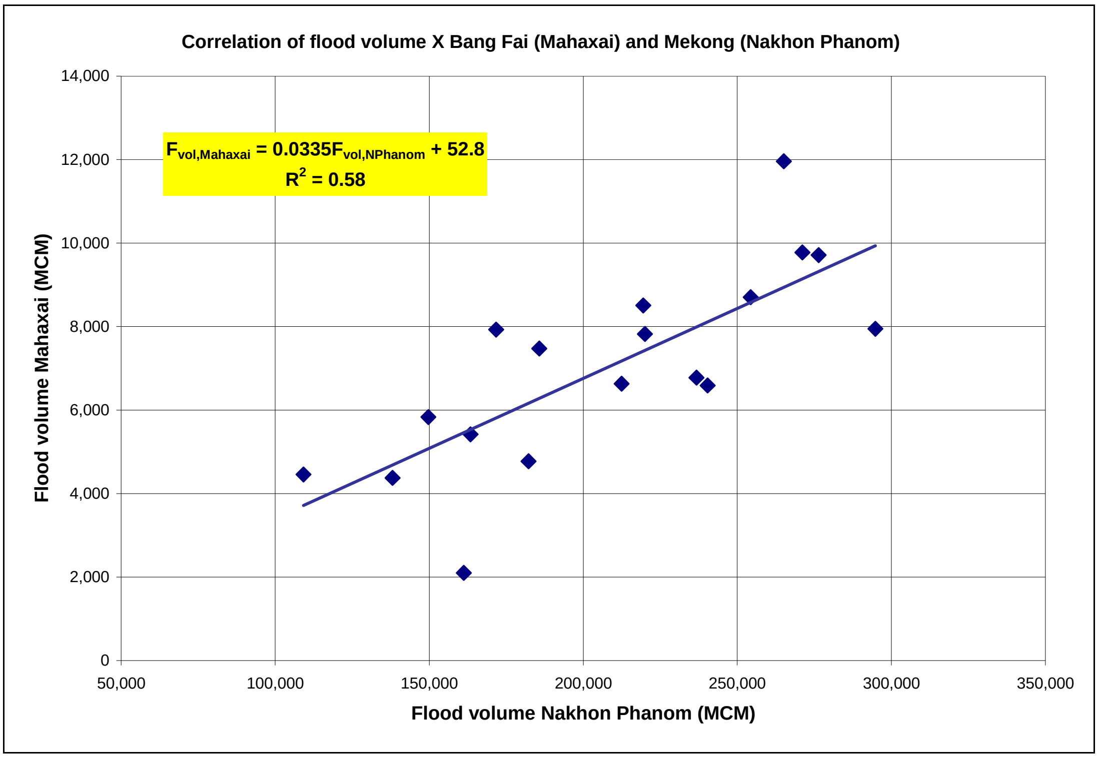


Figure 5-13 Relation between flood volume in the Xe Bang Fai at Mahaxai and in the Mekong at Nakhon Phanom.

The correlation between the peak flows at Mahaxai and at Nakhon Phanom is also significant but not as close as between the volumes:

$$Q_{peak,Mahaxai}(m^3/s) = 0.0436\, Q_{peak,NakhonPhanom}(m^3/s) + 561 \quad (R^2 = 0.42) \qquad (5.6)$$

6. Flood Hazard Assessment

6.1 General

The floods in the Lower Xe Bang Fai are classified as combined floods. The hazard assessment procedure for combined floods was outlined in Chapter 2. The flood hazard is derived from the hydrological hazard, described in Chapter 5.

The steps used to derive the flood hazard from the hydrological hazard using the hydraulic model and subsequently applying the Monte Carlo technique is outlined in Sub-section 6.2. The flood hazard will be determined for:

1. the Base Case, i.e. without embankments along the Lower Xe Bang Fai;
2. the situation with embankments dykes along the left bank of the Lower Xe Bang Fai;
3. the situation with embankment along both banks of the Lower Xe Bang Fai;
4. the situation with a diversion canal from the Xe Bang Fai, 25 downstream of Ban Xe Bang Fai, to the Mekong River. The results are presented in Sub-section 6.3. The resulting flood maps are presented in Sub-section 6.4. Finally, the effect of a bypass canal from the Lower Xe Bang Fai to the Mekong, which as a shortcut for discharge of floodwater, on the flood levels have been investigated in Sub-section 6.5.

6.2 Applied boundary conditions

The procedure used to derive the boundary conditions for the hydraulic model as input to the Monte Carlo method has been:

1. Selection of 5 flood volumes (very low, low, medium, high and very high) at Nakhon Phanom for 6 different peak discharge levels with return periods of T = 2, 5, 10, 25, 50 and 100 years. Use is made of the regression relation between flood volume and peak flow, described Chapter 5, Table 5-3:
   - very low = regression – 1.96 x S_e (S_e = standard error about regression)
   - low = regression -1 x S_e
   - medium = regression
   - high = regression + 1 x S_e
   - very high = regression + 1.96 x S_e.

   The standard error about regression for Nakhon Phanom S_{eNP} = 19,987 MCM.
2. Selection of discharge hydrographs of the Mekong at Nakhon Phanom with volumes close to those computed in Step 1.
3. Adjustment of selected historical discharge hydrographs to fit into the scheme of step 1.
4. Using equation (5.5), generation of 3 corresponding flood volumes in the Xe Bang Fai for each selected flood volume at Nakhon Phanom:
   - low = regression -1.96 x S_e,
   - medium= regression, and
   - high = regression +1.96 x S_e.

   The standard error about regression for Mahaxai S_{eM} = 1,524 MCM.
5. Selection of hydrographs in the Xe Bang Fai series with volumes close to those computed in Step 4.
6. Scaling of Xe Bang Fai series to match with the required flood volume, and final adjustment based on peak discharges.

7. For the Nam Theun 2 scenario: add 220 m^3/s to the discharge at Mahaxai.
8. Computation of total lateral inflow using equation (4.2), and
9. Partitioning of the lateral inflow between Se Noy (44%), Q81 (29%), Q38 (15%) and Q35 (11%) as proposed by the LNMC & MRC modelling teams.

With this procedure 6 x 5 x 3 = 90 flood seasons have been created to represent the full gamma of physically realistic water level/discharge combinations as input for the Monte Carlo simulation procedure.

Monte Carlo simulations have been executed to derive exceedance frequencies of water levels along the Xe Bang Fai River at every grid cell. The error introduced by the Monte Carlo techniques decreases with increasing number of samples. Therefore, a relatively large number of samples (100,000) were taken to make sure errors were minimal. To test if this is indeed the case, two successive Monte Carlo runs were executed, and results were compared. It turned out that the absolute difference in resulting 100-year water levels between the two runs differed at maximum two centimetres for all locations in the river, which is negligible.

6.3 Simulation results

6.3.1 Cases

Hydraulic model and Monte Carlo simulations were executed for three different schematisations (“cases”) of the river system:

Case 1: situation with no embankments, i.e. the river conditions till 2002;
Case 2: situation with embankments along the left bank, which are the present conditions;
Case 3: situation with embankments on both banks, i.e. the planned layout.

In the Cases 2 and 3 the embankments are situated along the stretch from the Xe Bang Fai NR13S Bridge down to the confluence with the Mekong River.

6.3.2 Water levels in the Xe Bang Fai River

Performance test

For each location along the river and the floodplain exceedance frequency distribution of water levels have been obtained with the Monte Carlo procedure by interpolation between the results obtained with the hydraulic model. Figure 6-1 shows an example of an exceedance frequency distribution for model node XBFi-9822, near Mahaxai station, as derived from the Monte Carlo simulations. These results are for the situation with no embankments along the river. The figure consists of a large number of dots, each representing a threshold value for which the exceedance probability is derived. The thresholds are all multiples of a centimetre, i.e. the vertical distance between neighbouring dots is exactly one centimetre. For each of these threshold values the exceedance probability is computed in the straightforward crude Monte Carlo manner: the number of exceedances is counted and this number is divided by the total number of simulations (100,000). So for example in case of Figure 6-1 the threshold water level of 154.5 m amsl is exceeded 1,000 times, which gives a probability of exceedance of 1,000/100,000 = 1/100 per year. In other words: for location XBFi-9822 the 100-year water level is equal to 154.5 m amsl.

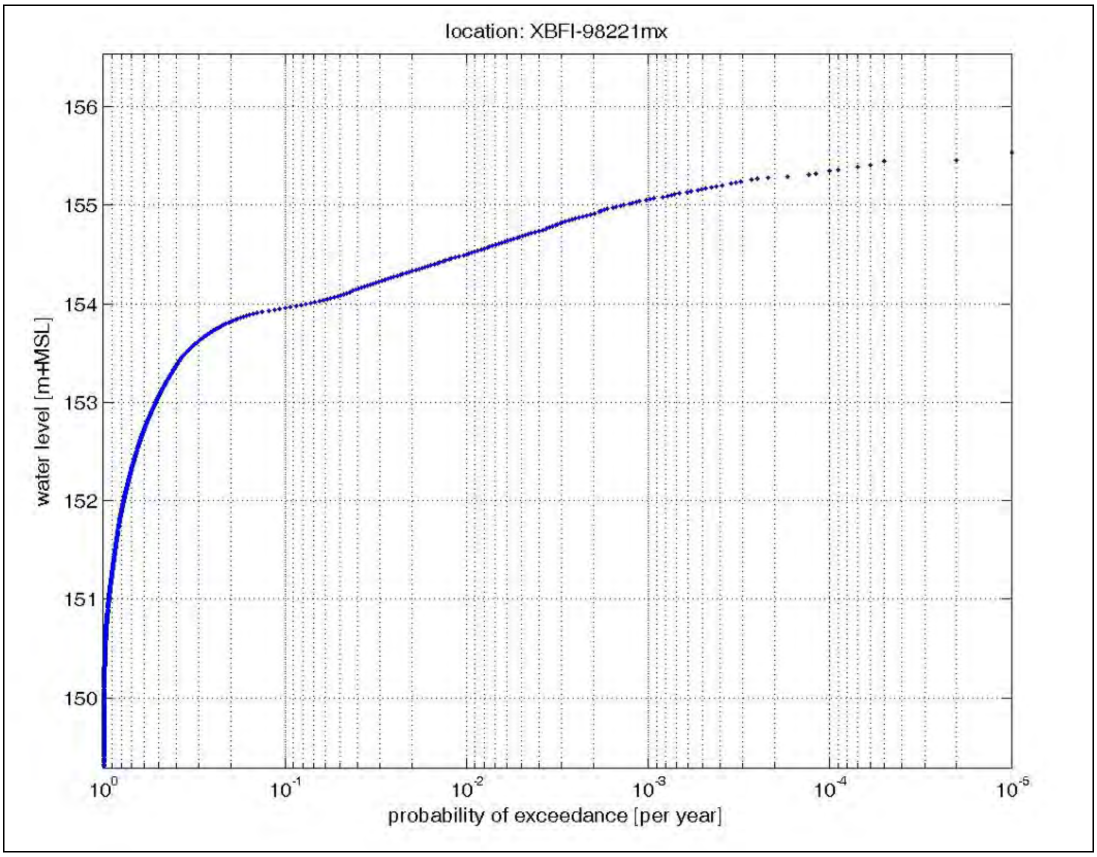


Figure 6-1 Derived flood frequency distribution of water levels at location XBFi-9822, near Mahaxai station; case with no embankments.

The performance of the procedure in reproducing the observed water level distribution at Ban Xe Bang Fai/ NR13S Bridge mouth is shown in Figure 6-2. For return periods larger than 2 a proper reproduction is observed. Figure 6-3 shows a similar plot for the upstream discharge at Mahaxai. Again, the observed discharges and corresponding return periods are well reproduced by the model. It implies that the boundary conditions as generated by the Monte Carlo procedures are sound.

Comparisons with measurements at the river mouth are a bit more complex, since the Mekong River is morphologically very active. Observed water levels are therefore strongly influenced by the varying bottom levels of the Mekong River. To make a fair comparison between the derived flood hazard statistics and observed water levels, the “observed” water levels at the Xe Bang Fai River mouth were derived as follows:

- Derive annual maximum discharges at Mukdahan;
- Derive annual maximum water levels at Mukdahan by applying the stage discharge relation of Figure 4-20;
- Derive annual maximum water levels at That Phanom (Xe Bang Fai River mouth) by applying an h-h relation that is derived from the hydraulic model.

For the resulting annual maximum water levels at That Phanom, exceedance frequencies are derived and compared with the results of the flood hazard assessment (Figure 6-4). Again results are in accordance.

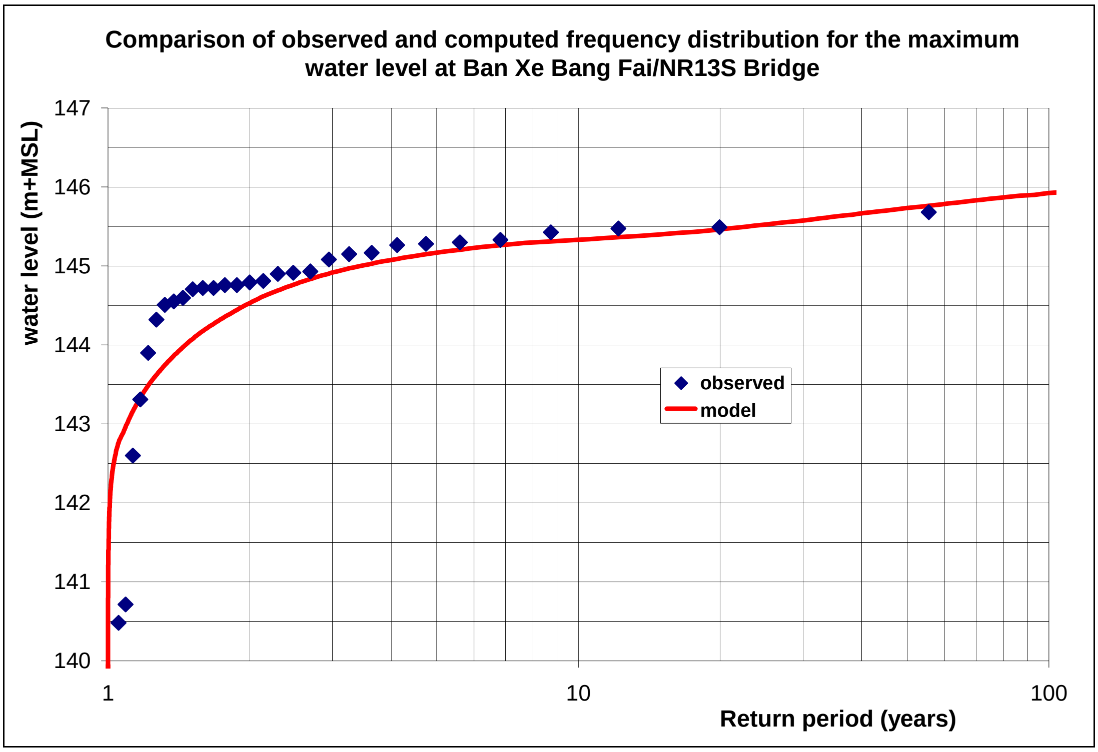


Figure 6-2 Comparison of observed and computed frequency distribution of the annual maximum water level at Xe Bang Fai NR13S Bridge.

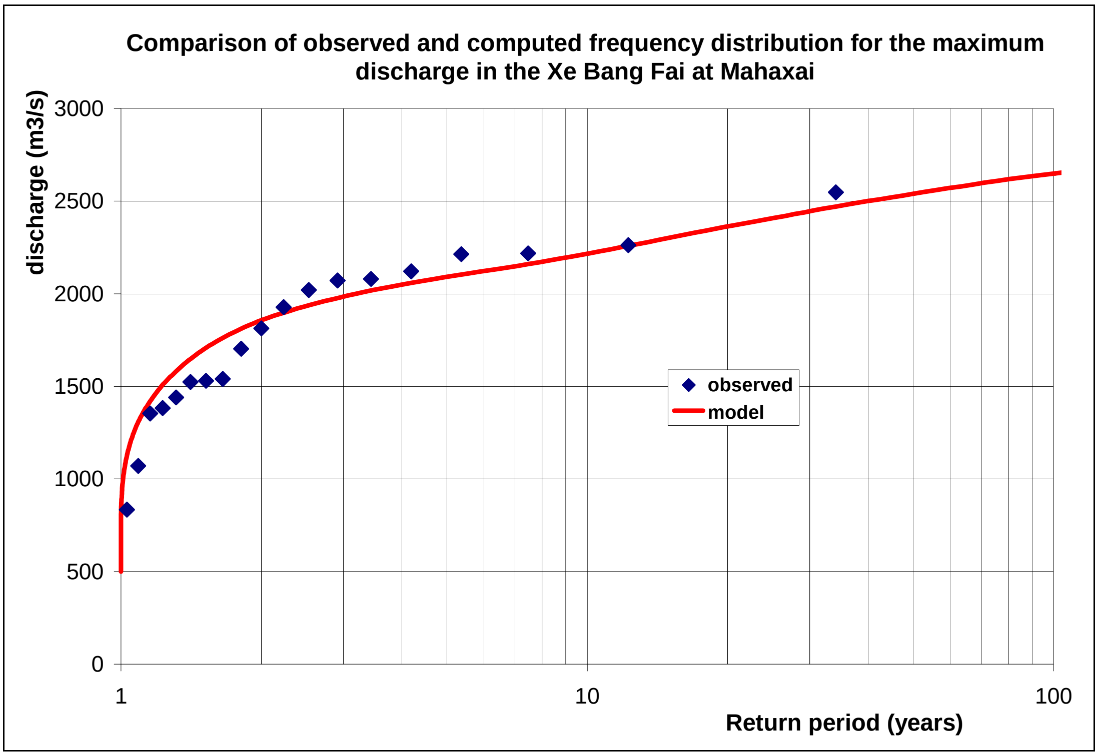


Figure 6-3 Comparison of observed and computed upstream discharge at Mahaxai.

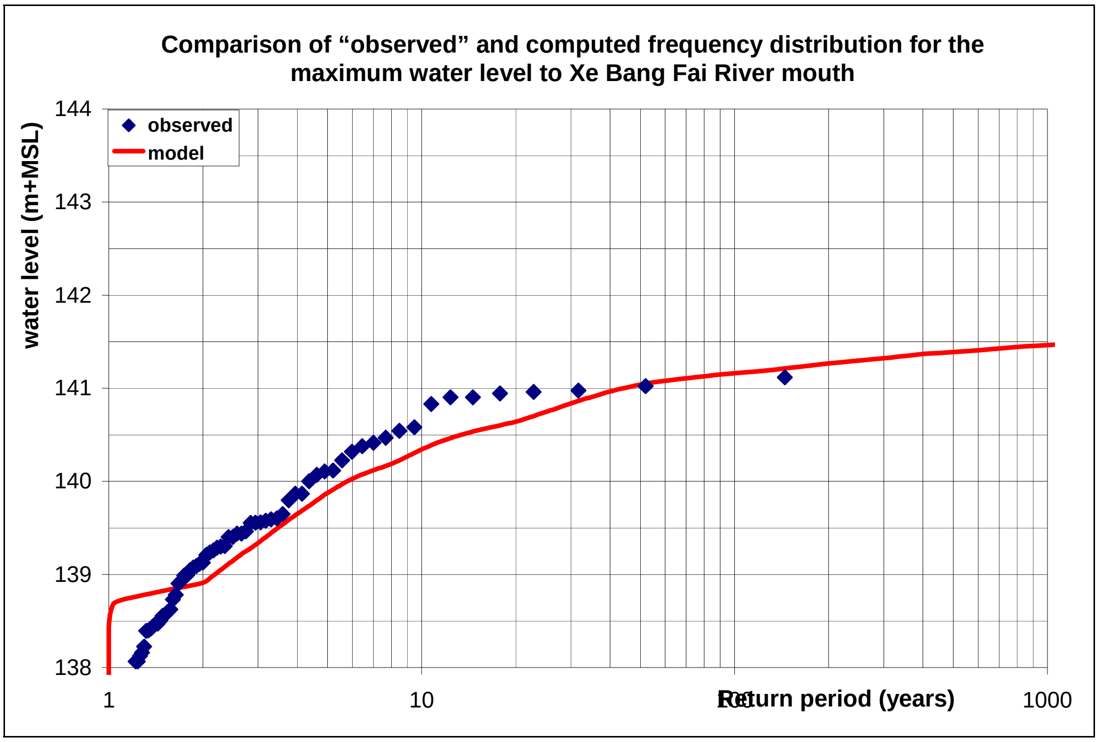


Figure 6-4 Comparison of observed and computed frequency distribution of the water level at the river mouth.

Comparison of development cases

Based on the method described above, the 2, 10, 25 and 100-year water levels have been derived for all locations along the lower reach of the Xe Bang Fai River. Figure 6-5 shows the results for Case 1 (no embankments). The horizontal axis shows the distance along the river to the downstream boundary, i.e. the confluence with the Mekong River. The location on the far right is the upstream boundary of the model, and it is located approximately 3 km upstream of the Mahaxai gauge. The location to the far left is the confluence of the Xe Bang Fai with the Mekong at That Phanom. Figure 6-6 shows a similar figure for Case 3 (embankments on both sides).

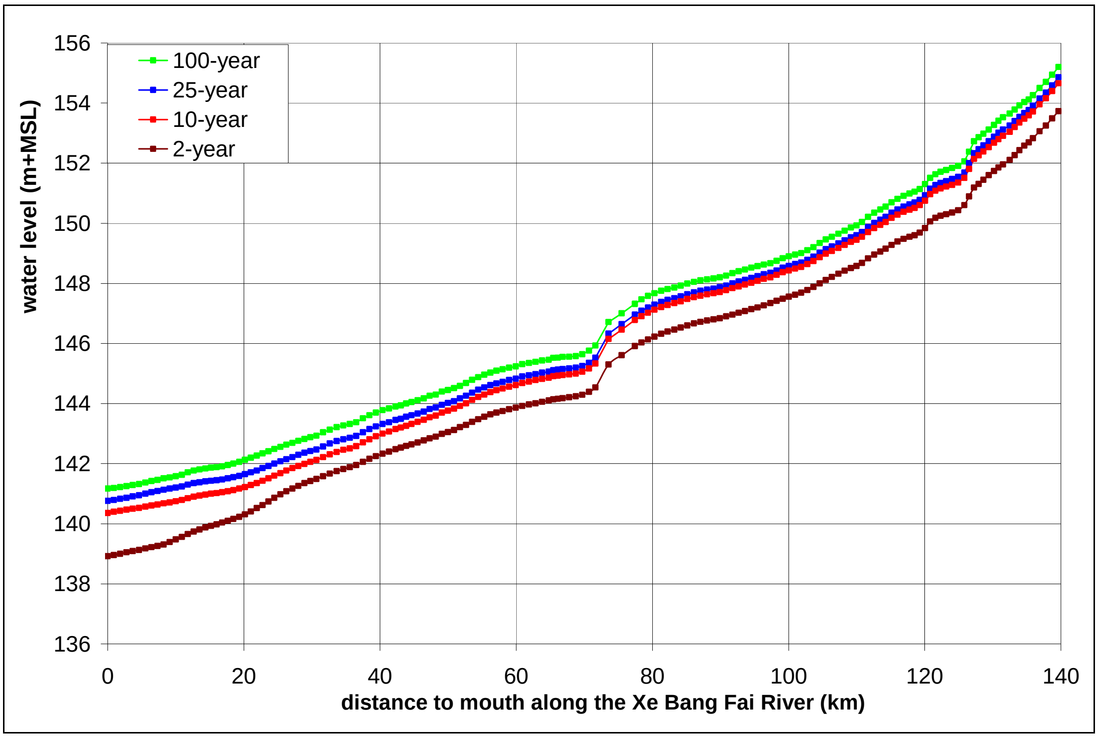


Figure 6-5 Computed 2, 10, 25 and 100-year flood level along the Xe Bang Fai River for the case with no embankments.

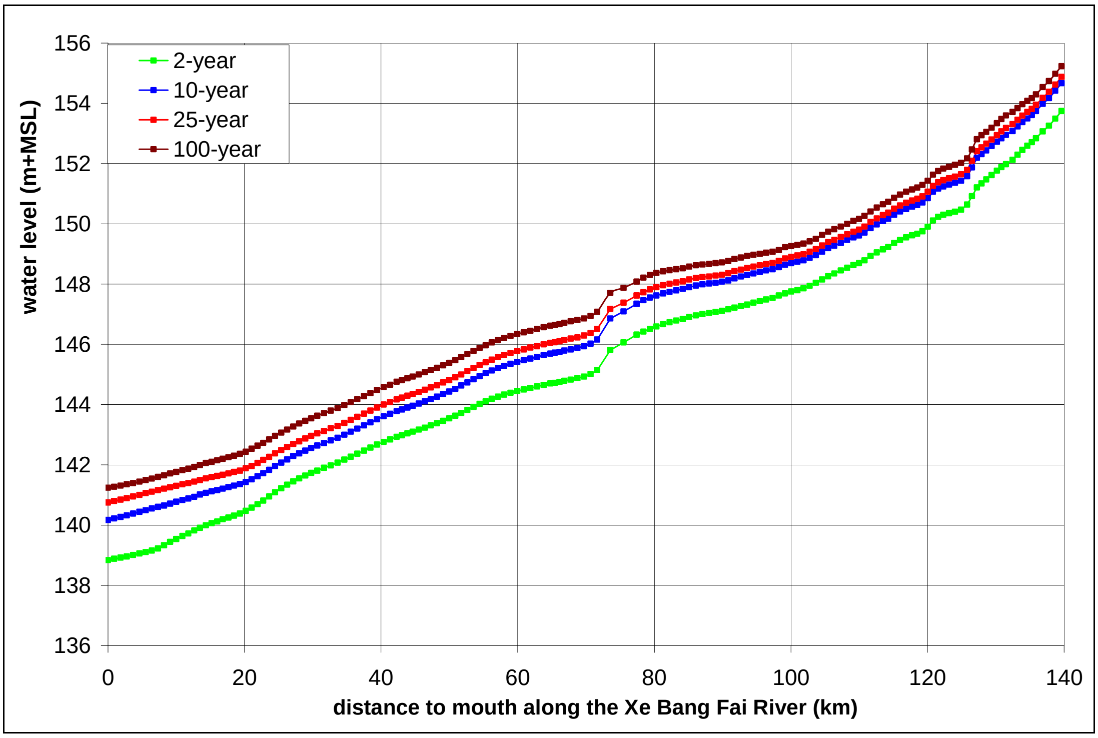


Figure 6-6 Computed 2, 10, 25 and 100-year flood level along the Xe Bang Fai River for the case with embankments on both sides of the river.

Figure 6-7 shows the results for the three simulated situations of the river. Figure 6-8 shows the mutual differences in 100-year water level between the three cases. From the figures it can be seen that differences are negligible at both the upstream and downstream model boundary. For the upstream boundary this is because it is outside the backwater reach of the location where the embankments begin (at NR13S Bridge). At the downstream end differences are small because the flow in the Mekong dominates the water levels and therefore water levels are not influenced by the embankments along the Xe Bang Fai. Moving to the middle sections, differences are increasing, being at maximum around 70 kilometres from the river mouth. The embankments cause water to stay in the river and keep the floodplains dry. As a result, water levels in the river rise higher than in case of a situation with no embankments. For the 100-year water level the embankments cause a maximum rise in water level of 1.2 m.

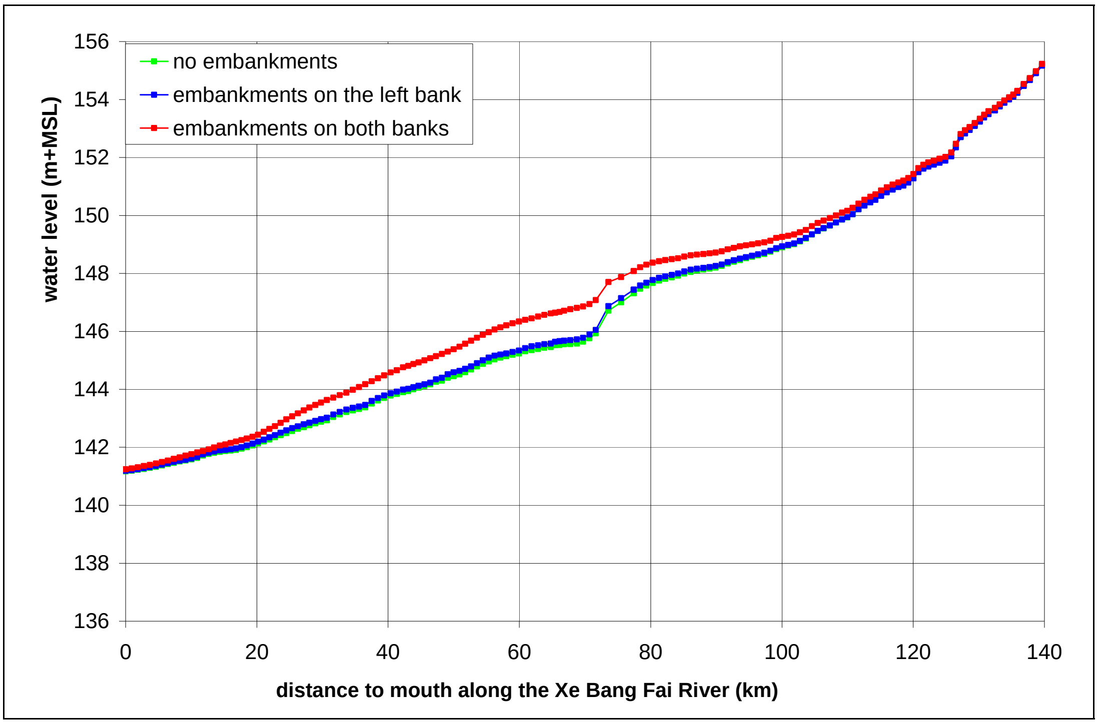


Figure 6-7 Computed 100-year flood level along the Xe Bang Fai River for the cases with [a] no embankments [b] embankments along the left bank and [c] embankments along both banks.

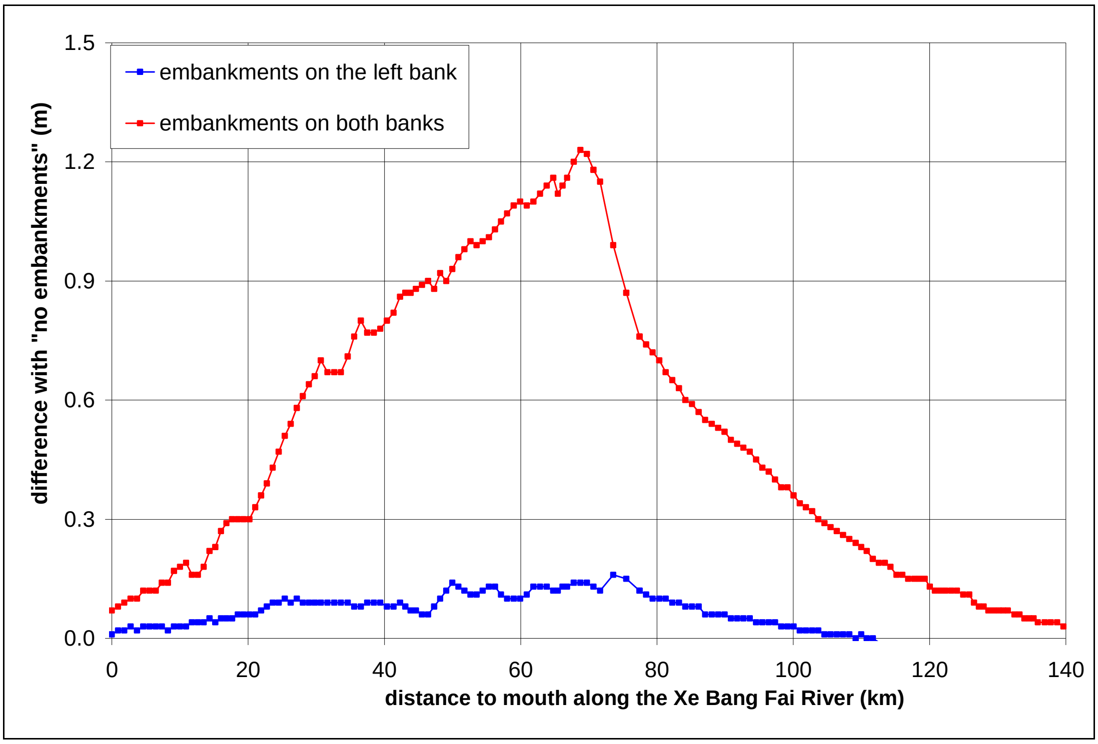


Figure 6-8 Differences in the computed 100-year flood level along the Xe Bang Fai River for Cases 2 and 3 relative to Case 1, the Base Case.

6.3.3 Water levels in the floodplains

Similar analyses as in the previous section have been executed for the floodplains adjacent to the Xe Bang Fai River. In the hydraulic model, nodes are defined to represent different floodplain areas. Each node is modelled as a reservoir. For each node the water levels with return periods 2, 10, 25 and 100 years have been derived, and this is repeated for each of the three cases. Figure 6-9 shows the rivers Xe Bang Fai and Mekong in combination with all the floodplain nodes of the Hydraulic model. The nodes have been divided into four different groups:

- Green points: locations in the right floodplain, downstream of the measures;
- Light blue points: locations in the left floodplain, downstream of the measures;
- Black points: locations in the right floodplain, upstream of the measures;
- Red points: locations in the left floodplain, upstream of the measures.

The reason for this division is that the protective measures are mainly designed to protect the areas downstream (i.e. the green and blue location). Furthermore, the measure “left bank” is designed to protect the area on the left (blue locations).

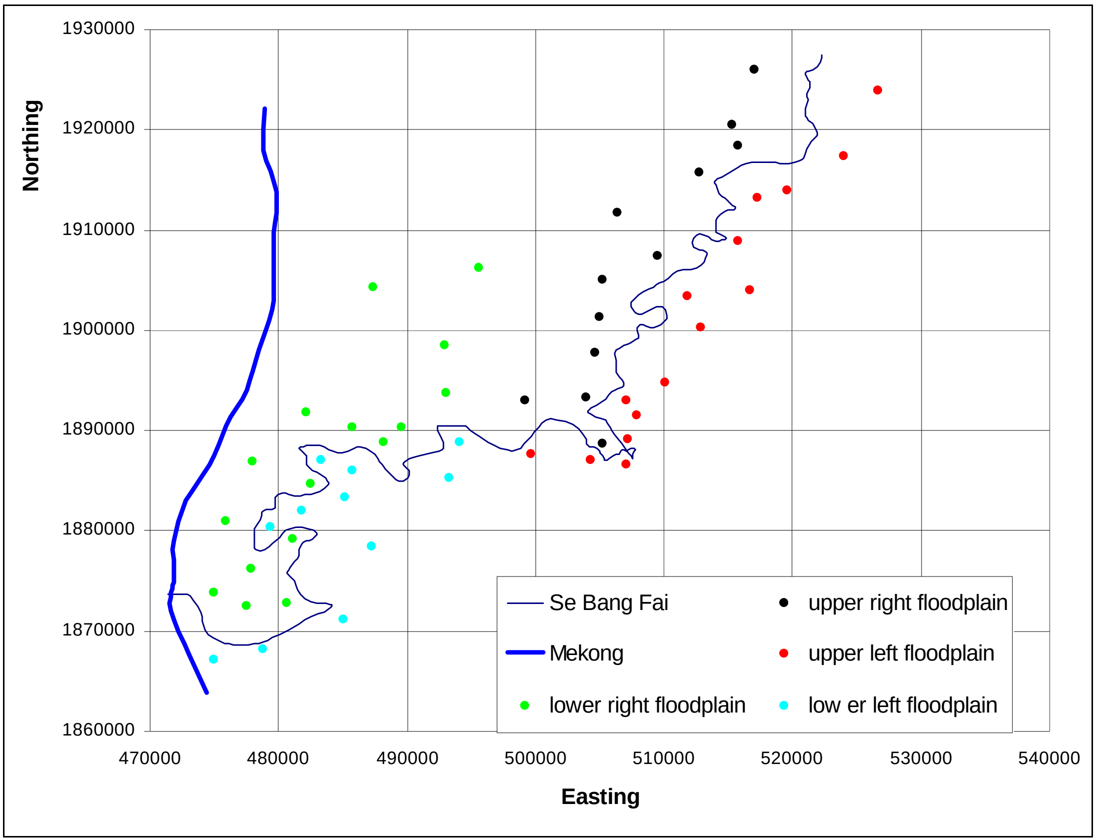


Figure 6-9 Rivers Xe Bang Fai and Mekong and floodplain nodes of the Hydraulic model.

Table 6-1 shows [a] the resulting water levels for the situation of no embankments [b] the change in water levels in comparison with situation [a] as result of embankments on the left side and [c] the change in water levels in comparison with situation [a] as result of embankments on both sides. The locations in this table are the ones downstream of the measures (i.e. green and light blue locations of Figure 6-9). Table 6-2 shows similar numbers for the locations upstream of the measures (i.e. red and black locations of Figure 6-9).

The effects of embankments are clearly visible from the results; the embankment protect the downstream floodplains but back up the water further upstream. The situation with only embankments on the left is profitable for the floodplain locations on the left (light blue points) but disadvantageous for locations on the right (green locations).

It is noted that the values presented in the table have to be used with care in view of the uncertainties in the hydraulic model, particularly with respect to the interaction between river and floodplain. The results are just indicative and should not be used for design.

Table 6-1 Water levels and changes in water levels with return periods of 2, 10, 25 and 100 years in the floodplains of the Xe Bang Fai River Basin; locations downstream of embankments.

	no embankments				**change in water level as a result of embankments on the left bank**				**change in water level as a result of embankments on both banks**			
node	**2**	**10**	**25**	**100**	**2**	**10**	**25**	**100**	**2**	**10**	**25**	**100**
	Right bank (green locations of Figure 6-9**)**											
SP246nD	143.99	144.89	145.10	145.51	-0.21	0.03	0.07	0.13	-1.38	-2.28	-2.49	-2.90
SP202D	144.15	144.92	145.12	145.52	-0.05	0.05	0.08	0.13	-2.66	-3.43	-3.63	-4.03
SP226D	144.01	144.76	144.97	145.37	-0.04	0.05	0.07	0.12	-2.60	-3.35	-3.56	-3.96
SP227D	143.49	144.36	144.59	145.01	-0.05	0.05	0.07	0.12	-2.44	-3.31	-3.54	-3.96
SP245D	142.99	143.72	143.99	144.43	-0.06	0.05	0.07	0.13	-5.20	-5.93	-6.20	-6.64
SP245nD	141.34	141.73	142.30	143.32	0.01	0.10	0.19	0.34	-0.08	-0.47	-1.04	-2.06
SP248D	144.10	144.92	145.12	145.52	-0.05	0.05	0.08	0.13	-2.05	-2.87	-3.07	-3.47
SP261D	142.85	143.56	143.83	144.26	-0.07	0.03	0.05	0.09	-1.80	-2.51	-2.78	-3.21
SP266D	142.10	142.76	143.11	143.60	-0.11	0.02	0.04	0.09	-3.06	-3.72	-4.07	-4.56
SP284U	142.28	142.96	143.28	143.75	-0.12	0.01	0.04	0.09	-1.91	-2.59	-2.91	-3.38
SP295D	141.76	142.39	142.74	143.20	-0.11	0.01	0.03	0.09	-3.75	-4.37	-4.72	-5.18
SP307D	141.16	141.61	141.89	142.29	-0.09	0.01	0.02	0.06	-1.17	-1.62	-1.90	-2.30
SP312U	140.98	141.63	142.00	142.48	-0.08	0.00	0.04	0.08	-0.96	-1.61	-1.98	-2.46
SP343D	139.75	140.92	141.37	141.80	-0.11	-0.07	0.00	0.04	-2.76	-3.93	-4.38	-4.81
SP361D	139.35	140.68	141.13	141.50	-0.07	-0.13	-0.03	0.03	-1.34	-2.67	-3.12	-3.49
SP376D	139.17	140.48	140.93	141.30	-0.02	-0.22	-0.05	0.03	-0.11	-1.42	-1.87	-2.24
	Left bank (light blue locations of Figure 6-9**)**											
SP201D	144.15	144.92	145.12	145.52	-4.16	-4.93	-5.13	-5.53	-4.16	-4.93	-5.13	-5.53
SP219D	143.14	144.57	144.83	145.28	-2.50	-3.93	-4.19	-4.64	-2.50	-3.93	-4.19	-4.64
SP238D	141.22	143.58	144.00	144.66	-2.30	-4.66	-5.08	-5.74	-2.30	-4.66	-5.08	-5.74
SP258D	142.75	143.49	143.76	144.20	-2.70	-3.44	-3.71	-4.15	-2.70	-3.44	-3.71	-4.15
SP277D	136.06	137.66	139.27	141.61	-0.65	-2.25	-3.86	-6.20	-0.65	-2.25	-3.86	-6.20
SP285D	135.42	136.45	137.94	140.22	-0.01	-1.04	-2.53	-4.81	-0.01	-1.04	-2.53	-4.81
SP286D	139.87	140.93	141.56	142.14	-0.21	-1.27	-1.90	-2.48	-0.21	-1.27	-1.90	-2.48
SP300D	137.67	138.02	138.84	140.56	0.00	-0.35	-1.17	-2.89	0.00	-0.35	-1.17	-2.89
SP344D	139.56	140.80	141.38	141.84	-0.07	-1.31	-1.89	-2.35	-0.07	-1.31	-1.89	-2.35
SP362D	138.91	140.34	141.07	141.49	-0.03	-1.46	-2.19	-2.61	-0.03	-1.46	-2.19	-2.61
SP375D	133.80	135.50	137.85	139.90	-0.01	-1.71	-4.06	-6.11	-0.01	-1.71	-4.06	-6.11

Table 6-2 Water levels and changes in water levels with return periods of 2, 10, 25 and 100 years in the floodplains of the Xe Bang Fai River Basin; locations upstream of embankments.

	no embankments				**change in water level as a result of embankments on the left bank**				**change in water level as a result of embankments on both banks**			
node	**2**	**10**	**25**	**100**	**2**	**10**	**25**	**100**	**2**	**10**	**25**	**100**
	Right bank (black locations of Figure 6-9**)**											
SP109D	147.28	148.15	148.30	148.61	-0.85	-0.03	-0.02	0.05	-0.42	0.29	0.36	0.42
SP131D	146.70	147.59	147.75	148.08	-0.57	-0.02	0.00	0.07	-0.12	0.38	0.47	0.55
SP143D	146.35	147.21	147.39	147.77	-1.07	0.00	0.02	0.10	-0.54	0.49	0.59	0.67
SP188nD	140.01	140.02	140.18	141.25	0.00	0.01	0.25	0.97	0.01	0.95	2.42	4.35
SP41D	141.66	148.67	149.85	151.56	-0.85	-0.91	-0.73	-0.77	0.25	0.28	0.24	0.12
SP434D	143.48	146.09	146.26	146.59	2.35	0.10	0.10	0.16	2.73	0.74	0.86	1.04
SP50D	139.34	145.02	146.51	149.57	-0.81	-1.17	-1.07	-0.59	0.42	0.77	0.82	0.60
SP67D	138.86	143.69	144.82	147.35	-0.94	-0.84	-0.69	-0.32	0.38	0.77	0.93	0.95
SP7D	147.36	151.82	152.57	153.67	-0.37	-0.56	-0.45	-0.46	0.01	0.01	0.03	0.02
SP83D	148.05	149.02	149.17	149.50	-0.81	-0.06	-0.04	0.01	-0.46	0.20	0.25	0.27
SP98D	147.53	148.40	148.55	148.87	-0.14	-0.03	-0.02	0.03	0.17	0.26	0.32	0.36
SP29D	116.20	125.60	128.21	134.56	-1.03	-1.66	-1.52	-0.79	0.24	0.48	0.70	0.85
	Left bank (red locations of Figure 6-9**)**											
SP97D	147.71	148.49	148.64	148.95	-1.20	-0.04	-0.03	0.03	-0.75	0.25	0.30	0.35
SP115D	146.70	148.05	148.20	148.53	-0.93	-0.06	-0.02	0.05	-0.45	0.31	0.38	0.44
SP132D	146.75	147.57	147.72	148.06	-1.16	-0.02	0.01	0.07	-0.70	0.38	0.48	0.56
SP146D	146.45	147.23	147.39	147.76	-1.13	-0.01	0.03	0.10	-0.62	0.46	0.58	0.66
SP162D	138.48	138.49	138.74	139.73	0.00	0.04	0.19	0.44	0.01	0.84	1.68	2.96
SP191D	145.26	145.96	146.13	146.50	-1.38	0.29	0.32	0.38	-0.70	0.89	1.03	1.16
SP30D	151.01	152.26	152.46	152.85	-0.13	-0.10	-0.07	-0.03	0.03	0.05	0.07	0.08
SP40D	143.56	148.96	150.02	151.51	-0.60	-0.79	-0.74	-0.63	0.21	0.27	0.23	0.17
SP416nD	141.65	145.04	145.88	147.13	0.99	0.32	0.17	0.01	2.02	1.75	1.47	0.93
SP424D	139.91	139.92	140.06	140.79	0.00	0.02	0.15	0.50	0.01	0.60	1.55	3.52
SP425D	145.63	146.98	147.23	147.70	-0.29	-0.03	0.00	0.08	0.48	0.64	0.66	0.67
SP51D	145.07	149.70	150.47	151.00	-0.70	-0.27	-0.13	-0.08	0.31	0.24	0.14	0.14
SP68D	143.73	148.56	149.39	150.23	-0.52	-0.30	-0.28	-0.25	0.40	0.35	0.37	0.20
SP84D	148.04	149.01	149.16	149.48	-0.57	-0.06	-0.04	0.01	-0.26	0.19	0.24	0.27
SP8D	147.50	151.95	152.66	153.46	-0.38	-0.29	-0.28	-0.24	0.03	0.04	0.03	0.06

6.4 Flood hazard determination

In order to be able to estimate damages from Table 6-1, water depths have been derived from the water levels. This means ground levels of the floodplains are required. These ground levels need to be very precise, since a few extra decimetres of water depth can cause severe damage to the crops. Use is made of the DEM available for the Xe Bang Fai area.

Flood extent and depth as derived from the difference of the computed water levels and the ground elevation from the DEM are shown in Figure 6-10 to Figure 6-13 for the Base Case for return periods T = 2, 10, 25 and 100 year. Such information is basic input for damage calculations. Further refinements can be made relative to the cropping calendar, as the full hydrographs for each location for each simulated year is available from the database. Similar pictures can be made for the cases with embankments along one or both sides. The effectiveness of the measures can directly be assessed from maps showing the differences between the maximum levels, water depths etc. or damages between the different cases. Reference is made to Annex 3 for application of the results for flood damage assessment.

Comparison of the flood maps with the observed flooding in the year 2000 (see Figure 6-14) learns that qualitatively the flooding extent in the downstream part is well reproduced by the model.

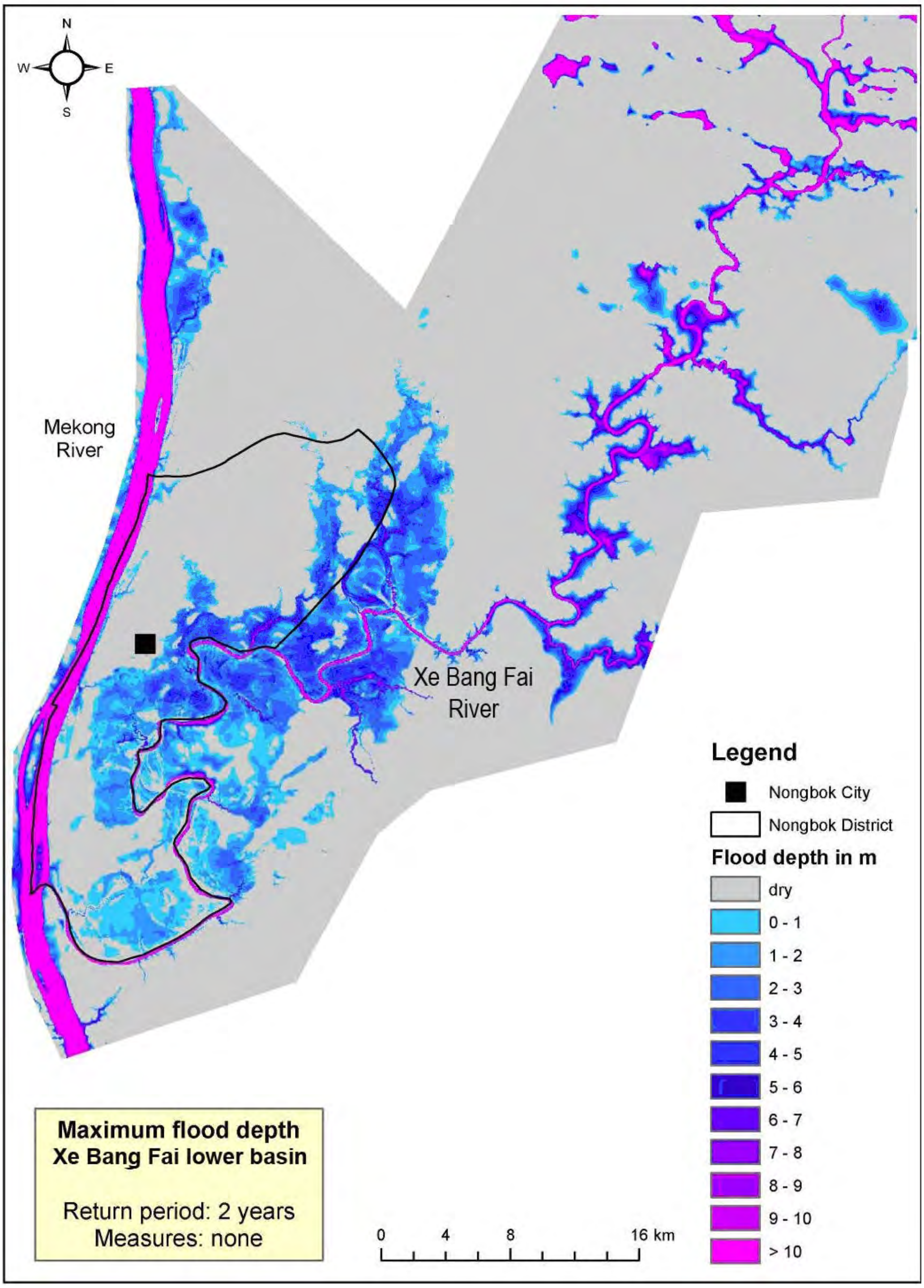


Figure 6-10 Flood depth and extent map Lower Xe Bang Fai, T= 2 years.

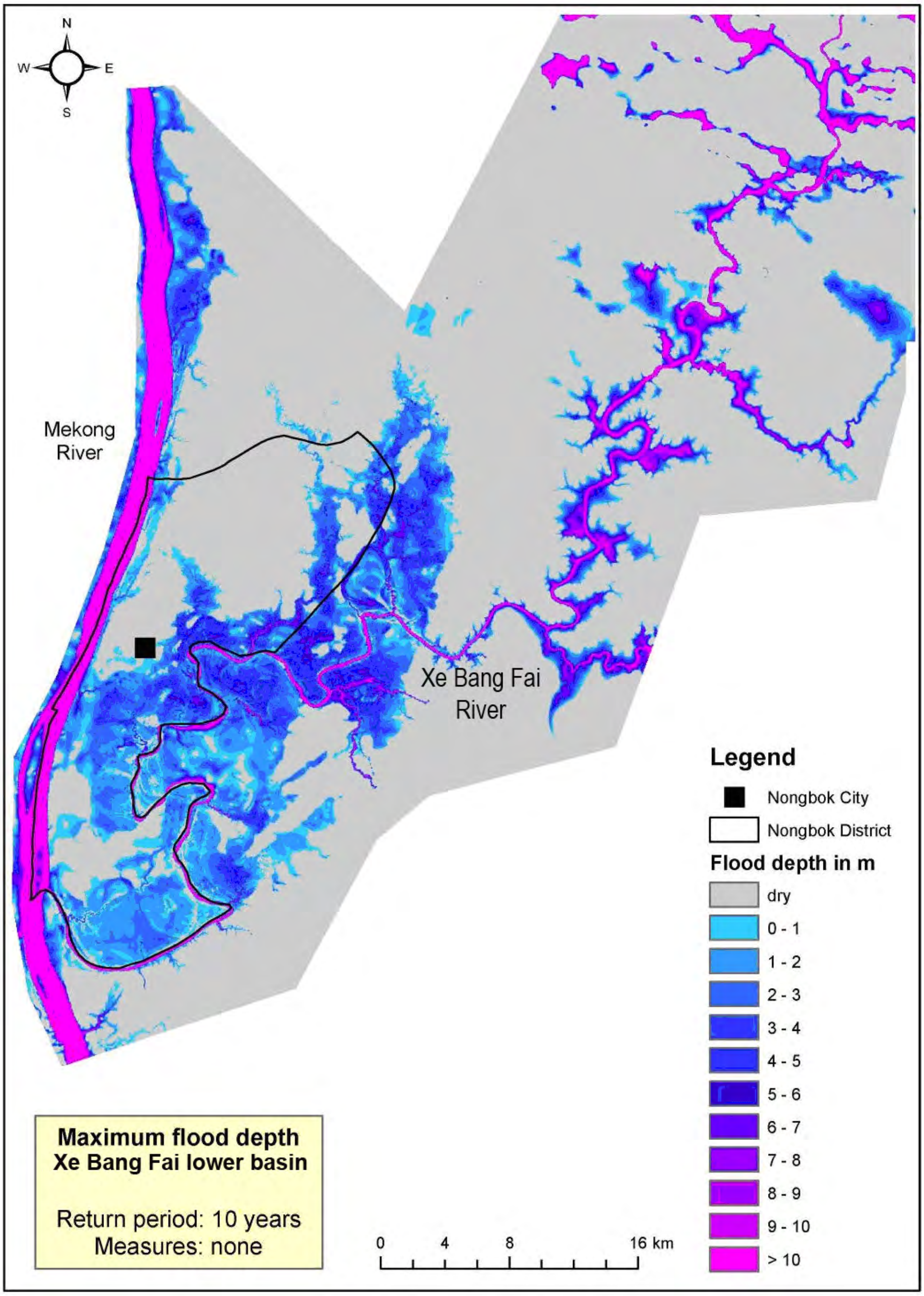


Figure 6-11 Flood depth and extent map Lower Xe Bang Fai, T= 10 years.

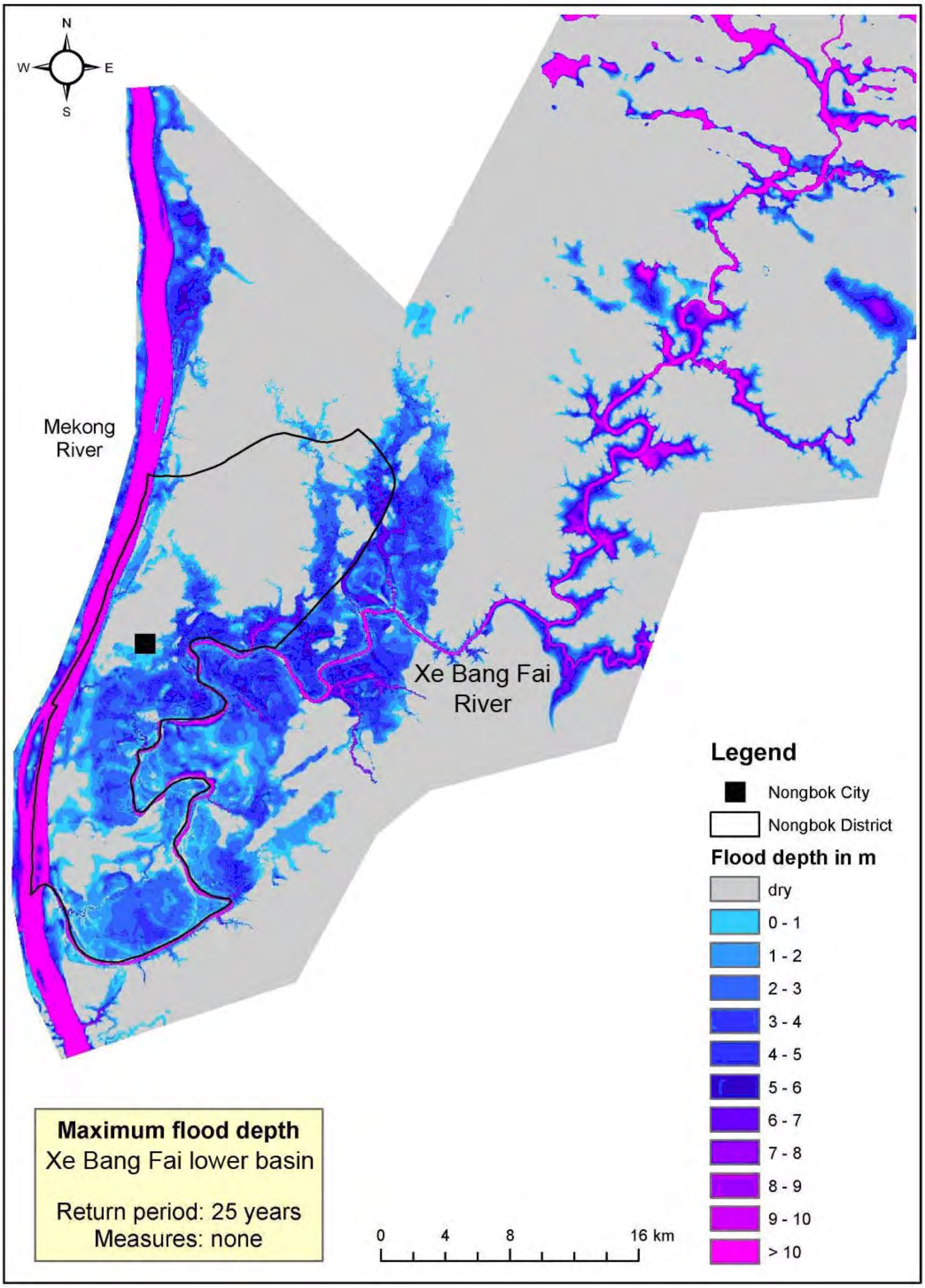


Figure 6-12 Flood depth and extent map Lower Xe Bang Fai, T= 25 years.

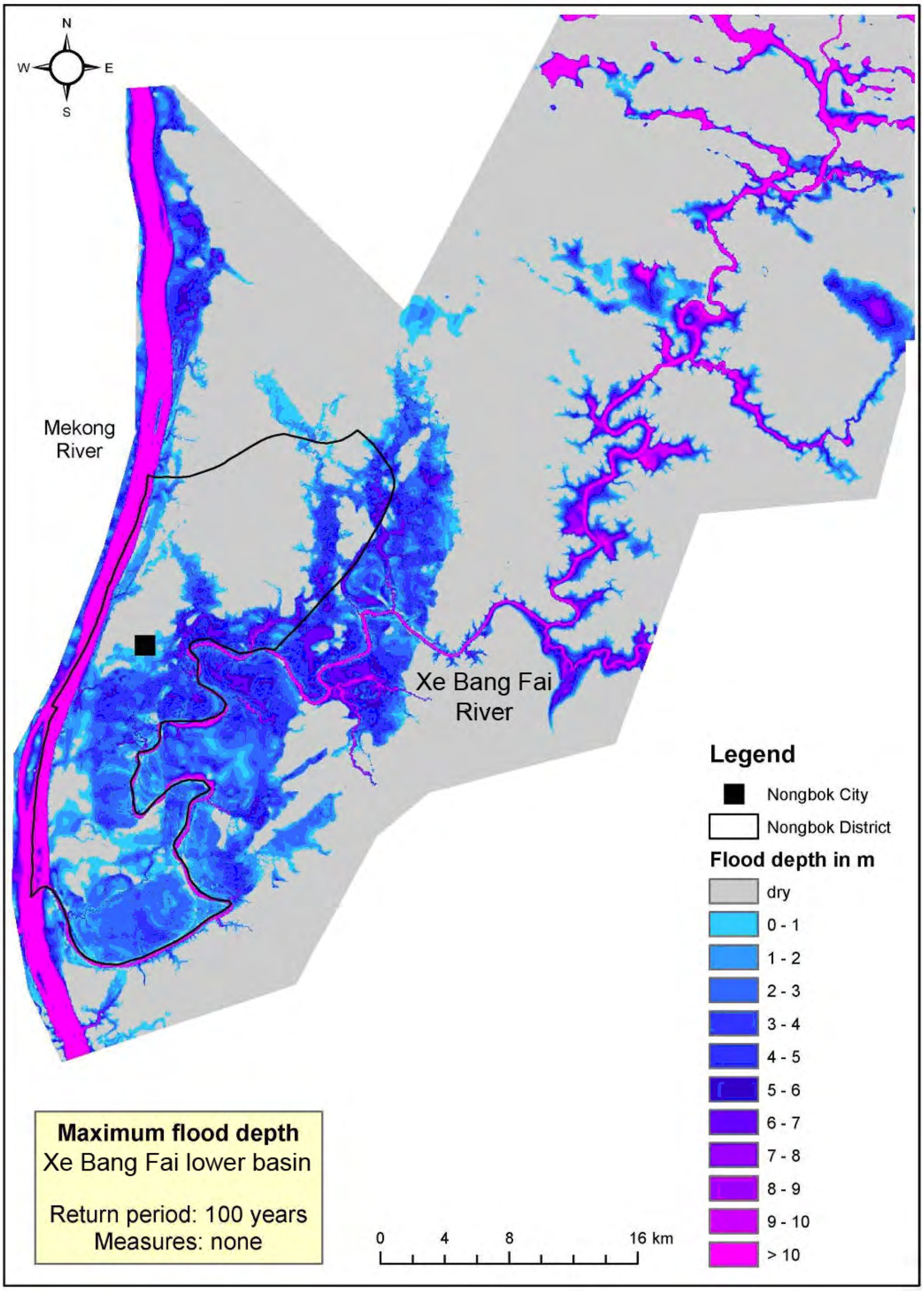
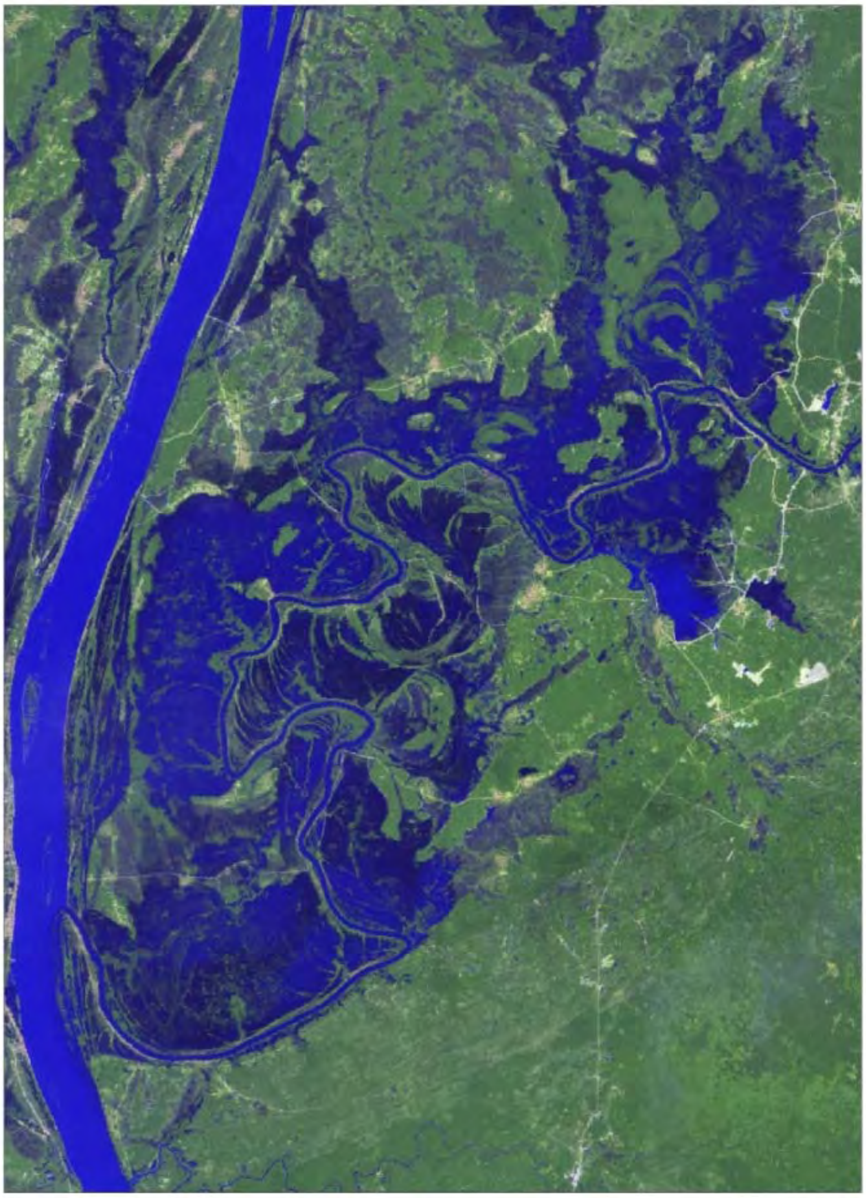


Figure 6-13 Flood depth and extent map Lower Xe Bang Fai, T= 100 years.



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

Figure 6-14 Extend of flooding along lower Xe Bang Fai and Mekong in year 2000.

6.5 Bypass canal

6.5.1 Introduction

As Option 2 for flood risk reduction a bypass canal from the Xe Bang Fai (see Figure 3-10) has been presented. First, its effect has been assessed for the flood seasons of the years 1995 to 2000 (section 6.5.2). Subsequently a probabilistic analysis was executed (section 6.5.3) for the diversion canal, similar to the analysis in the previous sections.

A 200 m wide bypass, with bed-elevation at 138 m amsl and side slopes of 1:2 has been assumed, with a hydraulic roughness of n = 0.025. For this the hydraulic model was extended with the Mekong reach Thakhek-That Phanom, see also Chapter 4.

6.5.2 Simulations for the years 1995 until 2000

The results of the simulations are presented in the following, Figure 6-15 to Figure 6-27. From these figures it is observed that the canal diverts at maximum discharges up to 500 to 1,000 m^3/s, dependent on the absolute level in the Xe Bang Fai and the level difference between the level at the offtake and the intake into the Mekong River. The effect on the maximum water level in the river at the offtake varies generally from 0.5 to 1.0 m gradually reducing away from the offtake. This implies that a bypass canal will not eliminate the need for improvement of the embankment but rather reduce the required crest level.

The effect of the bypass on the maximum level in the floodplain is of the same order of magnitude as along the river, but as shown in Figure 6-27, its effect on the reduction of the flood duration is also to be taken into account and may be considerable.

For the dry year 1998 the bypass did not function as the level at the offtake hardly exceeded 138 m amsl.

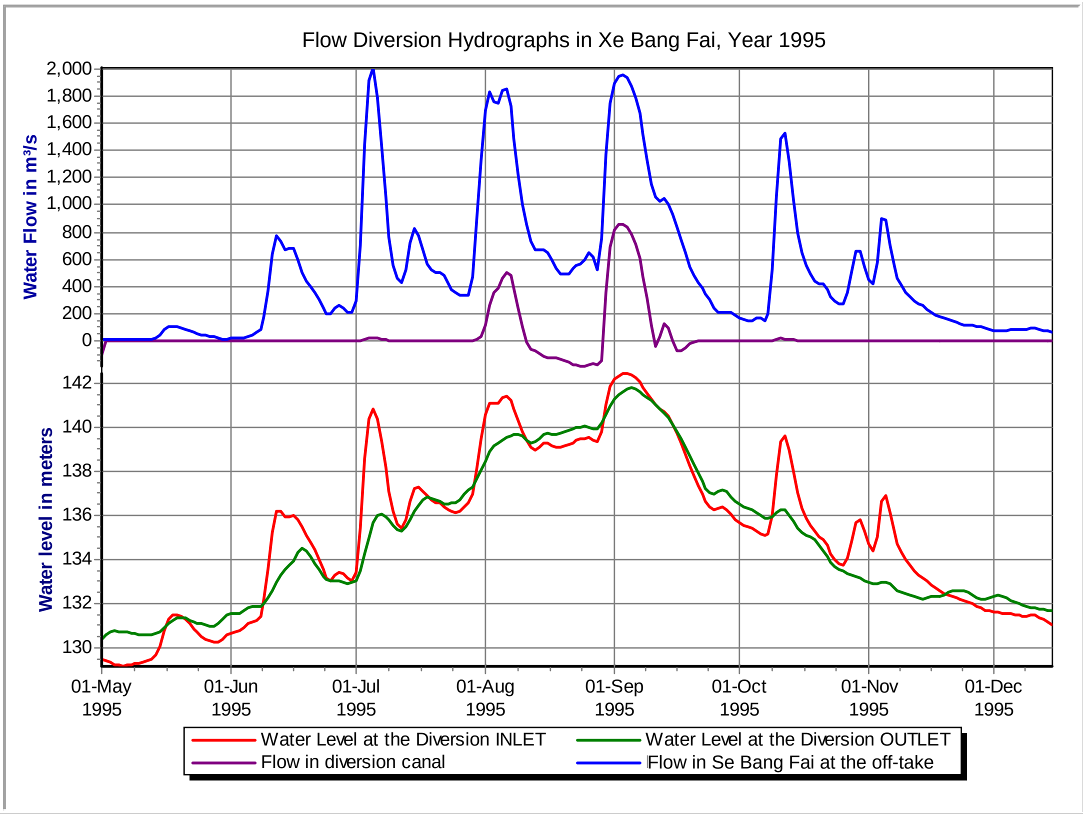


Figure 6-15 Water levels in Xe Bang Fai and Mekong and discharge in canal and river (20 km d/s offtake), year 1995.

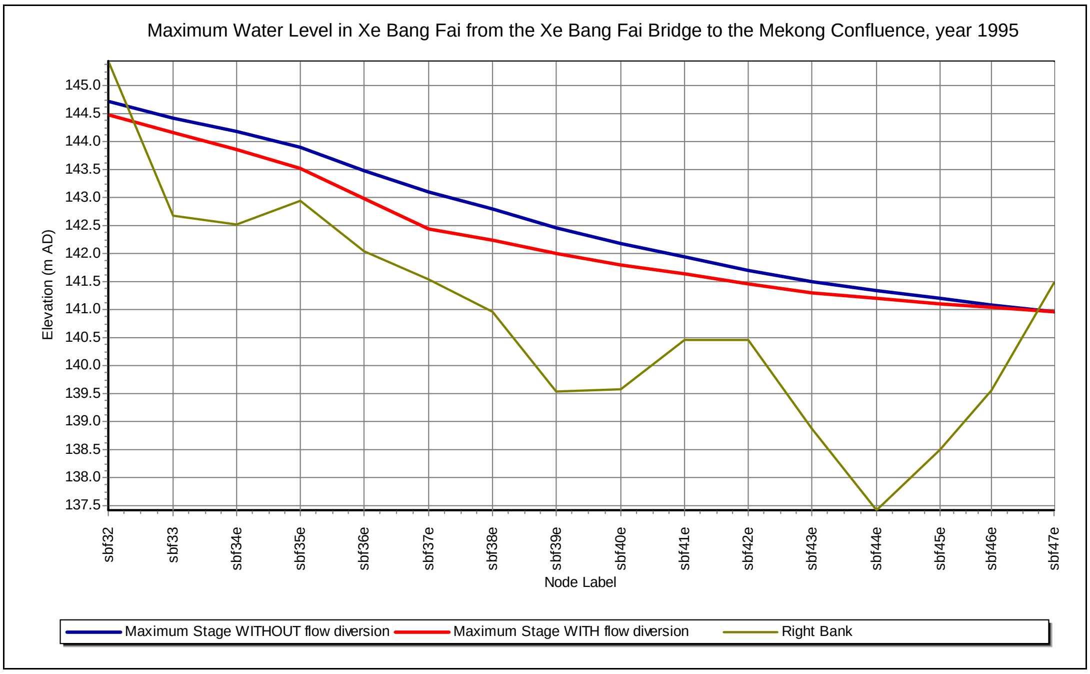


Figure 6-16 Maximum water level along Lower Xe Bang Fai from NR13S Bridge to mouth with and without bypass canal, year 1995.

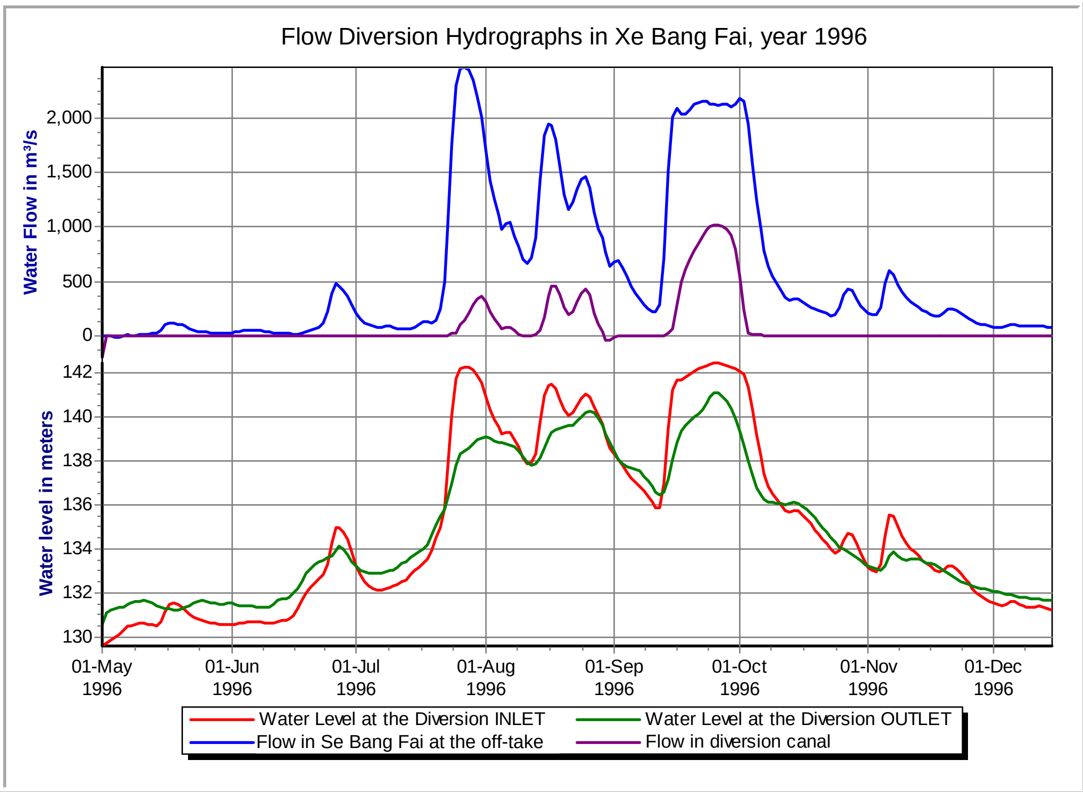


Figure 6-17 Water levels in Xe Bang Fai and Mekong and discharge in canal and river (20 km d/s offtake), year 1996.

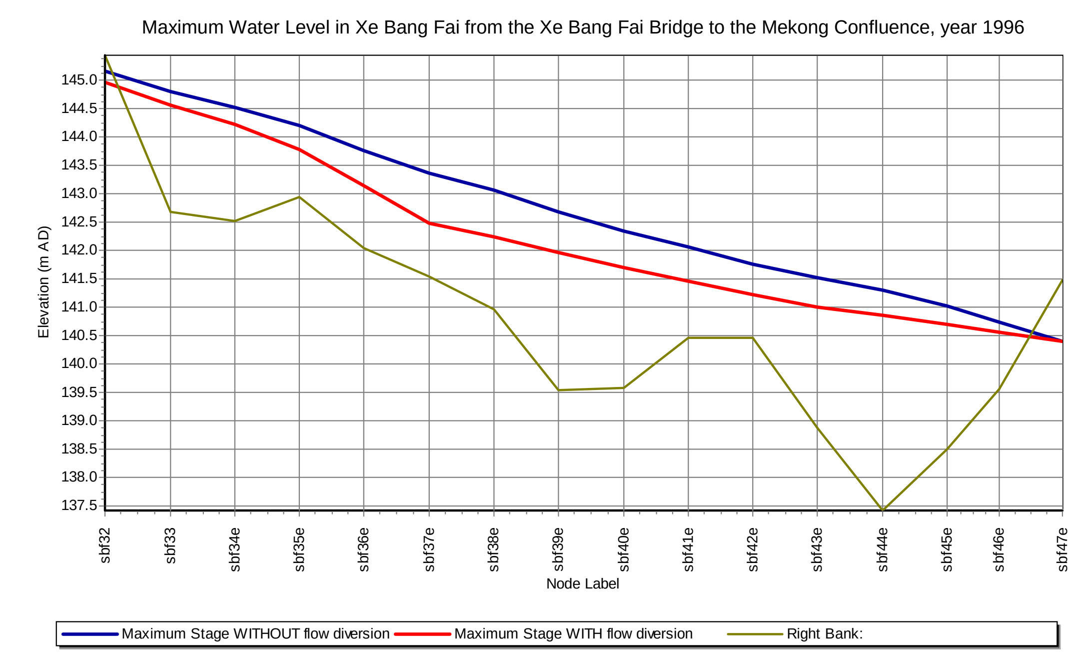


Figure 6-18 Maximum water level along Lower Xe Bang Fai from NR13S Bridge to mouth with and without bypass canal, year 1996.

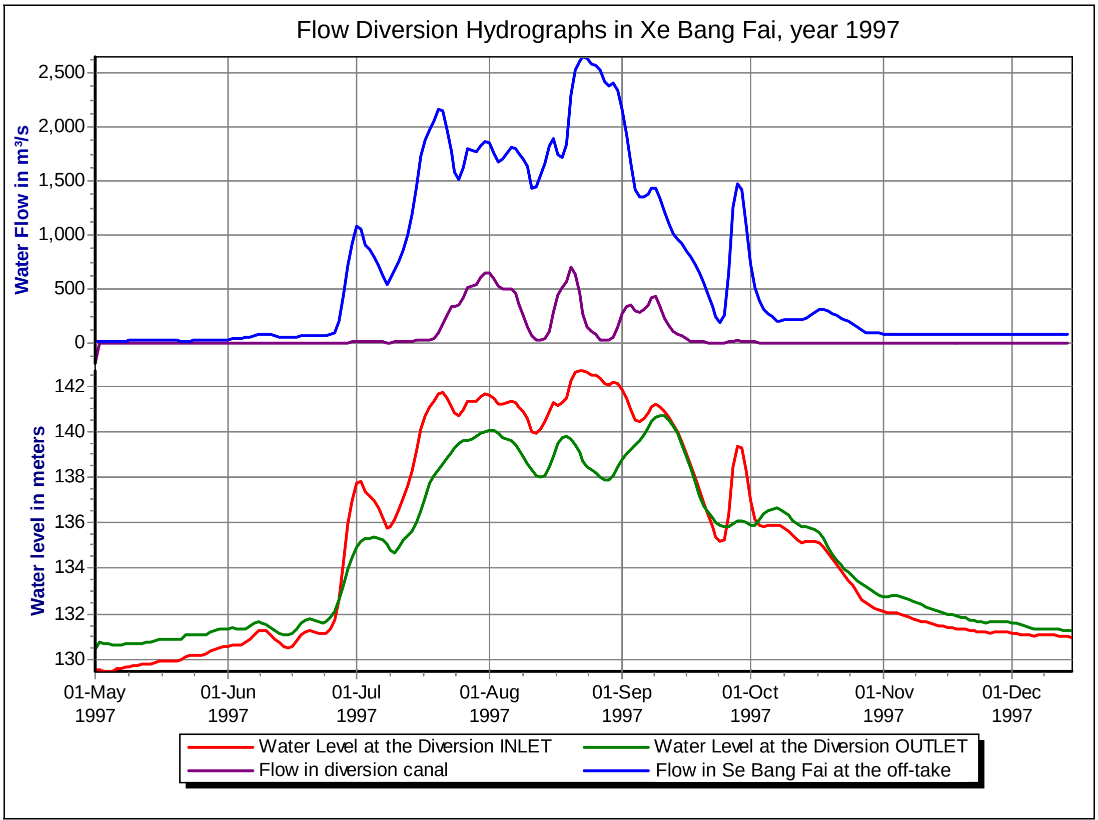


Figure 6-19 Water levels in Xe Bang Fai and Mekong and discharge in canal and river (20 km d/s offtake), year 1997.

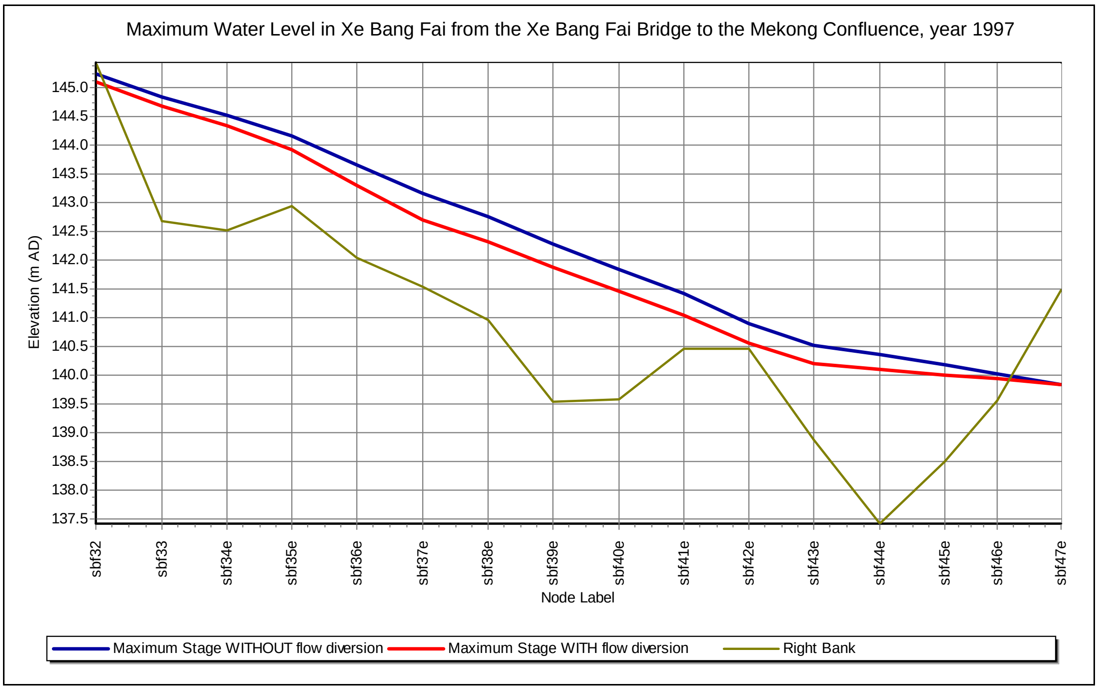


Figure 6-20 Maximum water level along Lower Xe Bang Fai from NR13S Bridge to mouth with and without bypass canal, year 1997.

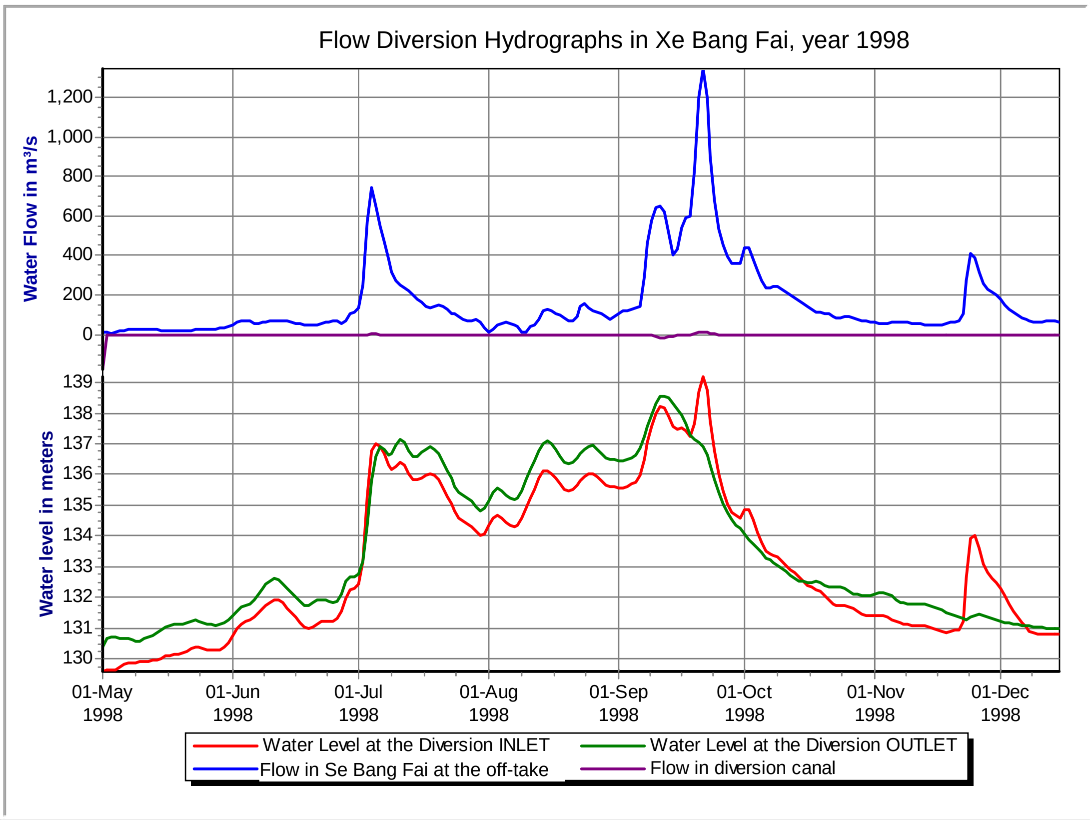


Figure 6-21 Water levels in Xe Bang Fai and Mekong and discharge in canal and river (20 km d/s offtake), year 1998.

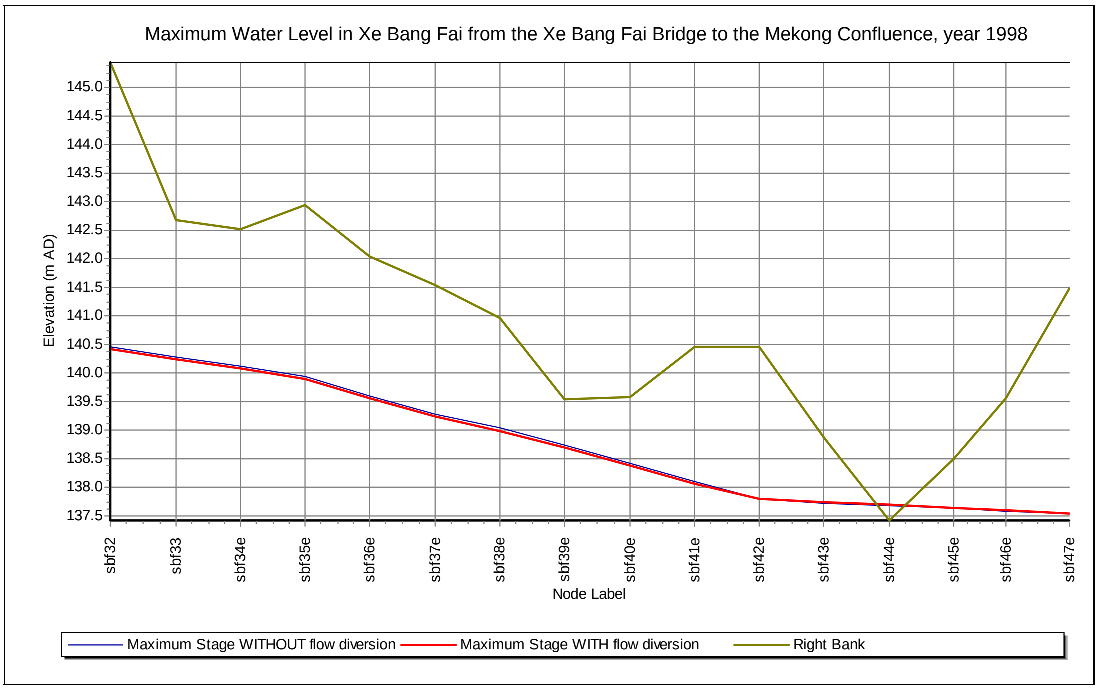


Figure 6-22 Maximum water level along Lower Xe Bang Fai from NR13S Bridge to mouth with and without bypass canal, year 1998.

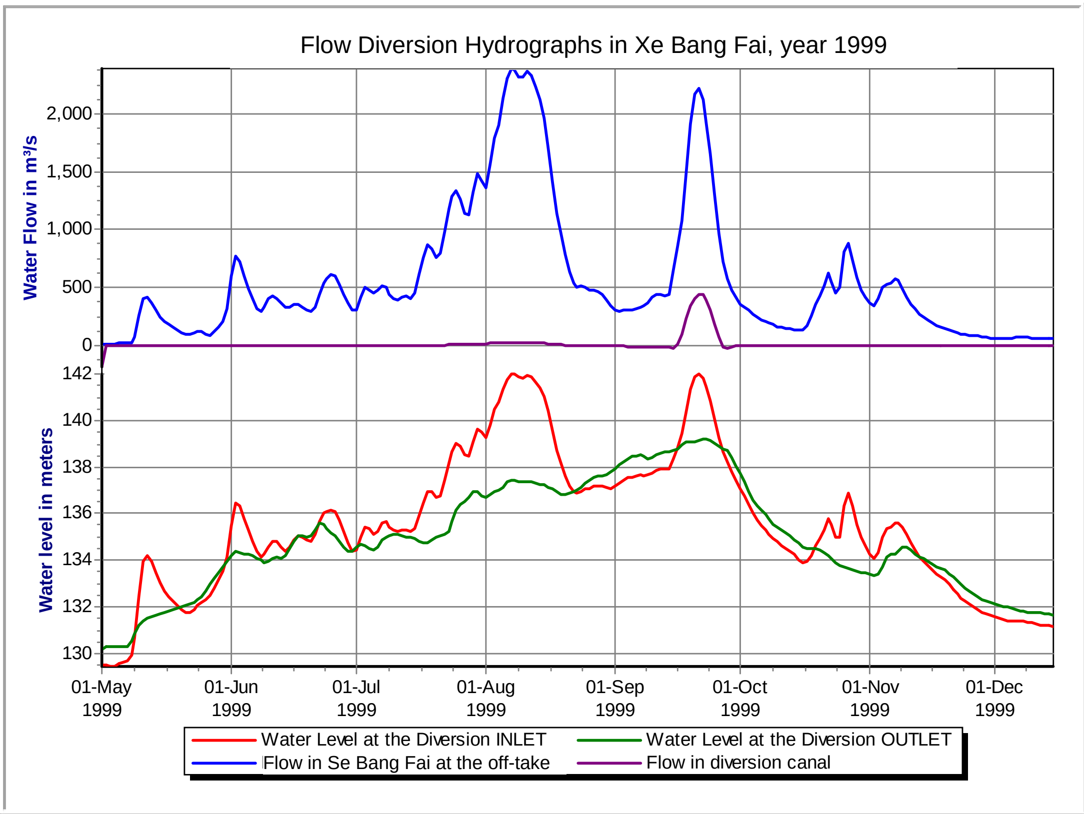


Figure 6-23 Water levels in Xe Bang Fai and Mekong and discharge in canal and river (20 km d/s offtake), year 1999.

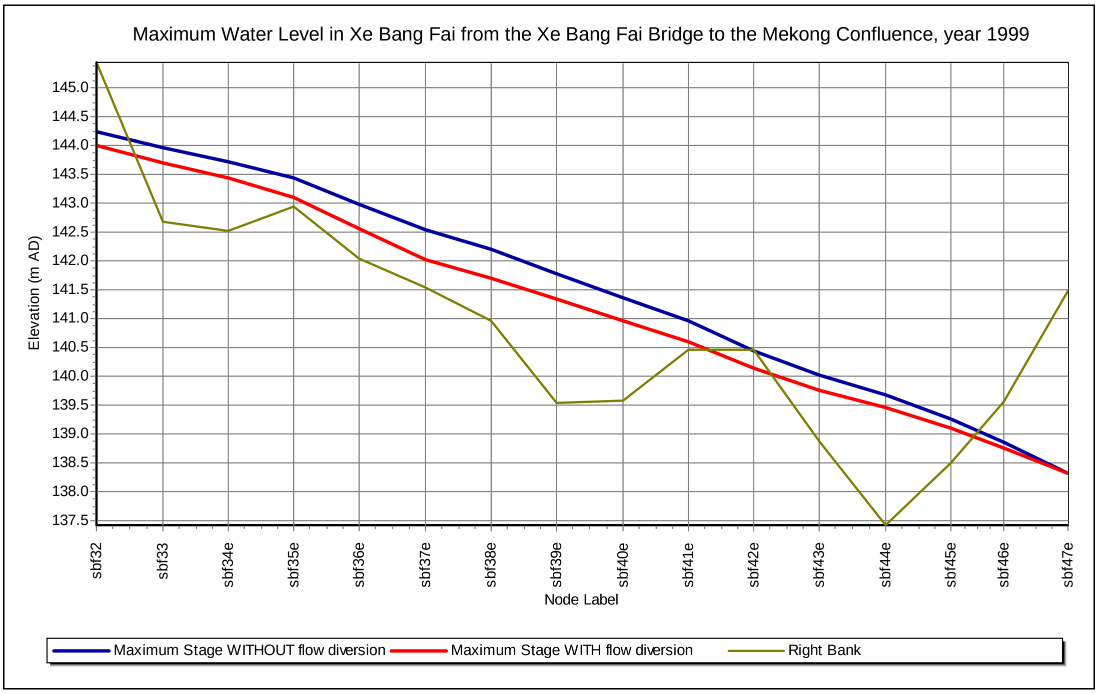


Figure 6-24 Maximum water level along Lower Xe Bang Fai from NR13S Bridge to mouth with and without bypass canal, year 1999.

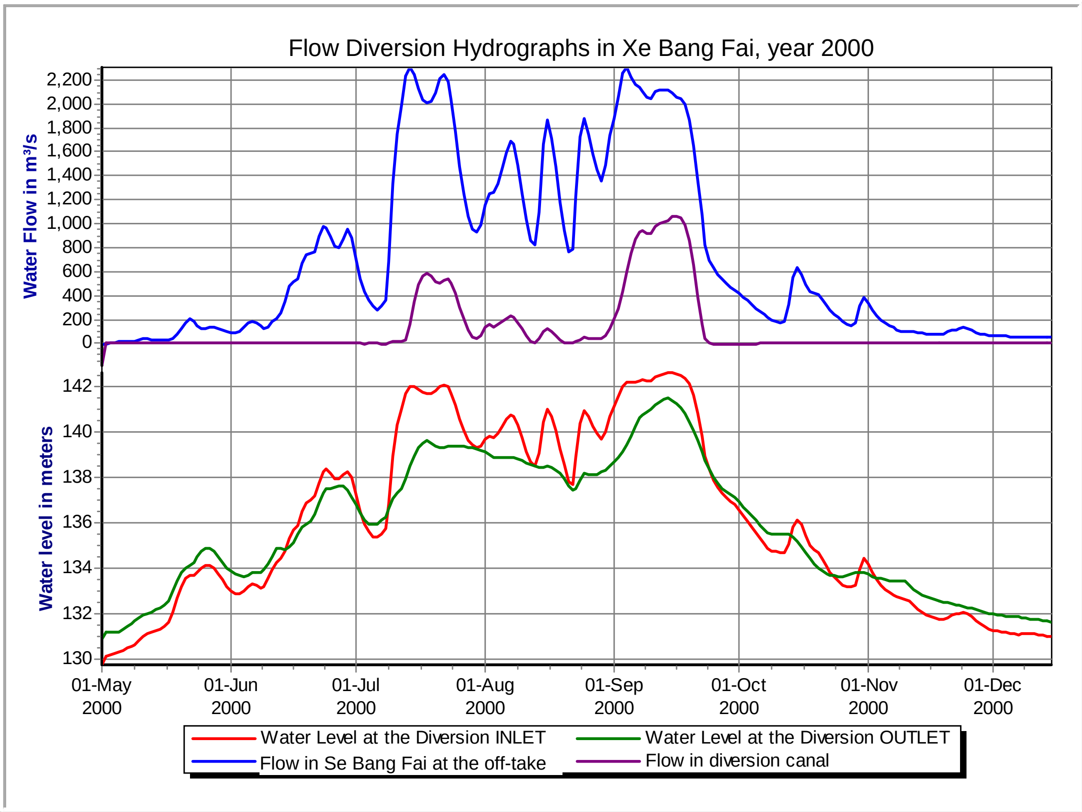


Figure 6-25 Water levels in Xe Bang Fai and Mekong and discharge in canal and river (20 km d/s offtake), year 2000.

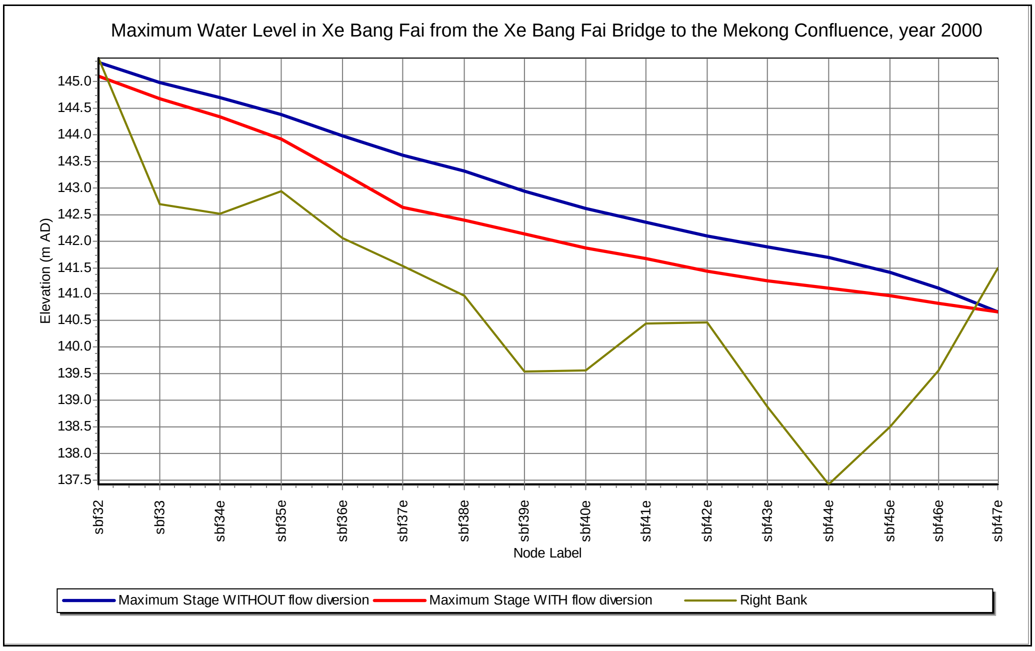


Figure 6-26 Maximum water level along Lower Xe Bang Fai from NR13S Bridge to mouth with and without bypass canal, year 2000.

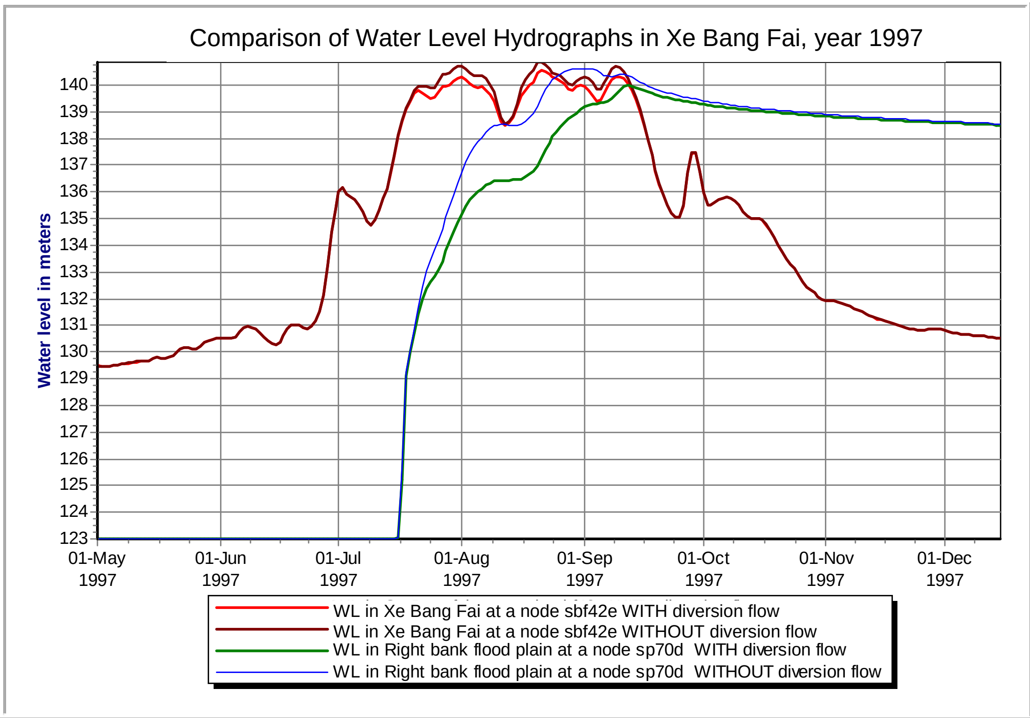


Figure 6-27 Water level in right bank floodplain of Xe Bang Fai with and without bypass canal, year 1996.

6.5.3 Probabilistic analysis for the diversion channel

Based on the method described in section 6.3.2, the 2, 10, 25 and 100-year water levels have been derived for all locations along the lower reach of the Xe Bang Fai River, assuming the existence of the diversion canal shows the results for Case 1 (no embankments). Figure 6-28 compares the resulting 100-year water level with the reference situation in which no diversion canal is present (N.B. this is the same reference situation as before, i.e. the case previously described as “no embankments”). Figure 6-29 shows the difference between the two cases. The diversion canal has a maximum reducing effect of almost 2 m on the 100-year water level in the river, approximately 50 km from the river mouth. Similar to section 6.3.2 the reduction reduces to approximately 0 at the upstream and downstream boundaries. For the 100-year water level a maximum reduction (near the offtake) of 1.83 m is observed.

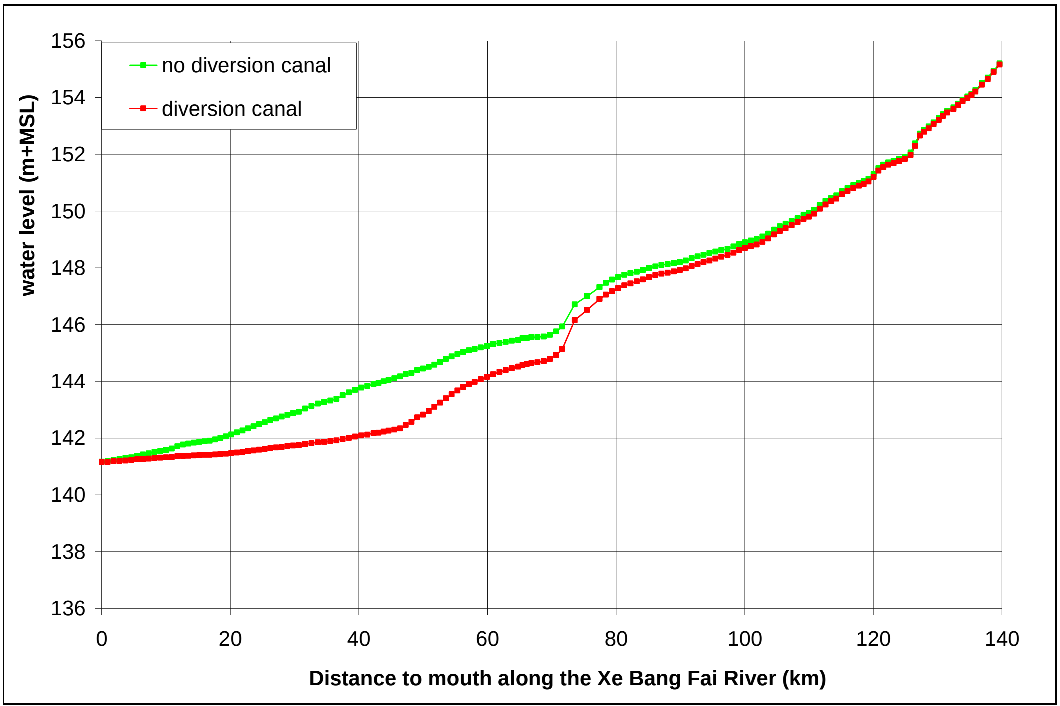


Figure 6-28 Computed 100-year flood level along the Xe Bang Fai River for the cases with [a] no diversion canal and [b] diversion canal.

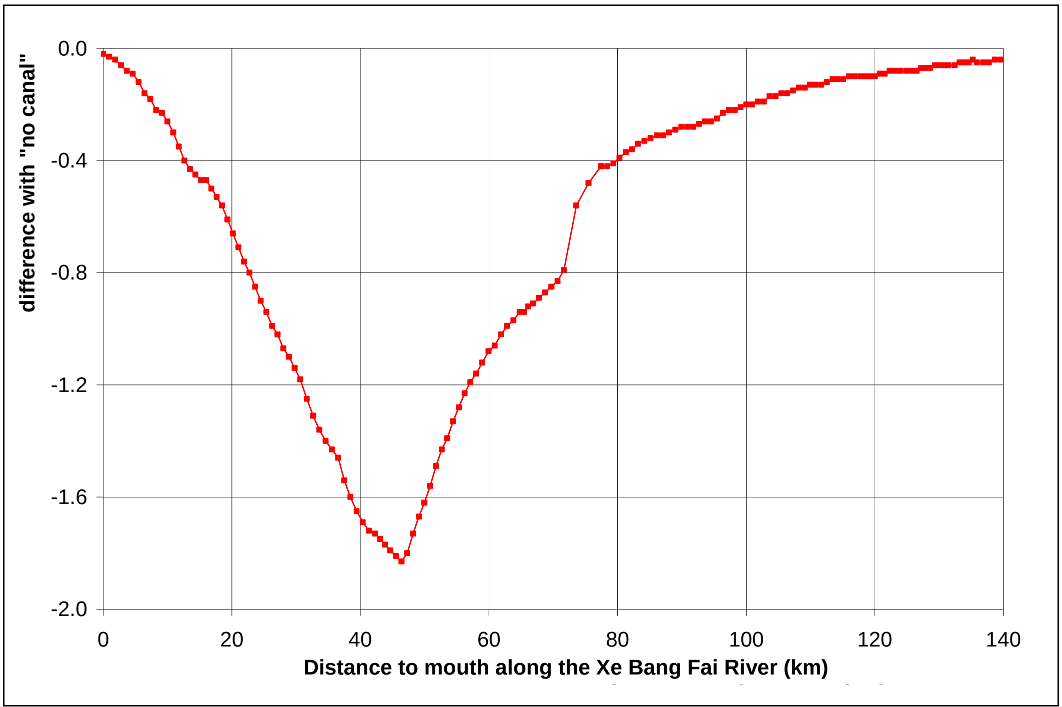


Figure 6-29 Differences in the computed 100-year flood level along the Xe Bang Fai River for the case of “diversion canal” relative to the Base Case in which no diversion canal is present.

Table 6-3 and Table 6-4 show the effect of the diversion canals on water levels in the floodplain areas. It can be seen that, in contrast with the embankments, the bypass canal has a reducing effect on water levels for all floodplain locations.

Table 6-3 Water levels and changes in water levels with return periods of 2, 10, 25 and 100 years in the floodplains of the Xe Bang Fai River Basin; locations downstream of diversion canal.

	water levels with no diversion canal				**change in water level as a result of the bypass canal**			
node	**2**	**10**	**25**	**100**	**2**	**10**	**25**	**100**
	right Bank (green locations of Figure 6-9**)**							
SP246nD	143.99	144.89	145.10	145.51	-1.14	-1.41	-1.15	-1.01
SP202D	144.15	144.92	145.12	145.52	-0.75	-0.84	-0.85	-0.92
SP226D	144.01	144.76	144.97	145.37	-0.79	-0.88	-0.90	-0.98
SP227D	143.49	144.36	144.59	145.01	-0.97	-1.14	-1.14	-1.23
SP245D	142.99	143.72	143.99	144.43	-1.48	-1.62	-1.61	-1.70
SP245nD	141.34	141.73	142.30	143.32	-0.08	-0.46	-1.03	-1.82
SP248D	144.10	144.92	145.12	145.52	-0.69	-0.84	-0.85	-0.92
SP261D	142.85	143.56	143.83	144.26	-1.36	-1.55	-1.56	-1.67
SP266D	142.10	142.76	143.11	143.60	-1.44	-1.47	-1.47	-1.62
SP284U	142.28	142.96	143.28	143.75	-1.51	-1.58	-1.55	-1.69
SP295D	141.76	142.39	142.74	143.20	-1.31	-1.30	-1.25	-1.36
SP307D	141.16	141.61	141.89	142.29	-0.92	-0.81	-0.73	-0.78
SP312U	140.98	141.63	142.00	142.48	-0.87	-0.88	-0.78	-0.90
SP343D	139.75	140.92	141.37	141.80	-0.58	-0.54	-0.40	-0.42
SP361D	139.35	140.68	141.13	141.50	-0.24	-0.39	-0.25	-0.21
SP376D	139.17	140.48	140.93	141.30	-0.04	-0.31	-0.13	-0.08
	left Bank (light blue locations of Figure 6-9**)**							
SP201D	144.15	144.92	145.12	145.52	-0.75	-0.85	-0.86	-0.93
SP219D	143.14	144.57	144.83	145.28	-1.82	-2.10	-1.65	-1.20
SP238D	141.22	143.58	144.00	144.66	-2.26	-4.09	-3.97	-3.44
SP258D	142.75	143.49	143.76	144.20	-1.80	-1.82	-1.75	-1.83
SP277D	136.06	137.66	139.27	141.61	-0.65	-2.25	-3.85	-6.19
SP285D	135.42	136.45	137.94	140.22	-0.01	-1.04	-2.53	-4.81
SP286D	139.87	140.93	141.56	142.14	-0.20	-0.93	-0.94	-0.86
SP300D	137.67	138.02	138.84	140.56	0.00	-0.35	-1.17	-2.89
SP344D	139.56	140.80	141.38	141.84	-0.06	-0.66	-0.49	-0.46
SP362D	138.91	140.34	141.07	141.49	-0.02	-0.44	-0.21	-0.20
SP375D	133.80	135.50	137.85	139.90	0.00	-0.43	-0.58	-0.15

Table 6-4 Water levels and changes in water levels with return periods of 2, 10, 25 and 100 years in the floodplains of the Xe Bang Fai River Basin; locations upstream of diversion canal.

	water levels with no diversion canal				change in water level as a result of the bypass canal			
node	**2**	**10**	**25**	**100**	**2**	**10**	**25**	**100**
	Right bank (black locations of Figure 6-9**)**							
SP109D	147.28	148.15	148.30	148.61	-0.18	-0.19	-0.20	-0.22
SP131D	146.70	147.59	147.75	148.08	-0.27	-0.26	-0.27	-0.30
SP143D	146.35	147.21	147.39	147.77	-0.27	-0.34	-0.35	-0.38
SP188nD	140.01	140.02	140.18	141.25	0.00	0.00	-0.16	-1.04
SP41D	141.66	148.67	149.85	151.56	-0.51	-0.55	-0.40	-0.33
SP434D	143.48	146.09	146.26	146.59	-1.50	-0.77	-0.54	-0.52
SP50D	139.34	145.02	146.51	149.57	-0.58	-0.97	-0.92	-0.68
SP67D	138.86	143.69	144.82	147.35	-0.67	-0.86	-0.88	-0.88
SP7D	147.36	151.82	152.57	153.67	-0.14	-0.22	-0.17	-0.13
SP83D	148.05	149.02	149.17	149.50	-0.17	-0.14	-0.14	-0.16
SP98D	147.53	148.40	148.55	148.87	-0.21	-0.18	-0.18	-0.21
SP29D	116.20	125.60	128.21	134.56	-0.58	-0.90	-0.91	-0.95
	Left bank (red locations of Figure 6-9**)**							
SP97D	147.71	148.49	148.64	148.95	-0.15	-0.17	-0.17	-0.19
SP115D	146.70	148.05	148.20	148.53	-0.17	-0.22	-0.21	-0.24
SP132D	146.75	147.57	147.72	148.06	-0.22	-0.27	-0.27	-0.31
SP146D	146.45	147.23	147.39	147.76	-0.25	-0.32	-0.32	-0.36
SP162D	138.48	138.49	138.74	139.73	0.00	0.00	-0.24	-0.87
SP191D	145.26	145.96	146.13	146.50	-0.32	-0.48	-0.49	-0.55
SP30D	151.01	152.26	152.46	152.85	-0.06	-0.06	-0.06	-0.07
SP40D	143.56	148.96	150.02	151.51	-0.38	-0.48	-0.40	-0.28
SP416nD	141.65	145.04	145.88	147.13	-1.07	-2.39	-2.06	-1.40
SP424D	139.91	139.92	140.06	140.79	0.00	0.00	-0.14	-0.67
SP425D	145.63	146.98	147.23	147.70	-0.62	-0.57	-0.56	-0.52
SP51D	145.07	149.70	150.47	151.00	-0.52	-0.30	-0.18	-0.10
SP68D	143.73	148.56	149.39	150.23	-0.49	-0.60	-0.57	-0.20
SP84D	148.04	149.01	149.16	149.48	-0.18	-0.15	-0.14	-0.16
SP8D	147.50	151.95	152.66	153.46	-0.17	-0.18	-0.17	-0.10

6.6 Effects of varying bottom levels in the Mekong River

In section 4.3.5 it was noted that the Mekong River in this area is morphologically very active with varying bottom levels as a consequence. At location Mukdahan the levels for high discharges, based on the year 2000 curve, may be up to 0.75 m off, up and down. A quickscan was executed to assess the effect varying bottom levels (and, consequently, water levels) in the Mekong on water levels in the Xe Bang Fai. For this purpose, the 90 model were redone twice for the following adapted conditions:

- Situation of lower bottom level: -0.75 m:
  - stage discharge relation at Mukdahan such that it leads to water levels -0.75 m in comparison with the Base Case of the previous sections;

  - Manning coefficient of 0.028 m. (instead of 0.032 in the Base Case).
- Situation of higher bottom level: +0.75 m:
  - stage discharge relation at Mukdahan such that it leads to water levels +0.75 m in comparison with the Base Case of the previous sections;
  - Manning coefficient of 0.036 m. (instead of 0.032 in the Base Case).

In the probabilistic analysis, the bottom level is now introduced as an additional random variable. The above two situations (plus and minus 0.75 m) are considered to be the extremes of a uniform distribution function. In other words, if h* is the water level at Mukdahan that follows from discharge Q*, using the stage discharge relation based on the year 2000 curve, then the "real" water level at Mukdahan is uniformly distributed between h*-0.75 and h*+0.75 m. This means on average the water level is still h*. Nevertheless, applying this distribution increases the probabilities of extreme water levels as a result of the contribution of increased bottom levels.

For instance, with the introduction of the new random variable "bottom level", the 100-year water level at Mukdahan increases from 137.81 to 138.07, an increase of 0.26 m. Figure 6-30 shows the effect on 100-year water levels along the Lower Xe Bang Fai. At the river mouth the effect is about 10 cm, and it diminishes 30 km upstream.

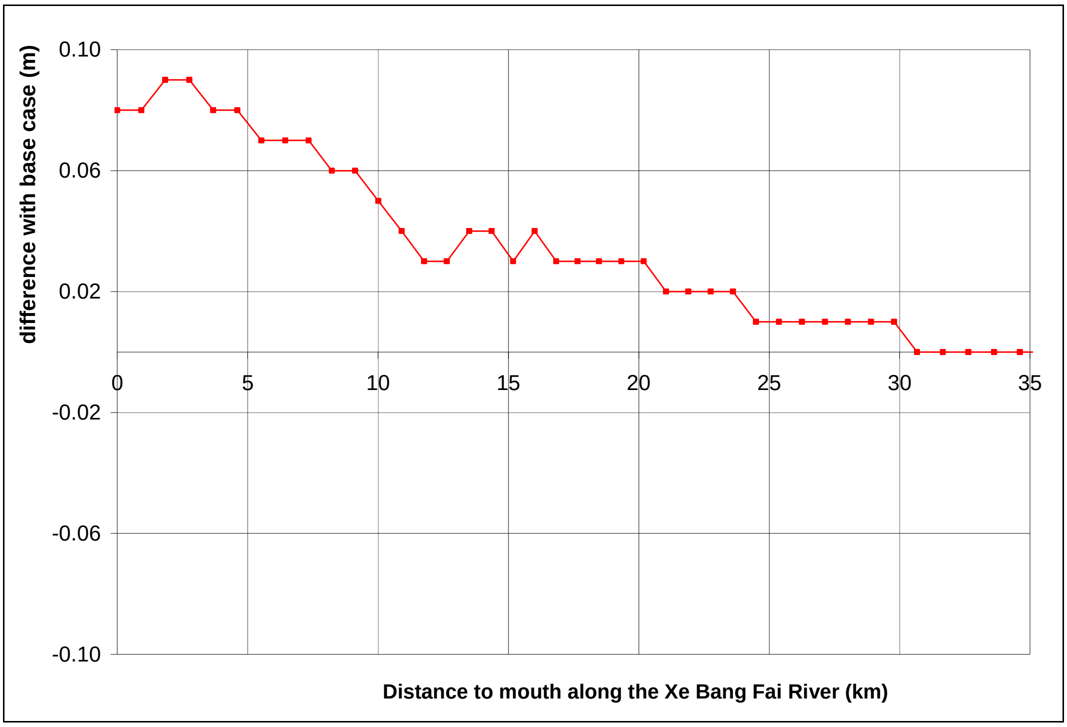


Figure 6-30 Increase of water levels along the Xe Bang Fai River as a result of the introduction of the varying bottom level as a new random variable.

The reason why the effect at Xe Bang Fai River mouth is far less than at Mukdahan is due to the fact that for high discharges the effect of increased (or decreased) water levels at Mukdahan are almost halved at That Phanom. This is shown in Figure 6-31 and Figure 6-32: for low water levels the differences with the bases case at That Phanom are 0.75 m (similar to Mukdahan) whereas for high water levels these differences decrease to about 0.40 m. The analysis above provides a good insight in effects of varying bottom depth on the 100-year water level. However, with the assessment of effects of measures like embankments or diversion canals we are mainly interested in relative differences. Therefore, the analyses of the previous sections (without the varying bottom levels as random variable) are sufficient.

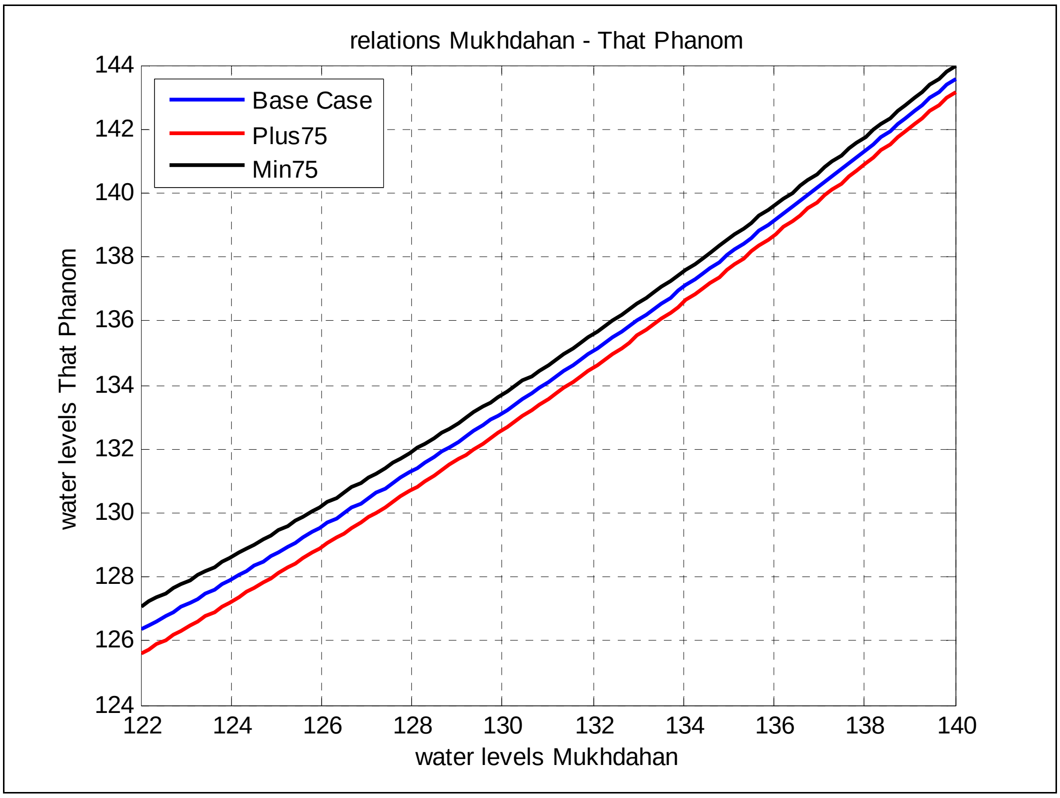


Figure 6-31 Relation between water levels at Mukdahan and That Phanom for the Base Case and two additional cases (water level +/- 0.75 m).

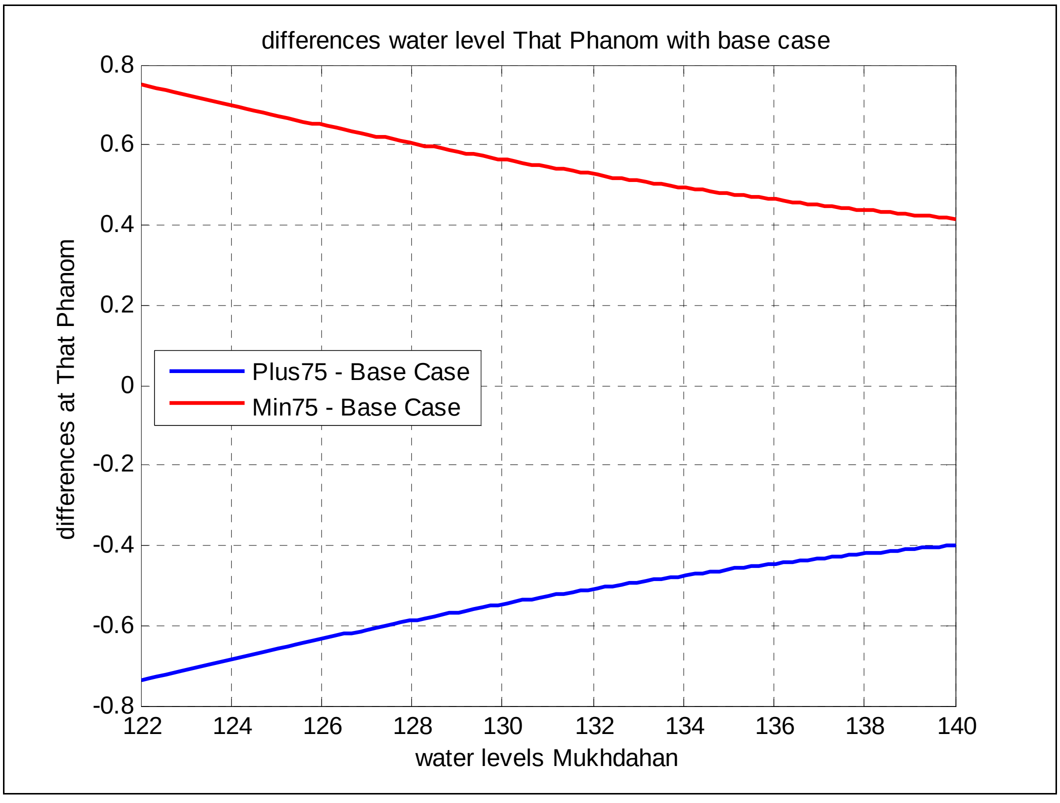


Figure 6-32 Differences in water level at That Phanom between the cases of Figure 6-31.

7. Conclusions and Recommendations

7.1 Conclusions

Based on the analyses presented in the previous chapters the following conclusions can be drawn.

Type of floods and flooded area

1. Flood prone areas in the Xe Bang Fai Basin are:
   - between the Mekong and NR13S, north of Xe Bang Fai River, creating extensive and of long lasting flooding; and
   - near NR01F between Mahaxai and Nam Oula with flooding of one week duration per year on average.
2. The flood levels in the Lower Xe Bang Fai are not only due to high river discharges but are also affected by high water levels in the Mekong at the river mouth at That Phanom. The floods in this region are therefore classified as combined floods. Bivariate distributions of Xe Bang Fai River flows and Mekong water levels are required to describe the phenomenon in statistical terms.

Data availability and validation

3. Water level series, discharge measurements and discharge series are available for Mahaxai from 1988 onward. The rating curve is regularly updated. The discharge series are suitable for extreme value analysis.
4. Water level series, discharge measurements and discharge series are also available for Xe Bang Fai NR13S Bridge, with a discharge record from 1960 onward with some gaps. The latter record is not corrected for backwater and therefore not suitable.
5. Discharge measurements at NR13S Bridge and flows at Mahaxai do correlate well. A consistent discharge series has been established for NR13S Bridge based on regression with Mahaxai. The difference between these series provides an estimate of the lateral inflow between Mahaxai and the flood prone area downstream of NR13S Bridge.
6. The water levels at the Xe Bang Fai River mouth are determined by the combined Mekong discharge recorded at Nakhon Phanom and the Xe Bang Fai discharge and the conveyance capacity of the Mekong and imposed level conditions in the reach That Phanom – Mukdahan and beyond, downstream of the confluence.
7. Discharge records for Nakhon Phanom are available since 1924. The series is generally consistent with the flow at Mukdahan.

Hydrological characteristics

8. Average annual rainfall in Xe Bang Fai ranges from about 2,500 mm in the upper reaches to less than 1,600 mm near the mouth. Rainfall occurs mainly from May to September, with August as the wettest month on average.
9. Annual potential evapo-transpiration in the Lower Xe Bang Fai reaches 1,550 to 1,600 mm. The values are highest in the period March-May. Evaporation exceeds rainfall from October till April.

10. Annual average flow at Mahaxai amounts 7,000 MCM. The runoff depth is about 1,650 mm, i.e. higher than the average annual rainfall at mouth. The monthly flow is highest in August followed by September and July.
11. The average annual flow at NR13S Bridge is estimated at 12,700 MCM or 1,480 mm.
12. The regime of the Xe Bang Fai coincides with that of the Mekong hence floods on both rivers may occur at the same time which will aggravate the flooding.
13. From December 2009 onward the discharge of the Xe Bang Fai will be augmented with the flow of Nam Theun via the Regulating dam and Downstream Channel of the hydro-power plant. On average the discharge of the Xe Bang Fai will increase with 220 m^3/s.

Hydrological hazard

14. The hydrological hazard expressed as extreme discharge and flood volume for selected return periods have been determined for Mahaxai on Xe Bang Fai and Nakhon Phanom on Mekong. The GEV-distributions fit well to the distributions of both annual maximum discharge and annual flood volume.
15. Flood volumes and to a lesser extent flood peaks on Mekong and Xe Bang Fai do correlate.
16. The bivariate distribution of annual flood peaks and flood volumes in the Mekong at Nakhon Phanom can be described by regression equations and GEV-distributions for the regression residuals.
17. The discharge rating of the Mekong at Mukdahan, which acts as downstream boundary in the hydraulic model, varies from year to year. For a fixed high discharge the water level varies +/- 0.75 m about the assumed rating in the hydraulic model. This affects the water level at That Phanom with +/- 4 dm.

Flood hazard

18. The flooding in the Lower Xe Bang Fai is complex and its extent is preferably modelled with a 1D/2D hydraulic model. Such model eliminates subjectivities in the schematisation of the interaction between river and floodplain.
19. The 1D hydraulic model of the Xe Bang Fai as developed and calibrated by LNMC in 2009 leads on average to 7 to 8 dm higher water levels than observed water levels at NR13S Bridge. The roughness of the model has subsequently been adjusted to arrive at an average unbiased result at the NR13S Bridge.
20. The quality of the model to correctly simulate floodplain flooding is uncertain, in absence of detailed data on flooding extent.
21. For flood hazard assessment in regions of combined floods use is made of the Monte Carlo procedure, taking into account the joint occurrence of peak flows and flood volumes in Mekong and Xe Bang Fai.
22. The water levels in Xe Bang Fai River and floodplains for some 90 combinations of Mekong and Xe Bang Fai peak flows and flood volumes have been determined with the hydraulic model to create a database the Monte Carlo procedure is drawing from to determine the flood hazard.
23. The flood hazard for the following cases have been determined including preparation of flood depth and flood extent maps:
    – Case 1: situation with no embankments, i.e. the river conditions till 2002;
    – Case 2: situation with embankments along the left bank since 2002;
    – Case 3: situation with embankments on both banks, i.e. the planned layout.

24. The embankment protect the downstream floodplains but back up the water further upstream. The situation with only embankments on the left is profitable for the downstream floodplain locations on the left but disadvantageous for locations on the right.
25. The flood extent derived by the model for the lower reach of the Xe Bang Fai is qualitatively in line with flood maps of the year 2000.
26. Effects of a bypass channel from the Xe Bang Fai to the Mekong to improve the drainage conditions have been investigated. A 200 m wide bypass with bed level at 138 m amsl conveyed for selected years up to 500 to 1000 m^3/s, lowering the maximum water levels along the rivers near the offtake with about 0.5 to 1.0 m. Similar values are found for the floodplains with substantially reduced flood duration. For the 100-year water level a maximum reduction (near the offtake) of 1.83 m is observed.

7.2 Recommendations

To improve the flood hazard assessment for the Lower Xe Bang Fai the following recommendations are made:

1. Establish a discharge measuring station on the Se Noy and (temporary) water level stations in the river (one additional) and floodplains downstream of NR13S Bridge.
2. Carry out a detailed topographic survey of river, floodplain and embankment levels from Mahaxai to river mouth and develop an accurate DEM.
3. Update the land use maps valid for flood and dry seasons.
4. Develop a new 1D/2D hydraulic model of the Lower Xe Bang Fai including the Mekong from Nakhon Phanom to Mukdahan. With the availability of the DEM and land use data the development of such a model is much easier than of a 1D-model as the river-floodplain interaction is objectively derived from the DEM.
5. Simulate the water level and flow conditions in the Xe Bang Fai River and floodplain downstream of Mahaxai for the selected 90 combinations of water levels at That Phanom and discharge hydrographs at Mahaxai under different river and floodplain settings (Cases 1 to 3 and bypass channel).
6. Apply the Monte Carlo procedure to arrive at the water levels for selected return periods.
7. For design purposes always verify your calculations on flood levels with the larger values of two cases:
   7.a Case 1: 100 year peak flow at Mahaxai with annual peak level at mouth (derived from annual peak flow at Nakhon Phanom);
   7.b Case 2: annual peak flow at Mahaxai and 100 year peak level at mouth (derived from annual peak flow at Nakhon Phanom).

   In both cases the maximum effect of bed level changes on the discharge rating at Mukdahan should be taken into consideration, as well as effects of extreme winds (speed and direction) during typhoons.

8. Reference

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Mekong Secretariat (1981), The Se Ban Fai Plain, Lao PDR. Feasibility study of floodway and small structures. Interim Progress Report. MKG/R314, May 1981.

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Appendix 2

Flood Damage Assessment and Flood Risk Assessment

Lower Xe Bang Fai, mapping flood levels, flood depths, flood damages and flood risks

Summary and Conclusions

- *The Best Practise Guidelines for Flood Risk Assessment in the Lower Mekong Basin*' gives the methodology to produce maps of flood levels, flood depths, flood damages and flood risks. These have been applied for the Xe Bang Fai area following the absolute damages assessment approach for combined flooding (tributary and mainstream flooding).

- The Flood hazard has been assessed with the aid of the ISIS model for four situations
  1. No measures (embankment, diversion) along the Xe Bang Fai/Se Noy;
  2. A left embankment on the downstream part of the Xe Bang Fai;
  3. A left and right embankment on the downstream part of the Xe Bang Fai;
  4. A diversion canal creating a shortcut from the Xe Bang Fai to the Mekong.

- The embankments prevent water flowing out of the XBF (left side or both sides), but upstream and downstream of the embankment water can still inundate the surrounding areas and flow partially behind the embankment. The diversion canal alternative, as currently schematised, does not evacuate water from the surrounding areas; it only links the XBF with the Mekong.

- Sixteen water level maps are the result (combinations of return periods 2, 10, 25 and 100 years, and 'no embankment', 'left embankment', 'left and right embankment', 'diversion canal'). By subtracting the Digital Elevation Model values from the water levels the water depth maps are produced.

- Based on the damage inventories, graphs have been constructed giving the relationship between a certain type of damage and the water level at a point in or near the affected area. Damage figures for certain flood return periods are extracted from this curve.

The damages for housing, agriculture and infrastructure/ relief are in the following table:

Damage type	**Damage (10^6 USD) 2 year r.p.**	**Damage (10^6 USD) 10 year r.p.**	**Damage (10^6 USD) 25 year r.p.**	**Damage (10^6 USD) 100 year r.p.**
Housing	0.01	0.05	0.08	0.12
Agriculture	1.91	6.83	9.64	13.88
Infrastructure	0.28	0.89	1.24	1.77
Total	2.20	7.77	10.96	15.77

- From the return period and the damage as given by the above table the probability – damage curve is produced. The expected damage or risk can be determined by calculating the area under the curve. For the Nongbok District the expected annual risks are:

Damage type	**Risk (10^6 USD/yr)**
Housing	0.014
Agriculture	2.605
Infrastructure	0.362
Total	2.981

Mapping flood levels, flood depths, flood damages and flood risks in the Xe Bang Fai lower catchment area, Lao PDR

1. Introduction

The '*Draft Best Practise Guidelines for Flood Risk Assessment in the Lower Mekong Basin*' gives the methodology to produce maps of flood levels, flood depths, flood damages and flood risks for the Cambodian and Vietnamese transboundary area in the delta of the Lower Mekong. This methodology is, in general, also applied for the lower Xe Bang Fai catchment area in Laos. The differences are due to the limited number of hydraulic modelling nodes in Xe Bang Fai, the hilly terrain (compared to the flat delta areas), and the proposed measures. Listed below the steps to come for the different types of maps are briefly explained, indicating the differences with the methodology described in the Guidelines mentioned above. In the Final version of the Guidelines the assessment approach for combined flooding as experienced in the Xe Bang Fai area will be incorporated.

2. Damage and risk calculations

As is described in detail in the '*Draft Best Practise Guidelines for Flood Risk Assessment in the Lower Mekong Basin*', two approaches for damage and risk calculations may be applied: the absolute approach and the relative approach. The FMMP-C2 looks at damages and risks for housing, agriculture and infrastructure/ relief. For the absolute approach, damage data at district level are available from governmental institutes, for the relative approach detailed land use maps must be available. For the Xe Bang Fai area only limited information is available within the FMMP-C2 on village locations, giving an indication on housing (based on household figures). The other two damage categories considered in the project, agriculture and infrastructure/ relief, are not (yet) on hand. Therefore, at this stage, the absolute approach has to be followed, using the damage reports from the district authorities as collected in Stage 1 of FMMP-C2.

3. Geographic Information System (GIS) data

To create flood level, flood depth, flood damage and flood risk maps several digital data sets need to be available: see the FRA Guidelines. The maps are created with ArcGIS (ArcMap/ArcInfo). The map layers all need to have the same datum and projection in order to be able to combine them. The standard at the MRC for the datum is Indian 1954, while the standard MRC projection for Lao PDR is UTM zone 48 north. As the data sets from the hydraulic model use another datum, they were converted to Indian 54.

4. Flood level and flood depth maps

The water level calculations in the hydraulic model ISIS are based on the levels of both the Mekong and Xe Bang Fai/Se Noy rivers. Different combinations of water levels in the two rivers, together with various return periods, have been calculated by ISIS. In addition three measure scenarios are modelled with ISIS (giving a total of 90 combinations):

1) No measures (embankment, diversion) along the Xe Bang Fai/Se Noy;
2) A left embankment on the downstream part of the Xe Bang Fai;
3) A left and right embankment on the downstream part of the Xe Bang Fai;
4) A diversion canal creating a shortcut from the Xe Bang Fai to the Mekong.

The embankments prevent water flowing out of the XBF (left side or both sides), but upstream and downstream of the embankment water can still inundate the surrounding areas and flow partially behind the embankment. The diversion canal, as currently schematised, does not evacuate water from the surrounding areas; it only links the XBF with the Mekong.

The new schematisation in ISIS for the Xe Bang Fai/Se Noy catchments resulted in water levels for 264 nodes (cross-section nodes and reservoir nodes) in the Xe Bang Fai, Se Noy and the Mekong. In addition, connected to each (central) cross-section node in the Mekong, coordinates of 50 to 90 cross-section points are available, covering a width up to 2 km perpendicular to the Mekong flow. These additional points are assumed to have the same water level as the central node. Also additional cross-section data is available for the Xe Bang Fai, but without coordinates and covering only a few hundred meters wide. These have not been used.

Most of the flat areas in the Xe Bang Fai catchment are schematised in the ISIS model with reservoirs. ISIS assumes a horizontal water level in each reservoir, represented by one node per reservoir. The reservoir limits follow more or less the isohypses, but according to the DEM the terrains in most reservoirs seem to have a slope, in particular the ones further away from the Mekong. Therefore the reservoirs are not used in the interpolations for creating the water level maps; only their hydraulic node.

With MatLab (also a spreadsheet could be used) the annual maximum water levels for the return periods of 2, 10, 25 and 100 years are distilled from the ISIS data. In Access these maximum levels for the four return periods and for each of the four scenarios (so 16 datasets in total) are merged into one table and linked to the 264 nodes in the GIS and to the Mekong cross-section points (27 central cross-section points linked with 1902 'lateral' cross-section points).

SBF_ISIS_AllLevels : Table

X	Y	Node_Label	Node_Type	River	NoB_002	NoB_010	NoB_025	NoB_100	LB_002	LB_010	LB_025	LB_100	LRB_002	LRB_010	LRB_025	LRB_100	Div_002	Div_010	Div_025	Div_100
481291.724	1876908.485	XBFI2-22329i	RIVER_SECTION	XBF	140.32	141.23	141.65	142.12	140.17	141.2	141.67	142.19	140.47	141.43	141.87	142.42	139.34	140.5	141.07	141.47
480916.695	1876322.662	XBFI2-23184i	RIVER_SECTION	XBF	140.23	141.17	141.6	142.06	140.09	141.14	141.61	142.12	140.38	141.36	141.81	142.34	139.31	140.48	141.05	141.45
480666.367	1875735.252	XBFI2-24040i	RIVER_SECTION	XBF	140.16	141.12	141.55	142	140.03	141.09	141.57	142.06	140.31	141.31	141.76	142.29	139.29	140.47	141.04	141.44
481244.71	1875018.265	XBFI2-24863i	RIVER_SECTION	XBF	140.1	141.08	141.51	141.95	139.97	141.04	141.52	142.01	140.25	141.26	141.71	142.23	139.27	140.45	141.02	141.42
481511.727	1874088.645	XBFI2-25686i	RIVER_SECTION	XBF	140.04	141.05	141.47	141.91	139.91	141	141.49	141.97	140.18	141.21	141.67	142.18	139.26	140.44	141.01	141.41
482081.438	1873181.614	XBFI2-26510i	RIVER_SECTION	XBF	139.98	141.02	141.45	141.88	139.86	140.97	141.46	141.94	140.12	141.16	141.62	142.13	139.24	140.43	141	141.41
482979.165	1872827.44	XBFI2-27333i	RIVER_SECTION	XBF	139.93	141	141.43	141.87	139.82	140.94	141.44	141.92	140.05	141.12	141.58	142.08	139.23	140.42	141	141.4
484092.691	1872602.841	XBFI2-28157	RIVER_SECTION	XBF	139.88	140.98	141.41	141.84	139.77	140.92	141.42	141.9	139.99	141.07	141.54	142.04	139.22	140.41	140.99	141.39
483566.14	1871851.301	XBFI2-29019i	RIVER_SECTION	XBF	139.82	140.94	141.38	141.81	139.71	140.88	141.39	141.86	139.91	141.01	141.49	141.98	139.2	140.39	140.98	141.38
482522.102	1871378.787	XBFI2-29882i	RIVER_SECTION	XBF	139.74	140.9	141.35	141.77	139.64	140.84	141.36	141.82	139.82	140.94	141.43	141.91	139.18	140.38	140.96	141.37
481641.61	1870628.386	XBFI2-30745i	RIVER_SECTION	XBF	139.66	140.85	141.3	141.7	139.56	140.78	141.3	141.75	139.72	140.88	141.38	141.85	139.17	140.36	140.95	141.36
480749.646	1870092.612	XBFI2-31608	RIVER_SECTION	XBF	139.56	140.79	141.24	141.62	139.47	140.71	141.23	141.67	139.64	140.83	141.34	141.8	139.15	140.34	140.92	141.33
480132.56	1869671.857	XBFI2-32500i	RIVER_SECTION	XBF	139.48	140.75	141.2	141.58	139.4	140.65	141.19	141.62	139.54	140.77	141.29	141.74	139.13	140.32	140.91	141.32
479452.346	1869327.785	XBFI2-33392i	RIVER_SECTION	XBF	139.39	140.71	141.16	141.54	139.32	140.6	141.15	141.58	139.44	140.71	141.24	141.68	139.11	140.3	140.89	141.31
478786.053	1868977.185	XBFI2-34285i	RIVER_SECTION	XBF	139.31	140.68	141.13	141.51	139.23	140.56	141.11	141.55	139.33	140.65	141.2	141.64	139.09	140.28	140.88	141.29
478121.307	1868704.357	XBFI2-35177i	RIVER_SECTION	XBF	139.26	140.64	141.09	141.46	139.14	140.5	141.06	141.5	139.22	140.59	141.15	141.58	139.07	140.27	140.86	141.28
477223.58	1868617.973	XBFI2-36070	RIVER_SECTION	XBF	139.22	140.61	141.05	141.41	139.09	140.45	141.01	141.46	139.15	140.54	141.1	141.53	139.06	140.25	140.85	141.26
475750.589	1868729.22	XBFI2-36991i	RIVER_SECTION	XBF	139.18	140.56	141	141.36	139.05	140.39	140.96	141.4	139.1	140.48	141.05	141.48	139.04	140.23	140.82	141.25
474852.097	1869401.986	XBFI2-37912i	RIVER_SECTION	XBF	139.13	140.53	140.95	141.32	139.01	140.33	140.91	141.36	139.06	140.42	140.99	141.43	139.01	140.2	140.81	141.23
474239.226	1870162.165	XBFI2-38833i	RIVER_SECTION	XBF	139.09	140.49	140.91	141.28	138.97	140.27	140.86	141.32	139.01	140.37	140.94	141.38	138.99	140.18	140.79	141.21
474058.526	1871045.014	XBFI2-39754i	RIVER_SECTION	XBF	139.05	140.45	140.86	141.25	138.93	140.21	140.81	141.28	138.96	140.31	140.88	141.34	138.97	140.16	140.77	141.19
473940.943	1871894.544	XBFI2-40675i	RIVER_SECTION	XBF	139	140.42	140.82	141.22	138.89	140.16	140.76	141.25	138.92	140.25	140.83	141.3	138.95	140.14	140.75	141.18
473324.279	1873023.381	XBFI2-41596i	RIVER_SECTION	XBF	138.96	140.39	140.79	141.19	138.85	140.11	140.71	141.21	138.88	140.2	140.79	141.26	138.93	140.12	140.73	141.16
472902.944	1873663.654	XBFI2-42518	RIVER_SECTION	XBF	138.92	140.35	140.75	141.16	138.82	140.06	140.68	141.19	138.84	140.15	140.74	141.23	138.91	140.1	140.72	141.15
504961.698	1901282.09	SP109D	RESERVOIR	XBF	147.28	148.15	148.29	148.6	146.44	148.12	148.28	148.65	146.84	148.43	148.65	149.02	147.1	147.96	148.1	148.39
512905.016	1900274.02	SP115D	RESERVOIR	XBF	146.7	148.05	148.2	148.52	145.79	147.99	148.17	148.57	146.24	148.35	148.57	148.96	146.53	147.83	147.99	148.29
504672.271	1897764.956	SP131D	RESERVOIR	XBF	146.7	147.59	147.74	148.07	146.14	147.57	147.75	148.14	146.58	147.97	148.21	148.62	146.43	147.33	147.48	147.78
510065.47	1894848.69	SP132D	RESERVOIR	XBF	146.75	147.57	147.71	148.05	145.62	147.55	147.72	148.12	146.04	147.95	148.18	148.6	146.53	147.3	147.45	147.75
503957.305	1893311.387	SP143D	RESERVOIR	XBF	146.35	147.21	147.38	147.76	145.3	147.21	147.41	147.86	145.8	147.7	147.96	148.42	146.08	146.87	147.04	147.39
507051.81	1893055.788	SP146D	RESERVOIR	XBF	146.45	147.23	147.39	147.74	145.34	147.22	147.42	147.85	145.82	147.69	147.95	148.41	146.2	146.91	147.07	147.4
507067.594	1886595.996	SP162D	RESERVOIR	XBF	138.48	138.49	138.75	139.73	138.48	138.53	138.94	140.17	138.49	139.32	140.42	142.61	138.48	138.49	138.5	138.86

To create a water level map with the water level info attached to the ISIS nodes in the GIS (264 + 1902), an interpolation needs to be done. There are many methods to create a continuous surface based on spatial points with values. The type of data, the spatial distribution of the points, the range in the values etc. determine the appropriate method. A few methods have been considered for creating the Xe Bang Fai water level maps (IDW, Spline, Kriging, and Natural Neighbours). Although no in-depth analysis has been done, the Inverse Distance Weighting (IDW) method seemed to be the most suitable. It has the option to include 'barriers' or 'linear discontinuities', which suits the inclusion of embankments or canals in the interpolation. Details on the IDW interpolation can be found on the Internet.

The IDW parameters set in ArcGIS are: power = 1, number of points to include = 12, distance to search for points = variable, output grid cell size = 50 m.

Sixteen water level maps are the result (combinations of return periods 2, 10, 25 and 100 years, and ‘no embankment’, ‘left embankment’, ‘left and right embankment’, ‘diversion canal’).

By subtracting the Digital Elevation Model (DEM) values from the water levels the water depth maps are produced (also 16).

4.1 Flood damage maps

The Xe Bang Fai (Nongbok) flood damage data in the ‘absolute approach’ originate from Lao PDR Government institutes, who inventories damages after each major flood. Based on these inventories, graphs can be constructed giving the relationship between a certain type of damage (e.g. housing, agriculture, and infrastructure) and the water level at a point in or near the affected area (gauging station, hydraulic modelling node). The damage curves are linked to the long-term flood levels from the same gauge station, resulting in a damage probability curve. Damage figures for certain flood return periods are extracted from this curve.

The damages for housing, agriculture and infrastructure/ relief are summarised in the following table:

Damage type	**Damage (10^6 USD) 2 year r.p.**	**Damage (10^6 USD) 10 year r.p.**	**Damage (10^6 USD) 25 year r.p.**	**Damage (10^6 USD) 100 year r.p.**
Housing	0.01	0.05	0.08	0.12
Agriculture	1.91	6.83	9.64	13.88
Infrastructure	0.28	0.89	1.24	1.77
Total	2.20	7.77	10.96	15.77

4.2 Flood risk maps

The relationship between the return period and the damage as given by the above table can be plotted on a graph (probability – damage curve). The expected damage or risk can be determined by calculating the area under the curve.
For the Nongbok District the expected annual damage or risks are:

Damage type	**Risk (10^6 USD/yr)**
Housing	0.014
Agriculture	2.605
Infrastructure	0.362
Total	2.981

5. Mapping results

The interpolation of the point water levels is based on only a few points in the areas further away from the rivers. The error, in particular vertically, is considerable and increases with the distance to a hydraulic node. The interpolation result is far less detailed than the DEM, so when the DEM values are subtracted from the (interpolated) water levels, the resulting water depth will reflect the details of the DEM. In the case of the embankment scenarios, when no or little water is assumed to get behind the dikes, the maps will still show inundated areas because of the inaccuracies in the interpolation.

The vertical accuracy of the DEM is estimated at ± 1 m; that of the ISIS water levels unknown.

There is only one way to improve the interpolation accuracy: by getting more points with water levels (hydraulic nodes). As an alternative: if it is known that the areas behind an embankment stay dry during high water levels, the water depths of these areas can artificially be set to zero with the GIS, or these are can be 'masked'.

Examples of flood depths maps are presented in Volume 6C, Appendix 1, Attachment 1 and flood risk maps in Volume 6C, Appendix 2, Attachment 3.

Appendix 3

Socio-economics and Agriculture

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1. Introduction

In the Stage 1 Workshop of the Component 2 of the Flood Management and Mitigation Program (FMMP-C2), held in Ho Chi Minh City, Viet Nam, on 25 September 2008, it was agreed that the preparation of an Integrated Flood Risk Management Plan for the Lower Xe Bang Fai in Lao PDR will be one of the Demonstration Projects (DP) during the Stage 2 Implementation of the FMMP-C2.

The scope of this project was presented in the Workshop as follows:

1. The strategic directions as formulated under Stage 1 will be translated into IFRM plans. For this planning exercise the input of BDP is required for the formulation of land use and water resources development scenarios in these areas.

2. The plan will consist of a number of sub projects which will be formulated.

3. Terms of References will be prepared for the preparation of priority projects of the IFRM plan.

The Demonstration Projects are also meant to apply best practice guidelines that are developed under the FMMP-C2. The following best practice guidelines are intended to be used in the implementation of this Demonstration Project:

1. Guidelines for IFRM Planning and Impact Evaluation;

2. Guidelines for the Development and Design of Structural Measures.

The Demonstration Project is an extension of the activities that were carried out during the Stage 1 regarding the flood risk assessment and development of strategic directions in the Xe Bang Fai Focal Area.

2. Project Area

2.1 Location and area

The Xe Bang Fai flows mainly through Khammoune Province in the central part of Lao PDR. The Upper Xe Bang Fai originates in Boualapha District, before flowing into Mahaxai District. The river then flows through Xe Bang Fai District before entering the Lower Xe Bang Fai floodplain in which it forms the southern border of Nongbok District, Khammoune Province, and the northern border of Xaybouly District, Savannakhet Province.

The Lower Xe Bang Fai project area is located in the MRC Basin Development Plan (BDP) Sub-area 4L. The Source: Nam Theun 2 Power Company, 2005b
and Figure 2-2 show the location of the project area in Lao PDR.

Source: Nam Theun 2 Power Company, 2005b

Figure 2-1 Location of the Xe Bang Fai project area.

The project area is the flood-prone area located along the Lower Xe Bang Fai River, downstream of the crossing with the National Road Nr 13 South (NR13S). To the west the area is bounded by the Mekong River and is part of the Khammoune Province. To the east, in the Savannakhet Province, NR13S forms the boundary.

The area covers the whole area of Nongbok District and some villages of the Middle Xe Bang Fai District on the right bank of Xe Bang Fai River, and part of the Xaybouly District on the left bank of the river. See Map in Figure 2-2.

Figure 2-2 Location of the project area in the Nongbok District, Lao PDR.

The flood protection for the area is mainly establishment of dyke on the right and left banks of the river and partly along the Mekong to control flood water. The development of Xe Bang Fai irrigation schemes may go beyond the flood prone areas. These areas are to be included in the overall evaluation of the water resources development and management in the Lower Xe Bang Fai.

2.2 Population and living conditions

2.2.1 Community characteristic

According to the Nongbok District statistics, the population in 2006 was about 41,000 people with 7,600 households. Average household size was 5.41 persons and the average annual population growth rate during the period of 2001-2006 was 0.49%. Sex distribution was as 49% for male and 51% for female in almost all age groups except for the group more than 65 years old.

Ethnicity in Nongbok District is mainly Lao (71%) and it is followed by Phouthyai (25%), Mangkong (3%) and King (1%). Most households are headed by males, occupying 95% of the total families in the district.

The communities are culturally and linguistically homogenous. This contributes to effective social and community networks that are important assets for the collective actions around flood planning and management.

Household Characteristics
Xe Bang Fai Focal Area, Lao PDR

Indicator		*Unit*	*District*
HH size (aver.)		Pers.	5.4
HH head	Male	%	95.0
	Female	%	5.0
Male/female ratio		ratio	1.02
Children < 15 years		%	35.5
Dependency ratio		ratio	0.71

Source: District Flood Vulnerability Database, Lao PDR

The implications for social vulnerability include:

(i) The large proportion of children in Nongbok tends to increase vulnerability to the impacts of flooding. Children are 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 during floods. If flooding damages schools, children's education will be disrupted. Moreover, the high dependency ratio places extra burdens on parents and other adults to provide for children's needs for food, shelter, etc.

2.2.2 Household characteristics

Households in Nongbok have, on average, 5.4 persons. The majority (95%) are headed by men who slightly outnumber women in the district population. However, more than one-third of the population (35%) is under the age of 15 years. This high proportion of children in combination with elderly people living in the district results in an age dependency ratio of 0.71. This means that every working-age person in the district must produce enough to support his or her own needs plus 70% of the needs of another, dependent person.

Household Characteristics
Xe Bang Fai Focal Area, Lao PDR

Indicator		*Unit*	*District*
HH size (aver.)		Pers.	5.4
HH head	Male	%	95.0
	Female	%	5.0
Male/female ratio		ratio	1.02
Children < 15 years		%	35.5
Dependency ratio		ratio	0.71

Source: District Flood Vulnerability Database, Lao PDR

2.2.3 Housing structures and other assets

Structures **Xe Bang Fai Focal Area, Lao PDR**		
Indicator	*Unit*	*District*
Main structures – total	No.	9,030
Residential - % total	%	88.4
Permanent	%	*20.0*
Semi-permanent	%	*70.0*
Temporary	%	*10.0*
HH owns structure	%	*100.0*
Commercial - % total	%	10.6
Permanent	%	*20.6*
Semi-permanent	%	*79.4*
HH/business owns structure	%	*100.0*
Industrial - % total	%	0.2
Semi-permanent	%	*100.0*
Institution - % total	%	0.9
Permanent	%	*40.5*
Temporary	%	*59.5*

Source: District Flood Vulnerability Database, Lao PDR

Residential and separate commercial structures account for, respectively, 88% and 11% of the main structures in the district; however, many business activities are accommodated in spaces that are attached directly to residential structures. These types of structures are generally owned by their occupants. Industrial and institutional structures make up about 1% of the total.

Permanent structures made from brick and/or concrete account for 20% of these structures; 70% are semi-permanent construction, generally wood; and, the remainder are constructed of thatch, bamboo and other temporary materials. Based on data provided by surveyed households, permanent and semi-permanent house structures tend to have similar sizes and value.

Flood risks are a major factor in the sitting and design of housing in the focal area. In raised safe areas, people will construct one-story brick houses. However, in most areas, the traditional coping mechanisms include:

Housing Area & Value **Xe Bang Fai Focal Area, Lao PDR**		**% HH**	**Area**	**Value**
			m^2	**KIP million**
Average			67	40.1
By house type	Permanent	84.3	66	39.8
	Semi-permanent	15.7	70	42.2

Source: Household surveys, Lao PDR

(i) Houses are raised 2.5-3 m on concrete poles to protect them against annual floods. The concrete poles have replaced wood poles that were traditionally used as they are more resistant to water logging.

(ii) Retail shops, repair garages/workshops and other commercial structures are generally not raised. However, the foundation will be made stronger to withstand potential damage from flood waters.
(iii) Within commercial structures, people frequently make provisions for temporary storage of inventory and equipment above the normal flood level that may occur within the structure. For commercial activities located in structures adjacent or attached to houses, the inventory and equipment will often be moved and stored within the raised house.
(iv) Other industries such as rice mills will often be located on higher ground within the community to provide protection during floods.

There are also numerous small agricultural structures such as rice huts and animal shelters (the number is nearly equal to the number of main structures). These are all temporary structures.

In terms of household assets, people in Nongbok rely on motorbikes as their principal means of transport; less than 1% of district households own a car or truck. Although the district is bounded by the Xe Bang Fai and Mekong rivers, only 2% of households own small boats (without motors); an even smaller proportion (0.5%) own larger, motorised boats. More than a third of households own a hand tractor, but very few if any households own other types of production equipment such as mechanised tractors, water pumps, diesel generators, rice mills.

The implications for assessing the vulnerability of households to flood damages are as follows:
(i) The traditional house form reduces the risks of flood damages to people's housing. In most years in Nongbok, there are no flood-affected houses; even in the serious floods in 2001 and 2005, there were only 2-3 damaged houses.
(ii) The establishment of safe areas and/or the sitting of non-residential structures on higher ground help to minimise flood damages.
(iii) However, the low proportion of households that own small or larger boats will be reflected in the lack of access that many people have during floods to health care and other services outside their immediate village. The lack of boats may also constrain local emergency response activities.

2.2.4 Occupation and income

The main occupation in the district is agricultural production, including crops, fishery and working as hired labour in agriculture (68% of the population). About 25% of the population works as hired labour in Thailand, particularly in factories. Very few people do business, trading or offer services. This indicates that the population directly depends on its immediate environment.

(i) Vulnerability to economic losses due to flooding is directly related to the proportion of people engaged in agricultural activities.
(ii) The incidence of working people who migrate to Thailand reflects better job prospects and wages that are available to people living in Nongbok, as well as possible constraints on economic activities in the district (e.g., lack of agricultural land, non-farm employment). The higher wages contribute to the low poverty levels in the district. At the same time, however, the absence of younger family members during a flood event may increase household vulnerability. In addition, a greater burden is place on women when adult men are absent from the household.

Occupations, Economically Active Population Xe Bang Fai Focal Area, Lao PDR		
Indicator	*Unit*	*District*
Number of persons 18-60 yrs.	No.	24,098
Agriculture	%	63.5
Fishery	%	1.5
Agricultural labour	%	3.7
Construction labour	%	0.9
Other labour – Thailand	%	24.9
Business owner	%	1.9
Employee – private sector	%	0.8
Employee – government	%	2.8

Source: District Flood Vulnerability Database, Lao PDR

Agricultural Production & Income Xe Bang Fai Focal Area, Lao PDR		*Paddy Area*	*Prod. Sold*	*Annual Income*
		ha	*%*	*KIP million*
Overall	Average	2.2	39.6	20.1
By house type	Permanent	2.3	38.1	18.3
	Semi-permanent	1.5	47.3	29.7

Source: Household surveys, Lao PDR

Each household has, on average, 2.2 ha of rice land. People living in semi-permanent structures have an average of 1.5 ha per household; that is, they have about 30% less productive land than households in permanent structures. Average annual income was 20.1 million KIP (2,365 USD/year). Given the average size of household of 5.4 persons, it is equivalent to 36 USD/capita/month.

2.2.5 Access to water sanitation and electricity

Only about 1,000 households in the district (14%) are actually connected to piped water in the district town, most families take water from wells and rivers. During floods people rely on rainwater and purchased water for washing and bathing.

There is no wastewater collection or treatment system in the district. There are 52% of total households with their own toilet/latrine, in most instances water-sealed. The remaining households have no facilities.

There is a high rate of households connected to the national power grid (95%). The implications for the assessment of social vulnerability to flooding include the following:

(i) Due to inadequate supplies of safe drinking water and, particularly, poor sanitation conditions (defecation in the open and in paddy fields), there is a high risk of diarrhoea and dysentery.

(ii) Bathing and washing clothes in flood waters increases the incidence of skin rashes and infections due to contamination of the water.

2.2.6 Access to health care

Floods in Nongbok are associated with a variety of health problems: diarrhoea and dysentery; malaria and dengue fever; colds; and, skin and eye infections.

In Nongbok District, the health care facilities include: 1 district hospital with 15 beds, 2 clinics and 10 dispensaries. The 2 clinics provide services for the 72 villages in the district, with a ratio of 3,797 households per clinic. There is one dispensary for each village cluster, or a district-wide ratio of 759 households per dispensary. Due to the lack of adequate medical facilities and the difficulties of travel during the flood season, many households rely on traditional herbal medicines to treat diarrhoea, dysentery and the various types of skin and eye infections. The implications for social vulnerability due to flooding include:

(i) The inadequate (and often ill-equipped) health care facilities are a major source of people's vulnerability when they are injured and/or become ill during or following the flood.

(ii) 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 the resources of households, particularly poor households.

2.3 Land use

Land Uses,
Xe Bang Fai Focal Area, Lao PDR

Indicator	*Unit*	*District*	*Unit*	*District*
District area	%	100	ha	31,300
Rice land – rainfed	%	33.7	ha	10,548
Rice land – irrigated (originally)	%	7.3	ha	2,285
Upland crop land	%	5.5	ha	1,722
Plantation land	%	0.3	ha	94
Rural residential (gardens)	%	1.6	ha	501
Urban land	%	0.4	ha	125
Lakes, ponds & wetlands	%	8.7	ha	2,723
Forest - dry Dipterocarpus	%	30.0	ha	9,390
Forest - non-productive	%	11.3	ha	3,537
Communal	%	1.2	ha	376

Source: District Flood Vulnerability Database, Lao PDR, 2006

Almost the entire territory of Nongbok District is land that contributes to the rural livelihoods of people living in the district. Cultivated land encompasses more than 45% of the district area and includes irrigated paddy (7%), rainfed paddy (34%) and other land such as upland crops land and residential gardens (6-7%). In addition, people rely on riverbanks, wetlands and forests to grow and/or harvest food crops, as well as for other productive uses such as building materials, medicines, etc.; together, these resources account for nearly 40% of the district area.

Legal title to agricultural land in Lao PDR generally takes the form of a land certificate issued by local authorities. In Nongbok District, the ratio of land certificates to households is 0.95, meaning that nearly all households have secure tenure to their productive land. Landless households account for 1.7% of all people in the district. All households in the district also have a land certificate for their residential land. The issues of social vulnerability to the impacts of flooding include:

(i) The reliance of livelihoods on land and natural resources increases the direct and indirect costs of flooding. Household expenditures for food and other basic needs will increase if people are unable to cultivate vegetables in riverbank gardens or harvest forest or wetlands products they normally use for different purposes.

(ii) Secure land tenure as well as house ownership (see section below) provide households with collateral that will facilitate their ability to obtain loans and other assistance to rehabilitate property damaged during a flood or to meet other households needs (health care, new agricultural inputs, etc.). This is an important and positive point with regard to future development in a flood secure area, because it will allow access to micro-credit.

(iii) 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). In Nongbok, the needs of the small number of landless people may be effectively met through the strong family and social networks that exist.

2.4 Existing agriculture

Rice cropping and vegetable growing are the main agricultural activities in the project area. Agriculture is the area's largest sector of employment. Vegetables and other crops are grown by residents on the somewhat elevated Xe Bang Fai riverbanks, as well as in the floodplains around natural lakes as water recedes. Lowland wet rice is cultivated in the lower lying areas.

In Nongbok District, 10,535 ha of wet season rice of which is 50% for staple rice and the remainder for commercial rice. The dry season rice was only 1,880 ha under irrigation and 1,230 ha of non-rice crops on riverbank slopes cultivated after rainy season using residual soil moisture and flood recession. The existing cropping intensity was 97%. There would be a potential for irrigation development in the area to increase cropped area in dry season.

In Xaybouly District, where irrigation exists, wet season rice was 8,617 ha and dry irrigated rice was 8,520 ha. Beside rice cultivation in lowlands, there was 2,884 ha sugarcane on highlands, where flooding has no impact. The cropping intensity in the area was 165%. There would be no room for new irrigation development in the area except improving and/or modernising existing irrigation schemes. See Table 2-1.

2.4.1 Rice cropping

The Xe Bang Fai plain is one of the 4 main rice production areas in central Lao. Success or failure of lowland rice is closely link to the natural flood cycle and every year some of the crop is damaged by the flood. In the project area, there are two main types of rice production: rain-fed lowland (wet season from June till November) rice and irrigated lowland (dry season from December to April) rice.

The rainy season in the area lasts for 5 months (May-September) occupying 87% of total annual rainfall. It plays an important role in wet season crop cultivation as cultivated area and cropping calendar. The dry season lasts 7 months (October-April), and there is almost no rain in November-January. See Figure 2-3.

Table 2-1 Existing agricultural land use, 2009.

Items	Nongbok	Xaybouly
Gross area	**31,300**	**NA**
Non-agricultural land	**17,150**	**NA**
Agricultural land	**14,150**	**14,500**
Cultivated crop area	**13,794**	**23,934**
Cropping intensity	**97%**	**165%**
I Wet season cultivated land	**10,684**	**11,772**
A. Cultivated rice	**10,535**	**8,617**
1. Staple Rice	5,268	8,617
2. Commercial rice	5,267	-
B. Cultivated non-rice	**149**	**3,155**
1. Chili	-	9
2. Sweet corn	149	80
3. Sugarcane	-	2,884
4. Other crops	-	182
II Dry season cultivated land	**3,110**	**12,162**
A. Cultivated rice	**1,880**	**8,520**
1. Staple Rice	-	-
2. Commercial rice	1,880	8,520
B. Cultivated non-rice	**1,230**	**3,642**
1. Tobacco	35	112
2. Chili	170	63
3. Sweet corn	53	94
4. Sugarcane	-	2,884
5. Other crops	746	489

Source: FMMP-C2: Secondary data collection, April-June 2009

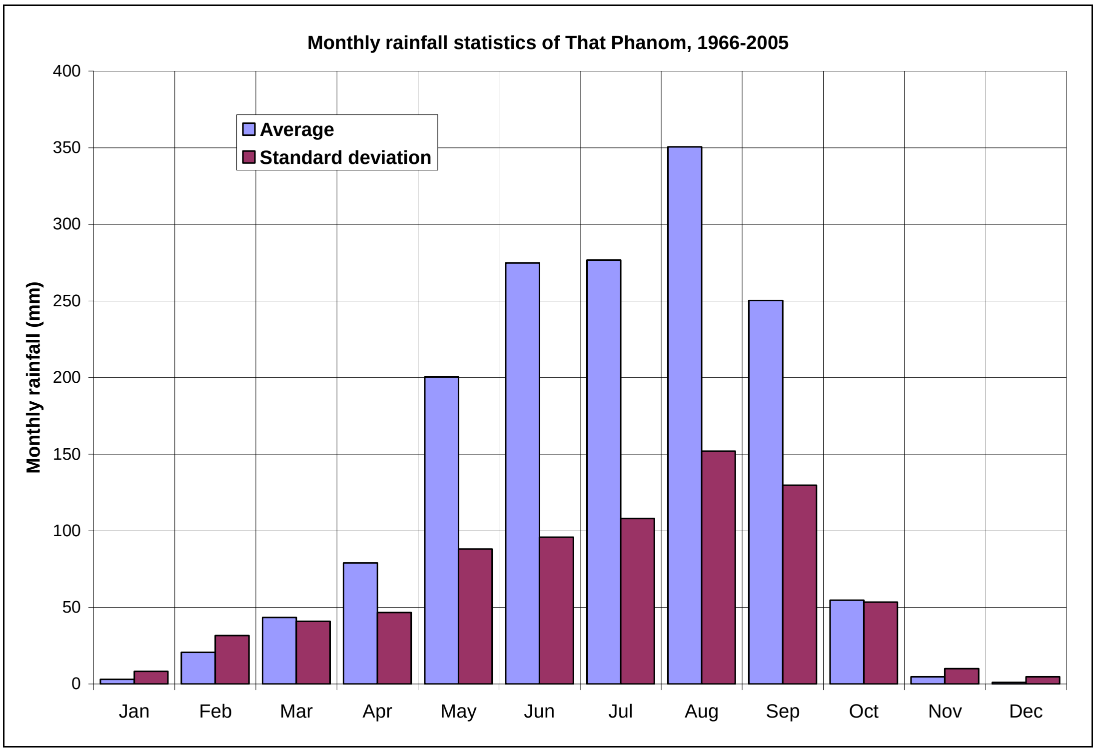


Figure 2-3 Monthly rainfall statistics of station That Phanom, period 1966-2005.

Wet season rice

The rain-fed rice requires sometimes supplemental irrigation water by a diversity of small-scale irrigation systems. In the wet season 10,535 ha are cropped with a yield of 4.3 tons/ha. Rice is the staple food for all households. More than half of the rice production is required to meet basic household consumption needs. However, sale of surplus rice in Thai markets is an important source of income for households in this district.

In years of heavy flooding, such as which occurred in the rainy season of 2000, a large percentage of the cultivated area was damaged. Farmers report that rice production is very sensitive to flooding in the region (slightly higher or of longer duration than normal can make the difference between having a large or small harvest).

Dry season rice

In dry season, the cultivated area is only 1,880 ha. It is irrigated by several small irrigation schemes. The average yield is 6.2 tons/ha for that period, much higher than in the wet season. Ideally the dry season paddy should provide supplementary rice to farmers, both for consumption and for sale on the local markets. However, the dry season cropping has not been as successful as envisaged. Most villagers see dry season rice cultivation as a potential supplement — not as a replacement — to the main rice crop grown during the rainy season.

The expansion of pump-based irrigation, and the economic rationale for this expansion, is increasingly problematic and questionable. This is due in part to (i) high water conveyance losses of the canal system; (ii) the falling value of the Lao currency, the KIP, making imports of fuel and chemical fertiliser more expensive; (iii) high price of electricity.

The market price for rice, however, remains relatively low. Installed about 10 years ago, none of the diesel-powered pumps along the Xe Bang Fai River are in operation, most having been used for only a single season. The economics for the electric pumps are better but still marginal at best. Farmers are being told to repay the costs of these government-provided irrigation systems. This added expense is contributing to disillusionment and frustration felt by many farmers regarding dry season rice cultivation. This negative experience works against the setting-up of any collective action for flood management and development of the area in partnership with government representatives.

Farmers have also encountered other major problems with dry season rice farming including pest infestation. Continued use of the electrical pumps appears to be dependent on large government subsidies and the strong encouragement of district officials. While local officials continue to report an expansion of the area of dry season rice farming, villagers report that in fact it is declining.

Even though the cash generation of dry season rice appears to be higher than the wet season rice, the farmers don't find it attractive to crop. The inputs appear to be much higher. The benefit is related to the input-output market prices. All in this results in a higher risk taking. The problem farmers might encounter could be the cash-flow for this more risky venture. This should be confirmed by more detailed investigations.

Although food security appears not to be an issue in the area, the Government has embarked on a major program of irrigation development along the Xe Bang Fai; most villages along the Xe Bang Fai now have irrigation pumps. Originally there were 9 gated-sluices and 25 pumping stations in the district serving the command area of 1,750 ha.

The water to be discharged by the Nam Theung-2 dam provides an opportunity for increasing agricultural production during the dry season. A number of large irrigation schemes have been made and are being planned for the Xe Bang Fai area, but recent experiences are reason for caution.

2.4.2 Rice bank vegetable

Cultivation of vegetables is carried out mainly by women, and is an important activity, which provides food and income to the families. About 25% of villagers are involved in riverbank gardening in the Nongbok and Xaibouly districts in the lower Xe Bang Fai region. The average size of riverside crop fields is 0.15 ha/household.

Vegetables are grown in 2 periods: September-December and December-February. The first crops are onion, yam, water melon, long bean, cucumber etc. These are grown in the moist fertile soil on the riverbanks and tributary banks.

The second vegetables are planted down the riverbank as water recedes further. They are of shorter duration and must be harvested by February-March. Main crops are lettuce, garlic, chilli and eggplants.

2.4.3 Upland crops

Other upland crops and fruit trees represent a small proportion of agricultural activities in the district. Crops such as tobacco, corn and beans are grown where rice cannot be grown. According to 2009 statistics, there were 149 ha of corn cultivated in the wet season and total 1,230 ha of non-rice crops cultivated in the dry season.

Part of the production is sold on local markets and tobacco forms the largest single source of cash income. Tobacco is sold not only on the provincial markets, but also in Vientiane and across the border in Thailand. The choice and volume of these crops is determined by market demands in Lao PDR and in Thailand.

2.4.4 Use of agrochemicals and fertilisers

In 2003, the FAO conducted a case study on pesticide use in Lao. The study found that pesticide use is relatively low compared to other countries of the region, and that active promotion of pesticides is not widespread. However, the study also found that pesticides are widely available, and that most of those for sale are highly toxic. Folidol, a class 1a pesticide, was found to be the most widely available and used pesticide, even though it is officially banned. It was also reported that a clear trend toward increasing use of pesticides is noted, particularly by farmers producing for urban markets. Although these farmers are aware of the dangers, they repeatedly stated that they know of no other way to meet the demands of the market, consumers and middlemen, other than to use more pesticides. The study concluded that merely not promoting pesticides is not enough, and that more concerted policies, strategies, and action are urgently needed.

In general, pest attack on rice crops is low in Lao PDR. Although there is a range of pests mentioned both by farmers, officials and in the literature, these are rarely of economic importance. Consequently pesticide use per unit area of rice is low. A recent survey indicated that in Savannakhet Province 50% of farmers sprayed rice one or more times per year, with 25% sprayed once and 25% sprayed more than once. In general pesticide use is higher in irrigated areas, partly to protect the extra investment in the dry season irrigated crop, but partly because double cropping leads to an increase in the number and intensity of pests attacking the crop. Rice diseases are rarely treated with chemicals (e.g. fungicides) weed control with herbicides is also very rare.

Pesticide use for vegetable growing is believed to be significant. The number of treatments applied is apparently not excessive, but every farmer treats his vegetables with insecticides. There has been no analysis of pesticide residues in fresh produce in Lao PDR, since there are no laboratory facilities for this.

Inorganic fertilisers are used predominately on the dry season rice crop, but increasingly also in the wet season. The type of usage varies according to the recommendations of extension workers and local availability. Farmers mentioned using an NPK 16-20-0 compound fertiliser to "prime" the land at around 200 – 350 kg/ha followed by Urea 46-0-0 at around 50 kg/ha. These fertilisers contain no K, making the rice susceptible to diseases such as brown spot disease in K deficient conditions. Farmers and officials in the Xe Bang Fai plain indicated that inorganic fertiliser use appears to follow no particular guidelines with respect to soil analyses or the analysis and usefulness of organic fertiliser. Some inorganic compound fertilisers appear to be used on the basis of availability from donors rather than on need. In the Xe Bang Fai plain organic fertiliser, mainly manure is used in combination with inorganic fertiliser at around 250 kg/ha; a relative low rate, but beneficial if applied annually.

2.5 Crop benefits

Representative crop-budgets for the project area were collected in April-June 2009 under framework of the FMMP-C2 activities. The standard crop-budget forms were developed and the Lao Consulting Groups carried out the data collection at the field.

Economic benefit of crops was derived from financial benefit by applying conversion factors[1] (CF) to remove transfer-payments (taxes, tariffs, and loan interest). The CF was 70% for unskilled labour, 80% for fertilisers, 200% for electricity tariff[2] applied for agriculture and irrigation; and 90% for other cost items as seed, mechanical equipment.

For rain-fed crops, high economic net benefit was found in commercial rice (690 USD/ha) and it is followed by wet season cotton (407 USD/ha), wet staple rice and sugarcane (383-384 USD/ha).

For irrigated crops, high economic net benefit was found in commercial rice (936 USD/ha). It is followed by sugarcane (599 USD/ha), corn (522 USD/ha), and staple rice (504 USD/ha). They are summarised in Table 2-2 and details are in Attachment 3.1 and 3.2.

2.6 Fisheries

Next to rice cropping, fisheries are one of the most important livelihood activities in the Xe Bang Fai Basin, and many villagers devote much of their time and energy to fishing. Fishing activities in the mainstream Xe Bang Fai River are most prevalent in the dry season, while people generally fish in wetlands, streams and inundated rice fields during the rainy season.

There are a wide variety of fishing methods and fishing gears utilised by villagers in the Xe Bang Fai Basin including nylon monofilament gill nets, spears, hook and line, cast nets, scoop nets and many types of trap, but also explosives and, poisonous plants. Drift and gillnets are the most important gear in terms of the size of fish landings made by fisherman from the Xe Bang Fai.

[1] ADB Bac Hung Hai irrigation improvement project, Viet Nam. Royal Haskoning 2009 and consultant estimates.
[2] Electricity tariff for irrigation and agriculture was 295 KIP/kWh which is about half of average tariff applied for Industry and Government office.

Table 2-2 Net benefit of selected crops.

No	Crops	Production (kg/ha)	Revenue (USD/ha)	Total Inputs (USD/ha)	Physical input (USD/ha)	Financial NB (USD/ha)	Economic NB (USD/ha)
1	Wet Rice	4,300	759	516	223	243	384
2	Dry Rice (irrigated)	6,200	1,094	721	416	373	504
3	Wet Cotton	1,500	618	280	178	338	407
4	Dry Cotton	800	329	178	112	151	192
5	Wet Commercial rice	4,500	1,059	509	217	550	690
6	Dry commercial rice (irrigated)	6,500	1,529	726	421	803	936
7	Rain-fed Sugarcane	45,000	794	546	340	248	383
8	Irrigated Sugarcane	65,000	1,147	647	434	500	599
9	Irrigated Corn	8,000	941	525	321	416	522
10	Rain-fed Corn	5,000	588	475	273	113	238

Source: FMMP-C2: Survey data, April-June 2009

Seasonal fish migrations between the Mekong and Xe Bang Fai rivers, and through the Xe Bang Fai River and its tributaries, are an important characteristic of the river basin and are essential to the fisheries and livelihood security of the communities living in the Xe Bang Fai Basin. The first major fish migration of the year commences at the beginning of the monsoon season. When the rains begin in May or early June, seasonal streams begin flowing, and the water level and flow volume of the Xe Bang Fai River begin to rise.

At that time, according to villagers, a large number of fish species begin migrating up the Xe Bang Fai River from the Mekong River, while other fish species are believed to move from deep-water pools in the Xe Bang Fai River. At around the same time that fish move up the Xe Bang Fai River, they also begin to migrate up its larger tributaries.

After the fish migrations at the beginning of the rainy season have taken place, there is considerable fishing activity in wetlands for the duration of the rainy season, and no important fisheries in the large rivers during this time of the year. In October, as the rainy season ends, an important fishery based on migrating fishes of the cyprinid family takes place.

When the water recedes, many villagers make barrier traps (*tone*) at the edges of rice fields and on streams to catch fish, and in some cases large quantities of fish are caught. Fishing in oxbow lakes, natural depressions and streams is extremely important for people living in the Xe Bang Fai Basin, particularly for those communities situated away from the Xe Bang Fai River and other major rivers as it is only during this period that many of these fish can be caught in locations away from the major rivers.

Ethnic Lao villagers have a number of traditional practices for catching fish including the trapping of wild fish in ponds when flood waters recede (*nong sa*) and communal taking of fish in wetland areas (*pha nong*). These systems are dependent on the seasonal flood cycle of the Xe Bang Fai River system.

Wild capture fisheries are clearly one of the most important livelihood resources in the Xe Bang Fai Basin. While fisheries have always been important to local people, their relative importance to society may actually be increasing. In areas where rice production does not provide families with a supply of rice sufficient for an entire year, wild capture are their main means for getting rice — either through direct barter trade with other villages or through selling fish and using the money to buy rice.

After rice, fish is the most important item on the diet for all ethnic groups in the area. Fish are a significant component of the local economy. Fish traders from Khoua Xe (the trading centre at the NR13S Bridge crossing the Xe Bang Fai River) and other population centres travel to riverside villages to buy fish on a regular basis, some villages selling tens of kilograms or more per day. In some areas, villagers sell their own fish at district centres. Marketing patterns differ from place to place. The sale of fish at local markets adds considerably to the income of most households.

Besides fish, many other living aquatic resources are gathered from rivers and wetlands by villagers. These aquatic resources include shrimp, snails, earthworms (used for fish bait), frogs, crabs and aquatic insects. These resources are especially important in villages with a small area of wet rice fields or fields that are particularly vulnerable to flooding. While many non-fish living aquatic resources are utilised as food within individual households, some people realise substantial income from their sale. Women and children often play the major role in the collection of these resources.

Table 2-3 Percentage of fish catch caught at different locations.

From	Percentage of catch caught at different locations
Xe Bang Fai River	54%
Xe Bang Fai Tributaries	3%
Paddy fields	14%
Other small bodies of water	10%
Back swamps and natural ponds	19%
Total	**100%**

Source: Nam Theun-2 Power Company, 2005b

Families in the lower reach of Xe Bang Fai catch on average 168 kg fish/HH/year, sufficient for daily consumption and the production of 2 - 8 jars (= 22 kg) of 'Padek' /HH/year. Padek, salted fermented fish, is the second staple food in Lao PDR, after rice. The remaining catch, on average 20% or some 35 kg/HH/year, is sold on the market. Anecdotal information suggests that production has declined over the last 10-15 years. Average fish size and the number of species caught have also declined. The reason for the decline is thought to be over-fishing and use of small mesh monofilament gillnets.

Results from focus group discussions held in focal areas[3] showed in the Nongbok District 70-80% of the households fish for selling while the remaining households only fish for their own consumption. The duration of fishing is reported to be 10-20 days. According to the group discussion, benefits from natural fishing for people living in flooded areas vary from 150-3,200 USD/household in normal flood years to USD 290-6,400 for big flood years. The fishing is mainly from river and creeks, the amount of caught from rice fields is only 14% of total catch as indicated in Table 2-3.

According to an MRC-Technical Paper[4] on fish yields, the data for typical yields of fish in paddy fields in Lao is limited. However, it is reasonable to assume that the fish yield in Lao PDR would be lower than in the Cambodian and Vietnamese floodplains. The lower limits of natural fish in Cambodia and Viet Nam were 55-80 kg/ha. The floodplain in Xe Bang Fai is

[3] See Annex 2 of the Stage-1 Report for detailed analysis of the focal group discussions
[4] MRC-Technical Paper, No: 16, October 2007: Consumption and the yield of fish and other aquatic animals from the Lower Mekong Basin.

under rainy seasonal paddy from June-October, with much shorter flooding duration compared to floodplains in Cambodia and Viet Nam. It is estimated that the fish yield would be about 20 kg/ha, resulting in a value of 6 USD/ha.

2.7 Aquaculture

The level of aquaculture activity in the Xe Bang Fai is low, with less than 3% of households involved. Backyard ponds, rice field fish culture, and village swamp fish culture are the most important types of fish culture. Net cages are least important. No production estimates are available for aquaculture activity in the Project area.

One reason for the low level of aquaculture might be the relative abundance of fish within the river and adjacent wetlands. Lack of infrastructure and well-developed market systems or transport services are other valid explanations, as well as lack of knowledge about fish culturing techniques. However, aquaculture is becoming more common in the lower Xe Bang Fai zone, in part due to population pressure and in part due to availability of irrigation waters which are also used in aquaculture.
Natural and man-made fish ponds are stocked in the late spring and early summer for harvests 9-10 months later. The yields vary from 0.5 ton/ha for 6,000 ha of natural ponds and 1.2 ton/ha for 3,000 ha of man-made ponds. During a field mission in 2009, a fishpond farm was visited where 6 ponds of 10 by 4 m were exploited. A net return on investment of 100 USD/month was estimated.

2.8 Livestock and animal husbandry

In many villages, livestock is a major source of income. Water buffaloes, cows and pigs act as de facto ‘banks’ for many families; animals are raised and can be sold for cash during times of particular need, such as during rice shortages or illness of a family member, or to pay the costs of wedding and funeral ceremonies.

Livestock are frequently to be found along, and in, the rivers of the basin. Along the Xe Bang Fai River, pigs forage for worms along the riverbanks, water buffaloes wallow in the river and eat large amounts of algae and other water plants, ducks swim and feed in the river, and chickens, goats and cows drink from the river and forage vegetation along its banks. These ‘free’ services provided by the Xe Bang Fai reduce the amount of resources that the owners of livestock would otherwise need to provide to these animals, reducing people’s workloads and making the raising of livestock an efficient economic activity.

In the Lower Xe Bang Fai area every household has on average 1 - 2 head of cattle, 0 - 1 pig and some 10 chicken. Buffaloes are still an important source of draft power for land preparation, although power tillers are becoming more common, particularly in the larger and more prosperous villages.

3. Future Agricultural Development

The proposed project is provision of dyke system and flood control structures for (i) the area of Nongbok District by right bank embankment of the Xe Bang Fai River and; (ii) part of Xaibouly District by left bank embankment of the Xe Bang Fai River. Irrigation development in the project area could be seen as independent activities, there would be a little link between flood protection measures and irrigation in dry season. Future agricultural development is investigating potential increase cultivated crop area and/or land use change due to the project in a case of (i) flood protection measures; and (ii) flood protection combined with irrigation development.

3.1 Crops and crop calendar

3.1.1 Staple rice

Actually, the main rice season is rain fed, seeded in June and transplanted in July. It is harvested in October or November, depending on the length of the rainy season. Due to the long rainy season, and as harvesting of a majority of the crops is to take place in dry periods, a combination of 2 crops are assured with additional irrigation.

As mentioned earlier in this report, the first priority of the local farmers is to provide enough rice for their households. As such and as already expressed by the local farmers in public participation sessions, they want to carry on cropping common rice for household consumption in the flood-protected area. This is based on their experiences of farming in a flood prone area and it is part of their risk management strategies. After having secured food, the farmers will consider growing a second crop to generate cash.

At a later stage, when the farmers consider that rice as a staple crop can be secured on smaller land surface or by buying it on the market, larger areas for cash crop production will become available.

The farmer's choice to grow a second particular crop will depend on a series of different parameters:

1. The proposed cash production must be more productive than the usual sticky rice, in relation to the local limiting factor: labour. The farmer expects a higher earning per working day.
2. The market of that particular crop must be secured.
3. The higher return on investment will have to be demonstrated.
4. The required investments must remain within his resources and land exploitation capacities.
5. The farmers must have acquired knowledge for growing that particular crop.
6. The farmer must have the required capacities to crop and many other parameters that only local farmers perceive as important based on their situation, experience and collective history.

Based on the existing agricultural experience in Lao PDR a number of crops can be envisaged. In terms of tons of agricultural production, the top 5 crops in Lao PDR in order of importance are rice, vegetables and beans, sugarcane, starchy roots, and tobacco.

Since 1990, among these 5 leading crops, production of vegetables and beans has grown the fastest in percentage terms, followed by sugarcane. In the decade since 1990 rice production has increased 47.9 percent. Among agricultural products often produced as cash crops are mung beans, soybeans, peanuts, tobacco, cotton, sugarcane.

This chapter names some crops that might have market options in the Lower Xe Bang Fai project area. Commercial rice, long cotton and sugarcane have been identified as potential cash crop. The choice was made on the consultant's perception of possible market development, and on the existing Laotian cropping experience.

Considering the efforts of the World Health Organisation to control tobacco (WHO Framework Convention on Tobacco Control, FCTC), intensively growing tobacco in the Lower Xe Bang Fai area was not considered as an option in this assessment, even if it was raised during the Public Participation activities, and even if marketing opportunities exist in Savannakhet.

The cropping calendar in Table 3-1 provides an overview of the possible cropping combinations with the rainy seasonal paddy rice grown from July till November.

3.1.2 Commercial rice

Cropping a commercial rice variety would take advantage of growing demand for rice to supply inputs for noodle production and brewing. A pilot programme has been launched in Khammounane province to promote the cultivation of polished rice, following a study showing that the demand for high-quality products remains high.

Also called "Polished rice", commercial rice attracts a higher price compared to sticky rice, of which the country currently has a surplus. However, not more than 20 percent of commercial rice used in Lao factories is produced by local farmers while the rest is imported[5].

In order to open up and create a market for this commercial rice, the coordinated chain between farmers, rice purchasing agencies and financial institutions needs to be strengthened. Development of contract farming would as such be endeavoured.

During local field visits (July 2009), local farmers expressed an interest in growing these commercial rice strains, because a study showed that growing commercial rice brings considerably more profit.

3.1.3 Sugarcane

A large market opportunity for sugarcane exists since Khone Kaen Sugar Industry Public Ltd, Thailand's fifth largest sugar manufacturer, plans to invest up to 300 million baht (about 86,000 USD) to establish an ethanol production plant in Lao PDR, expanding its investment in the country. The plant, scheduled to begin production in Savannakhet in 2010, is the second phase of the investment in Lao PDR for Khon Kaen Sugar Industry Plc (KSL).

A joint-venture agreement was signed with Ban Pong Inter-trade Ltd (BPI) and the Laotian government to develop a 10,000 ha sugarcane plantation and sugar mill in Savannakhet province. KSL and BPI agreed to establish the Savannakhet Sugar Corporation to execute the project, which is worth around USD 11 million USD. The company plans to produce 600,000 tonnes of sugarcane over the next four years, but additional sugarcane for KSL's mill will come from other Laotian plantations, operated by firms including Mitr Phol Co,

[5] Study done by Provincial Agriculture and Forestry Department and SNV (Netherlands Development Organisation)

Thailand's largest sugar business, which two years ago invested USD22 million in a 6,000 ha plantation. KSL will export most of its Laotian output to the EU with some going to local clients.

In Vientiane Municipality, sugarcane is mainly supplied to PakSap Sugar Factory. This is a small factory, but their demand for sugar cane is rising. They are still under their maximum processing limit. National wise, the government of Lao PDR imports sugar from Thailand. This means that, next to the huge KSL ethanol project, the national market for sugar remains an option.

The waste from sugarcane, bagasse, also has the potential to feed the energy production sector using biomass (Bouathep Malaykham, Ministry of Energy and Mines, Department of Electricity, Brief Report of Biomass in Lao PDR).

3.1.4 Cotton

Cotton is most commonly found as an intercrop in Lao, with several hundred square metres of cultivation being sufficient to satisfy the weaving needs of one household. Local cotton varieties yield 200 - 800 kg of seed cotton/ha and have ginning outturns of between 20 and 33%. The short coarse fibres provide a rough-textured cloth for everyday use.

In the south of Lao, farmers sow cotton as an off-season flood-plain crop. Where lowland rice is the major crop, the most common association is groundnut–cotton in order to have a smooth work schedule for farmers. It is not common practice to use organic fertilisers or to apply pest control for cropping cotton in Lao.

Long fibre cotton has higher economic value that the local short fibre strains. Of all varieties tested in Lao, only S 295 and SRI F4 (cultivated in Chad) and G 31 9-1 6 (Côte d'Ivoire) adapt well to Laotian ecosystems. But the Indian cotton variety G. Hirsutum (known as Kham Khao 1 in Lao PDR) - which is extremely hairy and behaves very well in the field- offers the best results (about 2,500 kg/ha of seed-cotton with intensive crop protection).

Lao PDR has the possibility of opening its rather restrictive national market towards Thailand, and perhaps Viet Nam, on condition that it develops production of the medium long fibre varieties demanded by cotton manufacturers. To illustrate the potential in these outlets, Thailand processed 377,000 tonnes of lint, including almost 90% imported fibre, in 1991, while Viet Nam consumes 70,000 tonnes of lint annually.

The current socioeconomic climate is favourable for the expansion of cotton cultivation. National and international markets appear to exist and farmers appear to be receptive.

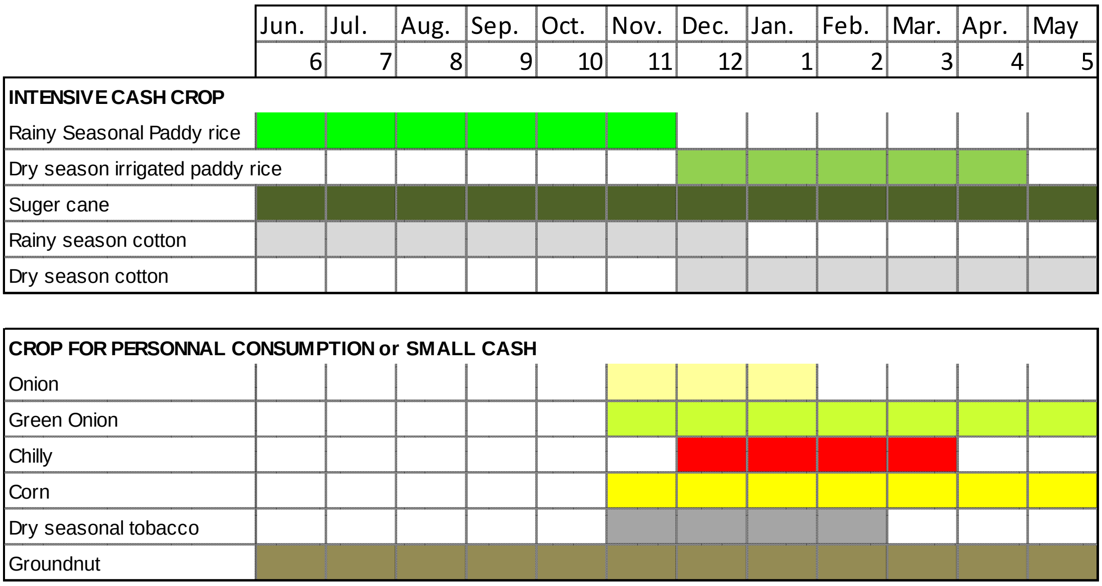
A national coordination of production appears to be essential to coordinate production input procurement, and purchase of smallholders' harvests. A rural cotton research base and a ginning unit presently exist in Savannakhet.

Aiming at the establishment of a sustainable cotton sector, a fair-trade approach might be considered, respecting labour and environment. The international “fare-trade” market is growing.

3.1.5 Crop calendar

Most annual crops are planted during the rainy season, starting from June, and harvested in dry season. Vegetables are mainly cultivated after rainy season and/or flood recession period taking advantage of soil moisture after the wet season. See Table 3-1.

Table 3-1 Possible farming calendar for the Lower Xe Bang Fai area.



3.2 Future without project

Promoting new crops requires sound thinking and progressive research in on-farm conditions. A new crop cannot be a sustainable answer, especially in term of risks for farmers, but must be considered into existing farming systems, always mixed between many plant and animal productions. Introducing a new cropping system is not guaranteed. It is only possible if the farmers take it over. However, the local farmers are risk averting and presently not ready to reduce their staple food cropping, which is wet season rice. Presently, farmers perceive a land-use change as taking risks.

In the project area, there are several small-scale irrigation schemes. In a future without project, some irrigation schemes may be improved to increase irrigated area. However, it is assumed that the area increased by new developments would counter balance the existing irrigation scheme deteriorated. Therefore, it is expected that a future irrigated area would be the same as the current irrigated one.

Future agricultural land use in case of without project would be the same as current land use.

3.3 Future with flood protection project

It is expected that the proposed project would remove (i) annual flood damage to agriculture; (ii) flooding constraints on agricultural development in the area. It has a potential for expansion of cultivated area in the wet season and/or replacing short-duration crops by longer-duration ones which generate more benefits.

Under full flood protection for crops, it would be possible to change annual crops (rice, and non-rice crops) into perennial crops such as sugarcane if it is more profitable.

Financial and economic net benefit of crops presented in section 2-5 shows that commercial rice has high return compared to other crops in the same cultivated conditions (rain-fed and/or irrigated). Expansion of commercial rice cultivation in the project area would not depend on flood protection measures, but depend on market and production contract between farmer and business. Replacing the rice with sugarcane is not economically justified, since the net benefit from rice (cultivated in wet season) is higher than that from sugarcane (cultivated year-round).

In general, flood protection measures can remove the potential flood damages but cannot increase cultivated crop area neither in the dry season nor in the wet season, since it is currently full crop cultivation already in the wet season. Therefore, agricultural land use in future with flood protection would likely be the same as the agricultural land use in future without Project.

3.4 Future with flood protection and irrigation project

As mentioned above, irrigation schemes have been developed for Xaybouly District. There are some small irrigation schemes in Nongbok with irrigated area of 1,880 ha out of 10,355 ha. The potential crop cultivation with new irrigation schemes would increase dry irrigated crop from the existing low level to a full level of 10,355 ha. Other non-rice crops such as vegetables, corn, beans etc. are assumed to be the same as the future without project. The cropping intensity in Nongbok District would be increased from 96% to 157%.

In short, future agriculture land use in Nongbok District under flood control and irrigation development would mainly change dry season rice from 1,880 ha to 10,535 ha. See Table 3-3.

Table 3-2 Future agricultural land use.

Items	Future Without Project		Future With Project	
	Nongbok	Xaybouly	Nongbok	Xaybouly
Gross area	**31,300**	**NA**	**31,300**	**NA**
Non-agricultural land	**17,150**	**NA**	**17,150**	**NA**
Agricultural land	**14,150**	**14,500**	**14,150**	**14,500**
Cultivated crop area	**13,794**	**23,934**	**13,794**	**23,934**
Cropping intensity	**97%**	**165%**	**157%**	**165%**
I Wet season cultivated land	**10,684**	**11,772**	**10,684**	**11,772**
A. Cultivated rice	**10,535**	**8,617**	**10,535**	**8,617**
1. Staple Rice	5,268	8,617	5,268	8,617
2. Commercial rice	5,267	-	5,267	-
B. Cultivated non-rice	**149**	**3,155**	**149**	**3,155**
1. Chili	-	9	-	9
2. Sweet corn	149	80	149	80
3. Sugarcane	-	2,884	-	2,884
4. Other crops	-	182	-	182
II Dry season cultivated land	**3,110**	**12,162**	**3,110**	**12,162**
A. Cultivated rice	**1,880**	**8,520**	**10,535**	**8,520**
1. Staple Rice	-	-	-	-
2. Commercial rice	1,880	8,520	10,535	8,520
B. Cultivated non-rice	**1,230**	**3,642**	**1,230**	**3,642**
1. Tobacco	35	112	35	112
2. Chili	170	63	170	63
3. Sweet corn	53	94	53	94
4. Sugarcane	-	2,884	-	2,884
5. Other crops	746	489	746	489

Source: Consultant estimates

Table 3-3 Future agricultural land use.

Items	Future Without Project		Future With Project	
	Nongbok	Xaybouly	Nongbok	Xaybouly
Gross area	**31,300**	**NA**	**31,300**	**NA**
Non-agricultural land	**17,150**	**NA**	**17,150**	**NA**
Agricultural land	**14,150**	**14,500**	**14,150**	**14,500**
Cultivated crop area	**13,794**	**23,934**	**13,794**	**23,934**
Cropping intensity	**97%**	**165%**	**157%**	**165%**
I Wet season cultivated land	**10,684**	**11,772**	**10,684**	**11,772**
A. Cultivated rice	**10,535**	**8,617**	**10,535**	**8,617**
1. Staple Rice	5,268	8,617	5,268	8,617
2. Commercial rice	5,267	-	5,267	-
B. Cultivated non-rice	**149**	**3,155**	**149**	**3,155**
1. Chili	-	9	-	9
2. Sweet corn	149	80	149	80
3. Sugarcane	-	2,884	-	2,884
4. Other crops	-	182	-	182
II Dry season cultivated land	**3,110**	**12,162**	**3,110**	**12,162**
A. Cultivated rice	**1,880**	**8,520**	**10,535**	**8,520**
1. Staple Rice	-	-	-	-
2. Commercial rice	1,880	8,520	10,535	8,520
B. Cultivated non-rice	**1,230**	**3,642**	**1,230**	**3,642**
1. Tobacco	35	112	35	112
2. Chili	170	63	170	63
3. Sweet corn	53	94	53	94
4. Sugarcane	-	2,884	-	2,884
5. Other crops	746	489	746	489

Source: Consultant estimates

4. Expected Agricultural Net Benefits

4.1 Future with flood protection measures

There would be no incremental net benefit from crop cultivation due to the proposed project.

4.2 Future with flood protection and irrigation development

4.2.1 Nongbok District

With provision of irrigation facilities in Nongbok District, it would bring dry irrigated rice from 1,880ha to 10,535ha for commercial rice. Economic net benefit of irrigated commercial rice would be 936 USD/ha, resulting in an incremental net benefit of 8.1 million USD/year.

4.2.2 Xaybouly District

Since the area is under irrigation, there would be no new irrigation development and therefore it is expected that incremental net benefit would be zero.

Attachment 3.1 Summary of crop benefits

Summary of crop benefits

No	Crops	Production (kg)	Revenue Kip	Total Inputs Kip	Physical input Kip	Financial NB Kip	Economic NB Kip
1	Wet Rice	4,300	6,450,000	4,382,661	1,896,451	2,067,339	3,261,794
2	Dry_Rice (irrigated)	6,200	9,300,000	6,129,261	3,536,451	3,170,739	4,285,394
3	Wet_Cotton	1,500	5,250,000	2,378,331	1,514,451	2,871,669	3,457,194
4	Dry_Cotton	800	2,800,000	1,515,681	954,451	1,284,319	1,630,194
5	Wet_Commercial rice	4,500	9,000,000	4,323,021	1,840,451	4,676,979	5,862,194
6	Dry_commercial rice (irrigated)	6,500	13,000,000	6,171,861	3,576,451	6,828,139	7,953,394
7	Rainfed_Sugarcane	45,000	6,750,000	4,644,651	2,892,451	2,105,349	3,254,794
8	Irrigated_Sugarcane	65,000	9,750,000	5,496,651	3,692,451	4,253,349	5,094,794
9	Irrigated_Corn	8,000	8,000,000	4,465,731	2,724,451	3,534,269	4,439,194
10	Rainfed_Corn	5,000	5,000,000	4,039,731	2,324,451	960,269	2,019,194

No	Crops	Production (kg)	Revenue US$	Total Inputs US$	Physical input US$	Financial NB US$	Economic NB US$
1	Wet Rice	4,300	759	516	223	243	384
2	Dry_Rice (irrigated)	6,200	1,094	721	416	373	504
3	Wet_Cotton	1,500	618	280	178	338	407
4	Dry_Cotton	800	329	178	112	151	192
5	Wet_Commercial rice	4,500	1,059	509	217	550	690
6	Dry_commercial rice (irrigated)	6,500	1,529	726	421	803	936
7	Rainfed_Sugarcane	45,000	794	546	340	248	383
8	Irrigated_Sugarcane	65,000	1,147	647	434	500	599
9	Irrigated_Corn	8,000	941	525	321	416	522
10	Rainfed_Corn	5,000	588	475	273	113	238

Attachment 3.2 Financial crop-budget

Attachment 3.2.1

Financial crop-budget (wet season staple rice)

1 US$ = 8,500 KIP

		Yield /ha	Selling price KIP /kg	revenue KIP /ha
1 Gross income	*seeds (kg)*	4,300	1,500	**6,450,000**

		Input amount /ha	Cost price KIP /unit	revenue KIP /ha
2 Input	*Seeds (kg)*	80	5,600	448,000
	Salaried Labour (ploughing, harrowing, weeding, harvasting) (days)	90	25,000	2,250,000
	Fertilizers (kg)	200	4,500	900,000
	Insecticides (kg)	1	36,000	36,000
	Irrigation electricity (lumpsum)	n/a		0
	Irrigation maintenance cost (lumpsum)	n/a		0
	TOTAL			**3,634,000**

		Purchase price KIP	depreciation time years	Capital cost per year
3 Equipment	*Purchase of Equipment (Hand tracktor and accessories)*	16,000,000	5	**202,334**
	Fuel (KIP/ha)	300,000	n/a	**300,000**
	Equipment maintenance cost (5% per year)	n/a	n/a	**10,117**

		Loan required capital	Interest rate % per year	Credit cost KIP /ha
4 Credit	*6 month loan for input*	3,634,000	13	236,210
	loan for equipment			
	TOTAL			**236,210**

5 Net margin (1-2-3-4)	KIP/ha	**2,067,339**
	Financial NB (US$/ha)	243
	Economic NB (US$/ha)	384

Attachment 3.2.2

Financial crop-budget (dry season staple rice irrigated)

1 US$ = 8,500 KIP

		Yield /ha	Selling price KIP /kg	revenue KIP /ha
1 Gross income	*seeds (kg)*	6,200	1,500	**9,300,000**

		Input amount /ha	Cost price KIP /unit	revenue KIP /ha
2 Input	*Seeds (kg)*	70	5,600	392,000
	Salaried Labour (ploughing, harrowing, weeding, harvasting) (days)	90	25,000	2,250,000
	Fertilizers (kg)	400	4,400	1,760,000
	Insecticides (kg)	2	36,000	72,000
	Irrigation electricity (lumpsum)	1	400,000	400,000
	Irrigation maintenance cost (lumpsum)	1	400,000	400,000
	TOTAL			**5,274,000**

		Purchase price KIP	depreciation time years	Capital cost per year
3 Equipment	*Purchase of Equipment (Hand tracktor and accessories)*	16,000,000	5	**202,334**
	Fuel (KIP/ha)	300,000	n/a	**300,000**
	Equipment maintenance cost (5% per year)	n/a	n/a	**10,117**

		Loan required capital	Interest rate % per year	Credit cost KIP /ha
4 Credit	*6 month loan for input*	5,274,000	13	342,810
	loan for equipment			
	TOTAL			**342,810**

5 Net margin (1-2-3-4)	KIP/ha	**3,170,739**
	Financial NB (US$/ha)	373
	Economic NB (US$/ha)	504

Attachment 3.2.3

Financial crop-budget (long fibre cotton rainfed)

long fibre cotton are cotton flowers producing fibres of 27 - 30 mm, such as Kham Khao 1 (Indian cotton)
The economic study considers 1 crop during dry season
1 US$ = 8,500 KIP

		Yield */ha*	Selling price *KIP / kg cottonseeds*	revenue *KIP / ha*
1 Gross income	*Cottonseeds (kg)*	1,500	3,500	**5,250,000**

		Input amount */ha*	Cost price *KIP / unit*	revenue *KIP / ha*
2 Input	*Seeds (kg)*	25	2,000	50,000
	Salaried Labour (ploughing, harrowing, weeding, harvasting) (days)	30	25,000	750,000
	Fertilizers (kg)	200	4,400	880,000
	Insecticides (kg)	2	36,000	72,000
	Irrigation electricity (lumpsum)	n/a		0
	Irrigation maintenance cost (lumpsum)	n/a		0
	TOTAL			**1,752,000**

		Purchase price *KIP*	depreciation time *years*	Capital cost *per year*
3 Equipment	*Purchase of Equipment (Hand tracktor and accessories)*	16,000,000	5	**202,334**
	Fuel (KIP/ha)	300,000	n/a	**300,000**
	Equipment maintenance cost (5% per year)	n/a	n/a	**10,117**

		Loan *required capital*	Interest rate *% per year*	Credit cost *KIP / ha*
4 Credit	*6 month loan for input*	1,752,000	13	113,880
	loan for equipment			
	TOTAL			**113,880**

5 Net margin (1-2-3-4)	KIP/ha	**2,871,669**
	Financial NB (US$/ha)	338
	Economic NB (US$/ha)	407

Attachment 3.2.4

Financial crop-budget (long fibre cotton_Dry season no irrigation)

long fibre cotton are cotton flowers producing fibres of 27 - 30 mm, such as Kham Khao 1 (Indian cotton)
The economic study considers 1 crop during dry season
1 US$ = 8,500 KIP

		Yield /ha	Selling price KIP /kg cottonseeds	revenue KIP /ha
1 Gross income	*Cottonseeds (kg)*	800	3,500	**2,800,000**

		Input amount /ha	Cost price KIP /unit	revenue KIP /ha
2 Input	*Seeds (kg)*	25	2,000	50,000
	Salaried Labour (ploughing, harrowing, weeding, harvasting) (days)	20	25,000	500,000
	Fertilizers (kg)	160	2,000	320,000
	Insecticides (kg)	2	36,000	72,000
	Irrigation electricity (lumpsum)	n/a		0
	Irrigation maintenance cost (lumpsum)	n/a		0
	TOTAL			**942,000**

		Purchase price KIP	depreciation time years	Capital cost per year
3 Equipment	*Purchase of Equipment (Hand tracktor and accessories)*	16,000,000	5	**202,334**
	Fuel (KIP/ha)	300,000	n/a	**300,000**
	Equipment maintenance cost (5% per year)	n/a	n/a	**10,117**

		Loan required capital	Interest rate % per year	Credit cost KIP /ha
4 Credit	*6 month loan for input*	942,000	13	61,230
	loan for equipment			
	TOTAL			**61,230**

5 Net margin (1-2-3-4)	KIP/ha	**1,284,319**
	Financial NB (US$/ha)	151
	Economic NB (US$/ha)	192

Attachment 3.2.5

Financial crop-budget (Wet season commercial rice)

1 US$ = 8,500 KIP

		Yield /ha	Selling price KIP /kg	revenue KIP /ha
1 Gross income	*seeds (kg)*	4,500	2,000	**9,000,000**

		Input amount /ha	Cost price KIP /unit	revenue KIP /ha
2 Input	*Seeds (kg)*	70	5,600	392,000
	Salaried Labour (ploughing, harrowing, weeding, harvasting) (days)	90	25,000	2,250,000
	Fertilizers (kg)	200	4,500	900,000
	Insecticides (kg)	1	36,000	36,000
	Irrigation electricity (lumpsum)	n/a		
	Irrigation maintenance cost (lumpsum)	n/a		0
	TOTAL			**3,578,000**

		Purchase price KIP	depreciation time years	Capital cost per year
3 Equipment	*Purchase of Equipment (Hand tracktor and accessories)*	16,000,000	5	**202,334**
	Fuel (KIP/ha)	300,000	n/a	**300,000**
	Equipment maintenance cost (5% per year)	n/a	n/a	**10,117**

		Loan required capital	Interest rate % per year	Credit cost KIP /ha
4 Credit	*6 month loan for input*	3,578,000	13	232,570
	loan for equipment			
	TOTAL			**232,570**

5 Net margin (1-2-3-4)	KIP/ha	**4,676,979**
	Financial NB (US$/ha)	550
	Economic NB (US$/ha)	690

Attachment 3.2.6

Financial crop-budget (dry season commercial rice - irrigated)

1 US$ = 8,500 KIP

		Yield /ha	Selling price KIP /kg	revenue KIP /ha
1 Gross income	*seeds (kg)*	6,500	2,000	**13,000,000**

		Input amount /ha	Cost price KIP /unit	revenue KIP /ha
2 Input	*Seeds (kg)*	70	5,600	392,000
	Salaried Labour (ploughing, harrowing, weeding, harvasting) (days)	90	25,000	2,250,000
	Fertilizers (kg)	400	4,500	1,800,000
	Insecticides (kg)	2	36,000	72,000
	Irrigation electricity (lumpsum)	n/a	400,000	400,000
	Irrigation maintenance cost (lumpsum)	n/a	400,000	400,000
	TOTAL			**5,314,000**

		Purchase price KIP	depreciation time years	Capital cost per year
3 Equipment	*Purchase of Equipment (Hand tracktor and accessories)*	16,000,000	5	**202,334**
	Fuel (KIP/ha)	300,000	n/a	**300,000**
	Equipment maintenance cost (5% per year)	n/a	n/a	**10,117**

		Loan required capital	Interest rate % per year	Credit cost KIP /ha
4 Credit	*6 month loan for input*	5,314,000	13	345,410
	loan for equipment			
	TOTAL			**345,410**

5 Net margin (1-2-3-4)	KIP/ha	**6,828,139**
	Financial NB (US$/ha)	803
	Economic NB (US$/ha)	936

Attachment 3.2.7

Financial crop-budget (Rainfed Sugarcane)

1 US$ = 8,500 KIP

		Yield /ha	Selling price KIP /kg	revenue KIP /ha
1 Gross income	*seeds (kg)*	45,000	150	**6,750,000**

		Input amount /ha	Cost price KIP /unit	revenue KIP /ha
2 Input	*Seeds (kg)*	4,000	200	800,000
	Salaried Labour (ploughing, harrowing, weeding, harvasting) (days)	60	25,000	1,500,000
	Fertilizers (kg)	200	4,400	880,000
	Insecticides (kg)	2	350,000	700,000
	Irrigation electricity (lumpsum)	n/a		0
	Irrigation maintenance cost (lumpsum)	n/a		0
	TOTAL			**3,880,000**

		Purchase price KIP	epreciation tim years	Capital cost per year
3 Equipment	*Purchase of Equipment (Hand tracktor and accessories)*	16,000,000	5	**202,334**
	Fuel (KIP/ha)	300,000	n/a	**300,000**
	Equipment maintenance cost (5% per year)	n/a	n/a	**10,117**

		Loan required capital	Interest rate % per year	Credit cost KIP /ha
4 Credit	*6 month loan for input*	3,880,000	13	252,200
	loan for equipment			
	TOTAL			**252,200**

5 Net margin (1-2-3-4)	KIP/ha	**2,105,349**
	Financial NB (US$/ha)	248
	Economic NB (US$/ha)	383

Attachment 3.2.8

Financial crop-budget (Irrigated Sugarcane)

1 US$ = 8,500 KIP

		Yield /ha	Selling price KIP /kg	revenue KIP /ha
1 Gross income	*seeds (kg)*	65,000	150	**9,750,000**

		Input amount /ha	Cost price KIP /unit	revenue KIP /ha
2 Input	*Seeds (kg)*	4,000	200	800,000
	Salaried Labour (ploughing, harrowing, weeding, harvasting) (days)	60	25,000	1,500,000
	Fertilizers (kg)	200	4,400	880,000
	Insecticides (kg)	2	350,000	700,000
	Irrigation electricity (lumpsum)	n/a	400,000	400,000
	Irrigation maintenance cost (lumpsum)	n/a	400,000	400,000
	TOTAL			**4,680,000**

		Purchase price KIP	epreciation tim years	Capital cost per year
3 Equipment	*Purchase of Equipment (Hand tracktor and accessories)*	16,000,000	5	**202,334**
	Fuel (KIP/ha)	300,000	n/a	**300,000**
	Equipment maintenance cost (5% per year)	n/a	n/a	**10,117**

		Loan required capital	Interest rate % per year	Credit cost KIP /ha
4 Credit	*6 month loan for input*	4,680,000	13	304,200
	loan for equipment			
	TOTAL			**304,200**

5 Net margin (1-2-3-4)	KIP/ha	**4,253,349**
	Financial NB (US$/ha)	500
	Economic NB (US$/ha)	599

Attachment 3.2.9

Financial crop-budget (Irrigated Corn)

1 US$ = 8,500 KIP

		Yield /ha	Selling price KIP /kg	revenue KIP /ha
1 Gross income	*seeds (kg)*	8,000	1,000	**8,000,000**

		Input amount /ha	Cost price KIP /unit	revenue KIP /ha
2 Input	*Seeds (kg)*	20	10,000	200,000
	Salaried Labour (ploughing, harrowing, weeding, harvasting) (days)	60	25,000	1,500,000
	Fertilizers (kg)	350	4,400	1,540,000
	Insecticides (kg)	2	36,000	72,000
	Irrigation electricity (lumpsum)	n/a	200,000	200,000
	Irrigation maintenance cost (lumpsum)	n/a	200,000	200,000
	TOTAL			**3,712,000**

		Purchase price KIP	depreciation time years	Capital cost per year
3 Equipment	*Purchase of Equipment (Hand tracktor and accessories)*	16,000,000	5	**202,334**
	Fuel (KIP/ha)	300,000	n/a	**300,000**
	Equipment maintenance cost (5% per year)	n/a	n/a	**10,117**

		Loan required capital	Interest rate % per year	Credit cost KIP /ha
4 Credit	*6 month loan for input*	3,712,000	13	241,280
	loan for equipment			
	TOTAL			**241,280**

5 Net margin (1-2-3-4)	KIP/ha	**3,534,269**
	Financial NB (US$/ha)	416
	Economic NB (US$/ha)	522

Attachment 3.2.10

Financial crop-budget (Rainfed Corn)

1 US$ = 8,500 KIP

		Yield /ha	Selling price KIP /kg	revenue KIP /ha
1 Gross income	seeds (kg)	5,000	1,000	**5,000,000**

		Input amount /ha	Cost price KIP /unit	revenue KIP /ha
2 Input	Seeds (kg)	20	10,000	200,000
	Salaried Labour (ploughing, harrowing, weeding, harvasting) (days)	60	25,000	1,500,000
	Fertilizers (kg)	350	4,400	1,540,000
	Insecticides (kg)	2	36,000	72,000
	Irrigation electricity (lumpsum)	n/a		0
	Irrigation maintenance cost (lumpsum)	n/a		0
	TOTAL			**3,312,000**

		Purchase price KIP	depreciation time years	Capital cost per year
3 Equipment	Purchase of Equipment (Hand tracktor and accessories)	16,000,000	5	**202,334**
	Fuel (KIP/ha)	300,000	n/a	**300,000**
	Equipment maintenance cost (5% per year)	n/a	n/a	**10,117**

		Loan required capital	Interest rate % per year	Credit cost KIP /ha
4 Credit	6 month loan for input	3,312,000	13	215,280
	loan for equipment			
	TOTAL			**215,280**

5 Net margin (1-2-3-4)	KIP/ha	**960,269**
	Financial NB (US$/ha)	113
	Economic NB (US$/ha)	238

Appendix 4

Public Participation Plan

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1. Introduction

The MRC is aware that stakeholder involvement in decision-making is fundamental to achieving feasible, equitable and lasting solutions in water management and that the quality of decisions can be improved by the inclusion of a broad range of stakeholders who can bring important local knowledge and relevant perspectives to the process[1]. The MRC further recognises both internal stakeholders (Government bodies in MRC structure such as MRC Council, Joint Committees, NMCs and Line Agencies in each country) and external stakeholders (non-state bodies such as NGOs, implementing partners, civil society organisations, policy advocates, media or any other who have stake to lose or gain). MRC emphasises that for the participation to be genuine, all relevant stakeholders should have an opportunity to directly or indirectly influence project design, implementation and effects. Participation should be also inclusive of women, elderly, young people and minority groups.

Information on the benefits of public participation, forms of public participation and how they need to be facilitated at various stages is already available in the MRC system.

The FMMP-C2 Stage 1 Evaluation Report provides an outline of the need for public participation in the demonstration projects based on the public participation principles recognised at MRC.

In Stage 2 of FMMP-C2, five demonstration project areas have been selected for e.g. planning structural measures for flood protection or flood risk assessment. Apart from reducing the risk of damage to houses, property, and creating better living conditions for the people, they will bring economic benefits to the people mainly through better land use and agriculture. A concrete public participation plan is crucial to ensure that the needs of community and stakeholders supporting the community are incorporated in the design of the demonstration project and support systems are put in place to adapt to these changes.

[1] MRC – Public Participation in Lower Mekong Basin

2. Objective of Public Participation in Component 2

The objectives of Public Participation Strategy in Stage 2 planning of the structural flood protection measures demonstration project are to:

1. Develop Public Participation Plan for the structural flood protection measures demonstration projects to ensure inputs from stakeholders are incorporated in the design and that any potential negative impact on stakeholders is minimised;
2. Prepare Best Practice Guidelines to help the facilitators in conducting Public consultation exercises;
3. Training of NMC and Line Agencies in facilitating public participation during the implementation of the demonstration project.

3. Preliminary Stakeholder Consultation

The Lower Mekong Basin Development Plan has defined broad groups of key stakeholders. In conducting a preliminary stakeholders' analysis in February and March 2009 by the Public Participation Specialist, the list of stakeholders defined by the BDP was used. From this list, the MRC, NMC, Water Resources Department, Agriculture Department, and fisheries administration are identified as the key internal stakeholders. Community groups, Water User's Association, Commune committees and Civil Society Organisations such as NGOs are identified as key external stakeholders.

This list provided a basis for conducting a preliminary consultation with these stakeholders to understand the issues that are important for different stakeholders in the Xe Bang Fai Demonstration Project area in Lao PDR.

1.1 Specific Purpose of preliminary exploratory stakeholders' consultations

1. Assess existing participatory processes in place;
2. Identify stakeholders that should be engaged at various stages of the project planning and implementation;
3. Understand the type of public participation activities that would be feasible;
4. Gather information at community level on the problems due to flooding and to understand the need for integrating support systems to capitalise on the benefits of structural flood protection measures;
5. Get preliminary feedback on the proposed structural measures for flood protection.

Attachment 4.2 highlights the summary of consultations with the key stakeholders. The key highlights are related to problems due to flooding in the two areas, present livelihoods options, any existing structural flood protection measures and the extent of public participation and a preliminary feedback on the demonstration project ideas.

In Xe Bang Fai, the preliminary consultations were conducted together with the National Consultant's Social Sector Specialist, and Provincial and District Social Welfare Council representative with the permission of LNMC coordinators, as they were not available to join during the period of these visits.

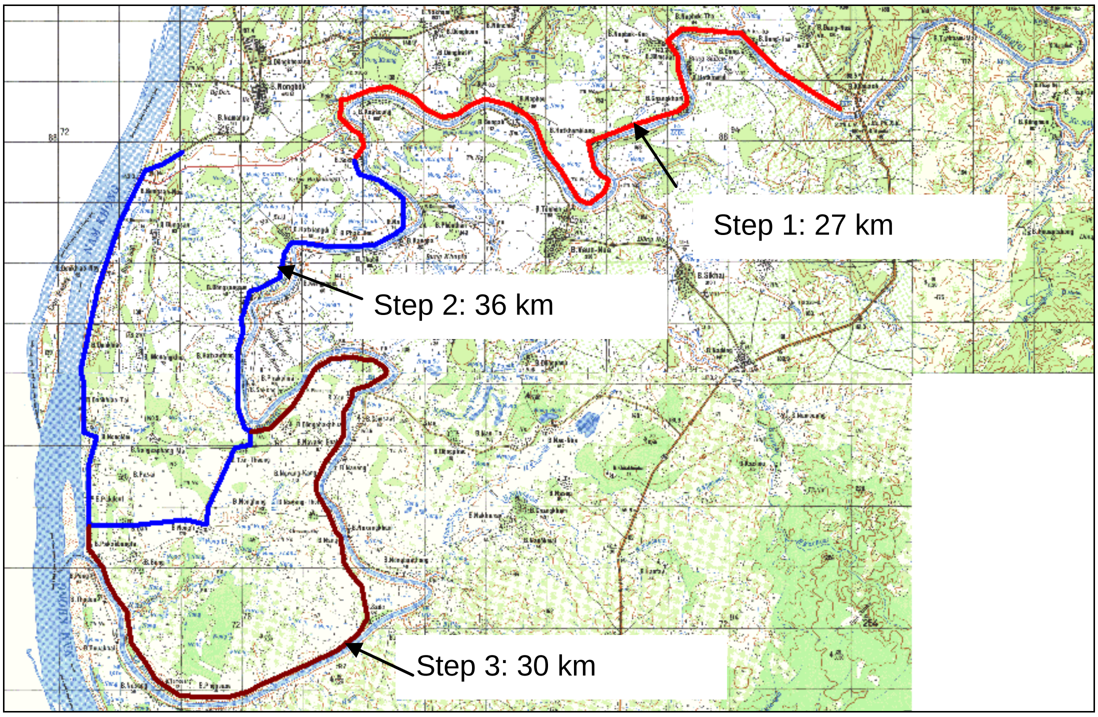
Since this was a preliminary consultation, the stakeholder groups were consulted individually to gain in-depth understanding of the problems, issues and opportunities. The consultation process involved first understanding the existing situation with floods, coping mechanisms, community profile, vulnerability analysis, existing agriculture and fisheries practices and sharing the FMMP-C2 structural measures project design and objective to get preliminary feedback.

The information gathered from these consultations will help in preparing the best practice guidelines for public participation and developing a training plan for the NMC, Line Agencies and Civil Society Organisations who would potentially be involved in conducting or facilitating the actual consultations.

1.2 Xe Bang Fai, Lao PDR

The project area refers primarily to the flood prone area of the Xe Bang Fai downstream of the crossing with the National Road Nr 13 South (NR13S). The location of the area is shown in the following figure:

The development of Xe Bang Fai irrigation schemes may go beyond the flood prone areas. These areas are to be included in the overall evaluation of the water resources development and management in the Lower Xe Bang Fai. For the evaluation of flood protection schemes, though, these areas are not taken into account.



1.2.1 Stakeholders consulted in Xe Bang Fai, Lao PDR

1. Stakeholders' consulted in a group at LNMC
    a. Department of Irrigation;
    b. Department of hydrology & Meteorology;
    c. Department of Water Resources;
    d. National Disaster Management Office;
    e. Lao National Mekong Committee;
    f. Department of Land Use;
    g. Water Resource and Environment Research Institute (Newly formed);
    h. Department of Waterways;
    i. National Disaster Management Committee.
2. Social Welfare Council, Thakhek and Nongbok;
3. Community at Sok Boe and Hatsai Phong villages;
4. Water user association vice chief of Tan Theung Village.

1.2.2 Highlights of Stakeholder Consultation in Xe Bang Fai

Problems due to flooding

The flood in this area comes quickly and lasts for a short period of about 30 to 45 days. Since it's more of a combined flood, the damage to properties and assets are considerable. It also impacts the water quality causing health problems. The main damage to the crop is to wet season paddy.

Existing Structures

- Dykes and floodwater control gates can be seen at many places along the Xe Bang Fai River. The Government is already investing in these infrastructure as and when resource are mobilised;

- Pumping stations and irrigation channels can be seen along Xe Bang Fai;

- Dry season rice crop is grown with irrigation;

Feedback on Demonstration Project

- Farmer groups, SWC, Dept. of water resources and land use all see the benefit of the project.
- Flood protection measures in this area will help in growing the wet season rice. Farmers will likely allocate more area under rice during the flood season when flood protection measures are implemented as the cost of cultivation is low. It is expensive to cultivate dry season rice and the farmers don't earn more than USD 100/ha. Farmers are likely to reduce area under dry season rice after the project is implemented. It costs USD 400 to cultivate dry season rice, which includes cost of seed, transplanting, other labour, fertiliser and pest management. In addition to this, farmers pay a USD 60 electricity fee (which includes tax) to the commune for maintaining the irrigation pumping stations.
- People in this area hate floods as they are for a short period and they destroy their crops, livestock, houses and other assets.
- Fishing doesn't seem to be a big issue in this area.
- The project ideas as preliminary developed by the consultant during Stage 1 of FMMP-C2 are in line with the design submitted by the SWC to the Lao PDR Government.

Issues to consider

- Damage to property and assets is high;
- Male farmers prefer to save crops rather than houses and assets. Women would like to save the houses and assets as well, but will go with the decision made by the men considering they are head of family. Men prefer to have the dyke after the village and not before the village. The reason is that if the dyke is constructed before the village and if it breaches, it will destroy their houses. Dykes after the village will cause flood in the village, but water flow can be controlled and damage to houses and assets will be minimal. The women are worried about loss to paddy storage;
- Area under rice might reduce in the dry season after the project is implemented as farmers are likely to cultivate more wet season rice;
- Dry season rice more expensive to cultivate;
- Land holding is small. Less than 1 ha for majority of the farmers, which needs additional organisation of farmers to create market linkages;
- Existing pumping stations and irrigation system all along the Xe Bang Fai in Nongbok District;
- Existing plan of the Government to construct flood protection structures. Many dykes have been planned;
- Operation & Maintenance of structures considering the present experience with pumping station and irrigation schemes.

4. Public Participation Process Summary

The preliminary consultation is an opportunity to highlight issues that will be important to consider for designing the demonstration project. Some of the issues are already known, but there may be other issues which have not been considered. At this stage, there are assumptions as to the needs of the communities and perceptions about various stakeholders in supporting or opposing this project.

A broader consultation with key stakeholders in the area will provide inputs for the design of the project as well as highlight what resources each stakeholder can bring into this project at various stages.

As has been highlighted before, the needs of the communities and within the community for men and women vary considerably. This cannot be known unless a proper stakeholder analysis is done with participation of the communities. Similarly, the internal and external stakeholders can contribute considerably in integrating agriculture, fisheries and environmental impact of the project. Facilitating to gather these inputs constructively can lead to the contribution of this input into the project preparation.

Participation can range from simply informing people about the project, wherein people or stakeholders have no opportunity to influence the decision making, up to empowerment of stakeholders in the design and implementation of the structural measures, wherein people and stakeholders have an opportunity to influence the decision making. Various types of public participation between these two extremes can be consultations, participation and creating ownership. The level of participation desired should be clearly defined before starting the consultation process. The tools and methods adopted are different for these different types of participatory process.

Empowering the community and stakeholders in joint decision making is the ideal participation process. More often than not the facilitators end up simply informing the people and stakeholders about the project and conduct consultation exercises that may not give enough room for decision making by the people and stakeholders. This can have serious consequences when the project is at the implementation stage. Hence, training the facilitators in appropriate training tools and methods to undertake public participation process, which is inclusive and empowers or at least creates ownership opportunities for influencing the decision making process becomes crucial.

The next step is how to integrate the inputs from consultation into design changes or adding elements to the design. Multi-stakeholders facilitation skills can be important for this process.

The Best Practice Guideline on Public Participation and Training materials will provide the required tools and methods to conduct these exercises effectively.

The public participation plan and process is described in detail in Attachment 4.1. The following is the summary of public participation process envisaged for Stage 2 and project implementation stage:

Project Conceptualisation Stage – Demonstration phase FMMP-C2

The public participation specialist will train the NMC, Line Agencies, Social Sector Specialist and Project Consultant Engineers by equipping them with the right tools and skills to conduct public consultation exercises. A Best Practice Guidelines will be prepared to help the facilitators in conducting the public consultation. The following is the summary of steps that will be followed in Stage 2:

- Prepare Fact Sheets describing the project, area covered, intended benefits, potential impacts in local language to be used to inform and educate the communities as well as Line Agencies and NGOs;
- Facilitate consultation sessions at community level to identify vulnerable groups and issues important for women, agriculture and fisheries. These sessions should be facilitated by local external facilitator and separately with women by female facilitators;
- Facilitate consultation sessions with Line Agencies and NGOs separately. This will be done by trained facilitators at the NMC or Line Agencies;
- Conduct multi-stakeholder workshop with representatives from farmer groups, communes, district and provincial level Line Agencies and representatives from ministries;
- The outputs of these consultations will be used by the project design team to incorporate the needs and wishes of the community and stakeholders in the design.

Project Design Stage

- Identify NMC and key staff of project executing agency and also NGOs to lead consultation session on structural design;
- Train the facilitators in participatory tools (land use mapping, resource mapping, seasonality, timelines and visioning) after conducting training needs assessment of these facilitators;
- Conduct focus group interviews of all stakeholders explaining the detailed project at local level to understand how to mitigate the negative impacts, if still any after incorporating the wishes and needs of community. Identify contentious issues that need to be resolved further by negotiation and bring them to the multi-stakeholders platform;
- Conduct multi-stakeholder workshop to incorporate the needs and wishes of the communities and other stakeholders and communicate the final project design.

Project Execution Stage

- Communicate the project design, launch and progress made during the implementation through mass media;
- Communicate the project design to executing agency staff at various level;
- Conduct sessions at community level to identify participation in the construction of the structural flood control measures;
- Train the community in operation and maintenance and create user groups for efficient management and use of structures.

Attachment 4.1 Public Participation Plan for Structural Flood Protection Measures

Stakeholder Groups

Involved in project preparation exercise: Project implementing agency National and Provincial Line Agencies Contractors Provincial governments	*For consultation:* Local governments (province, district, commune) Village leaders, village members Community-based organisations (Farmers' groups, Water-User Groups, Conservation/Forest User Groups) Civil society organisations or mass organisations (e.g. Women's Union)

Project type	**Structural Flood Protection Measures**		
Stages	**Activities**	**Events**	**Resource required**
During Stage 2: Demonstration Phase			
1. Project Conceptualisation:	1.1 Prepare a clear fact sheet describing the project, its expected location and coverage, and the estimated costs. The language and terminology used in the description should be accessible to those people who will be affected by the project. Provide information on who to contact to know more about the project. 1.2 Conduct stakeholder analysis with project implementing agency, Line Agencies (national and provincial), and concerned local governments to determine which groups, household, settlements will be most affected by the project, in particular, vulnerable groups. 1.3 Distribute the fact sheet in the affected area as widely as possible through leaflets and posting in community spaces. 1.4 Organise a public information session open to all to inform the community about the project and answer questions. 1.5 At the public information session, collect contact information from those that consider themselves affected or inform them of how to notify the project that they wish to attend future consultations. 1.6 Map out the communities to be consulted in the design based on most affected settlements, and representation of different types of geographic/ethnic areas that will be affected. 1.7 Assess the important characteristics of communities in the target area that must be considered in assessments and consultations. These will include: ▪ Language and cultural practices for community decision-making ▪ Opportunities and constraints to women's participation in planning ▪ Potential sources of conflict / competition for resources that need to be considered in the participatory process.	Stakeholder inception workshop; Public information session.	0.5 mth International PP Spec. 1 month National SS Specialist Leaflets / Information poster Workshop and travel costs.

Project type Stages	Structural Flood Protection Measures Activities	Events	Resource required
During Stage 2: Demonstration Phase			
2. Project Design: Assessment	2.1 Identify key NMC and/or Project Executing Agency personnel or Sub-contractors (Mass organisations/NGOs) that can be trained to lead consultation and planning exercises in communes and villages. This group would be the Community Facilitators 2.2 Conduct a rapid training needs assessment of the Community Facilitators. 2.3 Adapt sets of participatory development and social tools to be relevant to structural project design preparation. ▪ Participatory Hazard, Vulnerability and Capacity Assessment, including assessing negative and positive impacts of flooding, traditional coping mechanisms, and needs for external support in flood protection and disaster management. ▪ Participatory Rural Appraisal Tools for Mapping land use and community resources and assets, historical changes, ▪ Social Assessment: Key informant interviews and Focus Groups with Affected populations to contribute to assessment of social impacts: on land-use, forest use, water use, Gender assessment, Ethnic profile as per the guidelines. 2.4 Establish a format for summarising information from the consultations for use by the Project Executing Agency in the design process. 2.5 Conduct a Training of Community Facilitators. ▪ Day 1 of Training would be Introduction to design of Structural Flood Protection Works in the LMB; ▪ Day 2 - 3: Training on tools and facilitation skills for participatory planning, including practicum in one of the communities to be consulted within the project preparation.		0.5 mth International Public Participation Specialist 1 mth National SS Specialist

Project type	Structural Flood Protection Measures		
Stages	**Activities**	**Events**	**Resource required**
During Stage 2: Demonstration Phase			
3. Project Design: Analysis of Impacts and Mitigation	3.1 Based on mapping from 1.6 Community Facilitators conduct consultations, focus groups sessions and key information interviews in targeted localities with support from National SS. 3.2 Identify one person (e.g. leader of a community-based organisation) in each settlement cluster to be a focal point for continued feedback on the design and progress of the project. 3.3 Hold debriefing session of National SS Specialist and Community Facilitators at mid-way point between consultations to review quality of information collection and summarisation. 3.4 Finish consultations and document results of social impacts and community priorities for flood protection/livelihood development and their inputs on how to mitigate negative impacts of the proposed project. 3.5 Use information from the communities in finalising the project design. Develop options for compensation of negative impacts of the project, or options to support communities to be able to take advantage of positive impacts (e.g. Diversifying cropping patterns based on flood protection; training on alternatives to agricultural production in areas of potential increased flooding). 3.6 Design resettlement plans and land compensation in keeping with government / donor regulations. 3.7 Hold community consultations to either i) validate the options that will be included in the project design for compensation or ii) select among the options according to community priorities. Whether the purpose is validation or selection will depend on the nature of the project, and the resources available to compensate affected people. 3.8 Identify other supports in the community (other projects, NGOs, Government programs) that can support communities to mitigate negative impacts or take advantage of positive impacts of changes brought by the project. 3.9 Identify existing community-based organisations (Water User Groups, Mass Organisations, Co-operatives, Disaster Management Committees) that could play a role in Operation and Maintenance.		0.5 mth Int. PP Spec 1 mth National SS to supervise the CF and assist in compilation of results. CFs: Travel allowances Travel costs Workshop and meeting costs

Project type	Structural Flood Protection Measures		
Stages	**Activities**	**Events**	**Resource required**
During Stage 2: Demonstration Phase			
4. Dissemination of Public Participation Practice in other NMCs.	4.1 Review and refinement of public participation process and tools based on the experience by National SS and International PP. 4.2 Experience sharing workshop/training on Public Participation in each country by National SS Spec. (could also be held at the regional level). 4.3 Finalisation of Public Participation in Toolkit and documentation of recommendations for its future use in project design.	Experience Sharing Workshop;	0.5 mth International PP Spec. 0.5 mth National SS Spec.
During full implementation of Structural Measure			
5. Project Implementation & Monitoring	The process of public participation in the implementation of structural projects would be elaborated in more detail within the final project based on the specific type of project, location, and following the Guidelines on Public Participation, and Environment, Economic and Social Impact. The important steps in this process would be: 5.1 Disseminate information about the project final design, start-up and progress through media, local broadcasts and other available means. 5.2 Refresher training on facilitation skills with Community Facilitators to re-engage them in the process. 5.3 Mobilise existing or new Community-based organisations (Women's Union, Water User Groups, and Farmer Groups) for participatory monitoring of project implementation. 5.4 Establish checklist to monitor: ▪ Access routes, waste disposal, use of land, environmental impacts during construction ▪ Quality of construction when appropriate ▪ Monitoring and reporting of negative impacts on land and natural resources as construction progresses ▪ Implementation of compensation packages ▪ Implementation of resettlement plan 5.5 Community facilitators provide training on project design and activities to be monitored by the community. 5.6 Establish feedback mechanism with Project Executing Agency, Contractors, dedicated Government Authority to address problems during construction, or adjust design for unanticipated negative impacts. Establish mechanism for reporting and solving problems related to resettlement and compensation packages.	Press releases, Press conferences; Workshops with stakeholder groups. Community monitoring meetings.	International Public Participation Specialist National Social Sector/ Public Participation Specialists Allowances for Community Facilitators Travel costs Workshop and meeting costs

Project type	Structural Flood Protection Measures		
Stages	**Activities**	**Events**	**Resource required**
During full implementation of Structural Measure			
6. Project Implementation: Operation and Maintenance	6.1 Provide training on Operation and Maintenance (O&M) to final Project Holder (local government, line agency, etc.). 6.2 Identify in the training how the community can be involved in the O&M, depending on the type of structural work, size, and location and anticipated maintenance requirements. 6.3 Based on information from consultations, work with Project Holder to form community O&M groups. 6.4 Provide training and support to O&M groups organisational development (Statutes of operation, Schemes to recover costs of maintenance where appropriate, small supports for operations) depending on the type of structure. 6.5 Prepare materials and organise community meetings on what they should do or not do to contribute to maintenance of the structure.	Training on O&M - to Community Facilitators , Project Holders; - to Community.	

Attachment 4.2 Stakeholder Consultation

Lao PDR

Stakeholder consultation Interviews in Xe Bang Fai Demonstration Project Area: March 2 to 4, 2009

During the three days field visit, the Line Agencies were consulted at a group meeting organised at LNMC. The SWC was consulted at province and district level and a focus group interviews were conducted at community level.

The interviews focused on the following aspects:

1. Role and function of the department & water users association;
2. Damage due to floods and existing coping mechanisms;
3. Existing flood protection measures in the area;
4. Extent and type of public participation in flood protection measures implemented in the area;
5. Stakeholders' Analysis: Identifying stakeholders who are likely to support or oppose the structural flood project measures demonstration project.

1. LNMC – Stakeholder consultation

The following stakeholders participated in the preliminary consultation meeting.

j. Department of Irrigation;
k. Department of hydrology & Meteorology;
l. Department of Water Resources;
m. National Disaster Management Organisation;
n. Lao National Mekong Committee;
o. Department of Land Use;
p. Water Resource and Environment Research Institute (Newly formed);
q. Department of Waterways;
r. National Disaster Management Committee.

Many staffs present were new and because of the institutional changes, some departments were recently formed. The Department of Agriculture and Fisheries were not present. This created hurdle in effective participation of the stakeholders in the meeting.

Each Line agency shared the role of the department, involvement in flood protection and disaster mitigation, and the extent of public consultation. They provided feedback to the extent possible on the demonstration project but could not go into details.

However, this provided an opportunity to understand the restructuring of some departments, role of LNMC and it highlights the need for conducting a proper stakeholder analysis

2. Nongbok District Administration

Mr. Khanty Phothin, District chief, Nongbok District Administration Bureau
This was a courtesy visit before meeting the district SWC.

3. Social Welfare Council (SWC)

Mr. Menang Ma Phetsinha, head, SWC Khammuane Province.

Mr. Kao Intha Pakkathong, Vice President, Head of Labour & Social Welfare Nongbok District.

Role:

- Main coordinating body for disasters – reconstruction, recovery and rehabilitation of structures.

Existing Public Participation:

- People participate in construction;
- Disputes about dyke passing through someone's land is settled through negotiation;
- Assist in modifying land title without fee;
- People mobilise help from within the community to repair damaged houses.

Feedback on Demonstration Project:

- They have not heard about it so far;
- Aware of the flood mitigation issues through involvement of ADPC & Red Cross;
- The project is in line with their thinking and feel happy that their inputs at the earlier stages have been incorporated;
- They already have plans to construct several dykes for flood control and is implemented as and when the Government is able to mobilise resources.

4. Sok Boe & Hatsai Phong villages, Nongbok District

Village Background:

- No. of households = 125;
- Population = 725;
- Land holding: Majority have 1.5 ha and a few farmers have up to 6 ha;
- During the floods, everyone is involved in fishing;
- Tobacco, corn, chillies, beans and vegetables grown on the banks of the Xe Bang Fai where possible.

Problem due to floods:

- Everyone in this area hate floods;
- Floods destroy houses, damage crops, and also destroys or damage other assets;
- Women don't like the floods as the grain and food stock Is also destroyed;
- Big floods once in 3 years.

Feedback on Demonstration project:

- They always wished to have dyke along Xe Bang Fai like in the Savannakhet province on the other side of river;
- Will create positive benefits for agriculture, but not sure how it will impact fishing;
- Will help in growing the wet season rice. Farmers will likely allocate more area under rice during the flood season when flood protection measures are implemented as the cost of cultivation is low. Dry season rice is expensive to cultivate. The farmers don't earn more than USD 100/ha. Farmers are likely to reduce area under dry season rice after the project is implemented. It costs USD 400 to cultivate dry season rice, which includes cost of seed, transplanting, other labour, fertiliser and pest management. In addition to this, farmers pay USD 60 as electricity fee (which includes tax) to the commune for maintaining the irrigation pumping stations;
- Men would like to have dyke after the village, while women would like before the village.

Issue to consider:

- Potential change in land use, crops etc. depending on the affordability of farmers;
- Need to analyse alternative crops as dry season rice is expensive;
- Integrated approach to maximise the benefits;
- Link Agriculture and Fisheries;
- Existing pumping stations and irrigation schemes.

Appendix 5

Implementation Public Participation Plan

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1. Introduction

A preliminary stakeholder analysis and consultation was conducted in March 2009 to identify the key stakeholders for consultation on structural flood protection measures in the Lower Xe Bang Fai and understand the issues that the communities want to prioritise for dealing with floods. In the field area, the preliminary consultations were conducted together with the National Social Sector Specialist, and Provincial and District Social Welfare Council representative.

Subsequently, the Best Practice Guidelines on Public Participation was updated to help the NMC and Line Agencies facilitators conduct stakeholder consultation exercises in the demonstration projects. The stakeholder consultation schedule was prepared and implemented in the Lower Xe Bang Fai in Nongbok District from May 26 to 29, 2009 (Attachment 5.1). Given the time and budget, the focus of public participation was on community consultation.

The participation of communities in giving feedback on the ideas for demonstration project is aimed to better understand the situation and take into account the priorities of the communities, especially the vulnerable groups within the community. The consultation helped in validating the assumption regarding benefits and concerns of the communities when the project is implemented.

1.1 Objective of Stakeholder consultation

The objectives of Stakeholder consultation in Stage 2 planning of the structural flood protection measures demonstration project are to:

1. Better understand the priorities and needs of the community in flood risk management;
2. Get feedback on the demonstration project and incorporate the needs and priorities into the project;
3. Build capacity of NMC and Line Agencies in facilitating community consultation during the implementation of the demonstration project.

1.2 Scope of Stakeholder consultation

This stakeholder consultation in the Lower Xe Bang Fai in Khammouane Province is restricted to Nongbok District, as this area is highly flood prone. Flooding in this area is from the Xe Bang Fai, Mekong and also from rainfall in the floodplain area when it does not drain out quickly enough.

Although, consultation on the northern districts in Khammouane Province above Nongbok and on the Savannakhet Province on the left bank would provide more detailed information and capture the needs and priorities of a wider population, it was decided to focus only on Nongbok District given the time and budget limitations. This approach allowed conducting consultation with larger number of Line Agencies' representatives and the communities in Nongbok District.

The consultation educates the Line Agencies and communities on the demonstration project ideas and sets the stage for future participation. The consultation should be seen to build the rapport with the community, while getting initial feedback on the structural measures, its benefits and impacts on agriculture, fisheries, livelihoods and environment. While the time required to explain and knowledge level of communities may, at times, be insufficient to foresee the impact on environment issues. The output of this consultation captures the needs and priorities of the communities and Line Agencies representatives based on their experience in the area. This needs to be integrated into the design and the results of other studies related to environmental examination, agricultural development scenarios and economic impact studies.

2. Capacity Building of Line Agencies in Community Consultation

The public participation plan developed in Stage 1 envisaged that the consultation with the community would be done by the Line Agencies representatives and they be trained in conducting community consultation sessions. This plan was implemented in May 2009.

The LNMC and Line Agencies facilitators who have responsibility for making consultation at community level were selected by LNMC to implement a public participation plan in the demonstration project areas.

In Lower Xe Bang Fai, representatives from LNMC and Nongbok District Line Agencies were trained to facilitate community consultation on getting feedback on structural measures for flood protection. A community consultation facilitation guide was also prepared and translated into Lao language and the Line Agencies representatives were trained to facilitate community consultation (Attachment 5.1).

2.1 Learning Objective of Capacity Building of Line Agency

The objective of the capacity building exercise was that at the end of the implementation of the community consultation exercise, the line agency participants are able to:

1. Explain the need for public participation in structural flood protection project;
2. Explain how to conduct stakeholder analysis;
3. Conduct stakeholder consultation using participatory methods;
4. Summarise findings from stakeholder consultation exercise and propose alternative solution.

2.2 Participants

Based on the experience in preliminary stakeholder consultation in March 2009, the following participants were proposed for consultation in Lower Xe Bang Fai field area in Nongbok District:

1. One LNMC representatives;
2. One representative from WREA;
3. Khammouane Provincial Labour and Social Welfare (Provincial Disaster Management Committee) representative;
4. Labour and Social Welfare Officer representative, Nongbok District;
5. Line Agency representatives responsible for facilitating at community level in Nongbok District.
    a. One representative from Irrigation office, Nongbok District;
    b. One representative from Agriculture office, Nongbok District;
    c. One representative from Fishery Office, Nongbok District;
    d. One representative from Water and Environment Office, Nongbok District;
    e. One representative from Planning Office, Nongbok District;
6. Any NGO or Mass Organisation representatives at Nongbok District level.

Apart from these participants, the National Social Sector and Public Participation specialist and representative from a Lao PDR consulting group also participated to help with facilitation and translation. List of participants is in (Attachment 5.3).

2.3 Consultation with Line Agencies and Capacity Building

The capacity building focused on the need for community consultation and some of the tools that would be used in community consultation. The exercise also served to get feedback on the demonstration project from the Line Agencies participants.

In the plenary, the participants discussed the hazards, disasters or problems in Nongbok District and their proposed solution to overcome these hazards and disasters. The following hazards & disaster and solutions were highlighted.

Problems	Solution
Flood Rice Marketing Road Network Diseases during flood River Bank Erosion Insufficient Irrigation Irrigation Infrastructure destroyed by floods every year Drought	Create public awareness in the flood prone area Construction of dyke Flood control gates Supply additional seeds after flood damage to crops Supply boats Supply medicines Improve irrigation system Additional irrigation system Improve access to credit Widen natural drainage canals Increase cultivated area (low lying area during dry season) Organise market linkages

Flood is the most important hazard in Nongbok District. A number of disasters like destruction to houses and properties, diseases, erosion of river banks and damage to other infrastructure in the village occurred, causing loss to productive assets and hence further economic losses.

The solution proposed covers both structural and non-structural measures and creating financial and market support and linkages.

The participants were then divided into two groups and they prioritised the solution based on what they would choose depending on whether funding was available or not to implement the suggested solutions.

<u>Preferred Solution (funding is not a problem)</u>
For all the participants the preferred solution was:

1. Increase irrigation;
2. Dyke + Drainage + Pumps.

<u>Preferred Solution (No funding)</u>
This discussion was in three groups. The idea was to introduce consultation in separate groups giving opportunity for different perspectives and opinions to be expressed leading to further discussion, analysis and consensus building.

Group 1 and 3 focused on soft measures of improving irrigation during the dry season to create economic benefits through better credit and marketing. Group 2 focused on structural measures to control flood combined with non-structural measure of early warning system and supply of seeds and piglets during the wet season.

Group 1	Group 2	Group 3
1. Improve irrigation system; 2. Access to credit for pig rearing (Vientiane market); 3. Alternative crops: tobacco, vegetables.	1. Flood control gate: improve + new, widen drainage canals (construct dyke only in lower areas – flood proofing); 2. Public awareness: Early warning system; 3. supply seeds: rice + other crops; piglets.	1. Improve irrigation; 2. access to credit; 3. Marketing + price guarantee.

The demonstration project and the two proposed alternatives were introduced and consultation for feedback on the demonstration project was done in three groups. One group discussed Alternative 1 and the other two groups discussed Alternative 2.

Feedback	Group 1	Group 2	Group 3
Option	Dyke along Xe Bang Fai and Mekong	Dyke along Xe Bang Fai only	Dyke along Xe Bang Fai only
Positive	1. flood free; 2. Increase in livestock grazing area; 3. Village assets like schools, irrigation systems, offices will not be affected.	1. flood free; 2. reduction in animal disease; 3. crop productivity will increase; 4. ground water recharge will increase; 5. fish in Xe Bang Fail will increase.	1. Houses will not be damaged; 2. productivity will increase; 3. aquaculture will not be destroyed; 4. investment risk reduced 5. roads will not be affected; 6. village infrastructure will be safe.
Negative	1. Fish will decrease; 2. River bank erosion will increase.	1. river bank erosion; 2. level of flood could be higher than before in the villages; 3. dyke construction through paddy field (loss of productive land - land acquisition); 4. fish in floodplain will be reduced; 5. area near Mekong may be flooded.	1. fish will be reduced in floodplains; 2. river bank erosion will increase.
Conclusion	Positive impacts outweigh the negative impacts		

The major concern expressed by the participants is increase in erosion to river bank as the water level in the river will increase because of the dyke and flood control gates. The other concern is reduction of fish in the floodplains. Controlled flooding will ensure that fish catch does not diminish in the floodplains. River bank erosion is an issue that needs to be addressed in the design of the structural measures.

Participants recapped the steps in consultation and how creating structure of discussing in pairs and groups ensured that each and everyone in the group could participate to share their ideas. The participants expressed that the advantage of listening to everyone's idea was that a comprehensive set of solutions could be discussed and when implemented, it would satisfy everyone's needs.

2.3.1 Instructions on Community Consultation Steps

This set the stage for discussing how to conduct a community consultation session. The community consultation guide was introduced (Attachment 5.2). Are there different needs of people in the community in the event of flood? Are the people affected equally? Poverty, location of the house in the village, type of houses, women and children were some of the factors that would determine the way in which people would be impacted. All these groups of people would be affected differently and hence it is important to discuss with them separately in groups. How to conduct a vulnerability analysis was also explained.

The focus of the session was exploring with the participants their understanding of vulnerability or sensitivity of the people in the village to floods. The Line Agency participants had not been thinking of different effects of floods on different groups of people. This session helped them to understand the meaning of vulnerability and how to conduct vulnerability analysis and identify these groups in the community consultation session by exploring based on some criteria such as location within the village, age, gender, coping mechanism, and poverty level.

The steps in conducting vulnerability analysis were explained to the participants. This was followed by exploring the tools that would be employed by them in the community consultation. Group Discussion (separately with men, women, poverty groups), time Line (floods and its severity, other hazards), village asset mapping (location of schools, temples, govt. offices, houses, fields, irrigation infrastructure etc.) to understand vulnerability was explained.

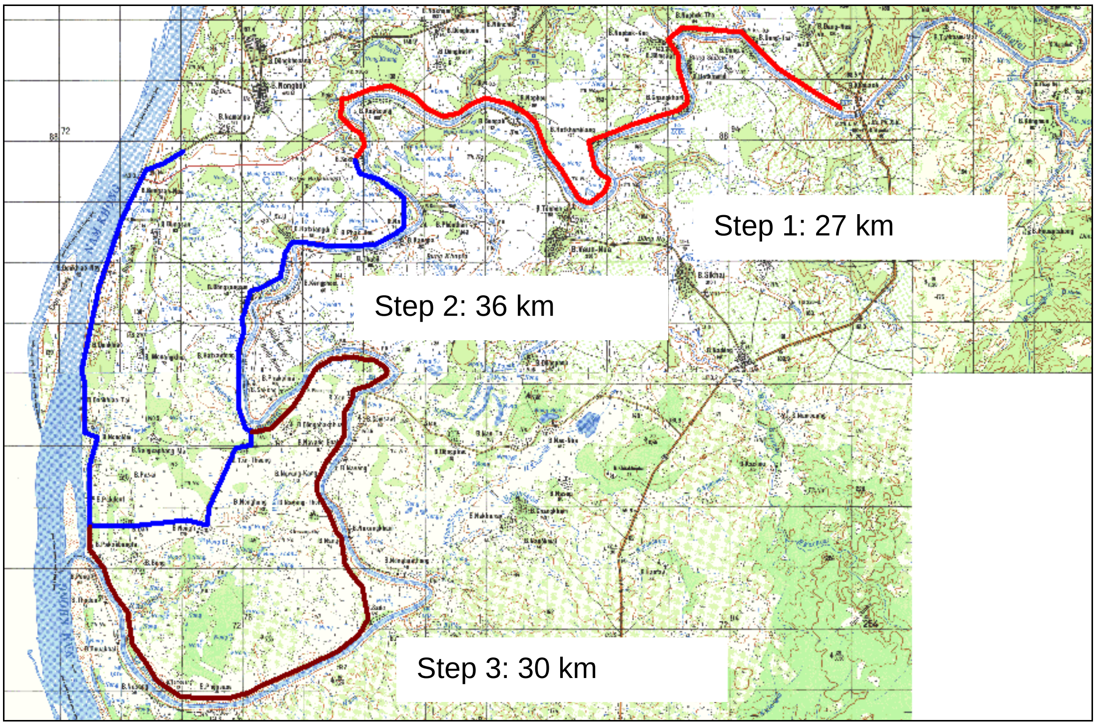
The steps in conducting community consultation exercise were explained to the participants. The logistics was finalised and the team was divided into four groups and villages were assigned.

	Group 1	Group 2	Group 3	Group 4
Team Members	Khonpachim Sukhi Khampeng	Khamphouthone Khamphene Phonapaseuth	Suvanno Inthaua Dilip Chinnakonda Malayveng	Khampeng Lat Than Sae Senpathy
Day 2 villages	Phon Soa Ae, Sam Nady, Sadoue	Tha Muang, Pakse, Non Glom	Hat Xieng Fong, Dong Samgam, Na Tay	Sok Boe, Phak Itu, Dong Kasin
Day 3 villages	Phone	Nongbok	Dong Khoung	Naman Pa

3. Implementation of Community Consultation

3.1 Lower Xe Bang Fai, Lao PDR

The project area refers primarily to the flood prone area of the Xe Bang Fai downstream of the crossing with the National Road Nr 13. The location of the area is shown in the following figure:



3.2 Demonstration Project Alternatives

The following two demonstration project alternatives were explained to the community to get their feedback with the help of the above map.

<u>Alternative 1:</u> Construction of dyke along right bank of Xe Bang Fai and Mekong rivers in three phases:

Phase 1
A dyke between Banne Nongbone in the Xe Bang Fai District, and Banne Sokbo in the Nongbok District (27 km), 4 new control gates at tributaries that discharge into Xe Bang Fai, 4 pumping stations, 3 km long drainage channel

Phase 2
The dyke will be extended over a length of 36 km from Banne Sokbo to Banne Bungsanetha, 4 new control gates and 5 gates will be repaired, 9 pumping stations, 5 km long drainage channel.

Phase 3
Another 30 km of dyke will be constructed between Banne Tantheung and Banne Dannepakse in the Nongbok District, 1 new control gates and 5 gates will be repaired, 2 pumping stations; 3 km long drainage channel.

Alternative 2:
Another consideration is to construct a dyke only along the Xe Bang Fai. The dyke runs between Banne Nongbone in the Xe Bang Fai District and Banne Danpakse in the Nongbok District and has a length of 65 km; 9 new control gates and 5 existing gates have to be repaired and drainage channel at 4 locations.

3.3 Selection of Villages

The Xe Bang Fai focal area encompasses Nongbok District which is located in the south western corner of Khammouane Province. The district is situated to the north of the Xe Bang Fai River between the Mekong River (to the west) and National Road Nr 13 South (NR13S) (to the east). It is affected annually by combined floods that are the result of the flat topography, high flows and poor conveyance capacity of the Xe Bang Fai River and high water levels in the Mekong River that back up into the tributary. A normal flood starts in mid-to-late July and lasts 15 to 30 days. There is usually one peak up to 1.5 m; waters rise over 5-7 days and then take about 30 days to recede.

A total of 16 villages were selected, which accounts for 22% of the 72 villages in Nongbok District. The villages were selected based on the vulnerability characteristics. Since the villages on the levee are more prone to flooding than villages in the hinterland, 12 villages on the levee were selected while the other 4 villages were selected from hinterland villages.

Xe Bang Fai Community Consultation Village list

Name	Riparian /Hinterland	Latitude	Longitude	Elevation (mts)
Dong Kasin	Riparian	17 5’17.14”	104 51’ 10.23”	143
Sok Boe	Riparian	17 3’41.31”	104 49’ 50.64”	145
Na Tay	Riparian	17 2’ 27.83”	104 50’ 29.01”	144
Phak Itou	Riparian	17 2’ 18.51”	104 49’ 54.27”	145
Dong Sangam	Riparian	17 1’ 18.10”	104 47’ 45.69”	150
HatXieng Fong	Riparian	17 0’ 4.76”	104 47’ 34.13”	144
Sam Nady	Riparian	16 59’ 33.23”	104 49’ 37.72”	145
Sadeu	Riparian	16 55’ 34.07”	104 50’ 3.24”	144
Phone Sao A	Riparian	16 54’ 9.67”	104 47’ 12.69”	141
Tha Muang	Riparian	16 54’ 11.56”	104 46’ 24.78”	142
Pakse	Riparian	16 56’ 45.09”	104 44’ 48.48”	139
Nong Lom	Riparian	16 58’39.68”	104 44’ 53.22”	146
Na Man Pa	Hinterland	17 4’ 18.93”	104 47’ 20.39”	150
Doung Khoung	Hinterland	17 5’ 45.88”	104 47’ 54.22”	161
Nongbok	Hinterland	17 4’38.85”	104 48’ 10.54”	152
Phone	Hinterland	close to Nongbok Town, location details not available		

Nearly everyone living in Nongbok District belongs to Tai speaking ethnic groups (96%), with only a small proportion of minority ethnic groups. Nongbok is not a designated priority poor district as identified in the poverty reduction strategies of the Government of Lao PDR (GoL).

According to a Social survey conducted in 2008, the ethnic and poverty conditions reduce the social vulnerability of these communities for the following reasons:

(i) These communities are culturally and linguistically homogenous. This contributes to effective social and community networks that are an important asset in dealing with flooding planning, response and recovery on an individual, household and community basis.

Everyone in the village is brothers and sisters, aunts and uncles or very close friends. So, during the flood they help each other out as a gift or a loan without interest (Nongbok Focal Groups).

(ii) The low levels of poverty mean that, in general, households in Nongbok are less vulnerable to harm caused by flooding and other natural disasters. People live in substantial housing, have livelihoods, assets and incomes that meet (or exceed) basic household needs, have better levels of health and education and other characteristics that enable them to protect themselves from flood damage and/or to recover more easily following flooding.

The implications for social vulnerability include:

(i) The large proportion of children in Nongbok tends to increase vulnerability to the impacts of flooding. Children are 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 during floods. If flooding damages schools, children's education will be disrupted. Moreover, the high dependency ratio places extra burdens on parents and other adults to provide for children's needs for food, shelter, etc.

Traditional methods of flood warning include markings on riverside trees, other markers on river banks and water levels at houses and other structures. These have been associated with staged actions such as relocating animals, removing possessions to upper levels of structures, stocking rice and water for one month, relocating children and elderly people and, finally, tying the house to nearby trees. The strength of this system was that it was easy for people to learn and remember, and it could indicate rather precisely when different actions should be taken. However, when a tree is cut or a portion of the riverbank is eroded, important markers are lost.

In Nongbok, different strategies have been used to respond to floods although the success has not been high according to FG participants:

The Office of Social Welfare is responsible for emergency response. The planning is done without consultation of people living in the area although they participate as much as possible in flood protection practice/drills. However, in a bad flood the waters rise too fast and too high.

3.4 Community Consultation in Xe Bang Fai

The consultation in 16 villages was carried out during two days by four teams consisting of 3 to 4 members each from Line Agencies. Each team consisting of Line Agencies' participants and one each from the facilitation group conducted community consultation exercises in four villages over two days.

The teams followed the steps in consultation, conducting vulnera-bility analysis and dividing the groups on this basis. About 20 villagers pre-selected by the village chief on the basis of criteria of equal representation of women and vulnerable people participated in the consultation.

The groups were either divided into men and women or poor and rich depending on the situation in the village. One of the important indicators of vulnerability during the floods was whether the families possessed a boat. Families with boat could easily move with their belongings to neighbouring villages, while the families without a boat were unable to move with their belongings easily. They had to wait until help arrived, which in most cases arrived too late and they were not in a position to save their belongings and food stock. In some villages, the consultation was done separately with the group that had boats and the group that did not have boats. In other villages, it was done separately with male and female groups. Phone Sao Ae and Tha Muang, located on the lower elevation had to be reached by boats as road access is not possible once it starts raining.

3.4.1 Summary of Group Presentations

The four groups presented a summary of consultation in the respective villages. The presentation was organised according to the consultation form. It was organised as follows: exploring hazards and disasters, feedback on demonstration project and preferred option, its benefits and negative impact, what changes they would bring in agriculture and other livelihoods after the demonstration project, the developments they want to see in their village, and what resources they could bring to the demonstration project.

The discussion on the location of dykes during the community consultation led to difference in opinion between men and women. The women would prefer to have the dyke in between the river and the village to protect the houses and livestock as well. However, they agree with the men when they argue that it poses greater risk in the event of dyke breaking. They also understand that if the dyke is to be constructed in between the village and the river, there should be at least 30 m distance between the river and the dyke. All the villages are too close to the river and many houses would have to be resettled if this option is chosen.

All groups in the 16 villages opted for the Alternative 2, which is construction of dyke along the right bank of Xe Bang Fai River with drainage and flood control gates.

In Xe Bang Fai, the attitude of the people is to reduce the existing risk and damage of flood and to have a modest improvement in livelihoods opportunities:

1. Dykes, flood control gates and irrigation systems are very important for them to reduce exposure of flood to the agriculture areas.
2. Irrigation system maintenance will become easier and this will reduce the cost of electricity and irrigation.

3. Most of the villages are too close to Xe Bang Fai River and hence they cannot be protected by dyke, although women would prefer to protect the village as well. The men would want to protect the agriculture land and live with floods in the village for few weeks. However, women demand that all the families in the village have boats, medicine, and safe shelter to move during the floods and remain disease free. They are not prepared to move as they are already on the higher ground.
4. Some villages like Dong Sangam can be protected by dykes and this option should be explored.
5. Dyke around the village (polder) option can be explored. In this case, the dyke should be higher than the agriculture dyke.
6. Land acquisition for dyke construction is a concern and they would prefer to be compensated with land rather than cash.
7. Impact on fishing and environment was not expressed clearly by the communities. They expressed that the amount of fish might be reduced. They are aware of fish migration and breeding and that majority of it takes place in the ponds in the floodplains.

Since the dyke will not protect the village from flooding, as it will be built between the village and the agricultural land on the existing road, it will be important to integrate non-structural measures and create opportunities to increase the number of boats in the village for vulnerable groups to move to neighbouring village with their belongings.

They are ready to participate in the construction of dyke and some are also willing to contribute land if it is a small portion. They are also willing to contribute labour for the construction of dyke.

The detailed consultation result is presented in the following table:

Presentation of Community Consultation
Province: Khammouane
District: Nongbok
Villages: 16 villages
Groups: 4

Description	Group 1	Group 2	Group 3	Group 4
Village	Phon Soa Ae, Sam Nady, Sadoue, Ban Phone.	Tha Muang, Pakse, Non glom, Nongbok.	Hat Xieng Fong, Dong Samgam, Na Tay, Dong Khoung.	SokBoe, Phak Itu, Dong Kasin, Naman pa.
Vulnerable groups	Women, children, elderly and families without boats.	Women, children, elderly and families without boats.	Women, children, elderly and families without boats.	Women, children, elderly and families without boats.
Hazards	Flood is the main hazard.	Flood	Flood	Floods (Aug to Sep)
Disasters due to flood	Apart from destruction to rice and cash crop, other disasters relate to River bank erosion. Houses at risk. Human and animal disease. 60% of households at risk.	Damage to paddy: 278 ha.	Damage to crops and also houses.	Rice crop. 174 ha in Sok Boe, 130 ha in Phak Itu and 200 ha in Dong Kasin. About 30 ha of cash crop destroyed.
Existing Structure	There are no existing structures for protecting against flood.	No structural measure to protect from floods.	No existing structures to protect from flood.	Floods occur every year and there are no structural measures to protect against the flood. Sand bags are provided by the Disaster committee.
Occupation	Farmers, merchants, labour.	Farmers, livestock, crops, fisheries, business (small number).	Farmers, livestock rearing, fisheries, business.	agriculture, fishing, pig rearing, hand-craft and small business in the village.

Description	Group 1	Group 2	Group 3	Group 4
Effect of flood				
Coping mechanism			Move animals to neighbouring village on higher ground.	The only coping mechanism is Early warning system, flood markings and moving animals to another village.
Feedback on Demo project	Their preferred option for dyke is to construct it along the road, which is outside the village and hence there will be minimal need for land acquisition or house resettlement. They see that drainage will be very important to ensure that rain water is drained out as well. They also would like to have pumping stations for removing rain water from the paddy fields in the low lying area into drainage canals. Their preferred option is option 2. Land acquisition is a concern for Bon Phone village (hinterland village), while the other three riparian villages are not concerned about losing small area of their land to construction of dyke.	Option 2 is preferred by Nongbok and Nong Lao and Option 1 is preferred by Tha Muang and Pakse.	Option 2, dyke only along the Xe Bang Fai River is the preferred option. Dyke construction is preferred on existing road in between the village and the agriculture land by three villages except Dong Sangam to protect the crops. They are willing to have floods in the village for a few weeks as they are used to living with the floods. Dong Sangam is located 100 m away from the river and hence they would prefer the dyke in between the river and the village to also protect the houses and other village assets. They suggest that the dyke should be about 2 m as the flood level is about 1.5 m in this village.	The preferred option is dyke along Xe Bang Fai only. They fear that dyke along the Mekong might not drain out water sufficiently causing flooding. Dyke construction might need acquisition of productive land and houses. They propose to avoid this situation. If this cannot be avoided they would like to receive land as compensation and not cash. They also propose to construct a flood control gate at Sok boe and drainage channels at Bam Na man pa and Thon Kala Tha.
Additional Structure	Flood control gates at Hoen Bonka di and Pakse, Heng Pa Nm to Sam Naday. Drainage from Nam Voun (Sam Naday), Nong Phakse	Flood control gates at 3 places.		

Description	Group 1	Group 2	Group 3	Group 4
Effect of flood				
Positive impact	Increase in rice production. Good road. Income from cash crop.	same as other groups.		The demonstration project will make the area flood free, which will help in increasing production of both wet season and dry season. Since the irrigation channels will not be destroyed or easier to maintain, they will also be able to grow some cash crop. This will also lead to reduction of payment for electricity as the water use efficiency will increase because of less wastage from irrigation channels. They will be able to use well water all year round. They will also be able to use toilets all the year round.
Negative Impact	On paddy land that is not protected by dyke. Productive area could reduce due to land acquisition for dyke construction and loss of fertilisation effect of floods.	land acquisition.	There could be potential negative impact on fishing as fish migration in the floodplain may be affected.	They don't see any major negative impact from the demonstration project, except for land acquisition because of the dyke building and loss of fishing during flooding season. The flood season also offers opportunity to travel in floodplain for social gathering and entertainment on higher ground. They will lose this social and entertainment benefit from the floods.

Description	Group 1	Group 2	Group 3	Group 4
Effect of flood				
Changes				From rice farming to aquaculture. Dry season rice to more wet season rice. Cash crops like corn, sugarcane instead of dry season rice.
Development	Village fund (credit). Better quality cash crop can be exported to Thailand.		Boats for 55 to 60 people. Hospital and medicines. Sand bags to protect from flood in case of big flood.	Village dispensaries (hospitals). Government run schools. Paved roads. Government offices in the village. Markets for a group of villages.
Resource	Contribute land for construction of dyke. Provide labour. Maintenance of structure.	Contribute labour for construction of dyke.	Contribute labour for construction of dyke.	Participate in construction of the dyke. Some agree to give their land for construction of dyke if it's a small portion of land they have to lose. Contribute labour. Load material.

Attachment 5.1 Stakeholder Consultation Implementation Schedule

Facilitator: Mr. Dilip Chinnakonda, Public Participation specialist supported by Mr. Sae Senpathy, National Public Participation Specialist

Day 1: May 26, 2009
Location: Thakhek
Venue: Disaster Management Committee office
Purpose: Instructions on Stakeholder Consultation Process

Time	**Topic**	**Resource / Method**
8:30 to 9:00	Registration	Registration sheet
9:00 to 9:15	Welcome and Opening	LNMC/WREA
9:15 to 9:45	Introduction to the consultation process and Expectations	Input
9:45 to 10:30	Introduction to the Xe Bang Fai Demonstration Project Options	Input
10:30 t0 10:45	Break	
10:45 to 11:30	Explore Participants' understanding of the need for Public Participation	Open Questions
11:30 to 12:00	Introduction to Public Participation Methods	Input
12:00 to 13:00	Lunch	
13:00 to 13:30	Introduction to Stakeholder Analysis	Input
13:30 to 14:30	Discuss a. Stakeholder Analysis Matrix b. Type of Information c. Questions to ask the Stakeholders Prepare Stakeholder Consultation plan for Day 2 and 3	Group Work
14:30 to 15:30	Presentation and discussion: How to conduct stakeholder consultation by participants	Plenary
15:30 to 15:45	Break	
15:45 to 16:30	Prepare Field Visit Consultation Logistics – Divide in 4 groups - Materials required - Transport - Tea / Lunch in the field - Number of stakeholders to be consulted by each group and expected outcome - ensure participation of all men, women and excluded communities	Plenary
16:30 to 17:00	Wrap Up	

Day 2: May 27, 2009
Location: Communities in Nongbok District
Tea and Lunch to be managed during field visit
Purpose: Consultation at community level

Time	**Activity**	**Resource / Method**
7:30	Depart for field	
9:00 to 10:00	Consultation with District level stakeholders	Information sharing, focused group discussion
10:00 to 10:30	Travel to field	
10:30 to 13:00	Community Consultation (first community) - Present Xe Bang Fai demonstration project Options - Vulnerability, Social analysis and impact on environment - Potential benefits and negative impact discussion - Alternative solution for potential problems from perspective of different stakeholders (men, women, vulnerable groups separately) - Development Vision of stakeholder	Information sharing – Visual Flip Charts, Maps PRA tools Transect walk Focused Group Discussion Visioning Exercise
13:00 to 13:30	Travel to second community	
13:30 to 16:00	Community Consultation (second community) Same as First Community	
16:00 to 17:00	Travel back	

Day 3: May 28, 2009
Location: Communities in Nongbok District
Tea and Lunch to be managed during field visit
Purpose: Consultation at community level

Time	**Activity**	**Resource / Method**
7:30	Depart for field	
09:00 to 09:30	Travel to field	
09:30 to 12:00	Community Consultation (third community) - Present Xe Bang Fai demonstration project options - Vulnerability, Social analysis and impact on environment - Potential benefits and negative impact discussion - Alternative solution for potential problems from perspective of different stakeholders (men, women, vulnerable groups separately) - Development Vision of stakeholder	Information sharing – Visual Flip Charts, Maps PRA tools Transect walk Focused Group Discussion Visioning Exercise
12:00 to 12:30	Travel to second community	
12:30 to 13:00	Community Consultation (fourth community) Same as above	
13:00 to 16:00	Travel back	
16:00 to 17:00	Summarise findings	

Day 4: May 29, 20009
Location: Thakhek
Venue: Disaster Management Committee Office, Thakhek
Purpose: Analysis of Community consultation

Time	**Topic**	**Resource / Method**
8:30 to 9:00	Introduction to day's activities and status check	
9:00 to 10:00	Prepare Presentation of Consultation	
10:00 t0 10:15	Break	
10:15 to 11:15	Group 1 Presentation - Consultation process - What was the experience - Summary of findings - What are the anticipated changes in the project - Discussion	Charts, Pens, Boards
11:15 to 12:15	Group 2 Presentation	
12:15 to 13:00	Lunch	
13:00 to 14:00	Group 3 Presentation	
14:00 to 15:00	Group 4 Presentation	
15:00 to 15:15	Break	
15:15 to 16:00	Summary and Further Consultation and Communication mechanism	
16:00 to 16:30	Wrap Up	

Attachment 5.2 Community Consultation Guide: Xe Bang Fai Demonstration Project, Nongbok District

1 Purpose of Consultation

The purpose of the consultation with the community is to get feedback on the structural measures options for flood control in the Lower Xe Bang Fai area. The project is at conceptualisation stage; hence it might be difficult to outline the detailed structures at village level. However, participation of stakeholders in discussing the conceptualised options can help in better design and planning of flood risk management in the subsequent stages.

This should be seen as an initial consultation to develop a common understanding about the options for flood control measures. It will lay the foundation for future consultations and greater participation of all stakeholders in decision making.

2 Village Selection

The consultations will be carried out during two days by four teams consisting of 3 to 4 members each. The team should be able to manage to visit at least two villages in a day. A total of 16 villages will be selected, which will account for 22% of the 72 villages in Nongbok District.

There are 20 villages along the Xe Bang Fai River and the other 18 villages in the hinterland that were chosen for selection. Only the villages along the Xe Bang Fai are prone to flooding. Hence, 12 villages will be selected along the Xe Bang Fai and the rest 4 will be selected from the Hinterland. Each team will cover visit 3 villages along the Xe Bang Fai River and one village in the hinterland.

3 Community Selection

While selecting the people in the village for consultation, equal representation of men, women, ethnicity and vulnerable groups should be considered. A village socio-economic profile can be used to randomly select the community members for participation.

3.1 Identifying Vulnerable Groups

Vulnerability is the term used to describe exposure to hazards or shocks. People are more vulnerable if they are more likely to be affected by events that are beyond their control like floods, storm, drought, earthquake etc.

Different people in a community will be affected differently by hazards. While planning for options to check the likelihood of occurrence of hazard or reduce the chances of occurrence of hazard, it is important to consult with different groups of people in the community who will be affected to hazards differently.

A vulnerability analysis should be conducted before conducting stakeholder consultation for getting feedback on the demonstration project options to ensure that the feedback from the community represents opinion of all groups of people, and especially the vulnerable group.

If vulnerability analysis for a village community was already conducted, then use the results from that analysis to do stakeholder consultation for the demonstration project options.

3.2 Steps

1. Introduce the purpose of meeting;
2. Explain what information will be collected and how will it benefit the community;
3. Explain how the information will be collected;
4. Explain the need for talking to all the groups in the village;
5. Explain what vulnerability is and participatory vulnerability analysis.

3.3 Vulnerability Analysis

The following information will help in identifying the vulnerable analysis;

1. Vulnerable levels by groups, location etc.;
2. Identifying flooding and other hazards, when they occurred and how often;
3. Differences in vulnerabilities by gender, age, ethnicity, location etc.;
4. How does each group cope with various hazards?
5. Identify the Govt. supported structures (like dykes, safe shelters etc.) and systems (early warning).

3.4 Tools

- Group Discussion (separately with men, women, ethnicity);
- Time Line (floods and its severity, other hazards);
- Village asset mapping (location of schools, temples, govt. offices, houses, fields, irrigation infrastructure etc.).

3.5 Key Questions

1. What are the major hazards that the village has been faced with in the past. When did it occur, what the level of damage was?
2. Which groups of households are more exposed to flooding and other hazards in the village?
3. Why were some groups able to cope better than the others?
4. What are the existing structures and systems for coping with floods and other hazards?

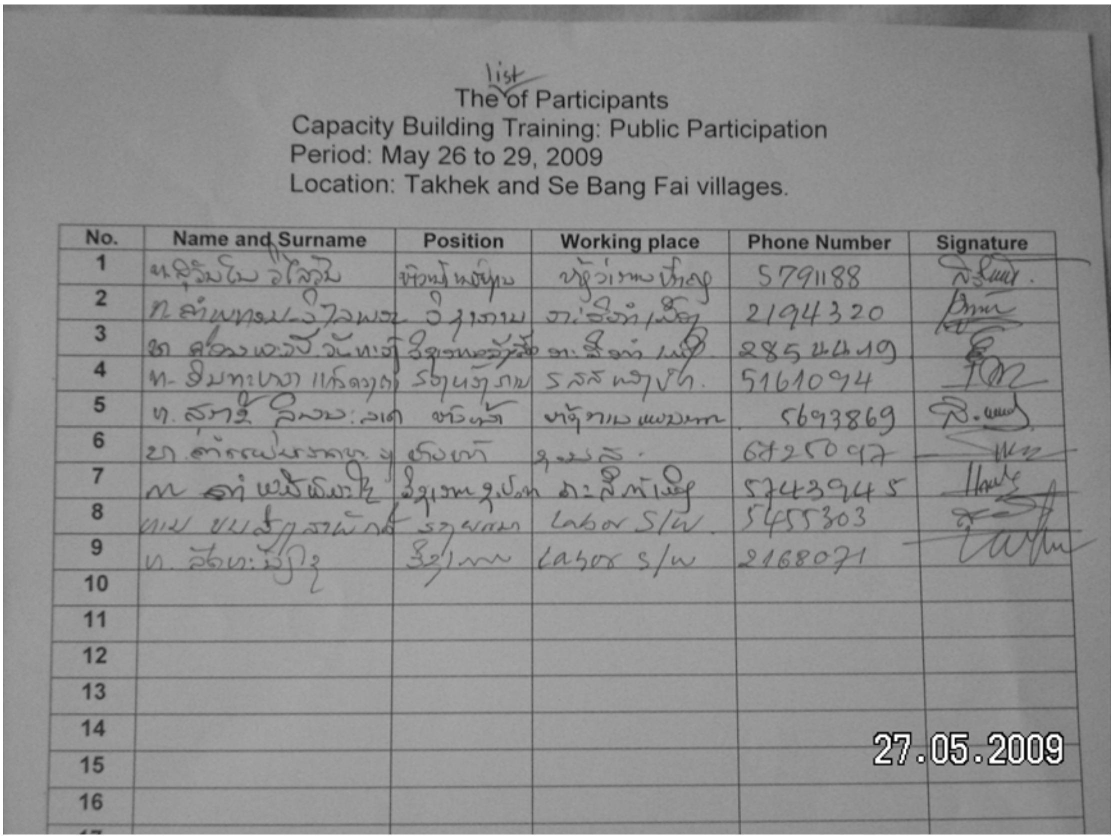
3.6 Steps in Community Consultation

1. Divide the larger group into smaller groups based on the vulnerability analysis;
2. Present the demonstration project options poster;
3. Explain the likely structure in the village;
4. Explain the intended benefits; which people are likely to benefit and in what way;
5. Facilitate focused group discussion (smaller interest groups based on vulnerability) to collect feedback on the demonstration project options using PRA tools;
6. Jot down on the chart paper, concerns expressed by the smaller interest groups and discuss;
7. Note down solutions suggested by them to address the concerns;
8. Analyse the options with the people and conclude which option is likely to work and which one is not likely to work and why;
9. Use the questions in the consultation analysis form, note down on chart paper and fill the form.

Community Consultation Analysis Form

Community Background
Name of Country :
Name of District :
Name of Village :
No. of Households :
Name of Group consulted : (e.g vulnerable men, vulnerable women, better off men, better of women)
 Vulnerability Analysis
• What are the major hazards that the village has been faced with in the past. When did it occur, what was the level of damage? • How was this group of households affected by flooding and other hazards in the village? • How was this group able to cope with flooding and other hazards? • What are the existing structures and systems for coping with floods and other hazards? What is the livelihood for this group (e.g. rice, fishing, labour, business etc.).
Feed-back on Demonstration project Options
Structural Measures
• Which option is preferred by this group? • Does this group perceive any clash with neighbouring village or community because of the structures? • What is the major concern about each of the options? • What solution does this group suggest for the problems with flooding in relation to the proposed options? • What type of flood control or mitigation structure would this group want for their village, where should they be located in the village and why?
Intended Benefits
• Does this group perceive the same intended benefit of the demonstration project options? • What negative impacts does this group perceive (on agriculture, fisheries, environment)? • How will the different demonstration project options impact their present livelihood? • What changes in cropping, fishing or any other livelihood activity will this group make if the demonstration project option is implemented and why?
Development Vision
• What type of development does this group want to see in the village and why? • What additional support systems would be required to capitalise on the benefits of the demonstration project options – if this group is in favour of demo project options?
Future Participation
• How does this group want to be engaged in flood control structural measure project in future? • What resource can this group bring to such project?
Evaluation of Consultation
• To what extent did the group understand the demonstration project options and their purpose? • What additional information does this group require to answer the questions in a better way?

Attachment 5.3 List of Line Agencies Participants



The list of Participants
Capacity Building Training: Public Participation
Period: May 26 to 29, 2009
Location: Takhek and Se Bang Fai villages.

No.	Name and Surname	Position	Working place	Phone Number	Signature
1	[illegible]	[illegible]	[illegible]	5791188	[illegible]
2	[illegible]	[illegible]	[illegible]	2194320	[illegible]
3	[illegible]	[illegible]	[illegible]	2854419	[illegible]
4	[illegible]	[illegible]	[illegible]	5161094	[illegible]
5	[illegible]	[illegible]	[illegible]	5693869	[illegible]
6	[illegible]	[illegible]	[illegible]	6425097	[illegible]
7	[illegible]	[illegible]	[illegible]	5743945	[illegible]
8	[illegible]	[illegible]	Labor S/W	5455303	[illegible]
9	[illegible]	[illegible]	Labor S/W	2168071	[illegible]
10					
11					
12					
13					
14					
15					
16					

27.05.2009

Attachment 5.4 Consultation by sub-groups within the 16 villages

Group 1
Riparian Village:
Nonglom
Thamuang
Dan Pakse
Hinterland village
Nong Bok
Facilitators:
Khonphachan
Soukkhy

	Phonsao E		Sadeu		Sam Nadee	
	Men	Women	Men	Women	Men	Women
Vulnerability Analysis						
What are the major hazards that the village has been faced with in the past. When did it occur, what was the level of damage?						
Flood normally occurs during August to September	1	1	1	1		1
How was this group of households affected by flooding and other hazards in the village?						
Rice crop destroyed (ha)	1	1	1	1	1	1
Road destroyed		1	1		1	1
Toilet disrupted	1	1		1		1
Irrigation canal destroyed			1		1	1
Cash crop destroyed (ha)	1	1	1	1	1	
grazing land disrupted	1		1	1		1
Fishpond destroyed	1	1		1	1	
Student absent from school		1		1	1	
Spend money on repair houses and toilet						
Spend money on repair irrigation canal						
Spend money on repair houses						
Spend money to repair temple						
How was this group able to cope with flooding and other hazards?						
Traditional warning meter as a tree or made of stake on the bank of the river warning villagers on time:	1		1		1	
Move to temporary safety place	1	1	1	1	1	1
Move animals and collect grass for buffalo and cattle	1	1	1	1	1	1
Move pigs and spare animal feeds	1		1			
Prepare spare man's food		1		1		1
Take a chance to fish for sale and household consumption	1		1		1	
What are the existing structures and systems for coping with floods and other hazards?						
Nothing	1	1	1	1	1	1
Sand bags	0	0	0	0	0	0
What is the livelihood for this group (e.g. rice, fishing, labor, business etc.)						

	Phonsao E		Sadeu		Sam Nadee	
	Men	Women	Men	Women	Men	Women
Wet paddy farmer	1	1	1	1	1	1
Dry paddy farmer						
Crash crop farmer	1	1	1	1	1	1
Fishery	1		1		1	1
Small trader	1	1	1	1	1	1
Laborer	1		1		1	
Feedback on demonstration project options						
Structural Measures						
Which option is preferred by this group?						
From Nongbone to Dan Pakse to Dong Nasan	1	1	1	1	1	1
From Nongbone to Dan Pakse	1	1	1	1	1	1
Does this group perceive any clash with neighboring village or community because of the structures?						
Clash with neighbors	0	0	0	0	0	0
No clash at all	1	1	1	1	1	1
What is the major concern about each of the options?						
Paddy land acquisition		1	1			1
Garden land acquisition						
Residential land acquisition	1		1			1
Houses						
Trees						
What solution does this group suggest for the problems with flooding in relation to the proposed options						
Compensation in cash	1	1	1	1	1	1
Compensation in land by land	0	0	0	0	0	0
Contribution	0	0	0	0	0	0
What type of flood control or mitigation structure would this group want for their village, where should they be located in the village and why?						
Flood control gate	1		1		1	
Drainage	1	1	1	1	1	1
Pumping station						
Does this group perceive the same intended benefit of the demonstration project options?						
As all the area will be free from flood:	1	1	1		1	1
Full paddy area, wet and dry will be utilized for cultivation	1	1		1	1	
Irrigation facilities will be fully used		1	1		1	1
All lands can be used for diversified crops						
Save time and labor from not to do with:						
Maintenance of irrigation canals	1	1		1	1	1
House maintenance						
Grazing land rehabilitation	1	1	1		1	1
Animal pen rehabilitation	1		1	1	1	1
Fishpond maintenance						
Having large production rice	1	1	1		1	1
Having large production cash crop						

	Phonsao E		Sadeu		Sam Nadee	
	Men	Women	Men	Women	Men	Women
Having large number of animals because of:	1	1	1	1		1
Availability of grazing area	1		1	1	1	1
Animals are free from diseases						
Large production raised fish for sale as:						
Fish ponds remain in good condition						
Fish are not gone with water and growing very well	1	1		1	1	1
Having good diet as plenty of rice, fruit, vegetable, fish and meat						
Large production rice for sale	1		1	1		1
Large production cash crop for sale						
Large number of animals for sale as:	1	1	1	1	1	1
Availability of grazing area	1		1		1	
Animals are free from diseases		1	1	1	1	1
Have more time to earn income from selling labor						
Have good road with good transportation	1	1	1	1	1	1
Have good health and sanitation as:	1	1	1	1	1	1
Good drinking water supply		1		1		1
Good toilet	1		1		1	1
What negative impacts does this group perceive (on agriculture, fisheries, environment)?						
Loss of paddy land	1		1	1	1	
Loss of residential land		1	1		1	1
Loss of garden land	1	1		1		1
Loss of houses	1	1	1	1	1	1
Water will not drained well						
How will the different demonstration project options impact their present livelihood?						
None	1	1	1	1	1	1
What changes in cropping, fishing or any other livelihood activity will this group make if the demonstration project option is implemented and why?						
From dry paddy to wet paddy	1		1	1		1
From wet paddy to fish ponds	1	1		1	1	1
From dry paddy to fish pond	1		1	1	1	1
From pig raising to fish culture	1	1	1	1		
From farmer to agriculture trader	1	1	1	1		1
What type of development does this group want to see in the village and why?						
Good road						
Good hospital with doctors and medication						
A village-group market						
Village funds						

	Phonsao E		Sadeu		Sam Nadee	
	Men	Women	Men	Women	Men	Women
What additional support systems would be required to capitalize on the benefits of the demonstration project options – if this group is in favor of demo project options						
Credit with low interest						
How does this group want to be engaged in flood control structural measure project in future?						
Yes	1	1	1	1	1	1
What resource can this group bring to such a project?						
Land where structure site will be located	1		1		1	1
Earth for filling						
Poles						
Bamboo						
Labor	1		1		1	
Coordination	1		1		1	
To what extent did the group understand the demonstration project options and their purpose?	1					
Very well (100%)	1	1	1	1	1	1
Ok	1	1	1	1	1	1
Not well	0	0	0	0	0	0
What additional information does this group require to answer the questions in a better way?						
None	1	1	1	1	1	1

Group 2
Riparian Village:
Sam Nadee
Sadeu
Phosao E
Hinterland village
Phon
Facilitators:
Khamphouthone
Khamphene

	Nong Lom		Thamuang		Pakse	
	Men	Women	Men	Women	Men	Women
Vulnerability Analysis						
What are the major hazards that the village has been faced with in the past. When did it occur, what was the level of damage?						
Flood normally occurs during August to September	1	1	1	1	1	1
How was this group of households affected by flooding and other hazards in the village?						
Rice crop destroyed (ha)	1	1	1	1	1	1
Road destroyed	1	1	1	1	1	1
Toilet disrupted		1		1	1	1
Irrigation canal destroyed	1	1	1	1		1
Cash crop destroyed (ha)						
grazing land disrupted	1		1	1	1	1
Fishpond destroyed	1	1	1	1	1	1
Student absent from school						
Spend money on repair houses and toilet						
Spend money on repair irrigation canal						
Spend money on repair houses						
Spend money to repair temple						
How was this group able to cope with flooding and other hazards?						
Traditional warning meter as a tree or made of stake on the bank of the river warning villagers on time:						
Move to temporary safety place	1	1	1	1	1	1
Move animals and collect grass for buffalo and cattle	1		1	1		1
Move pigs and spare animal feeds	1	1	1	1		1
Prepare spare man's food	1	1	1		1	1
Take a chance to fish for sale and household consumption						
What are the existing structures and systems for coping with floods and other hazards?						
Nothing	1	1	1	1	1	1
Sand bags	0	0	0	0	0	0
What is the livelihood for this group (e.g. rice, fishing, labor, business etc.)						
Wet paddy farmer	1	1	1	1	1	1
Dry paddy farmer						

	Nong Lom		Thamuang		Pakse	
	Men	Women	Men	Women	Men	Women
Crash crop farmer	1		1	1	1	1
Fishery	1	1	1		1	1
Small trader	1		1	1	1	1
Laborer	1	1	1	1	1	
Feedback on demonstration project options						
Structural Measures						
Which option is preferred by this group?						
From Nongbone to Dan Pakse to Dong Nasan	1	1	1	1	1	1
From Nongbone to Dan Pakse	0	0	0	0	0	0
Does this group perceive any clash with neighboring village or community because of the structures?						
Clash with neighbors	0	0	0	0	0	0
No clash at all	1	1	1	1	1	1
What is the major concern about each of the options?						
Paddy land acquisition	1		1	1		1
Garden land acquisition						
Residential land acquisition						
Houses	1	1		1	1	
Trees						
What solution does this group suggest for the problems with flooding in relation to the proposed options?						
Compensation in cash	1	1		1	1	1
Compensation in land by land						
Contribution						
What type of flood control or mitigation structure would this group want for their village, where should they be located in the village and why?						
Flood control gate	1	1	1	1		1
Drainage			1	1		1
Pumping station	1	1			1	1
Does this group perceive the same intended benefit of the demonstration project options?						
As all the area will be free from flood:						
Full paddy area, wet and dry will be utilized for cultivation	1	1	1	1		1
Irrigation facilities will be fully used	1		1		1	1
All lands can be used for diversified crops						
Save time and labor from not to do with:						
Maintenance of irrigation canals	1	1		1	1	
House maintenance						
Grazing land rehabilitation						
Animal pen rehabilitation						
Fishpond maintenance						
Having large production rice	1	1		1	1	1
Having large production cash crop						
Having large number of animals because of:	1		1	1	1	1
Availability of grazing area		1	1	1		1
Animals are free from diseases	1	1		1	1	1
Large production raised fish for sale as:						

	Nong Lom		Thamuang		Pakse	
	Men	Women	Men	Women	Men	Women
Fish ponds remain in good condition	1	1	1		1	1
Fish are not gone with water and growing very well						
Having good diet as plenty of rice, fruit, vegetable, fish and meat						
Large production rice for sale	1	1	1	1	1	1
Large production cash crop for sale						
Large number of animals for sale as:						
Availability of grazing area		1	1		1	
Animals are free from diseases	1	1		1	1	1
Large production raised fish for sale as:						
Fish ponds remain in good condition						
Fish are not gone with water and growing very well						
Have more time to earn income from selling labor	1	1	1		1	1
The cost of maintenance of irrigation canals						
The cost of house maintenance						
The cost of grazing land rehabilitation						
The cost of animal pen rehabilitation						
The cost of fishpond maintenance						
Cost of electricity for irrigation water	1		1	1	1	1
The cost of household medication						
The cost of veterinary service	1	1	1	1		1
The cost of house maintenance						
The cost of grazing land rehabilitation						
The cost of animal pen rehabilitation						
The cost of fishpond maintenance						
The cost of agriculture added cost of production						
The purchase of fingerlings						
The purchase of seeds and seedlings						
The purchase of drinking water	1		1		1	1
The cost of boat transport						
Have good road with good transportation	1	1	1	1		1
Have good health and sanitation as:						
Good drinking water supply	1	1		1	1	
Good toilet		1	1	1	1	1
What negative impacts does this group perceive (on agriculture, fisheries, environment)?						
Loss of paddy land	1		1	1	1	1
Loss of residential land						
Loss of garden land	1		1	1		1
Loss of houses	1	1		1	1	1
Water will not drained well						
How will the different demonstration project options impact their present livelihood?						
None						
What changes in cropping, fishing or any other livelihood activity will this group make if the demonstration project option is implemented and why?						
From dry paddy to wet paddy	1		1	1		1
From wet paddy to fish ponds	1	1		1	1	1

	Nong Lom		Thamuang		Pakse	
	Men	Women	Men	Women	Men	Women
From dry paddy to fish pond	1	1	1		1	1
From pig raising to fish culture		1	1	1	1	1
From farmer to agriculture trader	1	1	1	1		1
What type of development does this group want to see in the village and why?						
Good road	1		1	1	1	1
Good hospital with doctors and medication	1	1	1	1		1
A village-group market		1	1		1	1
Village funds	1	1	1	1	1	
What additional support systems would be required to capitalize on the benefits of the demonstration project options – if this group is in favor of demo project options						
Credit with low interest	1	1	1	1	1	1
How does this group want to be engaged in flood control structural measure project in future?						
Yes	1	1	1	1	1	1
What resource can this group bring to such a project?						
Land where structure site will be located	1	1	1	1	1	1
Earth for filling						
Poles						
Bamboo						
Labor	1	1	1	1	1	1
Coordination						
To what extent did the group understand the demonstration project options and their purpose?						
Very well (100%)	1	1	1	1	1	1
Ok	1	1	1	1	1	1
Not well	0	0	0	0	0	0
What additional information does this group require to answer the questions in a better way?						
Nothing	1	1	1	1	1	1

Group 3
Riparian Village:
Na Tai
Hatxaiphong
Dong SaNgam
Hinterland village
Dongkhouang
Facilitators:
Souvano
Inthava

Village:	Natai		Hatxaiphong		Dong Sangasm	
	Who has boasts	Who have boats	Who has boats	Who have boats	Who has boats	Who have boats
Vulnerability Analysis						
What are the major hazards that the village has been faced with in the past. When did it occur, what was the level of damage?						
Flood normally occurs during August to September	1	1	1	1	1	1
Normal flood occurs every year, by heavy one is every 3 years	1	1	1	1	1	1
How was this group of households affected by flooding and other hazards in the village?						
Rice crop destroyed (ha)	>100	1	192	1	1	1
Road destroyed	1	1	1	1	1	1
Diarrhea and dysentery epidemy	1	1	1	1	1	1
Animal disease epidemy	1	1	1	1	1	1
Toilet disrupted	1	1	1	1	1	1
Irrigation canal destroyed	1	1	1	1	1	1
Cash crop destroyed (ha)						
grazing land disrupted	1	1	1	1	1	1
Fishpond destroyed	1	1	1	1	1	1
Student absent from school						
Spend money on repair houses and toilet						
Spend money on repair irrigation canal						
Spend money on repair houses						
Spend money to repair temple						
How was this group able to cope with flooding and other hazards?						
Traditional warning meter as a tree or made of stake on the bank of the river warning villagers on time:						
Move to temporary safety place	1	1	1	1	1	1
Move animals and collect grass for buffalo and cattle	1	1	1	1	1	1
Move pigs and spare animal feeds						
Prepare food as much as possible	1	1	1	1	1	1

Village:	Natai		Hatxaiphong		Dong Sangasm	
	Who has boasts	Who have boats	Who has boats	Who have boats	Who has boats	Who have boats
Take a chance to fish for sale and household consumption	1	1	1	1	1	1
What are the existing structures and systems for coping with floods and other hazards?						
Nothing	1	1	1	1	1	1
Sand bags	0	0	0	0	0	0
What is the livelihood for this group (e.g. rice, fishing, labour, business etc.)?						
Wet paddy farmer	1	1	1	1	1	1
Dry paddy farmer	1	1	1	1	1	1
Crash crop farmer						
Fishery	1	1	1	1	1	1
Small trader	1	1	1	1	1	1
Laborer						
Feedback on demonstration project options						
Structural Measures						
Which option is preferred by this group?						
(1) From Nongbone to Dan Pakse to Dong Nasan	1	1	1	1	1	1
(2) From Nongbone to Dan Pakse	0	0	0	0	0	0
Does this group perceive any clash with neighboring village or community because of the structures?						
Clash with neighbors	0	0	0	0	0	0
No clash at all	1	1	1	1	1	1
What is the major concern about each of the options?						
May lose paddy land due to dike and drainage project	1	1	1	1	1	1
May lose garden land						
May lose residential land	1	1	1	1	1	1
Houses	1	1	1	1	1	1
Trees						
What solution does this group suggest for the problems with flooding in relation to the proposed options?						
Compensation	0	0	0	0	0	0
Compensation in cash	0	0	0	0	0	0
Compensation in land by land	0	0	0	0	0	0
Contribution	0	0	0	0	0	0
What type of flood control or mitigation structure would this group want for their village, where should they be located in the village and why?						
Flood control gate	1	1	1	1	1	1
Drainage from Houay Khe to Bung Sane	1	1	1	1	1	1
Pumping station						
Dike crossing way						

Village:	Natai		Hatxaiphong		Dong Sangasm	
	Who has boasts	Who have boats	Who has boats	Who have boats	Who has boats	Who have boats
Does this group perceive the same intended benefit of the demonstration project options?						
Increase wet rice production	1	1	1	1	1	1
Increase dry rice production	1	1	1	1	1	1
Have good road	1	1	1	1	1	1
Increase animals	1	1	1	1	1	1
have more fish in fish ponds	1	1	1	1	1	1
increase cash crop production	1	1	1	1	1	1
Reduce electricity charged by irrigation						
Have well water all year round	1	1	1	1	1	1
Reduce toilet repair cost						
What negative impacts does this group perceive (on agriculture, fisheries, environment)?						
Due to construction, they are afraid of:			1	1	1	1
Loss of paddy land			1	1	1	1
Loss of residential land			1	1	1	1
Loss of garden land						
Loss of houses						
Fish in natural fish will reduce						
loss fertility of land	1	1				
Water will not drained well						
How will the different demonstration project options impact their present livelihood?						
None	1	1	1	1	1	1
No chance to fish in flood	0	0	0	0	0	0
Difficult to cross the dike to access to paddy field	1	1	1	1	1	1
What changes in cropping, fishing or any other livelihood activity will this group make if the demonstration project option is implemented and why?						
Some people said that they will change:						
From dry paddy to wet paddy	1	1	1	1	1	1
From wet paddy to fish ponds						
From dry paddy to fish pond	1	1	1	1	1	1
From pig raising to fish culture						
From farmer to agriculture trader		1	1	1		1
What type of development does this group want to see in the village and why?						
Good road	1		1		1	
Good hospital with doctors and medication		1		1		1
A village-group market	1	1	1	1	1	1
Village funds		1		1		1
Village Office	1		1		1	

Village:	Natai		Hatxaiphong		Dong Sangasm	
	Who has boasts	Who have boats	Who has boats	Who have boats	Who has boats	Who have boats
What additional support systems would be required to capitalize on the benefits of the demonstration project options – if this group is in favor of demo project options?						
Credit with low interest		1		1		1
Rice and cash crop marketing contract	1		1		1	
How does this group want to be engaged in flood control structural measure project in future?						
Yes	1	1	1	1	1	1
What resource can this group bring to such a project?						
Some land where structure site will be located	1	1	1	1	1	1
Earth for filling						
Poles						
Bamboo						
Labor	1	1	1	1	1	1
Coordination						
To what extent did the group understand the demonstration project options and their purpose?						
Very well (100%)	1	1	1	1	1	1
Ok	1	1	1	1	1	1
Not well	0	0	0	0	0	0
What additional information does this group require to answer the questions in a better way?						
Nothing more	1	1	1	1	1	1
Some better picture	1	1	1	1	1	1

Community Consultation Form

Community Background

Country: Lao PDR

Province: Khammouane

District: Nongbok

Group: 4

Facilitators: Khamphoumy Latthanouxay

Village:	Dongkasin				Sor Boe			Phak I Too		
	Men well off	Men poor	Women well off	Women poor	Men well off	Men poor	Women	Men well off	Men poor	Women
Vulnerability Analysis										
What are the major hazards that the village has been faced with in the past. When did it occur, what was the level of damage?										
Flood normally occurs during August to September			1	1	1	1	1	1	1	1
How was this group of households affected by flooding and other hazards in the village?										
Rice crop destroyed (ha)	130				174			200		
Road destroyed	1	1	1	1	1	1	1	1	1	1
Toilet disrupted	1	1			1	1	1	1	1	1
Irrigation canal destroyed	1	1			1	1	1	1	1	1
Cash crop destroyed (ha)	30				1	1	1	1	1	1
grazing land disrupted	1	1	1		1	1	1	1	1	1
Fishpond destroyed			1	1	1	1	1	1	1	1
Student absent from school							1			
Spend money on repair houses and toilet							1			
Spend money on repair irrigation canal							1			
Spend money on repair houses							1			
Spend money to repair temple							1			
How was this group able to cope with flooding and other hazards?										
Traditional warning meter as a tree or made of stake on the bank of the river warning villagers on time:	1	1			1	1		1	1	
Move to temporary safety place	1	1	1	1	1	1	1	1	1	1
Move animals and collect grass for buffalo and cattle	1	1			1	1	1		1	1
Move pigs and spare animal feeds	1	1			1	1	1	1		1
Prepare food as much as possible			1	1	1	1	1	1	1	1
Take a chance to fish for sale and household consumption			1	1	1	1	1		1	1
What are the existing structures and systems for coping with floods and other hazards?										
Nothing	0	0	0	0	0	0	0	1	1	1

Village:	Dongkasin				Sor Boe			Phak I Too		
	Men well off	Men poor	Women well off	Women poor	Men well off	Men poor	Women	Men well off	Men poor	Women
Sand bags	0	0	0	0	1	1	1	0	0	0
What is the livelihood for this group (e.g. rice, fishing, labor, business etc.)?										
Wet paddy farmer	1		1	1	1	1		1	1	1
Dry paddy farmer	1		1		1	1	1	1		1
Crash crop farmer		1	1	1	1	1		1		1
Fishery	1		1	1	1	1	1	1	1	1
Small trader		1	1	0	1	1		1	1	1
Laborer	1	1			1	1	1	1	1	1
Feedback on demonstration project options										
Structural Measures										
Which option is preferred by this group?										
1) From Nongbone to Dan Pakse to Dong Nasan	1	1	1	1	1	1	1	1	0	1
2) From Nongbone to Dan Pakse	0	0	0	0	0	0	0	0	1	0
Does this group perceive any clash with neighboring village or community because of the structures?										
Clash with neighbors	0	0	0	0	0	0	0	1	1	0
No clash at all	1	1	1	1	1	1	1	0	0	1
What is the major concern about each of the options?										
May lose paddy land due to dike and drainage project	1		1	1		1	1	1	1	1
May lose garden land						1	1	1	1	1
May lose residential land					1	1	1	1	1	1
Houses			1	1		1	1	1	1	1
Trees		1			1	1	1	1	1	1
What solution does this group suggest for the problems with flooding in relation to the proposed options										
Compensation			1	1	1	1	1	1	1	1
Compensation in cash										
Compensation in land by land										
Contribution			1	1	1	1	1	1	1	1
What type of flood control or mitigation structure would this group want for their village, where should they be located in the village and why?										
Flood control gate	1	1			1	1	1	1	1	1
Drainage	1	1			1	1	1	1	1	1
Pumping station	1	1			1	1	1	1	1	1
Dike crossing way							1			
Does this group perceive the same intended benefit of the demonstration project options?										
Increase wet rice production	1	1	1	1	1		1	1		1

Village:	Dongkasin				Sor Boe			Phak I Too		
	Men well off	Men poor	Women well off	Women poor	Men well off	Men poor	Women	Men well off	Men poor	Women
Increase dry rice production			1	1	1	1	1		1	1
Have good road	1	1	1	1	1	1	1	1	1	1
Increase animals	1	1	1	1	1	1	1	1	1	1
have more fish in fish ponds	1		1	1	1		1		1	1
increase cash crop production	1		1	1	1	1	1	1	1	1
Reduce electricity charged by irrigation	1		1		1	1	1		1	1
Have well water all year round					1	1	1	1	1	1
Reduce toilet repair cost							1			1
What negative impacts does this group perceive (on agriculture, fisheries, environment)?										
Due to construction, they are afraid of:						1	1	1	1	1
Loss of paddy land			1	1		1	1	1	1	
Loss of residential land			1	1		1	1	1	1	
Loss of garden land		1		1			1			1
Loss of houses		1		1	1	1	1	1	1	
Fish in natural fish will reduce	1	1	1	1	1		1			
loss fertility of land	1	1	1	1	1		1			
Water will not drained well	1	1	1	1	1	1	1	1	1	1
How will the different demonstration project options impact their present livelihood?										
None	1	1			1			1		
No chance to fish in flood		1		1		1	1		1	1
Difficult to cross the dike to access to paddy field			1	1			1		1	1
What changes in cropping, fishing or any other livelihood activity will this group make if the demonstration project option is implemented and why?										
Some people said that they will change:						1	1	1	1	
From dry paddy to wet paddy		1			1	1	1	1	1	1
From wet paddy to fish ponds	1	1			1		1	1	1	
From dry paddy to fish pond	1	1	1			1	1	1	1	1
From pig raising to fish culture			1	1	1		1	1	1	
From farmer to agriculture trader			1	1	1		1	1	1	1
What type of development does this group want to see in the village and why?										
Good road	1	1	1	1	1	1	1	1	1	1
Good hospital with doctors and medication	1	1	1	1	1	1	1	1		1
A village-group market	1	1	1	1	1	1	1	1	1	1
Village funds	1	1	1	1	1	1	1		1	
Village Office	1	1			1	1	1			

Village:	Dongkasin				Sor Boe			Phak I Too		
	Men well off	Men poor	Women well off	Women poor	Men well off	Men poor	Women	Men well off	Men poor	Women
What additional support systems would be required to capitalize on the benefits of the demonstration project options – if this group is in favor of demo project options										
Credit with low interest			1	1	1	1	1	1	1	1
Rice and cash crop marketing contract					1	1	1	1	1	1
How does this group want to be engaged in flood control structural measure project in future?										
Yes	1				1	1	1	1	1	1
What resource can this group bring to such a project?										
Some land where structure site will be located	1	1	1		1		1			
Earth for filling	1	1			1		1			
Poles	1	1			1	1	1	1	1	1
Bamboo	1	1	1	1	1	1	1	1	1	1
Labor	1	1		1	1	1	1	1	1	
Coordination	1	1	1	1	1		1	1	1	
To what extent did the group understand the demonstration project options and their purpose?										
Very well (100%)	1		1	1	1	1	1	1	1	1
Ok	1			1	0	0	0	0	0	0
Not well					0	0	0	0	0	0
What additional information does this group require to answer the questions in a better way?										
Nothing more	1				0	0	0	0	0	0
Some better picture	1	1	1	1			1		1	

Community Consultation Form

Community Background	
Country:	Lao PDR
Province:	Khammouane
District:	Nongbok
Group:	4
Village Type:	Riparian
Facilitators:	Khamphoumy Latthanouxay

Village:	Nongbok		Phon		Dongkhouang		Na Manpa	
	Men	Women	Men well off	Women	Men	Women	Men	Women
Vulnerability Analysis								
What are the major hazards that the village has been faced with in the past. When did it occur, what was the level of damage?								
Flood normally occurs during August to September	1	1	1	1	1	1	1	1
How was this group of households affected by flooding and other hazards in the village?								
Rice crop destroyed (ha)	NA		60%		NA		250	
Road destroyed	1	1	1	1	1	1	0	0
Human disease epidemy	1	1	1	1	1	1		
Animal disease epidemy	1	1	1	1	1	1		
Irrigation canal destroyed							1	1
Cash crop destroyed (ha)							1	1
How was this group able to cope with flooding and other hazards?								
Did not manage to cope with any problems	1	1	1	1	1	1	1	1
What are the existing structures and systems for coping with floods and other hazards?								
Nothing	1	1	1	1	1	1	1	1
Sand bags	0	0	0	0	0	0	0	0
What is the livelihood for this group (e.g. rice, fishing, labour, business etc.)								
Wet paddy farmer	1	1	1	1	1	1	1	1
Dry paddy farmer	1	1						
Crash crop farmer			1	1	1	1	1	1
Fishery	1		1	1			1	1
Small trader		1	1	1		1	1	1
Laborer	1		1	1	1		1	1
Government Officers	1	0			1			
Feedback on demonstration project options								
Structural Measures								
Which option is preferred by this group?								
(1) From Nongbone to Dan Pakse to Dong Nasan	1	1	0	0	1	1	1	1
(2) From Nongbone to Dan Pakse	0	0	1	1	0	0		
Does this group perceive any clash with								

Village:	Nongbok		Phon	Dongkhouang			Na Manpa	
	Men	Women	Men well off	Women	Men	Women	Men	Women
neighboring village or community because of the structures?								
Clash with neighbors	0	0	0	0	0	0	0	0
No clash at all	1	1	1	1	1	1	1	1
What is the major concern about each of the options?								
May lose paddy land due to dike and drainage project	1	1	1	1	1	1	1	1
May lose garden land	0	0	0	0	0	0	0	0
May lose residential land	0	0	0	0	0	0	0	0
Houses	0	0	0	0	0	0	0	0
Trees	0	0	1	1			1	1
What solution does this group suggest for the problems with flooding in relation to the proposed options								
Compensation	1	1	1	1	1	1	1	1
Compensation in cash	1	1	1	1	1	1	1	1
Compensation in land by land	0	0	0	0	0	0	0	0
Contribution	0	0	0	0	0	0	0	0
What type of flood control or mitigation structure would this group want for their village, where should they be located in the village and why?								
Flood control gate	1		1		1	1	1	1
Drainage	1		1			1	1	1
Pumping station			1	1			1	1
Does this group perceive the same intended benefit of the demonstration project options?								
Increase wet rice production	1	1	1	1	1	1	1	1
Increase dry rice production	0	0	0	0	0	0	0	0
Have good road	1	1	1	1	1	1	1	1
Increase animals	0	0	0	0	0	0	0	0
have more fish in fish ponds	1	1	1	1	1	1	1	1
increase cash crop production	0	0	0	0	0	0	0	0
Reduce electricity charged by irrigation	0	0	0	0	0	0	0	0
Have well water all year round	0	0	0	0	0	0	0	0
Reduce toilet repair cost	0	0	0	0	0	0	0	0
What negative impacts does this group perceive (on agriculture, fisheries, environment)?								
Due to construction, they are afraid of:	1	1	0	0	0	0	1	1
Loss of paddy land	1	1	1	1	1	1	1	1
Loss of residential land	0	0	0	0	0	0	0	0
Loss of garden land	1	1	1	1	1	1	1	1
Loss of houses	0	0	0	0	0	0	0	0
Fish in natural fish will reduce	1	1	0	0	0	0	1	1
loss fertility of land	1	1	0	0	0	0	1	1
Water will not drained well	1	1	0	0	0	0	1	1
How will the different demonstration project options impact their present livelihood?								
None	1	1	1	1	1	1	1	1

Village:	Nongbok		Phon	Dongkhouang			Na Manpa	
	Men	Women	Men well off	Women	Men	Women	Men	Women
No chance to fish in flood	0	0	0	0	0	0	0	0
Difficult to cross the dike to access to paddy field	0	0	0	0	0	0	0	0
What changes in cropping, fishing or any other livelihood activity will this group make if the demonstration project option is implemented and why?								
Some people said that they will change:								
From dry paddy to wet paddy	1	0	0	0	1	0	1	0
From wet paddy to fish ponds	0	0	0	0	0	1	0	1
From dry paddy to fish pond	1	0	0	0	1	0	1	0
From pig raising to fish culture	1	0	0	0	1	1	1	1
From farmer to agriculture trader	1	1	1	1	1	1	1	1
What type of development does this group want to see in the village and why?								
Good road								
Good hospital with doctors and medication								
A village-group market		1	1	1		1		1
Village funds		1	1	1		1		1
Village Office	1		1		1		1	
What additional support systems would be required to capitalize on the benefits of the demonstration project options – if this group is in favor of demo project options								
Credit with low interest	1	1	1	1	1	1	1	1
Rice and cash crop marketing contract	1	1	1	1	1	1	1	1
How does this group want to be engaged in flood control structural measure project in future?								
Yes							1	1
What resource can this group bring to such a project?								
Some land where structure site will be located	1		1	1	1		0	0
Earth for filling	1		1		1		1	0
Poles	1		1		1		1	1
Bamboo			1				1	1
Labor	1	1	1	1	1	1	1	1
Coordination							1	0
To what extent did the group understand the demonstration project options and their purpose?								
Very well (100%)	1	1	1	1	1	1	1	1
Ok	0	0	0	0	0	0	0	0
Not well	0	0	0	0	0	0	0	0
What additional information does this group require to answer the questions in a better way?								
Nothing more	0	0	0	0	0	0	0	0
Some better picture	1	1	1	1	1	1	1	1

Appendix 6

Initial Environmental Examination

SUMMARY

During Stage 1 of the FMMP-C2, a report was prepared on the Potential development in Xe Bang Fai area with the aim to investigate options for flood risk reduction and agricultural development. The proposed options flood protection embankments on both sides of the Lower Xe Ban Fai (downstream of the bridge on NR13S), a diversion canal and a storage reservoir. These options are currently considered as alternatives that are being investigated in the demonstration project for the development of an Integrated Flood Risk Management Plan for the Lower Xe Bang Fai area in Stage 2 of FMMP-C2.

The alternatives are tested concerning their impact on the flooding hazard and flood damage reduction.

In parallel, a Public Participation Plan was prepared and is will be implemented in May – June 2009 in order to involve all stakeholder groups in this planning exercise to better understand and take into account their interests and point of views.

The alternatives developed in Stage 1 of FMMP-C2 constitute rather large-scale structural measures for flood risk reduction. The potential environmental impacts of the measures can be substantial, therefore this Environmental Examination report was prepared already at an early stage of the Demonstration Project preparation in order to guide and influence the technical analysis of these alternatives. It will also aid in developing other alternative measures that are likely at a smaller scale to possibly better suit the local social and ecological environment.

The Xe Bang Fai Demonstration Project ideas consist of construction of flood protection dikes along the Xe Bang Fai River, downstream of the crossing with NR13S. Construction of drainage canals in the floodplain and construction of regulation structures in the small tributaries of the river is part of the project, as is the provision of irrigation infrastructure. Construction of a diversion channel may be an additional element to the project, as is possibly the construction of a flood storage reservoir in the Xe Bang Fai upstream of the Demonstration Project area, in combination with the construction of a control gate near the confluence of the river with the Mekong. The potential environmental impacts of implementation of the project are summarized briefly in the following.

The seasonally inundated Lower Xe Bang Fai floodplain is a sensitive and valuable ecosystem. It consists of a mosaic of fresh water lakes, river ponds, rice paddy and fresh water marshes. Close to the river, there are several old river channels with oxbow lakes, that silted up and form fairly large marshes. Although not much is known about the flora and fauna species present in the area, it is to be assumed that these areas are important habitats for fish and water birds. The wetlands are also important as refuges for ‘Black fish’ in the dry season and as spawning and nursing areas for both ‘Black’ and ‘White fish’ in the flood season.

No officially protected areas are located in Xe Bang Fai plain, however, BirdLife International on its website mentions an Important Bird Area (IBA) located in the area. Details are not known at present.

Population in the project area is concentrated along the river and in villages located on the higher, old levees in the floodplain, where densities are considerable. The river is an important source of water for domestic use.

Paddy rice is the main crop in the area, while the banks of the Xe Bang Fai River are intensively used for the production of fruits, vegetables and cash crops like tobacco. Fisheries

are important in the flood season. It is a source of food and additional income for a substantial part of the population.

Reduced flooding in the Xe Bang Fai plain 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 have a significant negative effect on the dry season refuge habitats, small lakes, ponds and marshes, which are important for the survival of floodplain fish. In the flood season, the flooded wetlands, forests and paddy fields are an important spawning and nursing area for both floodplain resident fish and migratory fish. It will be clear that fisheries in the area will reduce greatly if these habitats disappear, or cannot be reached anymore by migrating fish. If the objective of the project is reached by construction of a dam across the Xe Bang Fai, fish migration up and down the river will become impossible.

Other important impacts are related to the riverbank gardening. Riverbanks are cultivated intensively mainly by women. The fruits and vegetables grown there are important for the diet, tobacco is important as cash generator. Land acquisition for construction activities may be considerable, and since population is concentrated on, the riverbanks’ resettlement may be substantial. Construction of a dam in the Xe Bang Fai will flood a large area and a number of villages.

From an environmental point of view, making the Xe Bang Fai floodplain completely flood free is not recommended. A flood protection systems that would allow controlled flooding of the area during the main flood period of the Mekong River would sustain the precious wetland ecology and the fisheries potential.

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1. Introduction

1.1 Purpose of the report

During Stage 1 of the FMMP-C2, a report was prepared on the Potential development in Xe Bang Fai area with the aim to investigate options for flood risk reduction and agricultural development. The proposed options flood protection embankments on both sides of the Lower Xe Ban Fai (downstream of the bridge on NR13S), a diversion canal and a storage reservoir. These options are currently considered as alternatives that are being investigated in the demonstration project for the development of an Integrated Flood Risk Management Plan for the Lower Xe Bang Fai area in Stage 2 of FMMP-C2.

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In parallel, a Public Participation Plan was prepared and is will be implemented in May – June 2009 in order to involve all stakeholder groups in this planning exercise to better understand and take into account their interests and point of views.

The alternatives developed in Stage 1 of FMMP-C2 constitute rather large-scale structural measures for flood risk reduction. The potential environmental impacts of the measures can be substantial, therefore this Environmental Examination report was prepared already at an early stage of the Demonstration Project preparation in order to guide and influence the technical analysis of these alternatives. It will also aid in developing other alternative measures that are likely at a smaller scale so to possibly better suit the local social and ecological environment.

1.2 Extent of the Environmental Examination

This report presents the results of the Environmental Examination of one of the Demonstration Projects, the Integrated Flood Risk Management Plan for the Lower Xe Bang Fai area, proposed within the framework of the Flood Management Mitigation Program, Component 2, Structural Works and Flood Proofing, Stage 2 Implementation. The Assessment was carried out applying, and at the same time testing, the Best Practice Guidelines for Integrated Flood Risk Management Planning and Impact Evaluation, Environmental Evaluation, developed under the FMMP-C2 project.

The examination was carried out in April-May, 2009 by Royal Haskoning of the Netherlands and associates. The current study of the Xe Bang Fai Focal Area Project in the Khammouane and Savannaket Provinces of Lao PDR bases on very limited field studies. As such, the study had to rely heavily on secondary data, as well as data collected during the social survey.

The Xe Bang Fai project area is located in the MRC Basin Development Plan (BDP) Sub-area 4L. The yearly flooding area is located along the Lower Xe Bang Fai River. To the west the area is bounded by the Mekong River, to the east, NR13S forms the boundary shows the location of the project area.

Source: Nam Theun-2 Power Company, 2005b

Figure 1-1 Location of the Xe Bang Fai project area

1.3 Contents of the report

The results of the study are presented in the general format of an environmental impact assessment as presented in the Best Practice Guideline. Following this introduction, the balance of the report addresses the following topics:

- *Chapter 2 gives a description of the project and the distinguished project* alternatives. The type of project is discussed, as well as the need for the project. Besides the size and magnitude of the operation and the proposed schedule for implementation receive attention;
- Chapter 3 briefly addresses the (Lao) legislative framework of EIA;
- Chapter 4 describes the environment, not only the physical resources (topography, soils, climate, surface water, and ground water), but also the ecological resources (aquatic biology, wildlife, forests and rare endangered species), the human and economic development in the project area (population and communities, industries, infrastructural facilities, transportation, land use, fisheries and agricultural development), and the quality of life values (socio-economic values, public health);
- Chapter 5 discusses the environmental screening of the project, summarized in a screening table;
- Chapter 6 describes the potential environmental impacts of the project as well as a first assessment of their significance. Possible measures to mitigate the adverse impacts of the project or to enhance the distinguished positive impacts are addressed as well. Not only environmental problems due to the project location are discussed, but also impacts related to implementation and construction activities, as well as impacts that could arise during the project's operational phase.

2. Description of Project Options

The Xe Bang Fai floodplain, downstream of the crossing with National Road Nr 13 South (NR13S), experiences flooding problems during the rainy season nearly every year. According to a 36 yeas statistical record, there was flooding in 31 years.

Four districts in the Khammoune Province, Thakhek, Nongbok, Mahaxay and Sebanfai, are prone to flooding, as well as one district in Savannaket Province: Xaybouly. More than 80% of the flooding is caused by overflow from the Xe Bang Fai River. A second cause of flooding is improper drainage of the area after heavy rain. Drainage canals and other infrastructure (gates) to discharge the water out of the area into the Xe Bang Fai or the Mekong River are absent or in a poor condition. Finally, backwater of the Mekong River occasionally causes indirect flooding in the area. When the water in the Xe Bang Fai River exceeds a certain water level, backwater from high discharges in the Mekong River cause a reverse flow and flooding of up to 1.5 meters occurs in the lower areas. Flooding depths are thought to increase with about 20 cm, once the Nam Theun 2 Hydropower Development Project becomes operational. Flooding generally starts between the end of July and September, and normally last between 15 and 30 days. Most of the area flooded is used for agricultural purposes.

Three project alternatives have been developed to reduce the flooding in the area (Vongvixay, 2008):

- Providing full protection to the area by means of polder development;
- Providing full protection to the area by means of polder development, in combination with construction of a flood diversion canal; and
- Construction of a flood storage reservoir in the Xe Bang Fai at the confluence with the Se Noy, just upstream of the NR13S crossing, combined with construction of a floodgate in the Xe Bang Fai mouth.

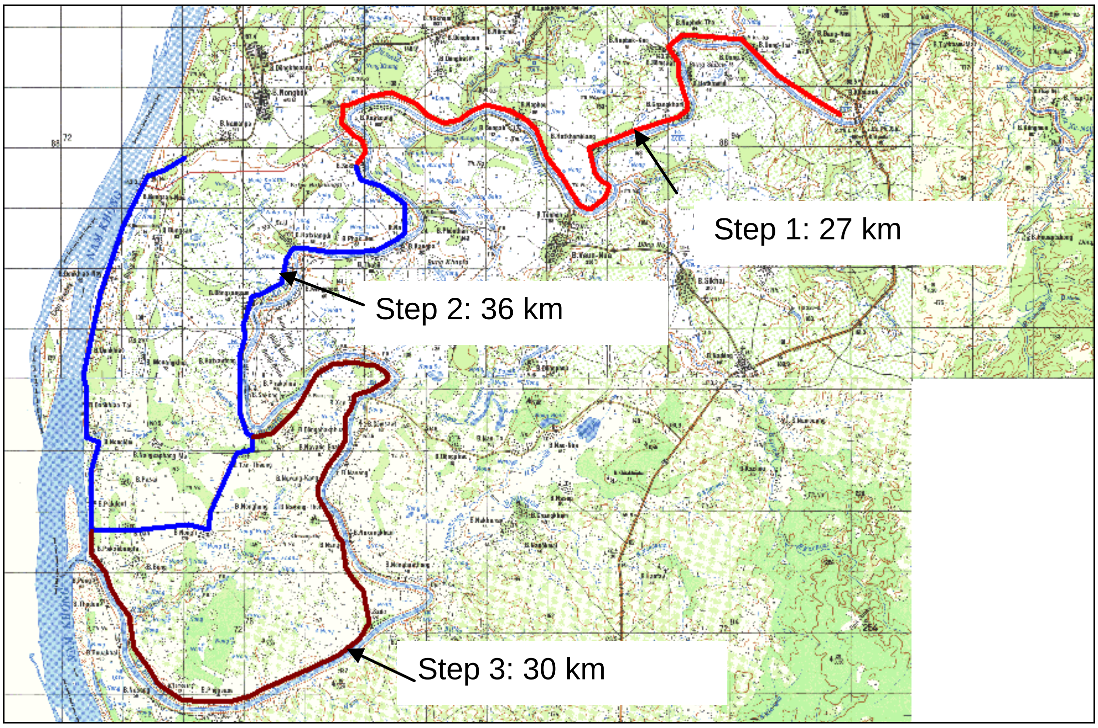
Source: Nam Theun-2 Power Company, 2005b

Figure 2-1 Location of the Nongbok, Xe Bang Fai and Xaybouly Districts.

Alternative 1: polder development

The construction of dikes along the Xe Bang Fai and the Mekong River will be carried out in 3 phases, see Figure 2-1. In phase 1 a dike between Banne Nongbone in the Xe Bang Fai District and Banne Sokbo in the Nongbok District (27 km) will be constructed along the right bank of the Xe Bang Fai. Four new control gates have to be constructed in tributaries that discharge to the Xe Bang Fai in this river stretch. Besides, four pumping stations and a 3 km long drainage canal have to be constructed.

After completion of this phase, 9,700 ha land and 26 villages are protected against flooding.



Source: Vongvixay, A., 2008, Potential development in Xe Bang Fai (XBF)

Figure 2-2 Layout of the polder construction alternative.

In phase 2 the dike will be extended over a length of 36 km from Banne Sokbo to Banne Bungsanetha. Four new control gates have to be constructed and 5 control gates have to be repaired next to the construction of 9 pumping stations and 5 km drainage canals. After phase 2 an additional 4,000 ha and 17 villages will be flood proof.

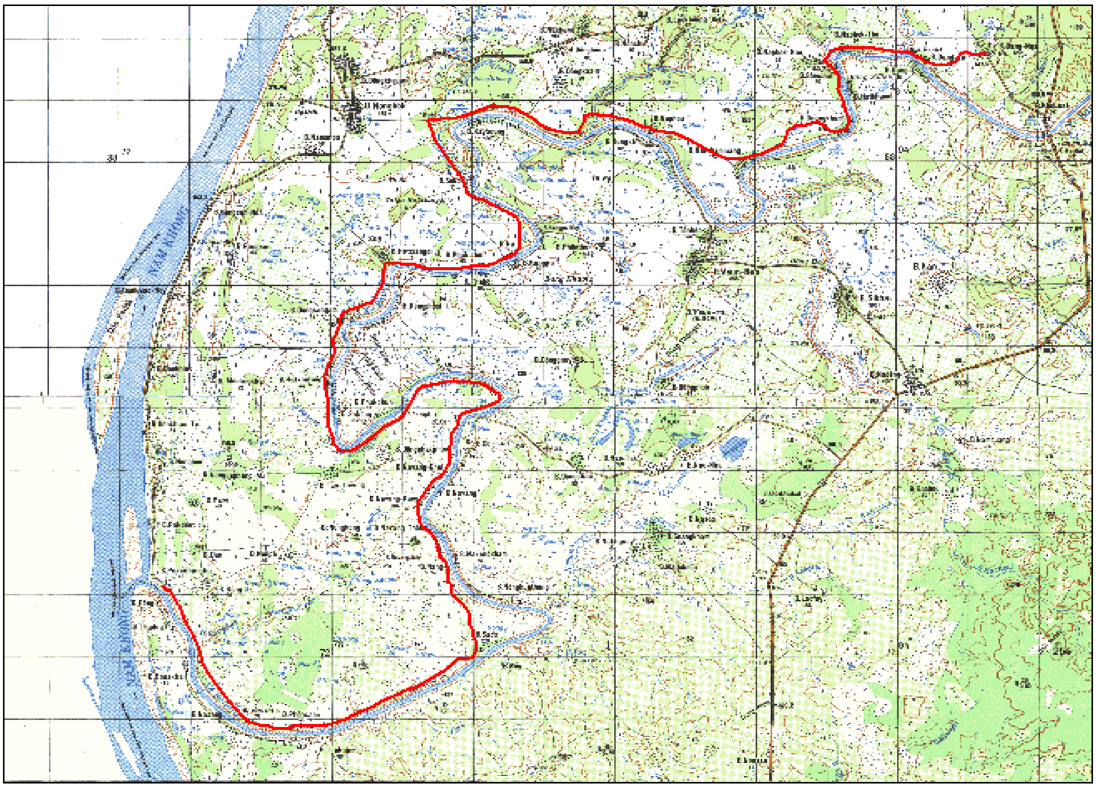
In the final phase 3 another 30 km of dike will be constructed between Banne Tantheung and Banne Dannepakse in the Nongbok District. One control gate will be constructed and one gate will be repaired. In this phase, also two (2) pumping stations and 3 km drainage canal have to be constructed. Phase 3 will provide protection against flooding for an area of 3,000 ha including 13 villages.

Table 2-1 gives a summary of the works to be carried out.

Table 2-1 Summary of works to be carried out and protection provided for the polder construction alternative.

No	Project component	Phase 1	Phase 2	Phase 3	Total
1	Dike construction	27 km	36 km	30 km	93 km
2	Construction of new control gates	4	4	1	9
3	Repair of existing control gates	0	5	1	6
4	Construction of pumping stations	4	9	2	15
5	Construction of drainage canals	3 km	5 km	3 km	11 km
	Area protected	9,700 ha	4,000 ha	3,000 ha	16,700 ha
	Villages protected	26	17	13	56

It is also considered to construct a protection dike along the right bank of the Xe Bang Fai only (Alternative 1a). The dike runs between Banne Nongbone in the Xe Bang Fai District and Banne Danpakse in the Nongbok District and has a length of 65 km (See Figure 2-2). For this alternative, 9 new control gates have to be constructed and six existing gates have to be repaired. At four locations, drainage canals have to be constructed.

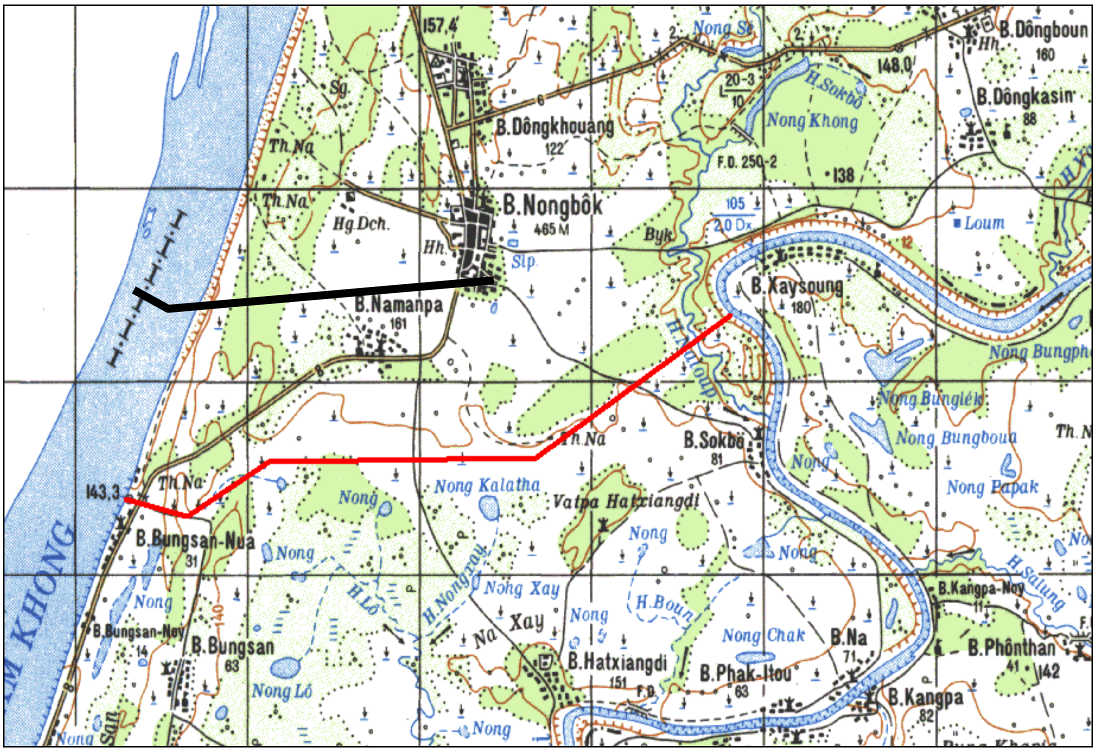


Source: Vongvixay, A., 2008, Potential development in Xe Bang Fai (XBF)

Figure 2-3 Layout of Alternative 1a, dike construction along the right bank of the Xe Bang Fai only.

Alternative 2: Polder development combined with flood diversion

This Alternative is actually an extension of Alternative 1, the polder development. Additional to the Alternative 1 components a diversion channel with a bed width of 20 m and a length of about 8 km will be constructed to divert water from the Xe Bang Fai near Banne Sokbo (about 35 km upstream of the confluence with the Mekong River) to Banna Bungsan Nua along the Mekong. Two possible layouts for the so-called Selat canal have been distinguished, see Figure 2-3. The bed elevation will be 138.0 m amsl.



Source: Vongvixay, A., 2008, Potential development in Xe Bang Fai (XBF)

Figure 2-4 Proposed alternative layouts of the Selat Diversion.

Alternative 3: Construction of a flood storage reservoir in the Xe Bang Fai at the confluence with the Se Noy

This alternative entails the construction of an earthen regulation dam in the Xe Bang Fai just downstream of the junction with the Se Noy River. The dam will be multi-purpose: in the wet season, floodwaters of the Xe Bang Fai will be stored, thus protecting the downstream area against flooding, in the dry season the stored water will be used for irrigation. Since part of the flooding in the Xe Bang Fai plain is caused by Mekong water flowing into the river channel, construction of a regulation dam will only be effective if it is combined with construction of a control gate in the Xe Bang Fai at the confluence with the Mekong River. Two alternative layouts of the scheme have been designed; the details are given in Table 2-2.

Table 2-2 Main characteristics of the proposed flood storage reservoir.

	Alternative 3a	Alternative 3b
Height of dam	25 m	30 m
Length of dam	200 m	450 m
Normal reservoir level	145 m amsl	150 m amsl
Reservoir surface	10,500 ha	-
Average water depth	8.0 m	-
Reservoir capacity	840 x 10^6 m^3	1,500 x 10^6 m^3
Flood protected area	92,910 ha	150,000 ha
Irrigated area	22,200 ha	33,200 ha

3. The Legal and Policy Framework

3.1 EIA legislation and institutional setting

Review of collected information on EIA in Lao PDR and discussions at the EIA Division, Water Resources and Environment Administration (WREA), Department of Environment in Vientiane revealed that EIA regulations date back to 2000 and has been drafted with SIDA support. They are presently being revised, again with SIDA support (Phase 2 of the project, lasting until 2010). Three EIA stages are applied: Screening, Initial Environmental Examination (IEE) and EIA. Development of sectoral guidelines is the responsibility of the sector ministries themselves. Until now specific guidelines have only been made for hydropower projects, road development and mining projects. Under the new decree (not yet enforced) the recently established WREA becomes responsible for the drafting of guidelines. Drafting of a specific guideline for flood protection works is not foreseen at the moment.

EIA legislation is laid down in the Regulation on Environment Assessment of the Lao PDR Decree No. 1770 (2000). The decree consists of 4 parts and 18 articles. It provides guidelines and standards for environmental assessments and a framework within which other ministries can develop their own set of standards and guidelines for EIA procedures. The EIA Decree stipulates “No construction or other physical activities shall be undertaken at a project site until an environmental compliance certificate for the project is issued.” Types or sizes of projects that do or do not require EA is presently not specified. In the current practice, the Development Project Responsible Authority (DPRA) reviews projects (based on their description) on a case-by-case basis and determines whether EA is required. The decision has to be approved by the EIA Division of WREA.

WREA was established under the Prime Minister Office in 2007. It comprises of the following units/departments: Department of Environment, Environmental Research Institute (which both were formerly part of the Science, Technology, and Environment Agency (STEA)), Department of Water Resources, Department of Metrology, and the Lao National Mekong Committee Secretariat. In August 2008, the Division of Environmental Impact Assessment under the Department of Environment became the Department of Environmental and Social Impact Assessment (ESIAD).

WREA is the principal Government agency for formulating and guiding environmental policy in Lao PDR. It develops environmental strategies, policies, regulations, programs and projects, implements Environmental Impact Assessment and monitoring and conducts research and training activities.

ESIAD is responsible for reviewing EA reports submitted by DPRA, issuing Environmental Compliance Certificates to project proponents and monitoring the project according to the Environmental Management Plan, which is part of EA report.

The EA process in Lao PDR can be summarised as follows:

- Prepare a description of the project and submit for screening;
- Screening of the project and determination whether an EA is required on not;
- If EA is required, an Initial Environmental Examination (IEE) is prepared including:
    - An Environmental Management Plan (EMP) if the IEE determines that no further EA is required; or
    - A ToR for an EIA if the IEE determines that further EA is required.
- Review of the IEE, and EMP, or ToR. If the IEE is sufficient and the EMP acceptable, an Environmental Compliance Certificate is issued. If the IEE and ToR

for an EIA are sufficient, the project proponent can proceed with the preparation of the EIA. If the IEE is insufficient, it must be revised;
- Preparation of the EIA and EMP;
- Review of the EIA and EMP: if they are acceptable, an Environmental Compliance Certificate will be issued (with conditions if necessary); if they are unacceptable, the project will either be rejected or WREA will request that the EIA be revised and resubmitted;
- Implementation of the EMP; and
- Project monitoring and evaluation.

The Environmental Protection Law of 1999 requires each sector Ministry to issue its own procedures on Environmental Impact Assessment, based on WREA regulations.

Other relevant legislation is given in the Decree on the Compensation and Resettlement of the Development Project. This decree defines principles, rules, and measures on compensation and resettlement resulting from development projects. It stipulates in article 6 that 'project owners shall compensate project affected people for their lost rights to use land and for their lost assets (structures, crops, trees and other fixed assets) affected in full or in part, at replacement cost'. Of importance is also the Wildlife and Aquatic Animals Law, this law provides principles and measures to protect and manage wildlife and aquatic animals. The law lists endangered species and states that habitat of those species needs to be protected.

Cumulative and/or transboundary assessment is not mentioned in the available documentation. However, in the National Mekong Committees (NMCs) of the four Lower Mekong Basin (LMB) countries it is realized that environmental effects do not respect political boundaries, certainly not in river basins. Sustainable development is high on the agenda and transboundary impacts of developments in the basin should be prevented. National environmental assessment legislation and procedures do not provide a framework for evaluation of transboundary impacts; therefore development of a common procedure could enhance cooperation and prevent disputes. MRC is committed to develop such a common approach.

The draft version of the Framework for Transboundary Environmental Impact Assessment (TbEIA, March 2006), developed by MRC for the Lower Mekong Basin, list the following projects as having potential transboundary impacts:

- Hydropower projects;
- Irrigation schemes;
- Ports and river works;
- Industrial and mining projects;
- Aquaculture projects;
- Navigation projects; and
- Water abstraction projects for water supply.

This implies that flood protection dikes and dams are considered as potentially having transboundary impacts. Flood management and industrial water supply projects were originally on the list as well, but have been removed, since flood issues and industrial water supply are considered national issues.

3.2 Wetland management policy

In Lao PDR, numerous policies refer to various aspects of the use and management of wetlands and related resources. Such policies generally exhibit two central features. The first is the explicit links between development, conservation, and poverty alleviation. The second is the constitutional right of access to natural resources by the Lao people and state, and their obligation to protect and use these resources sustainably.

A number of government organizations are involved in the management of wetland resources, and there is no formal framework for the coordinated management of wetlands in Lao PDR. The Ministry of Agriculture and Forestry has overall responsibility for the management of wetland resources, including agriculture and conservation, while other ministries have interests in wetlands as they relate to transport, construction, or electricity production. This distribution of responsibilities and interests highlights the division between agencies responsible for sustainable management of wetlands and those responsible for extractive uses.

The Lao PDR government recognizes the importance of international cooperation in environmental protection and is a signatory to a number of environmental agreements, including the 1992 Convention on Biological Diversity and the 1995 Mekong Agreement. The government is currently deliberating whether or not to become a signatory to the Ramsar Convention. The main difficulty in ratifying that Convention stems from the perception that Ramsar is primarily focused on the preservation of wetland resources through the exclusion of resource users, which comes into conflict with the Lao PDR constitutional right of access to natural resources.

4. Description of the Environment

The description of the environment in the Xe Bang Fai Focal Area is mainly based on data given in the Basin Development Plan of the MRC (MRC, 2006), the Feasibility Study of Floodway and small structures (Mekong Secretariat, 1981), and the Social Development Plan, Volume 3, Downstream Areas, and the Environmental Assessment and Management Plan of the Nam Theun 2 Hydropower Development Project (both published by the Nam Theun 2 Power Company, March 2005).

4.1 Physical Resources

4.1.1 Topography and General Characteristics

The Xe Bang Fai has a catchment area of about 10,240 km^2. The river takes its rise in the Annamite mountain range near to the border with Vietnam, west of Thakhek and joins the Mekong at km 1,166, opposite of the city of That Phanom in Thailand. The Xe Bang Fai has a number of tributaries, the largest of these, the Se Noy, joins the Xe Bang Fai just upstream of NR13S. The catchment area upstream of the bridge is 8,560 km^2, which is 84% of the basin.

The upper basin is steep, but downstream of Mahaxai the river slopes are small and the reach from 10 km downstream of Mahaxai to the mouth is affected by backwater from the Mekong. In this lower reach, the river strongly meanders in sandy alluvial deposits. Figure 4-1 shows the catchment.

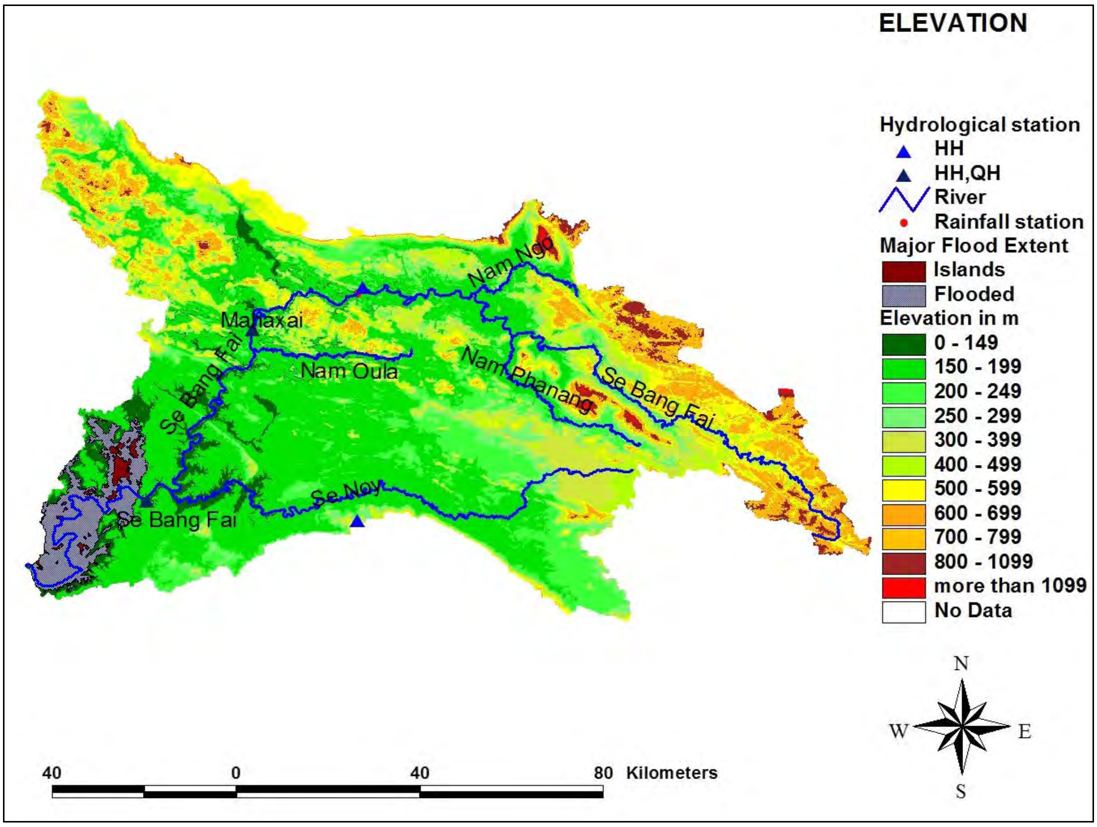


Figure 4-1 The Xe Bang Fai catchment.

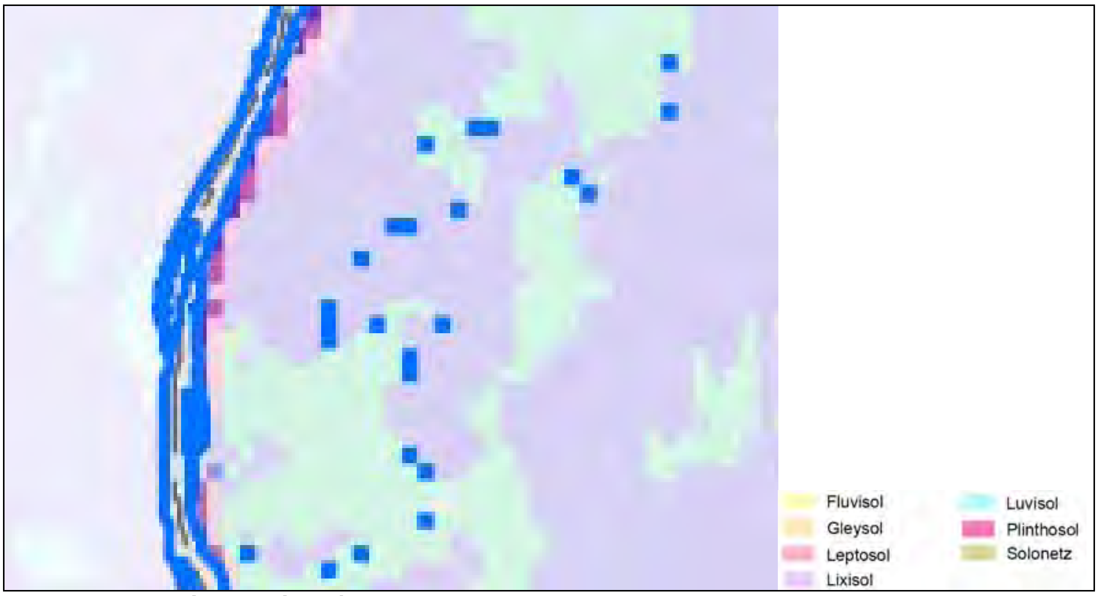
The Xe Bang Fai catchment downstream of the bridge on National Road Nr 13 South (NR13S) is called the Xe Bang Fai Plain. The plain is about 15 km wide, bounded by the Mekong River to the west and upland forest on an old alluvial terrace to the east. The area is approximately 500 km^2 from the confluence with the Mekong up to the NR13S crossing. The length of the river in this stretch is approximately 70 km. The area is fairly densely populated with some 60 villages and about 400 km^2 of rice paddy fields. It is a major area of rice production for the Khammouane Province.

The Xe Bang Fai is currently eroding, with slumping visible along its banks, generally as a result of either toe scour and undermining, or excess pore pressures as the water falls in the dry season. The banks of the river are generally 135 to 160 m apart, although the channel width locally exceeds 200 m. A trend of widening of the Xe Bang Fai channel has been observed over the period 1995 to 2002 based on a comparison of benchmarked cross-sections.

The topography of the Xe Bang Fai plain downstream of NR13S is rather flat. Along the river narrow natural levees have developed, further from the river the area consists of low-lying basins, old river channels with oxbow lakes that have silted up, separated from each other by relatively high lying old river levees. To the east, the floodplain is bounded by a higher lying old alluvial terrace. Most of the floodplain has an elevation of less than 140 m amsl, and floods frequently. The natural levees along the river and in the floodplain have a somewhat higher elevation and are less frequently and less deep inundated.

4.1.2 Soils

All soils in the project area are of alluvial origin. Four soil types can be distinguished: a narrow strip of Plinthosols and Leptosols along the Mekong riverbank, and Luvisols and Lixisols in the lowlying floodplain. The Plinthosols, Leptosols and Lixisols are characterized by a low fertility. The Luvisols are generally suitable or intensive agriculture, since they are more fertile and easy to cultivate.



Source: MRC Basin Planning Atlas, Sub-area 4L, 2006

Figure 4-2 Soils in the project area.

The soils of the natural levees have developed in relatively coarse sediments deposited by the floods, the surface texture ranges from sand to silty loam. The texture of the soils in the floodplain is finer: generally, very fine silty loam is encountered. Most of these soils are acidic and have a low cation exchange capacity.

4.1.3 Climate

The climate of the Xe Bang Fai catchment is influenced primarily by the seasonal southwest and northeast monsoons, the shift of the Intertropical Convergence Zone (ITCZ) and tropical cyclone disturbances such as tropical storms and tropical depressions.

The southwest monsoon (wet season) normally effects the catchments from mid-May to early October and is predominant when atmospheric pressure is low over Asia. This is a period of frequent and heavy rainfalls. However, rainfall during the wet season usually has a bimodal distribution, with a short dry period of one to two weeks, usually between June and July. After this period, rainfall becomes more frequent, including heavy storms, which result from tropical cyclones entering the region from the East Sea, mostly during September and November. Flooding frequently occurs when two or more of these storms occur in succession or when the ITCZ passes into one of its more active stages, with tropical cyclones following shortly thereafter.

A transition period, from mid-October to early November, is followed by the dry northeast monsoon (cold season) which normally lasts from October to February. This season is characterised by sparse, relatively light rainfall, lower temperatures and lower humidity. The northeast monsoon is followed by another transition period to the hot season from March to early May, which is characterised by increasing temperatures, rainfall and humidity. This transition is slower than the transition from the wet to the cold season.

A long rainfall record is available for station That Phanom, opposite the junction of the Xe Bang Fai with the Mekong. As can be observed from Table 4-1, the long-term annual rainfall for this station amounts 1,560 mm, varying from 890 to 1940 mm. About 87% of the annual rainfall occurs during the South-West Monsoon from May to September, with highest rainfall on average in August. See also Figure 4-3.

Table 4-1 Monthly rainfall statistics and evaporation (ETo) in mm around Lower Xe Bang Fai.

Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average	3.1	20.7	43.4	79.1	200.3	274.8	276.6	350.6	250.3	54.7	4.8	1.2	1559.5
Min	0.0	0.0	0.0	5.0	53.1	120.0	88.2	121.9	20.9	0.0	0.0	0.0	890.7
Max	31.3	161.7	150.9	226.4	377.1	516.8	542.8	758.8	538.1	257.9	58.3	27.6	1940.6
Evap.	122	122	156	162	150	124	127	120	112	129	128	121	1572

Monthly average daily reference evapotranspiration rates (ETo) are also given in Table 4-1. They have been taken from the Climwat-database of FAO. During the flood season, an average daily evapotranspiration rate of about 4 mm/day or 120 mm per month is observed. During these months, the rainfall exceeds the evaporation by far, whereas from October to April there is a water deficit.

Mean relative humidity at Nakai Tai station is below 70% during the dry season, and exceeds 80% in the wet season, peaking at a mean of 89% in July. Relative humidities near 100% can occur in the early mornings at any time of the year.

Temperatures are lowest in the months November until February and peak in April before the onset of the south-west monsoon in May. Mean temperatures at Nakon Phanom, along the Mekong in Thailand, vary from 21.9° C in January to 28.8° C in April, with an annual mean of 25.9° C.

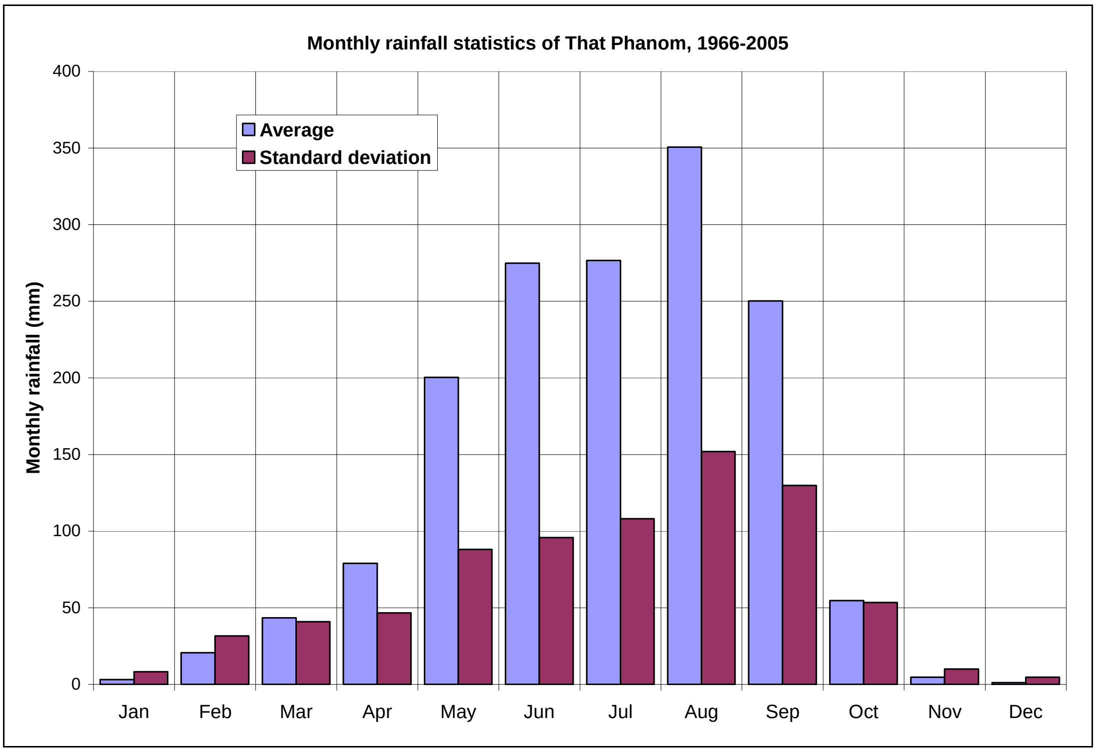


Figure 4-3 Monthly rainfall statistics of station That Phanom, period 1966-2005.

4.1.4 Hydrology and flooding

The frequency curves and extremes of the daily discharges of the Xe Bang Fai at Mahaxai indicate that in the period from July until early October high discharges can be expected on the Xe Bang Fai. The hydrograph of a single year shows distinct sharply rising and falling limbs. From the frequency curves of the daily average water levels of the Mekong at That Phanom near the Xe Bang Fai river mouth it is observed that these peaks are likely to coincide with high water levels on the Mekong. The flood levels in the Lower Xe Bang Fai are a function of the river discharge and the water levels in the Mekong. When the water surface in the Xe Bang Fai exceeds a certain level, usually late in the rainy season, backwater from high Mekong River discharges causes the flow in the river channel to be reversed and flooding takes place through the tributaries and overtopping of the riverbanks. To prevent flooding from tributaries floodgates have been installed in many of these. Most of these floodgates are poorly designed, i.e. they only open one way, and are poorly maintained. As a result, the low-lying areas flood nearly every year to up to 1.5 meter.

The districts most affected by flooding are Thakhek, Nongbok, Xe Bang Fai and Mahaxai. Major flooding takes place between the Mekong and NR13S, north of the Xe Bang Fai River, where flooding may last for several months in the areas below 140m amsl. Nongbok village is flood free at an elevation of 150 m amsl. South of the Xe Bang Fai in Savannaket Province flood protection is already in place.

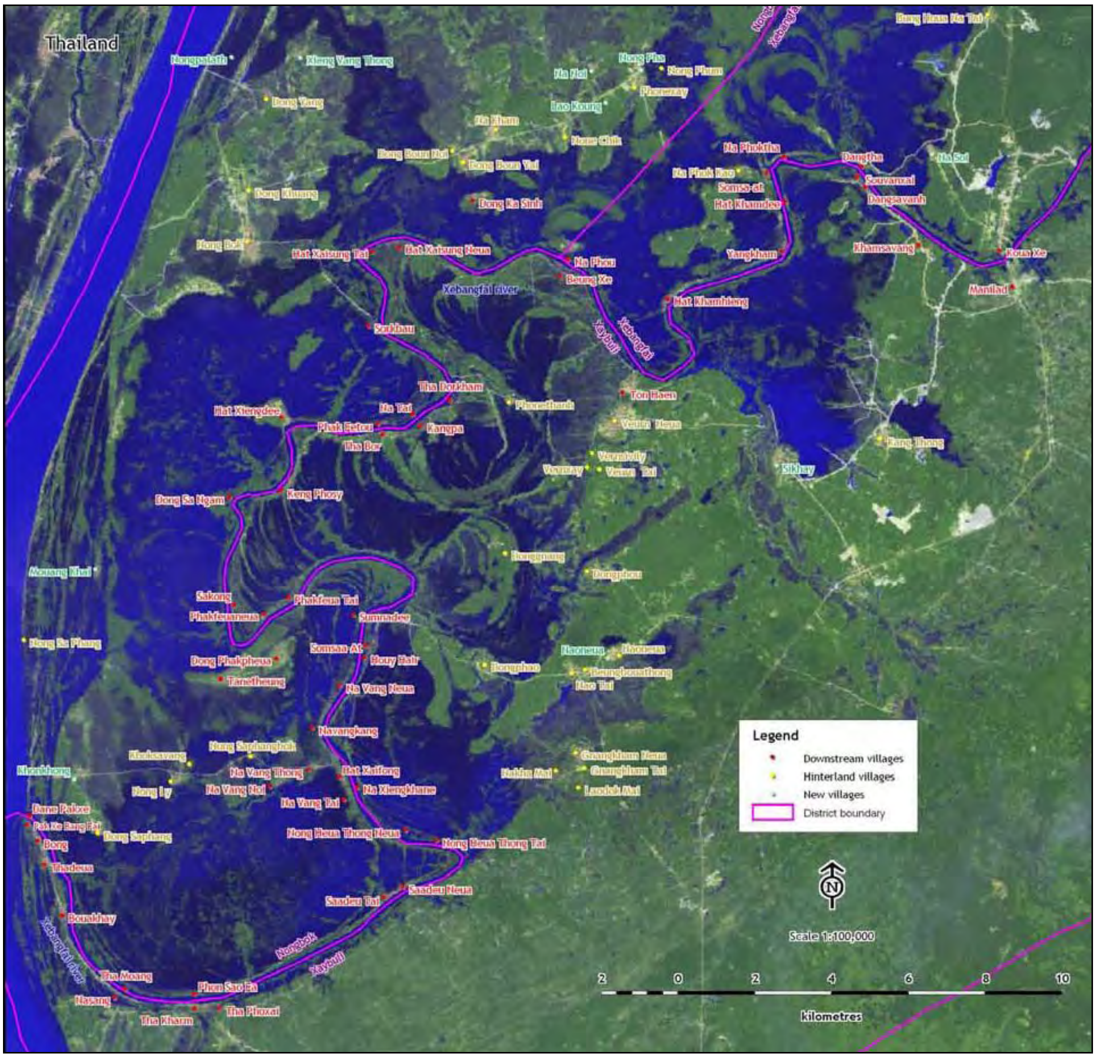
Apart from the area west of NR13S and north of the Xe Bang Fai there is also one smaller area in Mahaxai District facing floods according to local information. This area is located near Road 1F between Mahaxai and Nam Oula, and is flooded each year during about one week.

After completion of the Nam Theun-2 project, diversion of water from the Nam Theun/Nam Kading into the Xe Bang Fai will result in an increase of the average annual discharge of the Lower Xe Bang Fai with an estimated 220 m^3/s. However, it is expected that this will not greatly affect the flooding pattern, since the reduced flows of the Nam Theun/Nam Kading into the Mekong River will result in a fall of about 15 cm of the Mekong water levels during flood events. This should allow for quicker drainage of the Lower Xe Bang Fai during times of flooding, and consequently partially offset the impact of the increased flows in this portion of the river. Figure 4-4 shows the area prone to flooding in the Lower Xe Bang Fai catchment.

4.1.5 Water quality

In general, the water quality of rivers within the Lao PDR is considered good. The level of oxygen is high and the nutrient concentration is low. Due to rapid demographic growth, socioeconomic development and urbanization, however, water quality is deteriorating. It is common practice to dispose litter and sewage to watercourses and drainage channels. As a result, the surface water is invariably contaminated with faecal matter from latrines and coliforms from septic tank effluent.

The water quality-monitoring network of the Mekong River Commission measures water quality parameters in the Xe Bang Fai at the bridge of NR13S on a monthly basis since June 1985.



Source: Nam Theun-2 Power Company, 2005b

Figure 4-4 Flood prone area in the Lower Xe Bang Fai catchment.

Table 4-2 shows the summary results for the period June 1985 - December 2003. Information on bacterial pollution is not given.

A large part of its course the Xe Bang Fai flows through a limestone area, as the result the river water is slightly basic. Fairly low values of Dissolved Oxygen (DO) are observed after heavy rainfall and when water recedes from the floodplains and paddy fields. During these periods, also high Chemical Oxygen Demands (COD) are observed. Apart from occasional periods during the rainy season, when DO and COD concentrations do not meet Thai Class 2 surface water quality standards, the water quality of the Xe Bang Fai is quite good (MRC, 2007, Diagnostic study of water quality in the Lower Mekong Basin).

Maximum values of Total Suspended Solids (TSS) as high as 386 mg/l have been measured during the rainy season. Median values range between about 125 mg/l in the wet season to less than 25 mg/l in the dry season.

Table 4-2 Water quality observations in the Lower Xe Bang Fai, June 1985 - December 2003.

Parameter	Unit	Maximum	Mean	Minimum	Standard for 'Good' water quality*
Temperature	^oC	33.0	26.5	21.0	-
pH		8.82	7.81	6.38	6.0 – 8.5
TSS	mg/l	386	50	0	<25
Conductivity	mS/m	36.00	27.05	10.90	<30
Ca	meq/l	3.17	1.95	0.75	-
Mg	meq/l	1.38	0.52	0.03	-
Na	meq/l	0.543	0.093	0.016	-
K	meq/l	0.089	0.021	0.003	-
Alkalinity	meq/l	3.553	2.318	0.499	-
Cl	meq/l	0.318	0.035	0.001	-
SO_4	meq/l	2.461	0.160	0.006	-
Total-Fe	mg/l	0.934	0.090	0.005	-
$(NO^{3+} NO_2)$-N	mg/l	1.152	0.103	0.001	-
NH_4-N	mg/l	0.480	0.027	0.000	-
PO_4-P	mg/l	0.162	0.008	0.000	-
Total-P	mg/l	0.147	0.017	0.000	<0.2
Si	mg/l	9.70	4.30	0.98	-
DO	mg/l	9.93	7.48	4.21	>6
CODMn	mg/l	6.2	0.9	0.0	<7

* Standards for 'Good' quality given by MRC (Source: MRC, 2007, Diagnostic study of water quality in the Lower Mekong Basin. MRC Technical Paper No. 15

4.1.6 Ground water

Groundwater serves as a source for domestic (drinking) water to the local communities. After the completion of Nam Theun 2, flows in the Xe Bang Fai will increase, as will groundwater levels adjacent to the river. Increases would be most notable in the dry season, when the Nam Theun contributions would proportionally be largest in terms of the total discharge to the river.

There is little information available on groundwater quality in Lao PDR, even though it is the main source of rural water supply. No systematic monitoring of impacts of fluoride, pesticides, nitrate from fertilizers and other chemical pollutants is carried out. Arsenic contamination is not considered a high risk in Lao PDR. Groundwater surveys carried out in 2002/2003 in 7 Southern Provinces showed that only one percent of the 680 wells tested had levels over the current drinking water quality standard for Lao PDR of 0.05 mg/l. Bacteriological contamination of groundwater often occurs, due to poor construction and maintenance of sanitation facilities around water sources, and results in water-borne diseases.

4.2 Ecological resources

4.2.1 Aquatic habitats and fish

A survey for the whole of Lao PDR yielded 203 fish species in 1974, the list had grown to 481 species by 2001 (Kottelat, M (2001), Fishes of Laos, Wildlife Heritage Trust, Colombo, Sri Lanka, 198 pp) after five exploratory surveys. Even with Kottelat's significant contribution to the increase in knowledge of fish distribution in Lao PDR, information on fish distribution, biology and ecology remains basic.

The main dry season fish habitat types in the Lower Xe Bang Fai River and floodplain are pools and slow water stretches in the river, swamps, and stagnant pools on the floodplain. The riverbed is characterised by a muddy to sandy bottom, with occasional rocky outcrops and rapids. The water is turbid, although compared to most other lowland streams in the Mekong Basin it is still clear, with a visibility of about 50 cm. The depth is variable, from several metres to a few centimetres on some sandbars.

During the wet season, most of these habitats change completely and some are displaced to other areas. In this period, fish populations frequently use habitats that are not available during the dry season for spawning, incubation of eggs, and rearing of fry. In the Lower Xe Bang Fai Basin, flooded areas are important as nursery grounds and refuges for juvenile fish.

One hundred and thirty-one species have been observed in the Xe Bang Fai, sixty-seven (67) of these in the Lower Xe Bang Fai. No endemic species were recorder in the latter stretch. The fish fauna of the lower and middle Xe Bang Fai can clearly be described as a middle Mekong fauna. According to Kottelat and Whitten, 1996, the standing stock ranges between 6 and 23 kg per hectare. This is considerably less than what can be expected considering the high nutrient concentrations. This could be the result of fishing activities by local fishermen and because samples were taken during the dry season when few fish from the Mekong were in the river to spawn. Abundance was lowest at Dan Pakse at the confluence with the Mekong. Monthly variations in abundance along the river channel reflect seasonal migratory behaviour of fish. Most of the catch consists of medium size cyprinids (*Puntioplites spp*, *Hypsibarbus spp*, *Barbodes spp*, *Labeo chrysophekadion*, *Puntius orphoides*). Catfishes (*Pangasius siamensis*, *Clarias batrachus*, *Mystus wyckioides*, *Hemibagrus nemurus*) and snakehead (*Channa striata*) are less important.

Three geographically defined fish migration systems exist in the Mekong Basin: the lower, middle and upper Mekong migration system, the Xe Bang Fai Basin falls within the middle Mekong migration system. Within this river section, floodplain spawning and nursery habitats are associated with the tributaries. Adults and juveniles spend the dry season in deep refuge pools in the mainstream channel. At the onset of the wet season, they migrate upstream along the Mekong until they encounter a tributary, and then swim up the tributary until they encounter floodplain habitat or other possibly suitable spawning habitat. Many species spawn only once, soon after arriving on the floodplain, while others spawn several times during the flood season, and a few others spawn only once at the end of the wet season or beginning of the dry season. The fry grow out on the floodplain, which acts as a nursery and contains rich forage. As the floodwater begins to recede from the floodplain, adults and juveniles migrate back in the tributaries and move downstream to the Mekong. There are over thirty medium and large size species of cyprinid and pangasiidae catfish, which exhibit this general migration pattern. The first major fish migration of the year commences at the beginning of the wet season. At that time, according to villagers, a large number of fish species begin migrating up the Xe Bang Fai, and its larger tributaries, while other fish species are believed to move from deep-water pools to spawning areas in the Xe Bang Fai.

These two migrating groups include the following taxa: Cyprinids *(Labeo chrysophekadion, Labiobarbus sp., Sikukia gudgeri, Hypsibarbus sp., Puntioplites sp.),* Catfish *(Pangasius larnaudii, P. macronema, P. pleurotaenia, P. bocourti, Wallago attu, W. leeri, Bagarius sp, Hemibagrus wyckioides, H. nemurus, Helicophagus waadersi, Laides sp., Mystus spp.),* Mud perch *(Pristiolepis fasciata),* Glassfish *(Parambassis siamensis),* River loach *(Schistura sp. or Nemacheilus sp.)*. During overbank flooding events fish migrate laterally to adjacent floodplains for spawning and feeding.

4.2.2 Wetlands and terrestrial habitats

For the Lower Mekong River system, a number of important habitats for conservation can be distinguished as below:

- River channels;
- Small islands and riverine sand-bars;
- Marshes, small pools and seasonally-inundated floodplain wetlands;
- Seasonally-inundated riparian forest; and
- Inundated grasslands.

The river channels are vitally important for the seasonal longitudinal migration of fish species. The Mekong River and its low gradient tributaries, like the Xe Bang Fai, are also an important habitat for a distinctive guild of riverine bird species.

Small islands and riverine sandbars are formed by natural deposition during seasonal high river flow. They form a habitat for pioneer plant communities and breeding sites for water birds.

Seasonal wetlands inundate in the wet season when water levels of the Mekong are high. Groundwater and seasonal monsoonal rains maintain other wetlands year-round. Wetlands provide some of the most productive habitats in the Lower Mekong Basin and include reed and sedge beds, swamps, lotus ponds, and inundated forest. They are usually shallow, filled by seasonal rainfall and typically are connected to the river system which in the wet season forms the inundated plain of the Lower Mekong Basin. Submerged communities are dominated by *Ceratophyllum demersum* and *Utricularia aurea*. The seasonal changes in water level of the Mekong inundated plain drives a seasonal migration of large waterbirds between wetlands. In the dry season, many species move to permanent wetlands and grassy plains around Lake Tonle Sap and the Delta, while in the wet season they retreat to higher seasonal wetlands in northern Cambodia and Lao.

In the dry season, these wetlands are vital in maintaining breeding stocks of floodplain fish, including air-breathing species (e.g. gouramies, walking catfish), while in the wet season they function as breeding and nursery grounds for many fish species, the Black fish. These wetlands are important for almost all waterbirds in the Lower Mekong Basin, particularly cormorants, Oriental Darter, Spot-billed Pelican, Greater and Lesser Adjutants, Milky Stork, Woolly-necked Stork *Ciconia episcopus*, Black-necked Stork *Ephippiorhynchus asiaticus*, Painted Stork, the Globally Endangered White-shouldered Ibis *Plegadis davisoni*, Glossy Ibis *P. falcinellus*, Black-headed Ibis *Threskiornis melanocephalus*, White-winged Duck, Pallas's Fish Eagle *Haliaeetus leucoryphus,* Grey-headed Fish Eagle, and the Globally Vulnerable Masked Finfoot *Heliopais personata*.

One of the most important wetland habitats of the Lower Mekong Basin is the seasonally-inundated riparian forest found on the gently-sloping plains adjacent to lakes, rivers and tributaries and submerged by the seasonal flood of the wet season. Fish use this habitat as a feeding, breeding, and nursery ground and it is important for breeding colonies of large waterbirds.

Seasonally inundated grasslands are common on the floodplains of the Lower Mekong Basin. Close to the water edge, floating or emergent vegetation forms dense mats. As water levels rise, dense mats may dislodge and float, propelled by currents or the wind. The main species include *Achyranthes aquatica, Brachiaria mutica, Eichornia crassipes, Polygonium barbatum* and *Sesbania javanica*. Other plant species found on the upper reaches of the inundated plain include several grasses, including *Echinochloa stagina,* sedges including *Cyperus pilosis, Rhynchospora* sp., and dicotyledons such as *Aeschynomene indica, Impatiens sp., Ludwigia hyssopifolia* and *Nelumbo nucifera* (lotus). They are of crucial importance for a number of rare and endangered bird species.

According to the Inventory of Wetlands in Lao PDR (Claridge, G., 1996), the project area is a fairly important wetland area, consisting of a mosaic of fresh water lakes, river ponds, rice paddy and fresh water marshes. Most of the wetlands are located north of the Xe Bang Fai and is associated with the Houay Vay and the Houay Sayphay. Close to the river, there are several old river channels with oxbow lakes, that silted up and form fairly large marshes. Bung Xuak on the southern side of the river, just west of Bung Veun Nua, is the best example. It is possibly the only wetland in the area that retained a significant proportion of its original vegetation. It is also the largest, about 3 km^2, and has open water at the end of the dry season.

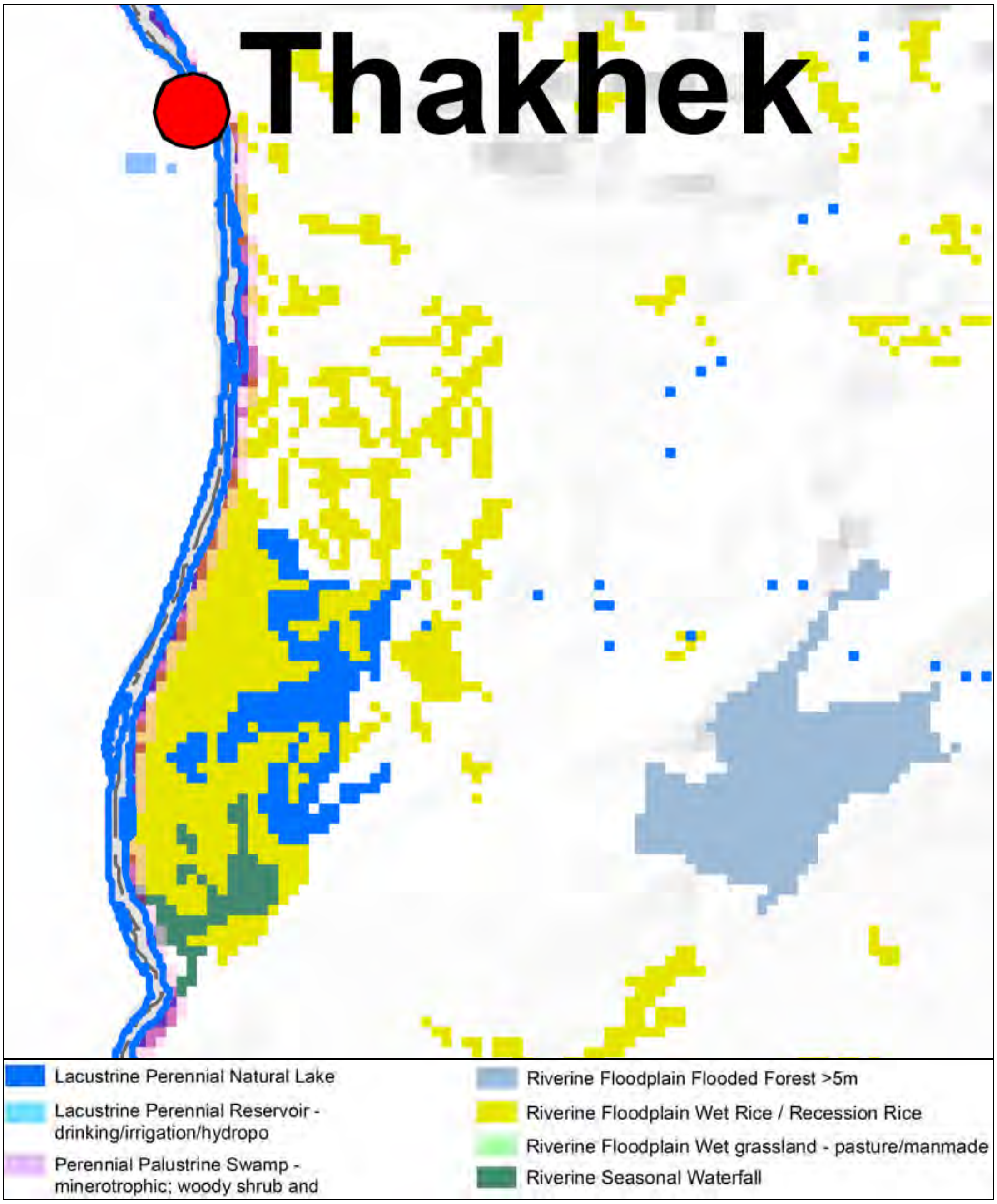
Nearly 9% (2,726 ha) of the Nongbok District, the district covering most of the project area) consists of wetlands. Some 30% of the district (9,400 ha) is under forest.

4.2.3 Wildlife and rare and endangered species

No information is available on the fauna in the project area. However, it is known that the wetlands of the Lower Mekong Basin supports some 15 globally-threatened bird species, namely the Critically Endangered Giant lbis *Pseudibis gigantea*, the globally Endangered Sarus Crane *Grus Antigone*, Greater Adjutant *Leptotilos dubius*, White-shouldered lbis *Pseudibis davisoni*, White-winged Duck *Cairina scutulata*, Bengal Florican *Eupodotis bengalensis* and Nordmann's Greenshak *Tringer guttifer*, the globally Vulnerable Spot-billed Pelican *Pelican Pelecanus Philippensis*, Lesser Adjutant *Leptoptilos javanicus*, Milky Stork *Mycteria cinerea*, Greater Spotted Eagle *Aquila clangula*, Green Peafowl *Pavo muticus*, Masked finfoot *Heliopais personatus*, Black-bellied Term *Sterna acuticauda*, and Indian Skimmer *Rynchops albicollis*.

Of the reptiles the Siamese Crocodile *Crocodilius Siamensis* is Critically Endangered. It was formerly widespread throughout the Lower Mekong Basin but it has declined drastically due to excessive hunting and habitat destruction. It is reported to be present in the vicinity of the project area. Also over twenty species of turtles occur in the Lower Mekong Basin, ten of which are listed in the Red Data book including the Chinese three-striped box turtle *Cuora trifasciata* that is Critically Endangered.

Possibly the wetlands in the project area are of importance for one or more of these rare or endangered species.



Source: MRC Basin Planning Atlas, Sub area 4L, 2006

Figure 4-5 Wetlands in the Lower Xe Bang Fai area.

4.2.4 Protected areas

According to ICEM, 2003, Lao PDR National Report on Protected Areas and Development, Review of Protected Areas and Development in the Lower Mekong River Region, no protected or proposed protected areas are located in the project area.

BirdLife International in Indochina, on its website, indicates that there is one important bird area (IBA) located in the project area.

4.3 Socio-Economic Development

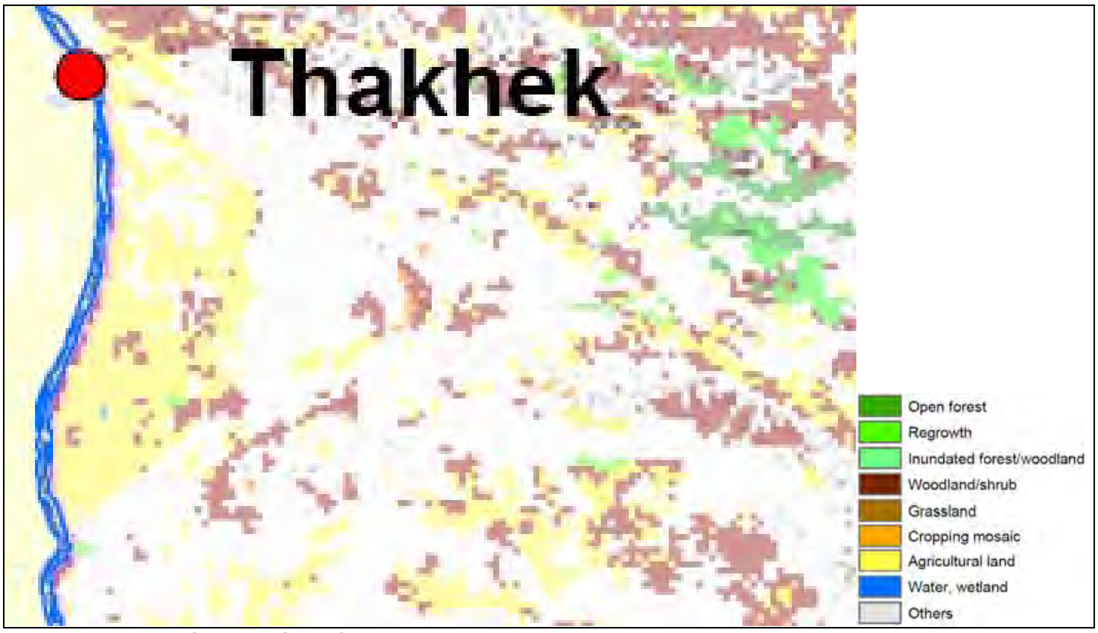
4.3.1 Land use

The project area mainly consists for of agricultural land (rice paddy), grasslands, minor areas of water/wetlands and wood- and shrub land are also encountered. On the natural levees along the Bassac Xe Bang Fai seasonal cash crop are grown in riverbank gardens.

Nongbok District, which is totally located within the project area, covers 31,300 ha. Nearly 50% of the area, 14,521 ha, is in use for agricultural purposes, not only for paddy growing (12,807 ha), but also for the cultivation of other crops (1,714 ha). Of the remaining area, 9,400 ha is forest and 2,726 ha is wetland. Table 4-3 gives an overview of the land use in the district.

Table 4-3 Land use in the Nongbok District.

Land use type	**Area**	
	(Ha)	(%)
Agriculture	14,521	46.4
Paddy rice	12,807	40.9
Other crops	1,714	5.5
Forest	9,400	30.0
Wetlands	2,726	8.7
Other	4,653	14.9
Total	31,300	100.0



Source: MRC Basin Planning Atlas, Sub-area 4L, 2006

Figure 4-6 Land use in the project area.

4.3.2 Agriculture

Rice cropping and vegetables growing are the main agricultural activities in the project area. Agriculture is the area's largest sector of employment, with 92 percent of the inhabitants having rice production as part of their livelihood systems. Vegetables and other crops are grown by residents on the somewhat elevated Xe Bang Fai riverbanks, as well as in the floodplains around natural lakes as water recedes. Lowland wet rice is cultivated in the lower lying areas.

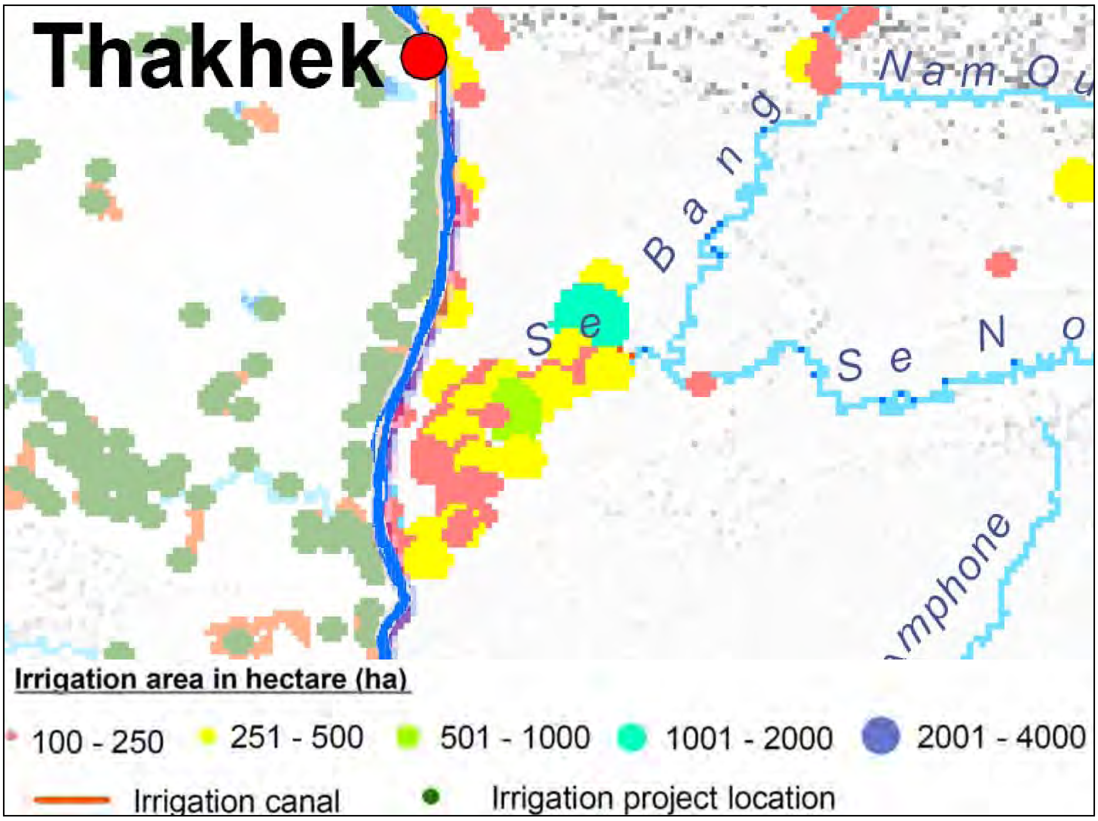
Paddy rice cropping

The Xe 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. According to Nongbok statistics yields are high, 4.3 ton/ha in the wet season and 6.2 ton/ha in the dry season on irrigated land.

In the project area there are two main types of rice production: rainfed lowland (wet season) paddy and irrigated lowland (dry season) paddy. In the wet season, some 10,500 ha are cropped. In the dry season, the cropping area is about 2,270 ha although food security appears not to be an issue in the area. The Government of Lao (GoL) has embarked on a major program of irrigation development along the Xe Bang Fai; most villages along the Xe Bang Fai now have irrigation pumps (see Figure 4-7), and a network of canals with water control structures has been constructed to deliver water to the fields in the dry season. There are 9 sluice gates and 25 pumping stations in the district.

Ideally, the dry season paddy should provide supplementary rice to farmers, both for consumption and for sale on the local markets. However, the dry season cropping has not been as successful as envisaged. Most of the irrigation pumps are electric, but some run on diesel, which is inefficient and relatively costly. In addition, some of the diesel pumps are in a bad condition, with the result that the total irrigation potential of currently installed pumps and systems is not fully utilized. Other problems are related to the high cost of the agricultural inputs (agro chemicals, irrigation fees etc.) as compared to the returns (low rice prices), soil characteristics (high infiltration rates resulting in rapid seepage), and a high incidence of pests.

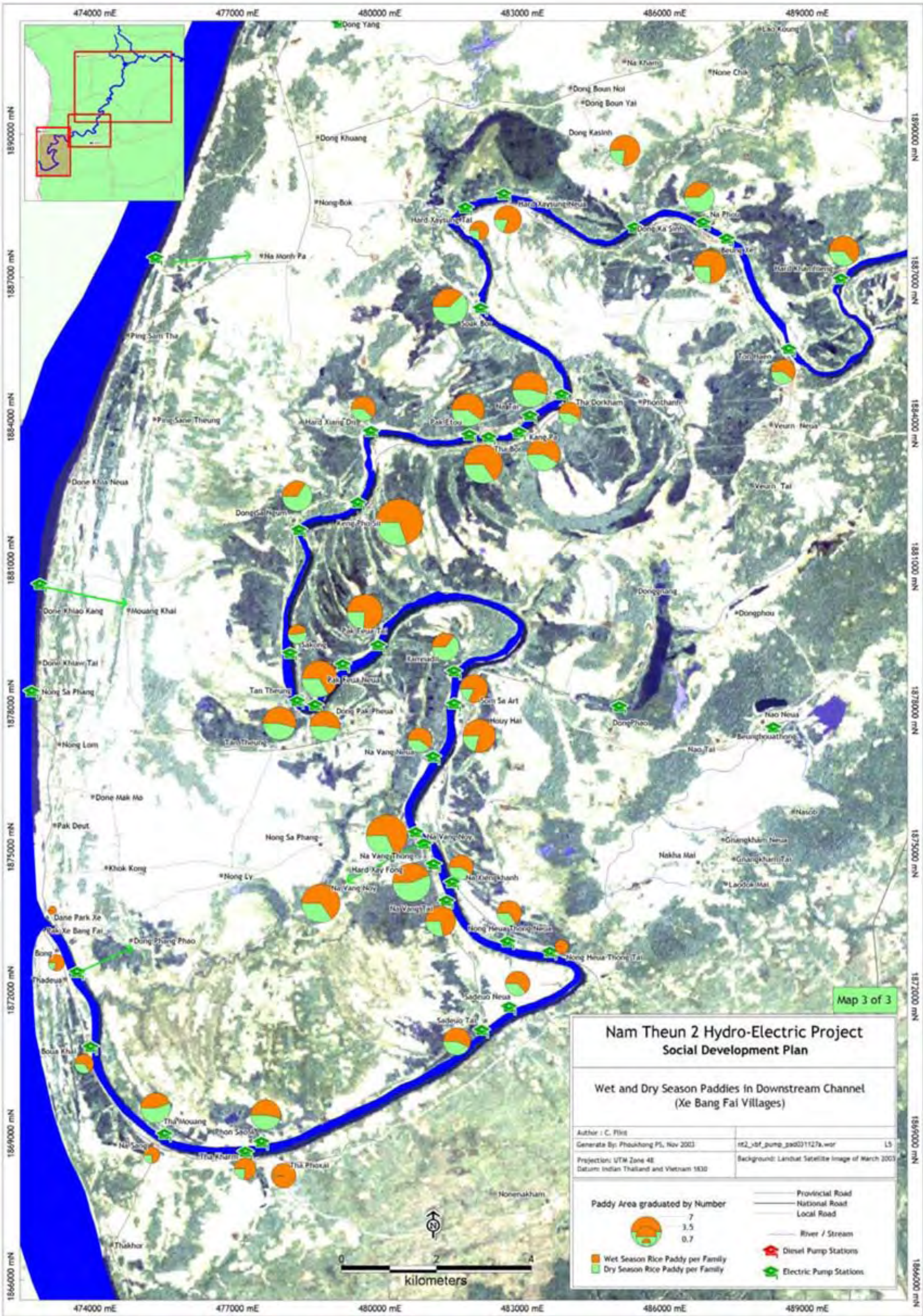
The water to be discharged by the Nam Theung-2 dam provides an opportunity for increasing agricultural production during the dry season. A number of large irrigation schemes have been made and are being planned for the Xe Bang Fai area, but recent experiences are reason for caution.



Source: MRC Basin Planning Atlas, Sub-area 4L, 2006

Figure 4-7 Location of irrigation projects along the Lower Xe Bang Fai.

Crops are grown in two overlapping periods; September - December and December - February. The first crops are corn, yam, watermelon, long bean, cucumber etc. These are grown in the moist fertile soil on the riverbanks and tributary banks. The second crop is planted down the riverbank as water recedes further. Crops grown are of shorter duration and must be harvested by February - March. Main crops are vegetables (lettuce, garlic, and eggplants) and tobacco. Part of the produce is sold on local markets and tobacco forms the largest single source of cash income. Tobacco is sold not only on the provincial markets, but also in Vientiane and across the border in Thailand. Some villages near the mouth of Xe Bang Fai, grow vegetables on riverbanks and on islands in the Mekong in large quantity for the market.



Source: Nam Theun-2 Power Company, 2005b

Figure 4-8 Wet and dry season paddy cropping in the Lower Xe Bang Fai area.

There are various types of riverbank gardens, although three main types can be identified:

- Gardens on the flat land on top of the riverbank. These are more or less permanent garden areas growing either tree crops, bananas, kapok for example, without irrigation, or vegetable crops in the dry season, which are irrigated either by small pumps or by buckets hand carried from the Xe Bang Fai;

– Riverside crop fields usually plants either at the start or the end of the wet season before the river rises, and as the river flow is decreasing. These crops are grown on the higher slopes of the riverbank, and grown on either rainfall (as start of the rainy season) or soil moisture (end of the rainy season and start of the dry season). Crops grown include maize, tobacco and sweet potato; and
– Riverside vegetable gardens, planted almost exclusively in the mid to late dry season and on the lower banks of the river. They are usually plants with vegetables or tobacco.

In the project area, where irrigation systems are fairly well developed, focus is changing from riverbank gardens to gardens watered from the irrigation systems, and thus located next to or in the vicinity of irrigated paddy fields.

Agrochemical use

Information in his section is derived from the Initial Environmental Examination of the Khammouan Rural Livelihood Project (KRLP), Prepared by the KRLP Project Implementation Unit of the Provincial Department of Planning and Investment of the Khammouane Provincial Government (2008).

In 2003, the FAO conducted a case study on pesticide use in Lao. The study found that pesticide use is relatively low compared to in other countries of the region, and that active promotion of pesticides is not widespread. However, the study also found that pesticides are widely available, and that most of those for sale are highly toxic. Folidol, a class 1a pesticide, was found to be the most widely available and used pesticide, even though it is officially banned. It was also reported that ‘a clear trend toward increasing use of pesticides is noted, particularly by farmers producing for urban markets. Although these farmers are aware of the dangers, they repeatedly stated that they know of no other way to meet the demands of the market, consumers and middlemen, other than to use more pesticides. The study concluded that merely not promoting pesticides is not enough, and that more concerted policies, strategies, and action are urgently needed.

In general, pest attack on rice crops is low in Lao PDR. Although there is a range of pests mentioned both by farmers, officials and in the literature, these are rarely of economic importance. Consequently, pesticide use per unit area of rice is low. A recent survey indicated that in Savannaket Province 50% of farmers sprayed rice one or more times per year, with 25% sprayed once and 25% sprayed more than once. Most probably, insecticide use is more prevalent in the Xe Bang Fai plain, where the influence of farming practice in Thailand and the intensity of rice production is high. However, in the Xe Bang Fai plain usage is nevertheless still low, with some blanket spraying against brown plant hopper in the dry season but generally being restricted to spot sprays of particularly severe infestations, of for example the rice bug, Leptocorisa oratorius. Stocks of pesticide do not appear to be kept on the farm (nor by local dealers) as the products are easily accessed from Thailand.

In general, pesticide use is higher in irrigated areas, partly to protect the extra investment in the dry season irrigated crop, but also because double cropping leads to an increase in the number and intensity of pests attacking the crop.

Rice diseases are rarely treated with chemicals (e.g. fungicides) weed control with herbicides is also very rare.

Pesticide use for vegetable growing is believed to be significant. The number of treatments applied is apparently not excessive, but every farmer treats his vegetables with insecticides.

There has been no analysis of pesticide residues in fresh produce in Lao PDR, since there are no laboratory facilities for this.

Inorganic fertilizers are used predominately on the dry season rice crop, but increasingly also in the wet season. The type of usage varies according to the recommendations of extension workers and local availability. Farmers mentioned using an NPK 16-20-0 compound fertilizer to ‘prime’ the land at around 200 – 350 kg/ha followed by Urea 46-0-0 at around 50 kg/ha. These fertilizers contain no K, making the rice susceptible to diseases such as brown spot disease in K deficient conditions. Farmers and officials in the Xe Bang Fai plain indicated that inorganic fertilizer use appears to follow no particular guidelines with respect to soil analyses or the analysis and usefulness of organic fertilizer. Some inorganic compound fertilizers appear to be used based on availability from donors rather than on need. In the Xe Bang Fai plain organic fertilizer, mainly manure is used in combination with inorganic fertilizer at around 250 kg/ha; a relative low rate, but beneficial if applied annually.

4.3.3 Fisheries

After rice, fish is the most important item on the diet for all ethnic groups in the area. Besides, the sale of fish on local markets adds considerably to the income of most households. Fish is caught with a variety of gear and equipment including explosives, poisonous plants, nylon monofilament gill nets, spears, hook and line, cast nets, scoop nets and many types of trap. Drift and gillnets are the most important gear in terms of the size of fish landings made by fisherman from the Xe Bang Fai. Fish is caught all year round by men, women and children. The seasonal fish migrations between the Mekong River and the Xe Bang Fai are important periods for fisheries.

The main Xe Bang Fai channel is the most important fishing ground during the dry season (when fish concentrate in refuge habitats), while habitats on the floodplain (flooded forests, swamps, backyard ponds, paddy fields) are important during the wet season (see Table 4-4). Catches consist mainly of cyprinids and catfishes, many of which in-migrate from the Mekong mainstream. Catches in the floodplains also include resident species such as snakehead, mud perch, spiny eels, climbing perch, walking catfish, and gouramies.

Table 4-4 Percentage of fish catch caught at different locations.

	Percentage of catch caught at different locations
Xe Bang Fai River	54%
Xe Bang Fai Tributaries	3%
Paddy fields	14%
Other small bodies of water	10%
Back swamps and natural ponds	19%
Total	100%

Source: Nam Theun-2 Power Company, 2005b

Families in the lower reach of Xe Bang Fai catch on average 168 kg fish/fam/year, sufficient for daily consumption and the production of 2 - 8 jars (= 22 kg) of ‘Padek’ /family/year. Padek, salted fermented fish, is the second staple food in Laos, after rice. The remaining catch, on average 20% or some 35 kg/household/y, is sold on the market. Anecdotal information suggests that production has declined over the last 10-15 years. Average fish size and the number of species caught have also declined. The reason for the decline is thought to be overfishing and use of small mesh monofilament gillnets.

4.3.4 Livestock and animal husbandry

In the Lower Xe Bang Fai area, every household has on average 1 - 2 head of cattle, 0 - 1 pig and some 10 chicken. Buffalos are still an important source of draft power for land preparation, although power tillers are becoming more common, particularly in the larger and more prosperous villages. Cattle are a form of savings, and when needed they are sold for cash to meet household expenditure requirements.

4.3.5 Aquaculture

The level of aquaculture activity in the Xe Bang Fai is low, with less than 3% of households involved. Backyard ponds, rice field fish culture, and village swamp fish culture are the most important types of fish culture. Net cages are least important. No production estimates are available for aquaculture activity in the Project area.

One reason for the low level of aquaculture might be the relative abundance of fish within the river and adjacent wetlands. Lack of infrastructure and well-developed market systems or transport services are other valid explanations, as well as lack of knowledge about fish culturing techniques. However, aquaculture is becoming more common in the Lower Xe Bang Fai zone, in part due to population pressure and in part due to availability of irrigation waters, which are also used in aquaculture.

4.3.6 Tourism

No major tourist attractions are located in the project area.

4.3.7 Roads and infrastructure

The road network in the project area is fairly dense with National Road Nr 13 South, connecting Thakhet with Savannaket forming the eastern boundary of the project area. Most villages in the Nongbok District are accessible by road, both in the rainy and in the dry season. There are 81 roads with a total length of 287 km in the district. Of these roads 71 (273 km) can be used in both seasons. There are 5 bridges in the district.

4.3.8 Navigation

The navigation on the Xe Bang Fai is inconvenient, only small volumes can be transported within fifty kilometers from the junction with the Mekong River. In the wet season the river is navigable for ships with a capacity up to 5 tonnes, in the dry season the capacity of the ships is limited to 0.2 tonne.

4.4 Social and Cultural Resources

4.4.1 Population and communities

According to the Nongbok District statistics, the population in 2006 was about 41,000 (7,600 households). Average household size was 5.41 persons and the average annual population growth rate during the period of 2001-2006 was 0.49%.

Ethnicity in Nongbok district is mainly Lao (71%), followed by Phouthyai (25%), Mangkong (3%) and King (1%). 95% of the household in the district is male headed.

Agriculture is the main economic activity in the area. Besides, there is a significant seasonal labour migration to Thailand (25%). A small proportion of the population is occupied in fisheries, business, trade and services. (See Table 4-5 for details).

Table 4-5 Main occupation in Nongbok District, 2006.

Occupation	**Number**	**Percentage**
Agriculture	15,293	63%
Fishery/aquaculture	358	1%
Agriculture - Hired laborer	898	4%
Construction - Hired laborer	216	1%
Seasonally working in Thailand	6,000	25%
Business	465	2%
Employee - Private sector	200	1%
Employee - Government	668	3%
Total	**24,098**	**100%**

Source: FMMP-C2, Phase 1, Socio-economic survey, District data-base

According to the FMMP-C2, Phase 1, Socio-economic survey, District data-base, housing in the Nongbok District consists mainly of semi-permanent (i.e. brick and tin roof) structures (70%), followed by permanent (i.e. concrete) houses (20%) and temporary houses (10%). All agricultural storage structures are temporary. The percentage houses connected to the power grid is very high: 95%.

4.4.2 Water supply and sanitation

Only about 1,000 households in the Nongbok District town are connected to a piped water supply system. Villagers along the Xe Bang Fai use river water for a variety of domestic purposes: drinking, cooking, bathing, dishwashing, washing of clothes and watering of gardens. Not only the river water is used, other water sources are used as well, depending on water resource availability, water resource developments, season, and personal inclination. They are:

- Xe Bang Fai - bank spring;
- Xe Bang Fai - dug wells on the edges of the river;
- Tributaries (creeks);
- Rainwater;
- Shallow dug well;
- Deep bore well;
- Lakes, ponds;
- Tapped water;
- Bottled water; and
- Irrigation canal water.

A survey carried out within the framework of the Nam Theung-2 project in 2003 - 2004 showed that the Xe Bang Fai is the most important water source in the dry season although for cooking and drinking other sources, mainly deep (bore) and shallow wells, are also important. In the wet season, rainwater and the Xe Bang Fai are equally important as a source of domestic water.

According to the Survey data, 52% of the households in the district are having their own toilet or latrine.

5. Environmental Screening of the Project

The Lao PDR EIA Decree stipulates that ‘No construction or other physical activities shall be undertaken at a project site until an environmental compliance certificate for the project is issued.’ Types or sizes of projects, which do or do not require EA, are presently not specified. Instead, based on the information in the project proposal document, the Development Project Responsible Agency (DPRA) assembles an ad hoc Project Review Team to complete an environmental screening of the proposed project. Projects that are such in nature, size and location that they are assumed to cause minimal environmental impacts do not require further Environmental Assessment. Those projects determined to be non-exempt from EA must proceed to conduct IEE, depending on the findings of the IEE, an Environmental impact assessment (EIA) may be required.

Keeping in mind the above, the outcome of the project screening, applying the project-screening table as given in the Best Practice Guidelines for IFRM Planning and Impact Evaluation, indicates the necessity of an environmental assessment (See Table 5-1). Although no official protected areas are located in Xe Bang Fai plain the area is an important wetland area, consisting of a mosaic of fresh water lakes, river ponds and fresh water marshes, these wetlands are important in sustaining fisheries, that are an important additional source of food and income to the rural population.

Table 5-1 Results of the environmental screening of the Integrated Flood Risk management Plan for the Lower Xe Bang Fai area.

SCREENING QUESTION	Yes	No	Remark
A. PROJECT SITING Is the project area adjacent to or within any of the following environmentally sensitive areas?			
– in or near sensitive and valuable ecosystems (e.g., protected areas, wetlands, wild lands, coral reefs, and habitats of endangered species).	X		the area is an important wetland area, consisting of a mosaic of fresh water lakes, river ponds and fresh water marshes. No official protected areas are located in Xe Bang Fai plain.
– in or near areas with cultural heritage sites (e.g. archaeological, historical sites or existing cultural or sacred sites).		X	-
– densely populated areas where resettlement may be required or pollution impacts and other disturbances may be significant.	X		population is concentrated along the riverbank where most construction works will take place and in villages on higher grounds. Alternative 3 of the project may require significant resettlement.
– regions subject to heavy development activities or where there are conflicts in natural resource allocation.		X	-
– watercourses, aquifer recharge areas, or reservoir catchments used for potable water supply.	X		river water is an important source for domestic water for a large proportion of the population in the area.
– lands or waters containing valuable resources (e.g. fisheries, minerals, medicinal plants, prime agricultural soils).	X		the area is an important rice producing area. Besides fisheries provides additional food and income to the rural population
B. POTENTIAL ENVIRONMENTAL IMPACTS Is the project likely to lead to:			
– permanent conversion of potentially productive or valuable resources (e.g. fisheries, natural forests, wild lands).	X		the wetlands in the project area are likely to be effected when flooding reduces. Reduced access to, and flooding of, the floodplain reduces fisheries potential greatly.
– destruction of natural habitat and loss of biodiversity or environmental services provided by a natural system.	X		a reduction of the flooded area will affect the flora and fauna diversity (fish and water birds). Under alternative 3 upstream migration of fish will be hampered.
– risk to human health and safety (e.g. from generation, storage, or disposal of hazardous wastes, inappropriate occupational health and safety measures, violation of ambient water or air quality standards).		X	limited, some construction activities related health and safety risks are to be expected. Improved flood protection on the other hand reduces risks and improves food security and thus health.
– encroachment on lands or rights of indigenous peoples or other vulnerable minorities.		X	-
– displacement of large numbers of people or businesses.	X		under Alternative 3 a considerable number of people will have to be resettled.
– absence of effective mitigation or compensation measures.		X	-

6. Identification and Assessment of the Potential Environmental Impacts

6.1 Introduction

For the identification of potential environmental impacts and mitigating measures the checklist of Environmental, Economic and Social Parameters for Flood Risk Management Projects, as given in the Best Practice Guideline for IFRM Planning and Impact Evaluation, has been used.

According to the checklists, the relevant parameters can be classified as follows:

- Environmental concerns related to project siting;
- Environmental concerns related to project implementation and construction activities;
- Environmental concerns related to project design, management, operation and maintenance; and
- Positive impacts related to project design, management, operation and maintenance.

In Attachment 6.1 the completed checklist is given.

In the following paragraphs the environmental parameters that are relevant within the framework of the proposed project will be discussed on an item by item base.

For the assessment of the significance of the impacts no formal assessment procedure was used and only a distinction between no significant impacts, small significant impacts, moderate significant impacts and major significant impacts was made. This assessment was based on expert judgment, taking into account the following general criteria to assess the significance of the impacts:

- Magnitude of the impact, the expected severity;
- The extent of the impacted area;
- The duration or frequency of the impact; and
- The risk involved; the probability of a serious impact occurring.

Where relevant a distinction is made between impacts occurring in the study area itself and off-site impacts, expected to manifest themselves in areas outside the proper project area. Possible mitigating measures to offset or reduce negative impacts and measures to enhance positive impacts are proposed. Possible transboundary impacts receive special attention.

6.2 Impacts and mitigating measures related to project siting

6.2.1 Land acquisition

Under Alternative 1 and 2 the dikes along the Xe Bang Fai, and partly the Mekong River, will be heightened. Because of their relatively elevated position, these riverbanks are the areas where population is concentrated. Construction/heightening of in total 93 km dike are planned. Land may actually not have to be acquired, probably people living on the banks of the river only have to be relocated temporarily and can return to their former lands once construction is finalized. Under alternative 1 and 2 also 11 km of irrigation/drainage canals have to be constructed. Assuming an average canal width of 4 m (including banks), a total of 44,000 m^2 has to be acquired. Construction of a diversion channel, a component additional to dike construction under Alternative 2, will entail additional land acquisition, some 200,000 m^2 and resettlement, as well as loss of agricultural area.

Alternative 3, construction of a storage reservoir, will require the acquisition of a large area: the impoundment area of the reservoir is estimated at 10,500 ha. This area includes agricultural land of 18 villages. Resettlement is a big issue under this Alternative.

Mitigation:

The area to be acquired should be minimized by careful design. If land acquisition and resettlement is unavoidable, losses have to be compensated and assistance has to be provided to relocate and restore living conditions. Compensation and assistance have to be described in a carefully designed and implemented Participatory Resettlement Action Plan.

6.2.2 Encroachment on historical monuments and cultural values

Whether or not pagodas, temples, sacred sites and graves or other sites of historical or cultural value are located in on or near proposed construction sites is not yet known. It is to be assumed that the reservoir construction under Alternative 3 will result in the loss of a considerable number of historical monuments and cultural values, since in total 18 villages will be flooded.

Mitigation:

Avoid, minimise or offset activities by careful design and consultation with local communities. Compensate for damage to or displacement of sacred sites, graves, etc.

6.2.3 Encroachment into forests, swamps, loss of precious ecology

The project area is a fairly important wetland area, consisting of a mosaic of fresh water lakes, river ponds, rice paddy and fresh water marshes. Important ecosystems associated with the wetlands are the seasonally inundated riparian forests and grasslands found on the gently sloping plains adjacent to lakes, rivers and tributaries and submerged by the seasonal flood of the wet season.

Direct impacts of encroachment are probably limited. However, the indirect impact of the project on the natural areas may be significant: increased protection against flooding and provision of irrigation infrastructure will result in an extension of agricultural activities to areas that are presently not used for rice growing. Other important indirect impacts on natural areas and ecology are related to the changing flood pattern, see Section 6.3.2.

Mitigation:

Avoid, minimise or offset encroachment into forests, swamps and the loss of precious ecology by careful design and consultation with local communities. Compensate or offset losses through replacement. An awareness campaign to inform the local communities of the importance of the area’s biodiversity and the benefits of sustainable use should start.

6.2.4 Impediment to movement of wildlife, cattle and people, including obstruction to navigation and obstruction of fish migration paths

Dike construction will not result in impediment to movement of wildlife, cattle and people; it may even improve mobility since the dikes will be flood free during the flood season. Irrigation canals may form more serious obstructions for moving wildlife, cattle and people. This will certainly be the case for the 20 m wide Xelat Diversion Canal, if constructed under Alternative 3. Creation of a large storage reservoir, Alternative 3, will seriously impede the movement of wildlife, cattle and people

Also serious is the obstruction of fish migration paths. With the onset of the flood fish migrate up the Xe Bang Fai and during the main flood they spread over the floodplain where they feed. Construction of a dam in the Xe Bang Fai, possibly combined with the construction of a control gate at the confluence of the river with the Mekong (Alternative 3) will make the upriver migration impossible. Embankment will prevent the fish from reaching suitable spawning/nursing and feeding habitats in the floodplain.

Mitigation:

Careful planning, design, and operation. Sufficient bridges/crossing over the irrigation canals/diversion canal have to be built. Construction of fish passages is advised, whereas the operation of the gates should be such that water flow between the Mekong River and the Xe Bang Fai is possible in periods of maximum migration. Controlled flooding of the existing wetlands could help in sustaining their important ecological function for migratory fish.

6.2.5 Loss of the aesthetic, visual or recreational amenity or value of the area

No significant impacts are foreseen, since the area has limited aesthetical and recreational value.

6.3 Potential impacts related to project implementation and construction activities

6.3.1 Soil erosion, increased turbidity and sedimentation of rivers and watercourses

Soil erosion during the construction phase may result from destruction of the vegetation or surface runoff over unprotected soil at the construction sites. Total magnitude of the works to be carried out is fairly large and overall impact could be considerable. Runoff water from exposed soil will be sediment laden and result in an increase in turbidity of the receiving water bodies. Excavation and disposal of excavated materials can also increase turbidity in the area close to the activity, either by direct disturbance of the soil or due to spillage of sediment-laden water. Increased turbidity will in turn intensify the existing sedimentation processes, as the sediments will resettle close to the construction areas. Increased turbidity has an adverse impact on all water organisms, not only on the fish but also on the invertebrate (zooplankton, zoobenthos) consumed by them. Benthic communities may smother because of re-sedimentation of suspended sediments and this may lead to a loss of species and a decrease in benthic biomass. High turbidity can negatively influence vital functions of the organisms, and may lead to complete or partial extinction of plankton and benthic species in high turbidity areas. However, these impacts are only local and temporary.

Mitigation:

Soil erosion and the consequent negative impacts on downstream water quality can be reduced by minimizing clearing activities, by compacting and protecting exposed soil as much as possible and by replanting areas where the vegetation has been damaged. If needed, construction activities should be limited to the dry season. Fencing may be applied to protect particularly sensitive areas. Removal of sediments (dredging) may be applied to maintain a certain water depth, e.g. for navigation purposes.

6.3.2 Loss of habitats/productive land by disposal of dredge spoil or solid waste/soil disposal

See 6.2.1. Soil excavated for the construction of irrigation drainage canals will probably be deposited directly along the canals to form small embankments, the amounts are limited. Of the estimated overall loss of 44,000 m^2 (6.2.1), about half will be loss resulting from deposition of spoils. Construction of the Xelat Flood Diversion will result in a fairly large amount of excavated material, assuming an average depth of the canal of 4 m, some 800,000 m^3 of soil will have to be disposed of.

Mitigation:

Works should be planned and designed in such a way that excavated soil can be used for the embankment construction.

6.3.3 Loss of soil fertility

No significant impact expected.

6.3.4 Worker accidents

A main health and safety issue during the construction phase is accidents of construction workers who are at risk at the workplace because they work with and near heavy machinery.

Mitigation:

Severity and frequency of accidents can be reduced considerably when construction equipment is well maintained and safety regulations and procedures are strictly implemented in conformity with the prevailing Labor Law, safety gear is issued and worn, and when construction workers are trained on safety procedures.

6.3.5 Accidents from increased traffic (construction equipment)

Movement of vehicles and equipment to and from the construction sites will cause traffic volume along the NR13S and along the local roads to increase considerably. This will increase the likelihood of accidents.

Mitigation:

Alternative routes should be selected to avoid densely populated areas as much as possible. Where construction traffic has to cross communities driving speed limits should be set and enforced. Local population has to be informed by means of a community awareness program.

6.3.6 Disruption of access to villages, damage of local roads with heavy machinery

During the construction period access to villages may be temporary disrupted and local roads may be damaged by heavy machinery. This may result in loss of income from farming, fishing and processing activities and temporary disruption of local businesses and access to community services (schools, clinics).

Mitigation:

Alternative routes should be identified to facilitate continued access. Disruptions should be limited to periods with low economic activity, e.g. outside the harvesting period. Losses of business income or wages have to be compensated. If needed community facilities/services should be relocated to guarantee continue access. Local population has to be informed by means of a community awareness program.

6.3.7 Temporary obstruction to navigation

No significant impact expected.

6.3.8 Disruption of utility services

No significant impact expected.

6.3.9 Noise/vibration/air pollution (including dust) from construction activities

Noise, vibration and air pollution because of the construction activities will be temporary but significant.

At present, noise levels in the rural areas in the project communes are low. During the construction phase noise may be caused by generators, construction equipment and vehicles used for material transport. Noise of this type of activities can reach 90 dBA at 15 meters distance, which is generally above the permissible noise levels for public and residential areas. However, construction will not take place in public or residential areas.

The major potential source of vibration is heavy vehicle movement. The routes used for material transport will not pass through densely populated areas. Therefore, this impact will be negligible.

In the construction phase, the air near the construction sites may be polluted by toxic gasses (SO_2, NO_X, CO and volatile organic compound (VOC) from construction machines and dust. Dust pollution may be significant during the construction phase, particularly in the dry months.

Mitigation:

Vehicles and construction equipment have to be well maintained and checked for operational noise levels, vibration and gas emissions to meet standards. Mufflers should be installed and maintained as necessary to meet these standards. If the distance between the construction site and sensitive receptors (residential areas, schools, offices) is insufficient, special measures of noise prevention should be considered: e.g. installation of adequate barriers. The routes used for material transport should avoid densely populated areas as much as possible and when needed vehicles should proceed at reduced speed. Transport and construction have to be minimal during rest times.

Dust production can be reduced by periodic watering of construction sites (important in the dry season) and access roads. Vehicles transporting construction material (sand, cement, stones) should be covered to prevent dust dispersion.

6.3.10 Soil/(ground)water contamination as a result of leakage and inappropriate storage of fuels and other chemicals, dumping of construction wastes or improper sanitation (worker camps)

Surface run-off from construction sites, leakage of combustibles and greases from construction equipment and discharge of domestic wastewater and solid wastes at construction workers campsites may form a source of soil and (ground) water pollution during the construction period. Loss of flora and fauna, and increased risk of health problems, e.g. skin rashes and eye infections from contaminated surface water, may be the result. Contamination of drinking water sources may lead to health problems like diarrhea and dysentery.

Mitigation:

(Ground) water and soil pollution at construction sites can be minimized by containment of fuels stored on-site and off-site refuelling, by following appropriate procedures and by proper maintenance of equipment. Disposal of solid waste (construction waste, sand, stones, etc.) and waste grease and oil from construction equipment to ponds, rivers or wells should be avoided: wastes have to be collected and transported to approve disposal sites. Sanitation facilities for construction workers should be provided to minimize the risk of transmission of diseases. The Contractor has to install adequate sanitation systems (for example mobile toilet facilities) for workers or require them to use public sanitation facilities to prevent untreated domestic waste discharge. Wastewater has to be collected and treated mechanically before being discharged to rivers, ponds or the soil.

6.3.11 Social/community disruption

Conflicts between construction workers and local people may be caused by differences in customs and traditions, differences in income, and encroachment of workers into historical or traditional sites.

Mitigation:

To avoid problems between construction workers and local people, construction workers should be recruited as much as possible locally, as such they will be familiar with local customs and traditions. Goods and services have to be purchased as much as possible locally. If workers from other areas are recruited, they should receive a proper awareness program about local customs and appropriate behavior.

6.3.12 Health impacts

Dust pollution may affect to health of workers and people living in the vicinity of the construction sites and transport routes. High concentrations of VOC, CO and NO_x in truck emissions may have a negative impact on the health of construction workers and local residents. However, the exposure is only temporary. For impacts related to contaminated water, see Section 6.3.10.

Influx of non-local workers for project construction and other people attracted by economic opportunities brings about an increased risk of sexually transmitted diseases, including HIV/AIDS, and other infectious diseases.

Mitigation:

The Contractor will be responsible for development and implementation of an occupational health and safety program for construction workers and for provision of medical facilities on the site. A proper domestic and human waste management plan has to be designed and implemented. A robust HIV/AIDS awareness and prevention program targeting workers and people in surrounding communities should be implemented and local health clinics need to be supported to meet the increased demands. For mitigating measures to reduce or offset impacts related to poor water quality, see Section 6.3.10.

6.3.13 Increased pressure on water supply and sanitation facilities

Influx of non-local workers for project construction and other people attracted by economic opportunities may put pressure on the existing water supply and sanitation facilities. This may result in health risks related to poor drinking water and sanitation conditions.

Mitigation:

Appropriate planning and design of water supply and sanitation facilities for worker camps

6.3.14 Employment opportunities for local people

This is a positive impact of the project, to enhance this impact; contractor contracts should specify employment for local workers and local purchase of goods and services.

6.4 Potential negative impacts related to project design, management, operation and maintenance

These impacts are mainly related to project induced changes in the hydrology/hydraulics: the timing, extent, depth and duration of flooding, which may result in a loss of flooding related benefits.

6.4.1 Loss of agricultural productivity

Information gathered during Focal Group discussions in the area showed that paddy yields after a year with a high flood are not different from yields in a year after a year with a normal flood. In addition, there was no difference in required agro-chemical inputs. Apparently, the silt deposition during the flood does not improve the soil fertility and there are no positive impacts of flushing of contaminants or sanitation (killing pests and bugs) of the soil.

Reduced flooding will reduce the replenishment of groundwater and surface water bodies in the area, which will have a negative impact on the amount of surface and ground water available for agriculture in the dry season.

Mitigation:

Provision of irrigation water will offset the negative impacts of reduced availability of surface and groundwater in the dry season.

6.4.2 Loss of capture fisheries production

After rice, fish is the most important item on the diet for all ethnic groups in the area. Besides, the sale of fish on local markets adds to the income of most households. Fish is caught all year round by men, women and children. The seasonal fish migrations between the Mekong River and the Xe Bang Fai are important periods for fisheries.

The main Xe Bang Fai channel is the most important fishing ground during the dry season (when fish concentrate in refuge habitats), while habitats on the floodplain (flooded forests, swamps, backyard ponds, paddy fields) are important during the wet season.

Reduced flooding of the floodplains will have a significant negative impact on fish stocks, both in the floodplain itself and in the river. Construction of a flood storage dam, Alternative 3, will end the migration runs up the river. At present fishing is most intensive during these migration periods. On the other hand, the construction of a dam will increase the possibilities for capture fisheries and aquaculture in the newly created reservoir.

Mitigation:

Allow sufficient flooding to maintain fish migration patterns and fish spawning, breeding, nursing and feeding areas.

6.4.3 Loss of wetland areas/productivity

Reduced flooding will have a significant negative impact on the biodiversity in the area. Species composition of flora and fauna will change and the diversity and extent of water bodies and swamps in the floodplain will decrease. Sixty-seven fish species have been recorded in the Lower Xe Bang Fai. No endemic species were among these. Most of the recorded species are highly migratory. Adults and juveniles spend the dry season in deep refuge pools in the mainstream Mekong. At the onset of the wet season, they migrate upstream until they encounter a tributary, and then swim up the tributary until they reach a floodplain or another suitable spawning/nursing habitat. There are over thirty medium and large size species of cyprinid and pangasiidae catfish, which exhibit this general migration pattern.

The first major fish migration of the year commences at the beginning of the wet season. At that time, according to villagers, a large number of fish species begin migrating up the Xe Bang Fai, and its larger tributaries, while other fish species are believed to move from deep-water pools to spawning areas in the Xe Bang Fai.

These two migrating groups include the following taxa: Cyprinids *(Labeo chrysophekadion, Labiobarbus sp., Sikukia gudgeri, Hypsibarbus sp., Puntioplites sp.)*, Catfish *(Pangasius larnaudii, P. macronema, P. pleurotaenia, P. bocourti, Wallago attu, W. leeri, Bagarius sp, Hemibagrus wyckioides, H. nemurus, Helicophagus waadersi, Laides sp., Mystus spp.)*, Mud perch *(Pristiolepis fasciata)*, Glassfish *(Parambassis siamensis)*, River loach *(Schistura sp. or Nemacheilus sp.)*. During overbank flooding events fish migrate laterally to adjacent floodplains for spawning and feeding.

In the dry season ‘Black fish’ species remain in lakes and swamps on the floodplain, where they are able to survive harsh conditions. The open waters and wetlands are vital in maintaining a breeding stock of these species. A decrease in number or area of the floodplain lakes, or even a later arrival of the floodwater, results in drying out of the floodplain lakes and ponds or the development of very poor water quality conditions and ultimately in a loss of species like snakehead, mud perch, spiny eels, climbing perch, walking catfish, and gouramies.

It will be clear that under Alternatives 1 and 2 the survival rate of ‘Black fish’ in the floodplain will decrease considerably and that lateral migration to spawning and feeding areas in the floodplain will be impossible for ‘White fish’. Under alternative 3, upstream fish migration in the Xe Bang Fai will be impossible and will ultimately lead to the disappearance of most of these migratory species.

Mitigation:

Allow sufficient flooding to safeguard silt and water supply to the wetlands.

6.4.4 Reduced possibilities for navigation/transportation by boat

Construction of a floodgate at the mouth of the Xe Bang Fai as well as construction of a storage reservoir near the confluence with the Xe Noi River will seriously hamper navigation.

6.4.5 Change in water availability in the dry season

Flooding in the area will prevented for the bigger part. This implies that replenishment of groundwater and surface water bodies, ponds and lakes in the floodplain with flood water will not take place.

Mitigation:

An important element of the project is the construction of irrigation canals to provide the area with water during the dry season. As such the project will improve the water availability in the dry season.

6.4.6 Changes in river morphology, salt water intrusion and delta growth

Flood protection measures in the Xe Bang Fai area will only result in a very limited reduction of the storage of flood waters. Impacts on the main Mekong discharges will be negligible and impacts on downstream river morphology, saltwater intrusion in the delta and delta growth are not expected.

6.5 Positive impacts related to project design, management and operation and maintenance

6.5.1 Increased safety for population living in the flood prone areas

Overall, the project will have a positive impact on human safety in the area. People will be better protected against flooding, and the likelihood of loss of life will decrease.

6.5.2 Reduced sanitation and public health problems in the flood season

Overall, the project will have a positive impact on human health situation in the area. The food situation in the area will probably improve, since rice production, will increase when irrigation facilities are in place and an additional crop can be grown in the dry season. However, this may partly be offset by a decrease of the amount of fish available in the flood season.

Participants in the Focal Group discussions in the Nongbok District in the Xe Bang Fai project area did not specifically mention poor water quality as an 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 contaminate 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. Hence, reduced flooding will probably reduce these health problems.

Fertiliser use in the district is limited, and pesticide use is reported to be almost zero. Stocks of agro-chemicals are brought to save 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, and hence there is no positive effect of reduced flooding.

6.5.3 Decrease in flood damages to crops, infrastructure and ecosystem

The Xe Bang Fai floodplain, downstream of the crossing with NR13S, experiences flooding problems during the rainy season nearly every year. The risk in the Nongbok District, which covers most of the Lower Xe Bang Fai floodplain, 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 NR13S is estimated that the flood risk in the Lwer Xe Bang Fai area is of the order of USD 2-3 million per year. 90% if this risk is related to agricultural damages.

Flooding not only has an impact on floodplain ecology, also the ecology of the river channel itself and the riparian zone may be affected. The quality of river water may change considerably during a flood. Turbidity levels of the river generally rise sharply as compared to the turbidity in low flow periods. High turbidity is primarily the result of the contribution of sediment rich surface runoff to the flood and erosion of the riverbed and banks. However, also an increased growth of algae, induced by increased levels of nutrients, may add to turbidity. High sediment contents may have a negative impact on aquatic organisms: fish gills may clog and decreased penetration of light in the water column results in decreased photosynthesis and lower water temperatures. As a consequence oxygen levels in the water may drop, a phenomenon that may be more serious when exotic plants that are intolerant of extended inundation are flooded, since decay of the organic matter extracts oxygen from the water.

Flooding of rural areas may result in contamination of flood waters with pesticides and herbicides and nutrients from fertilizers. This may certainly be the case when storage facilities of these agro-chemicals flood. Animal and human waste, either from open pit latrines or flooded septic tanks, contaminates the flood water with organic material and pathogens. High organic waste levels may result in reduced oxygen levels affecting aquatic life. Pathogen contamination is a threat to human health. Flooding of open solid waste dumps is another source of pollution, depending on the nature of the wastes this may result in increased levels of organic matter, chemical pollutants or microbiological pollutants in the flood water. Esthetical impacts, floating debris, may also result from flooding of dump sites.

High nutrient contents, nitrogen and phosphorous, may be limiting to the growth of the native floodplain and riparian plants and may enhance the growth of invasive species. Poor water quality in general may result in fish kills and impact on other aquatic biota.

Impacts related to physical disturbance are often related to forces acting upon biota, for example, destruction of riparian vegetation (stripping) results in a decrease in size and connectivity of habitats and thus in reduced structural complexity of the riparian zone. Loss of the riparian vegetation has a negative impact on the stability of the riverbanks.

Another form of physical disturbance is the coverage of flora and sometimes fauna with a layer of sediment. This may result in mortality of floodplain plants and fauna. Mortality may also be the result of prolonged inundation.

Yet another form of physical processes inducing impacts is the spread of organisms with the flood water. Exotic species, e.g. floating weeds, can be flushed out of the river into the floodplains and become invasive in floodplain ecosystems over large areas. Flood events also may be important in the release of exotic fish species from outside aquaculture ponds.

It will be clear that all these impacts of flooding on ecology and the environment will become less severe, once the project is implemented.

6.5.4 Opportunities to increase agricultural production

The main objective of the project is to reduce flooding of the Lower Xe Bang Fai floodplain. Realizing this objective would already imply an increase in agricultural production. It has been estimated as part of the Stage 1 analysis that the average annual damage in the present situation is 2 to 3 million USD, of which 90% can be attributed to damage to agriculture. In other words, crops with a value of 1.8 to 2.7 million USD are lost every year. This is equivalent to a prevented loss of 9,000 to 13,500 ton rice per year.

Of more importance is the fact that provision of irrigation infrastructure, a second objective of the project, will make a second rice crop possible in the area.

6.5.5 Improvement mobility/better road transportation network

Most probably heightening/improvement of the embankment will be combined with the construction of roads on these embankments. Also, banks along irrigation/drainage canals are usually used as footpaths/roads. As such implementation of the project is likely to improve the transportation network and improve mobility.

6.5.6 Poverty reduction and improved food security

Overall, the project will have a positive impact on poverty reduction and food security. Food (rice) production, and so food security, will increase. This is not necessarily the case for fish available in the flood season.

Besides, jobs generated for the execution of the construction works will reduce poverty of the local population. The same is valid for the intensification of the agriculture, which will follow the provision of irrigation infrastructure. This will create a fairly large number of jobs, not only in agriculture, but also in related economic sectors: transportation, agro-business etc.

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Attachment 6.1 Checklist of Environmental, Economic and Social Impacts

CHECKLIST OF ENVIRONMENTAL, ECONOMIC AND SOCIAL PARAMETERS FOR FLOOD RISK MANAGEMENT PROJECTS										
Environmental Concerns			Related Impacts		Recommended Feasible Mitigation Measures		No Significant Impact	Significant Impact		
								Small	Moderate	Major
A	Environmental concerns related to project sitting									
	1	Land acquisition	1	Loss of productive land and/or sources of income. Displacement of households, and/or economic activities. Social/ community disruption.	1	Avoid or minimize by careful design. If not possible, compensate for losses and provide assistance to relocate and/or restore living conditions/livelihoods. Prepare & implement participatory Resettlement Action Plan.			X	
	2	Encroachment on and/or damage to historical, cultural, religious or other sites and monuments that are important to the community and/or to social groups	2	Loss of valued sites. Disruption of social / community rituals. Indirect impacts: Loss of tourism potential. / income.	2	Avoid, minimise or offset activities by careful design and consultation with local communities. Compensate for damage to or displacement of sites, graves, etc.	X			
	3	Encroachment into or restricted access to forest/swamplands / wetlands	3	Loss of biodiversity, rare and endangered species. Loss of forest/swamp / wetland related production functions. Indirect impacts: Increased household expenditures for food, building materials, medicines, etc., that were harvested. Reduced strategies to deal with food shortages. Increased risks of poverty.	3	Avoid or minimize by careful design and consultation with local communities. Compensate and/or offset economic losses through replacement of resources, identification of alternative income sources, etc.			X	

CHECKLIST OF ENVIRONMENTAL, ECONOMIC AND SOCIAL PARAMETERS FOR FLOOD RISK MANAGEMENT PROJECTS										
Environmental Concerns			Related Impacts		Recommended Feasible Mitigation Measures		No Significant Impact	Significant Impact		
								Small	Moderate	Major
A	**Environmental concerns related to project sitting**									
	4	Loss of agricultural/aquaculture land	4	Loss of household income from sales and/or work as hired labor (with different impacts for men and women, landless HH). Loss of business revenues and wage employment (commercial agriculture, agro- and fish processing, etc.) Indirect impacts: Increased HH expenditures for food; reduced food security. Distress sales of land and other assets. Increased risk of out-migration to look for work. Increased poverty.	4	Consultation with affected communities and HH to identify and implement feasible alternative income sources. Training for new job skills, establish-ment of micro-enterprises. Compensation for economic losses.		**X**		
	5	Impediment to movements of wildlife,, including obstruction of fish migration paths	5	Impediment of wildlife, reduction in biodiversity and fish stocks Indirect impacts: Loss of income from fishery	5	Careful planning, design, and operation, construction of fish passages	**X**			
	6	Impediment to movements of people (e.g., navigation) and their animals	6	Disruption of economic activities and social movements.	6	Careful planning and design		**X**		
	7	Loss of aesthetic, visual or recreational value of the areas	7	Loss of precious values, economic losses	7	Careful planning and design	**X**			

CHECKLIST OF ENVIRONMENTAL, ECONOMIC AND SOCIAL PARAMETERS FOR FLOOD RISK MANAGEMENT PROJECTS										
Environmental Concerns			Related Impacts		Recommended Feasible Mitigation Measures		No Significant Impact	Significant Impact		
								Small	Moderate	Major
B	**Environmental concerns related to project implementation and construction activities**									
	1	Soil erosion	1	Water quality impact, loss of productive soil, sedimentation problems Indirect impacts: Reduced drinking water quality; higher agricultural input costs / reduced productivity and incomes.	1	Minimise clearing activities, limit activities to dry season, optimise soil cover and apply soil management techniques to minimise soil loss		**X**		
	2	Increased turbidity	2	Impact on flora and fauna, sedimentation problems. Indirect impacts: Reduced drinking water quality (stream/rivers & water supply systems)	2	Apply fencing, use silt screens in sensitive areas		**X**		
	3	Sedimentation of riverbeds	3	Loss of habitat, problems with navigation Indirect impacts: Temporary restrictions on navigation/accessibility for economic activities, social networks	3	Remove deposited sediments		**X**		
	4	Loss of habitats	4	Loss of biodiversity, reduction in fish stocks Indirect impacts: Reduced incomes from fishing/fish processing (differential impacts on men and women); reduced food security	4	Careful planning and design of disposal sites			**X**	

CHECKLIST OF ENVIRONMENTAL, ECONOMIC AND SOCIAL PARAMETERS FOR FLOOD RISK MANAGEMENT PROJECTS										
Environmental Concerns			Related Impacts		Recommended Feasible Mitigation Measures		No Significant Impact	Significant Impact		
								Small	Moderate	Major
B	**Environmental concerns related to project implementation and construction activities**									
	5	Loss of soil fertility	5	Loss of agricultural production Indirect impacts: Loss of income (potential differential impacts on men and women); reduced food security; increased poverty risks	5	Careful planning and design of soil movement, set aside fertile topsoil. Supply fertilisers	**X**			
	6	Worker accidents	6	Health impacts, economic losses due to injuries, loss of life; increased public health care costs	6	Implement safe working practices through training, site supervision and provision of safety equipment			**X**	
	7	Traffic accidents	7	Health impacts, economic losses due to injuries, loss of life; increased public health care costs	7	Identify alternative routes, limit & post driving speeds. Provide community awareness programs.		**X**		
	8	Disruption of access to productive land (e.g., farm land, fishing areas, forests) and/or to community facilities/services	8	Temporary loss of income from farming, fishing and processing activities (differential impacts on men and women); reduced food security. Temporary disruption of local businesses, business income, wage income for employees. Temporary disruption of community services (e.g., access to clinics)	8	Identify alternative routes to facilitate continued access; limit disruptions to periods of low economic activity, e.g. outside harvest periods Compensate for loss of business income and employee wages Assist to temporarily relocate community facilities/services to maintain access.		**X**		
	9	Obstruction to navigation	9	Temporary restricted access and/or extra costs for transport related to economic activities; restricted fishing activities Temporary restricted and/or more expensive transport to support social network.	9	Identify alternative routes, limit to periods of low economic activity, e.g. outside main fishing periods		**X**		

CHECKLIST OF ENVIRONMENTAL, ECONOMIC AND SOCIAL PARAMETERS FOR FLOOD RISK MANAGEMENT PROJECTS										
Environmental Concerns			Related Impacts		Recommended Feasible Mitigation Measures		No Significant Impact	Significant Impact		
								Small	Moderate	Major
B	**Environmental concerns related to project implementation and construction activities**									
	10	Disruption of utility services	10	Temporary disruption and/or extra costs for local businesses, economic activities (e.g., agricultural processing) and community facilities/services (e.g., health clinics)	10	Careful planning and quick repair in case of accidents. Provide community awareness and information programs.		X		
	11	Noise/vibration/air pollution	11	Temporary reduced living conditions (dust, noise); temporary increased risks of health impacts (e.g., due to dust)	11	Limit working hours in populated areas, use proper and well maintained equipment			X	
	12	1. Soil /water contamination related to leakage and inappropriate storage of fuels and other chemicals, dumping of construction wastes or improper sanitation	12	Loss of flora and fauna. Increased risks of health problems, e.g., skin rashes/eye infections from contaminated surface water, cuts, abrasions, etc., from unsafe dumping of construction wastes. Contamination of drinking water sources with related health risks (diarrhea, dysentery).	12	Containment of fuels stored on site and off-site refueling., follow appropriate procedures, proper maintenance of equipment, collection and proper handling of construction wastes, provision of proper sanitation facilities		X		
	13	2. Groundwater pollution related to leakage and inappropriate storage of fuels and other chemicals, dumping of construction wastes or improper sanitation	13	Contamination of drinking water sources with related health risks (diarrhea, dysentery).	13	Containment of fuels stored on site and off-site refueling., follow appropriate procedures, proper maintenance of equipment, collection and proper handling of construction wastes, provision of proper sanitation facilities		X		

CHECKLIST OF ENVIRONMENTAL, ECONOMIC AND SOCIAL PARAMETERS FOR FLOOD RISK MANAGEMENT PROJECTS

Environmental Concerns			Related Impacts		Recommended Feasible Mitigation Measures		No Significant Impact	Significant Impact		
								Small	Moderate	Major
B	**Environmental concerns related to project implementation and construction activities**									
	14	Influx of non-local workers for project construction and other people attracted by economic opportunities	14	Social tensions due to competition for paid work and other economic opportunities related to FRM project, inappropriate behaviour of non-local people, lack of knowledge/respect for local customs	14	Contractor contracts specify (i) employment of local workers, (ii) local purchase of goods and services, (iii) awareness programs about local customs and appropriate behavior			X	
	15	Health impacts/disease hazards due to influx of workers and other non-local people	15	Increased risks of sexually transmitted diseases including HIV/AIDS; increased risks of other infectious diseases	15	Contractor contracts specify robust HIV/AIDS awareness and prevention program targeting workers and people in surrounding communities. Plan proper domestic and human waste management. Support local health clinics to meet new demands		X		
	16	Pressure on water supply and sanitation due to influx of workers	16	Increased health risks related to poor drinking water and sanitation conditions (diarrhea, dysentery) Possible loss of business income due to lack of adequate water supply/sanitation	16	Appropriate planning and design of water supply and sanitation facilities, including supplementary resources. Plan proper domestic and human waste management;. Support for local health clinics to meet new demands	X			

CHECKLIST OF ENVIRONMENTAL, ECONOMIC AND SOCIAL PARAMETERS FOR FLOOD RISK MANAGEMENT PROJECTS

		Environmental Concerns		Related Impacts		Recommended Feasible Mitigation Measures	No Significant Impact	Significant Impact		
								Small	Moderate	Major
B	**Environmental concerns related to project implementation and construction activities**									
	17	Employment opportunities for local people	17	Poverty reduction, improved welfare	17	Contractor contracts specify (i) employment of local workers, (ii) local purchase of goods and services, (iii) awareness programs about local customs and appropriate behavior				**X**
C	**Environmental concerns related to project design, management, operation and maintenance**									
		Project induced changes in hydrology/hydraulics: the timing, extent, depth and duration of flooding, resulting in:								
	1	Loss of agricultural production (loss of flood benefits)		Increased input costs and reduced yields; loss of business revenue and household incomes; possible loss of jobs for agricultural workers Indirect impacts: reduced food security, increased incidence of distress sales of land and other assets, increased incidence of out-migration to look for work, increased poverty risks		Allow sufficient flooding to safeguard silt and water supply and prevent pests Strengthen and provide agricultural extension and other technical assistance to enhance agricultural productivity, diversify crop production, expand livestock raising, etc. (including services targeting men's and women's agricultural activities)	**X**			
	2	Loss of capture fisheries production (loss of flood benefits)		Loss of household incomes Indirect impacts: reduced food security, increased poverty risks		Allow sufficient flooding to maintain fish migration patterns and fish spawning, breeding, nursing and feeding areas				**X**

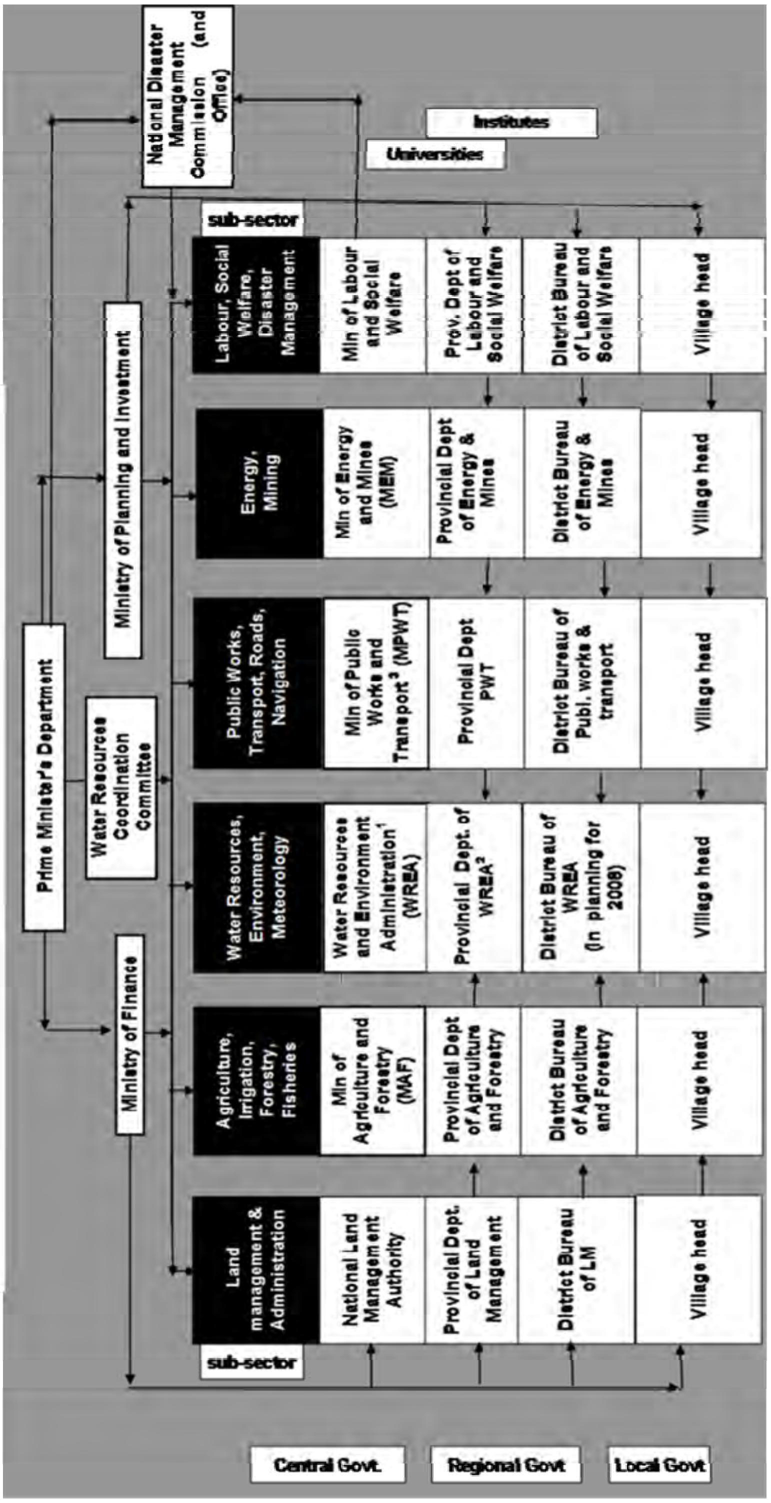
CHECKLIST OF ENVIRONMENTAL, ECONOMIC AND SOCIAL PARAMETERS FOR FLOOD RISK MANAGEMENT PROJECTS							
Environmental Concerns		Related Impacts	Recommended Feasible Mitigation Measures	No Significant Impact	Significant Impact		
					Small	Moderate	Major
C	**Environmental concerns related to project design, management, operation and maintenance**						
3	Loss of wetland area/productivity (loss of flood benefits)	Ecological impacts; loss of biodiversity. Economic losses (loss of income, extra expenditures), decreased food security, increased poverty risks	Allow sufficient flooding to safeguard silt and water supply				X
4	Hindrance to navigation/ transport by boat (loss of flood benefits)	Economic losses due to reduced accessibility and/or higher transport costs for businesses, marketing and other economic activities. Social impacts due to reduced mobility / travel to maintain social networks	Allow water levels high enough to make navigation possible	X			
5	Reduced water availability in the dry season (loss of flood benefits)	Economic losses due to lack of water for agriculture, other economic activities. Social and health impacts due to lack of safe drinking water; decreased food security, increased poverty	Allow sufficient flooding to safeguard replenishment of groundwater and surface water storage				X
6	Changes in river morphology	Economic losses due to hindrance to navigation, impacts on sand mining industry	Dredging, construction of bank protection works	X			

CHECKLIST OF ENVIRONMENTAL, ECONOMIC AND SOCIAL PARAMETERS FOR FLOOD RISK MANAGEMENT PROJECTS								
		Environmental Concerns	Related Impacts	Recommended Feasible Mitigation Measures	No Significant Impact	Significant Impact		
						Small	Moderate	Major
C	**Environmental concerns related to project design, management, operation and maintenance**							
	7	Changes in salt water intrusion	Damage to agriculture and aquaculture; loss of business revenue and household incomes; potential loss of jobs for agricultural/aquaculture workers	Maintain minimum flows	**X**			
	8	Decline in delta growth	Reduction in economic opportunities due to decline in land accretion	Maintain minimum (sediment carrying) flows	**X**			
D	**Positive impacts related to project design, management, operation and maintenance**							
	1	Increased safety	Improved well-being, reduced poverty					**X**
	2	Improved sanitation and health situation	Improved well-being, reduced poverty					**X**
	3	Decreased flood damage	Improved well-being, reduced poverty, improved food security					**X**
	4	Increased agricultural production	Improved well-being, reduced poverty, improved food security					**X**
	5	Improved mobility/transportation network	Social and economic welfare, reduced poverty				**X**	
	6	Poverty reduction/improved food security	Improved well-being					**X**

Appendix 7

Administrative levels in the water sector in Lao PDR

Appendix 7 Administrative levels in the water sector in Lao PDR.



* Remarks: WREA consists of various relevant departments:
- Water Resources Department
- Environment Dept. (previously part of Min. of Science, Technology and Environment (MoSTE)
- Lao National Mekong Committee
- Dept of Meteorology and Hydrology
- Institute of Water Resources and Environment (tentatively)

** However, the proposal about the formation of WREA and its composition, have not formally been approved by cabinet and P.M. yet*

2) The formation of Provincial (and regional/local) departments of WREA is still in the planning and not operational yet

3) The Ministry of Public Works and Transport was recently split off from Ministry of Communication, Transport, Post and Construction
It has various relevant departments for IWRM/IFRM:
- Dept of Housing & Urban Planning
- Dept. of River works
- Roads Dept.
- Watersupply Authority

4) Ministries generally have offices till at the District level, decisionmaking at village level by local government

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