Mekong River Commission
Regional Flood Management and Mitigation Centre
Phnom Penh, Cambodia

7th Annual Mekong Flood Forum

Integrated Flood Risk Management in the Mekong River Basin

Proceedings

13-14 May 2009

Bangkok, Thailand

The opinions expressed within are those of the authors and do not necessarily reflect the views of the Mekong River Commission.

Preface

On behalf of the Mekong River Commission (MRC) I am delighted to present to you the proceedings of the 7th Annual Mekong Flood Forum (AMFF-7), which was held on 13 and 14 May 2009 in Bangkok, Thailand. The proceedings contain general information, opening and closing addresses, papers, presentations, poster, the agreed Forum Statement and the list of participants.

The theme of the AMFF-7 was *Integrated flood risk management in the Mekong River Basin*. Discussions focused on the database systems and tools used for dissemination of flood forecasting and early warning products; the development of guidelines for the preparation of flood risk management plans and for evaluation of the impacts of flood risk management measures; the identification of potential trans-boundary issues for negotiation, mediation and conflict prevention; and the development of a regional flash flood early warning system. The Country flood reports, the MRC papers and other presentations from Government and International Organisations, Academic Institutions and the Private Sector were prepared within the framework of the Forum theme and fall under four defined topics:

I. Optimal packages for flood management;
II. Recent developments in flood forecasting and early warning;
III. Effective approaches towards trans-boundary flood management;
IV. Successful flood risk management approaches.

The 7th Annual Mekong Flood Forum also provided the opportunity to discuss the Annual Mekong Flood Report for 2008 produced by the MRC Regional Flood Management and Mitigation Centre (MRC-RFMMC). This report examines the impact of floods from the perspectives of the four MRC member countries, Cambodia, the Lao PDR, Thailand and Viet Nam. It also puts the flood events into a historical context by explaining the hydrological cycle of the Mekong.

It is expected that, based on the outcomes of the Forum, the MRC-RFMMC will be able to improve its flood forecasting services and strengthen its capability and cooperation mechanisms for flood risk management. The broader goal is that the MRC Member Countries continue to use the Annual Mekong Flood Forums as a mechanism to review and improve their own flood policies, strategies, plans and projects.

I would like to take this opportunity to thank the country report authors from Cambodia, the Lao PDR, Thailand and Viet Nam, from our dialogue partners, Myanmar and China and all the other authors for the timely submission of their invaluable reports and papers. On behalf of the MRC Secretariat I also would like to extend my gratitude to the governments of Denmark, Germany, Japan, the Netherlands and the United States of America, as well as to the Asian Development Bank and the European Union for their kind support of the MRC Flood Management and Mitigation Programme (FMMP).

I am confident that those participants and other readers will find much interesting information in these proceedings and that this will benefit both day-to-day practices and contribute to the improvement of our work with respect to integrated flood risk management in the Mekong River Basin.

Jeremy Bird
Chief Executive Officer
Mekong River Commission Secretariat
31 May 2009

Contents

PREFACE 3

CONTENTS 5

ADDRESSES OF THE INAUGURAL SESSION 11

Welcome address 13
Mr. Jeremy Bird
Chief Executive Officer of the Mekong River Commission Secretariat

Opening address 17
Dr. Siripong Hungspreug
Director General of the Department of Water Resources, Ministry of Natural Resources and Environment and Secretary General of Thai National Mekong Committee

Statement 20
Mr. Martien Beek
First Secretary Water Resources Management, Royal Netherlands Embassy

Statement 24
Ms. Dr. A. Sezin Tokar
Hydrometeorological Hazard Advisor, USAID Office of US Foreign Disaster Assistance (OFDA)

Statement 28
Dr. Timo Menniken
Representative of Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)

PAPERS FOR THE INAUGURAL SESSION 31

Summary of the 6th Annual Mekong Flood Forum (AMFF-6) and follow-up on recommendations of previous Flood Forums 33
Dr. Hatda Pich AN
Operations Manager, Regional Flood Management and Mitigation Centre (RFMMC), Mekong River Commission (MRC)

Objectives and expected outcome of the 7th Annual Mekong Flood Forum (AMFF-7) 43
Mr. Nicolaas Bakker
Chief Technical Adviser, Flood Management and Mitigation Programme (FMMP), Mekong River Commission (MRC)

PAPERS 49

SESSION 1. LESSONS LEARNED FROM 2008 FLOODING AND NATIONAL AND MRC-RFMMC EXPERIENCES WITH INTEGRATED FLOOD RISK MANAGEMENT 51

Cambodia country flood report for 2008 53
Sok Bun Heng

Lao PDR country flood report for 2008 68
Virana Sonnasinh

Thailand country flood report for 2008 79
Supapap Patsinghasanee and Ms. Srisunee Wuthiwongyothin

Viet Nam country flood report for 2008 94
Trinh Hoang Ngan and Bui Duc Long

Dialogue Partner report – China 125
Zhong Yong and Li Bo

Floods of Mekong River Basin (2008) in Myanmar Territory 129
U Hla Myint Thein and U Sein Tun

2008 Annual Mekong flood report 133
Peter Adamson and Ms. Janejira Tospornsampan

SESSION 2. TOWARDS INTEGRATED FLOOD RISK MANAGEMENT IN THE MEKONG RIVER BASIN 143

FMMP Component 2: Structural measures and flood proofing 145
Ms. Pham Thi Van Lan and Nicolaas Bakker

FMMP Component 1: Short and medium-term flood forecasting at the MRC Regional Flood Management and Mitigation Centre 155
Ms. Janejira Tospornsampan, Terry Malone, Bob Pengel, Phung Katry, and Hatda Pich AN

FMMP Component 3: Enhancing cooperation between Mekong River Commission (MRC) and MRC Member Countries in addressing trans-boundary flood and related issues 165
Ms. Pham Thi Van Lan and Nicolaas Bakker

FMMP Component 4: Flood emergency management strengthening. People-Centred Approach in Integrated Flood Risk Management 175
Thanongdeth Insisiengmay

FMMP Component 5: Flood information based land management (FIBLM) 184
Martin Falke

Contents

SESSION 3:	PARALLEL PAPER PRESENTATIONS FROM THE MEKONG REGION ON THE FOUR TOPICS FOLLOWED BY PARALLEL GROUP DISCUSSIONS	195
Topic I	*Optimal packages for flood management*	197
Paper 3-1-1	Integrated hydrologic, hydraulic, and damage analysis for selection of optimal flood management measures *Kittiwet Kuntiyawichai, Bart Schultz, Stefan Uhlenbrook and F.X. Suryadi*	199
Paper 3-1-2	Charting ICHARM's strategy for integrated flood risk management in the Lower Mekong River Basin *A. Chavoshian, K. Miyake, T. Sugiura, P.T. Hai, and L. Rajapakse*	210
Paper 3-1-3	Risk-based flood management for adapting to climate change *Toshio Okazumi and Eiji Ootsuki*	219
Topic II	*Recent developments in flood forecasting and early warning*	*227*
Paper 3-2-1	Flash floods, hydrometeorological forecasting and warning systems in Viet Nam *Bui Duc Long*	229
Paper 3-2-2	Recent developments in flood forecasting and early warning *Yin Savuth*	241
Paper 3-2-3	Help-desk for integrated flood management: supporting river basins in implementing an integrated approach *Wolfgang Grabs, Masahiko Murase, Joachim Saalmueller, Avinash Tyagi, Daisuke Yamashita*	250
Presentation	The WISDOM Project - Structure and First Results *Erich Plate*	254
Topic IV	*Successful flood risk management approaches*	*263*
Paper 3-4-1	An overview of community based disaster risk reduction initiatives in Cambodia *Khun Sokha*	265
Paper 3-4-2	Assessment on integrated flood management strategies in the Lower Dong Nai – Sai Gon River Basin, Viet Nam *Nguyen Anh Duc; Klaas-Jan Douben; Tang Duc Thang and Vu Minh Thien*	275
Paper 3-4-3	Best practice guidelines for flood risk assessment in the Lower Mekong River Basin *Gert Sluimer, Henk Ogink, Ferdinand Diermanse, Frank Keukelaar, Bas Jonkman, Tran Kim Thanh, Tes Sopharith*	283

SESSION 4.	SUMMARY OF DAY 1, PLENARY PAPER PRESENTATIONS, DISCUSSIONS	293
Report:	Summary of Day 1 *Nicolaas Bakker*	295
Paper 4-1	Flood hazard mapping in Nan River, Thailand *Somchit Amnatsan, J.S.M. Fowze, Arnob Bormudai, Manzul K. Hazarika and Lal Samarakoon*	297
Paper 4-2	Statistical ensemble flood forecasting for the Mekong River *Muhammad K. Shahzad, Falk Lindenmaier, Jürgen Ihringer, Erich J. Plate and Franz Nestmann*	304
Paper 4-3	Development of trans-boundary cooperation in the Rhine River Basin *Bart Schultz*	314
Paper 4-4	Hydrological risk zone mapping in Dong Thap Province for developing agricultural insurance *Dang Thanh Lam*	325
SESSION 5.	PARALLEL PAPER PRESENTATIONS BY INTERNATIONAL SPECIALISTS FOLLOWED BY PARALLEL GROUP DISCUSSIONS	333
Topic II	*Recent developments in flood forecasting and early warning*	335
Paper 5-2-1	The way forward in hydrodynamic flood modelling in the Mekong River Basin *Adri Verwey*	337
Paper 5-2-2	Real-time hydrometeorological observation networks - development possibilities for the early warnings system of the Mekong River Basin *P.J. Airaksinen, J. Ikonen, N.W.S. Demetriades and H. Pohjola*	346
Paper 5-2-3	Enhanced discharge measurements in irrigation canals using multi-frequency acoustics *Mike Cook, Victor Montano, John Sloat and Mark Tepper*	355
Paper 5-2-4	Status of MRC Hydro-meteorological network for river monitoring *Sompong Boonprasert*	365
Topic IV	*Successful flood risk management approaches*	373
Paper 5-4-1	An integrated approach to flood risk mapping for flood detention areas - a case study of Day River flood diversion basin in the Red River Delta, Vietnam *Nguyen Mai Dangand Mukand Singh Babel*	375
Paper 5-4-2	Flood damage assessment integrating geospatial technologies. A case study in Hue, Vietnam *Dinh Ngoc Dat, J.S.M. Fowze, Nguyen Duong Anh, Manzul K. Hazarika and Lal Samarakoon*	384

Paper 5-4-3 Development of a 1D hydraulic model for flood inundation mapping along the anabranched Mekong River, Siphandone, Lao DPR, as affected by recent land use changes 391
T.P.D. Van and P.A. Carling

Paper 5-4-4 Flood risk approach and use of the DACA instrument in the Lower Mekong River Basin 403
Ms. Jakolien Leenders, Ms. Astrid Janssen and Jurjen Wagemaker

SESSION 7. CONCLUDING SESSION 415

Reports presented during the concluding session: 417

- Session 1: Lessons Learned from 2008 Flooding and National and the MRC-RFMMC Experiences with Integrated Flood Risk Management. Rapporteur *Hak Socheat* 419
- Session 2: Towards Integrated Flood Risk Management in the Mekong River Basin. Rapporteur *Nguyen Anh Duc* 425
- Session 4: Summary of Day 1, Plenary Paper Presentations, Discussions. Rapporteur *Burachat Buasuwan* 427
- Parallel Sessions 3, 5 and 6:
  - Topic I: Optimal packages for flood management. Rapporteur: *Sok Bun Heng* 431
  - Topic II: Recent developments in flood forecasting and early warning. Rapporteur: *Trinh Hoang Ngan* 434
  - Topic III: Effective approaches towards trans-boundary flood management. Rapporteur: *Phonepaseuth Phouliphanh* 436
  - Topic IV: Successful flood risk management approaches.
  - Rapporteur: *Virana Sonnasinh* 437

Importance of integrated flood risk management packages. Experiences from practices in Bangladesh 438
Dr. M.A. Quassem
Former Director General. Water Resource Planning Organization (WARPO), Ministry of Water Resources

Summary of proceedings and recommendations for follow-up 450
Prof. Bart Schultz, PhD, MSc
Land and Water Development, UNESCO-IHE

Forum statement 471
Dr. Hatda Pich AN
Operations Manager, Regional Flood Management and Mitigation Centre (RFMMC), Mekong River Commission (MRC)

ADB Intervention 474
Mr. Ian Makin
Senior Water Resources Management Specialist, Asian Development Bank

Closing address 476
Mr. Te Navuth
Director of Technical Support Division of the Mekong River Commission Secretariat (MRCS)

POSTER

Stream flow simulation using remotely sensed rainfall data: Brahmaputra River 478
Guleid Artan, Shahriar Pervez and Mandira Shrestha

ANNEXES 485

I. Abbreviations and acronyms 487

II. Glossary 495

III. Characteristic data on the Mekong River Basin 499

IV. Forum programme 503

V. List of participants 507

ADDRESSES OF THE INAUGURAL SESSION

WELCOME ADDRESS

MR. JEREMY BIRD

Chief Executive Officer of the Mekong River Commission Secretariat (MRCS), Vientiane, Lao PDR

Dr. Siripong Hungspreug, Director General of the Department of Water Resources,
Ministry of Natural Resources and Environment and
Secretary General of Thai National Mekong Committee;

Excellencies and Dialogue Partners;
Representatives of Development Partners and International Organisations;
Distinguished Delegates;
Ladies and Gentlemen

As Chief Executive Officer of the Mekong River Commission Secretariat, it is my great pleasure to welcome you all here today to participate in the 7th Annual Mekong Flood Forum. On behalf of the MRC Secretariat, I would like to extend my special thanks to Dr. Siripong Hungspreug for finding the time in his busy schedule to take part in this important event.

The Flood Management and Mitigation Programme (FMMP) of the Mekong River Commission (MRC) has been in operation for almost four years now. Last Friday I listened to the report of an independent team, which has reviewed its performance, and although there were naturally lessons to learn, the overall message is that FMMP is well on its way to achieving its primary goals. The MRC Regional Flood Management and Mitigation Centre (MRC-RFMMC) has now been firmly established in Phnom Penh as a central part of FMMP and performs a vital river basin management function of MRC.

The Mekong River Basin is one of the world's largest river basins. Floods have always been part of the river's annual cycle and were a major influence on the characteristics of the river system that we see today - for example, the delta, the reverse flow into the Tonle Sap and the impressive inland fisheries that sustain so many people. Many of the effects of the floods are highly beneficial - by enriching aquatic habitat and replenishing soil fertility.

However, we also know that extreme floods can be devastating. This was very clearly demonstrated again in August last year by the flooding of northern Thailand and Laos, including the home of the Secretariat in Vientiane. It caused an estimated US$ 135 million worth of damage to property and crops. It also caused loss of life - while putting many others at risk. Livelihoods were destroyed in a region that is beset by poverty. Many of the people impacted by the August floods lost crops and are still receiving emergency food aid.

Last year's floods were caused by unusually high cyclonic rainfall. The water level reached on August 15 at Vientiane was the highest since records began in 1913. At 13.7 m above the gauge datum, the Mekong River was one metre higher than the maximum levels recorded in 1966, 1971 and 2002. Yet the flows represented only a 1 in 25 year flood, indicating that efforts to protect land through flood protection embankments can also lead to higher river levels. Flood management is a complex interaction of social, environmental and technical factors.

With the potential impact of climate change, we don't know if climactic events like last year's floods will continue to be considered *unusual* by future generations. What we can be sure of however, is that this underpins the strong need to plan, mitigate and more accurately forecast flooding.

The MRC Regional Flood Management and Mitigation Centre has been doing this for years. Last year's flood was a real test for the organisation. Throughout the crisis, the Mekong River Commission continued to work with meteorological and water resource agencies in its member states of Cambodia, the Lao PDR, Thailand and Viet Nam to monitor river and weather conditions and forecast the likelihood of flooding. Daily updates on water levels were provided on the MRC website, and more detailed information was routinely sent to the concerned government agencies, academic institutions, and international, regional and non-governmental organisations every day throughout the flood season.

The information provided by the MRC is designed as a service to assist relevant national agencies in implementing their flood warning, preparedness and response plans, including delivery of assistance to affected districts.

In Vientiane the impact of this information was dramatically visible. Volunteers joined the army in wielding shovels where - and I think it is safe to say - the government's efforts to rapidly deploy sandbags saved the city from serious flooding.

But there are lessons from those rather frantic days in August as well - which we would do well to learn.

The MRC was criticised in various media for its response to the flood - with accusations that warning systems failed. Improvements can always be made, but overall the trends and scale

of flooding were predicted well. The messages though highlight a need. We need to be work more closely with national agencies and be more open proactive in adopting a flood forecasting strategy that includes the media.

The 2008 flood season provided the first real opportunity to asses the performance of the MRC flood forecasting models and expertise in the face of an extreme event. I am pleased to say that in general - they performed very well up to two or three days ahead.

It became apparent that for various reasons flood forecasting was less accurate beyond three days. To improve this requires both more information from the network of measuring stations on the ground and better satellite interpretation that has gone through calibrations or ground truthing. Priority sub basins are being identified for these improvements.

Also was also clear that improvements in information flows are needed between the Mekong River Commission Secretariat (MRCS) and MRC Member Countries. MRCs action plan developed after August's floods is addressing such issues. There is also a clear need to improve the channels of communication between local communities and the relevant flood forecasting, mitigation and response agencies.

We are grateful to our Dialogue Partner China for the provision of daily hydrological data from the upstream part of the basin during the flood season. This enhances our capacity to provide more accurate flood forecasts and we are pleased that this partnership has recently been reaffirmed.

Some villagers in northern Thailand and Laos blamed the big flood on construction of dams in China on the Lancang River. It is perhaps not a surprising conclusion if you imagine yourself watching from the river bank as water levels rise beyond alarm levels and are aware of dam construction upstream. However, the reality is that the intense rain was a natural event resulting from the typhoon Kummuri and the dams currently in place are too small to make any significant difference to flood flows. Again there is a need to improve communication links and media coverage so that there is a better appreciation of the actual situation.

Increasing technical cooperation with China will continue to be important in years to come in order to develop a common understanding of the river system and improve our capability for flood management.

It is in the spirit of improving this performance that we are here today. Your ideas are what we are here for. We will present to you the 2008 Annual Mekong Flood Report and the reports of the five Components of our Flood Management and Mitigation Programme. I hope that we can use this as basis for the discussions - as to how we improve the delivery of the very important forecasting services and the services of the other Components.

I would briefly like to highlight the progress that we have made with respect to the

development of the Flash Flood Guidance System. A short video on this very important type of flooding will be shown at the end of this inaugural session.

I would also like to express my profound gratitude and sincere thanks to the governments of the MRC Member Countries and Dialogue Partners for their support to and intense cooperation with us. I also thank the Netherlands, Germany, Denmark, Japan, the United States, the Asian Development Bank and the European Commission for their continuing support for the MRC Flood Management and Mitigation Programme.

Excellencies, Distinguished Delegates, Representatives of Donors, International and Regional Organizations, Ladies and Gentlemen, I have come to the final part of my welcome address.

I look forward to the Forum Statement and its recommendations, which will help the MRC Member Countries and the MRC to manage the floods, their positive and negative effects, in an integrated manner and provide a more secure and better future to the flood vulnerable people in the Mekong River Basin.

Let me wish you all a fruitful and interesting 7th Annual Mekong Flood Forum.

Thank you.

OPENING ADDRESS

DR. SIRIPONG HUNGSPREUG

Director General of the Department of Water Resources, Ministry of Natural Resources and Environment and Secretary General of Thai National Mekong Committee, Bangkok, Thailand

Excellencies;
Distinguished Delegates of the MRC Member Countries and Dialogue Partners;
Donor Representatives, Partners and International Organisation Representatives;
Mr. Jeremy Bird, Chief Executive Officer of the MRCS;
Ladies and Gentlemen

I am very pleased to be here today as we begin the 7th Annual Mekong Flood Forum on the theme that is so important for our societies *'Integrated flood risk management in the Mekong River Basin'*.

This forum - organised by the Regional Flood Management and Mitigation Centre of the Mekong River Commission in close cooperation with the Thai National Mekong Committee - marks another significant achievement in the operations of this very important institution.

Since last year's Forum, with the extreme flooding of August 2008 in certain parts of our countries, we have had the benefit of increased experience with managing Mekong floods. It is with this experience in mind that we do our work with respect to the Mekong River Basin today. Hopefully the presentations and discussions during this Forum will contribute to the improvement of our practices.

Under the umbrella of the main theme – integrated flood risk management - I would like to encourage you to focus our discussions on four main issues such as:

- data collection, database systems and tools used for dissemination of flood forecasting and early warning messages to potentially flood affected communities. There is a strong need and there are possibilities for improvement in the accuracy of this information and in the timely manner of dissemination of information;
- development of guidelines for the preparation of flood risk management plans and for evaluation of the impacts of flood risk management measures. This topic is at my heart

and includes many governance issues. How can the governments and line agencies of the MRC member countries act to reduce the risk of injury and loss from flooding?

- identification of potential trans-boundary issues for mutual agreement of optimal solutions such as navigation and fisheries. MRC Member Countries - Cambodia, Lao PDR, Thailand and Viet Nam - have already demonstrated an impressive ability to co-operate on a range of issues – such as early warning and search and rescue. How can this be further improved?
- development of a regional flash flood early warning system. This by its nature requires good technology, efficient communication systems and swift action.

Much work has gone into preparing the country reports, scientific and other papers for this Forum and there are a range of presentations on the agenda that will be very informative for us all today and tomorrow.

This Forum offers an excellent opportunity to present and discuss the Annual Mekong Flood Report for 2008 produced by the MRC Regional Flood Management and Mitigation Centre. This report examines the impacts of floods from the perspectives of the four MRC Member Countries. It also puts the floods into a historical context by explaining the hydrological cycle of the Mekong River and the developments in our societies related to the Mekong River Basin.

Floods can also be beneficial. They belong in fact to a natural process that may improve lives. Fisheries, agriculture and biodiversity are all dependent on the annual flood. The 2008 report calls for us to understand this process and integrate it into our flood management strategies and our wider basin development plan.

I hope that the presentations and discussions of the next two days will act as a mechanism to review and improve our practices by adopting the principles of integrated flood risk management in our flood management and mitigation policies, plans and projects.

The rapid population growth in the region, urbanisation, intensification of agriculture, changes in land use and the very shape of the river require a holistic approach towards flood risk management covering the whole basin from upstream to downstream in which reliable and better lead-time flood forecasts and early warnings could be regarded as the first important element for flood preparedness and need to be improved. This is in the interests of everyone who lives in the Mekong River Basin.

Flood forecasting and warning is very complex and can only work if it is well coordinated - with the people interpreting data - line agencies - governments and even local communities. All need to play their part.

Let us start this process today with similarly well co-ordinated, dynamic presentations and discussions.

Excellencies,
Distinguished Delegates,
Ladies and Gentlemen,

I would like to take the opportunity to express my profound gratitude and thanks to my colleagues in the other MRC Member Countries and of the Dialogue Partners for the growing cooperation that we have with respect to the relevant issues of joint interest in the Mekong River Basin.

In addition I would like to thank the governments of the Netherlands, Germany, France, Denmark, Japan and the United States and other development partners, namely, the Asian Development Bank and the European Commission for their continuing support for the MRCs Flood Management and Mitigation Programme. Please be assured that our MRC Member Countries are fully committed to the important work that the MRC is doing for us and especially for the communities that potentially may suffer from flooding.

Upon this opportunity, I would like to declare the 7th Annual Mekong Flood Forum open and I hope that every participant has the opportunity to make a productive contribution and that everyone has a pleasant stay in Bangkok.

Thank you.

STATEMENT

MARTIEN BEEK

First Secretary Water Resources Management, Royal Netherlands Embassy, Hanoi, Viet Nam

Dr. Siripong Hungspreug, Director General of the Department of Water Resources, Ministry of Natural Resources and Environment and Secretary General of Thai National Mekong Committee;

Mr. Jeremy Bird, Chief Executive Officer (CEO) of the MRCS;
Excellencies and Dialogue Partners;
Donor Representatives, Partners and International Organisation Representatives;
Distinguished Delegates;
Ladies and Gentlemen

My predecessor, Mr. Armand Evers, has been participating in the fourth, fifth and sixth Annual Mekong Flood Forums, so it is my privilege to participate in this seventh Annual Mekong Flood Forum. It will be my first exposure to this Annual event, where national, regional and international knowledge and experiences are presented and shared on floods with particular relevance for the conditions in the Mekong River Basin.

As the Royal Netherlands Embassy has been closely involved since the formulation of the Flood Management and Mitigation Strategy in 2001, I like to express my gratefulness for allowing me to contribute to this opening session.

The Netherlands Embassy has emphasized earlier that the Annual Mekong Flood Forum needed broader donor support and representation. It was not considered the proper signal to refer to the funding by the Netherlands only, nor the fact that the Netherlands Embassy therefore was the only donor representation during the Opening Session.

The Annual Mekong Flood Forum is an open platform for discussion and as such it should demonstrate the interest of all donors in the Flood Management and Mitigation theme in this special event. I wish to thank the Mekong River Commission Secretariat (MRCS) and the Flood Management and Mitigation Programme (FMMP) for taking action and I was happy to

learn that financial contributions for this Seventh Annual Mekong Flood Forum have been made available by Germany, the USA, the Asian Development Bank (ADB) and the Netherlands.

Such an annual event can be an extremely powerful instrument to foster strengthening capacities and knowledge on flood forecasting, flood early warning, flood risk assessment, flood impact assessment, flood risk reduction, all under the overall theme of flood management and mitigation.

This year's theme of *Integrated Flood Risk Management in the Mekong River Basin* emphasizes the fact that floods impact many sectors, but that vice versa the sectors will impact floods, like the cumulative effects of land use changes, and the development of physical infrastructure, urbanization, etc.

Since the early initiation of the MRCs Flood Management and Mitigation Programme (FMMP) in 2003, and later broader initiation of all five components in 2004 and 2005, it became clear that the FMMP is a highly complex programme. The FMMP is dealing with the many elements which, if *gradually* and *jointly* developed in a balanced manner, contribute to a reduction of the flood vulnerabilities and a reduction of the flood risks.

During the last three weeks an External Review Mission of the FMMP, jointly organised by the Royal Netherlands - and Royal Danish Embassy, has been looking into the effectiveness and efficiency of the FMMP implementation. Although the mission had great respect for the progress of the FMMP implementation achieved up-to-date, a number of important findings have been identified. I will mention a few.

Firstly, although the Paris Declaration agreed to harmonize the donor support, the FMMP is certainly not the best example. The FMMP is funded by 7 donors, each with its own funding modality and administrative requirements. This has put a heavy burden on the shoulders of the FMMP and the MRCS to manage all agreements financially and administratively.

Secondly, the FMMP has been instrumental in establishing the permanent Regional Flood Management and Mitigation Centre (MRC-RFMMC) in Phnom Penh, Cambodia. The FMMP has been able to make good efforts in properly coordinating at National level through the National Flood Units, as well as with other MRC programmes, thanks to the Danish International Development Agency (DANIDA) supported coordination project. It is recognized that other programmes have difficulty in involving and/or supporting FMMP, maybe just because of the geographical location in Phnom Penh. The relocation decision therefore may provide an option to strengthen functional relationships with some MRC programmes, on which the FMMP relies heavily for support to its core functions.

Furthermore, the FMMP is presently in its fourth year of implementation and has some 18 months to go. The Review Mission has thereby identified to focus on the core business and to

particularly enhance for a selection of the FMMP products for dissemination. Many tangible products are being developed and the dissemination of these products to the user groups is most relevant. It will make the difference between success and failure.

The users are the ones at the end of the production chain, being the involved national line agencies, the national centres for flood forecasting and warning, provincial and district disaster managers, communities/villages.

A selection will have to be made jointly by the MRC/FMMP and the member country National Mekong Committees (NMC)/National Flood Units (NFU), regarding the identification of the relevant products, in terms of specific guidelines, approaches and methodologies, and to translate these in the riparian languages for further uptake in the national systems. Only in that way we can ensure that the tangible outputs will become tangible impacts.

In that respect, representing a donor organization, I appreciate the efforts of the MRCS to practise Result Based monitoring.

Another aspect identified by the Review Mission is the weak link between flood management and flood mitigation and poverty alleviation, which is one of the reasons of funding the FMMP. The relationship between poverty and flood management and flood mitigation should be made crisp and clear.

The Vulnerability Assessment project was already identified by the FMMP in 2006. I hope that through support of ADB/International Centre for Water Hazard and Risk Management (ICHARM) proper information is provided on the relationships in terms of the different vulnerability indices, the geographical relevance and the specific impact mechanisms. The results will play an important role for a potential follow-up phase of the FMMP.

The suggestions made by Dr. Siripong in his Opening Address, as well as the reference made by the CEO, to the lessons learned from the August 2008 Flood Event in Lao PDR, will provide useful contributions to focus on tangible outcomes of the FMMP for the MRC Member Countries and the vulnerable communities in the Lower Mekong River Basin.

The Netherlands Embassy is satisfied with the progress made so far. However, I would like to discuss the report, conclusions and recommendation of the FMMP Review Mission with the representatives of the MRC Member Countries and the MRCS during the next FMMP Steering Committee meeting. This to provide stronger focus and awareness on the most useful products.

After having discussed the report within the Embassy, I envisage a formulation process of a follow-up phase in which the MRC Member Countries are thoroughly involved, as well as the MRCS/FMMP, the Netherlands Embassy and other development partners. This phase in our perception should be aimed at securing the sustainability of the core functions of the MRC-

RFMMC by the end of the next Strategic Plan (2011-2015).

With these remarks Ladies and Gentlemen, I thank you for your attention, and I whish you all a very fruitful seventh Annual Mekong Flood Forum, here in Bangkok.

OPENING REMARKS

MS. DR. A. SEZIN TOKAR

Hydrometeorological Hazard Advisor, USAID Office of US Foreign Disaster Assistance (OFDA), Bangkok, Thailand

HE Dr. Siripong Hungspreug, Director General of the Department of Water Resources, Ministry of Natural Resources and Environment and Secretary General of Thai National Mekong Committee

Mr. Jeremy Bird, Chief Executive Officer of MRC Secretariat

Mr. Chairman, Excellencies, Distinguished guests, colleagues and friends
Ladies and Gentlemen:

On behalf of the US Agency for International Development (USAID), Office of US Foreign Disaster Assistance (OFDA), it is my pleasure and honour to welcome you to the 7th Annual Mekong Flood Forum.

Globally, floods affect more people and cause more economic damages than any other natural disasters. During the last decade, floods claimed over 90,000 lives, affected about 1.2 billion people and cost over US$ 0.2 trillion. About 95% of flood affected population lived in Asia, about 44% of fatalities were Asians and about 60% of economic losses were in Asia during this period. This figure doesn't include coastal flooding such as 2004 Indian Ocean tsunami. Therefore, floods have significant impact on lives and livelihoods in Asia.

In many parts of the world, disasters do not only lead to loss of human life, social economic damages but also may cause secondary impacts, which are difficult to quantify and recover from. Natural disasters set back economic growth and development due to the use of limited resources for disaster response and reconstruction. Damages to infrastructure may interrupt commerce or public services leading to additional suffering and socio-economic losses. Disaster Risk Reduction activities are the key in reducing fatalities and social, economic and political impacts of potential disasters.

The USAID Office of US Foreign Disaster (OFDA), is the US agency that is responsible for providing humanitarian assistance abroad when lives are threatened by natural hazards or accidental or human-caused catastrophes such as conflict and technological accidents. Clearly the most visible, photogenic, and expensive aspects of OFDAs work is responding directly to the effects of natural and human-made disasters. However, OFDA also funds disaster risk reduction (DRR) activities to reduce the impact of recurrent natural disasters. The DRR objective of our mandate enables us to work with partners like the Mekong River Commission (MRC) on increasing resilience to floods.

Flood mitigation and preparedness activities need to follow an integrated approach including monitoring, observing and forecasting hydrometeorological events, providing information to multi-sectoral users for decision making, disseminating these decisions and information to people at risk and taking measures to reduce potential impacts. State of the art data collection or models, or highly accurate forecasts will not save lives or reduce human suffering if the population at risk is not informed on time or does not have plans or policies in place in advance, or shortly does not know what to do when faced with a potential hazard. Similarly, a well prepared community will not avoid destruction or death if there is not enough lead time to take appropriate actions. Therefore, understanding the entire process and identifying and addressing weakness of the system is crucial.

Reducing vulnerability to flood hazard depends highly on human behaviour, which is a challenging task. Social and cultural consideration of communities and their traditional coping mechanisms are important factors in increasing resilience of communities to disasters. Therefore linking the technology, information, and policies to the social and cultural aspects of communities are crucial in sustainability and effectiveness of flood mitigation activities.

Floods also have beneficial impacts, especially for agriculture, fisheries, environment and ecosystems. Therefore, design of disaster risk reduction activities should consider beneficial aspects of floods as well as adverse impacts.

Our environment and vulnerabilities are changing continuously, which makes flood mitigation and management a dynamic process requiring constant attention and uninterrupted commitment.

During the last decade, floods were the leading cause of OFDA disaster response, around the world. USAID/OFDA has provided support in reducing vulnerability to floods and other hydrometeorological hazards, globally. USAID/OFDA and MRC collaboration on flood mitigation is an example of these activities. Our collaboration with MRC led to USAID/OFDA initiative called Asia Flood Network (AFN) and expansion of similar activities in South Asia in partnership with the International Centre for Integrated Mountain Development (ICIMOD).

AFN aims to reduce vulnerability to flood hazard in Asia with objectives to:

- build regional/national capacities on climate, weather, and hydrological forecasting and warning;
- encourage hydrometeorological data and information exchange in trans-boundary river basins;
- improve dissemination of forecasts and warnings to the users and population at risk.

One of the activities under AFN is the development of lower Mekong flash flood guidance system. USAID/OFDA helped to develop Central America Flash Flood Guidance System after Hurricane Mitch devastated Central America. The system is currently in operation in seven Central America countries to support National Meteorological and Hydrological Services issuing warnings of potential flood events and other relevant uses such as agriculture. Experience in Central America led to implementation of similar system in other parts of the globe including the Mekong system under development. After various workshops, consultative visits, meetings and discussions, we initiated implementation of Lower Mekong flash flood guidance system in 2008. An implementation workshop was conducted in February and operational training of riparian countries and MRC is scheduled in June 2009. We look forward to host the representatives of MRC and the MRC Member Countries in the USA.

In 2008, we also signed and agreement with the World Meteorological Organization, National Oceanic and Atmospheric Administration (NOAA) and the Hydrologic Research Centre (HRC) to extend these activities globally, for developing a global flash flood guidance system.

OFDA has participated in Mekong flood forums since MRC initiated its first forum in 2002. It is a pleasure to witness the progress and improvement on flood management and mitigation in the greater Mekong region since then. Establishment of MRC-RFMMC and implementation of FMMP activities are testimonies to significant progress. MRCs flood management and mitigation program can be a model for a basin-wide and integrated approach and cooperation in trans-boundary river basins around the world.

In conclusion, we are here today to hear the progress that has been made in MRC regional flood management and mitigation program, share our experiences and lessons learned from past floods and how to minimize our vulnerability to floods. I want to thank the government of Thailand for hosting the 7th Annual Mekong Flood Forum and the Mekong River Commission, National Mekong Committees, Regional Flood Management and Mitigation Centre for organizing this important forum. I would like to thank our implementing partners, the US National Oceanic and Atmospheric Administration, US Geological Survey, and National

Meteorological and Hydrological Services, Disaster Management agencies and Non-Governmental Organizations to continue to implement mitigation activities to reduce vulnerability to floods and flash floods. I wish you a successful forum.

OPENING STATEMENT

DR. TIMO MENNIKEN

Representative of Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Vientiane, Lao PDR

Dr. Siripong Hungspreug, Director General of the Department of Water Resources and Secretary General of the Thai National Mekong Committee,
Mr. Jeremy Bird, Chief Executive Officer of MRCS,
Delegates from the Lower Mekong Basin countries,
Dialogue Partners,
Donor Representatives,

Ladies and Gentlemen, dear Participants

Representing the German Technical Cooperation (GTZ) who is supporting the Flood Management and Mitigation Programme of the Mekong River Commission on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ), I am honoured to be invited to deliver an opening statement to the 7th Annual Mekong Flood Forum.

It is encouraging to see such a large number of participants from such a variety of countries and regions, backgrounds and, as I am also aware, with a variety of expectation towards this forum.

Being the fifth speaker in line this morning, most, if not all important things have already been said. Yet, there is one point I would like to make:

While the flood forums of previous years revolved much around the crucial topics of data and information sharing, modelling and forecasting, this year's event prominently features the challenge of integration.

Flood management and mitigation is known to be a highly complex issue; on a technical and managerial level as much as in the arena of communication and cooperation. The German development cooperation is therefore delighted to see these two days being designed around integration: integration of various aspects of flood management such as early warning, structural measures, disaster preparedness and land management; integration of perspectives from different parts of the basins; integration of approaches from practitioners and scientists; and, I

should not forget to add, following also the statement of the First Secretary of the Royal Netherlands Embassy in Vietnam, Mr. Martien Beek, integration and better coordination among different donors and their approaches.

Excellencies and distinguished delegates

During the recent review of the Flood Management and Mitigation Programme, the Annual Flood Forum was marked as one of the activities that received praise and appreciation from all sides. The Forum's declared aims are to raise awareness on the current state of flood risk management at the national and regional levels in the Mekong River Basin and to exchange of information on the progress of the components of the Flood Management and Mitigation Programme (FMMP).

GTZ on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ) is implementing two of the five components of the FMMP, a component on disaster preparedness and emergency management and a component on flood-related land management. It has also been noted by the recent review mission that these two components work with a genuine bottom-up approach towards flood management, starting with a systematic collection of experiences at and developing disaster and land management approaches for the commune, district and province level. This is complementary to the approach of the other three components that address the issue of flood management and mitigation from a regional and national perspective first. The challenge of integrating the excellent work that is being done in all these five components is apparent.

Here, as in other parts of the complex field of flood management and mitigation there is still a lot of work to do. Looking at this impressive audience it is obvious that there is no lack of people who want to take on that work and the following two days should provide a great opportunity to increase the coordination and integration within this group of experts represented here.

In that sense let me express our sincere thanks to those who made this event possible: the Mekong River Commission (MRC), the Thai National Mekong Committee (TNMC) and of course the dedicated individuals from the FMMP. I wish organizers and participants a fruitful and successful 7th Annual Mekong Flood Forum.

Thank you very much for your participation.

PAPERS FOR THE INAUGURAL SESSION

Paper 0-1

SUMMARY OF THE 6TH ANNUAL MEKONG FLOOD FORUM (AMFF-6) AND FOLLOW-UP ON RECOMMENDATIONS OF PREVIOUS FLOOD FORUMS

Dr. HATDA PICH AN

Operations Manager, Regional Flood Management and Mitigation Centre (RFMMC), Mekong River Commission (MRC), Phnom Penh, Cambodia

ABSTRACT

The Regional Flood Management and Mitigation Centre (MRC-RFMMC) of the Mekong River Commission (MRC) convened the 6th Annual Mekong Flood Forum (AMFF-6) in Phnom Penh, Cambodia on 27-28 May 2008, under the theme of '*Integrated approaches and applicable systems for medium-term flood forecasting and early warning in the Mekong River Basin*'. About 125 participants from including MRC Member Countries and Dialogue Partners, organisations working in the Mekong River Basin (MRB), international organisations, civil society organisations, institutions and companies, attended. There were 34 presentations in the plenary and parallel sessions, a workshop and eight booths in the exhibition.

In order to enable a proper presentation and discussion of various relevant aspects under the theme, the forum was structured in four main topics, which were run in both plenary and parallel sessions:

I. new developments with respect to flood forecasting and early warning;
II. land use based requirements for flood forecasting and early warning systems;
III. costs and benefits of flood forecasting and early warning;
IV. lessons learned from past flood events.

Based on the presentations and discussions, more detailed recommendations were documented for each topic. These recommendations have been used by the MRC-RFMMC for further development of its systems for medium-term flood forecasting and early warning in the Mekong River Basin.

In conclusion, there were good presentations by the MRC Member Countries and Dialogue Partners, making clear their situation with respect to floods in 2007 and how they are improving their institutions and data collection, storage and retrieval systems. The parallel group discussions were interesting and lively and they provided useful additional information. Considerable work was done by the rapporteurs in preparing their reports during the plenary and parallel sessions at very short notice. At the end of the forum the participants adopted the Forum Statement. This statement has also included the theme for the 7th Annual Mekong Flood Forum '*Integrated flood risk management in the Mekong River Basin*', which is the basis for the formulation of the sub-themes and the forum programme.

Since 2002, the Mekong River Commission (MRC) has successfully organised six Annual Mekong Flood Forums (AMFF) under different themes. Each forum produced its own conclusion and a set of recommendations as follow-up actions, which have served as the basis and justification for the organisation of the subsequent forum. In order to keep the future forums on the right track as well as to focus on meeting the emerging needs of the region with respect to flood risk reduction and management a review and reflection of the previous forum recommendations, especially of the 6th AMFF has been carried out. A number of recommendations were made for comprehensive follow-up after the 6th AMFF:

- continue with the annual flood forums, based on actual topics of joint interest of the MRC Member Countries and Dialogue Partners. However, the programme of the Forum needs to be modified in light of progress within the MRC Member Countries and the FMMP;
- work for the present phase of the FMMP will continue along the lines as presented, with input from Forum results for improvement;
- during the coming flood season the new system for flood forecasting will be tested in practice. Based on the test results decisions will be taken on introduction of the new system for flood forecasting in the MRC-RFMMC in close consultation with the Member Countries;
- every year there are flash floods in tributaries of the Mekong River especially in Lao PDR, Thailand and the Central Highlands of Viet Nam that cause significant damage. Therefore there is an increasing need for improved information on the probability of occurrence of flash floods through a flash flood guidance system, especially for the tributaries of the Mekong River;
- preparations for follow-up of the FMMP beyond 2010 need to be started soon.

All the recommendations have been carefully implemented by the FMMP for the organization of this 7th AMFF with the restructuring of the forum programme, the enhancement of components implementation for the FMMP, the test and setting of future operations of new flood forecasting systems have been done in close interaction and consultation with the MRC Member Countries, a Flash Flood Guidance System (FFGS) is being developed and the development of the Concept Note for future development and operations of the future FMMP by the MRC-RFMMC and the MRC Member Countries

INTRODUCTION

Flood management and mitigation is of increasing concern for the authorities and citizens of many countries with flood prone areas. Flood vulnerability is generally increasing due to population growth and the increasing value of public and private property in such areas, as well as due to land subsidence and impacts of climate change. The MRC Regional Flood Management and Mitigation Centre (MRC-RFMMC) of the Mekong River Commission (MRC) and the MRC Member Countries - Cambodia, Lao PDR, Thailand and Viet Nam - are improving their flood forecasting systems. For the MRC Member Countries this also concerns early warning systems.

The theme of the 6th Annual Mekong Flood Forum (AMFF-6) was '*Integrated approaches and applicable systems for medium-term flood forecasting and early warning in the Mekong River Basin'*. Stakeholders from the MRC Member Countries, MRC Dialogue Partners (China and Myanmar), donor agencies, MRC Programmes, scientists from the Mekong River Basin (MRB) and the international community, international and national civil society organisations and local communities joined the Forum, as has become a common practice.

The Forum was held on 27 and 28 May 2008 in Phnom Penh, Cambodia. About 125 participants coming from the MRC Member Countries and Dialogue Partners, organisations working in the MRB, international organisations, civil society organisations, institutions and companies, attended. There were 34 presentations in the plenary and parallel sessions, a workshop and six booths in the exhibition.

MAIN EXPECTED OUTCOME

The main expected outcome of the Forum was: *Based on the outcome of AMFF-6, the MRC-RFMMC and MRC Member Countries will be able to improve their flood forecasting services,*

and strengthen their systems, capabilities and collaboration mechanisms for real and near real-time data collection, transmission, processing and presentation in order to address the needs of the MRC Member Countries, which prefer the MRC-RFMMC to produce and timely disseminate medium-term flood forecasts and early warning information.

TOPICS

In order to enable proper presentations and discussion of various relevant aspects under the theme, the forum was structured into four main topics, which were run in both plenary and parallel sessions:

I. new developments with respect to flood forecasting and early warning;
II. land use based requirements for flood forecasting and early warning systems;
III. costs and benefits of flood forecasting and early warning;
IV. lessons learned from past flood events.

OBJECTIVES

The objectives of AMMF-6 may be summarised as follows:

- to promote regional cooperation to solve trans-boundary and regional issues related to floods and to share lessons learned on successful concepts and practices for coping with floods from the region and other parts of the globe;
- to promote the implementation of the strategy underlying the comprehensive Flood Management and Mitigation Programme (FMMP) that was formulated in 2002;
- to provide a platform to exchange experiences, to inform on new technologies and based on this to secure commitment as well as to strengthen cooperation for regional flood management;
- to contribute to the development and improvement of a sustainable network among participants and participating organizations;
- to provide the stage to present past activities, to discuss emerging needs and to review the progress each MRC Member Country and the MRC-RFMMC has made towards a holistic and balanced flood management plan;
- to share knowledge and experiences to strengthen regional cooperation

RESULTS OF THE AMFF-6

Country reports and presentations of Dialogue Partners

During the Forum the four MRC Member Countries presented their country flood reports for 2007. In addition there were presentations by the Dialogue Partners China and Myanmar. The country flood reports contain a good overview of the situation with respect to flood and flooding in 2007, as well as how the countries organised their flood forecasting and early warning approaches, what progress has been made, both technically and institutionally, how they organised the issuing of flood warnings and how they interact with the MRC-RFMMC. In addition the reports contain an impressive list of recommendations. Based on these lists, the presentations, discussions and the reports by the rapporteurs several key points have been derived that are listed underneath:

2007 flood events:

- as far as flooding is concerned 2007 was a moderate year. However, in several countries there were damaging flash floods. Floods on the mainstream of the Mekong River started late, were below average, similar or even below 2006 and the total damage was lower than in the last 5 years. There was one damaging typhoon - Lekima - with local rainfall in total 250 - 500 mm;
- there were flash floods in tributaries of the Mekong River in Laos, Thailand and the Central Highlands of Viet Nam that caused significant damage. The impression is that flash floods are increasing in frequency and damaging effect. Therefore there is an increasing need for improved information on the probability of occurrence of flash floods through a flash flood guidance system, especially for the tributaries of the Mekong River.

Flood forecasting and early warning:

- MRC daily forecasting news was disseminated before 10:00 in the morning, in order to enable the MRC Member Countries to use it effectively. Information on the new system of flood forecasting as it is now being tested by MRC-RFMMC needs to be frequently exchanged between MRC-RFMMC and the line agencies;
- little is known about flash flood behaviour due to lack of data and information in the sub-basin. Therefore, building knowledge on flash floods and finding a mechanism, methodology and facilities for flash flood forecasting and preparedness must be encouraged. Satellite information is very useful, especially for dealing with flash floods. However, one should always be aware of the relative accuracy of such information related to the intended use;
- there is a strong need for training and capacity building, especially for operational staff of National Flood Forecasting Centres. MRC-RFMMC needs to help strengthening capability of national forecasting institutions, from data collection, processing to development of forecasting models.

Flood preparedness and disaster management:

- based on an analysis of the water levels at Tan Chau station (as experienced by the farmers) in Viet Nam, floods and flooding in the Mekong Delta have been classified in 4 levels. The concept *'Living with floods'* has been successfully applied in the Mekong Delta. The measures for living with floods include: building residential clusters, flood proof housing, embankments, shifting of the cropping calendar, improvement of flood release capacity, establishment of child care centres, children safety training, and water borne disease prevention;
- meetings have been held before (April or May) and after (December or January) the flood season, including participants from MRC-RFMMC and the MRC Member Countries. The objectives of the meetings was: exchanging and sharing knowledge, experiences and technology in flood forecasting, disaster assessment, emergency response, preparedness land use planning in the floodplain, etc;
- as far as vulnerable communities are concerned, more attention has been paid to the strengthening of coping mechanisms in case of floods. Awareness on basic flood risk reduction and mitigation measures and knowledge to use hydro-meteorological information has been provided to these communities so that they can help themselves to reduce flood risk;
- within the MRC Member Countries the capacity for flood aftermath surveys is still very weak or non existent. The agencies in charge of disaster management focus rather on damages and humanitarian assistance. The countries are trying to find ways how to improve this situation.

Relief and reconstruction
Reconstruction and relief measures need to be improved, financial assistance would have to be made to affected communities so that their daily life can be sustained, the technical and financial assistance needs to be effectively and efficiently mobilized as soon as possible afterwards, and a financial reserve needs to be established for flood emergency response.

Benefit - cost aspects:
In order to identify an effective set of flood management and mitigation measures, a good process for assessment flood damage will be relevant. Such a process is also necessary because comprehensive assessment of damage gives important data that will reflect the economic loss of the country. This will result in significant supporting information for setting up of both structural and non-structural measures for flood prevention and mitigation.

MRC-RFMMC approach towards an improved medium-term flood forecasting and warning system

The MRC-RFMMC has made good progress with the development of its new short-term and medium-term forecasting system for the mainstream of the Mekong River, as presented in the video during the inaugural session. Important components are the HYDMET software for exchange, handling and storage of hydro-meteorological data, the URBS hydrological and flood routing model, and the forecasting environment Delft FEWS. This system enables linking of the models that are applied by the MRC-RFMMC and the MRC Member Countries. Input to the new hydrological models is primarily rainfall data with point and grid based products. In several papers as presented and discussed during the forum and published in the proceedings of AMFF-6 the general set-up and details of the new approach is shown. The new system has been run in parallel with the old forecasting system in a test mode during the 2008 flood season and the new system is also helping to promote the interaction between the MRC-RFMMC, the MRC Member Countries and the Dialogue Partners on data exchange.

Results of the plenary and parallel sessions

The content and summarised results of the plenary and the parallel sessions on the four topics were as shown underneath. Based on the presentations and discussions more detailed recommendations were presented on each topic. These are used by the MRC-RFMMC during the further development of the new approach.

There were five plenary presentations. Two papers concerned international experiences and developments of respectively the *Asia Flood Network: Flood Mitigation and Preparedness Program in Asia* by the Office of U.S. Foreign Disaster Assistance of U.S. Agency for International Development (USAID/OFDA) and the program on *Integrated flood management in the context of regional to global integrated observing and information systems* by the World Meteorological Organization (WMO). Two other papers concerned presentations on the progress made in two other Components of the Flood Management and Mitigation Programme (FMMP) of the MRC-RFMMC, respectively Component 3 on *Enhancing cooperation between MRC Member Countries in addressing trans-boundary flood and related issues* and on Component 4 on *Flood emergency management strengthening (FEMS).*

A Special presentation on *Flood forecasting for best management of floodplains* was given by Prof. Kuniyoshi Takeuchi, Director of the International Centre for Water Hazard and Risk Management (ICHARM) in Tsukuba, Japan. In his presentation he stressed that: action is needed, the benefits of floods need to be maintained and that disasters start when the developments start, which is a multi-generation problem. He also stated that trust in the forecaster is very important. He presented some aspects of the work of ICHARM.

Topic I. New developments with respect to flood forecasting and early warning

Under Topic I, five papers were presented of the seven papers that were submitted. The summarised points as taken from the presentations of the rapporteur of the topic were:

- an efficient data collection, processing and retrieval system for meteorological forecast data is of utmost importance for river flow modelling and issuing of forecasts;
- new methods of forecast to be applied for the Mekong River Basin were discussed;
- topographic and morphologic conditions in Mekong Delta have changed significantly after the 2000 flood event. Therefore models need to be recalibrated;
- it is time to improve gathering of historical and operational data;
- forecast messages should be understandable for the farmers.

Topic II. Land use based requirements for flood forecasting and early warning systems

For Topic II only two papers were submitted, of which only one could be presented. An additional paper on Extreme weather conditions, drainage, flood management and land use was presented as well. Some recommendations were:

- different types of land use require different types of flood forecasts and different measures. Agriculture and fisheries may need seasonal forecasts, while rural and urban areas need (flash) flood forecasts. All may need short and medium-term forecasts;
- a good mapping and zoning/land use planning is of importance, as well as identification of vulnerability.

Topic III. Costs and benefits of flood forecasting and early warning

For Topic III three papers were submitted and presented and a special workshop on *Costs and benefits of flood forecasting and early warning* was held. Some conclusions and recommendations were:

- estimation of costs and benefits of flood forecasting systems is a difficult task;
- there was a general consensus that benefit/cost ratios of flood forecasting and early warning were in the order of 10/1 – 15/1;
- in the comparison of benefits and cost primary damage and secondary damage need to be considered;
- damage should not only be expressed in monetary terms. Intangibles like: loss of life, cultural losses and long-term impacts on public health need to be considered as well;
- it is hard to convince people to invest in flood management and mitigation measures, as the benefit of this is hard to assess. However, it is easier to convince them that the benefits/cost are higher in urban as compared to rural areas.

Topic IV. Lessons learned from past flood events

For Topic IV four papers were submitted, of which three were presented. Some conclusions and recommendations were:

- floods are very harmful to children. Therefore the flood awareness activities need to be more oriented to children;
- it is considered to be more effective to start with collaboration with communities in flood hazard identification;
- more affordable and effective modelling and systems need to be considered (less sophisticated and making use of correlation).

FOLLOW-UP

Three types of follow-up action were formulated, including: follow-up directly after the Forum, recommendations for the 7th Annual Mekong Flood Forum (AMFF-6), more comprehensive follow-up actions. The more comprehensive follow-up actions concerned:

- continue with annual flood forums, based on actual topics of joint interest of the MRC Member Countries and Dialogue Partners. However, the programme of the Forum needs to be modified in light of the progress made within the MRC Member Countries and the FMMP;
- work for the present phase of the FMMP will continue along the lines as presented, with input from Forum results for improvement;
- during the 2008 flood season the new system for flood forecasting will be tested in practice. Based on the test results decisions will be taken on introduction of the new system for flood forecasting in the MRC-RFMMC in close consultation with the Member Countries;
- every year there are flash floods in tributaries of the Mekong River especially in Lao PDR, Thailand and the Central Highlands of Viet Nam that cause significant damage. Therefore there is an increasing need for improved information on the probability of occurrence of flash floods through a flash flood guidance system, especially for the tributaries of the Mekong River;
- preparations for follow-up of the FMMP beyond 2010 need to be started soon.

CONCLUDING SESSION

The concluding session started with presentations of the summary of the proceedings of the 6th Annual Mekong Flood Forum by the forum facilitator. At the end of the Forum the participants adopted the Forum Statement. This Statement clearly recognised the continuous updating of new approaches by the MRC Member Countries and Dialogue Partners in order to enable them to issue improved flood forecasts and early warnings, as well as to improve their flood preparedness measures. The devastating cyclone Nargis that struck the region and the frequently occurring flash floods have proved again the importance of such measures. Interstate collection and exchange of information with respect to flood forecasting allows the MRC Regional Flood Mitigation and Management Centre (MRC-RFMMC) of the Mekong River Commission (MRC) to provide daily short-term flood forecasting during the flood season. This supports the countries in preparing their own flood forecasting and early warning messages, improving flood preparedness measures and emergency management, relief and reconstruction. The efforts may substantially contribute to reduction of casualties and damages.

Finally, the concluding session ended with a vote of thanks to the organising staff of the MRC-RFMMC and the Cambodia National Mekong Committee (CNMC) by the Chief Technical Advisor of the Flood Management and Mitigation Programme (FMMP-CTA) and the concluding speech of the Chief Executive Officer (CEO) of the Mekong River Commission Secretariat (MRCS).

FOLLOW-UP ON RECOMMENDATIONS OF PREVIOUS FLOOD FORUMS

Since 2002 the MRC has successfully organised six Annual Mekong Flood Forums (AMFF) under different themes. Each forum produced its own conclusions and a set of recommendations as for follow-up action, which have, among others, served as the basis and justification for the organisation of the subsequent forum. In order to keep the future forums on the right track as well as to focus on meeting the emerging needs of the region with respect to flood risk reduction

and management a review and reflection of the previous forums' recommendations, especially of the 6th AMFF has been carried out.

The four countries established the Flood Forum in response to heavy flooding along the Mekong River in 2000 and 2001, which caused severe infrastructure damage and crop loss. In 2000, more than 800 people died in the floods, and damage was estimated at over US$ 400 million in Cambodia, Lao PDR, Thailand and Viet Nam. It was suggested, in the 1st Annual Mekong Flood Forum organized 2002, that the Mekong Flood Forum should be organized annually.

The MRC has convened six Annual Mekong Flood Forums since 2002, The 1st Flood Forum was held from 23 to 24 April 2002 under the theme '*Flood Preparedness*' for the immediate upcoming 2002 flood and for medium-term up to the 2005 flood. If the preparedness programme is properly planned and implemented, damages and losses caused by floods are significantly mitigated to a minimum level.

For the Second Annual Flood Forum in 2003, a broad 'umbrella-type' theme was proposed, because so many issues were high on the regional agenda, and were in imminent need of exchange of opinions: '*Make flood related information flow faster than flood water - flood forecasting and dissemination'* - which would fit with the upcoming improvement of Flood Forecasting tools, as well as the on-going dissemination pilot project. The theme was later changed to '*Information flow, networking and partnership'*. The 2nd Annual Mekong Flood Forum took place on 28 and 29 October 2003. It highlighted some of the newest procedures used for mapping and forecasting of flood with high accuracy, and particularly discussed how to transmit in timely manner flood information from regional/national centres to local communities, which are in need. The information is important for local people to get prepared before seasonal floods come.

From the list of themes proposed by AMFF-2, the Flood Management and Mitigation (FMM) Task Force of the MRCS at first suggested the theme '*Appropriate technology for flood and drought management*' for the 3rd Annual Mekong Flood Forum (AMFF-3). Due to the fact that implementation of FMMP would have started at the time of the AMFF-3 it was suggested to shift the theme to '*Flood Management and Mitigation in the Mekong Basin*'. AMFF-3 was held on 7 and 8 April 2005, under a timely theme because major components of the FMMP were being implemented by that time. The Forum provided a venue to review, discuss, and coordinate FMMP implementation, and national flood management and mitigation plans.

The 4th Annual Mekong Flood Forum (AMFF-4) was held in Siem Reap, Cambodia on 18 and 19 May, 2006. The theme of the Forum was, '*Improving flood forecasting and warning systems for flood management and mitigation in the Lower Mekong Basin'*. As the FMMP started its actual implementation and based on comments of previous Forums as well as the urgent needs of the FMMP the above mentioned theme was selected.

As a follow-up activity of the AMFF-4, it was decided by the MRC-RFMMC that the theme for the 5th Annual Mekong Flood Forum (AMFF-5) should be '*Improving inputs towards medium-term flood forecasting and warning in the Mekong Basin*'. This theme was chosen due to the fact that there was a trend for increasing the time between forecasting floods and actual flooding. AMFF-5 was held in Ho Chi Minh City, Viet Nam at 17 and 18 May, 2007. About 140 participants attended it.

Again, as a follow-up activity from the AMFF-5, the theme '*Integrated approaches and applicable systems for medium-term flood forecasting and early warning in the Mekong River Basin'* was chosen in close consultation with the MRC Member Countries, based on their requirements with respect to the enhancement of the flood forecasting and early warning system towards the attainment of reliable and dependable medium-term flood forecasting (6 – 10 days) and early warning by the MRC-RFMMC. The 6th Annual Mekong Flood Forum (AMFF-6) was held on 27 and 28 May 2008 in Phnom Penh. About 125 participants coming from the MRC Member Countries and Dialogue Partners, organisations working in the MRB, international organisations, civil society organisations, institutions and companies, attended. There were 34 presentations in the plenary and parallel sessions, a workshop and 6 booths in the exhibition.

At each forum conclusions and recommendations have been formulated. In this overview a summary is given of each of these conclusions and recommendations, followed by an analysis on how these conclusions have been developed and in which way they have been used to improve the tasks and activities with respect to flood forecasting and flood management by the Mekong River Commission and by the agencies and private sector in the MRC Member Countries. The key points from each forum may be summarised as follows:

- *AMFF-1.* A wide spectrum of flood management items and actions were listed with general recommendations for actions and improvement possibilities. Key issues that may be derived from this are prevention of overlaps and duplications, more coordination, better interaction with the public and improved forecasting;
- *AMFF-2.* The conclusions and recommendations of AMFF-2 are more concrete than those of AMFF-1. There is a reference to the conclusions and recommendations of AMFF-1 and how these have been followed up. The MRC Flood Management and Mitigation Programme (FMMP) has been presented and discussed;
- *AMFF-3.* AMFF-3 still dealt with the broad spectrum of flood management and mitigation activities. The focus was on three fields: communication, planning and implementation, coordination and new areas of cooperation. The conclusions and recommendations were of a general nature with respect to these three fields;
- *AMFF-4.* Compared to the previous three forums the scope of AMFF-4 was narrowed to only flood forecasting and warning systems. The advantage was that presentations and discussions could go much more in depth and therefore were more valuable and to the point. By looking back it can be concluded that a substantial number of the conclusions and recommendations have been followed up;
- *AMFF-5.* AMFF-5 was in line with AMFF-4, while the focus was still on flood forecasting and early warning. However, the issue of medium-term flood forecasting was added. During this Forum for the first time a Forum statement has been adopted by the participants. In addition a glossary and abbreviations and acronyms have been published. Both the glossary and the abbreviations and acronyms have been updated in the following forums. The presentations, discussions conclusions and recommendations were organised based on the four topics under the theme;
- *AMFF-6.* The scope of AMFF-6 was still on flood forecasting and warning. However, there was more focus on new models and systems that could be used for medium-term flood forecasting and early warning. In addition flood forecasting and early warning were more placed in the context of the costs and benefits and the land use aspects that are related to them, as well as on their effect on measures to be taken in relation to disasters. In addition there was a stronger focus on the problems with flash floods as during the previous forums. By the end of AMFF-6 the Forum Statement has been adopted as well.

If we review the developments over the six forums, then it can be observed that the conclusions of the first three forums covered the broad spectrum of floods and related aspects. AMFF-4 had a much more narrow scope while there was a strong focus on flood forecasting and early warning. The advantage was that presentations and discussions could go much more in depth and therefore were more valuable and to the point. In fact AMFF-5 and AMFF-6 have elaborated on this set-up, although gradually the other important aspects were increasingly taken into account. This trend will continue in AMFF-7.

The forums have played an important role in the development of flood forecasting activities for the mainstream of the Mekong River by the MRC-RFMMC and the flood forecasting and early warning activities by the MRC Member Countries. In addition the forums have undoubtedly played an important role in the networking among those who are involved in flood forecasting, early warning and other related activities with respect to flood management. They have also promoted the exchange of information between the MRC Member Countries and the international community.

Many of the conclusions and recommendations of the forums have been followed up. However, many others are still waiting for their implementation. However, all in all it may be stated that the forums are fulfilling their important role to contribute to the overall objective of the MRC *to promote, support, cooperate and coordinate in the development of the full potential of sustainable benefits to all riparian States.*

The impact of the forums for the MRC Member Countries and the FMMP can be observed in the MRC Member Countries' and the MRC-RFMMC's improved flood forecasting and warning systems and enhanced data collection, in the community people showed improved awareness and better networking and partnership between international organisations (IO) and Civil Society Organisations (CSO) through their participation in the MRC flood-related activities. Although seasonal floods in the Lower Mekong River Basin cause millions of dollars worth of damage every year, flooding also brings many benefits, including increased fish production, soil fertility for agriculture and sustained biodiversity and ecology, major agencies working in disaster preparedness now recognize that floods cannot be prevented, but that much of the damage can be mitigated by having reliable forecasting and early warning systems and better land-use planning measures.

Paper 0-2

OBJECTIVES AND EXPECTED OUTCOME OF THE 7TH ANNUAL MEKONG FLOOD FORUM (AMFF-7)

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ABSTRACT

Under the umbrella of the Mekong River Commission (MRC), the Regional Flood Management and Mitigation Centre (MRC-RFMMC) was recently established in Phnom Penh, Cambodia. The Centre plays an important role in maintaining (the national and regional) availability of important flood-related tools, data and knowledge; producing accurate regional forecasts with suitable lead time and timely and effective dissemination; and providing accurate, well documented and consistent tools for basin-wide flood risk assessment and trans-boundary impact assessment.

One of the important tasks of the MRC-RFMMC is to organize the Annual Mekong Flood Forum. The Forum provides the floor to present completed activities, to discuss emerging needs and to review the progress each country has made towards holistic and balanced flood management. As an on-going activity, it provides a suitable framework to strengthen cooperation and information exchange among the MRC Member Countries - Cambodia, Lao PDR, Thailand and Viet Nam - the Dialogue Partners - China and Myanmar - and the international community, international organisations (IO) and civil society organisations (CSO).

Since 2002, the MRC has successfully organized six Annual Mekong Flood Forums under the following themes '*Flood preparedness*', '*Information flow, networking and partnership*', '*Flood management and mitigation in the Mekong Basin*', '*Improving flood forecasting and early warning systems for flood management and mitigation in the Lower Mekong Basin*', *'Improving inputs towards medium-term flood forecasting and warning in the Mekong Basin' and 'Integrated approaches and applicable systems for medium-term flood forecasting and early warning in the Mekong River Basin'* respectively.

As an annual event of the MRC-RFMC, the 7th Annual Mekong Flood Forum is held on 13 and 14 May, 2009 under the theme *'Integrated flood risk management in the Mekong River Basin'*. The underlying considerations to propose this main theme were:

- the themes as discussed during the previous Forums;
- the broader goal of the Annual Mekong Flood Forums, which is that the MRC Member Countries will use them as a mechanism to exchange experiences and improve their own flood policies, strategies, plans and projects;
- the status of the development of the flood forecasting systems and the on-going concerns with respect to floods and flooding in the Mekong River Basin (MRB);
- the progress that has been made with the other Components of the Flood Management and Mitigation Programme (FMMP).

It is noticeable that the existing flood risk management approaches and practices need to be improved in the Mekong River Basin due to rapid population growth in the region, intensification of agriculture, changes in land use and river morphology, and rapid technology development as well as the change in technological progress.

The meeting will be very specific and result-oriented in order to assure that after the Forum the outcomes can be followed by concrete action plans and implementation by the MRC-RFMMC and the MRC Member Countries.

The main focus of this two-day Forum is to discuss the following issues:

- to review the progress each country has made towards a holistic and balanced flood management plan and to share lessons learned on the 2008 floods by the concerned agencies;
- to present the development progress of the new system on flood forecasting for the mainstream of the Mekong River as it is being tested by MRC-RFMMC;
- to review and assess the development of flood forecasting and early warning systems in the respective MRC Member Countries and their interaction with the MRC-RFMMC as well as to discuss the development of new needs of the MRC Member Countries;
- to present and share with the MRC Member Countries and other interested stakeholders the progress of developments with respect to the other Components of the Flood Management and Mitigation Programme (FMMP);
- to exchange experience, best practices and ideas with the international community, academic institutions, IOs and CSOs on institutional development and strengthening and technical capability requirements in order to have effective and efficient flood risk management approaches/strategies implemented in the Mekong River Basin;
- to come up with effective working arrangements to enhance the process of improving flood risk management between the MRC Member Countries and the MRC-RFMMC, as well as to strengthen the cooperation and information exchange among the international community, IOs and CSOs.

INTRODUCTION

Alarmed by the devastating floods of 2000, the MRC Council through its Secretariat formulated a MRC Strategy on Flood Management and Mitigation (FMM Strategy). It is regarded as a basis for a much stronger future involvement of MRC in regional flood management.

Based on the Strategy, which was approved by the MRC Council in November 2001 a Flood Management and Mitigation Programme (FMMP) has been approved once again by the MRC Council in November 2003.

Following the adoption of the FMMP, an extensive consultation process was made through national meetings, discussions and donor appraisals in order to consolidate and streamline the activities as well as to raise funding for the implementation of the programme. It took time to raise funds for the implementation of the programme, however, when funding was secured, all stakeholders were ready to take FMMP from its inception phase into full scale operation by the first half of 2006.

Presently, the MRC-RFMMC is a centre for the FMMP, which is located in the newly constructed building in Phnom Penh, Cambodia. The Centre plays an important role in maintaining (the national and regional) availability of important flood-related tools, data and knowledge, producing accurate regional forecasts with suitable lead time and timely and effective dissemination; and providing accurate, well documented and consistent tools for basin wide flood risk assessment and trans-boundary impact assessment.

Provided with full charge and responsibility, the MRC-RFMMC has taken the lead in organizing the Mekong Flood Forum, which is an annual event of the MRC. Subsequently, the MRC-RFMMC has organized the 7th Annual Flood Forum, with the theme *'Integrated flood risk management in the Mekong River Basin.*

MAIN EXPECTED OUTCOME

The main expected outcome of the Forum has been formulated as follows:
Based on the outcome of the 7th Annual Mekong Flood Forum, the MRC-RFMMC, MRC Member Countries will be able to improve their integrated approaches to flood management. This implies improved database systems and tools for dissemination of the flood forecasting and early warning products, application of flood risk assessment and management, the development of guidelines for preparation of flood risk management plans and for evaluation of the impacts of flood risk management measures, identification of potential trans-boundary issues for negotiation, mediation and conflict prevention, as well as the development of a regional flash flood early warning system.

OBJECTIVES

The *Development objective* of the FMMP was taken from the FMM Strategy '*People's suffering and economic losses due to floods are prevented, minimised, or mitigated, while preserving the environmental benefits of floods'*.

All projects, which are indicated in the FMMP, will directly or indirectly contribute to the achievement of this overall goal.

The *Immediate objective* of the 7th Annual Mekong Flood Forum (AMFF-7) describes how the target groups will use the outcome of AMFF-7 to achieve the development objective. It has been identified as:
'Based on the outcome of the 7th Annual Mekong Flood Forum, the MRC-RFMMC, MRC Member Countries, international organisations (IO) and civil society organisations (CSO) will be able to improve their services, and strengthen their capability and collaboration mechanisms for improving flood risk management practices in the Lower Mekong River Basin (LMB) in order to better address the aspects of human security due to floods, development and environment'.

More specifically, the 7th Annual Mekong Flood Forum for 2009 is set to discuss the following aspects:

- to review the progress each country has made towards a holistic and balanced flood management plan and to share lessons learned of the previous year floods by the concerned agencies;
- to present the development progress of the new system on flood forecasting for the mainstream of the Mekong River as it is being tested by MRC-RFMMC;
- to review and assess the development of flood forecasting and early warning systems by the MRC Member Countries and their interaction with the MRC-RFMMC as well as to discuss the development of new needs of the MRC Member Countries;
- to present and share with the MRC Member Countries and other interested stakeholders the progress of developments with respect to the other Components of the Flood Management and Mitigation Programme (FMMP);
- to exchange experience, best practices and ideas with the international community, academic institutions, IOs and CSOs on institutional development and strengthen and technical capability requirements in order to have effective and efficient flood risk management approaches and strategies implemented in the Mekong River Basin;
- to come up with effective working arrangements to enhance the process of improving flood risk management between the MRC Member Countries and the MRC-RFMMC, as well as to strengthen the cooperation and information exchange among the international

community, IOs and CSOs.

The Forum will be very result-oriented to ensure that it benefits the MRC-RFMMC and MRC Member Countries and improves services of flood risk management, especially the provision of flood information and early warning systems to the vulnerable communities in the LMB. The goal is that the countries will use the Annual Mekong Flood Forums as a platform to review and improve their own flood policies, plans and implementations.

FORUM TOPICS

Under the proposed theme the 7th Annual Mekong Flood Forum will be structured and organized with the following topics.

Topic I. Optimal packages for flood management

Measures with respect to flood management and flood protection are generally categorised in structural and non-structural measures. The structural measures concern: dams, dikes, storm-surge barriers, etc. In fact they concern physical provisions to reduce the risk of flooding. Non-structural measures concern: flood forecasting, flood warning, flood mapping, evacuation plans, land use zoning, etc. In practice one may expect that for a particular river basin an optimal (tailor made) package consisting of a balanced set of structural and non-structural measures has been, or will be developed.

Topic II. Recent developments in flood forecasting and early warning

The meteorology, weather forecasting and the conditions in the river basin create the basis for producing flood forecasting and early warning. An efficient data collection, processing and retrieval system for real or near-real time meteorological and weather forecast data will be of utmost importance to enable adequate inputs to river flow modelling and the issuing of forecasts. In the case of the Mekong River Basin most of the data is collected by the agencies in the riparian countries, while forecasts for the mainstream of the Mekong River are prepared by the MRC-RFMMC as well as by most of the riparian countries. This requires a good compatibility of the data, based on agreed accuracy and protocols. From the MRC-RFMMC short-term and reliable medium term forecasts (6 – 10 days) are expected. These forecasts need to be based on up to date technology for data collection, processing, retrieval and subsequent river modelling, with a focus on flood forecasting, related to the risks in flood prone areas. With respect to this a wide range of new developments may be observed regarding weather models, remote sensing techniques, global positioning systems, geographic information systems, automation in data collection, transmission, storage and retrieval, etc. The applicability of new developments for the interrelated database and flood forecasting systems in the conditions of the Mekong River Basin will be an important aspect of this Topic II.

Topic III. Effective approaches towards trans-boundary flood management

The Mekong River Basin covers parts of six countries, which implies the importance of coherent approaches in river management. This will especially be of importance during extreme conditions of floods and droughts, while under such conditions measures taken in one country may easily have a negative impact in the downstream country. Under certain conditions measures in a downstream country may even have impacts in an upstream country. In the context of Component 3 - *Enhancing regional cooperation in addressing trans-boundary flood issues* of the FMMP experience is being obtained in enhancing regional cooperation. In light of this it will be of importance to present such experiences, both for the Mekong River Basin, as well as for other trans-boundary river basins in the World.

Topic IV. Successful flood risk management approaches

The MRC Member Countries, Dialogue Partners, IOs, consultants, communities and CSOs have a 'treasure trove' of experience with successful flood risk management approaches. This experience is being increasingly documented and could be related to the effectiveness of flood forecasting and early warning, the effectiveness of communication and measures taken during and after the event of a flood, and the measures to be taken to reduce the risk of flooding in the future. For Topic IV the focus is on successful flood risk management approaches in the various river basins of the world.

PAPERS

SESSION 1

LESSONS LEARNED FROM 2008 FLOODING AND NATIONAL AND MRC-RFMMC EXPERIENCES WITH INTEGRATED FLOOD RISK MANAGEMENT

CAMBODIA COUNTRY FLOOD REPORT FOR 2008

SOK BUN HENG

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ABSTRACT

Mekong annual recurrent flood brings Cambodia important benefits, mainly during a normal flood, and also causes tremendous economic damage, during extreme floods. Flash floods caused by heavy rainfall, also cause severe damage to crops and infrastructure. In addition to this drought is another risk for rainfed cropping.

Floods in 2008 can be considered as normal floods, they brought more benefits rather than destruction. Little damage compared to previous years. The observed water levels at all mainstream stations along the Mekong, Bassac and Tonle Sap rivers in Cambodia were lower than the alarm levels, with -0.80 m at Stung Treng, -1.55 m at Kratie, -0.82 m at Kompong Cham, -1.49 m at Chaktomuk, -0.80 m at Neak Loung, -0.18 m at Koh Khel and -0.95 m at Prek Kdam.

During the second half of September 2008 a tropical storm with strong intensity covered the north-western part of Cambodia, produced heavy rainfall over those areas and caused flash floods in the two provinces of Preash Vihear and Bantay Meanchey. According to the Provincial Committees for Disaster Management (PCDM) these flash floods caused damage to rice and other crops in the two provinces at about 20,000 hectares and affected few hundreds households.

Damages by floods, especially Mekong floods during the last 10 years or so, is observed to be very little compared to the extreme floods during 1996, 2000, 2001 and 2002. This positive result is also part of the outcome of efforts by concerned agencies in management of floods and mitigation of their negative effects.

However, more effort is needed in order to maximize the benefit of floods and to minimize the damage by floods. In this context the government, together with its partners and non governmental organisations (NGO), has been working very hard to provide all kind of flood management and mitigation services to the affected people.

This paper gives the overview of the 2008 floods, the efforts and lessons learned and provides some recommendations for improvement for the flood year to come.

INTRODUCTION

Located in the Mekong floodplain Cambodia always receives Mekong annual recurrent flood. Some other parts of the country also experience flash floods caused by heavy rainfall mostly in tributaries around the Great Lake and eastern tributaries of the Mekong River. Cambodian people, especially people living in the Mekong floodplain, have been living with flood for many years, taking the advantage from flood, but they also have been suffering mainly from extreme floods.

Normal Mekong floods carry and distribute fertile silt into the floodplain for agriculture production, feeding food chain for fisheries, provide water supply for people living along the river side, provide navigation route and necessary environmental functions, but extreme floods usually cause severe damage and suffering, especially to people living in low-lying areas. It is, therefore important to find ways how to get the maximum benefits from floods and to minimize

the risk or damages from floods. To achieve this more effort and commitment as well as coordination and cooperation between institutions and people concerned are needed.

This report is the seventh in the series of national flood reports presented at each of the Annual Mekong Flood Forums (AMFF) of the Mekong River Commission (MRC). The topic of the forum for 2008 is 'Integrated flood risk management in the Mekong River Basin'. The report intends to present an overview of flood and drought characteristics of the country and reports on the lessons learned from the 2008 floods, it look at costs and benefits of floods in the past and provide recommendations for better management of floods so that their negative effects can be minimized and at the same time the positive effects can be maximised.

OVERVIEW OF THE 2008 FLOODS AND FLOODING

Mekong floods

In Cambodia, Mekong floods in 2008 can be considered as normal floods, with more benefits and less damage compared to floods in other years. According to the National Committee for Disaster Management damage by Mekong floods in 2008 was very small. The observed water levels at all mainstream stations along the Mekong, Bassac and Tonle Sap rivers in Cambodia were lower than the alarm level. The flood peak value at Mekong-Stung Treng station, with 0 gauge of 36.79 m+MSL, occurred on 9 October with a peak value of 9.90 m, while the flood peak at this station in 2007 occurred on 8 October with a peak value of 9.84 m.

Figures 1 to 3 show the hydrographs of the flood situations in 2008 compared with previous years in 3 stations along the Mekong, Bassac and Tonle Sap rivers, in 1991, 1994, 1997-1998, 2000-2001, 2005-2008 and mean from 1991-2007.

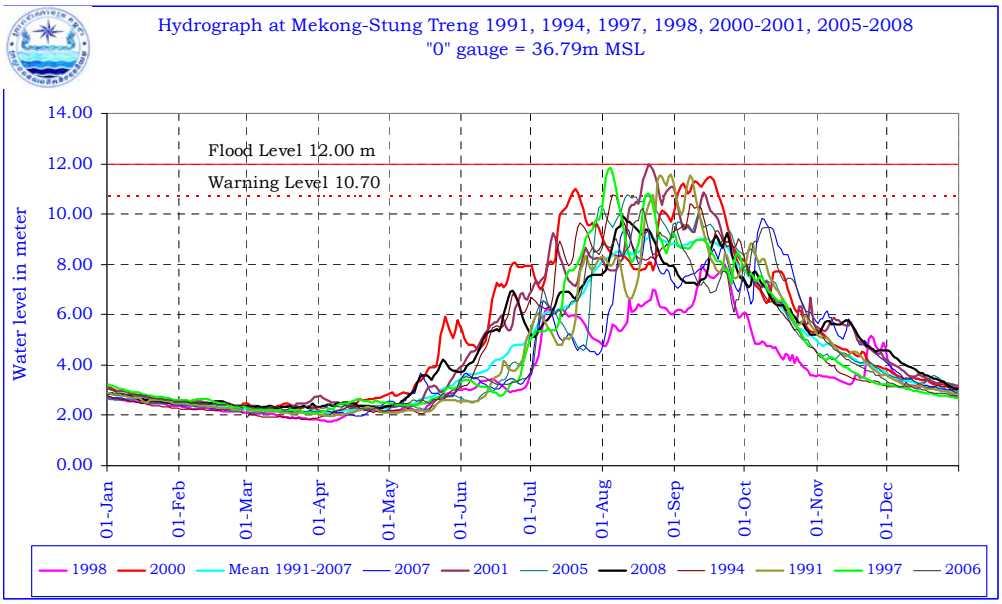


Figure 1. Hydrograph at Mekong-Stung Treng in 1991, 1994, 1997-1998, 2000-2001, 2005-2008

With reference to long-term observations, the 2008 flood was somehow similar to the long-term annual average flood. In 2008, annual maximum water levels at 7 stations occurred during early August to late September, while in 2007 they occurred during early September to late October.

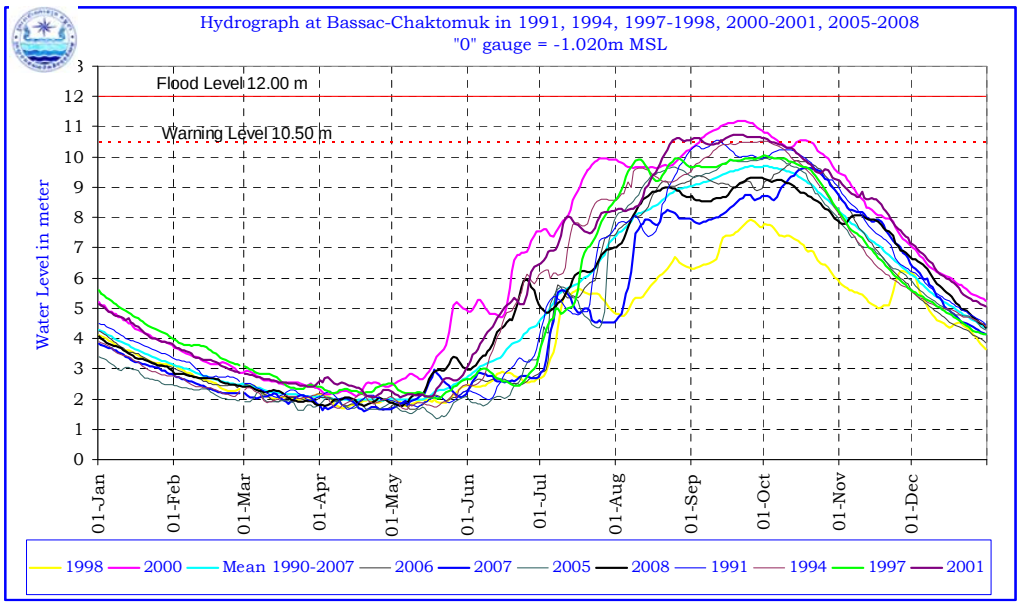


Figure 2. Hydrograph at Bassac-Chaktomuk in 1991, 1994, 1997-1998, 2000-2001, 2005-2008

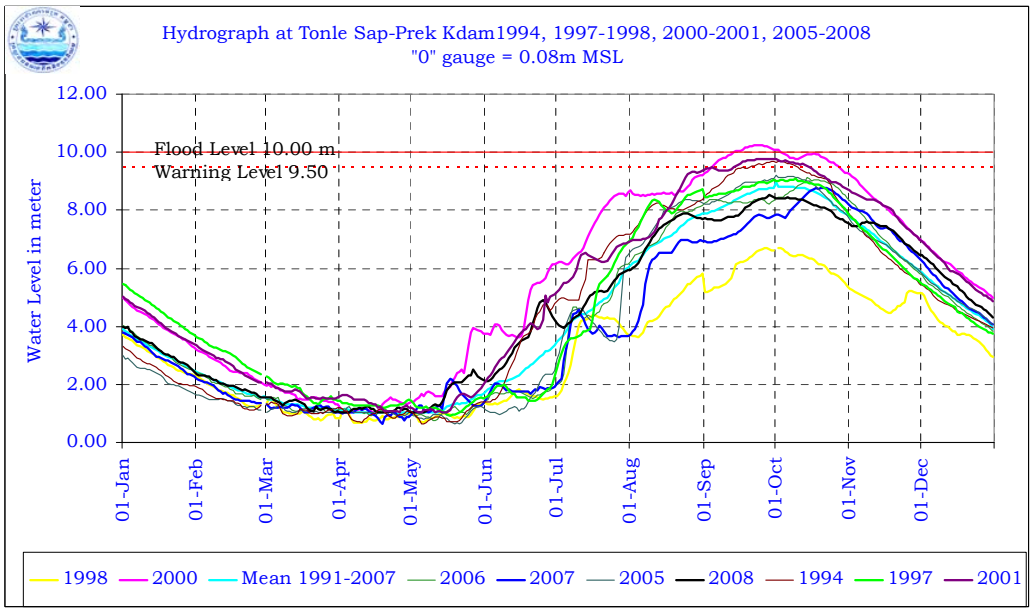
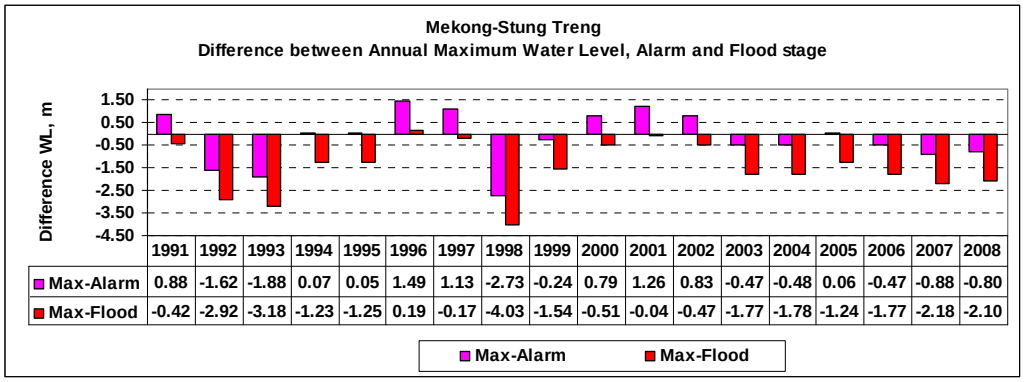


Figure 3. Hydrograph at Tonle Sap-Prek Kdam in 1991, 1994, 1997-1998, 2000-2001, 2005-2008

Charts in Figure 4 indicate the difference between Annual Maximum water level, Alarm level and Flood stage at Mekong-Stung Trent station:

- pink colour is difference between annual maximum water level and alarm stage;
- red colour is difference between annual maximum water level and flood stage;
- negative value is annual maximum water level is lower than alarm and flood stage;
- positive value is annual maximum water level is higher than alarm and flood stage.



	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Max-Alarm	0.88	-1.62	-1.88	0.07	0.05	1.49	1.13	-2.73	-0.24	0.79	1.26	0.83	-0.47	-0.48	0.06	-0.47	-0.88	-0.80
Max-Flood	-0.42	-2.92	-3.18	-1.23	-1.25	0.19	-0.17	-4.03	-1.54	-0.51	-0.04	-0.47	-1.77	-1.78	-1.24	-1.77	-2.18	-2.10

Figure 4. Mekong- Stung Treng: Difference between Annual Maximum Water Level, Alarm and Flood Stage.

The Great Lake

The Great Lake in Cambodia, which is fed annually by the Mekong reverse flow, plays an important role in flood peak attenuation and flow control to the Mekong Delta. The Lake receives over 50% of its volume from the Mekong flood flow. There is a limited comprehensive hydrological data collection in the Great Lake area. The Lake is the biggest freshwater lake in Southeast Asia with its volume and flooded areas fluctuating on an annual basis and normally the lake water level reaches its peak level during the period of heavy rainfall in the Great Lake sub-basins. The Great Lake has a mean dynamic surface area of 8,200 km^2, from about 2,500 km^2 in the dry season to over 15,000 km^2 in some wet seasons. A unique phenomenon occurs annually. That is, the water flows into the Lake during May/June and the stored water flows back into the Lower Mekong and Bassac rivers in September/October. The water level in the Lake fluctuates between wet and dry seasons by about 7 to 8 metres. Usually the maximum water level in the lake coincides with the period of heavy rainfall in the Great Lake sub-basins. The lake water level in 2008 reached its peak during 15-19 October with a water level of 8.06 m. Figure 5 shows the hydrographs of the water level in the Great Lake in 2008 compared with previous years in 1999, 2000, 2001, 2002, 20054, 2006, 2007, and 2008.

Flash Flood in 2008

Flash floods in Cambodia may be caused by local heavy rainfall in its river basins or by typhoons or storms affected from the neighbouring countries, Viet Nam and Thailand. There is no comprehensive data on these river basins, even not on rainfall distribution.

During last two weeks of September 2008 a low-pressure area and tropical storm with a strong intensity covered the northern part and coastal area of Cambodia, produced heavy rainfall over those areas and caused flash floods in the provinces Preah Vihear, Kampong Thom and Bantay Meanchey. These flash floods caused damage to crops at about 10,500 hectares.

According to reference stations in various provinces in 2008, maximum temperature can range from 30.0 ^oC to 33.6 ^oC and the average maximum temperature is 31.8 ^oC. The minimum temperature can range from 20.0 ^oC to 25.7 ^oC with average minimum temperature of 22.8 ^oC. Average annual rainfall is about 1,800 mm and it ranges from 1,100 mm in Bantay Meanchey Province to about 4,800 mm in Kosh Kong Province. On 15 September the daily rainfall observed in Preash Vihear was 127 mm. Total annual rainfall by province is shown in Figure 6.

Table 1. Annual Maximum Water Level along Mekong, Bassac and Tonle Sap rivers from 1991-2008

Station Name	**Stung Treng**		**Kratie**		**Kampong Cham**		**Chak Tomuk**		**Neak Loeung**		**Koh Khel**		**Prek Kdam**	
Station Code	**014501**		**014901**		**019802**		**033401**		**019806**		**033402**		**020102**	
Flood Level	12.00		23.00		16.20		12.00		8.00		7.90		10.00	
Warning Level	10.70		22.00		15.20		10.50		7.50		7.40		9.50	
Zero Gauge, m MSL	+36.79		-1.08		-0.93		-1.02		-0.33		-1.00		+0.08	
Year	Max	Date	Max	Date	Max	Date	Max	Date	Max	Date	Max	Date	Max	Date
1991	11.58	30-Aug	22.55	8-Sep	15.70	9-Sep	10.56	11-Sep	7.68	12-Sep			10.05	5-18 Oct
1992	9.08	28-Aug	20.08	23-Aug	14.06	2-Sep	9.01	2-3 Sep	6.24	3-Sep	6.99	27-28 Jul	7.54	6-Sep
1993	8.82	22-Aug	19.28	16-Sep	13.43	17-Sep	8.95	19-Sep	6.20	19-Sep	6.85	20-Aug	7.79	22-Sep
1994	10.77	5-Aug	21.65	6-Aug	15.17	12-13 Sep	10.53	29-30 Sep	7.52	15-16 Sep	7.53	26Aug-03Sep	9.69	2-Oct
1995	10.75	7-Sep	21.66	8-Sep	15.26	9-10 Sep	10.14	18-19 Sep	7.32	17-Sep	7.40	21-Aug	9.40	12-Oct
1996	12.19	24-Sep	23.01	28-Sep	16.11	29-Sep	10.94	2-Oct	8.00	2-Oct	7.78	2-5 Sep	9.74	2-3 Oct
1997	11.83	4-Aug	22.46	6-Aug	15.74	7-Aug	10.05	1-Oct	7.24	26-Aug	7.40	10-Jul	9.07	9-Oct
1998	7.97	22-Sep	17.86	24-Sep	12.24	25-Sep	7.92	25-Sep	5.42	25-Sep	6.44	26-27 Aug	6.70	2-Oct
1999	10.46	2-Aug	20.96	5-Aug	14.72	8-9 Aug	9.88	4-6 Oct	7.00	5-Oct	7.28	4-Oct	8.81	7-Oct
2000	11.49	16-Sep	22.61	17-Sep	15.91	18-Sep	11.20	21-Sep	8.12	20-Sep	7.94	23-Sep	10.26	23-25 Sep
2001	11.96	20-Aug	22.90	22-Aug	16.09	22-23 Aug	10.75	19-Sep	7.85	26-Sep	7.72	3-Sep	9.78	26-Sep
2002	11.53	23-Aug	22.49	23-Aug	15.91	25-Aug	10.65	29-Sep	7.89	29-30 Sep	7.72	29-Sep	9.92	30-Oct
2003	10.23	15-Sep	20.98	17-Sep	14.89	18-Sep	9.41	22-23 Sep	6.98	23-Sep	7.37	21-Sep	8.34	23-Sep
2004	10.22	15-Sep	21.19	17-Sep	15.07	18-19 Sep	9.97	25-26 Sep	7.41	25-Sep	7.53	25-Sep	9.09	27-Sep
2005	10.76	11-Sep	21.62	21-Aug	15.35	22-Aug	9.95	1-Oct	7.33	18-Sep	7.42	1-Oct	9.21	1-Oct
2006	10.23	18-Aug	21.19	18-Aug	14.96	19-Aug	9.90	14-Oct	7.16	16-Oct	7.44	14-Oct	9.07	14-Oct
2007	9.82	8-Sep	20.34	9-10 Oct	14.52	14-Sep	9.64	18-19 Oct	7.01	18-Oct	7.40	17-19 Oct	8.78	22-Oct
2008	9.90	09-Aug	20.45	13-Aug	14.38	14-15 Aug	9.32	26-Sep	6.70	28/30-Sep	7.22	26-Sep	8.55	28-Sep

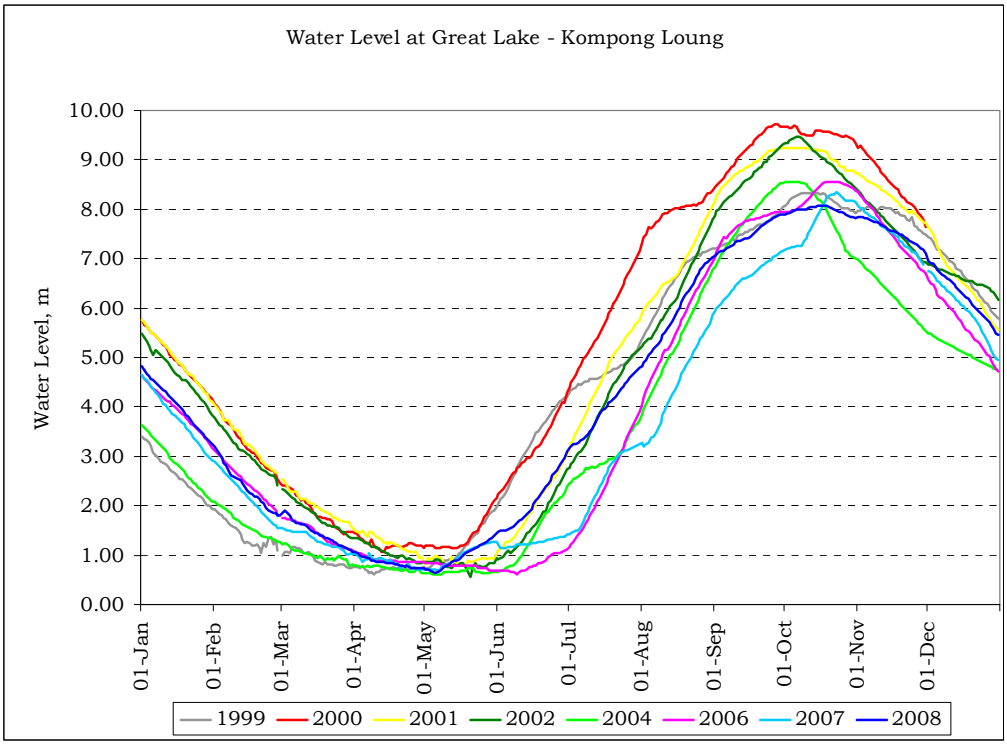


Figure 5. Hydrograph at Great Lake-Kampong Loung in 1999, 2000, 2001, 2002, 2004, 2006, 2007 and 2008.

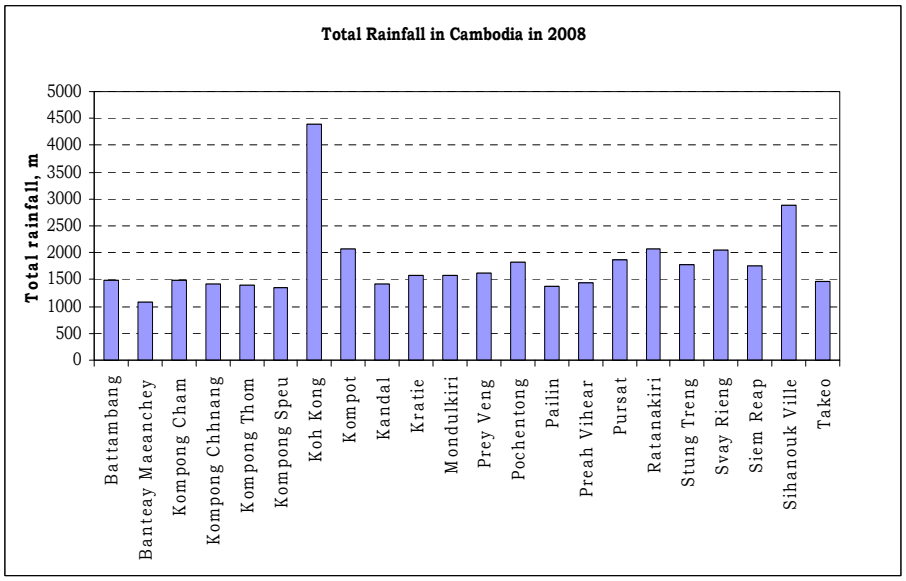


Figure 6. Total Annual Rainfall by Province in Cambodia in 2008.

Monthly rainfall observed at the main hydrological stations in 2008, as shown in Figure 3, shows that the rainfall increased from the beginning of May with a high amount of rainfall up to 362 mm in Stung Treng, drop to 111 mm in July and increase in August to 328 mm. The distribution somehow followed the same pattern as in 2007, with maximum rainfall of 388 mm in May and drop to 68 mm in June and increase to 410 mm in August, as shown in Figure 7.

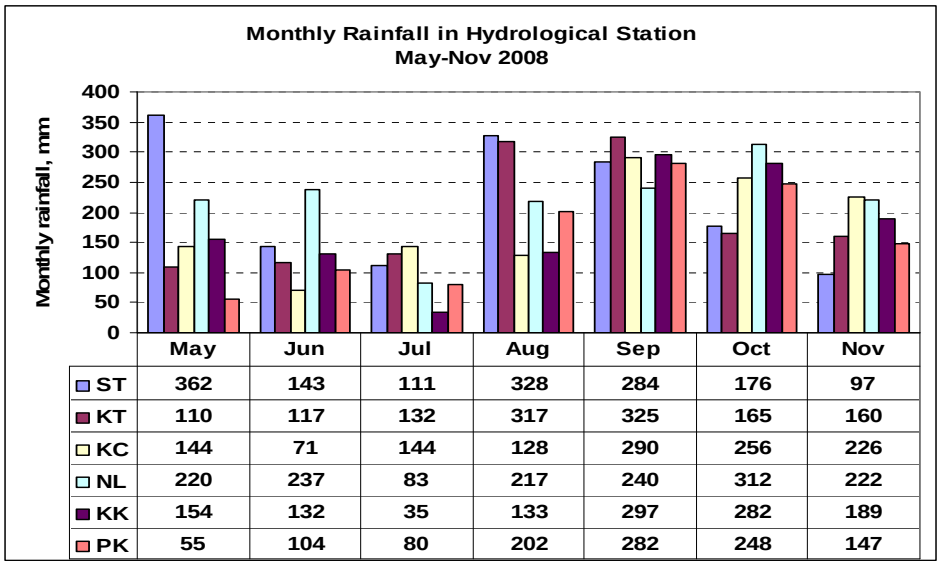


Figure 7. Monthly rainfall along mainstream of Mekong, Bassac and Tonle Sap rivers in 2008.

During the first week of August the Tropical Storm 'Kammuri' occurred in the Mekong River Basin with strong rainfall intensity, which caused floods and damage in Lao PDR, Thailand and Viet Nam. During that time the water level along the Mekong River in Cambodia increased sharply but did not reach the alarm stage.

Summary of positive and negative effects of floods

Cambodia considers Mekong floods to have dual effect. That means floods can produce benefits for socio-economic development of the country bringing fertile silt for agriculture production, food chain for fisheries, provide water supply for people living along the river side, navigation route and environmental cleaning function, but extreme Mekong floods have caused also severe damage and suffering to millions of people living in these low-lying areas and communication infrastructure such as roads and bridges including long periods of live disruption.

Table 2 shows rice and other crop productions and fish catch from 1998 to 2008, which is believed to be also partly the outcome of floods, especially for recession rice and inland fish.

Table 2. Rice and other crop production and fish catch during 1998-2008

Year	Rice		Other crops (1,000 ton)	fish	
	Wet season (1,000 ton)	Dry season (1,000 ton)		Total (1,000 ton)	Inland (1,000 ton)
1998	2,870	636	556	115	73
1999	3,330	708	773	122	76
2000	3,210	814	761	284	231
2001	3,280	823	773	296	246
2002	2,920	907	760	441	385
2003	3,840	873	1,140	421	360
2004	3,140	1,040	1,200	382	309
2005	4,730	1,250	1,470	327	250
2006	4,970	1,290	3,250	410	324
2007	5,360	1,360	3,540	517	422
2008	5,750	1,370	3,540	471	365

Sources: Ministry of Agriculture, Forestry and Fisheries.

Beside their positive effects, floods also cause damage to infrastructure, crops and cause casualties. Table 3 shows damage by floods from 1996 to 2008.

Table 3. Damage by flood during 1996 - 2008

Year	Total flood damage (million US$)	Major area affected	Type of flood	Major components of loss
1996	87	Along Mekong, Bassac and around Tonle Sap Lake	Mekong Flood and flash flood	Crops (250,000 ha), livestock (327), houses (3,770), schools (173), roads (802 km), bridges (290 sites), culverts (2,500 sites), dam (65 sites), dead (169 persons)
2000	161	Along Mekong, Bassac and around Tonle Sap Lake	Mekong Flood and flash flood	Crops (422,000 ha), houses (7,086), schools (6,620), soads (909,000 km), bridges (1,860 km), culverts (17sites), dams (397 sites), dead (347 persons)
2001	36	Along Mekong, Bassac and around Tonle Sap Lake	Mekong Flood and flash flood	Crops (164,000 ha), houses (2,251), schools (911), roads (7,980 km), bridges (175 sites), culverts (44 sites), dams (201 sites), livestock (956), dead (62 persons)
2002	12	Along Mekong, Bassac and around Tonle Sap Lake	Mekong Flood and flash flood	Crops (45,000 ha), houses (35), schools (2), health centres (7), roads (12 km), dam (201 sites), livestock (956)
2004	55	Along Mekong, Bassac and around Tonle Sap Lake	Mekong Flood and flash flood	Crops (247,000 ha)
2005	4	Along Mekong, Bassac and around Tonle Sap Lake	Mekong Flood and flash flood	Crop (1,500 ha), House (1,700 flooded, 32 collapses), School (30 flooded), Dead (4 persons)
2006	12	Along Mekong, Bassac and around Tonle Sap Lake	Mekong Flood and flash flood	Crop (13,800 ha), Road (70 km), Dam (41 sites), Bridge (24 sites), Dead (11 persons)
2007	9	Along Mekong, Bassac and around Tonle Sap Lake	Flash flood	Crop 18,800 ha, Houses 11, Road 34 km
2008	6		Flash flood	Crop 18,900 ha

Source: National Committee for Disaster Management.

It should be noted that the data on flood damage are collected at provincial level by Provincial Committees for Disaster Management (PCDM) they make a report and send to the National Disaster Management Committee (NCDM). There is no proper assessment of flood damage. The reports describe only the number of items that were flooded, but not the real damage and they report or make record only when there is an extreme flood, which causes a lot of damage. Table 3 therefore provides major damage by floods during 1996 to 2008.

Lessons learned

Based on its scale, a flood can be a benefit or a disaster. For many years, there have been efforts to reduce the negative effects of floods. Flood damages will be reduced if the gaps and needs in terms of flood management and mitigation are fulfilled and met. According to previous experiences the better preparedness will help to reduce considerably damage by floods. Till

present, the key gaps identified remain as follows:

- lack of systematic flood preparedness planning process at community level;
- weak or limited coordination between institutions and agencies concerned;
- poor access to flood information by local communities;
- lack of funds to support hydrological data collection as well as for operation and maintenance of equipment;
- isolated intervention will never assure sustainability of the activities initiated by the projects. Usually activities stop after completion of a project;
- flash floods are even more destructive as it are rare events, and the country still lacks human and financial resources, capacity and a methodology for flash flood forecasting;
- lack of continuity and technical expertise to assess aggregated cause-and-effect relationship.

UPDATE ON THE NATIONAL FORECASTING AND WARNING CENTRES

In general, flood forecasting in Cambodia can be described as in its early stage of development and still facing many challenges. The Department of Hydrology and River Works (DHRW) of the Ministry of Water Resources and Meteorology (MOWRAM) is responsible for hydrological data collection and forecasting in the country. The Department of Meteorology (DOM) is responsible for meteorological data collection and weather forecasting. The National Committee for Disaster Management (NCDM) and Cambodian Red Cross (CRC) use forecast products of the two departments to disseminate it to communities.

Current status of National Centres

Department of Hydrology and River Works (DHRW)

The Department of Hydrology and River Works (DHRW) is responsible for hydrological data collection and forecasting in the country. The DHRW also cooperates with the MRC Flood Management and Mitigation Centre (MRC-RFMMC) in forecasting and dissemination of flood information. The DHRWs forecasting time is only three days.

There are about 40 stations serving for hydrological data collection in the country. At the moment, only seven stations are operational due to lack of operation and maintenance funds. These 7 stations are: 1. Mekong-Stung Treng, 2. Mekong-Kratie, 3. Mekong-Kompong Cham, 4. Bassac-Chaktomuk, 5. Mekong-Neak Loung, 6. Bassac-Koh Khel, and 7. Tonle Sap-Prek Kdam. Currently DHRW forecasts only on the mainstreams of Mekong, Bassac and Tonle Sap rivers. Data for flood forecasting of the seven hydrological stations are transmitted real time water level and rainfall data to DHRW in Phnom Penh before 7:00 hr by telephone system. Usually data are collected and transmitted twice a day at 7:00 hr and 19:00 hr. In extreme cases the data can be sent up to 6 times per day, especially during the peak flood.

The DHRW reports to MOWRAM and other key agencies once data and information are received from the real time stations. The DHRW then enters these data into a computer base forecasting system for checking, analysing, processing and producing forecasts for 3 days ahead by using the method of station correlation.

Finally, a Flood Forecasting Bulletin is printed and approved, and then send to the mass media, concerned line agencies and end-users by fax, around 9:00 hr everyday to about 60 users.

The DHRW also exchanges data and information between countries in the Lower Mekong River Basin through Mekong River Commission Secretariat (MRCS) by using e-mail and Internet systems. DHRW receives MRCs flood forecasting products by e-mail and also sent back to MRC-RFMMC its Flood Forecasting Bulletin by fax.

Under Component 5 of the Flood Management and Mitigation Programme (FMMP) of

the MRC, DHRW is presently investigating the flood marks in the target villages in two districts of Leuk Dek in Kandal Province and Peam Ro in Prey Veng Province, which were installed under a five-year project (2003-2007) of the MRC-RFMMC, funded by the U.S. Agency for International Development (USAID), Office of Foreign Disaster Assistance (OFDA) with the aims to resume the activities implemented under previous projects.

As said before forecasting by DHRW was limited to only major mainstream stations along the Mekong, Bassac and Tonle Sap rivers with a maximum lead-time of 3 days and applying simple forecasting methods-station correlations. The capacity of DHRW is still limited both in terms of financial and human resources. They still lack adequate data, forecasting tools and qualified forecasters. Data collection has been neglected for many years due to lack of funds, qualified technical personnel and weak management. The current data collection system is not sustainable and limited to the mainstream stations only, which is mainly supported by the FMMP program. Only some stations can keep proper records with the limited funds of the Provincial Department of Water Resources and Meteorology (PDWRAM). The extension of forecasts to other vulnerable communities is supported by projects, which leaves an uncertain future after the end of a project.

Department of Meteorology (DOM)

The Department of Meteorology (DOM) is responsible for meteorological data collection and weather forecasting in the country. Although weather forecasting is limited due to various reasons it also can serve as complementary information for flood forecasting. There is no practical forecast and rainfall forecast. Currently weather forecasting done by DOM is mainly based on information obtained from Internet and the forecast is limited to a simple description of weather and temperature conditions. Due to the low capacity, it is foreseen that longer term forecasting using national rainfall forecasting is not possible in the near future.

There are some automatic rainfall stations that have been installed countrywide by different projects, but only some of them are in operation due to lack of operation and maintenance funds, inadequate training and poor management.

Other manual rainfall data are collected at the provincial and district level but not properly or not timely reported on a daily, monthly or annual basis to DOM. Often small monthly observation fees are paid to observers, creating difficult personnel communication. After each severe event such as droughts or storms, there is no report and analysis available in the media as reference to the degree of severity of the event. Archived data are not accessible without payment and usually only monthly data are available.

National Committee for Disaster Management (NCDM) and Cambodian Red Cross (CRC)

The National Committee for Disaster Management (NCDM) which was established in 1995 is responsible for providing timely and effective emergency relief to the victims of all kinds of disasters and also to develop preventive measures to protect or reduce the effect of the disasters. NCDM uses to work closely with the Cambodian Red Cross (CRC) as CRC has quite a good network down to the communities. The NCDM currently has developed down from national level to commune level and from early 2007 this network even has taken the role of the CRC in terms of warning and dissemination of flood information. The Provincial Committee for Disaster Management (PCDM), organizes annual seminars to prepare the provincial preparedness plan before each flood season. Under the project to support the implementation of the Flood Preparedness Program of MRC-RFMMC the provincial and district Committee for Disaster Management of the provinces along the Mekong have developed provincial and district Flood Preparedness Programs. Each PCDM has prepared its strategy and emergency plan to cope with flood, including safe water, food, safe areas, etc.

Extreme floods usually bring negative effects to the societies living in the flooded areas, therefore it is necessary to take immediate action after a flood to rehabilitate, especially the

infrastructure damaged during the flood season. PCDM with other agencies and private sector have been working together to mobilize funds for rehabilitation of the damaged infrastructure, but this kind of practice usually can cover only small rehabilitation. NCDM mobilizes all kind of supports from different sources to distribute to the victims such items as dry food, drinking water, rice, mosquito nets, etc.

Assessment of flood damage is usually aggregated at provincial level with data and information provided by communes and villages. The provincial areas are generally too large leading to data and information on the actual damage, which are not really reliable. The PCDMs sends their annual reports to NCDM, which will be compiled as national disaster report. There is no proper method to assess the actual damage due to floods. The assessment of losses concerns mainly the direct economic loss and excludes the recovery cost, cost for replacing damaged means of production and infrastructure and other indirect cost. In general, NCDM is a relatively newly established organization, which needs improvement in many aspects.

In 2007, the NCDM drafted a new strategic plan which is aligned with the Hyogo Framework of Action (HFA), the document signed by 167 countries at the World Conference on Risk Reduction (WCRR) in Kobe, Japan. The two year strategic plan details NCDMs strategies for strengthening partnerships, building capacity and building institutional capacity for Disaster Risk Management (DRM).

At the moment, the NCDM coordinates-disaster related programs among which is Community-Based Disaster Risk Management (CBDRM). As part of its strategy to institutionalize CBDRM, the NCDM worked with various NGOs to establish disaster management committees at the provincial, district, commune and village levels in target provinces, building capacity of local authorities and communities through various training.

The NCDM works closely with the Asian Disaster Preparedness Centre (ADPC) and specifically with its Partnerships for Disaster Reduction – Southeast Asia (PDR-SEA) program, which provides technical support.

Unmet need for forecast and warning product dissemination to flood-at-risk communities

There is no forecasting centre in the country, which integrates weather and hydrological forecasting. The Department of Hydrology and River Works (DHRW) produces 3 days flood forecasts for seven stations along the mainstream of the Mekong River, while the Department of Meteorology (DOM) carries out separate weather forecasts. Flood forecasting and early warning products are disseminated by DHRW through daily bulletins, emails and fax to relevant agencies and be disseminated further to the public by newspapers, hydrological boards, and public media networks.

The DHWR plan to provide forecast and early warning services to the target villages in two districts with technical and financial assistances from Component 5 of the MRC-FMMP, but most likely, there will be no possibility to so do for other areas.

The National Committee for Disaster Management (NCDM) uses flood and weather information from the DHRW and MRC-RFMMC to disseminate to communities through its provincial, district and commune committees for disaster management through hydrological boards, radio VHF and cell phone. CRC has also been doing a wonderful job in dissemination of flood forecast and warning products.

However, due to the lack of capacity and financial support, the forecast and the products can be done and reach only limited areas and because of their low level of education not all community members in those areas can access and understand all information provided.

There are many other kinds of efforts to disseminate forecast and warning products to flood-at-risk communities, but mostly those activities are carried out under programs and projects with limited time frame and usually stop after the end of the project.

People who are involved in recession agriculture along the Mekong River and around the Great Lake need seasonal forecasts so that they can plan properly the planting time, which is presently not available.

ASPECTS OF THE CENTRE-COMMUNITY RELATIONSHIP THAT MUST BE STRENGTHENED

Many agencies have been working hard with people living in flood prone areas to cope with floods, but due to the limited funds, lack of competent personal, poor management, or coordination and commitment make these efforts not very efficient in reducing flood risk. Therefore, close coordination and cooperation between agencies working in flood management and mitigation and the communities in flood prone areas is needed. To achieve this some aspects need to be strengthened:

- agencies carrying out flood forecasting and early warning should focus more on products that are useful for day to day activities of the people living in flood prone areas so that they provide practical information to the public and vulnerable people. This means that these agencies have to consult regularly with communities to get to know what kind of information is useful for them;
- arrange regular meetings and workshops to share and exchange information, knowledge and experiences among community members and with centres;
- more involvement of communities in the preparation of preparedness programmes and providing them with appropriate training in order to help them with better understanding of flood related issues.

ACTIVITIES AND ISSUES WITH RESPECT TO THE THEME AND TOPICS OF THE 7TH FORUM

Theme: Integrated flood risk management in the Mekong River Basin

Topic I. Optimal packages for flood management

Efforts have been made through policies, strategies, plans and projects to cope with negative effects of flood, especially after extreme floods, which cause a lot of damage. The Royal Government of Cambodia through the Ministry of Water Resources and Meteorology prepared a National Water Resources Policy that was approved by the Council of Minister on 16 January 2004 and ratified by the National Assembly in June 2007. Key statements of the policies are:

- Phnom Penh and other localities where is a high concentration of people and/or economic assets will be fully protected against flooding;
- other urban or industrial centres with lesser concentration of people and assets will be provided with levels of protection which are economically justifiable;
- all people and institutions will be encouraged and enabled, by means such as education and demonstration of technology, to adopt flood mitigation measures appropriated to their circumstances;
- all public facilities will be constructed above the estimated 50-years flood level in the particular locality, and will be provided with unimpeded drainage;
- following the policy statement, there are many activities being implemented with respect to flood management and protection. However, only in the capital city of Phnom Penh there is a proper flood protection structure. Almost all towns have no proper structural works to protect them from floods, although there are some forms of structural measures in place (floodwalls), especially in towns along the Mekong River and some towns around the Great Lake, for flood protection. Those flood protection dykes usually have multiple uses, mainly for river bank protection, road, flood protection, irrigation, etc. and only very few of them are gated and properly operated. The Ministry of Water Resources

and Meteorology is the national leading agency dealing with these water issues;

- many efforts have been made, in terms of non-structural measures, by different institutions including non-governmental organizations, but there is a lack of coordination between the institutions concerned and an integrated approach is not widely applied.

Topic II. Recent developments in flood forecasting and early warning

The Department of Hydrology and River Works (DHRW) is responsible for hydrological data collection and forecasting in the country. The DHRW also cooperates with MRC-RFMMC in forecasting and dissemination of flood information. The DHRW uses a station correlation method to produce 3 days forecasting. The DHRW also exchanges data and information between countries in the Lower Mekong River Basin through MRCS by using the e-mail and internet systems. DHRW receives MRCs flood forecasting products by e-mail and also sent back to MRC-RFMMC its Flood Forecasting Bulletin by fax.

The Department of Meteorology is responsible for meteorological data collection and weather forecasting. Although weather forecasting is limited and concerns a simple description of weather and temperature conditions, based on information obtained from Internet, it also can serve as complementary information for flood forecasting.

The National Committee for Disaster Management (NCDM) currently has developed its network down from national level to commune level and from early 2007. This network uses forecast products of DHRW to do warning and dissemination of flood information to local communities. Provincial Committees for Disaster Management (PCDM), organize annual seminars to prepare the provincial preparedness plan before each flood season. Under the project to support the implementation of Flood Preparedness Program of MRC-RFMMC the provincial and district Committees for Disaster Management of the provinces along the Mekong River have developed provincial and district Flood Preparedness Programs.

Topic III. Effective approaches towards trans-boundary flood management

Located in the same river basin, Cambodia believes that action taken in one country, in terms of flood management and mitigation, somehow might have an impact to the neighbouring countries. In this respect, Cambodia has already been working with its neighbouring countries to find optimum ways for flood management to assure mutual benefits.

In its water policy, Cambodia respects fully international agreement, taking into account in the use and allocation of water during periods of water shortage in rivers, streams along the border of neighbouring countries. Cambodia also promotes bi-lateral and multi-lateral relations, agreements, MOUs and implementing machinery with neighbouring countries including exchange visits of Heads of Government, joint commissions and committees, local authorities meetings, and applications of Disaster Risk Reduction (DRR) mechanisms.

In this context, various joint working groups and committees, from national level down to local level, have already been established with Viet Nam. The main objective of these working groups and committees is to work together, and exchange of ideas, experiences as well as data and information.

Topic IV. Successful flood risk management approaches

To cope with great losses of infrastructure, property and life of the people, all relevant institutions have been working very hard to minimize the losses. There are several institutions dealing with flood management, both government and non-governmental organisations. Two main government institutions dealing with forecasting are the Department of Hydrology and River Works and the Department of Meteorology (DOM). Two other main institutions dealing with dissemination of flood forecasts and early warning, as well as with flood preparedness and response are the National Committee for Disaster Management (NCDM) and the Cambodia Red

Cross (CRC).

At the moment, the NCDM coordinates disaster related programs among which is CBDRM. As part of its strategy to institutionalize CBDRM, the NCDM works with various NGOs to establish disaster management committees at the provincial, district, commune and village levels in target provinces, building capacity of local authorities and communities through various training.

The Disaster Management Department of the CRC was established in 1994. With lessons from the flooding of 1996, the CRC piloted its Community-Based Disaster Preparedness Program (CBDP) in late 1998. The goal of the CBDP program is 'to reduce the impact of disasters on the most vulnerable people affected by disasters in Cambodia'.

The CRCs CBDP has the widest coverage in the country spanning 9 provinces, 23 districts, 94 communes and 317 villages. The current phase of the CBDP focuses on Kratie, Prey Veng, Pursat and Svar Rieng provinces. Activities in the filed include the development of Hazard Vulnerability Capacity Assessments (HVCA), Village Disaster Reduction Plans (VDRP) and implementation of disaster risk reduction (DRR) measures. At the moment, 27 villages have developed their HVCAs and there are plans to increase this number to 40 villages. A number of commune councils have committed to incorporating the VDRPs into their commune development plans (CDP) and more commune councils in the target provinces will be encouraged to do the same.

Currently in its inception stage, the Disaster Response Preparedness project aims to strengthen the capacity of the CRC to efficiently meet the basic needs of people and communities affected by disasters. This is a capacity building project for the CRC, looking at strengthening its internal structure and its coordination with its external partners by clarifying roles and responsibilities. The DRP will also be integrated into the CBDP activities across the country.

RECOMMENDED PRAGMATIC WORKING ARRANGEMENT BETWEEN NATIONAL CENRES AND THE MRC-RFMMC

- MRC-RFMMC is located in the same compound of the DHRW who is responsible for forecasting in the country. This provides a good opportunity to exchange regularly knowledge and information;
- MRC-RFMMC should help strengthening capability of national forecasting institutions, from data collection, processing to development of forecasting models;
- MRC-RFMMC should allocate funds for longer term data collection and provide technical support;
- MRC-RFMMC should help to install more hydrological stations to extend the coverage areas, so that they can cover also main tributaries;
- MRC-RFMMC should continue to help taking care of some other manual hydrological and meteorological systems as they will continue to be served as a back up.

OTHER NATIONAL SUGGESTIONS ON FLOOD FORECASTING AND EARLY WARNING AT MEDIUM-TERM

Institutions dealing with flood issues such as the Department of Hydrology and River Works and the Department of Meteorology, NCDM and non-governmental organizations, have been working very hard to reduce flood effects, but their capacity and resources limit them from performing effective tasks. Hydrological data and information for the mainstream of the Mekong River are somehow efficient to assess the annual flood from year to year, while in tributaries they are incomplete. In general financial resources for data collection and forecasting

are limited. In order to achieve better flood forecasting and early warning at medium-term the following aspects need to be considered:

- flood management and mitigation need to be well placed in modern planning and operation;
- there is a need to build capacity in flood management and mitigation at all levels from data collection, processing to model development and operation. Funds for these activities need to be allocated;
- tasks of all institutions and people concerned need to be clarified and coordination among them need to be promoted in order to avoid duplication of tasks and to encourage the sharing of data and information;
- awareness on basic flood risk reduction and mitigation measures and knowledge to use hydro-meteorological information have to be provided to communities in flood risk areas so that they can somehow help themselves to some extent to reduce flood risk;
- quantity, quality and timeliness of data need to be improved;
- little is known on flash flood behaviour due to lack of data and information on the concerned river basins. Therefore, building knowledge on flash floods and finding a mechanism, methodology and facilities for flash flood forecasting and preparedness must be encouraged. More hydrological stations need to be installed.

USEFUL REFERENCES, WEB SITES AND CONTACT ADDRESSES

Cambodia National Mekong Committee: #23, Mao Tse Tong Road, Phnom Penh, Cambodia. Tel: 855 23 216 514. Fax: 855 23 218 506. Email: cnmc@cnmc.gov.kh.

Department of Hydrology and River Works: #576, NR. 2, Sangkat Chak Angre, Khan Mean Chey, Phnom Penh, Cambodia. Tel/Fax: 855 23 425 645. Email: dhrw.cambodia@online.com.kh. Website: www.hydrologycambodia.50megs.com.

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National Committee for Disaster Management: Road No. 516, Sangkat Toul Sangker, Khan Russey Keo, Phnom Penh, Cambodia. Tel/Fax: 855 23 882 045.

LAO PDR'S COUNTRY FLOOD REPORT FOR 2008

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ABSTRACT

Flooding is the common disaster in Lao PDR. Many parts of the country are often subjected to flooding, both from the Mekong River and its tributaries. In 2008, extreme weather events were observed throughout the country as a result of the seasonal variation. Hailstorms and whirlwinds were observed during the transition period between February and May. The monsoonal heavy rainfalls resulted in flooding due to flash floods in Oudomxay, Luangprabang, and Vientiane provinces. Moreover, the Kammuri tropical storm, which passed through Lao PDR during August has caused flooding from the Mekong River to the urban areas of Vientiane Capital, Luangprabang, Borikhamxay, and Khammouan provinces. In the Vientiane capital in particular, a flood level was observed that was higher than the historical highest level of the Vientiane flooding in 1966. The total damage from the Mekong flooding was more than 474 billion kip (US$ 56 million).

With the severe damage from the flooding in Vientiane Capital in 2008, the Government of Lao PDR is planning to rehabilitate the hydrological and meteorological stations and increase the network coverage in favour of accurate flood forecasting and warning. Moreover, the current reorganization of the National Disaster Management Committee with the view to raise its political profile and strengthen the inter agency coordination mechanism will undoubtedly help to improve its performance effectiveness and result in better flood management and mitigation in Lao PDR in the near future.

INTRODUCTION

Lao PDR is a land locked country in the Southeast Asia Region, which is bordered by China, Myanmar, Thailand, Cambodia and Vietnam. The country was ranged at 130th place of the United Nations Human Development Index in 2007. During the past decade, the country has experienced high economic development growth, the Gross Domestic Product (GDP) per capita on average during the 5th Socio Economic Development Plan (2001 – 2005) was between 500 and 550 US$ with 6.2% growth rate. Lao PDR is predominantly rural, more than 80% of the population is in the rural area. Most of the population has relied on subsistence agricultural practice. The agriculture sector contributes more than 44% to the GDP, while the industry and services are around 30 and 26% respectively (United Nations Development Programme (UNDP), 2007).

The climate characteristics of Lao PDR are tropical monsoon with alternating wet and dry seasons. The dry season (northeast monsoon) affects from mid October to mid May when the atmospheric pressure is high. It is a dry period with low humidity and temperature, the temperature is lowest in December – January and highest in April. The rainy season (southwest monsoon) affects from mid May to mid October. It is a period of frequent and heavy rainfall with high humidity. Most of the heavy rainfall is concentrated from May to September. The drought period is short; 2 weeks of drought period are often experienced from the end of June to the beginning of July (Souvany, 2007).

The monthly distribution of the flow of the rivers in Lao PDR closely follows the rainfall

pattern: about 80% during the rainy season (May-October) and 20% in the dry season (November to April). For some rivers in the central and southern parts of the country (particularly Se Bang Fai, Se Bang Hieng and Se Done), the flow in the dry season is less: around 10 to 15% of the annual flow. Annual rainfall ranges from about 1,300 mm in the North to 3,700 mm in the South. The total annual flow of the Mekong's tributaries within the territory of Lao PDR is estimated at 270,000 MCM (million cubic metres), equivalent to 35% of the average annual flow of the whole Mekong River Basin (Mekong River Commission Secretariat (MRCS), 2004).

HYDRO - METEOROLOGICAL CONDITION

In 2008, extreme weather events were observed throughout the country, during the transition period between February and May, hailstorms and whirlwinds have occurred in Vientiane Capital. Flash floods were reported with significant damage in Oudomxay, Luangprabang, and Vientiane provinces. The severe flooding in the urban areas of Vientiane Capital, Luangprabang, Borikhamxay, and Khammouan provinces was a result of flooding from the Mekong mainstream. The locations of extreme weather events are shown in (Figure 1).

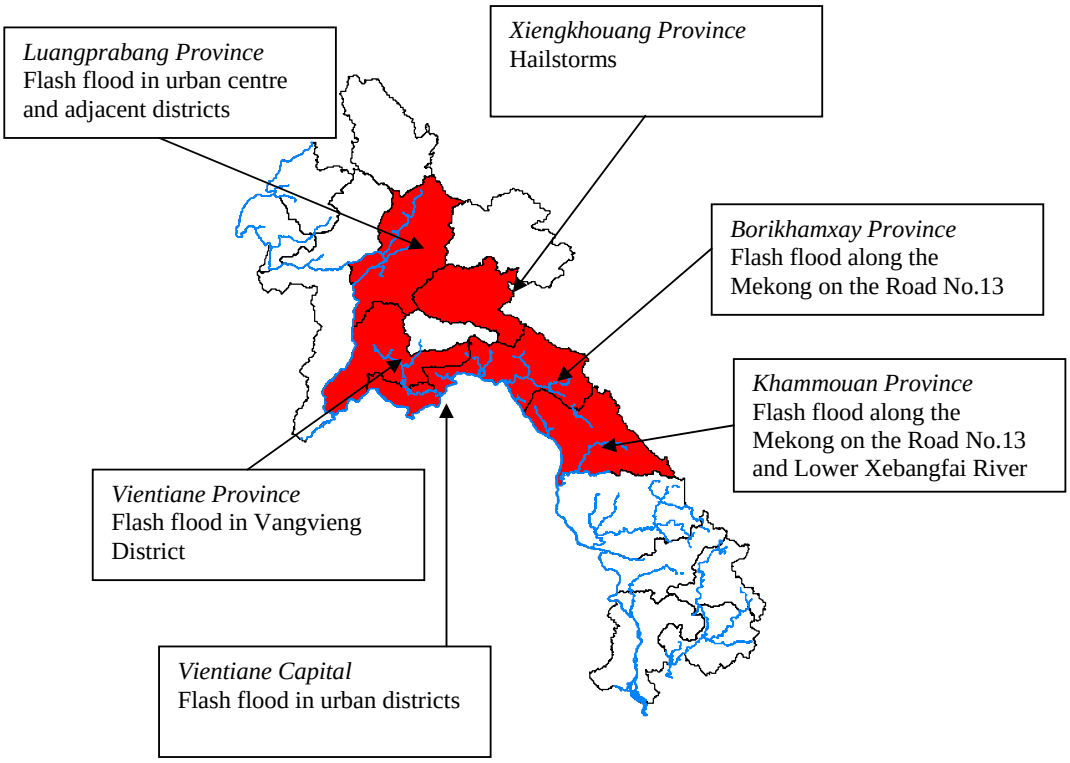


Figure 1. Provinces affected by extreme weather events in 2008

Hailstorms

During transition period, localized hailstorms were observed over the Sikhottabong, Chanthabouly and Sisattanak districts of Vientiane Capital at 15:30 hour and 17:30 – 18:00 hour on 17 March 2008 with 2 - 3 centimetres in size, similar hailstorms were also observed in Muang Kham District of Xieng Khuang Province and caused damage to people and properties.

Local storms

On 15 April a localized whirlwind was observed, which strongly moved southward through the KM 18 Dongxanghine Village, Saythany District of Vientiane Capital with wind speeds of 89 - 103 kph[1] causing structural damage to the building construction site of the Vientiane SEA GAME.

Flash flooding in Bolikhamxay Province caused by monsoon heavy rainfall during 17 – 20 June 2008

In the beginning of the rainy season, heavy rainfall could frequently be observed in the northern and middle parts of the country. The strong southwest monsoon was observed over the middle part of Lao PDR, particularly at Paksane Station where heavy rainfall was observed for more than five consecutively days. The absolute maximum daily heavy rainfall was recorded at 196 millimetres on 17 June and the total precipitation over the second 10 days of the month was recorded at 808 millimetres (Table 1).

Table.1. Daily rainfall (in millimetres) recorded for the period 11 - 20 June 2008 at Paksane Station, Bolikhamxay Province

Station	11/6	12/6	13/6	14/6	15/6	16 /6	17/6	18/6	19/6	20/6
Paksane	35.4	96.0	109.9	21.9	97.6	101.8	**196.2**	59.6	82.7	6.7
Total 11- 20 June	808 millimetres									

A large amount of precipitation caused flooding from the small river Hoeixayphay into the national road No.13. The flooding has spread over the road at Hoeixayphay and Phabath Phonsan villages over 500 metres length and 0.30 - 0.50 metres flood depth. For lowland areas adjacent to the road, the flood depth was measured between 0.60 - 0.80 metres. Although the flooding took a few days, the transportation between provinces was seriously affected.

Flash flooding in Vientiane Province by widespread monsoonal heavy rainfall during the period 17 – 22 July 2008

From 17 to 22 July 2008 a trough of low pressure with strong intensity was observed over the northern and middle parts of Lao PDR and associated with strong southwest monsoon over the country. The rainfall intensities in the middle of Nam Song and Nam Lik river basins from 17 to 19 July were recorded with a maximum daily precipitation in two days at 155 and 156 millimetres respectively, particularly at Vangvieng Dtation. The rainfall distribution over Vientiane Province is shown in Table 2.

Table 2. Daily rainfall (in millimetres) recorded in the period 16 - 25 July 2008 at different stations of Vientiane Province

STATION	16/7	17/7	18/7	19/7	20/7	21/7	22/7	23/7	24/7	25/7
Phonhong	18.0	25.8	39.2	13.1	-	33.3	14.8	1.8	0.5	2.8
Vangvieng *(Nam Song)*	-	71.5	**154.5**	**156.0**	53.0	17.7	49.2	21.0	62.6	17.1
Hinheup *(Nam Lik)*	1.5	16.9	21.9	31.3	6.3	-	0.5	-	1.4	9.7
Thalat *(Nam Ngum)*	-	-	16.5	22.5	9.5	-	-	-	11.5	5.0
Pakagnung *(Nam Ngum)*	-	18.5	22.5	27.5	8.0	-	13.0	13.5	5.5	32.5

Consequently the Nam Lik Sub-river at Hinheup Hydrometric Station raised over 5.20 metres in 24 hours on 18 July and the maximum water level recorded was 14.87 metres at 7:00

[1] this wind speed refers to the Beaufort number, when the trees uprooted that is indicated local storm

hour of 20 July 2008 (critical value is 14.00 m, danger level 15.00 m and altitude 179.26 m) (Figure 2). One day later at Pakagnung Hydrometric Station of Nam Ngnum River the maximum water level of 11.46 m, higher than the critical level for 0.44 metres (critical value is 11.00 m, danger level 12.00 m and altitude 159.53 m) and inundated the floodplain with a depth of more than 1.0 metre. The resulting flash flood inundated 70 villages and affected 2004 households in the Kasy, Vangvieng, Hinheup, Pheuang and Thoulakhom districts of Vientiane Province, landslides occurred at Kasy District by heavy rainfall, and four people were killed by flash floods and landslides.

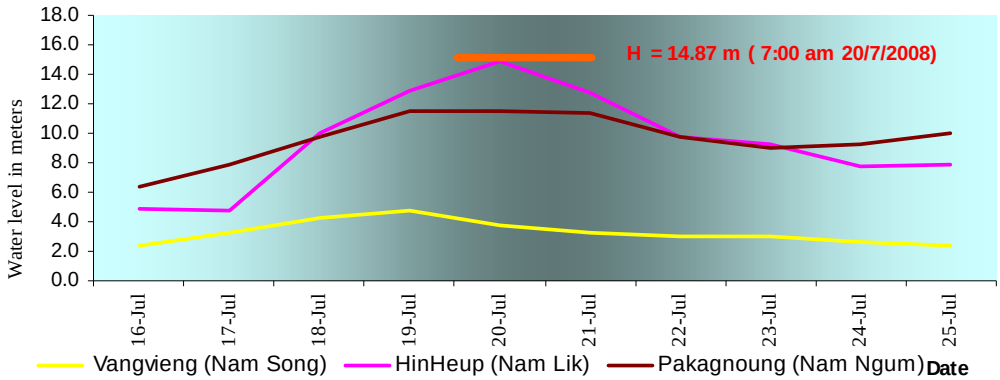
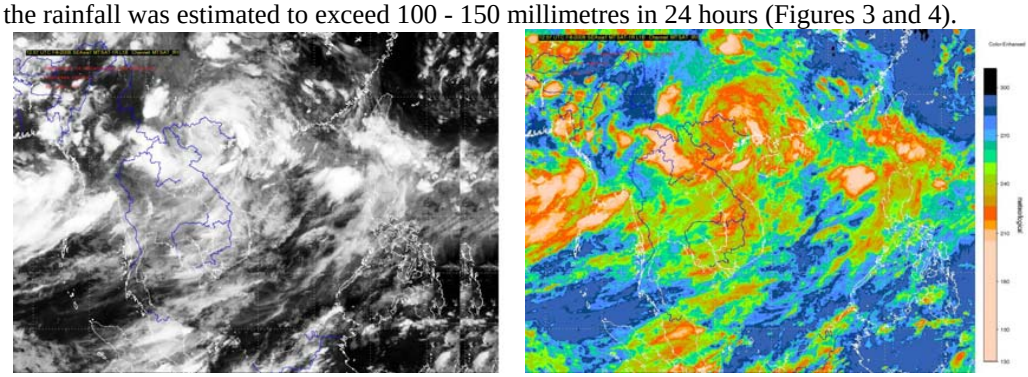


Figure 2. Hydrograph of sub-rivers Nam Song, Nam Lik and Nam Ngum during 16 - 25 July 2008

Flooding in urban cities along the Mekong River in Lao PDR caused by the tropical storm Kammuri (0809)

On 8 August, the tropical Storm Kammuri (0809) passed through the southern area of China. The spiral band of the tropical storm covered the northern and middle parts of Lao PDR. As a result, monsoonal heavy rains were observed over the upstream of Mekong River in Lao PDR, the rainfall was estimated to exceed 100 - 150 millimetres in 24 hours (Figures 3 and 4).



Figures 3 and 4. MTSAT–1R Infrared channel (3) and colour - enhanced image (4) of tropical storm Kammuri (0809) at 12:57 UTC on 7 August 2008

The water levels at the main hydrometric gauges in the north of Lao PDR rapidly increased from 11 August. Consequently, the inundation of the lowland areas of Bokeo Province started on 12 August. One day later water started flowing into low lying areas of Luangprabang and following inundation of the KaoLea, NongDa floodplain, Sikhottabong

District, Vientiane Capital. The maximum flood peak was observed 13.68 metres[2] at 7:00 hour on 14 August (Figure 5).

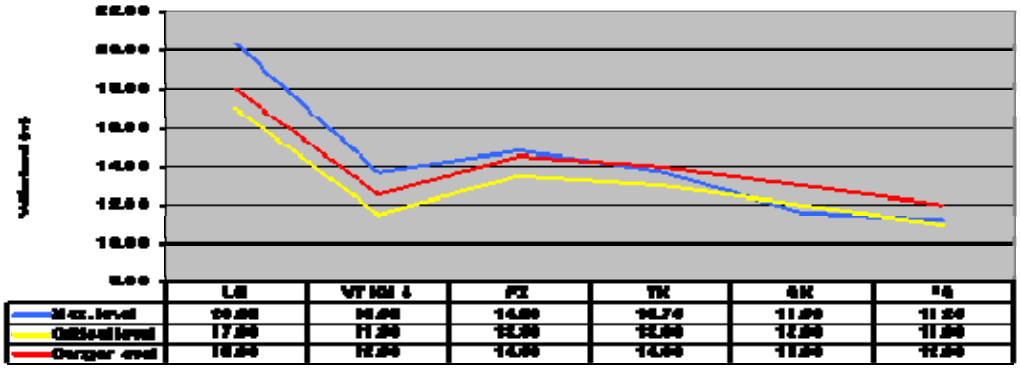


Figure 5. The annual flood peak at main stations along the Mekong River in 2008

Flash flooding in Oudomxay and Luangprabang provinces caused by Tropical storm HAGUPIT (0814) during 26 – 27 September 2008

Tropical storm Hagupit (0814) passed over the north-eastern Indochina in the early morning of 25 September, it downgraded into a tropical depression and moved through the northern part of Lao PDR. This tropical depression produced heavy rainfall over Oudomxay Province, with total daily rainfall recorded at 153 mm. Consequently, at 19:00 hour of 26 September, the water levels in the Nam Ko River at the Ban Cheung Station increased more than 5 metres within 8 hours[3]. The rapid increase in water level resulted in flash flooding, which inundated 3 districts of Odomxay Province (Xay, Namo and La districts) and 2 districts of Luangprabang Province (Nam Bak and Muangnoy districts**).**

IMPACTS OF FLOODING IN 2008

The flash flooding in the northern and central parts of Lao PDR during June, July and September affected over 11 districts, 90 villages, 2,487 households and 4 people died. Almost 2,250 hectares of rice and other crops were damaged, livestock was lost and damage to infrastructure was recorded.

In Luangprabang, Vientiane Capital, Bolikhamxay and Khammuane provinces, almost 664 villages and 32,610 households were affected. Three people died and almost 28,517 hectares of rice and other crops damaged, about 702 animals (buffalos, cows, pigs and goats) and 995 chicken were lost.

Significant damage and loss were directly related to the tropical storm Kammuri (0809) which passed through Southern area of China, while the spiral band of Kammuri covered the north-eastern part of Indochina. Monsoonal heavy rains were recorded on the 8th and 9th of the month over the upstream of Mekong River. They were estimated to have exceeded more than 100 mm in 24 hours. As a result of heavy rainfall, flooding water has intruded into the urban areas of Luangprabang, Vientiane Capital, Borikhamxay, Khammouane provinces**.** The Kammuri tropical storm has caused significant damage with more than 474 billion kip[4] to the four provinces, while the damage in Vientiane Capital accounts for 206 billion kip (Figure 6).

[2] The flood level was recorded at Km4 hydrometric station
[3] The water level at 19:00 hour 26 September recorded 2.18 metres, following 8.30 metres at 01:00 hour 27 September 2008
[4] 1 US$ = 8.450,00 Kip

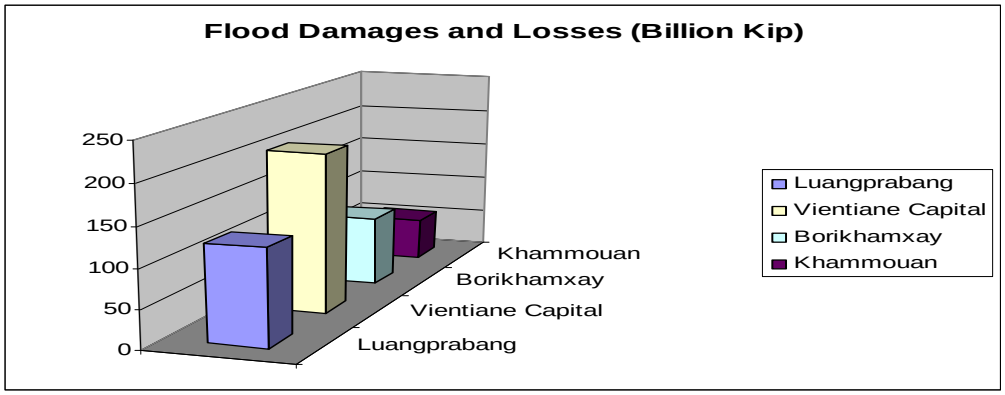


Figure 6. Flood damage per province caused by Kammuri tropical storm

Flooding is one of the major disasters in Lao PDR, which results in significant damage and loss to the national socio-economic development. During the past decade, twenty-seven 'major' floods have occurred in Lao PDR with an average reoccurrence of every 1.5 years, as per official statistics recorded for annual events during 1966-1999, floods and droughts are the most serious disasters for the country in terms of damage costs, with US$ 105 million damage caused by floods; US$ 598 million damage caused by droughts and for some years (1972, 1979, 1986, 1991, 1993 and 1997-1999) flood and drought damage assessed together amounting US$ 78 million, while the most severe damages from flooding in 2001, 2002, 2008 caused more than US$ 50 million damage each (Figure 7).

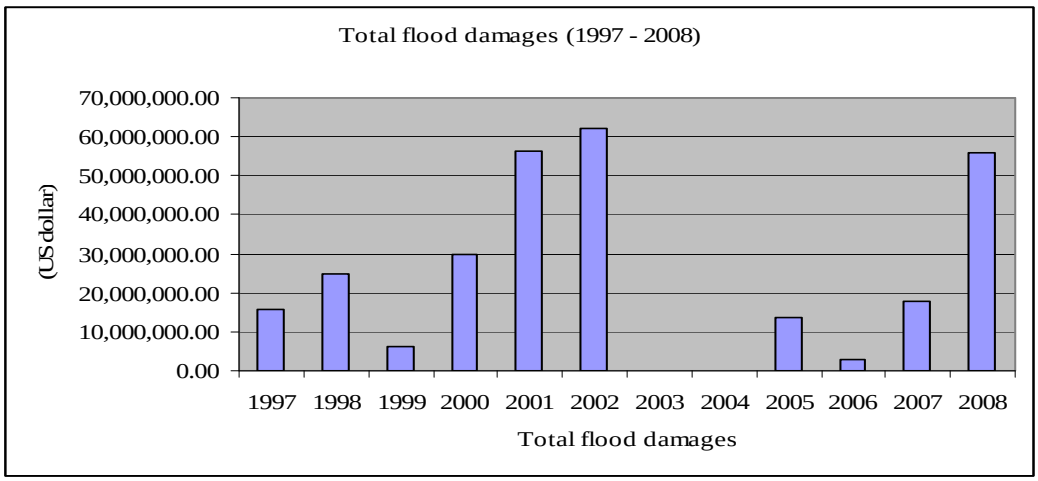


Figure 7. Flood damage per year

FLOOD MANAGEMENT AND MITIGATION MEASURES

Institutional arrangements

The Government of Lao PDR has regarded flood as one of the major disasters and considers the disaster management as an important issue that urgently needs to be properly managed, therefore, the National Disaster Management Committee (NDMC) was established, its secretariat, namely National Disaster Management Office (NDMO) was housed in the Department of Social Welfare under the Ministry of Labour and Social Welfare, according to its

mandate No. 158/PM dated 23 August 1999, the committee is chaired by the minister of labour and social welfare. The committee consists of the following agencies:

1	Minister of Labour and Social Welfare	Chairman
2	Minister of Agriculture and Forestry	Vice Chairman
3	Chief of Cabinet, Ministry of Foreign Affaires	Vice Chairman
4	Chief of Cabinet, Ministry of Defence	Member
5	Chief of Cabinet, Ministry of Security	Member
6	Chief of Cabinet, Ministry of Education	Member
7	Director General of Budget Department, Ministry of Finance	Member
8	Director General of Transport Department, Ministry of Public Works and Transport	Member
9	Director of Industry Department, Ministry of Industry and Commerce	Member
10	Director of Hygiene Department, Ministry of Public Health	Member
11	Director of Mass Media Department, Ministry of Information and Culture	Member
12	Director of Social Welfare Department, Ministry of Labour and Social Welfare	Member
13	Chairman of Lao Red Cross Society	Member

With the mandate to oversee disaster management, NDMO has closely coordinated with line agencies at central and provincial level, non-governmental organisations (NGO), and international organisations (IO) in implementing non-structural measures for disaster management. The 2003-2020 disaster management action frameworks have placed absolute emphasis on promotion of a Community Based Disaster Risk Reduction Approach. The Lao PDR has began to set up the disaster management committees at some provinces where flooding frequently occurs. The committee has focused its activities on flood preparedness at community level and flood relief.

With the view to improve the disaster management in Lao PDR, the government has currently reviewed the mandate of NDMC and NDMO and changes will be made to the structure and mandate of NDMC and NDMO. The NDMC will be chaired by the Deputy Prime Minister, and the Ministry of Planning and Investment. The Water Resources and Environment Administration (WREA), Ministry of Energy and Mines, Lao Women Union, and Lao Youth Union will become members of the NDMC, the mandate of NDMO will be strengthened, and an independent structure of NDMO is proposed.

Non-structural counter measures

Flood forecasting, warning, and dissemination

Under the Department of Meteorology and Hydrology (DMH), there are in total 50 stations, 17 stations are main synoptic surface stations, the rest are secondary synoptic stations (monthly data recording and rainfall observation only), there are 113 rain gauges. There are 119 staff gauge stations, 49 discharge measurement stations, and C-Band Doppler Radar[5] at DMH Headquarter and MTSAT-1R satellite receiving station (Souvany, 2007). The data from the stations are collected by the Provincial Meteorology and Hydrology Offices (PMHO) with the assistance from the local people who live close to the stations, the data will later be reported to the DMH in Vientiane Capital.

[5] The construction of C-Band Doppler Radar was funded by Japanese Government and completed in 2006

Flood forecasting

The Hydrological Division of the DMH receives real time data (water level and rainfall observed at 7:00 hour (00:00 UTC) from seven major stations at the mainstream (Pakbeng, Luangprabang, Vientiane, Paksane, Thakek, Savanakhet and Pakse) and main tributaries of Mekong River by high frequency/single slide band (HF/SSB) and telephone. Supplementary information real time data (water level and rainfall) observed at 7:00 hour (00:00 UTC) is collected by mail from two upstream stations of the Mekong River in China (Yanjinghon 92980 and Hana 92600).

Data exchange in the form of a mathematical model between DMH and the Mekong River Commission Secretariat (MRCS) has been done by email, and the DMH receives daily the MRC flood forecasting products. Additional real time rainfall, synoptic, climate data, weather situation and other information are received from the weather forecasting division of DMH, the flood forecasting in 2008 at the mainstream of Mekong River in Lao PDR still uses the method of stage correlation regression, between upstream and downstream water levels, with related a flood propagation time of 1 or 2 days. The necessary data are processed and analyzed based on Microsoft Excel, using the following formulas:

HVT, forecast = (HLB, yesterday – HLB, day before yesterday) * 0.35 + HVT, today
Where:
HVT = water level observed on 7:00 hour (local time) at hydrological station Vientiane Km4
HLB = water level observed on 7:00 hour (local time) at hydrological station Luangprabang

The preparation of daily flood bulletins is completed at 10:00 hour. The flood forecasting lead time is 48 hours (from 7:00 hour today to 7:00 hour the day after tomorrow) and updated daily. The flood forecasting concerns mainly water levels and the forecasting includes only six stations (Luangprabang, Vientiane, Paksane, Thakek, Savanakhet and Pakse). The capacity of providing flash flood forecasting at DMH is still limited.

With the recent flooding in Vientiane Capital and other major cities along the Mekong River during August 2008, the Government decided to improve and rehabilitate the stations along the Mekong River, especially, Luangprabang stations, so that the flood forecasting in Luangprabang and Vientiane Capital can be more accurate.

Flood warning and dissemination

The means for flood warning and dissemination have often been the communication equipments. The HF/SSB radio transceivers, public telephone, and facsimile are commonly used for the weather and flood forecasts and tropical cyclone warnings to the public. Moreover, the website of DMH has also been established in 2007, which can provide the weather and flood forecast information (see http://dmhlao.etllao.com/). The flood warning of DMH is divided into two stages (Table 3).

The flood forecasting, warning and dissemination are made by DMH through the Office of WREA, the Prime Minister's Office and to Provincial Governor Offices and later to concerned line agencies.

Flood preparedness, relief, and rehabilitation

Flood management and mitigation are important issues that need to receive attention, after a flood the degree of damage can vary from location to location. In most cases, the National Disaster Management Committee in coordination with the concerned line agencies at both central and local level is responsible for planning and implementation of flood preparedness, relief, and rehabilitation by mobilizing all available technical and financial means for flood

preparedness and relief. The disaster management committees will be set up at different levels (provincial, district, and village), their tasks include flood warning and preparation, relief assistance, damage assessment, and rehabilitation.

Table 3. Stages of flood warning by the Department of Meteorology and Hydrology (DMH)

Nearly warning	Urgent warning
In case the water level forecast at a station is expected to be at 0.50 m below warning level DMH has to provide the warning and timely delivering it to • mass media and Ministry of Agriculture and Forestry • Prime Minister's Office, Lao National Mekong Committee (LNMC) and NDMO • DMH makes an interview to mass media • DMH sends the warning information to Provincial Agriculture and Forestry Office (PAFO) and PMHO and to focus areas • the warning message is broadcasted through national and local radio stations during daily programme for disaster management	In case the water level exceeds the warning level. DMH has to provide an urgent warning to: • mass media and DMH makes an interview to the mass media • DMH reports to the Ministry of Agriculture and Forestry and later reports to the Prime Minister • Prime Minister's Office and LNMC • DMH sends the warning information to PAFO and PMHO and to focus areas • at the same time DMH sends urgent warning to NDMO • NDMO sends the urgent warning to Provincial Disaster Management Office and later to district office and focus areas • National radio stations will broadcast the warning massage through their program regularly

In the worst flooding case an ad hoc committee can be set up at the national level in order to gain political commitment and national support, e.g. for the flooding in Vientiane Capital during 11 – 16 August 2008, the national flood committee was set up and chaired by the Deputy Prime Minister. The committee set 3 goals for flood protection, these were: (1) protect the city from flooding; (2) minimize the losses of life and limb; (3) ensure the continuation of social economic activities. In doing so 58,333 people from central government agency, Vientiane Capital Authority, police, soldiers, and the residents were mobilized to protect the city from flooding. The major structural measures were removing the shelters and unauthorized constructions and buildings in the 17 km flood protection dike along the Mekong River in the city centre, the area where water intruded, pumps were installed to dry out the area, task forces were set up at the district level for emergency response and working 24 hours per day.

Structural counter measures

In the long-term, the permanent flood protection dikes and bank protection structures were planned in many parts of the country, mainly at the urban centres of the provinces located along the Mekong River, such as: Borkeo, Luangprabang, Vientiane Capital, Borikhamxay, Khammouan, Savanakhet, and Champasack, the construction of drainage channels was planned and implemented in the urban development projects, mainly, the Vientiane urban development project and the secondary towns development project (Luangprabang, Khammouan, Savanakhet, and Champasack). In the short-term or the emergency response, the sand bag - flood protection dike and drainage channel dredging were implemented.

LESSONS LEARNT

The damage caused by the flooding in 2008 can be considered as a natural phenomenon which is inevitable. However, some lessons need to pay more attention to better flood management and mitigation. They are as follows:

- the flooding in Vientiane Capital in 2008 was severe and exceeded the historical highest record of 1966, which initiated the improvement of the flood forecasting and warning system;
- the timely flood forecasting and dissemination provided by the Department of Meteorology and Hydrology is helpful for making arrangements and preparing measures by each level of Government Line Agencies in Lao PDR;
- improvements of data collection coverage are particularly needed over the north of Luangprabang in Lao PDR in favour of accurate flood forecasting along the Mekong River;
- awareness on meteorological/hydrological information to users and disaster prevention to flood risk communities need to be improved;
- strong political commitment is very crucial for successful large-scale flood preparedness;
- unplanned urban development and spontaneous settlements escalate the flood damages and losses;
- there is no standard format for assessing flood damages in Lao PDR, which could result in the misuse of the resources for flood management and mitigation.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

During the year 2008, the impact of flooding was much higher than the damage in 2007[6], the flooding has resulted in more damage and losses, especially, the flooding in August caused by the flooding from Mekong mainstream to the urban centres of the provinces located along the Mekong River, such as Luangprabang, Vientiane Capital, Borikhamxay, Khammouan provinces, the Vientiane Capital in particular, the flood level was observed at 13.68 metres against the historical highest level of 12.66 metres of the Vientiane flooding in 1966, the total damage from the Mekong flooding in 2008 was more than 474 billion kip or US$ 56 million.

With regard to the flood management and mitigation, the Department of Meteorology and Hydrology still plays a crucial role in flood preparedness activities by allowing the national, provincial and local authorities be informed with 48 hours lead time for flood forecasting and warning, the Disaster Management Committee is set up to provide better coordination at provincial and district level for better flood preparedness and responses. The committees provide support to the people for flood preparedness, rehabilitation, and relief. Currently, the Lao PDR is reviewing the institutional arrangements for disaster management, which is expected to increase the profile of the responsible agency and improve the framework for the disaster management.

The flooding in Vientiane Capital in 2008 has demonstrated the workable approach for large-scale flood management, with strong government commitment and public participation and ownership. The national ad hoc committee for Vientiane flood protection was set up chaired by the Deputy Prime Minister, all relevant ministries were called for technical and labour input, the local residents, government staffs, employees, police and soldiers, etc. were jointly protecting the city by building the sand bags dike along the Mekong River in the urban areas, despite the serous damages from Vientiane Capital flooding, the event has raised awareness among the Lao PDR government agencies to improve the flood forecasting and warning system by rehabilitating the hydro-met stations and increasing the network coverage throughout the country in the coming year.

[6] For more detail see Virana (2007)

Recommendations

A standard format for assessing flood damages and losses need to be developed both for assessing direct and indirect damage in favour of better flood management and mitigation.

The community based flood risk management should be strengthened. The community self reliance for flood management and mitigation has proven to be effective. The disaster management committee should focus on building capacity of the local community in flood preparedness and emergency responses.

In order to improve the flood forecasting and warning, the review of hydromet network coverage is needed to ensure sufficient data input for forecasting analysis.

Urban development should consider the flood implication and the spontaneous settlement should be controlled.

The MRC Flood Management and Mitigation Programme should consider orienting its activities to benefit the local level by providing a supportive role in building the capacity of local authority and community in flood management and mitigation.

The MRC flood forecasting and dissemination should focus on establishing the link with the national flood forecasting agency, so that the MRCS as the knowledge based river basin organization can provide its products to benefit the flood forecasting at the national level.

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THAILAND COUNTRY FLOOD REPORT FOR 2008

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ABSTRACT

In 2008, Thailand's flood situation almost only resulted from tropical storms that occurred due to low pressure and moved towards the North-East through the North of Thailand. This effect caused rainfall in many areas and prolonged heavy rain in some areas. Therefore, floods occurred such as flooding in low-lying areas and flash floods in mountainous areas. For example, in August there was heavy rainfall from 11 to 31 August and with overbank flow due to high water levels in the Mekong River. It has caused troubles to the people along the Mekong River and sub-basins in Thailand., from 30 September to 1 October, it has been 'Mekkhala', a tropical storm in Thailand and from 19 to 20 November, it has been a tropical storm named 'Noul'. The calamity of flood brought suffering in 65 provinces for 4,494,189 people of 1,197,253 households. These disasters caused about 67 casualties (in October about 32 people), destroyed about 18,300 houses in communities and an agriculture area of about 4,840 km^2. The cost of damage was US$ 72 million, especially in December was damaged about US$ 28 million, about 39% of total cost of damage in 2008. To respond to the flood damage, Royal Thai Government set some Policy Statements of the Council of Ministers against the flood disasters by implementing a flood management plan such as to develop and install early warning systems in mountainous areas, to set telemetry in low-lying flood prone areas, set up a closed circuit television (CCTV) and install water level staff gauges to check, look out, and follow flood events. Moreover, the government attempts to set a Water Act by the National Water Resources Committee, set up River Basin Committees in 29 basins, which are key organisations in water management in each river basin. The Ministry of Natural Resources and Environment (by the Department of Water Resources) has submitted a letter to the Secretariat of the Cabinet confirming that the draft Water Act has been reconsidered according to comments of involved governmental agencies and committee bodies and to present the draft Water Act to the Cabinet for approval.

GENERAL SITUATION

Thailand is influenced by two types of monsoon, i.e. the southwest monsoon and the northeast monsoon, which cause changes in the climatic seasons in Thailand. The southwest monsoon covers Thailand from mid May to October and carries mass humid air from the Indian Ocean to Thailand causing widespread rainfalls. After the southwest monsoon, the northeast monsoon starts from mid October and lasts until February. The mass dry cool air from Mongolia and China will blow and cover Thailand in upper north and northeast regions but will cause heavy rain in the South while the monsoon will carry moisture from the Gulf of Thailand.

According to the monthly rainfall during 1978-2007 in Thailand, the average annual rainfall was 1,581 mm, which is an average between 800-4,400 mm.

The average runoff in Thailand was 213,800 MCM (million cubic metres) and can be divided in 9,400 MCM (4.4%) flow to Salawin River, 65,000 MCM (30.4%) flow to Mekong River, 22,400 MCM (10.5%) flow to The Andaman Sea, and 117,000 MCM (54.7%) flow to the Gulf of Thailand and the specific runoff in Thailand is between 2.74-37.5 $l/s/km^2$.

WATER RESOURCES SITUATION IN 2008

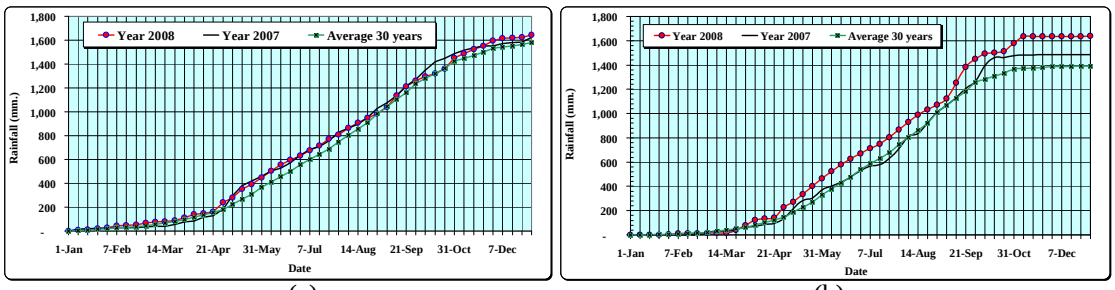
The collection of meteorological and hydrological data is done by many line agencies, e.g. Thai Meteorological Department, Department of Water Resources and Royal Irrigation Department as follows.

Climate

According to the climate data in 2008 from the Thai Meteorological Department, the variables of climate were considered including, humidity, cloudyness and evaporation. With the average of climate data it was found that Thailand has an average temperature of 27.0 ^{o}C, 76.4% of humidity, 1,622 mm of evaporation, 6.1 Octa of cloudyness, and 2.4 knots of wind. For the North-East of Thailand (Mekong, Chi and Mun river basin), the average temperature was 25.7 ^{o}C, 73.3% of humidity, 1,549 mm of evaporation, 5.4 Octa of cloudyness, and 1.6 knots of wind respectively.

Rainfall

In 2008, the cumulative rainfall was 1,643 mm, which was 62 mm more than the average cumulative rainfall of 30 years period and 20 mm more than the cumulative rainfall in 2007 (the cumulative rainfall in 2007 was 1,623 mm). In the North-East of Thailand there were 1,638 mm of cumulative rainfall, which was 248 mm more than the average cumulative rainfall of 30 years period and 154 mm more than the cumulative rainfall in 2007 (the average cumulative rainfall of 30 years period in the North-East of Thailand was 1,390 mm). The cumulative rainfall and isohyets can be shown in Figures 1 and 2.



(a) (b)

Figure 1. Comparison of cumulative rainfall in Thailand (a) and the North-East of Thailand (b)

The distribution of monthly rainfall in 2008 was close to the distribution of average monthly rainfall of 30 years period, except in September and November it was higher than the distribution of average monthly rainfall of 30 years period by 24 and 36 mm respectively. The distribution of monthly rainfall in 2008 is shown in Figure 3a.

For the North-East of Thailand it was found that the distribution of monthly rainfall in September and November was higher than the distribution of average monthly rainfall of 30 years period by 131 and 37 mm respectively, which was the cause of flood problems in the North-East of Thailand as shown in Figure 3b.

Water level in the North-East of Thailand

In 2008, the water levels were observed in the Mekong, Chi and Mun rivers in the key index stations E.23 Muang Chaiyaphum (Chi River), E.16A Muang Khon Kaen (Chi River), E.8A Muang Mahasarakham (Chi River), Kh.97 Chiang Khan Loei (Mekong River), Kh.1 Muang Nong Khai (Mekong River), Kh.16B Muang Nakhon Phanom (Mekong River), Kh.104 Muang

Mukdahan (Mekong River), M.6A Satuk Buriram (Mun River), M.5 Rasisalai Sisaket (Mun River) and M.7 Muang Ubon Ratchathani (Mun River) respectively. The water situation showed that the water level in the Chi River started to flow overbank in the middle of September, Mun River started to flow overbank by the end of September to November, and the Mekong River started to flow overbank in the middle of August as shown in Figure 4.

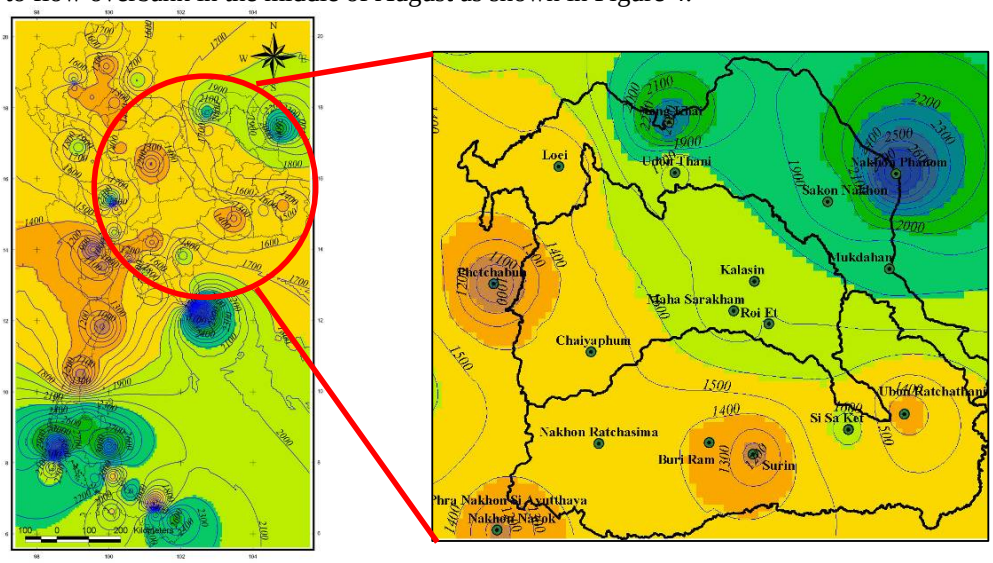
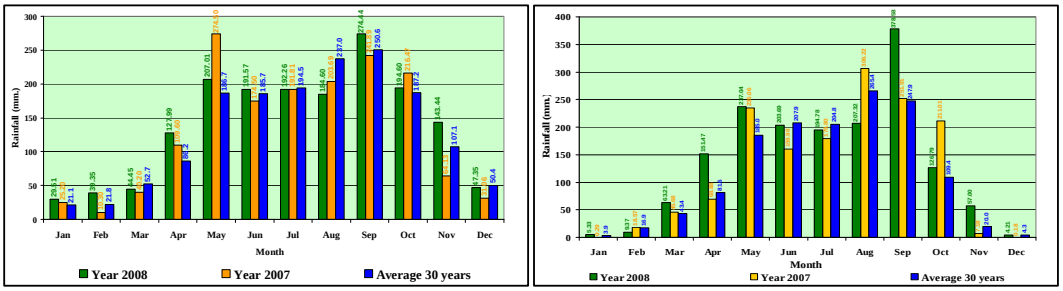


Figure 2. Isohyets of Thailand and the North-East of Thailand in 2008



(a) (b)

Figure 3. Distribution of monthly rainfall in 2008 in Thailand (a) and the North-East of Thailand (b)

SIGNIFICANT FLOOD EVENTS 2008

As for the frequent flood problems from the past until now floods took many lives and destroyed properties. The floods tend to become worse in the future. Because Thailand is located in a monsoon area the problems have been prevented and resolved by development of the hydraulic structures, increase in the efficiency of drainage of the water from the floodplain and such. During the past 30 years Thailand has faced flood problems up to 10 times in almost every province and there were 6 times more violent floods in 1975, 1983, 1995, 2002, 2005, and 2006. The flood occurrence in 2008 can be briefly described as follows.

Significant flood events in May to July

From May to July, Thailand was influenced by a tropical storm that occurred by low pressure moving toward the North-East through the north of Thailand and with southwest monsoon

movement towards the Andaman Sea and the Gulf of Thailand. This caused heavy rainfall in many areas and caused flooding and flash floods. There were 22 provinces, 152 districts, 759 sub-districts and 4,600 villages affected. Especially in the North-East of Thailand it were 5 provinces, namely Nakhon Ratchasima, Nong Khai, Udon Thani, Khon Kaen, and Chaiyaphum, that were suffering.

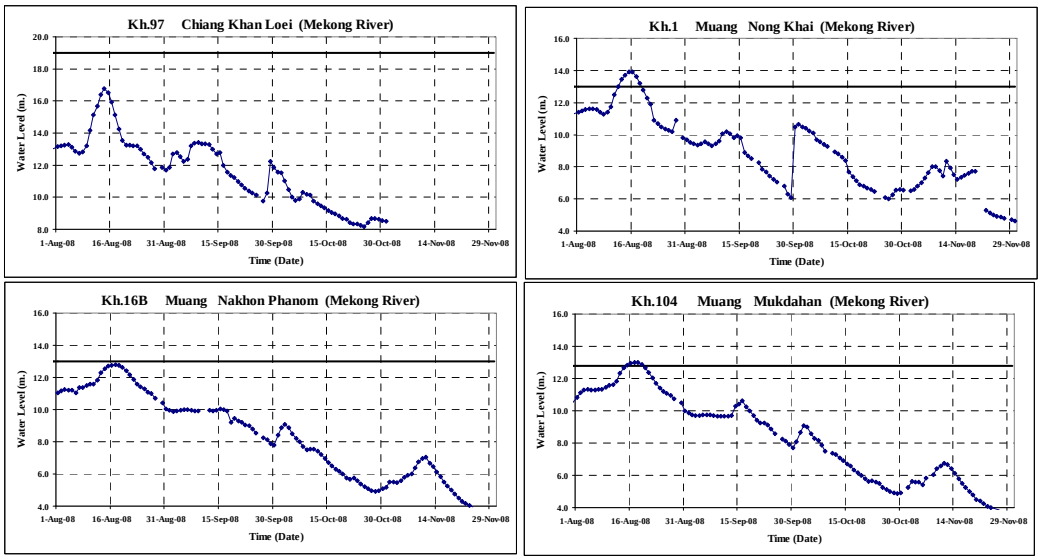


Figure 4. Water level at Mekong River

Significant flood events in August

As there was heavy rain between 11 and 31 August it resulted in bank overflow of Mekong River. It has caused trouble to the people along the Mekong River and sub-basins in Thailand. The calamity of flood brought suffering in 7 provinces, 48 districts, 298 sub-districts and 2,310 villages. It concerned Nan, Chiang Rai, Nakhon Phanom, Sakon Nakhon, Nong Khai, Mukdahan, and Phetchabun provinces. Due to this 6 people were dead (2 people from Nakhon Phanom and 4 from Nong Khai).

In Nakhon Phanom, due to heavy rainfall on 11 August (270 mm), there was bank overflow of Mekong River. This catastrophic flood brought suffering in 5 districts: Tha Uthen, Na Thom, Si Songkhram, Ban Phaeng and Phon Sawan. Flood occurrence in Nakhon Phanom is shown in Figure 5.

Figure 5. Flood occurrence in Nakhon Phanom Province (August 2008)

Significant flood events in September

The significant flood events in September came from the influence of ‘Mekkhala’, a tropical storm from 30 September to 1 October. This event caused heavy rain in the Northeast and the

lower part of Northern Thailand. Mekkhala can be seen by the weather chart and satellite image as shown in Figure 6.

There were 22 provinces that faced flooding, i.e. Phichit, Phitsanulok, Sukhothai, Tak, Phetchabun, Nakhon Sawan, Lop Buri, Saraburi, Loei, Khon Kaen, Nong Bue Lumphu, Ubon Ratchathani, Yasothon, Buri Ram, Si Sa Ket, Surin, Maha Sarakham, Nakhon Nayok, Prachin Buri, Sa Keaw, Chachoengsao, Chon Buri, and Trat. There were 26 people dead and 1 person missing.

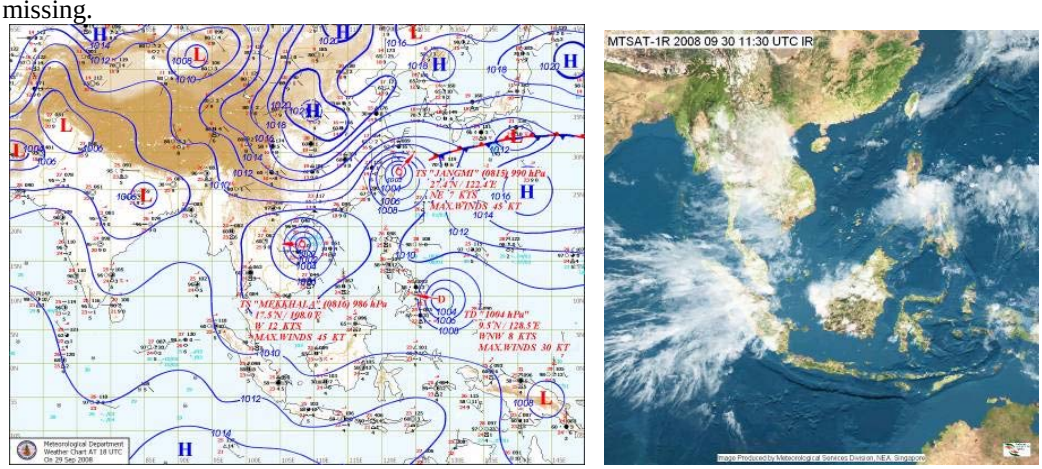


Figure 6. Weather chart and satellite image during tropical storm 'Mekkhala'

The flooding in Lop Buri, from 11 to 16 September, was due to heavy rainfall of about 149 mm on 11 September, which caused flash floods and damage of properties and agriculture areas in 10 districts. There were 3 people dead.

The flooding in Khon Kaen, from 13 to 17 September was due to heavy rainfall of about 158 mm on 17 September, which caused flooding and damage of properties and agriculture areas, were the flood depth was 0.2-0.3 m in 23 districts. There were 2 people dead. A flood occurrence is shown in Figure 7.

Figure 7. Flood occurrences in Khon Kaen Province (September 2008)

Significant flood events in October

The cause of the flood between 25 and 27 October was heavy rainfall in West Thailand, which resulted in flash floods in Tak, Uthai Thani, and Ratchaburi provinces. There were 32 people dead and 1 person missing.

On 26 October in Tak Province a flash flood occurred in Khlong Wang Chao National Park, which is bordered by Kamphaeng Phet and Tak provinces. Due to this the Khlong Wang Chao Bridge was destroyed. There were 7 tourists trapped in Khlong Wang Chao National Park.

Significant flood events in November to December

The flood in November to December came from tropical storm 'Noul' during 19 and 20 November. It occurred because heavy rainfall prolonged in South Thailand as shown in the weather chart and satellite image in Figure 8. It caused flooding in 10 provinces and 30 people were dead. In Nakhon Si Thammarat and Surat Thani provinces, there was 254 mm of heavy rainfall on 19 November and 240 mm on 20 November.

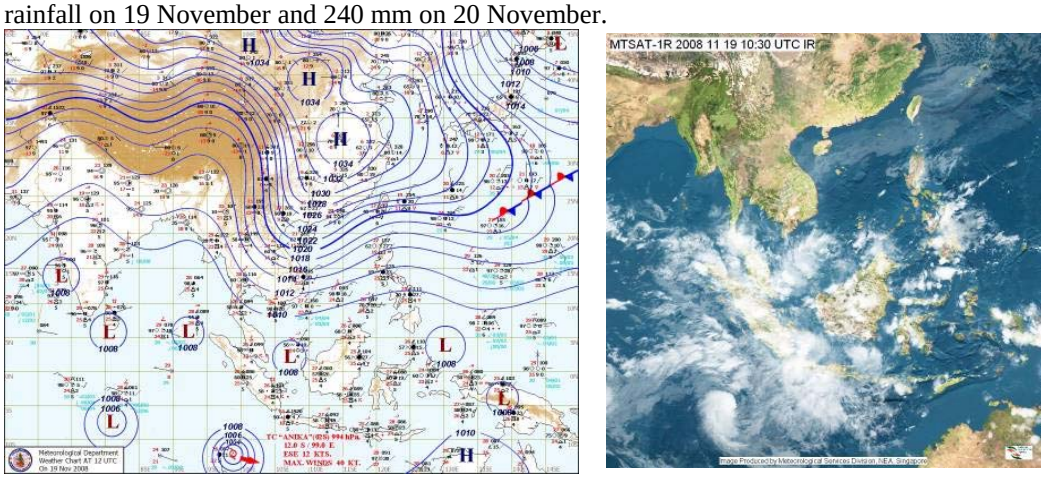


Figure 8. Weather chart and satellite image during tropical storm 'Noul'

Thailand's flood situation data for each month in 2008 and satellite images given by Geo-informatics and Space Technology Development Agency (GISTDA) show that there was flooding in 65 provinces and 584 districts. Figure 9, shows the flooded areas in Thailand and i the North-East of Thailand.

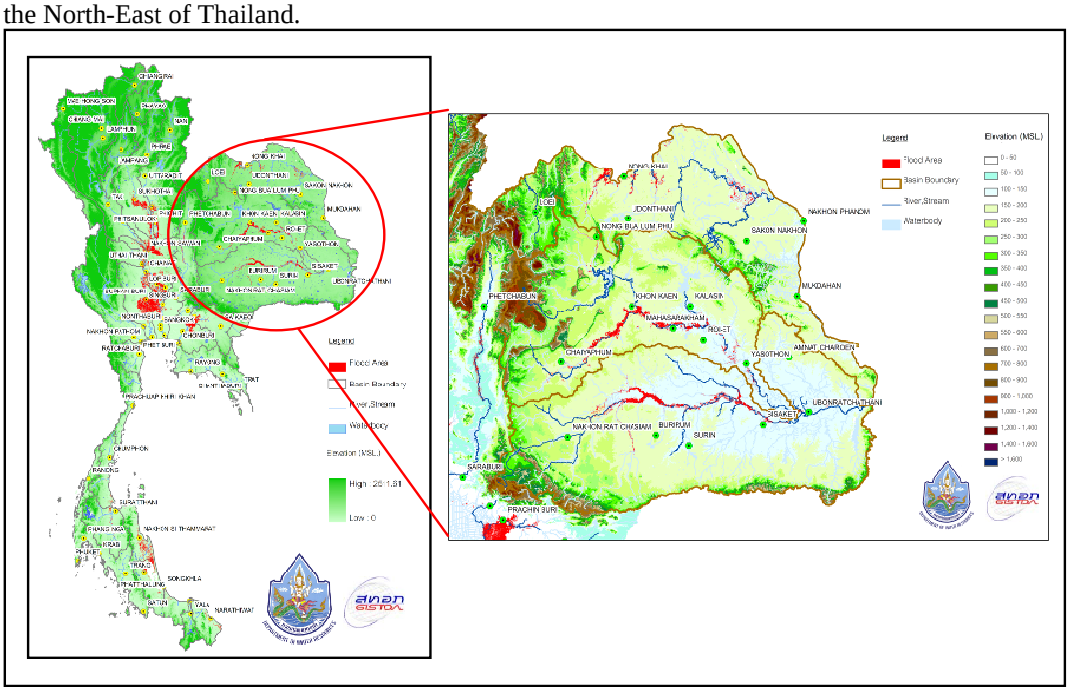


Figure 9. Thailand and the North-East of Thailand flood map in 2008

THE 2008 BASIC AID TO THE PEOPLE FROM FLOOD EVENTS

At the occurrence of floods in 2008 there was aid from many institutes such as the Rajaprajanugroh Foundation Under Royal Patronage, the Thai Red Cross Society, Department of Disaster Prevention and Mitigation, Thailand Local Administration Network, Royal Irrigation Department, Royal Thai Army, Department of Water Resources, etc. Not only the government sector; there were also many private sectors helping with donations to those people who were the victim of disasters from floods. The basic aids are summarized in Table 1 and the picture in Figure 10.

Table 1. The 2008 basic aid to the people suffering from flood events

Type	Month								
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Pump	17	112	110	33	77	-	393	-	742
preserve bag	1,500	-	-	4,150	113,000	19,500	39,200	3,000	181,000
Boat	-	-	-	4	6	130	-	-	140
Medicament	-	-	-	9,000	35,500	-	-	-	44,500
Truck	-	-	-	3	-	-	-	-	3
Back hole	-	-	-	-	2	-	-	-	2
Sand bag	-	-	-	-	2,740,000	-	-	-	2,740,000

Source: Department of Disaster Prevention and Mitigation.

Figure 10. The 2008 basic aid to the people suffering from flood events

IMPACTS OF FLOODING IN 2008

In 2008, the calamity of flood brought suffering in 65 provinces, 4,494,189 people of 1,197,253 households. This disaster caused about 67 casualties (in October about 32 people). Various assets were destroyed such as houses in communities, about 18,300 houses, 42,400 fish ponds, livestock and poultries 505,000, and agriculture area about 4,840 km^2. Moreover the flood situation had effect to many infrastructures such as 12,100 roads, 573 bridges, 561 drainage systems, and 197 buildings, including official buildings, schools, and temples. The cost of damage was US$ 72 million, especially in December was damaged about US$ 28 million, about 39% of total cost of damage in 2008. Flood damage assessment in 2008 is shown in Table 2 and comparison with impacts from disasters in (2003 -2008) is shown in Table 3.

From the 2008 flood damage data, which are compared with the previous 6 years (2003-2008) it is found that the flood damage in 2008 was more than in 2007. For example, the cost of damage in 2008 was about US$ 23 million more than 2007 and the number of provinces in 2008 was 19 provinces more than 2007. This was caused by Mekkhala a tropical storm during September and October and heavy rainfall in the South of Thailand in December. As shown in

Figure 11; comparing in number of provinces, people, and infrastructure affected and cost of damage.

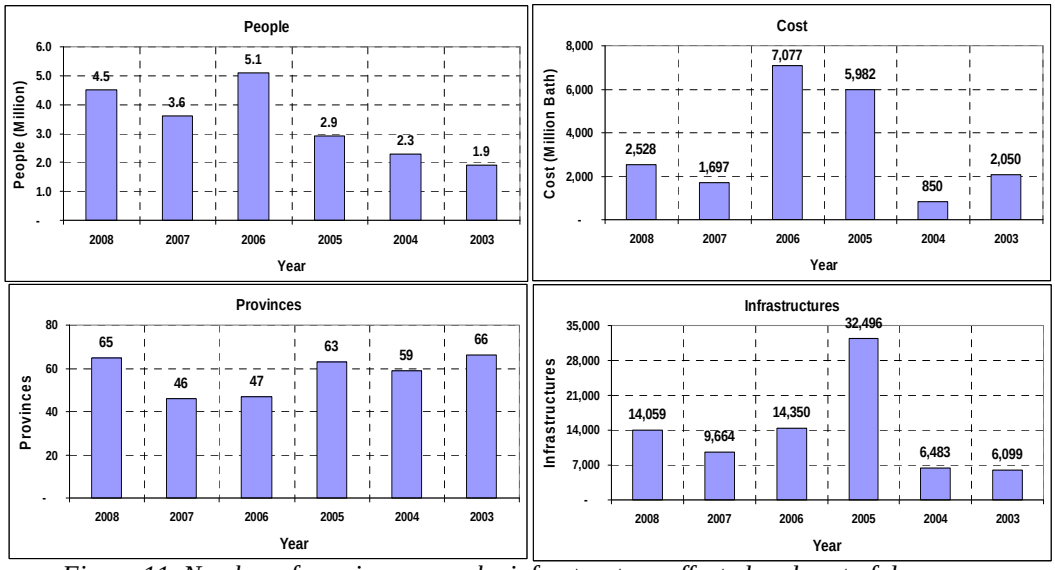


Figure 11. Number of provinces, people, infrastructure affected and cost of damage

RESPONSES TO FLOOD EVENTS IN THAILAND

The Policy Statement of the Council of Ministers delivered by the Prime Minister, H.E. Mr. Abhisit Vejjajiva, on 29 December 2008, about the Policy on Land, Natural Resources, and the Environment that relates to water resources management, is as follows:

- protect and conserve forest, wildlife, geological resources, water resources, mineral resources, marine and coastal resources, as well as, rehabilitate marine reservations systematically; expedite land demarcation by making clear distinction between public and private land; expedite the declaration of protected forest, determine areas for and promote reforestation, community forest; build stream check dams in accordance with His Majesty's initiatives; promote the cultivation of commercial forest in appropriate areas, suppress deforestation; encourage the planting of vetiver grass to prevent soil erosion; reduce chemical usage and rehabilitate soil, as well as, set up water management systems, for surface and underground water to meet the economic demand and consumption;
- put in place preventive measures, such as early warning systems to help alleviate victims of natural disasters by utilizing geo-informatics to locate and warn areas with high risk; develop a database and install early warning systems by setting up basic infrastructure in areas of high risk prone to the effects of global warming such as floods, land or mud slides, drought, earthquakes or tsunamis, particularly in important tourist destinations.

Development of surveillance, monitoring, forecasting and early warning systems

The Department of Water Resources has been implementing monitoring, forecasting and early warning systems, which are consistent with the Policy Statement of the Council of Ministers.

Table 2. Flood damage assessment in year 2008

Description		May	June	July	August	September	October	November	December	Total
Area	Provinces	8	5	9	7	23	3	5	5	65
	Districts	32	27	93	48	246	37	34	67	584
	Villages	518	906	3,176	2,310	12,092	3,218	203	451	22,874
Human	People	143,172	182,312	1,053,907	438,152	1,597,371	153,671	160,917	764,685	4,494,187
	Households	28,208	44,116	265,459	100,576	454,304	243,153	56,975	4,462	1,197,253
	Casualties	-	-	-	6	26	32	3	30	97
Assets	House	195	55	133	3,824	2,712	6,779	98	4,462	18,258
	Fish ponds	120	384	820	2,373	13,073	-	298	25,356	42,424
	Live stock	-	825	11,263	249,679	2,994	-	39,471	200,505	504,737
	Agriculture field (sq.km.)	481	211	59	794	875	1,030	391	992	4,837
Infrastructure	Roads	458	198	1,294	1,049	3,404	1,364	1,151	3,215	12,133
	Bridges	19	9	104	58	98	15	87	183	573
	Hydraulic structures	18	32	176	118	251	-	-	-	595
	Institute buildings	-	-	-	132	65	-	-	-	197
	Drains	83	-	112	309	57	-	-	-	561
Cost million US$.		5	2	4	7	16	6	5	28	72

Source: Department of Disaster Prevention and Mitigation.

Table 3. Comparison of impacts from disasters in 2003 – 2008

Descriptions		2008	2007	2006	2005	2004	2003
Areas	Provinces	65	46	47	63	59	66
	Districts	584	486	482	541	337	349
	Villages	22,874	20,499	20625	10326	9,964	5,281
Human	People	4,494,187	3,640,978	5,198,814	2,874,673	2,324,441	1,882,017
	Households	1,197,253	940,663	1,430,085	763,847	619,797	485,436
	Casualties	97	62	340	88	31	54
Assets	House	18,258	7,369	49,611	6,040	5,947	10,329
	Fish ponds	42,424	34,767	125,683	13,664	12,884	22,339
	Live stock	504,737	38,079	142,211	696,123	71,889	301,343
	Agriculture field (Sq.km.)	4,837	4,233	8,968	2,722	5,277	2,552
Infrastructures	Roads	12,133	8,330	10,391	5,697	4,173	5,071
	Bridges	573	309	671	667	173	393
	Hydraulic structures	595	591	778	22,527	716	179
	Institute buildings	197	271	1,425	2,123	827	174
	Drains	561	163	1,085	1,482	594	282
Cost million US$.		72	48	202	170	24	58

Source Department of Disaster Prevention and Mitigation.

Water crisis prevention and solution by installation of early warning systems for flood and land slide prone sites at mountainous slope areas.

The Department of Water Resources under the Ministry of Natural Resources and Environment has been approved by Cabinet to install the early warning systems in the flood and land slide risk areas at the mountainous slope villages all over the country covering 2,300 villages. The priority for installation is considered by the risk level:

- *benefits obtained from the early warning system:*
  - allowing people to be aware of the disaster in advance so that they can be prepared for prevention and evacuation prior to the occurrence of the disaster;
  - reducing damages that might occur to life and properties of the people;
  - raising understanding and participation of people on early warning, which contributes to timely saving of their lives and assets;
- *accomplishment:*
  - in the fiscal year 2008, the implementation covers risky areas in 134 villages;
  - in the fiscal year 2009 the implementation covers risky areas in 232 villages;
  - during year 2010-2012 implementation will cover risky areas in 1,540 villages.

Establishment of Water Operation Centre (Mekhala Centre)

The Department of Water Resources has established the Water Operation Centre (Mekhala Centre) as the centre for monitoring, data accumulation and data processing regarding water resources, management of GIS and meteorological and hydrological data in the water crisis areas. The Mekhala Centre allows the officials involved to be aware and understand the water situation in advance in order to be prepared for giving any suggestions, solving problems, coordinating with agencies concerned to mitigate disasters caused by water crisis. It is also assisted in efficient management and control damages from disasters.

The main target for establishment of the Mekhala Centre is to step out in advance together with the national economy and to upgrade communities' quality of life with the standard quality for overall water crisis management to decrease water problems or obstacles to the least as much as possible.

As mentioned previously in 2008, Mekhala Centre has improved its efficiency of monitoring the water situation by installation of closed circuit television (CCTV) systems. There are procedures as well as procurement and installation of equipments as follows:

- the installation of broadcast and image signal transfer by installation of closed circuit television (CCTV) and water level staff gauges in flood risk areas for check, look out, and following act with flood events;
- installation of 23 CCTV systems and 2 mobile systems. The locations of CCTV are shown in Figure 12;
- the water crisis display system that displays the water crisis data and the Decision Support Systems (DSS) for managing the water crisis situation. The display system is shown in Figure 12.

Flood forecasting in the Chi and Mun river basins

To increase flood forecasting in Chi and Mun river basins in 2008 the Department of Water Resources has installed a telemetry system in the Lower Mun, and Chi river basins, in order to increase its flood forecasting efficiency.

The objectives are to have the centres for following up and monitoring the data on meteorology and hydrology as well as other relevant data, which are precise and timely. These data can be used as the database for analyzing surveillance; warning and solving water crisis problems, which contributes to efficient water resources management as follows:

- to develop the telemetry system and to collect meteorological, hydrological and water quality data in real time. The system can be developed as forecast and warning system and also be effectively developed as the model for water management in the river basin. The telemetry stations in the Chi and Mun rivers are shown in Figure 13;
- to study and design remote stations: 17 remote stations and established regional data centres are used for surveying meteorological, hydrological and water quality data. They are used to be the database for collecting data of Chi and Mun river basins. This study is applied to the flood forecasting, flood warning and communication network;
- to collect and review the area information;
- to apply a mathematic model for flood forecasting and flood warning in Infowork RS and Floodwork Model.

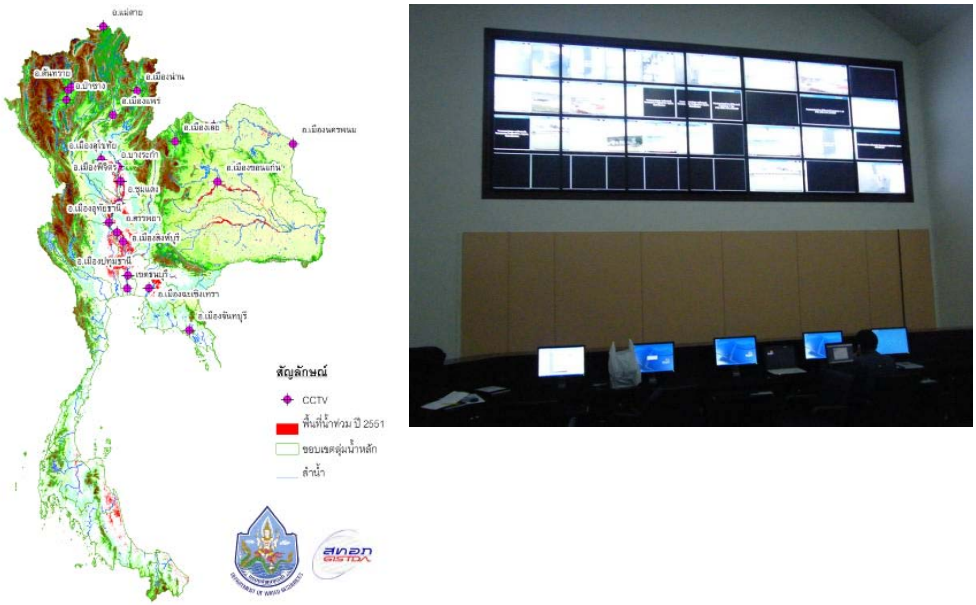


Figure 12. Location of closed circuit television systems and water crisis display system

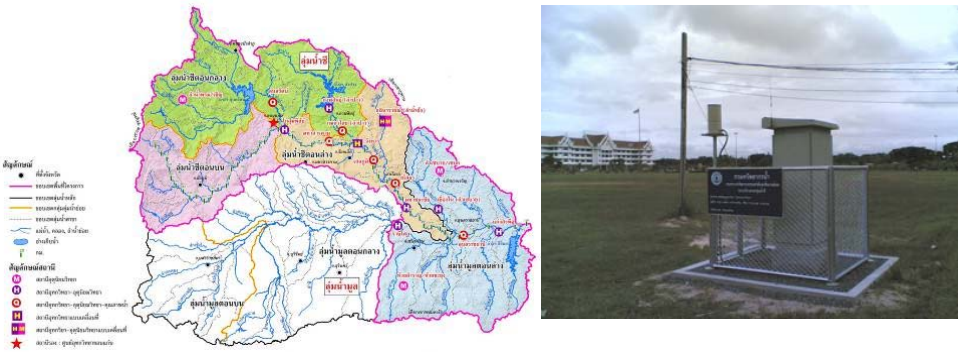


Figure 13. Location of Telemetry stations in the Chi and Mun River

Water management organization and Water Act

To succeed in water management, it is necessary to establish national, river basin, and local organizations for water resources management with supporting legislation (Water Act). The national-level organization will formulate policy, and oversee and coordinate the implementation of the policy. River basin and local organizations will prepare basin-wide water management plans with emphasis on stakeholder participation.

National Water Resources Committee

The National Water Resources Committee is a national-level organization established under the Office of the Prime Minister. The committee is chaired by the Prime Minister and consists of members who are appointed by the Prime Minister. The policies have the following authority and duties (summary):

- to submit to the Cabinet for approval of the objectives and policy on ensuring the availability of large, medium and small-scale water resources to meet water the demand of the people;
- to set guidelines and directive for government agencies, state enterprises and various organizations regarding formulation of plans or projects for water resources development, or construction as well as coordination;
- to scrutinize and approve plans, and direct, control, supervise, and oversee implementation of plans and reports in terms of water quantity and quality;
- to consider and solve any urgent problem or impediments.

River Basin Committee

A River Basin Committee comprises members selected from government officials, state enterprise representative, representatives of local organizations and water users organizations, stakeholders who work or live in the concerned river basin, and qualified persons who have knowledge and experience related to water resources management. The policies have the following authority and duties (summary):

- to submit to National Water Resources Committee comments on policies, plans, projects, and solutions to any problem or obstacle to development, utilization, conservation, and any other necessary implementation related to water resources management as well as any pertinent action of the concerned agencies in a river basin;
- to monitor and evaluate performance of the agencies relevant to water resources in a river basin;
- to conduct public relations, receive comments, and promote understanding among the general public of performance or work procedure of the River Basin Sub-Committee.

Draft of Water Act

The legislation of the Water Act is performed by the Department of Water Resources under the Ministry of Natural Resources and Environment to act as the principal law in water resources management. To prevent and resolve problems related to water resources and to proceed systematically and include in all related issues, which there are:

- to have the principle law for development, management, maintenance, rehabilitation, and to protect the water resources;
- to set up the water resources management organization into national level, basin level and water user level;
- to give an opportunity for water users to have participants in water resources management and establish water users organizations.

LESSONS LEARNT

The excessive water quantity in the rainy season cannot be controlled, in combination with lack of good management this can result in suffering to lives, properties, and economies. The flooding problem is extreme because it is happening continuously and seems to be increasing

every year. The problem mentioned reflects some lessons as follows:

- lack of action plan in managing, developing, protecting, and rehabilitating of water resources by involvement of communities;
- lack of evaluation of water resources management plans following the policy, master plan, action plan, and measurement are determining at river basin and national level;
- lack of an integrated database system and data network information is systematically;
- lack of promotion, support, and suggestions with respect to technique and law in water resources management to local organizations.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

In 2008, Thailand's flood situation almost only resulted from tropical storms that occurred due to low pressures moving towards the Northeast through the North of Thailand. This effect caused rainfall in many areas and prolonged heavy rain in some areas. Therefore, flooding occurred such as flooding in low-lying areas and flash floods in mountainous area. For example there was heavy rainfall from 11 to 31 August with overbank flow of water of the Mekong River. It has caused trouble to the people along the Mekong River and sub-basins in Thailand. From 30 September to 1 October, it has been 'Mekkhala', a tropical storm in Thailand and from 19 to 20 November, it has been the tropical storm 'Noul'.

The calamity of flood brought suffering in 65 provinces, 4,494,189 people of 1,197,253 households. These disasters caused death of about 67 people (in October about 32 people). Assets were destroyed such as 18,300 destroyed houses in communities and agriculture areas of about 4,840 km^2. The cost of damage was US$ 72 million, especially in December was damaged about US$ 28 million, about 39% of total cost of damage in 2008.

During the flood events, there was aid from many institutes, such as: the Rajaprajanugroh Foundation Under Royal Patronage, the Thai Red Cross Society, Department of Disaster Prevention and Mitigation, Thailand Local Administration Network, Royal Irrigation Department, Royal Thai Army, Department of Water Resources, etc. Not only the government sector but also many private sectors helped with donations to those people who were the victim of flood disasters.

Recommendations

The following recommendations can be given:

- due to some problems of water resources concern in many sectors the process of resolving flood disasters is performed by many agencies as follows from their authority and it is limited due to many legal issues, which implies that there is no leading role in the Water Resources Law that causes the resolving operation to become less effective. Therefore the Water Act should be supported more seriously;
- to improve flood management, there must be an agency that takes direct responsibility to plan and coordinate with the related organizations at community, river basin and national level. In order to encourage stakeholders to participate in many procedures to support, develop tools, and act as key mechanism to manage, a water operation centre would have to take care for the development of surveillance, monitoring, forecasting and early warning systems to support the decisions support system, etc.

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VIET NAM COUNTRY FLOOD REPORT FOR 2008

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ABSTRACT

Located in the monsoon tropical zone Viet Nam's territory also faces the typhoon centre of the East Sea, which is one of the five largest typhoon centres of the World. Given the coincidence of typhoon and monsoon seasons with heavy rains, and mainly mountainous topography floods and flooding occur frequently.

Within the Mekong River Basin, Viet Nam has five sub-areas (SA); of which the Mekong Delta (SA-10V), a tidal flat plain, is characterised by long time flooding phenomena, while the other four SAs, the mountainous landscapes, are characterised by flash and river floods.

Recorded data show that 28 big floods occurred in the Mekong Delta (SA-10V) since 1926; of which four flood events in 1937, 1961, 1966 and 2000 are considered as the extremes.

Flash floods frequently occur in the Central Highlands (SA-7V), but the maximum damage on human and properties was caused by flash floods that occurred in the upper Se San and Srepok tributaries during the flood seasons in 2000 and 2007.

In 2008 there was a small flood season (maximum water level at Tan Chau Station, Mekong River, was 3.77 m+MSL) having less damage on human and properties. The farmers in the Delta considered it as a nice flood season when they got big benefits from flood flow to agriculture, fishery, ecology, etc., while flash floods still appeared in the upper Se San and Srepok tributaries, causing damage on human and properties in Dak Lak, Dak Nong and Kon Tum provinces.

Responses to flood events in Viet Nam concern non-structural and structural measures that have been executed by a network of natural disaster management offices from national to local level including non-governmental organisations (NGO) This network is being updated and improved in functioning, facilitating, and staffing.

Regarding the 7th Annual Mekong Flood Forum under the theme *'Integrated flood risk management in the Mekong River Basin'* four topics are discussed in this Country Report.

This Country Report presents an overview of the 2008 floods and flooding; 'Costs' and 'Benefits' of the annual floods; responses to flood events in Viet Nam; updating the status of the flood forecasting and warning organizations; as well as sharing ideas regarding the 7th Annual Mekong Flood Forum, in Bangkok, Thailand, on 13 and 14 May, 2008.

INTRODUCTION

Location and flood nature of the Mekong River Basin in Viet Nam

Figure 1 indicates the location map of the Lower Mekong River Basin (LMB) and its sub-areas (SA); of which Viet Nam has five SAs, including a partly Delta (SA-10V), the most downstream part of the MRB; and four SAs placing upstream river basins of the Mekong tributaries: Nam Ou (SA-1V); Se Bang Hieng (SA-4V); Se Kong, Se San, Srepok (SA-7V); and Prek Chh Long (SA-8V). Total area of the MRB in Viet Nam is 7,251,307 km^2 occupying some 22% of the total country area and some 20.0 million people are living in those SAs, representing

23% of the total country population.

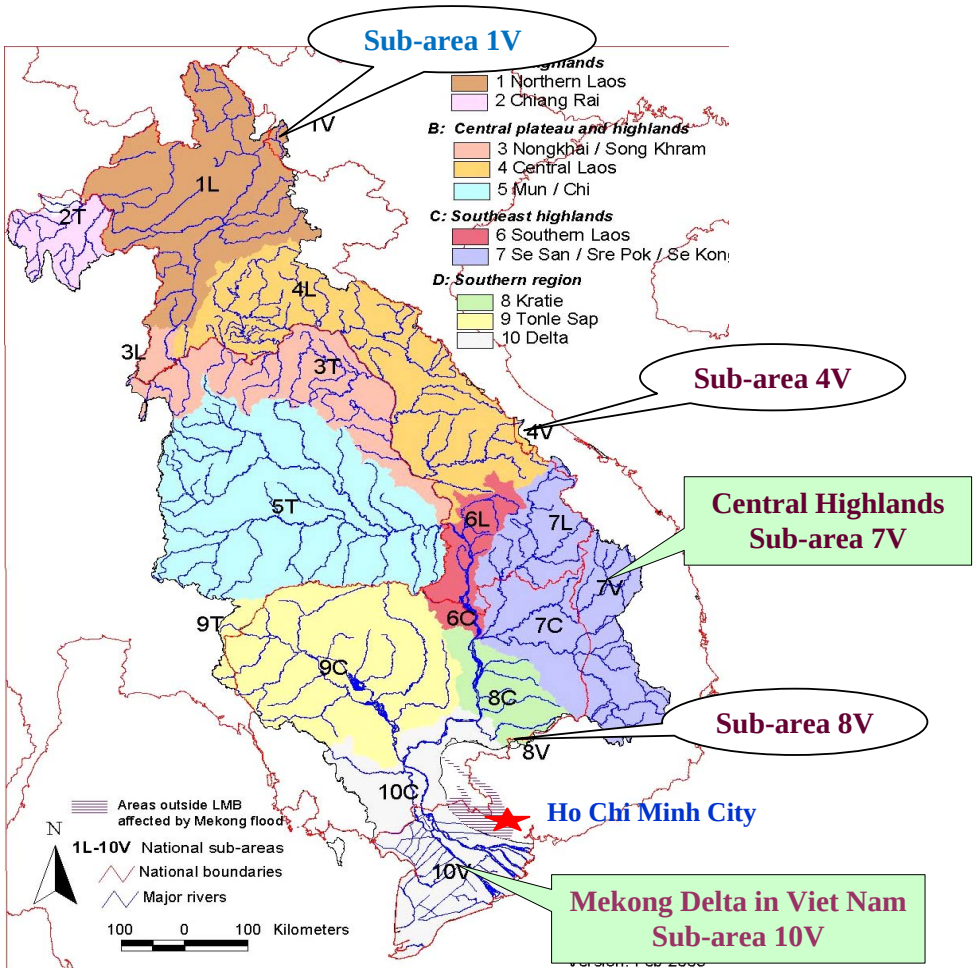


Figure 1. Sub-areas of the Lower Mekong River Basin in Viet Nam

Located in the monsoon tropical zone Viet Nam's territory also faces to the East Sea, where is one of the five largest typhoon centres of the World. Given the coincidence of typhoon and monsoon seasons with heavy rains, and mainly mountainous topography floods and flooding occur frequently.

According to geo-morphological classification the MRB in Viet Nam can be divided into two zones characterised by a mountainous landscape and a coastal plain. The mountainous area offers potential for hydropower and water shortage, but also promotes rapid flash flood concentrations that intensify soil erosion and land sliding while the coastal plain, a flat and low-lying land area, suffers from river flooding, tidal effects and local rainfall. Besides, based on geographical and hydrological theory, the MRB in Viet Nam can be classified as mainstream and tributary floods.

In general, the nature of floods and flooding in the Mekong River Basin in Viet Nam is normally caused by storm rainfall in the upstream river basins and local heavy rainfall, resulting from a strong tropical monsoon with an Inter - Tropical Convergence Zone (ITCZ) combined with tropical storms originating from the East Sea. In contrary, the Delta floods mainly depend on the mainstream flood volumes while the mountain floods appear mainly depending on river discharges.

'Nice flood season', a new concept of floods and flooding in the Mekong Delta

For agricultural production purpose, the flood scale can be classified according to yearly flood peaks (Figure 2) observed in the Mekong Delta where the farmers consider a nice flood season or a floating season when it has three factors: (i) maximum water level at Tan Chau Station varies from 3.5 m+MSL to 4.5 m+MSL; (ii) flood peak starts late (after July); (iii) flood intensity is slow (4-10 cm per day).

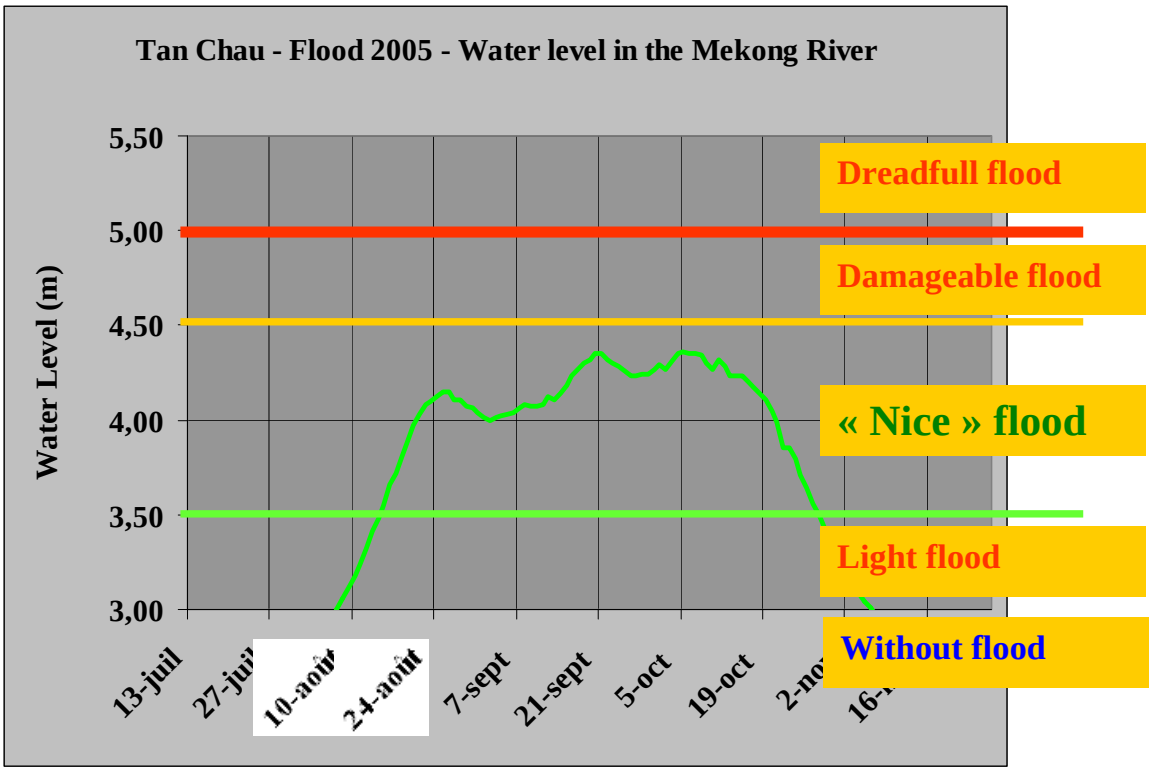


Figure 2. Flood scale classification in the Mekong Delta

General introduction to the content of country report

This country report outlines and analyzes the key issues and factors related to the Flood Management and Mitigation Programmes (FMMP) activities for the Vietnamese's SAs and disaster management in Viet Nam. It includes seven sections; of which section 2 analyzes the characteristics of the 2008 floods and flooding that occurred in both sub-areas: the Mekong Delta (SA-10V) and the Central Highlands (SA-7V) of upper Se San and Srepok rivers; summaries of positive and negative effects of the annual floods; as well as the lessons that have been experienced, improvements made and actions taken. Section 3 presents an update on the organizations dealing with the various aspects of flood risk management covering current status, forecasting and warning system, unmet needs of forecasting and warning, and aspects to be strengthened regarding centre-community relationship. Section 4 is devoted to discuss the Theme 'Integrated flood risk management in the Mekong River Basin' of the 7th Annual Mekong Flood Forum, Bangkok, Thailand, 13 and 14 May, 2009. In the next sections the specific recommendations on working arrangement between the riparian centres and Regional Flood Management and Mitigation Centre of the Mekong River Commission (MRC RFMMC) are shown, as well as further national suggestions on integrated flood risk management. At the end of the report, useful biography, communication network are also provided.

OVERVIEW OF THE 2008 FLOODS AND FLOODING

In 2008, it was a nice flood season in the Mekong Delta (SA-10V), but flash floods occurred in some places in the Central Highlands (SA-7V).

Brief overview of the past extremes

For the MRCs programs, a typical hydrological period (1985 – 2000) was selected for the present studies. Figure 3 shows flood peaks (maximum yearly water levels) observed during the selected period and recent years at Tan Chau Station, Mekong River.

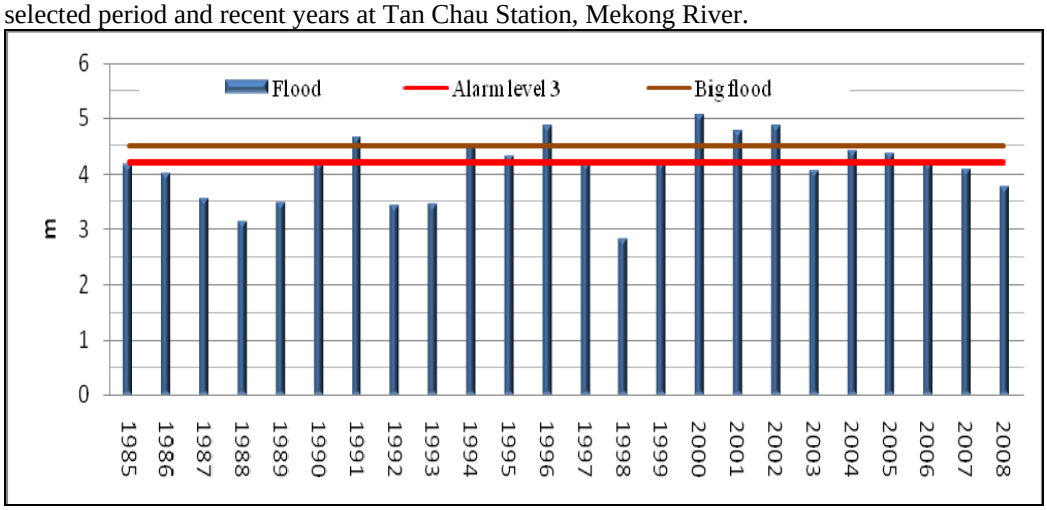


Figure 3. Yearly flood peaks at Tan Chau Station (Mekong River) from 1985 to 2008

Further recorded data on floods and flooding in the Mekong Delta during the past 77 years (since 1926) show 28 big floods (Hmax > 4.50 m+MSL), including 4 flood extremes (Hmax > 5.0 m+MSL) that classified as 3 basin wide flood events in 1937, 1966 and 2000; and one local flood extreme in 1961. The 2000 flood event was considered as a historical flood disaster when 453 people died and some US$.250 million was lost to the regional economy. Table 1 indicates main parameters at the main stations of the extremes in 1961, 1966 and 2000.

Table 1. Main parameters at the main stations of the past extremes (1961, 1966 and 2000)

Year	Tan Chau (Mekong River)		Chau Doc (Bassac River)		Moc Hoa (Vaico River)	
	H_{max} (cm)	Q_{max} (m^3/s) Date	H_{max} (cm)	Q_{max} (m^3/s) Date	H_{max} (cm)	Date
1961	512	28,800 12/10	489	7,840 13/10	2.43	19/10
1966	511	* 27/9	484	* 28/10	2.50	3/10
2000	506	25,500 23/10	490	7,660 23/9	3.27	25/9

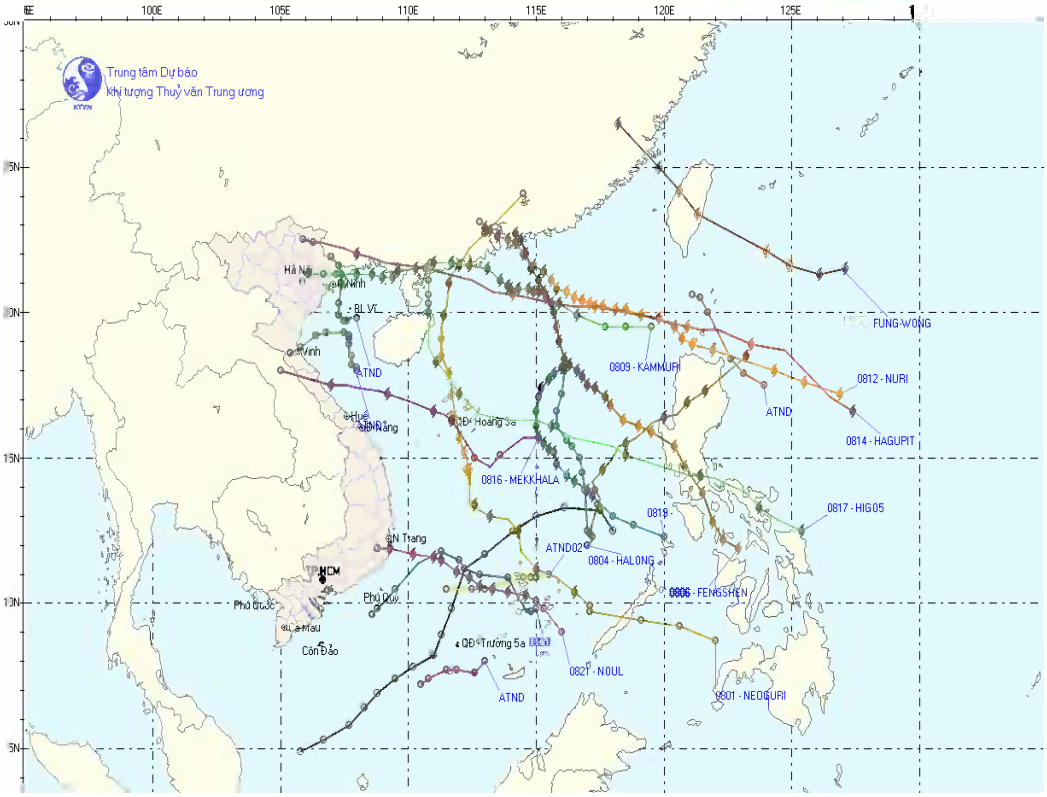
Source: National Centre for Hydrometeorological Forecasting, 2001
* No data

Characteristics of the floods and flooding in 2008

Summary of weather conditions

The meteorological conditions in Viet Nam during 2008 were very complicated with several extreme weather events in the Northern part of Viet Nam. There were four low pressures and ten tropical storms approaching from the East Sea, of which 4 tropical storms and 1 tropical depression that exerted their direct impacts on Viet Nam's territory (Figure 4).

Cold weather condition occurred with a very severe magnitude as compared to many previous years causing great damages to agriculture. Unusual weather phenomena occurred during the dry season when two tropical depressions formed right in the first haft January; and then the first tropical storm No.1 (Neogur-0801) also appeared in the central region of the Philippines in middle April.



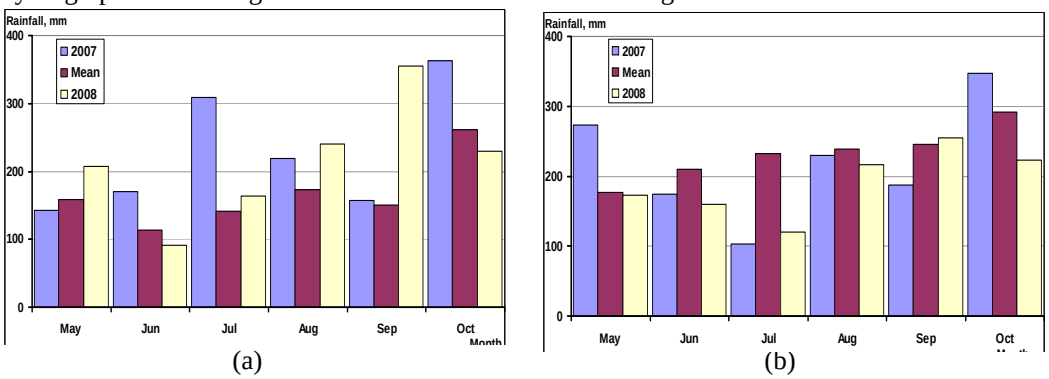
In addition, consecutive whirlwinds, hails and unusual rains did occurred covering large parts of many provinces of the country. The onset of the southwest monsoon took place in April, earlier than normal, and the wet season lately ended until December. River floods and serious flash floods occurred at some places in river system from north to central Viet Nam, but a small flood season came in to the Mekong Delta, an extreme flood event occurred in the northern part of the Lower Mekong River Basin in mid August, 2008.

Rainfall distribution and flooding in the Mekong Delta (SA-10V)

Starting right in April, earlier than in a normal rainy season, rainfall distribution over the Delta was recorded positive normally, but not very big amount and limited areas covering most of the stations observed during the rainy season, lasting until December. Compared to the normal flood year (2003) clearly shows the distribution of the 2008 annual rainfall, approximately the 2007 values, but much lower than the historical flood year 2000. Figure 5 presents a comparison of monthly rainfall values during the rainy seasons in 2008, 2007 and long-term average in the Delta at Chau Doc and Can Tho main stations.

Analyzed data and information collected indicate a light flood season observed in the Delta, where water levels at the main stations along the Mekong and Bassac rivers at the beginning of the flood season occurred on 21 June, earlier than the long-term average date; and kept going a few days only and then were down to the long-term average water level until middle July. The flood levels step by step increased and reached flood peaks (3.77 m+MSL at

Tan Chau Station, Mekong River) and (3.20 m+MSL at Chau Doc Station, Bassac River), on 1 October. Both of the flood peak values were little higher than the flood warning level II (3.60 m+MSL for Tan Chau and 3.0 m+MSL for Chau Doc station). Table 2 shows the comparison of the maximum water levels at the main hydrological stations in 2007, 2008 and 2000. The flood hydrographs of Mekong and Bassac rivers are indicated in Figures 6 and 7.



(a) (b)

Figure 5. The 2008, 2007 and mean monthly rainfall at Chau Doc (a) and Can Tho (b) stations

Table 2. Maximum water levels at hydrological stations on the main stream and on-farm areas

Station	2007		2008		2000	
	H_{max} (cm)	Date	H_{max} (cm)	Date	H_{max} (cm)	Date
Tan Chau	408	23/10	377	1/10	5.06	23/9
Chau Đoc	356	24/10	320	1/10	4.90	24/9
My Thuan	185	26/10	184	15/10	180	30/9
My Tho	167	27/10	166	16/10	163	14/11
Long Xuyen	246	06/11	234	23/10	263	27/9
Can Tho	203	26/10	200	16/10	179	30/9
Moc Hoa	199	31/10	186	16/11	327	25/9
Tan Hiep	131	3/11	128	16/10	185	8/10
Cao Lanh	229	26/10	216	17/10	261	27/10

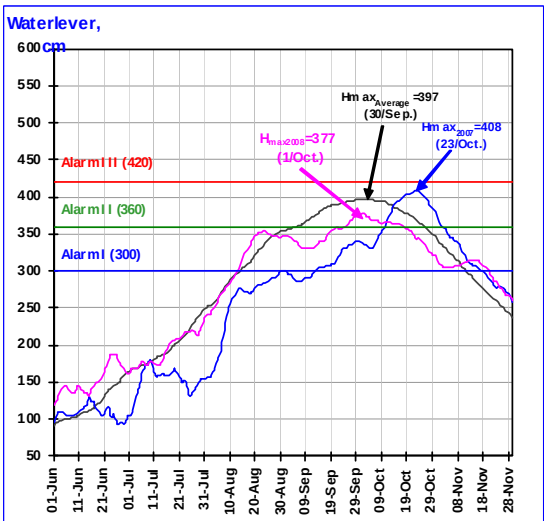


Figure 6. Flood hydrographs at Tan Chau

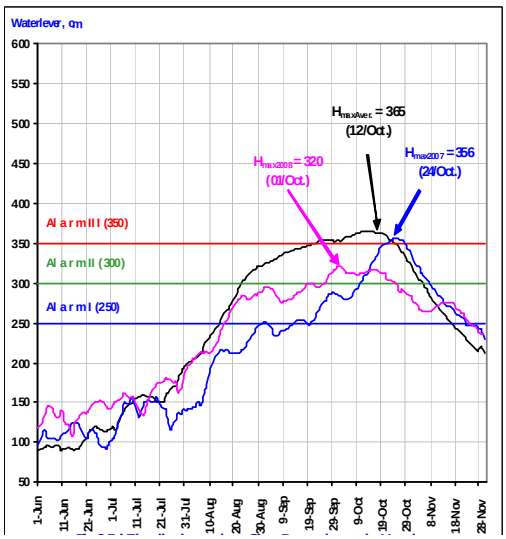


Figure 7. Flood hydrographs at Chau Doc

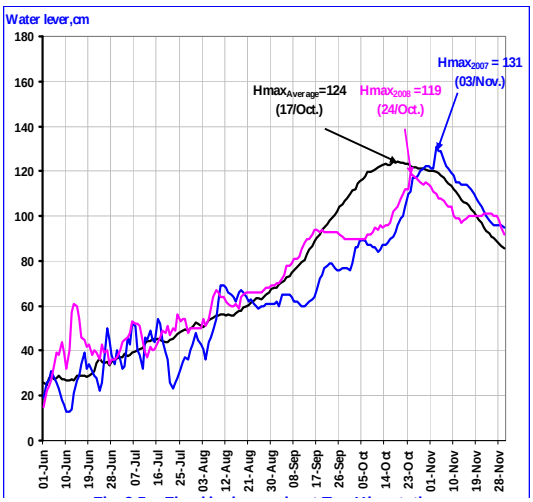


Figure 8. Flood hydrographs at Tan Hiep Station

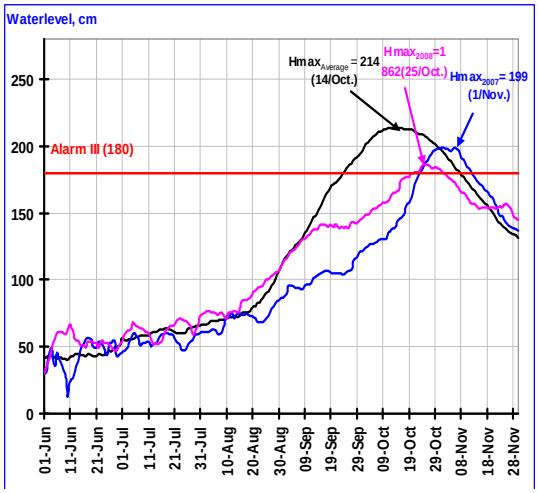


Figure 9. Flood hydrographs at Moc Hoa st.

After reaching the flood peak and keeping it in 10 days in Mekong River and 20 days in Bassac River, the water levels at both stations started to go down to the beginning levels of the flood season until the end of December. These phenomena can be explained due to the effects of tropical storm No. 10 (Noul - 0821) passing the Viet Nam territory and the Lower Mekong River Basin in a later week of November.

In middle October a spring tide period occurred causing inundation situations in many provinces of the Delta, especially in Can Tho City where at 16 October the water level at Can Tho Station was recorded at 2.00 m+MSL. Table 3 illustrates the water levels at Moc Hoa Station (Plain of Reeds) during the flood seasons in 2007 and 2008.

Rainfall distribution and floods in the Central Highlands (SA-7V)

Earlier than normal, the rainy season 2008 started at the end of April when rainfall dropped over most of the Lower Mekong River Basin including the Central Highlands. Total rainfall from June to the end September varied from 500 - 100 mm (northern part), 600 - 1,600 mm (central part) and 1,000 - 1,200 mm (southern part). These values were approximately the same as in the same period in 2003 and the long-term average level, but it was 30 - 40% higher than the long-term average value at the end of the rainy season. Table 4 indicates the rainfall distribution over the SA-7V during the early days of August.

Table 3. Water levels at Moc Hoa Station during the flood season of 2008

Month	Hmax 2008 (m)	Hmax 2007 (m)	Long-term average water levels
June	0.67	0.57	0.10m higher
July	0.73	0.60	0.13m higher
August	1.10	0.87	0.23m higher
September	1.44	1.20	0.24m higher
October	1.86	1.98	0.12m lower
November	1.81	1.99	Equivalent

Statically, there were 6 rainy periods from average to very heavy rainfall lasting from 3 days to 8 days, of which two significant rainfall periods (Tables 4 and 5) occurred in early August and by the end of November. Especially, the heavy rainfall period resulting from the interaction between tropical storm No. 10 (Noul-0821), a high pressure area from China Continental associated with southwest monsoon from the Gulf of Thailand, occurred at the end of November causing flash floods in some places in the upper Se San and Srepock river basins.

Comparison of monthly rainfalls of 2007, 2008 and the long-term average at the representative stations in the Central Highlands is presented in Figures 10 and 11.

Table 4. Recorded rainfall at specific stations in the Central Highlands (2-8 August, 2008)

No.	Name of station	River basin	Rainfall (mm)	Flood type
1	Mang Canh	Dak bla	175	River flood
2	Sa Thay	Dak bla	192	River flood
3	Dak Lay	Dak bla	184	River flood
4	Plei ku	Dak bla	278	Local flash flood
5	Dak Mot	Se San	155	River flood
6	Kon Plong	Se San	283	Local flash flood
7	Dak To	Daktakan	186	River flood
8	Kon Tum	Se San	354	Local flash flood

Table 5. Recorded rainfall at specific stations in the Central Highlands (14-26 November, 2008)

No.	Name of station	River basin	Rainfall (mm)	Flood type
1	Buon Ma Thuot	Srepok	136	River flood
2	Buon Ho	Srepok	158	River flood
3	Giang Son	Srepok	223	Local flash flood
4	Duc Xuyen	Srepok	113	Local flash flood
5	Bridge 14	Srepok	114	River flood
6	Ban Don	Srepok	69	River flood
7	Krong Buk	Srepok	286	Local flash flood
8	Dak Mot	Se San	77	Small river flood
9	Kon Plong	Se San	79	Small river flood
10	Kon Tum	Se San	52	River flood

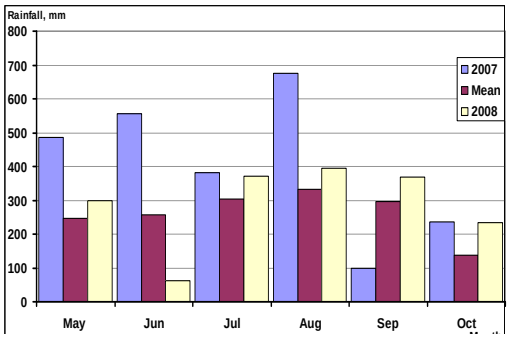


Figure 10. Monthly rainfall at Kon Tum Station

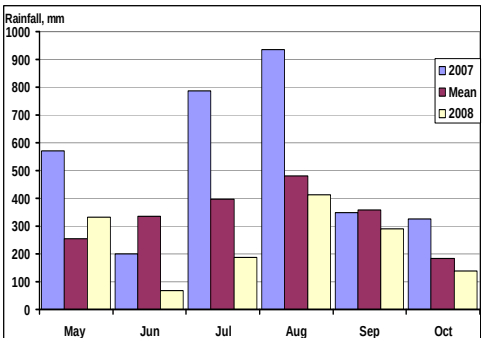


Figure 11. Monthly rainfall at Pleiku Station

In SA-7V, the 2008 flood peaks reached alarm level I to level III only, smaller than the 2007 flood peaks. However, a rather big flood event appeared in the upper Srepok River from 14 to 28 November when flood peaks reached alarm level III, even higher than alarm level III in most of the tributaries of Srepok River Basin, such as Giang Sơn Station (425.37 m+MSL), 1.87 m above the alarm level III at Bridge No.14 station (302.06 m+MSL). Tables 6 and 7 indicate flood characteristics at the hydrological stations along Se San and Srepock rivers during two significant rainfall periods; while Figures 12 and 13 show the flood hydrographs at Kon Tum Station, upper Se San and Ban Don stations, upper Srepok.

Table 6. Flood characteristics at hydrological stations, Se San tributaries, early August, 2008

River	Station	Hmax (m) (2008)	Hmax (m) (2007)	Recorded time	Date	Alarm	Hmax/ha (m).
Dak Bla	Kon Plong	591.86	594.09	16:00	7/08/08		
Dak Bla	Kon Tum	517.38	520.45	03:00	4/08/08	I	< 0.62
Poko	Dak Mot	588.58	584.45	15:00	7/08/08		
Daktakan	Dak To	577.45	576.24	12.00	7/08/08		

Table 7. Flood characteristics at hydrological stations, Srepok and Se San, 14-28 November, 2008

River	Station	Hmax (m) (2008)	Hmax (m) (2007)	Recorded time	Date	Alarm	Hmax/ha (m)
Krong Na	Giang Sơn	425.37	424.43	07.00	28/11/08	III	> 1.37
Ea Krong	Bridge 14	302.06	303.41	05.00	29/11/08	III	> 1.06
Bridge 14	Ban Don	173.25	176.10	23.00	29/11/08	III	< 0.25
Dak Bla	Kon Plong	592.58	594.09	19:00	25/11/08		
Dak Bla	Kon Tum	517.74	520.45	23:00	19/11/08	I	< 0.26
Poko	Dak Mot	582.52	584.45	07:00	26/11/08		

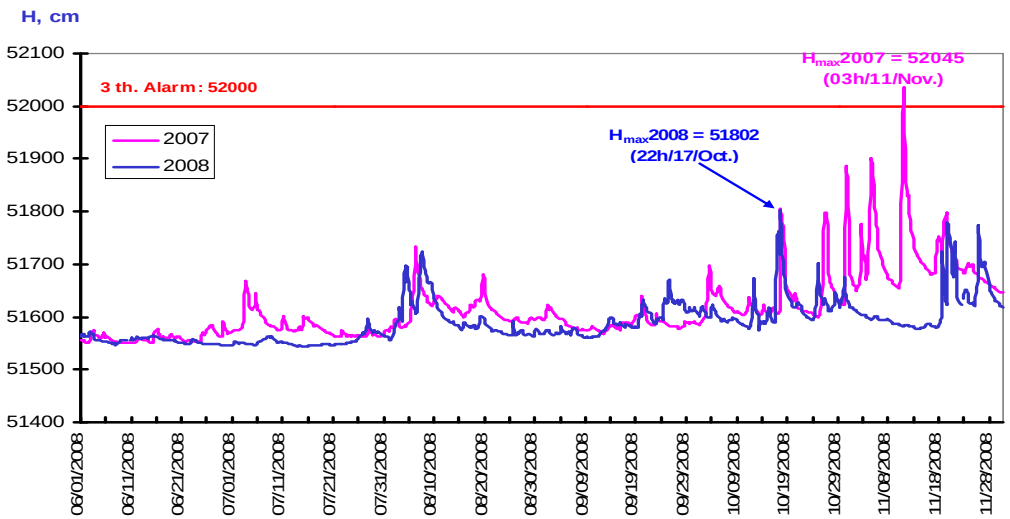


Figure 12. Flood hydrographs at Kon Tum Station, upper Se San

Flash flood in Upper Se San River

Heavy rains over large areas of the Mekong River Basin in early August influenced by the Southwest monsoon from the Gulf of Thailand combined with tropical storm No.4 (Kammuri) causing an extreme flood event in the Northern part of the Lower Mekong River Basin. At the same time flash floods occurred in Upper Se San River Basin covering Krong No, Krong Buk, Ea Krong tributaries, etc. where a significant flash flood occurred at 5:00 hour on 7 August 2008 causing extreme damage on human lives and properties in Đăk BLà Village, Kon Tum Town, Kon Tum Province. As reported at the end of 7 August 2008, in Kon Tum Province: one person died and another was injured; Đăk Kơ Wet bridge (Km 163+436) collapsed, 8 rural bridges were damaged, 97 ha paddy area were lost and 143 ha paddy were inundated. Total damage was estimated over 15.5 billion VND (US$ 620,000). Figure 14 indicates the locations in Kon Tum Province where flash floods occurred in 2008.

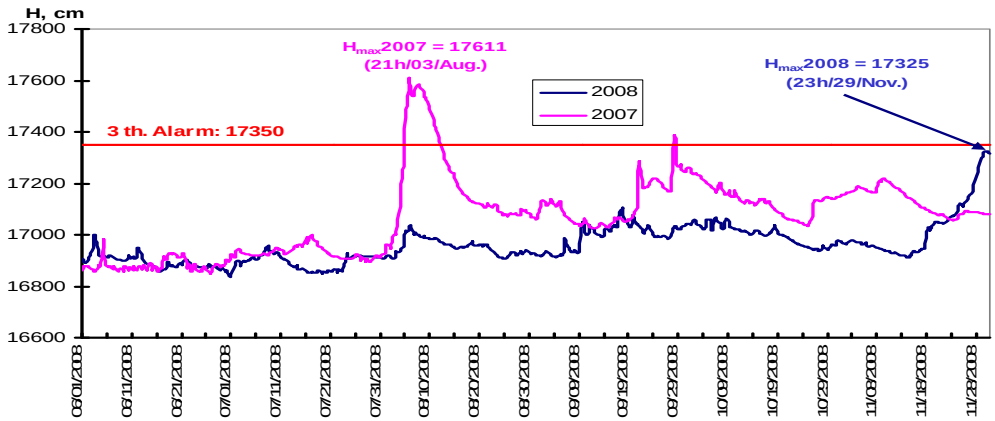


Figure 13. Flood hydrographs at Ban Don Station, upper Srepok

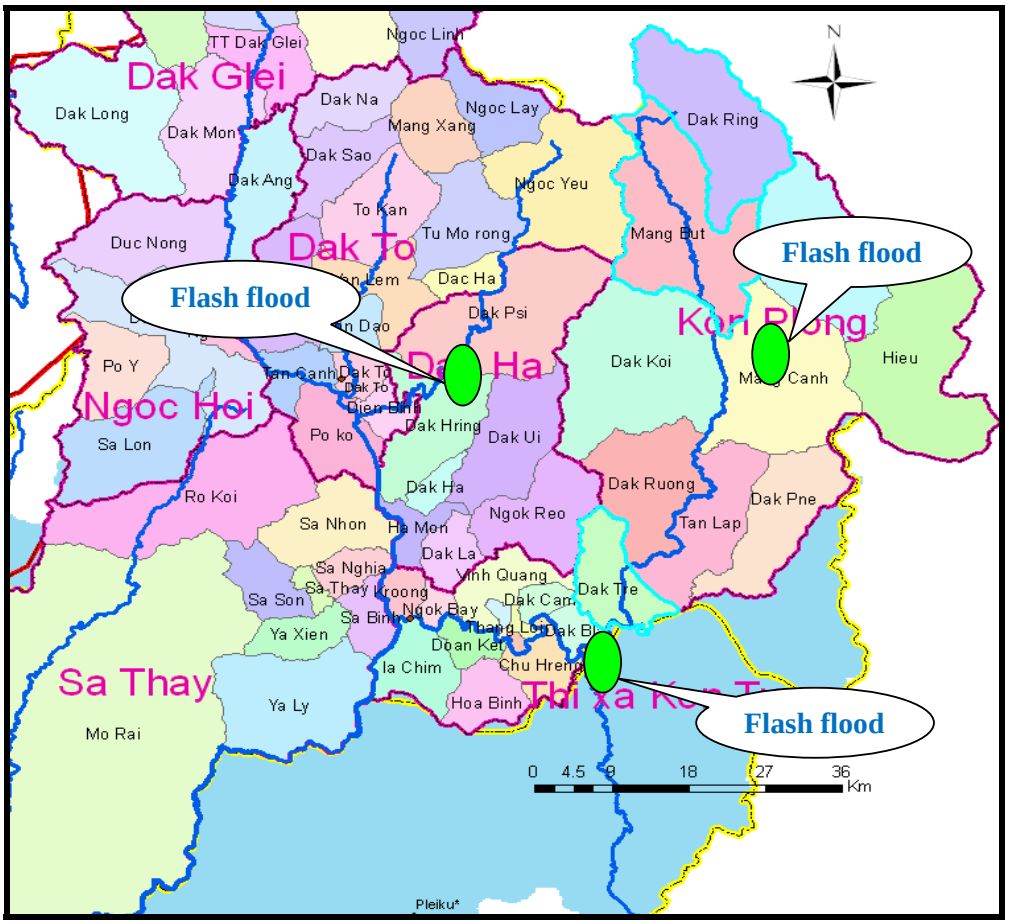


Figure 14. Flash floods that occurred in Kon Tum Province in early August, 2008

Flash flood in Upper Srepok River

Due to the influence of Typhoon No.10 (Noul-0821) at the end of November, 2008, heavy to very heavy rains occurred in the Central Highlands. In Dak Lak Province where rainfall reached 100-150 mm covering large areas. Locally, daily rainfall was recorded at 123 mm at Ma Drak

District (26 November), causing flash floods in Krong Pong and Ma Drak districts. These flash floods caused damage on human lives (2 people died), 60 houses were inundated, etc. In addition 4 districts, including Krông Ana, Ea Kar, Krông Bông, Krông Păk and Cư Kuin, were also damaged by flash floods. Figure 15 inlustrates the locations in Dak Lak Province where flash floods appeared in 2008.

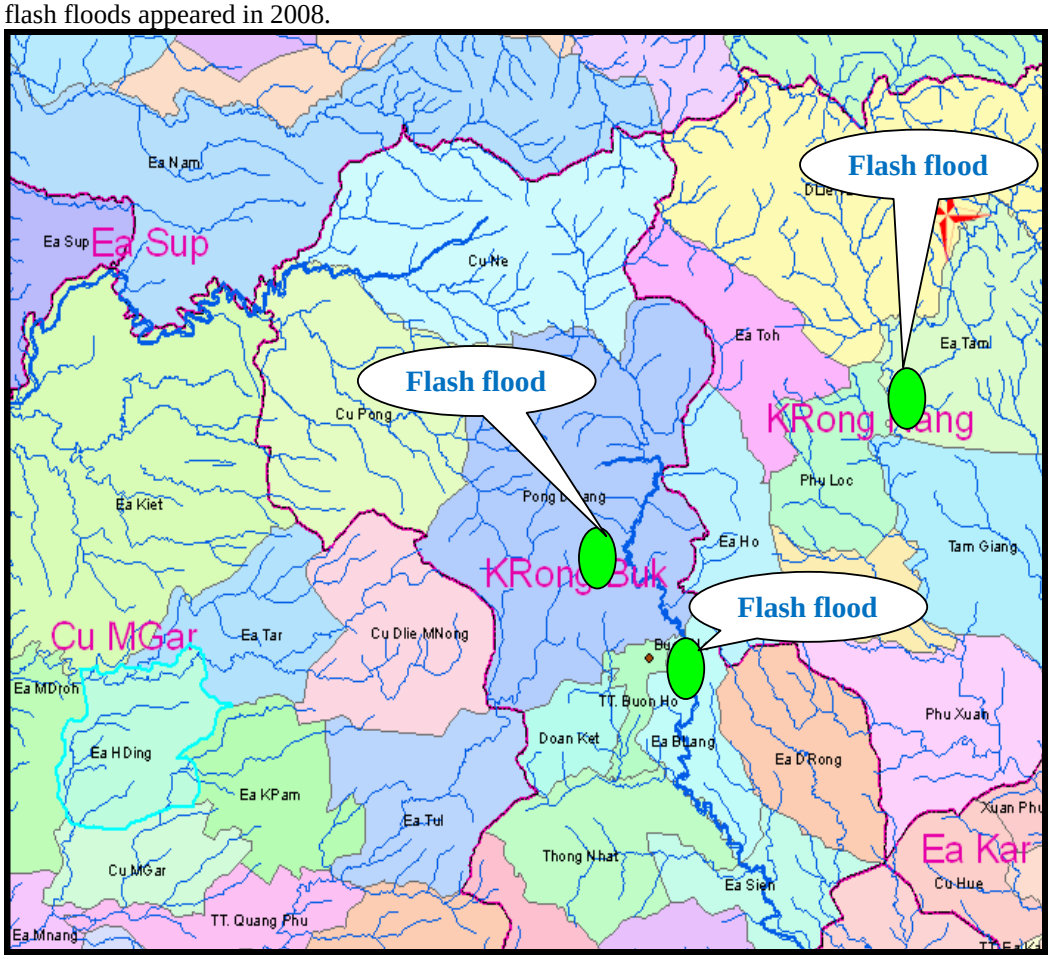


Figure 15. Flash flood that occurred in Dak Lak Province, during 20-27 November, 2008

Summary of positive and negative effects of the floods

Impacts of floods can be negative and positive. In the annual flood report this year, negative impacts of floods can be interpreted as 'costs' that refer to annual flood damage and loss, while positive impacts are considered as 'benefits' that refer to the value of the annual flood in such areas as fisheries, the environment such as wetlands and to agriculture.

Negative effects – 'costs'

The Delta (SA-10V)

Annually, an area of some 1.4 to 1.9 million hectares is inundated in the Vietnamese Mekong Delta during 3 to 6 months with depths between 0.5 and 4 m. Flooding phenomena provide constraints to agricultural production, settlement and development of infrastructure as well as disruption to people's lives, transportation, education and health services. Figure 16 shows the flooding situation during the flood season in the Delta.

Figure 16. Flooding in the Mekong Delta during the big flood seasons in 1996, 2000 and 2001

Bank erosion phenomena along the Mekong and Bassac rivers in Viet Nam have been increased in the recent years (Figure 17). An analysis was carried out by the Southern Institute for Water Resources Research, presented in the report 'Changing morphology and flow mechanism river bank system during both dry and flood seasons' that the conclusions on the bank erosion situation of Mekong River in the Delta have been made as follows:

- number of erosion areas has increased;
- the erosion mechanism has changed in both space and time;
- erosion level is changing;
- erosion phenomena occurred around the year, but the eroded level in the flood season is more serious than in the dry season;
- direct relation between erosion and sedimentation.

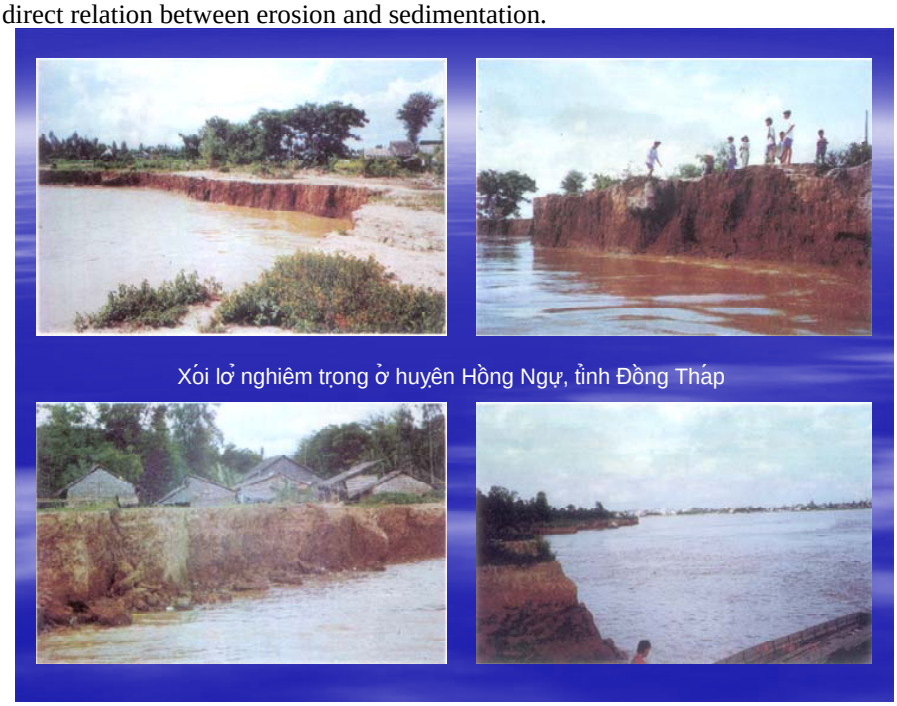


Figure 17. Erosion situation at Thuong Phuoc village, Hong Ngu district, Dong Thap province

Based on data collected from the Central Committee for Flood and Storm Control (CCFSC), Department for Dyke Management and Flood Control and Storm Preparedness (DDMFCSP), Provincial Flood and Storm Control (PFSC) and other sources, a list of key items of damage on human and properties that were caused by floods in the Delta over three years (2000, 2007 and 2008), is presented in Table 8. It can be explained that because of small-scale of the 2008 floods they brought much benefits for people living in the Delta who considered it as a nice flood season this year.

Table 8. Negative effects by floods in the Delta during 2007, 2008 and 2000

Description	Flood impacts in 2007	Flood impacts in 2008 *	Flood impacts in 2000
Number of affected provinces	5	5	13
Number of affected families	13,500	*	800.000
Number affected people	67,500	*	10,000,000
Number of people killed	30	7	453
Rice & upland crop damaged (ha)	14,688	68	2,000,000
Total 'Cost' estimated (mil. US$)	1.50	*	250.0

Data sources from CCFSC, MARD and MONRE, 2007, 2008 and 2000
** Data of Dong Thap province up to December 8, 2008, provided by PFSC*

Figure 18 shows the history of damage on human life of the whole county and the Mekong Delta from 1990 to 2007, while Figure 19 indicates damage on properties of both the country and the Delta from 1990 to 2007.

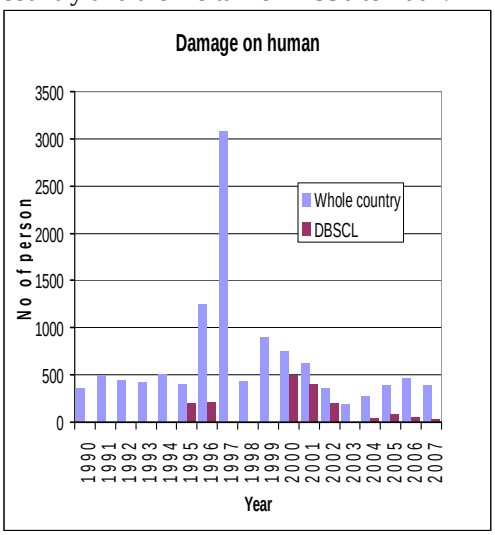


Figure 18. Human loss graph in Delta and Viet Nam

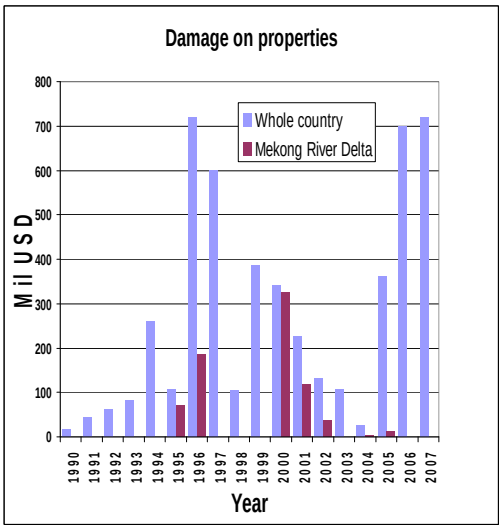


Figure 19. Property loss graph in Delta and Viet Nam

Central Highlands (SA-7V)

History of damages in the Central Highlands is summarized in Table 9. It can be noted that data and information regarding the 'cost' showing in Table 9 is collected from many resources, but not always available in CCFSC as well as in PFSC.

Table 10 indicates damage on human and properties of Dak Lak, Dak Nong and Kon Tum provinces caused by flash floods during the flood season 2008.

Table 9. History of damages caused by flash floods in Central Highlands (SA-7V)

No.	1990	1994	1995	1996	1998	1999	2000	2002	2003	2006	2007	2008
People killed	22	2	3	4		13	>20	2	6	0	29	6
People missing				5		41			2	0	4	1
People injured								1	1	0		
House: lost Inundated	22							 1500	7 	 5	166 d. 12,447	
Agriculture: lost Inundated		400						 9000	 1000	24 126	20,344 24,393	79
Fish pond damage											593	
Bridge: destroyed Damage		32				10				1	59 14	8
Water Cont: damage Eroded		4									37 33,1837	
Number of provinces	4	4	4	4	4	4	4	4	4	4	4	4
Total cost (US$)	0.5	1.0	*	*	*	0.2	*	3.0 mil.	0.5 mil.	*	50.8 million	1.0 million

** No data*

Table 10. Damages on human and properties in Central Highlands, 2008

Items/province	Kon Tum	Dak Lak	Dak Nong
Number of people killed	1	2	4
Number of affected families		60	
Number injured people			
Agriculture damaged (ha)	79 ha lost; 252 ha inundated		
Assets	Some houses inundated		
Fishery	8 fish ponds inundated		
Water control structures	8 rural bridges sluice gate damaged		
Transport	A bridge collapsed Eroded road		
Total 'Cost' estimated (billion VND)	15.5	*	*

* No data

Positive effects – 'benefits'

Positive impacts of floods are crucial by supplying fresh water for irrigation, drinking water, increasing fishery resources; improving navigation, bringing natural fertilizer, killing insects, flushing acid water caused by potential acid sulphate soils, pushing salt water to the sea, etc.

Benefits to agriculture

Agricultural production is the major product in the Delta where 50% of the total food production of Viet Nam is produced, a key area to implement the strategy on 'National Food Security'. Paddy production has been stably developed from 9.4 million tons in 1990 to 16.8 million tons in 2000 and it reached 20 million tons by 2008. Achievement of agricultural development on yield and production of paddy is indicated in Figures 20 and 21.

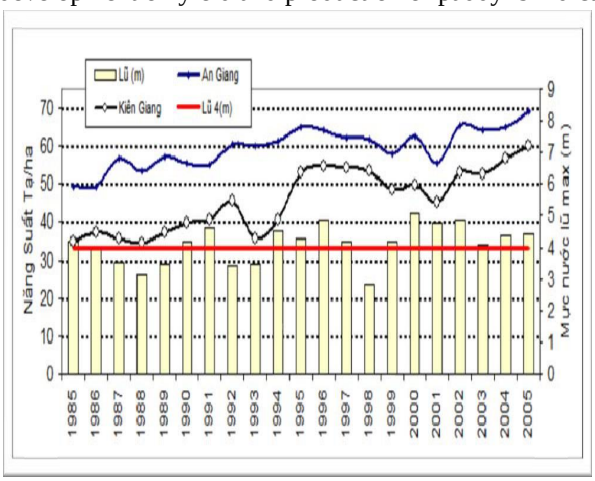
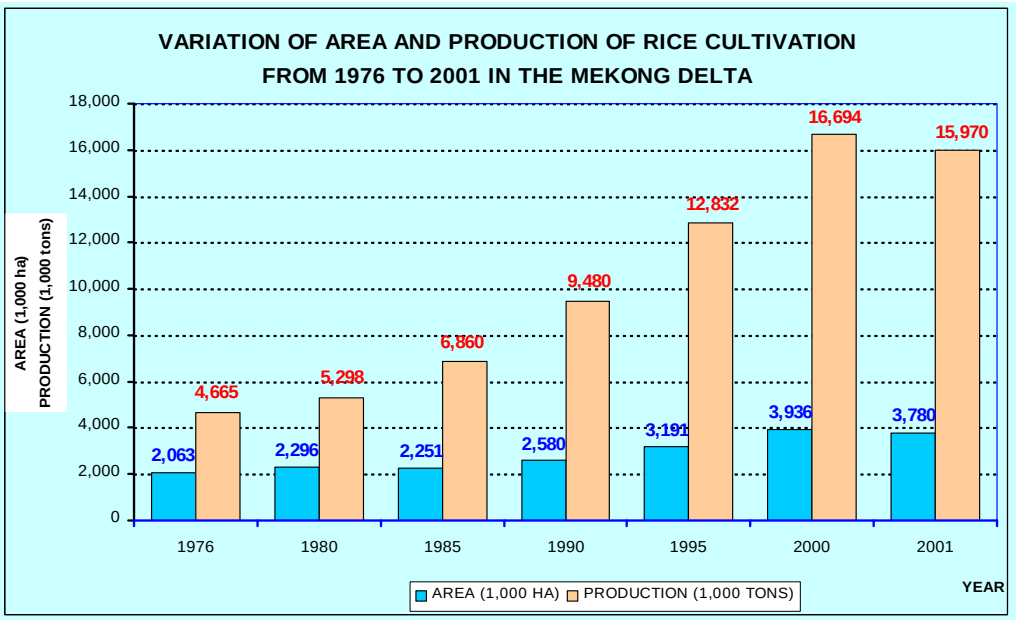


Figure 20. Relation between floods and paddy yields (winter-spring crop season)

Benefits to fishery resources

The second advantage in the Delta is fishery and aquaculture development, because there is a large water body in the Delta creating a good habitat for fish varieties living and migrating upstream and downstream. The people living in the Mekong Delta can have an income by fishing; collecting post laver as well as aquaculture during the flood season (Figure 22). Figure 23 indicates fish migration in the Lower Mekong River Basin



Source: Sub-Institute for Agriculture Projection and Planning (Sub-NIAPP).

Figure 21. Achievement of rice production in the Mekong Delta

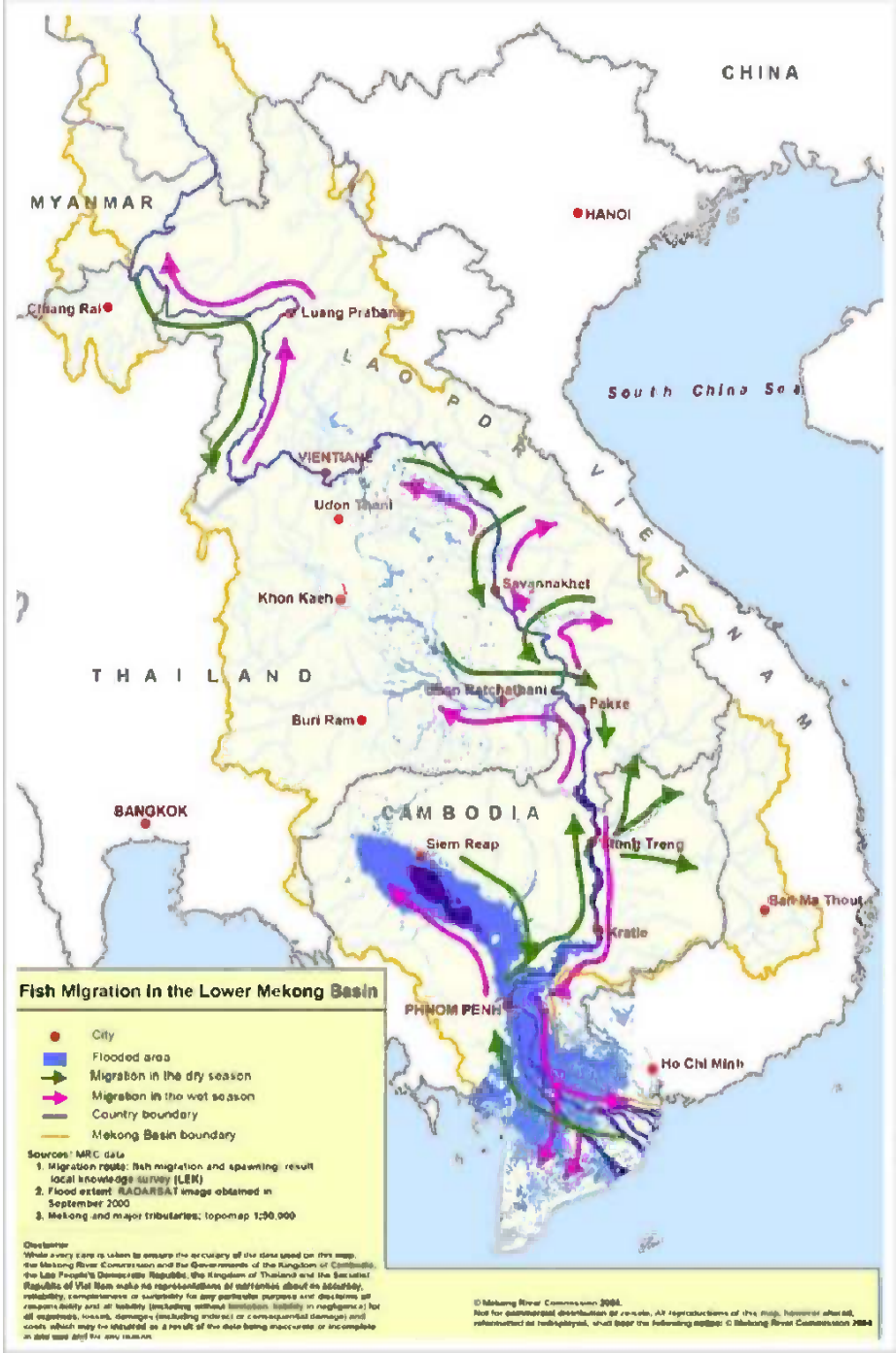
Figure 22. Fishing during flood season in the Delta

Benefits to water quality

Improvement of water quality in the acid sulphate soil areas (Long Xuyen Quadrangle and Plain of Reeds) by flood water is acknowledged not only in theory but also in practice. As result of a scientific study, namely 'Study on changing socio-economic environment and sustainable development under low flood conditions in the Long Xuyen Quadrangle and recommending the measures for solving problems' carried out by Nguyen An Nien in 2007, showing that the pH values have been changed by flood flow in the acid sulphate soil areas (Table 11 and Figure 24).

Table 11. Field survey at acid sulphate (pH) soil areas during the flood season on 30 November

Year	2001	2002	2003	2004
pH	6.53	6.33	4.97	5.43



Source: Mekong River Commission (MRC), Fish Program

Figure 23. Fish migration in the Lower Mekong RiverBasin

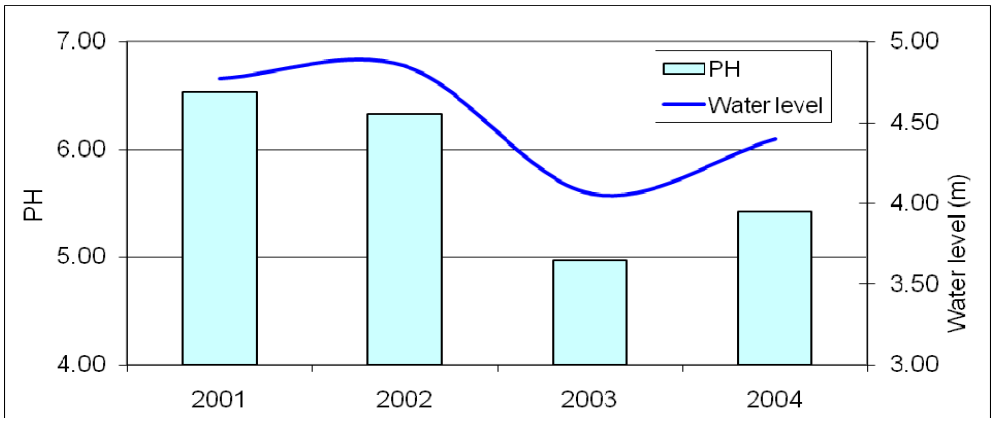


Figure 24. Relation between pH and flood water level during the flood season

In the coastal areas of Long Xuyen Quadrangle, flood flow can be used to push salt water down to the sea (Figure 25)

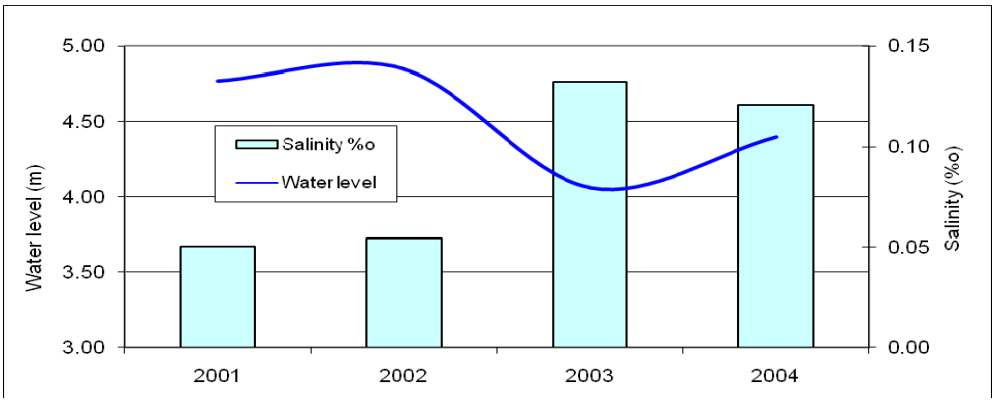


Figure 25. Relation between salinity and flood water level during flood season

Benefits to ecology

The relationships between living organisms (fishes, aquatic invertebrates, shells, plants) and the non-living components of the environment in which they live in the river and floodplain. Figures 26 and 27 indicate a natural wetland area of floodplain with a swamp inland Melualeka forest ecosystem, which has been maintained by flood water of the Mekong River.

Lessons learned

The following lessons have been experienced, improved, taken actions as well as adopted:

1. a flood is not necessary a disaster, unless and until it affects people. The annual moderate flood is a natural phenomenon that is essential to food security and biodiversity;
2. extreme mainstream flood events can be destructive and cause enormous damage on human and properties in the affected areas where people could not receive advance forecasting and warning of approaching water;
3. flood flow plays a role as the natural resources (fresh water, fishery, natural fertilizer, etc.) to be widely acknowledged in the Mekong Delta;
4. annual flood preparedness planning responding to flood emergency supports the affected people to reduce flood damages;

5. maintain close cooperation with the Flood Management and Mitigation Program of MRC;
6. adopt a National Strategy for Natural Disaster Prevention, Response and Mitigation (was approved by the Government in November 2007);
7. improve peoples' awareness on the world climate changes and how to live with floods.

Source: Sub-Institute for Forestry Inventory and Planning

Figure 26. Melualeka forest ecosystem in the floodplain

Figure 27. Room for Redhead Crains landing

UPDATE ON THE NATIONAL CENTRES DEALING WITH THE VARIOUS ASPECTS OF FLOOD RISK MANAGEMENT

Current status of National Centres

A committee that is legally covering various aspects of flood and storm risk management at national level is the Central Steering Committee for Flood and Storm Control (CSCFSC) gathering the concerned ministries, committees and associations, of which the two key sectoral ministries, the Ministry of Natural Resources and Environment (MONRE) and the Ministry of Agriculture and Rural Development (MARD), are implementing agencies. Under MONRE, the national Centre for Hydrometeorological Forecasting (NCHMF) is a legal agency performing both forecasting and warning services; while the Department for Dyke Management and Flood Control and Storm Preparedness (DDMFCSP), under MARD, is responsible for managing the flood and storm risks. More details regarding duties and responsibilities of the major agencies are presented hereafter.

Central Steering Committee for Flood and Storm Control (CSCFSC)

The CSCFSC is a Government agency, responsible for emergency response to disastrous floods and storms. It has the comprehensive system of organizations spanning from the central to local levels. The budget for their activities comes from three sources: Government, local community's participation and external assistance. Figures 28 shows the updated organization chart of CSCFSC.

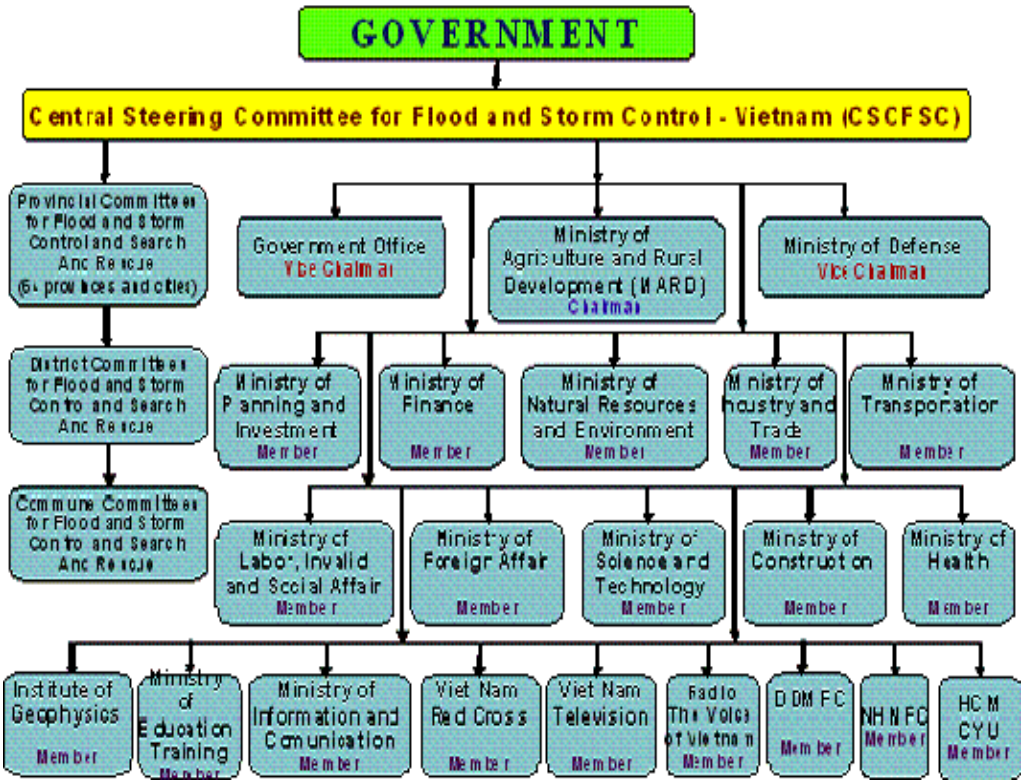


Figure 28. Indicative organization chart for responding to disastrous floods and storms

The chairmen of people's committees are the decision makers to establish the Provincial Flood and Storm Control Offices (PFSCO) at provincial, district and commune levels. The PFSCO members include: a Representative of provincial people's committee is the chairman, a leader of DARD (Chief of Water Resources Sector) is vice-chairman/standing member and other members include the representatives of the concerned sectors related to flood and storm control services (Figure 29)

Each PFSCO has a Standing Office placed at the Water Sector Sub-Department, under DARD. The budget for FSCO activities is subsidised by the provincial financial sources providing for Water Resources Sector services.

The PFSCOs are responsible for developing and implementing the flood and storm control measures in their areas; protecting the dike system and economic and residential areas; overcoming the aftermaths of flood and storm; as well as preparing planning for flood and storm response and prevention.

The PFSCOs work in close collaboration with the CSCFSC, NCHMF and Regional or Provincial Hydrometeorological Services in order to monitor the hydrometeorological situation; and to issue timely information on the flooding and raining situation.

The Standing PFSCOs provide the specific duties to their members in their areas and frequently conduct monitoring, supervising and solving difficulties in the field.

Department for Dyke Management and Flood Control and Storm Preparedness (DDMFCSP)

The Statute on flood and typhoon mitigation was promulgated on 20 March 1993, establishing the responsibilities and powers of DDMFCSP (under the former Ministry of Water Resources, under MARD now). This Statute also empowers authority's officers to take the necessary steps to response to flood and typhoon risks, and to participate in emergency repairs and protective

works. It was improved and revised through a Governmental Decree No. 08/2006/ND-CP, dated on 16 January 2006, detailing the specific tasks and responsibilities of the concerned ministries, committees and associations regarding the management and mitigation of damage on human and properties caused by floods and storms.

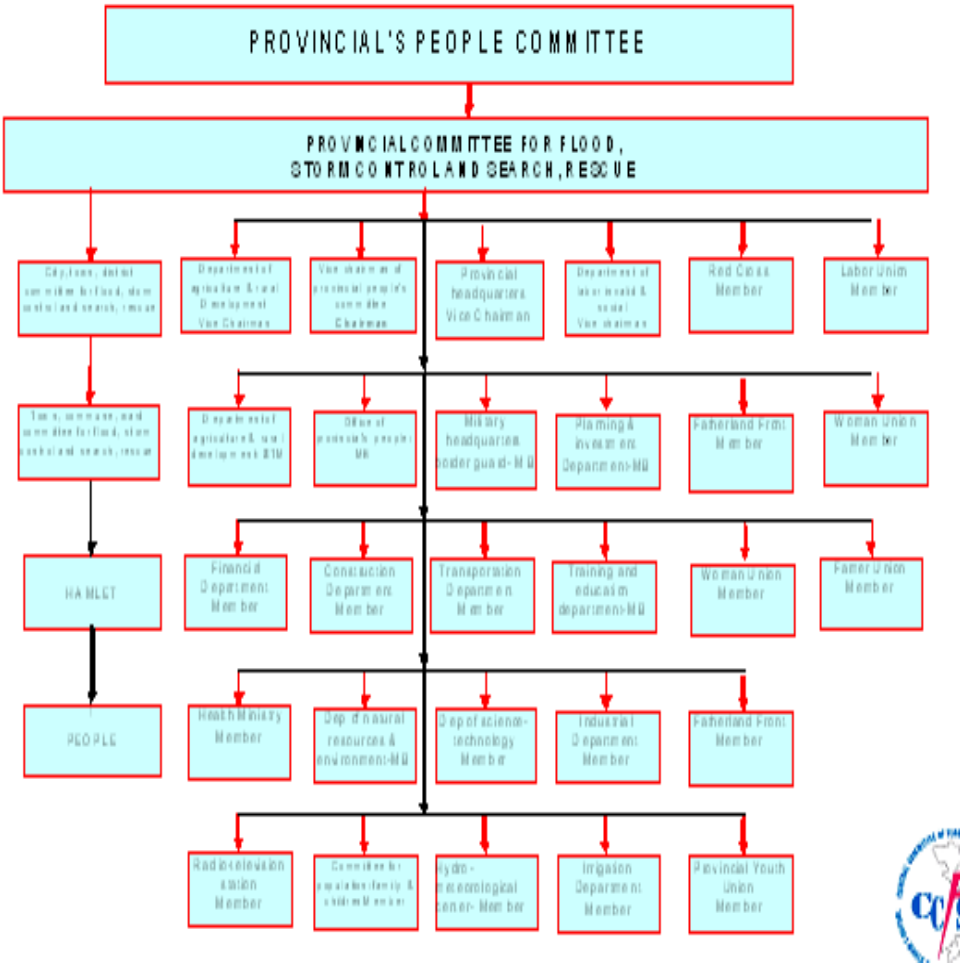


Figure 29. Implementation organization chart at provincial level

The DDMFCSP is to work as a representative of MARD (on be haft of the Government of Viet Nam) to:

1. chair, coordinate and cooperate with the ministries, sectors and local authorities to manage the planning work, plans for flood and storm management and mitigation as stated in Article 32 of the Statute;
2. draft planning and plans for flood and storm management and mitigation as well as indication and implementation of activities and services for preparing for and overcoming of damage caused by floods and storms;
3. issue and indicate implementing enforcement of laws, stipulations as authorized in protecting the dyke system and flood and storm preparedness;
4. chair, coordinate with local authorities in arranging production, cropping pattern and protection of products in the flood and storm prone areas. In addition, take care of protection of forest in upstream areas, reservoirs in the flash flood hazardous areas as well as the protection of forests at river mouths and coastal areas;
5. indicate, supervise and speed up the local authorities to complete yearly maintenance of

the dyke system; to construct hydraulic structures as flood protection; prepare solutions for safe protection of dams, reservoirs and other structures that belong to MARD;

6. collect and process data and information as well as application of advanced technologies and sciences for flood and storm control; build capacity for the people in the flood and storm prone areas;
7. coordinate with other ministries, sectors and local authorities to:
    - inform/propagandize and disseminate knowledge, experiences and laws/statutes on flood and storm preparedness;
    - supervise and inspect the enforcement of laws, solve complains, promote flood and storm preparedness as well as to overcome consequences caused by floods and storms;
    - indicate and implement international relations for flood and storm preparedness.

The following paragraphs indicate the roles and relations of DDMFCSP with other partners in addressing and overcoming consequences caused by floods and storms:

- pre-disaster, the DDMFCSP regularly receives updated information from the National Hydrometeological Centres. It keeps contact/communication with MARD, Office of the Government (OOG), Ministerial Committee for Flood and Storm Control (MCFSC), the FSCOs and also the mass media, i.e. TV, radio and newspapers, etc.;
- when a disaster actually occurs, and if emergency relief is needed, a joint mission of the members of CSCFSC visits the affected areas to assess the damage. DDMFCSP reports directly to the OOG, and a meeting of CSCFSC is held, the Ministry of Planning and Investment (MPI) and the Ministry of Finance (MOF) will submit to the OOG a plan for emergency relief, using domestic resources. In the event that international assistance is required, OOG will authorize the Ministry of Foreign Affairs (MOFA) to issue an appeal. MOFA coordinates with other agencies concerned to organize a field visit for staff of the international community within and outside Viet Nam. The Committee for Coordination and Reception of Foreign Aid (AIDRECEP) of MOFA and/or Viet Nam Red Cross are responsible for the delivery of relief goods received from the international community.

Two key achievements have been implemented by DDMFSC as bellows:

- the National Strategy for Natural Disaster Prevention, Response and Mitigation until 2020 was approved by the Government (2007);
- the Dike Law was approved by the Parliament (2006).

Figure 30 shows a natural disaster map of Viet Nam as identified by the Vietnamese and International Experts who darted the National Strategy for Natural Disaster Prevention, Response and Mitigation.

A Disaster Management Centre (DMC), under DDMFSC, has been already established according to the Decision No. 73 QD/DD, dated on 26 March, 2008. The functioning, tasks and responsibilities of DMC are indicated in the following paragraphs.

Roles and functions:

- DMC is responsible for arrangement and implementation of communication and warning services to assist the Leader of DDMFSC in coordination with other partners for flood and storm preparedness as well as natural disaster management and mitigation;
- DMC is to work as a consulting/advisory division to implement the missions for flood and storm preparedness as well as natural disaster management and mitigation at the country scale to serve for the national production and socio-economic development.

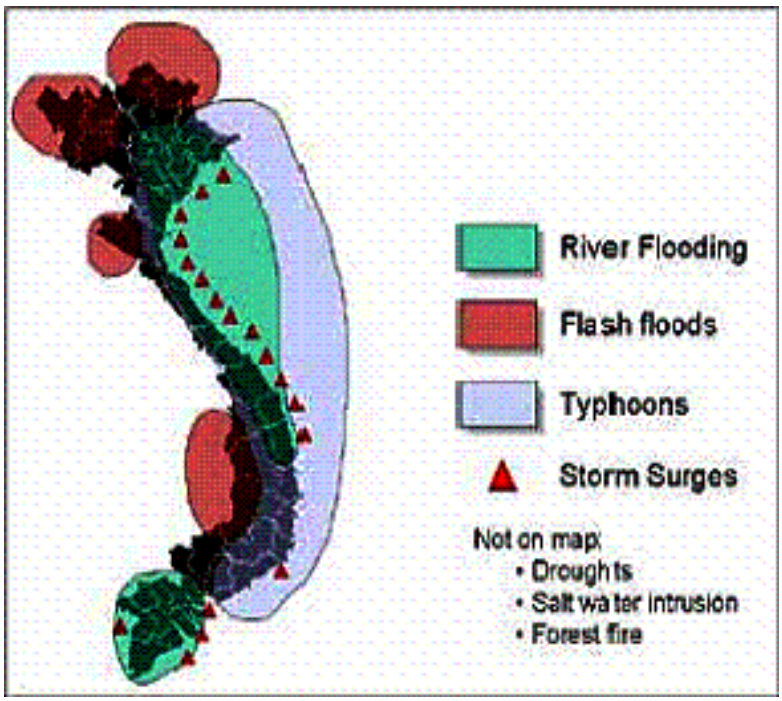


Figure 30. Nature disaster map in Viet Nam

Tasks and responsibilities:

- coordinate with the National Centre for Hydrometeorological Forecasting to collect and monitor data and information on the weather and disaster situation, climate change to serve for MARD and SCFSC on timely coordination of activities and submit detailed indications;
- participate in calculations and proposals of regulation schedules of the reservoirs for cutting overflow discharge to downstream areas based on the operation and maintenance rules of the reservoirs of Da and Lo rivers as well as diversion of flood flow to the Day River that to be used for timely coordination of the SCFSC;
- coordinate and cooperate with the Flood and Storm Management and Mitigation Division to speed up, monitor and assess the outputs of implementation of the National Strategy for Natural Disaster Prevention, Response and Mitigation until 2020 that has been countrywide executed by the organizations and individuals. In addition, to propose improving and revising this strategy responding to disaster situations due to future climate change;
- consult to formulate the institutional arrangements concerning flood and storm management and mitigation activities as well as disaster management works that respond to climate change;
- apply advanced technologies and sciences; establish a sectoral database network to collect data and information for timely serving for warning, indicating works for flood and storm preparedness responding to climate change; update data and information as well as maintain the existing website of the SCFSC: http://ccfsc.org.vn;
- to be responsible for implementing disaster risk management; to be involved in summarising damage caused by natural disasters; assess the demands and analyse the reasons; propose solutions for overcoming consequences, disaster mitigation and response to the impacts of climate change;
- implement the programs on public dissemination of knowledge and experiences in disaster management and mitigation at the specific physical areas; conduct the

programs/projects on disaster management based on community participation;
- to be an international relation headquarter in the field of disaster management and mitigation of the DDMFSC;
- etc.

Hydrometeorological Forecasting Centres

The Hydrometeorological forecasting system includes three levels as follows:
- Central level is performed by a National Centre for Hydrometeorological Forecasting;
- Regional level is implemented by nine Regional Hydrometeorological Centres;
- Provincial level is executed by 54 Provincial Hydrometeorological Centres.

The above system is operated during the whole year, especially during the storm and flood seasons. Detailed task and responsibilities of these agencies are presented in the following sections.

National Centre for Hydrometeorological Forecasting (NCHMF)

The National Centre for Hydrometeorological Forecasting (NCHMF) is responsible for the collection and exchange of domestic and international hydrometeorological information. The domestic hydromet telecommunication system is used by radio, telephone, computerised wide area network (WAN) and MetTV to store received data from the hydrometeorological observation network to NCHMF and transmit the forecast information from NCHMF to the Regional Hydrometeorological Centres (RHMC) and Provincial Hydrometeorological Centres (PHMC).

There are three kinds of forecasting products as follows:
- short-term predictions (1 - 5 days);
- medium-term predictions (6 - 15 days);
- long-term predictions (month to season).

Short-term forecasts
The short-term forecasting results are issued based on analysing synoptic charts, numerical weather prediction products, satellite images, and radar observations. The weather forecast products of other meteorological centres in the region as well as the worldwide network are also taken into consideration. During the flood season, water level forecasts are made for the main river systems. The flood forecasts are issued by application of the models: Streamflow Simulation and Reservoir Regulation (SSARR), Nedbør-Afstrømnings-Mode (NAM), regression and hydraulic models. The Hydrometeorological forecasts are broadcasted via national and local radio, television networks and published in the various daily newspapers.

Medium-term predictions
For medium-term predictions daily rainfall and flow data are needed. Forecasting methods are applied including the Rainfall-Runoff TANK model and regression method.

Long-term predictions
For long-term predictions series of flow data, meteorological data, and monthly sea water temperature at the El-Nino regions: A, B, C and D, ENSO, etc. are used.

Southern Region Hydrometeorological Centre (SRHMC)

In the Mekong Delta (SA-10V), the Southern Region Hydrometeorological Centre (SRHMC) is responsible for forecasting by two main stations namely Tan Chau (Mekong River) and Chau

Doc (Bassac River). The forecasting results are posted on the website/internet and delivered to the concerned agencies.

Locating in Ho Chi Minh City, SRHMC is responsible for management of activities regarding the hydrometeorological field in the South of Viet Nam, including the Mekong Delta and the Eastern provinces of the South of Viet Nam. The tasks and responsibilities are:

- to collect hydrometeorological data from international and national network stations from the NCHMF and the field station network. Data is processed to prepare forecasts and to transmit hydrometeorological forecasting information towards provincial stations;
- to manage the hydrometeorological network in the South of Viet Nam, including 19 provinces and cities;
- to manage, measurement and survey of hydrometeorological elements, and to process data on meteorology, hydrology, oceanography, environment, radar, radiation and ozone;
- to provide meteo-hydrological and oceanographic forecasts (short, medium and long-term);
- to carry out the warning of severe weather and hydrological phenomena as well as tropical storms, floods, flash floods, drought, salinity intrusion, serious thunderstorm and heavy rain, etc. to satisfy the requirements of socio-economic activities and prevent the natural disasters;
- to research and conduct meteorology, hydrology, oceanography, and environment services.

Central Region Hydrometeorological Centre (CRHMC)

Located in Gia Rai Province, the Central Region Hydrometeorological Centre (CRHMC) is responsible for management of activities regarding the hydrometeorological field in the Central provinces of Viet Nam including the Central Highlands (SA-7V). The tasks and responsibilities are similar as for the SRHMC.

Provincial Centres for Hydrometeorological Forecasting (PCHMF)

The tasks and responsibilities of the Provincial Centres for Hydrometeorological Forecasting (PCHMF) are to collect data from regional stations and provincial stations within its area. Collected data are processed and forecasted internally within the region. In addition, every province has a local network subsided by local funds (PPCs source). Most of the stations of the local network are located along irrigation canals. Based on the forecast results issued by the Regional Centre, the PCHMFs shall also forecast the hydrometeorological factors in their local networks.

Flood forecasting and warning system

Scheme of flood forecasting system

Flood forecasting and warning service is an integrated process including data collection, communication, management system and computer modelling system to forecast floods and flooding that may happen in an affected area. This system consists of real-time rainfall and water level data to be collected at the selected stations in the basin. Collected data is transferred to the master computer at the control station by radio links, lease lines, satellite. All collected data at the control centre computer is then input into a modelling software system to simulate flood events including peak water levels, flooding area and duration of inundation and flood extent. Figure 31 describes a scheme of the flood forecasting and warning system in Viet Nam.

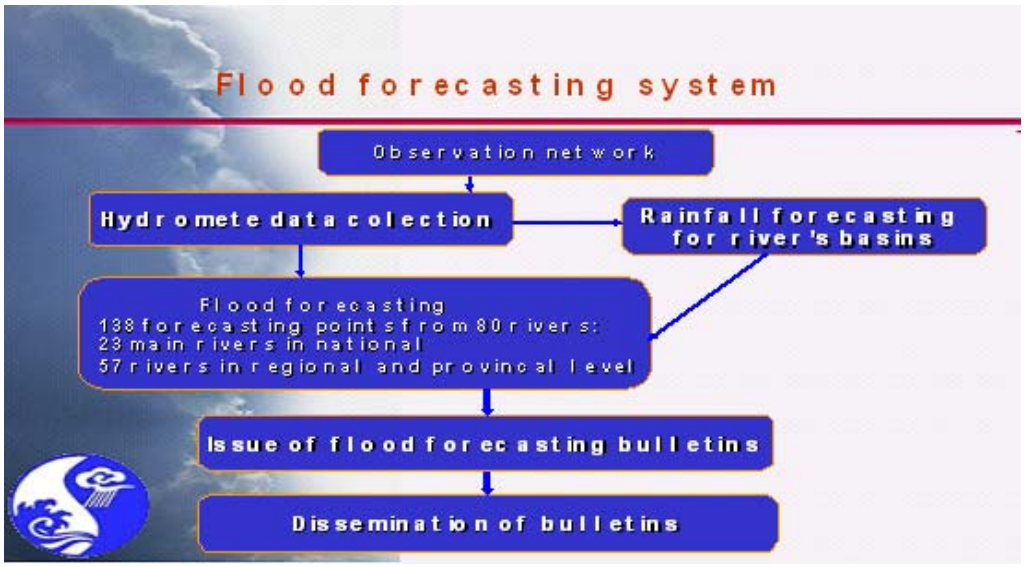


Figure 31. Scheme of the flood forecasting system in Viet Nam

Process of flood forecasting at SRHCMC

Data receipt and transmission

Data receive from MRCS by e-mail:

- at 7:00 hour: real time data on water levels at the upstream stations along Mekong River;
- at 9:30-10:30 hour: daily rainfall data at the water gauge stations.

Data receipt from the regional hydrometeorological stations in SA-10V and SA-7V by telephone lines or LAN:

- at 1:00; 7:00, 13:00; 19:00 hour: real time data on water levels at the un-affected tidal stations and highest and lowest water levels at the affected tidal stations;
- at 7:30-8:30 hour: Daily rainfall data at the water gauge stations.

Data transfer to the NCHMF by LAN:

- at 8:30 hour: water levels and rainfall data at the hydrological stations in the South Viet Nam.

Data transfer to MRC by e-mail:

- at 8:30 hour: water levels and rainfall data at Tan Chau and Chau Doc stations.

Hydrological forecasting

Regularly information include: daily, ten days, monthly, season.

Flood information notes: flood forecasting and warning process based on the special weather situation, such as Southwest monsoon or typhoon activities in the East Sea then flood notes shall be executed according to an alarm water levels system including three stages:

- the *water rising warning stage* will be issued in case the highest forecasted flood water level is lower than level III, such as less than 4.2 m+MSL at Tan Chau Station, Mekong River;
- the *flood warning stage* that will be issued in case the water level can rise up to alarm level III, such as equal to 4.2 m+MSL at Tan Chau Station, Mekong River;

- the *urgent flood warning stage* that will be issued in case the flood water level of 4.2 m+MSL can be reached and then continuously rises up at Tan Chau Station, Mekong River.

Contents of the flood notes bulletin cover the following issues:

- flood causes (weather situation and forecasting rainfall distribution);
- existing water levels in the river system;
- prediction of water levels changes in the coming five days and ten days;
- forecast of maximum water levels in five to ten days at the same period.

Two steps of flood warning (normal and urgent) are being applied in Viet Nam; of which the normal step will be started at the beginning of the rainy season while the urgent step starts in case the water level exceeds the alarm level III, especially when it is over 4.5 m+MSL at Tan Chau Station, Mekong River.

Bulletin dissemination

The national television, radio broadcasting, telephone, facsimile, e-mail, website and newspaper network is used for delivering the weather, flood and storm massages to the public.

The flood forecasting bulletins have to be delivered to the following users:

- GOV. Office, Members of CSCFSC, MARD and MRC;
- PPCs, PFSCOs; DFSCOs;
- mass-media, daily newspapers;
- television, broadcasting network informing with many programs per day frequency.

Unmet needs for forecasting and warning product dissemination to flood-at-risk communities

The flood forecasting and warning products have been more and more developed by many offices including MRC and published on websites, newspapers and public media networks. However, access to these data and information is limited only to the concerned agencies and people who are able to reach an internet connection. In the remote areas, such as the SA-1V, SA-4V, SA-7V and SA-8V, where the poor and low education ethnic people are, they cannot receive advance forecasting and warning of approaching water.

Aspects of the centre-community relationship that must be strengthened

The following aspects should be strengthened:

- at present there is no coordination and relation between the MRC Member Country centres for flood forecasting and warning at the time of occurrence of flood events, or other natural disasters. MRC-RFMMC should arrange meetings and workshops for sharing and exchanging knowledge and experiences among the MRC Member Country agencies concerned;
- flood preparedness programmes involving the local communities and the Governmental centres can be useful to manage and mitigate flood risk and hazard;
- a community communication centre together with capacity building to the community should be made.

ACTIVITIES AND ISSUES WITH RESPECT TO THE THEME AND THE TOPICS OF THE 7th FORUM

Theme. Integrated flood risk management in the Mekong River Basin

Topic I. Optimal packages for flood management

Methods and experiences of the Vietnamese specialists to develop optimal packages for flood management are not so strong. However, flood management packages should be partly of a framework of the integrated water resources management strategy for sustainable development. Initial comments on this subject could be made as bellow:

- the purpose to develop optimal packages for flood management is to reduce the vulnerability of communities in the LMRB to the negative impacts of floods;
- key activities of the proposed optimal packages for flood management will be:
  - to identify and prioritize flood issues in each country in the LMRB through he development of regional and national road-maps for improved flood risk management;
  - to develop a prioritize programs of structural and non-structural flood risk management intervention in each county;
- it can be noted that flood risk management is a national responsibility, and each country may have different problems and priorities;
- flood phenomena can be recognised easily but the nature of flood of the Mekong River should be carefully analysed in the context of physical conditions/hydrological cycle.

Topic II. Recent developments in flood forecasting and early warning

Recent application

Hydmet software is applied at the NHMFC and RHMF Centres for receiving data. Rainfall satellite imageries and rainfall forecast products from the international network for flood forecasting and early warning.

The 72 hours rainfall forecast products, produced by Fifth Generation Mesoscale Model (MM5) and High Resolution Model (HRM) etc., are used as input data for the flood forecast models.

New software is applied such as Marine software developed by French experts and Vespa software developed by Belgian Consultants, etc. The French software is being applied for simulation of flood flow on the river system affected by tide at Hue province, while the Vespa software is used for the Central provinces. In addition, Mike 11 is applied for flood forecasting now.

Updating on the flood warning system

The flood warning system applied for the river network in Viet Nam is under review and being assessed by the Science Institute for Hydrometeorology and Environment through a specific study on the existing flood warning water levels. This case study has been carried out for three years from 2006 to 2008. As procedure, a new flood warning system will be applied in the coming years after getting the approval by the Government of Viet Nam.

Capacity building

Two projects, one funded by the World Bank for upgrading and improving the national meteorological network while the local project mainly focuses on capacity building for official

staff, have been implemented since 2007.

Plan up to 2020

A plan to improve the flood forecasting services for the National meteorological network was approved. 400 new meteorological stations will be installed to increase to 2,000 stations in total, of which the automatic stations shall be 50% of the total network.

Topic III. Effective approaches towards trans-boundary flood management

The Mekong River Basin covers parts of six countries, which implies the importance of coherent approaches in river management. This will especially be of importance during extreme conditions of floods and droughts, while under such conditions measures taken in one country may easily have a negative impact in the downstream country. Under certain conditions measures in a downstream country may even have impacts in an upstream country.

Experiences of Viet Nam dealing with trans-boundary flood issues

The lessons and experiences with effective approaches towards trans-boundary flood management in Viet Nam have been applied as following:

- the 'win-win' approach has been considered as a key tool addressing trans-boundary flood issues with the neighbouring counties;
- open discussion in the spirit of mutual respect and cooperation dealing with trans-boundary flood issues;
- promote and strengthen bilateral cooperation from National to local levels in development of social and technical infrastructure in the border areas;
- information and data sharing and exchanging concerning water resources management in the Lower Mekong River Basin as a whole and the infrastructural development projects along the boundary areas in particular;
- international cooperation and capacity building on trans-boundary issues.

Experiences of international river basins dealing with trans-boundary flood issues

The experiences dealing with trans-boundary flood issues of the following river basins in the World have been respected: Rhine and Elbe river basins in the European Union.

Topic IV. Successful flood risk management approaches

Experiences in flood risk management in the Mekong Delta

Floods and flooding in the Mekong Delta can be managed and mitigated by structural and non-structural measures. The following issues can be addressed:

- *non-structural measures:*
  - improve awareness of people;
  - improve early flood warning and forecasting;
  - improve flood emergency response;
  - improve flood preparedness;
  - capacity building;
  - enhance international cooperation;
  - establishment of inundation map;
- living in harmony with floods in the Mekong Delta:
  - land use planning and crop diversification;

  - flood proofing;
  - shifting of crop calendar;
  - building residential clusters with flood-proof houses;
  - establish care centres for children;
  - school safety training;
- *structural measures:*
  - open hydraulic system;
  - diversify Mekong flood flow to Vai Co River, to Bassac River as well as to the West Sea;
  - fully protect the shallow area; partly control the main flooded area up to early August; no protection for the deep flooded areas.

Successful experiences in flood risk management in the World

Great experiences in flood risk management have been addressed during the Aquaterra Forum 'Delta and coastal development' that was held in Amsterdam, the Netherlands, dated on 10-12 February, 2009. The Aquaterra in Amsterdam, the Netherlands, was the meeting place of choice for everyone involved with the management and development of delta and coastal areas around the world. Aquaterra contributed to robust and sustainable developments and focused on bringing together all stakeholders, questioning, showing and discussing a variety of international cases, projects, and concepts. For all delta professionals in the world, Aquaterra provided:

- a platform for presenting and sharing knowledge and experience;
- a place to meet and develop collaboration with potential partners;
- bridging the gap between sectors and finding mutual interests.

The Delta Dialogues of Aquaterra Forum aim to create an interactive setting in which different stakeholders from different delta's 'bridge the divide' and learn from each others views on the challenges, the strategies they have adopted and work together to find and formulate concrete solutions. The Delta Dialogues aim to identify and present the rapidly expanding range of solutions for flood risk reduction and discuss their applicability and application. The dialogues will focus on strategies for both urban and rural parts of deltas. The dialogues aim to enhance and expand (international) cooperation to adapt to climate change and develop sustainable development strategies to reduce flood risks.

The lessons learned and successful experiences in flood risk management stated in the Aquaterra Forum should be shared and exchanged with the Mekong River Stakeholders.

RECOMMENDED PRAGMATIC WORKING ARRANGEMENTS BETWEEN NATIONAL CENTRES AND THE MRC-RFMMC

Meetings involving representatives for the MRC-RFMMC and riparian agencies should be held before flood and after flood season. The objectives of the meetings would be concerning: exchanging and sharing knowledge, experiences and technology in forecasting flood, disaster assessment, emergency response, preparedness land use planning in the floodplain, etc. between MRC -RFMMC and country agencies.

A networking of the forecasting agencies dealing with not only flood forecasting but also respond to climate change should be made.

OTHER NATIONAL SUGGESTIONS ON INTEGRATED FLOOD RISK MANAGEMENT

The following suggestions on flood forecasting and early warning at medium-term can be made:

- MRC should publish the forecasting news on rainfall, floods, especially early flood forecasting in early April every year so that the riparian line agencies will follow to prepare plans responding to urgent hydrological circumstance;
- MRC daily forecasting news should be broadcasted before 10:00 hour, in order to be referred by the riparian agencies;
- additional water level and rainfall data at 19:00 hour should be provided daily;
- the new technology on forecasting and warning should be frequently exchanged between MRC-RFMMC and the riparian line agencies;
- training courses for riparian forecasters should be conducted by MRC-RFMMC every two years;
- the local flood extreme that occurred in the Northern areas of Laos and North-eastern Thailand in August, 2008 should be considered as a lesson learned in responding to flood risk management. A meeting dealing with such an extreme should be held during or after the event;
- an overview of the flood extremes in the Lower Mekong River Basin should be made.

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DIALOGUE PARTNER REPORT - CHINA

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Your Honourable Mr. Bird , the CEO of MRCS,,
Your Honourable Mr. Siripong, the Secretary General of TNMC,
Distinguished delegates,
Ladies and gentlemen,
Good morning!

Lancang River/Mekong River is a very important international river in Asia which bears a significant influence on the politics, economy, history and culture of the countries where it flows. In order to maintain the economic prosperity and sustainability as well as the political and social stability of its riparian areas, all the relevant countries need to carry out friendly coordination and cooperation for the reasonable utilization of the water resources of Lancang River/Mekong River, the prevention and mitigation of flood as well as the protection of river basin ecological environment, etc. We highly appreciate the Mekong River Commission (MRC) for its unremitting efforts over the past years and for its impressive achievements. The founding and convening of this flood forum is a perfect testimony to this hard work. The forum will serve as an excellent platform for the MRC Member Countries and the Dialogue Partners to share the experiences of flood management and the achievements in flood warning and forecasting.

As the representatives of the Ministry of Water Resources of the Peoples Republic of China, we are very pleased to be invited to this forum. My presentation will be composed of the following three parts: the cooperation on the provision of flood information between the Ministry of Water Resources of China and the Mekong River Commission, the flood management of Lancang River and the 2008 flood review of Mekong River.

1. The cooperation on the provision of flood information between the Ministry of Water Resources of China and the Mekong River Commission

China started to participate in the annual dialogue meeting among China, Myanmar and the Mekong River Commission in 1996, communicating on various subjects including hydrology, navigation, hydropower, environment and water resources development, etc. As an upstream country, China attaches great importance to and made tremendous efforts for the flood control security of the downstream countries. Based on the agreement of flood information provision and the implementation plan, the Ministry of Water Resources of China appointed the Hydrology and Water Resources Bureau of Yunnan Province for the provision of flood season hydrological information to Mekong River Commission since 2002. Up to now, the information has been provided for seven consecutive years, contributing to the downstream flood forecasts and disaster mitigation. During the cooperation, the Chinese side made a large amount of investment in the infrastructure innovation of Yunjinghong and Manan hydrological stations and fully mobilized manpower and material resources for accurate data collection and provision and for careful maintenance of facilities and equipment. All these efforts have guaranteed the normal operation of the information provision system, thanks to which timely and accurate information is provided to the MRC Member Countries for flood prevention and early warning.

When the original agreement on flood information provision expired in 2006, without the extension of the agreement, Chinese party continued providing the information for the next two years in the spirit of humanitarianism. In 2008, the Ministry of Water Resources of China, the Hydrology and Water Resources Bureau of Yunnan Province and the Mekong River Commission Secretariat (MRCS) renewed the Agreement between the Ministry of Water Resources (MWR) of China and the Mekong River Commission on the Provision of Hydrological Information of Lancang River/Mekong River in the flood season by the MWR to the MRCS and the Implementation Plan between the Bureau of Hydrology and Water Resources, Yunnan Province and the MRCS upon the Provision of Hydrological Information of the Lancang River/Mekong River in the Flood Season by China to MRCS. As a result, the cooperation of the two parties in the flood season hydrological information provision has been consolidated and intensified.

In return, the MRCS has been very cooperative to the Chinese side. They installed the automatic data collection and reporting system for the two Chinese hydrological stations and sent experts every year before the flood season to visit the Yunjinghong and Manan hydrological stations as well as the Kunming Data Centre for facility checking, technological training and exchange. Besides, the Secretariat has also timely paid part of the operation and maintenance cost to the Chinese side for the provision of information. Thanks to the joint efforts of the both parties, our cooperation has always been friendly and effective.

The Lancang River/Mekong River has become a string of friendship that closely connected China and the downstream riparian countries with the protection of people's security and happy life against flood as our common objective. The cooperation in the past seven years has deepened the friendship among the people of all the nations in the Mekong River Basin, which is the manifestation to the success of this practice.

2. Flood management of Lancang River

Flood management is an important mandate of the government of China. Lancang River is a very important river in south-western China. The riparian areas of the river are significant economic zones with intensive concentration of cities and towns, arable land and population. The utmost effort for flood prevention and loss control through proper flood management is extremely significant for the security of people's life and property in Lancang River Basin. Therefore it is not only a priority of the local government but also a major concern of China's Central Government and government at all levels. Under the leadership of the government, the main measures adopted to manage the flood in Lancang River Basin are as follows:

i. establishing a standing agency in the government of each level for flood control, drought relief and disaster mitigation; Allocating special funds by the government to reinforce the embankment when conditions require this;

ii. establishing a flood warning system, setting flood warning water levels for all the crucial river sections, and setting flood season limit water levels for all the key reservoirs and hydropower stations (i.e. identifying a safe low water level which enables a relatively large storage for flood control in the flood season). Either the flood warning water level for river channels or the flood season limit water level for hydro projects will have to be checked and approved annually by the designated agencies authorized by the government. It is a coercive stipulation of the government that all the reservoirs and hydro projects must be operated below the limit water level in flood seasons;

iii. a 24-hours-on-duty system is implemented with non-stop monitoring over all the important targets during flood seasons. The hydrological data (water level, discharges and

precipitation volume) of the monitored targets has to be reported to the flood control department of the government at a specified time every day. The data of some key targets even has to be reported to the State Headquarter of Flood Control and Drought Relief;

iv. governments at all levels have all prepared an Emergency Action Plan (EAP) for different circumstances, and the government is responsible for the reservation of necessary materials for emergency rescue and disaster relief;

v. real-time water and rainfall monitoring information plays a very important role in flood control and disaster mitigation, which is also the basis for flood warning and forecasting. In recent years, Chinese government has increased the investment for the development of flood prevention communication network, having installed remote sensing equipment for most of the hydrological stations which undertake flood report duty. With the automatic transmission of real-time information through satellites, radio stations, telephones and mobile communication network, etc, the local data centres can have a real-time monitoring over the water and rainfall information of rivers and projects, and the information of key stations can be directly reported to the Central Government. The local governments and enterprises in Lancang River Basin are all equipped with their own water regime remote sensing system, and a mechanism for the sharing of the available information.

While the government plays a leading role, the enterprises also share the responsibility of flood control and disaster mitigation. As for the hydro projects in operation or under construction on the mainstream of Lancang River, every project needs to formulate a detailed Work Plan for Flood Prevention before the flood season every year in order to ensure the flood control security of the project and its downstream area. In case of contradiction between the economic profit of power generation and flood control security, the principle of 'security first' prevails, i.e., the flood control security is always the top priority. For instance, during the historical extreme floods in China's Yangtze River Basin and Huaihe River Basin in 1998, many reservoirs and hydro projects were operated in accordance with the government regulation and order. They played a significant role in flood storage, proper discharge and successful staggering of flood peaks, making great contribution to the damage control. Such mode for flood management is also applied in the Lancang River Basin.

Currently, the development of the mainstream of Lancang River is focused on the hydropower resources. Therefore the flood regulation effect of existing hydro projects is limited, bearing not much influence on the downstream hydrological process during the flood season. Even so, China still considers the flood prevention security and the interest of downstream countries in its upstream flood management. Taking the Jinghong Hydro Project for example, the discharge volume of the station during the flood season is not larger than the inflows in principle; the discharge volume in the dry season is minimal 504 m^3/s, i.e. the minimum discharge volume is much larger than the natural minimum discharges. This is beneficial for both flood control and navigation downstream.

3. The 2008 flood review of Mekong River

Based on the statistical analysis of the measured data from the hydrological stations set in Lancang River Basin by the Water Resources and Hydrology Bureau of Yunnan Province, there was no abnormal flood in Lancang River Basin in China during the 2008 flood season. At Yunjinghong Hydrological Station, the most important mainstream controlling station, the maximum discharge was measured on 7 September. The peak discharges stood at 6,390 m^3/s, ranking the 35th in the data series of the past 53 years, which was much smaller than the long-

term average value of 7,320 m^3/s. Hence, as far as the Lancang River Basin within Chinese territory is concerned, the year 2008 was a normal while relatively small year for basin flood.

Mid August 2008, The Laos and Thailand in the downstream of Mekong River experienced an extraordinary flood due to an abnormal regional rainstorm. However, the maximum discharge upstream at the Yunjinghong Hydrological Station in China was only 5,630 m^3/s for the same period. Therefore, this extreme flood in downstream countries was mainly caused by the abnormal rainstorm in the local areas. During this period, the hydropower stations in China maintained a normal discharge volume based on the natural inflows.

We have noticed that the Mekong River Commission has attributed the 2008 flood to the downstream meteorological and hydrological process in its Flood Situation Report August 2008, as the CEO reiterated in his speech, which explicitly ruled out the possibility of upstream projects aggravating the flood. The objective, reasonable and fair position of the Mekong River Commission on this issue is highly appreciated by the Chinese side.

Your Honourable Mr. CEO of MRCS,
Distinguished delegates,
Ladies and gentlemen,

Lancang River/Mekong River is the mother river, which nourishes the livelihood and development of the people of all riparian countries. It is our shared responsibility to protect and develop this river of beauty and abundance. The Ministry of Water Resources of China attaches great importance to the cooperation with the Mekong River Commission and the member countries, and has devoted a great deal of its efforts to this issue while fully considering the concerns of downstream countries.

The previous achievements have clearly demonstrated the friendship and sincerity devoted by our two parties to this cooperation. This is undoubtedly very beneficial for enhancing the mutual understanding and for seeking the possible future cooperation in other fields. On the condition of promoting regional peace and stability as well as the regional sustainable development, we would like to further strengthen our cooperation in flood prevention for the socio-economic development of the Great Mekong Sub-region and bring benefits to all the riparian people.

Thank you for your attention !

FLOODS OF MEKONG RIVER BASIN (2008) IN MYANMAR TERRITORY

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ABSTRACT

The Mekong River Basin in Myanmar falls in the Eastern Shan State comprising seven townships, which are sparsely populated. The section of the Mekong River that falls in Myanmar territory is 265 kilometres and five tributaries of the Mekong River are in Myanmar. 2008 was significant for the region due to the flooding by Mekong River and its tributaries. Although this area is sparsely populated, we should consider severe floods in future. More cooperation with Mekong River Commission (MRC) in this matter is one of the most effective measures for this region.

GENERAL DESCRIPTION OF THE MEKONG RIVER BASIN IN MYANMAR

The Mekong River, after flowing through Yunnan Province in China, forms international river boundaries between the People's Republic of China, Laos PDR and the Union of Myanmar. The river boundary between China and Myanmar is about 31 km and between Laos PDR and Myanmar about 234 km, thus the total length of Mekong River, which falls into Myanmar is about 265 km. Below the place called 'Golden Triangle' (which is a triangle point of Myanmar-Lao PDR-Thai boundary) the river forms the boundary between Laos PDR and Thailand.

The basin area of the tributaries of the Mekong River, which falls in the territory of Myanmar is about 21,000 km^2 and is located in the most eastern and remote part of Shan State.

Previously the area has been under insurrection for many years and only after 1988 peace prevails in the region again and since then some development activities have been initiated by the various government departments.

According to 1990 statistics the population of the townships of Kengtung, Monghsat, Mongyawng, Mongyang, Monghpyak, Tachileik and Monghkat are 167,657, 40,761, 24,919, 14,000, 26,776, 67,700 and 17,271 respectively and total population is 359,084.

Shan State is a continuation of the Yunnan Plateau of China and thus maintains the plateau's features of mountain ranges separated by deep valleys. The area covered by the Mekong River Basin are hill areas made up of mostly rolling and steep-sided hills interspersed with a network of valleys along which run mainly perennial tributaries of the Mekong. There are narrow and broad valleys, the former from 0.5 to 1.5 km wide and the latter up to about 5.0 to 10.0 km wide.

Tributaries of Mekong River

Throughout the course of the river from China-Myanmar boundary pillar No. 243 to the Golden Triangle; there are five main tributaries within Myanmar territory. These are: Nam Loi, Nam Lin, Nam Yawng, Na Mae Sai and Nam Mae Kok.

Of these, the Nam Loi River originates in Xishaungbanna in Yunnan and flows to the South through the towns Maing Hkat and Maing Yan. This river stretch is called the Nam Hkun and it merges with another small tributary, the Nam Lap; about ten kilometres (six miles) north of Kyaingtong town. From then the river flows eastward and becomes the Nam Loi, which

enters the Mekong River.

The next tributary to the south is Nam Yawng, which flows from the Maing Yawng area after passing Maing Palio into the Mekong River. The next tributary is Nam Lin, it flows through Loimwe and Maing Hpyak to enter into the Mekong River. The Nam Mae Sai in the southern part of the basin flows, forming the Myanmar-Thailand boundary and enters the Mekong River at the Golden Triangle after passing through Tachileik.

Nam Mae Hok originates in the mountains to the northeast of Monghsat and flows south. It crosses into Thailand and merges with the Nam Mae Fang in Thailand before entering the Mekong River from the East.

All these five tributaries form the Mekong River are in Myanmar. The basin area of each tributary is tabulated as follows:

Nam Loi	- - -	8,358 km^2.
Nam Yawng	- - -	1,741 km^2.
Nam Lin	- - -	1,739 km^2.
Nam Mae Sai-Mae Hok	- - -	2,181 km^2.
Nam Kok	- - -	2,980 km^2.
Sub basin	- - -	4,000 km^2.
Total basin area in Myanmar	- - -	21,000 km^2.

The Department of Hydroelectric Power is responsible for the management, exploitation, development as the primary user of water for power production. This department is also responsible to collect and disseminate the hydrological data together with generated firm power for past, present and future projects.

At the same time the Irrigation Department is also undertaking the multipurpose water resources projects including various scales of hydropower generation.

Climate

The Mekong River Basin belongs to the Asian monsoon climate zone. The climate of this area is divided into two seasons: the rainy season caused by the southwest monsoon from the Indian Ocean and the dry season due to the northeast monsoon from the northern continent. Average rainfall within the basin increases from the northern portion to the southern portion of the Basin. Average annual rainfall at Kyaington is about 1,280 mm and at Tachileik about 1,980 mm. The majority of the rain falls within a six months period (May to October) and for half of the year evapotranspiration exceeds or equals precipitation. Accordingly river flow and other meteorological conditions are strictly affected by characteristics of the monsoon climate.

Information on meteorological stations

No.	Station	Date of opening	Location	Specification
1	Keng Tong	11-3-51	Lat 21º 18’, Long 99º 37’	Meteorological Station
2	Mong Hsat	20-9-66	Lat 20º 33’, Long 99º 16’	Meteorological Station
3	Mong Yang	16-1-94	Lat 21º 50’, Long 99º 44’	Meteorological Station
4	Mong Phat	1986	-	Part time Station
5	Mong Yong	1980	-	Part time Station
6	Tachileik	1999	-	Part time Station

Installing the auto water level gauge station at Wang Pong Port area is in process. At present water level observation at Wang Pong Port is being carried out manually.

REVIEW OF FLOODS IN 2008

According to the reports of officials from the Wang Pong Port Check Point, 2008 was a significant year for the Mekong River flooding. During 72 hours (10 August 2008 to 12 August 2008), the river rose up 1.5 metres and jumped over the bank of port area. River water level started to fall at the evening of 12 August 2008. Within 24 hours the river water level fell down up to 3 metres. Not only flooding but also land slide and river bank erosion were caused by the flood accompanied with the heavy rain.

Some lowland area of Kiang Lat sub township was inundated by the Mekong River starting from 10 August 2008. The inundation lasted 72 hours and the water reached about 1.5 metres deep and 3.0 metres at its deepest 20 hectares (50 acres) of paddy field were damaged and the flood victims (31 families) were evacuated from their house in case of emergency. Some bridges situated on Tarlay-Kiaing Lat road were damaged by flooding.

Local authorities also reported the flooding of Nam Mae Sai, one of the tributaries of the Mekong River. Tachileik and its surrounding areas were inundated starting from 20 August 2008. During 24 hours the water reached 2 metres at its deepest. The victims were moved from their houses for a few days.

All reports revealed no casualties in their respective area.

Warning, forecasting and management

During the previous Mekong Flood Forums concerning with the flood warning, forecasting and management, the practice on inland Myanmar major rivers was presented in detail by respective experts. Within the Mekong River Basin there are two work bodies which take responsibility for flood warning and management. Warning means the precaution measures.

One work body concerns the Check Point officials of Wang Pong Port. These officials come from concerned agencies of Upper Mekong River Commercial Navigation, i.e.: Directorate of Water Resources and Improvement of River Systems (DWIR), Custom Department, Immigration Department, Border Trade Department. The other one is the township level local authority. The townships are the most important of the public bodies involved in organizing the management for the towns and villages. They are nominally responsible for their needs, however, very few of them have the levels of specialist knowledge and needed departments are called in to assist with funding and technology.

To introduce the flood warning, even the danger level is not yet demarcated for stations and townships along the Mekong River. For the demarcation of the danger water level the Directorate of Water Resources and Improvement of River Systems and the Department of Meteorology and Hydrology are the most responsible agencies, under the Ministry of Transport.

CONCLUSION AND FUTURE NEEDS

In August 2008, a flood occurred along the Mekong River in Myanmar territory. Damage of crops, bridges and roads, etc. was reported but not very severe. However, such kind of flooding is significant for the local population.

Management activities were taken by Wang Pong Port Check Point officials and Township authorities.

Considering severe floods in future, it is necessary to initiate and improve the flood warning, forecasting and management for this specific area. More cooperation with the Mekong River Commission (MRC) in this matter is one of the most effective measures for this region.

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2008 ANNUAL MEKONG FLOOD REPORT

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ABSTRACT

The 2008 flood season in the Lower Mekong River Basin was defined by discharges and water levels between the Chinese border and Vientiane/Nong Khai not seen since 1966. Extensive flood inundation occurred in Lao PDR and Thailand, mainly in rural agricultural areas but also within urban areas. Parts of the city centre of Luang Prabang were flooded while peri-urban areas of Vientiane and Nong Khai were inundated to depths of up to 1.5 metres. Elsewhere in the basin, particularly in Cambodia and the delta, flood damage during the year was minimal, reflected in the fact that of the total regional flood damage estimate for 2008 of US$ 135 million 95% occurred in Lao PDR and Thailand.

The events of August provide the focus of the review of the 2008 season, which is set in its historical context following the types of analysis already established in the earlier Annual Reports. A review of the Country Reports for the year provides a riparian perspective on the year's events.

The 2008 season provided the first real opportunity to asses the performance of the flood forecasting models and expertise of the Regional Flood Management and Mitigation Centre (RFMMC) of the Mekong River Commission (MRC) in the face of an extreme event and in general they performed reasonably well, though obviously room for improvement is recognised. The major constraint to forecasting accuracy over lead times in excess of two to three days is the emerging conclusion that the storm rainfalls indicated by satellite images are probably too low and that the network available for ground truthing needs to be improved in key areas of the basin. The principal the lessons learnt concern the need to address the concerns raised by MRC Member Countries regarding information flow in times of extreme flooding and the need to improve the channels of communication between the local communities and the relevant flood forecasting, mitigation and response agencies.

The theme of the 2008 report considers the benefits and costs of the annual Mekong floods emphasizing at the outset, however, that the material presented does not contend to provide a detailed economic assessment. Rather the objective is to use the widely available data on the value of key regional sectors such as fisheries and agriculture in particular and compare them with annual damage figures, which have been systematically reported over the years by the riparian states. For the first time perhaps the degree to which the benefits far outweigh the costs has been demonstrated, while the material and information presented hopefully provides a useful introduction to a detailed economic cost/benefit analysis of the annual floods, which is a contractual obligation of the FMMP programmed to begin in 2009.

INTRODUCTION AND SUMMARY

Consistent with the format established in the 2006 and 2007 Annual Flood Reports, the 2008 document comprises four major sections:

1. the annual theme, which this year considers the benefits and costs of the annual Mekong floods. The aim is not in any way to provide an in-depth economic assessment but rather to establish the fact that the regional benefits that accrue from the floods far exceed the

losses and damage, which in the past have been the almost exclusive focus of attention;

2. a detailed review of the hydrological aspects of the flood season, which in 2008 witnessed extreme discharges and water levels in the northern areas of the Lower Mekong River Basin between Vientiane/Nong Khai and the Chinese border;
3. a brief summary of each of the four annual country reports;
4. a consideration of the major lessons learnt over the year and the provision of recommendations that might be considered in the future.

This brief overview brings out the major points and may be seen in the context of providing an executive summary of the main report.

THE HISTORICAL ROLE OF THE ANNUAL MEKONG FLOOD

Conventionally, floods and flooding are perceived as geophysical hazards within a common framework of natural disasters that also covers storms and hurricanes, earthquakes, volcanic eruptions, landslides and tsunami. In each case, socio-economic losses and damage increase exponentially with event magnitude and as a function of civil exposure and vulnerability. Such hazards are perceived as random events that have entirely negative impacts, ignoring the fact that floods also have a positive ecological and socio-economic function. Great civilizations have developed within floodplains where, on the face of it, exposure and vulnerability have been high. Such societies have included Sumerian Mesopotamia along the Lower Tigris and Euphrates Rivers, ancient Egypt along the Nile, the Harappan culture of the Indus valley in Pakistan and India, the founding cultures of China in the Yellow River Valley and the Angkor civilization of the Lower Mekong Basin itself. Exploiting the benefits and avoiding the risks brought by the annual flood stimulated such societies to put greater efforts into social organization and water management systems, which endorsed them as landmark civilizations.

The Mekong Delta and Cambodian floodplain are sites of one of the earliest civilizations in mainland Southeast Asia. Called Funan by visiting Chinese dignitaries, by the 3rd Century it was centred around two major urban centres, namely Oc Eo in Viet Nam and Angkor Borei in Cambodia. It has been argued that dry season flood recession rice cultivation formed the agricultural basis of Angkor Borei and may have dictated the location of the city itself. The link between the rich agricultural possibilities provided by the annual Mekong flood and the genesis of such pre-Angkor civilizations is clear from Figure 1 which compares the location of 2nd and 3rd Century archaeological sites with the flood recession rice growing areas (see Fox and Wood. 1999). It is entirely likely that this farming system became the future basis for later Lower Mekong civilizations such as that of Angkor itself which has its classic period between 800 and 1300 AD. Angkor eventually evolved into a true ‘hydraulic civilization’ organised around the need to manage water through a vast system of irrigation canals.

The ability to maintain soil fertility over time has been a major challenge to Asian civilizations. The Chinese, for example, developed a sustainable agricultural system based on meticulous schemes for recycling organic waste; agriculture in Japan, Java and the Philippines was based on rich volcanic ash soils. In Cambodia most soils are not naturally fertile but farmers recognised over 1800 years ago that, being located within a floodplain and deltaic system that allowed rising floodwater to spread out across the landscape and deposit millions of tons of fertile sediment annually, they could develop a highly productive and sustainable system of agriculture. In NE Thailand vestiges of an age old traditional system called ‘Tham Nop’ for flood irrigation to grow recession rice remains. The evidence suggests that the opportunity to grow recession rice and fish was the major factor in the pattern of settlement in this part of Thailand up until the early to mid 20th Century.

The picture that clearly emerges is that the annual flood has been pivotal to the cultural and socio-economic evolution of the Mekong region and that despite the fact that some loss and damage occurs in most years, those that are significant at the regional and national scales have a

frequency that is low enough to ensure that over time flood benefits exceed the flood costs by a considerable margin.

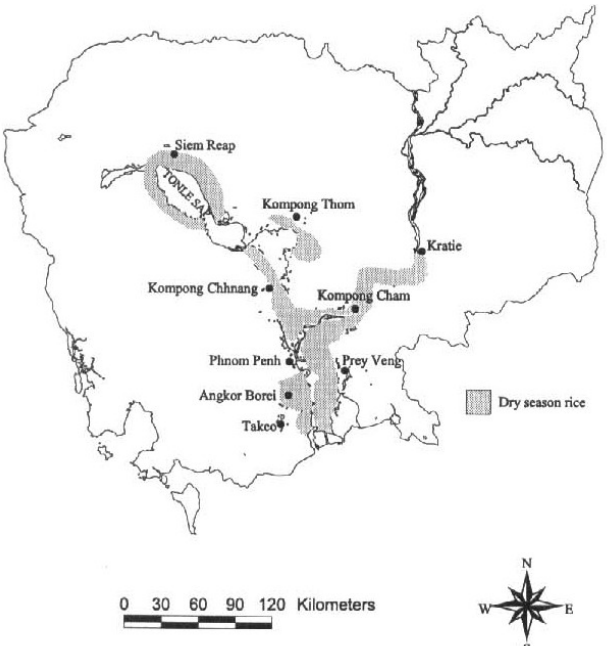

Figure 1. The distribution of flood recession rice cultivation areas and pre Khmer archaeological sites in Cambodia. (Source: Fox and Wood. 1999)

FLOOD BENEFITS

The major economic flood benefits arise in the agricultural and fisheries sectors, though by maintaining wetlands the annual flood also ensures that the products and services that such areas provide are maintained from year to year, though these are difficult to value in financial terms. On the basis of the value of production the main agricultural region in the basin is the delta in Viet Nam which contributes 30% of national Gross Domestic Product (GDP) and is the major source of export rice, Viet Nam being the second largest contributor to the international rice trade. Of course it would be quite wrong to suggest that these contributions to the national economy are entirely the result of the Mekong flood regime – they are the outcome of converting the delta into a highly controlled and intensive agricultural landscape. But the nature of the landscape that provided the opportunity to do so is the result of the hydrology of the river and the benefits that have accrued from the annual flood over thousands of years.

In Cambodia flood inundated areas of the delta are also amongst the most fertile regions for agricultural production, with extensive double cropping. Rice occupies 90% of the total cultivated land of which 32% lies in flood prone areas. Because of the fact that only 7% of the land is irrigated it is only in these naturally flooded areas that a second crop is possible on any large scale using receding water around lakes and rivers. Interestingly this second dry season flood recession crop usually gives higher yields than the wet season crop due to more controllable water management, the lower risk of crop losses due to excessive water depth and the benefits obtained from the deposition of fertile sediment during the flood itself.

In Lao PDR and Thailand the link between agriculture, rice cultivation in particular, and the benefits of the annual flood on the Mekong is less evident since most crops are rain fed or irrigated. The regional agricultural financial benefits derived from the flood are therefore as proposed in Table 1.

Table 1. Summary value of regional agricultural output which benefits directly from the annual Mekong flood. The estimates are based on rice production valued at US$ 500 per ton (February, 2009 prices).

Country	Estimated annual agricultural value accruing from the annual Mekong flood	Comments
Cambodia	US$ 1 billion	2006 figures. Based on rice occupying 90% of agricultural area of which 32% lies in flood prone areas.
Lao PDR	not significant	Only local flood recession agriculture – most production combines rain fed summer and irrigated winter crops.
Thailand	not significant	
Viet Nam	US$ 3.5 billion	2004 figures for production in the delta, which is itself a long-term product of the annual flood.
Total	US$ 4.5 billion	

The link between the regional fisheries production and the annual flood is now well established. For example, Halls et al. (2008) have demonstrated that there is a significant correlation between the extent and duration of flood inundation and the biomass of fish caught in each season, while the MRCs Fisheries Programme has conducted considerable research to establish a figure for the annual value of the capture fishery. The figures presented in Table 2. These huge figures regarding the value of the regional aquatic resources, particularly fish, are regarded as conservative as they do not take account of the economic benefits that flow from the trade, processing and preservation of fish products. Nor do they include the very considerable indirect values of the fishery such as its contribution to the nutrition, employment and well being of millions of rural people who generally have few other income earning and livelihood options (Barlow et al., 2008).

Table 2. Estimated annual value of the regional capture fishery and that of other aquatic resources such as crabs, molluscs and shrimps and in the Lower Mekong River Basin (based on 2000 figures in Hortle, 2007).

Aquatic resource	Regional value
Capture fishery	US$ 2,600 million
Other aquatic products.	US$ 249 million
Total	US$ 2,849 million

Other flood benefits accrue but they are much more difficult to value in financial terms. This applies in particular to wetlands which provide ‘goods’, such as fish and aquatic products, and ‘services’ such as flood attenuation and the retention, recovery and removal of excess nutrients and pollutants. Wetland values are considered in the main report but the arguments as to what these values might be are lengthy and so are not presented in this brief review. Any such values are, however, comparatively small in relation those that arise in the agriculture and fisheries sectors.

FLOOD COSTS

Flood damage arises from a combination of direct losses due to the fact of inundation and secondary losses as a result of the suspension of normal economic activities in the commercial and service sectors which can accumulate long after the event itself and until such time as damage is repaired and stocks and inventory replaced. Assessing these figures in dollar terms reasonably accurately requires detailed surveys of pilot areas - the results of which are then

applied to the flood affected region on a loss per unit area basis. This is the methodology adopted in each country in the basin and from data available from the relevant National Disaster Management Agencies the losses that are estimated to arise in an average year are as shown in Figure 2 and amount to a regional total of US$ 76 million.

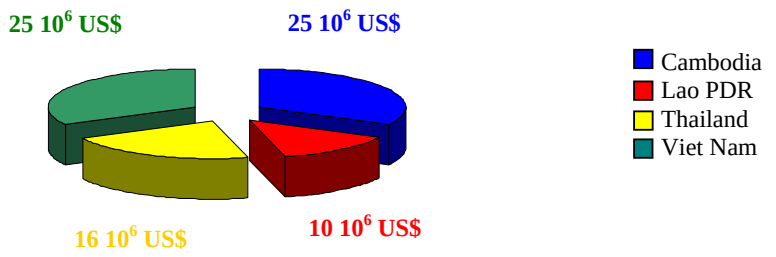

Figure 2. Indicative distribution of average annual regional flood costs of US$ 76 million

The most destructive regional flood conditions of recent decades occurred in 2000 in the south of the basin and in 2008 in the northern parts. As Figure 3 shows, by far the larger overall damage occurred in 2000 and amounted to US$ 811 million.

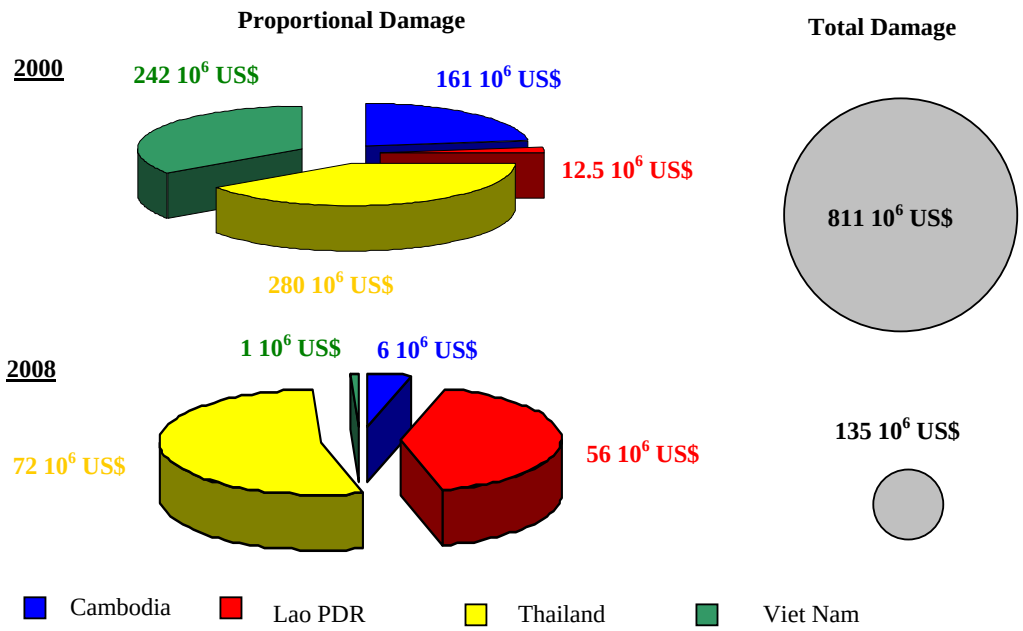

Figure 3. 2000 and 2008 Mekong floods – proportional and total damage

It is standard practice to breakdown total flood damage into that occurring within the various economic sectors, usually domestic, commercial and agricultural:

- the domestic category includes private housing and small commercial businesses carried out from home such as family shops;
- commercial / services covers industrial premises, schools, hospitals, roads, bridges and services such as power and telecommunications facilities;
- agriculture covers crops, livestock, aquaculture losses and damage to irrigation infrastructure.

Although based on local but detailed surveys, the results available in Haskoning (2008) clearly indicate that there are significant regional distinctions in the composition of overall damage which reflect differences in population density, the degree of urbanisation and the structure of the local socio-economy. As Figure 4 shows agricultural losses dominate in Lao PDR while those in the infrastructure sector are highest in the delta which is much more densely populated and therefore has much more extensive commercial and service sectors at risk.

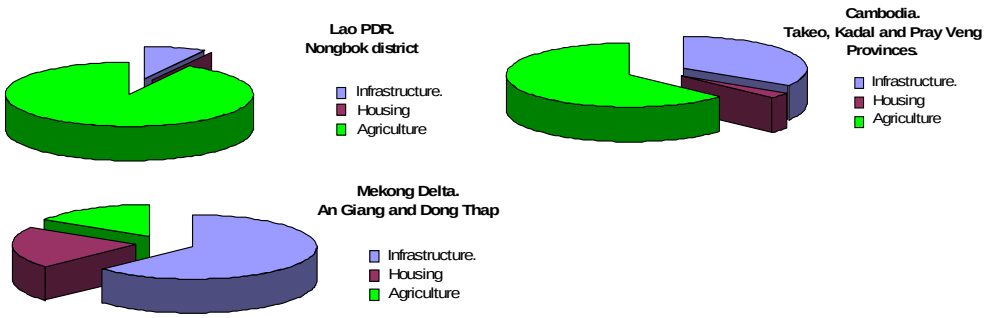

Figure 4. Proportion (%) of total flood damage by sector during 2000 (based on local survey data given in Haskoning, 2008)

THE BALANCE OF FLOOD BENEFITS AND COSTS

The objective of the AFR 2008 has not been to set out a detailed economic analysis of the benefits and costs of the annual Mekong flood, as has already been emphasised, but to compare the two in financial terms based upon the generally available macro data. These data, such as those with respect to the annual value of the Mekong fishery, are widely accepted not least by the MRCs fisheries program itself. In addition, the annual value figure for the fishery of US$ 2.85 billion refers only to that at the first point of sale. In comparison, the estimated average annual costs of flood damage only amount to US$ 76 million or just 2.5% of the fisheries benefit alone.

The additional figures for the agricultural benefits are harder to assess since the linkage between the annual floods is not as clear as it is with the fishery. Flood recession rice production in Cambodia is reported to account for 32% of national production, valued at US$ 3.1 billion in 2006 (based a February 2009 international price of US$ 500 / ton). The value of the agricultural benefit accruing directly from the flood in Cambodia is therefore US$ 3.1 billion x 0.32 = US$ 1 billion.

In the delta in Viet Nam agricultural production in 2004 had a reported market value of US$ 3.5 billion. That this is a benefit of the flood is based on the argument that the 9 to 13 millions tons of sediment deposited annually across the delta , most of it during the flood season, has over millennia resulted in some of the most productive agricultural land in Southeast Asia, thus establishing the link.

Table 3 summarises the relative benefits and costs of the annual flood on this simple basis. Costs in terms of loss and damage are quoted both for an average year and for 2000, which witnessed the most extreme regional flood losses of recent decades.

OVERVIEW OF THE 2008 FLOOD SEASON.

The 2008 flood season across the Lower Mekong Basin illustrated a common feature of the regional flood hydrology that is extreme flooding in one part of the basin and average to below average conditions elsewhere. In 2008 it was the northern parts between the Chinese border and

Vientiane that witnessed flood levels not seen for almost 50 years, while further downstream in Cambodia and Viet Nam discharges and water levels were average at best.

Table 3. Relative costs and benefits of the annual Mekong flood (the benefits refer only to the sum of the value capture fishery and other aquatic products and the annual value of flood linked agricultural output in Cambodia and Viet Nam).

Annual flood benefit	Annual flood costs		Costs as % benefit	
	Average year	Extreme year (2000)	Average year	Extreme year (2000)
US$ 7.35 billion	US$ 76 million	US$ 811 million	1%	11%

Volumes of flood runoff, discharges and water levels in the northern part of the region up until mid July had been average but an intensification of the South-West Monsoon saw repeated tropical storms and higher flood runoff. The storm situation then intensified dramatically during the first week of August with the passage of tropical storm Kammuri across the northern provinces of Lao PDR. Only satellite indications of the associated 3 to 5 day rainfalls are available (the rain gauge network here being very sparse) but cumulative rainfalls considerably in excess of 500mm are indicted. Volumes of flood runoff in the large northern Lao tributaries such as the Nam Ou and Nam Khan increased to extreme levels.

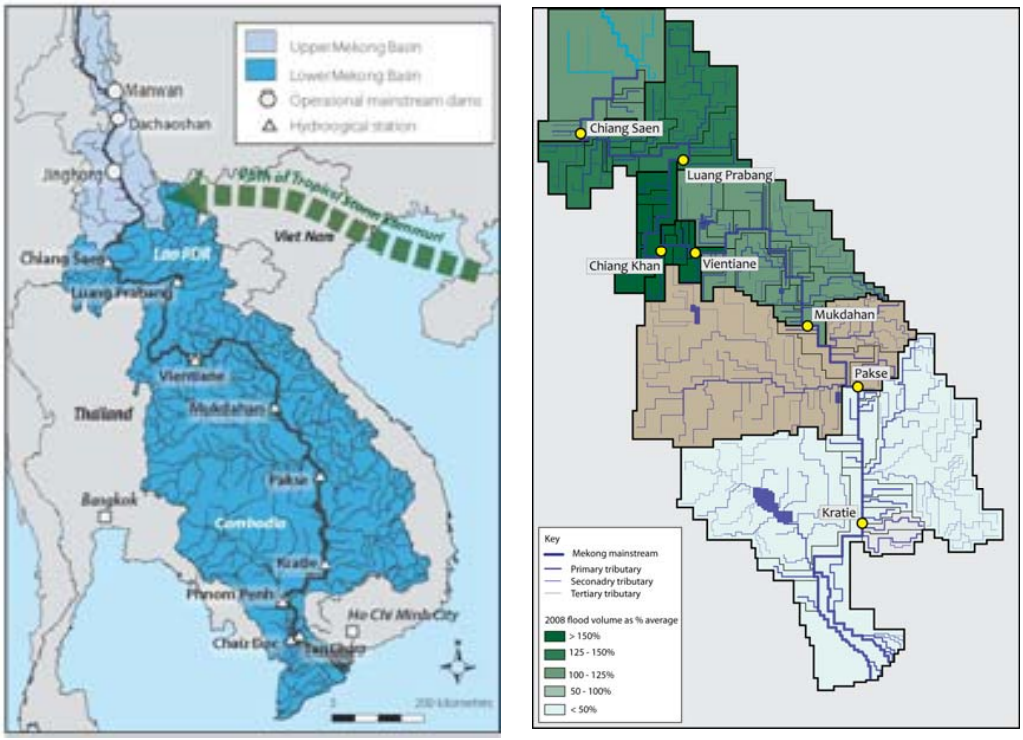

Figure 5. The track of cyclone Kammuri during the 1st week of August 2008 and the geographical distribution of flood runoff for the year as a percentage of average

Maximum discharges at Luang Prabang and Vientiane/Nong Khai occurred on the 14th and 15th of the month and were in the region of 23,000 m^3/s or 50% above the annual average. The associated water levels were comparable to those of 1966, when both city centres were flooded. Some urban flooding again occurred at Luang Prabang since water levels were elevated due to backwater effects on the Nam Khan upstream of the Mekong confluence. At Vientiane large scale urban flooding was avoided principally due to the sandbagging of the river bank

adjacent to the central business district, but large areas of suburbs and peri-urban the area were flooded to depths locally exceeding 1.5 m.

These conditions soon dissipated downstream of Vientiane/Nong Khai since flood flows into the mainstream from the large left bank tributaries in Lao PDR, starting with the Nam Ngum, were average. This becomes quite clear from Figure 6, flows at Pakse and Kratie coming close to those for an average flood season overall, while water levels in the delta at Tan Chau and Chau Doc were below average throughout most of the season.

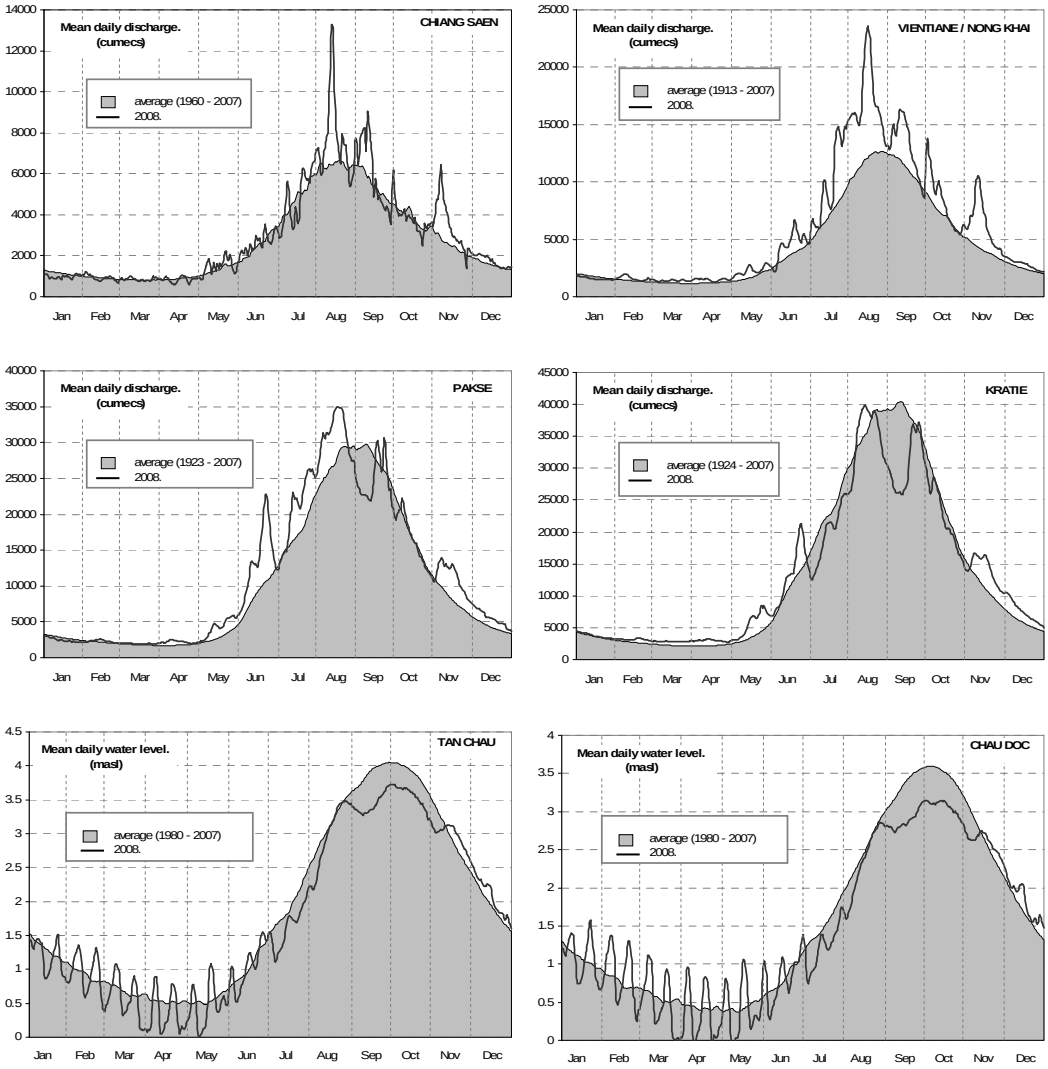

Figure 6. 2008 daily discharge and water levels at selected sites on the Mekong mainstream, compared to their long-term average.

When considered in terms of the joint distribution of flood peak and volume (Figure 7) mainstream conditions over the 2008 season at Luang Prabang and Vientiane emerge as being extreme while at Kratie the seasonal peak discharge was significantly below average while the overall seasonal flood volume was marginally below average. The recurrence interval of the peak flows of mid August at Luang Prabang and Vientiane were of the order of 1:25 and 1:30 years (Table 4). Further downstream at Pakse and Kratie the 2008 peaks were no more than average with annual return periods of the order of 1: 2 years.

Apart from these events on the mainstream local and often seriously damaging flash

floods occurred as they do in most years. In Lao PDR such conditions occurred in Bolikhamxay province during June with over 800 mm in 10 days and as much a 200 mm in 1 day. In the Thai Mekong region during September in the Khon Kaen area heavy rainfall of almost 160 mm. on the 17th caused of flood inundation and damage to property and crops and the deaths of two people. In Cambodia no significant flood damage was reported for the year while in Viet Nam the only events to cause any significant damage occurred in the Upper Sre Prok during May and in the Upper Se San Basin during the first week of August. The former saw two lives lost and the latter resulted in some bridges being damaged and about 100 ha of rice padi lost or seriously damaged. Overall damage from flash floods for the year in Viet Nam amounted to US$ 1 million. Regionally, however, the number and severity of flash flood episodes was well below average.

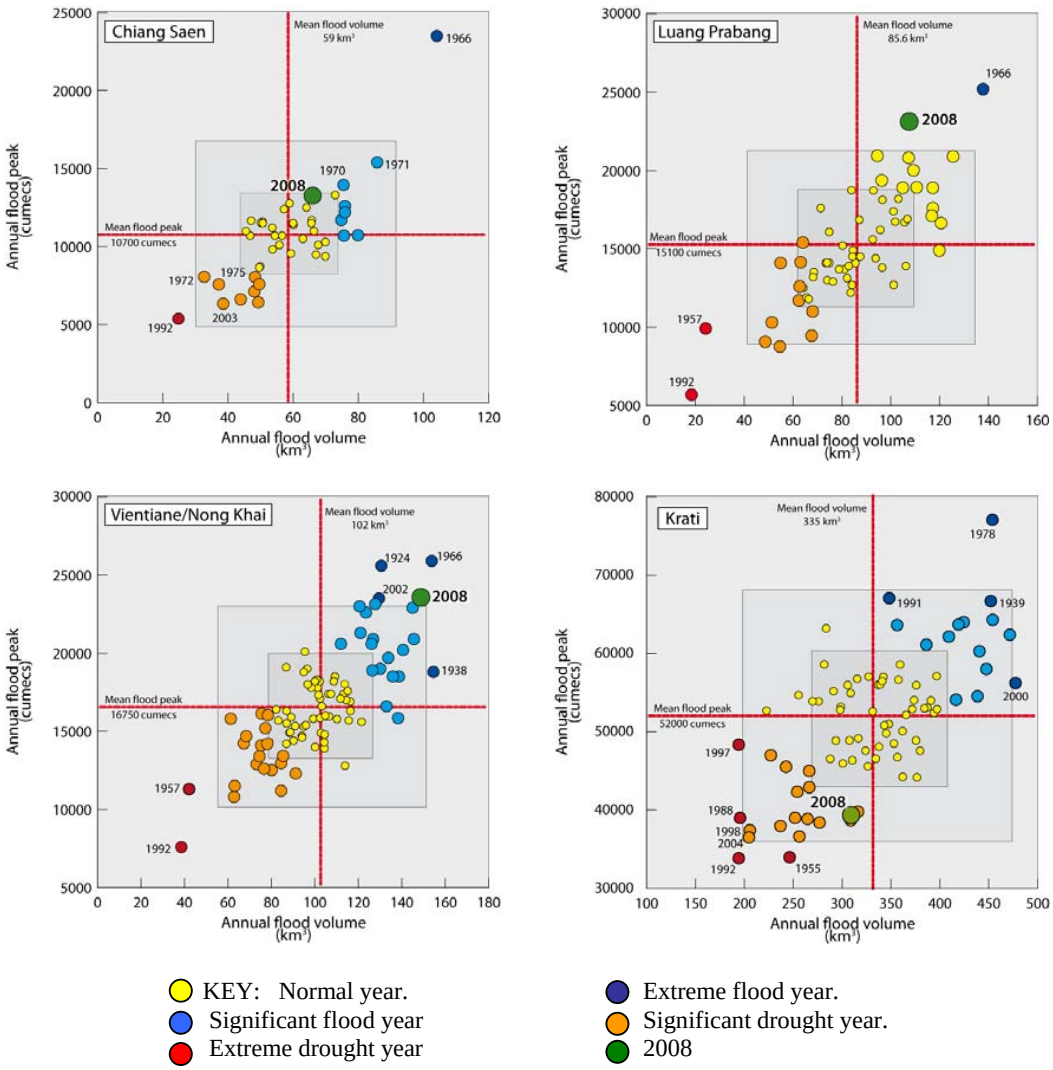

Figure 7. Scatter plots of the joint distribution of the annual maximum flood discharge (m^3/s) and the volume of the annual flood hydrograph (km^3) at selected sites on the Mekong mainstream. The 'boxes' indicate one (1δ) and two (2δ) standard deviations for each variable above and below their respective means. Events outside of the 1δ box might be defined as 'significant' flood years and those outside of the 2δ box as historically 'extreme' flood years.

Table 4. Estimated annual recurrence interval of the 2008 maximum flood discharge.

Mainstream site	Peak discharge	Recurrence interval
	(m^3/s)	(years)
Chiang Saen	13,300	1:7
Luang Prabang	23,100	1:30
Chiang Khan	23,200	1:25
Vientiane	23,500	1:25

LESSONS AND RECOMMENDATIONS

The 2008 season provided the first real opportunity to asses the performance of the flood forecasting models and expertise of the Regional Flood Management and Mitigation Centre (RFMMC) of the Mekong River Commission (MRC) in the face of an extreme event and in general they performed reasonably well, though obviously room for improvement is recognised. The major constraint to accuracy over lead times in excess of 2 to 3 days is the emerging conclusion that the storm rainfalls indicated by satellite images are probably too low and that the network available for ground truthing needs to be improved in key areas of Lao PDR in particular.

Otherwise the lessons and recommendations put forward in the four country reports generally repeat those of earlier years and focus up such issues as strengthening community based flood risk management and self reliance and building capacity within local communities with regard to flood preparedness and emergency response. A need is also recognized to improve the channels of communication between the local communities and the relevant flood forecasting, mitigation and response agencies. In Viet Nam once again attention is drawn to diverting more financial support for dealing with flash floods in the Central Highlands. Finally, a call is once more made to consider translating the Annual Flood Report into each of the four riparian languages.

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SESSION 2

TOWARDS INTEGRATED FLOOD RISK MANAGEMENT IN THE MEKONG RIVER BASIN

FMMP COMPONENT 2

STRUCTURAL MEASURES AND FLOOD PROOFING

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ABSTRACT

Component 2 (FMMP-C2) of the Flood Management and Mitigation Programme (FMMP) of the Mekong River Commission (MRC) has two objectives:

- to reduce the vulnerability of people living in the Lower Mekong River Basin (LMB) to the negative impacts of floods;
- to establish sustainable capacity in the MRC, Mekong River Commission Secretariat (MRCS), National Mekong Committees (NMC) and national line agencies.

The first objective requires the preparation of concrete measures at all steps that are crucial for a socio-economic and environmentally sound flood risk management.

Integrated Flood Risk Management (IFRM) is defined as applying the most attractive mix of all possible measures, hard and soft, for the reduction of flood damage risk. There are five steps: the first step in the process is the proper assessment of flood damage risk. Secondly, structural flood risk management measures. The third step involves the evaluation of the effects and impacts of the different types of measures and developing a strategy for flood risk management - for different types of flooding. In the fourth step, Integrated Flood Risk Management (IFRM) plans are to be developed on the basis of the four previous steps. These plans will 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.

The second objective will be met through a series of consultations and training sessions to the MRC, National Mekong Committees and national line agencies. Capacity building is also being applied through the implementation of selected demonstration projects. The implementation of the selected demonstration projects will apply IFRM planning exercises in a limited number of focal areas. From these exercises ‘best practice’ guidelines (BPG) for the preparation of flood risk management plans and for the evaluation of impacts of flood risk management measures will be developed.

Implementation of the Component is divided into three phases: The Inception Phase, Stage 1 and Stage 2. This paper introduces an overview of Component 2, progress and recommendations.

INTRODUCTION

On 4 July 2007 a contract was signed between the Mekong River Commission Secretariat (MRCS) and Haskoning Nederland BV, in association with WL|Delft Hydraulics and UNESCO-IHE, for a consultancy service for the Flood Management and Mitigation Program (FMMP). Consultancy services were initiated in September 2007 and will be completed by the end of September 2009. The implementation of the project is divided in three periods:

- Inception Phase : from October 2007 - January 2008;
- Stage 1 Implementation : from February 2008- October 2008;

- Stage 2 Implementation : from January 2009 – September 2009.

REVIEW OF THE INCEPTION PHASE

The inception phase was implemented in a four months period of which a substantial part was spent by consulting with the Mekong River Commission (MRC) and the riparian countries. An inception report was produced to present findings during the review process. These findings refer to the structuring of the project itself as well as to the assessment of the conditions in which the project will be developed. Based on these findings a design was presented for the next project implementation phase.

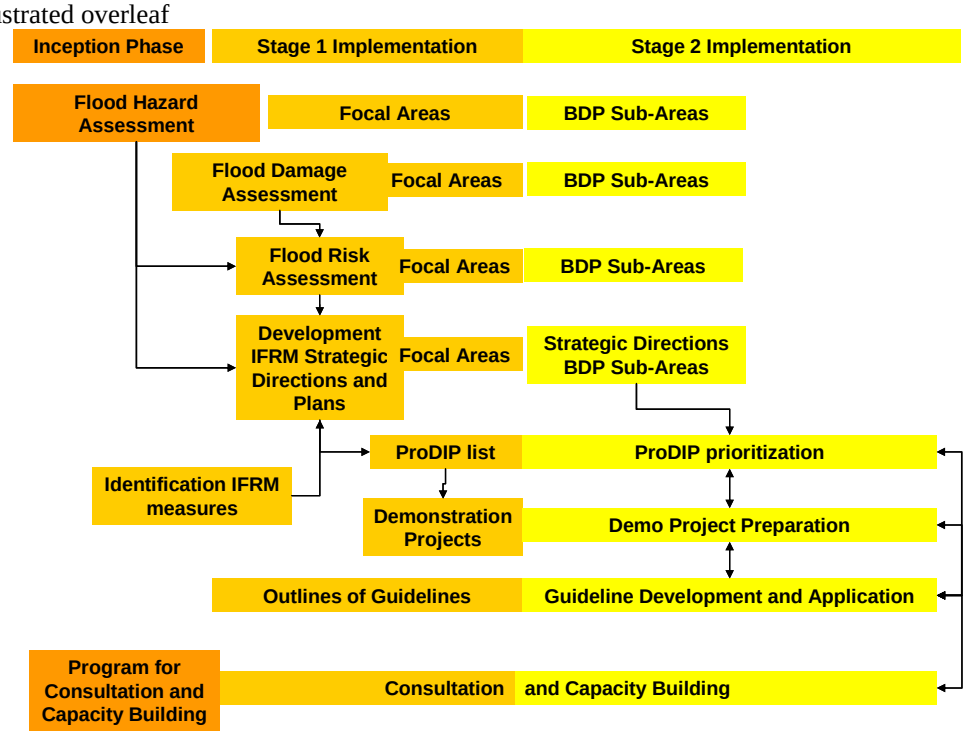
Project implementation

Upon the conclusion of the Inception Phase, the Stage 1 Implementation Phase started at the end of January 2008 and was completed at the beginning of August 2008. A detailed work plan was prepared for that period, in which the preparation of Integrated Flood Risk Management (IFRM) strategies and plans for the focal areas formed the core activity.

In order to be successful in the next phase, the following conditions had to be met: 1) an early selection of the focal areas: 2) Successful completion of the flood hazard assessment and mapping with the help of available modelling tools, 3) successful completion of flood damage data collection at district level and of the socio-economic surveys.

These conditions can only be met with good cooperation between the programme at the national line agencies. The form of such cooperation was agreed upon after the selection of the focal areas and the respective line agencies. Line-agencies' staff were assigned to the consultant's team. The cooperation with other FMMP components and MRC programmes, especially the Basin Development Plan (BDP) and Information and Knowledge Management Programme (IKMP), was crucial for the further development of the project.

The overall project schedule with consecutive stages of the Implementation Phase is illustrated overleaf



Guidelines

The IFRM guidelines for the BDP are to provide the MRC, National Mekong Committees (NMC) and National Line Agencies with guidelines for the assessment of the impact of development scenarios and projects on flood damage risk in the basin. In this respect it is important to bear in mind that flood damage risk has two elements: the flood hazard and the vulnerability, or potential damage. The guidelines for BDP will, therefore, not only address the assessment of impacts (positive or negative) on flood hazards, but will also address the impact of development scenarios and projects on the vulnerability, or potential flood damages.

Based on these observations the consultant plans to prepare Flood Risk Management (FRM) specific checklists for the different types of guidelines and use these checklists in the evaluation of the suitability of existing national guidelines for FRM specific issues.

Grouping of 'best practice' guidelines for the following topics is recommended:

- best practice guidelines for the evaluation of socio-economic and environmental impacts of flood management measures, these guidelines include also:
  - Best Practice Guidelines to assess the Socio-Economic and Costs of Flooding;
  - Best Practice Guidelines to assess the Socio-Economic, Environmental and other Benefits of Flooding;
- best practice guidelines for the development and design of structural and flood proofing measures, these guidelines include:
  - Best Practice Guidelines for Flood Proofing Buildings and Infrastructure in Urban and Rural Areas;
  - Best Practice Guidelines for the Use, Design, Construction, Maintenance and Operation of Structural Flood Mitigation Works and Floodplain Infrastructure;
  - Best Practice Guidelines to Control and Repair Riverbank Erosion;
- best practice guidelines for IFRM planning, these guidelines include:
  - Best Practice Guidelines for the Selection and Use of Soft Measures to Manage Flood Risks;
  - Best Practice Guidelines for the Selection of an Appropriate Mix of Hard and Soft Flood Risk Management Measures;
- Best Practice Guidelines to Evaluate the Impacts of Sub-area Development Scenarios on Flood Risks (IFRM guidelines for BDP).

The development of the guidelines will follow the IFRM planning process in the stage 1 implementation stage, while application and fine-tuning of these guidelines is envisaged in the preparation of the demonstration projects and the prioritization of the Project Development and Implementation Plan (ProDIP) during the final implementation stage.

Demonstration projects

The project aims on the one side at a basin wide introduction of IFRM, while on the other hand demonstration projects are to be prepared. Two approaches can be considered:

- demonstration projects are selected on the basis of rough sub-area IFRM strategies without going through the entire IFRM planning process;
- demonstration projects are selected on the basis of fully fledged IFRM planning exercises in a limited number of focal areas.

The second approach suits much more the purpose of capacity building and guideline development than the first one. The consultant has opted for the second approach and has pointed out a number of potential focal areas.

Consultation and capacity building

Based on the project approach and the training needs assessment a combined programme for consultation, workshops and training was drafted. Consultations will focus on the selection of focal areas and demonstration projects and the formulation of IFRM strategies. Workshops intend to present and discuss the outputs of the project. Finally stakeholder workshops are envisaged in relation with the individual demonstration projects.

The training plan aims at increasing sustainable flood risk management capacity of the target groups. It was planned for the following courses will be implemented during the stage 1 and stage 2 implementation:

- an introduction course 'Introduction IFRM concepts and planning in the Lower Mekong River Basin (LMB)';
- three training courses on Flood Risk Assessment (FRA) and the use of the guidelines.
- an on-the-job training related to the demonstration projects.

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.

REVIEW OF THE STAGE 1 IMPLEMENTATION:

During the Stage 1 Implementation phase the efforts concentrated on a number of focal areas spread over the LMB were selected in the Inception Phase. These focal areas are characterised by the different types of flooding and flood risks that occur in the LMB.

Component 2 involves also a programme of capacity building and training which was initiated in Stage 1 with courses on the basic concepts of IFRM in the four riparian countries. Follow-up courses on the application of the different guidelines will be given in Stage 2. The selected focal areas are:

- *in Thailand.* Lower Nam Mae Kok, regarding flood risk management at Chiang Rai (flash tributary floods) and near the confluence with the Mekong River (combined floods);
- in Lao PDR:
  - Bokeo Province, regarding management of erosion risk of the Mekong River bank;
  - Lower Se Bang Fai basin, regarding flood risk management in the area prone to combined floods;
- *in Cambodia:*
  - Kratie Province, regarding erosion risk management along the Mekong River in this province;
  - Right Bank Bassac River, regarding flood risk management in the floodplains south of Phnom Penh Municipality (delta flood);
  - Left Bank Mekong River, regarding flood risk management south of the National Road No 1 (delta flood);
- *in Viet Nam:*
  - Upper Se San Basin, regarding flood risk management in the upper mountainous catchment (flash flood);
  - Plain of Reeds (POR), regarding flood risk management in deep flooded areas (Delta flood) east of the Mekong River;

* Long Xuyen Quadrangle (LXQ), regarding flood risk management in the deep flooded zones (delta flood) west of the Bassac River.

The four delta focal areas in Cambodia and Viet Nam compose two trans-boundary areas, one east of the Mekong River and the other west of the Bassac River.

Priority investment (ProDIP) and Demonstration projects

In an intensive consultation process all riparian countries have nominated a number of flood risk management projects to include in the Project Development and Implementation Plan (ProDIP). The consultant has added to these lists a number of projects that emerged from the development of the strategic directions for the focal areas.

A first evaluation of these long-lists of projects was carried out by the consultants. In this evaluation the impact on risk reduction and on flood benefits were the key criteria. These evaluation results were discussed with the respective NMCs with the objective to arrive at short lists of the preferred 12 projects for Cambodia and Viet Nam each, and 6 projects for Lao PDR and Thailand each.

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

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

- *Risk Assessment Lower Nam Mae Kok Basin:*
  1. the results of the ongoing socio-economic surveys will be used for the elaboration of damage curves for the urban and rural districts in the province;
  2. hazard maps will be prepared with the help of hydraulic models under preparation of the Information and Knowledge Management Program of the MRC (IKMP);
  3. flood risk maps will be prepared for the province on the basis of the results of 1 and 2;
  4. measures for flood risk reduction will be formulated;
- *IFRM plans for Lower Se Bang Fai in Lao PDR and the West Bassac Region in Cambodia:*
  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 resource development scenarios in these areas;
  2. the plan will consist of a number of sub projects which will be formulated;
  3. terms of References (TOR) will be prepared for the preparation of priority projects of the IFRM plan;
- *Flood protection criteria in the Mekong Delta in Viet Nam*. This demonstration project will focus primarily on the methodology for the development of design criteria for diking schemes for flood protection in the Vietnamese part of the delta. The link between design criteria, flood risk and risk acceptance will be formulated. For areas with known flood risks it will be shown for different protection criteria what the economic impact is and what the residual risk;
- *Joint project for trans-boundary flood risk mitigation in the border zone between Viet Nam and Cambodia:*
  1. assessment of the impact of the existing flood risk management plans on both sides of the border on the flood risks in the Vietnamese and Cambodian part of the Mekong Delta;
  2. identification of measures in the border zone for mitigating the negative impacts on flood risk in the neighbouring country;
  3. formulation of a plan for flood risk mitigation in the border zone;
  4. preparation of a TOR for priority work for flood risk mitigation in the border zone.

Consultation and capacity building

National consultations were held in Stage 1 regarding:

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

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

The FMMP-C2 training program was initiated during Stage 1 with the training course 'Introduction IFRM concepts and planning in the LMB'.

In total 84 participants participated in the four training courses (Bangkok, Hanoi, Vientiane and Phnom Penh) and received a certificate. In general there was sufficient and good participation, both with regard to quantity and quality. In all four countries there were around 20 to 25 participants, partly (50% on average) from the NMCs, and the remainder from line agencies and/or other related parties/institutions. There were not many real decision makers from line agencies.

PRESENT THE STAGE 2 IMPLEMENTATION

Design and approach

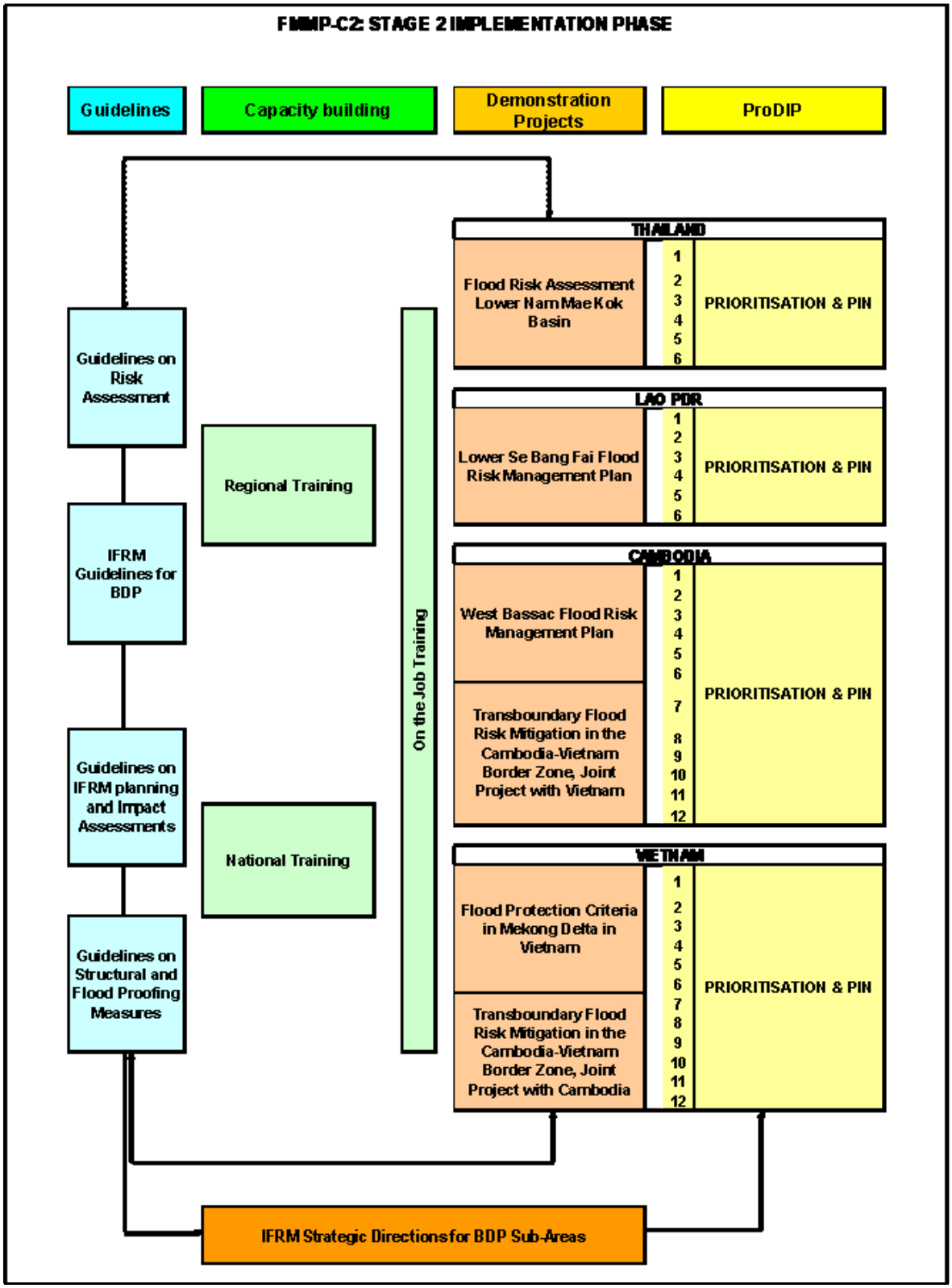
The approach that is proposed to be followed to achieve the main objectives and outputs of the FMMP-C2 during Stage 2 is illustrated in the schedule overleaf. It shows the four main outputs of Component 2:

- understanding of flood risks in the BDP Sub-Areas and strategic directions for their management;
- guidelines for Integrated Flood Risk Management;
- capacity building in IFRM practices;
- demonstration projects and list of priority investment projects.

Of special importance in the Stage 2 implementation is the interaction between guideline development, capacity building and the development of the demonstration projects is crucial. Guidelines are meant to be applied in the development of the demonstration projects. On the other hand, the development of the demonstration projects will provide lessons for improvement and/or fine tuning of these guidelines.

The application of the guidelines in the demonstration projects provides an excellent opportunity to work in groups where consultants and local experts will meet for 'on the job' transfer of technology. Furthermore, the training program focuses on the understanding and use of these guidelines.

Apart from creating synergy through interaction between the main elements of the project, this interaction is also indispensable from the point of view of available resources. The combination of activities related to guideline development, training and project development (ProDIP as well as Demonstration) is crucial for an optimum use of the limited resources.


FMMP-C2: STAGE 2 IMPLEMENTATION PHASE
Guidelines
Capacity building
Demonstration Projects
ProDIP
Guidelines on Risk Assessment
IFRM Guidelines for BDP
Guidelines on IFRM planning and Impact Assessments
Guidelines on Structural and Flood Proofing Measures
Regional Training
National Training
On the Job Training
THAILAND
Flood Risk Assessment Lower Nam Mae Kok Basin
1 2 3 4 5 6
PRIORITISATION & PIN
LAO PDR
Lower Se Bang Fai Flood Risk Management Plan
1 2 3 4 5 6
PRIORITISATION & PIN
CAMBODIA
West Bassac Flood Risk Management Plan
1 2 3 4 5 6
Transboundary Flood Risk Mitigation in the Cambodia-Vietnam Border Zone, Joint Project with Vietnam
7 8 9 10 11 12
PRIORITISATION & PIN
VIETNAM
Flood Protection Criteria in Mekong Delta in Vietnam
1 2 3 4 5 6
Transboundary Flood Risk Mitigation in the Cambodia-Vietnam Border Zone, Joint Project with Cambodia
7 8 9 10 11 12
PRIORITISATION & PIN
IFRM Strategic Directions for BDP Sub-Areas

Status of the stage 2

The Stage 2 Implementation Phase started in January 2009 with the implementation of the five Demonstration Projects. Progress of the Stage 2 Implementation Phase are summarised as follows:

Best practice guidelines

The development of best practice guidelines for flood risk assessments and for the preparation and evaluation of integrated flood risk management plans is well underway. IFRM is a relatively new subject in the MRC Member Countries. This allows the preparation of these guidelines more or less independently from existing standards and guidelines in these countries.

A common understanding of flood risk and its assessment is essential for effective dialogue between the MRC Member Countries on flood related trans-boundary issues. The BPG on FRA is currently being prepared by a number of experts and will be available before the Regional Training Course on this subject to be held during the last week of April in Phnom Penh.

ProDIP and demonstration projects

Two of the demonstration projects also involve the agricultural development potential that emerges once the floods are managed. These projects (West Bassac in Cambodia and Se Bang Fai in Lao PDR) call for an integrated approach and could produce a number of attractive investment projects for irrigation, drainage and flood control. Consensus has been achieved with BDP for a common approach in which FMMP-C2 takes the lead.

The preparation of demonstration projects has started and kick off meetings with the five Working Groups have been held during the third week of January 2009.

The flood hazard assessment for the five demonstration projects was undertaken and completed by the end of February 2009.

Public Participation Plans have been prepared for two DPs, Lower Se Bang Fai and West Bassac and documented in the technical notes.

Field data collection is ongoing to enable a comprehensive flood damage assessment in the DPs, a socio-economic data collection was defined and organized with teams in Viet Nam (for 33 districts) and in Cambodia (for 25 districts).

Consultation and capacity building

The five Working Groups (WG) have been established at the national level to assist and guide the consultant in the preparation of the demonstration projects. The WGs are providing comments to the consultant's technical notes.

Under the stage 2 implementation, the following training courses are planed to implemented:

- regional training course on Best practice Guidelines on Flood Risk Assessment;
- bi-national training courses on Best Practice Guidelines on IFRM Planning and Impacts Evaluation;
- bi-national training courses on Best Practice Guidelines on Structural and Flood Proofing Measures.

The training course on Flood Risk Assessment (FRA) is focussed on the use of the Best Practice Guidelines for FRA. The evaluation of impacts of basin developments on flood risks can be integrated in this course. This course will also cover the IFRM guidelines for BDP. The objective of the FRA training course aims at increasing sustainable flood risk assessment

capacity in the Lower Mekong Basin, by using the proper methodologies to flood risk assessment, including the hydrological and flood hazard assessments, vulnerability and damage assessment, flood risk mapping, and evaluation of the impacts of flood risk management measures.

The Regional training course on FRA will cover the following topics:

- introduction to FRA;
- meteorological and hydrological hazard;
- hydraulic analysis of flooding and flood hazard maps;
- vulnerability and damage assessment and flood damage maps;
- Flood risk assessment and mapping;
- use of BPG for FRA;
- parallel sessions for exercises on the use of Best Practice Guidelines for Flood Risk Assessment with a case study.

RELEVANCE TO OTHER MRC PROGRAMMES

Basin Development Plan Programme. The Flood Management and Mitigation Programme is linked to the Basin Development Plan Programme (BDP), like all MRC programmes. However, FMMP C2 has a very strong link with the Basin Development Plan, as Component 2 provides a number of direct inputs into the BDP, such as the Best Practice Integrated Flood Risk Management Guidelines and the Projects Implementation Development Plan (ProDIP). The first of these is guidelines to be used by the BDP for the assessment of flood impact in the analysis of scenario. The latter is a list of prioritised projects, which will be considered for further processing under the BDP-2.

Fisheries Programme. A special project under Component 2, called 'Best Practise Guidelines for Integrated Planning and Design of Economically Sound and Environmentally Friendly Roads in the Mekong Floodplains of Cambodia and Viet Nam' has touched on the topic of fish corridors and the way in which the fish may be impacted by the construction of environmentally un-friendly roads in the Mekong floodplains in Cambodia and Viet Nam.

Agriculture, Irrigation and Forestry Programme. The Agriculture, Irrigation and Forestry programme (AIFP) is in the process of developing a new agriculture component. The draft strategy has identified the need to increase the agriculture potential through small and large scale irrigation. Component 2 has suggested options to increase the agriculture potential in Xe Bang Fai in Lao PDR and in the West Bassac and East of Mekong areas in the Cambodian floodplain. These options fit well within the draft agriculture strategy, while there is good information regarding the characteristics of floods, damage caused by floods and flooding and the coping mechanism of farmers during floods in the LMB, which the AIFP can benefit from.

Environment Programme. The Environment Programme (EP) is a cross cutting programme of the MRC and basically all MRC programmes relate to the EP. Within the context of Component 2 many links are established with the environment sector.

Integrated Capacity Building Programme. Under Component 2 capacity building is being implemented with various courses on BPGs for IFRM and through consultations with representatives of line agencies and NMCs. All training materials will be made available to the Integrated Capacity Building Programme (ICBP), so information and replication of the courses for later use is facilitated.

RECOMMENDATIONS

The implementation of Component 2 is limited to the achievement of its outputs as indicated in the Component 2 document and further specified in the Terms of Reference of the RHL

consultancy services. In the context of C2 results and outputs link to poverty reduction and the Millennium Development Goals (MDG), the Component 2 of FMMP achievements run short. Donors emphasise the importance of 'outcomes' and 'impacts' of MRC programmes, indicating that outputs and results are only intermediate products, but the ultimate products deals with impact. How far have the final products of Component 2 contributed to impacts link to poverty and MDG? What changes have been generated by Component 2? How far have each country gone in starting to use the principles of integrated flood risk management and Best Practices Guidelines on road and floods in planning and construction? How far have these guidelines been embraced by concerned agencies and integrated or improved in each riparian country?

It is too simple to expect that Component 2 reports will be used properly, as these cannot be read easily by the majority of staff in riparian agencies. Even if translated, the material is too far off knowledge and national practices of the LMB member countries. This is a general shortcoming of the C2 and other FMMP components. This shortcoming might be relevant for other programmes of MRC as well. A follow-up process is required in order to facilitate the concerned agencies in a very practical manner to absorb the material, the products of Component 2. It is strongly recommended to look into the follow-up processes to understand the needs for real outcomes and impacts.

We can only conclude after the completion of Component 2 that a good job has been done, but only a few people will benefit from the results and outputs. In order to improve this there should be consensus between the working group, the dedicated line agencies, but also National Mekong Committees, the MRC Secretariat and Donors. Only through a consensus at all levels, modalities can be agreed to make the C2 products benefit many and to enhance the outcomes and impact of development activities.

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FMMP COMPONENT 1

SHORT AND MEDIUM-TERM FLOOD FORECASTING AT THE REGIONAL FLOOD MANAGEMENT AND MITIGATION CENTRE

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ABSTRACT

The first version of the new Mekong Flood Forecasting System based on the Unified River Basin Simulator (URBS) model and the Deltares Flood Early Warning System (Delft-FEWS) platform has been established at the Regional Flood Management and Mitigation Centre (MRC-RFMMC) of the Mekong River Commission (MRC). The new system was operated in 'test mode' during the 2008 flood season in conjunction with the existing Streamflow Simulation and Reservoir Regulation (SSARR) based system. The performance of the first test has been evaluated and compared to the existing system. The results show satisfying improvement of forecasts made by the URBS model at stations between Luang Prabang and Mukdahan. However, further improvements are required at some locations, especially in the area downstream of Pakse. After the 2008 flood season a second version of the system, coupled with the ISIS hydrodynamic model has been developed and the initial analysis indicates that on average there are significantly fewer errors than with the original version. An investigation at Vientiane during the August 2008 flood shows that the water levels were accurately predicted with the improved system.

The new flood forecasting system is currently capable of producing a medium-term forecast (up to 10 days). However, there is a need for further development and continuous improvement in order to obtain more accurate and acceptable forecasts. The possibility in providing medium-term forecast using the new system is discussed in the paper.

INTRODUCTION

The Regional Flood Management and Mitigation Centre (MRC-RFMMC) of the Mekong River Commission (MRC) completed the first version of the new MRC Flood Forecasting System based on the Unified River Basin Simulator (URBS) model (Carroll, 2007) and the Deltares Flood Early Warning System (Delft-FEWS) platform in May 2008. The new system was operated in 'test mode' during the 2008 flood season, running in parallel with the existing Streamflow Simulation and Reservoir Regulation (SSARR) based system. After the 2008 flood season the ISIS hydrodynamic model, used in the Mekong Decision Support Framework (DSF), was introduced to the system for the Cambodian Floodplain/Great Lake system and the Mekong Delta. In addition to the implementation of the ISIS model for the lower part of the Lower Mekong River Basin, some improvement of the URBS hydrologic models has also been undertaken.

This paper describes the current steps towards a state-of-the-art flood forecasting system inside the MRC-RFMMC. General overview of the new flood forecasting tools consisting of URBS, Delft-FEWS, and ISIS are briefly introduced. The post evaluation of system

performance (both existing and new systems), data availability for flood forecasting, as well as the possibility of providing medium-term forecast using the new system are also discussed.

BACKGROUND

The Mekong River Commission Secretariat (MRCS) basin-wide river flood forecast has been in operation since 1970, for the benefit of the riparian countries, i.e., Cambodia, Lao PDR, Thailand, and Viet Nam, while the MRC-RFMMC plays an important role in maintaining the availability of flood-related tools, data and knowledge; producing accurate regional forecasts with suitable lead time and a timely and effective dissemination. The core objective of the MRC-RFMMC is to establish an improved, robust and reliable flood forecasting system for short and especially medium term forecast periods. To that aim three main issues need to be tackled: improved, timely and reliable data availability; improved and extended use of rainfall forecasts; and improved flood forecast models.

The Regional Consultation Meeting on 1st December 2006 decided to implement the model URBS as a trial model for flood forecasting which is expected to replace the existing SSARR model. A suite of URBS models have been developed since 2007 by a modelling team, consisting of staff of the MRC-RFMMC and international consultants. In early 2008, the MRC-RFMMC decided to use Delft-FEWS as the flood modelling platform and in March 2008 a connection was made between Delft-FEWS and URBS. By June 2008, the first version of the new system was ready for testing and ran in parallel with the existing SSARR based system over the 2008 flood season. The system performance over the 2008 flood season was evaluated. A review of technical needs and requirements for using hydrodynamic models within the Mekong flood forecasting system was undertaken and the results led to the implementation of the ISIS hydrodynamic model in March 2009 as well as some improvement for the URBS hydrologic models.

DATA AVAILABILITY IN THE MRC-RFMMC

The MRC-RFMMC has been jointly working with the four riparian countries to improve and upgrade their hydrometeorological networks with the aim of achieving a reliable and timely data transfer/exchange for flood forecasting. Although the new flood forecasting systems are presently running with grid-based Satellite Rainfall Estimates (SRE) and Numerical Weather Prediction model (NWP) results, the system is capable of utilizing either the grid based rainfall or point rainfall data. It is anticipated that expanded network coverage and availability of real-time rain gauges, coupled with the grid based inputs, will lead to increased accuracy of the rainfall inputs.

Both the existing and new Flood Forecasting System (FFS) are based on hydrologic models, which use observed and forecast rainfall as well as observed water levels as the primary inputs. Water levels are mainly sourced from manual observations while there is an increasing use of data from the Appropriate Hydrological Network Improvement Project (AHNIP) and Hydrological Cycle Observing System (HYCOS) stations. At present both systems use rainfall inputs from the same data source; SRE and NWP from National Oceanic and Atmospheric Administration (NOAA). An accurate representation of the spatial and temporal variation of observed and forecast rainfall across basin is the key input for the improvement of forecast accuracy, especially medium and long term forecasts. The sensitivity analysis study of Malone (2009) shows that the current rainfall input from SRE and NWP is not sufficiently accurate to generate accurate flows within the basin, an accurate estimate of rainfall in time and space is critical to produce accurate flood forecasts. Malone (2009) also suggests that improvements in the collection of real time rainfall from the riparian countries should be ongoing and that a combination of ground based rainfall observations and SRE will give more realistic estimates of

the rainfall within the basin and thus lead to more accurate flood forecasts. Correction of the SRE and NWP with this near real time data is expected to lead to considerable improvements in short to medium term forecasts of flood flows.

In addition to the gridded rainfall estimates, daily rainfalls from several locations are collected. The software package, HYDMET, is the primary database management system by which rainfall and water levels observations are collected from the riparian countries and collated for use within the old and the new systems. In 2008 during the flood season, rainfall data were available at around 100 rain gauges. With the enhanced cooperation among the MRC-RFMMC and the member states on network improvement and data transfer, it is expected that in 2009 a number of up to 138 stations manual rain gauges will be available through HYDMET.

In addition, the MRC-RFMMC has successfully connected the Global Telecommunication System (GTS) rainfall data of the World Meteorological Organisation (WMO) to the new system by linking up with the Department of Meteorology (DOM) of Cambodia. One hundred and twelve stations covering the entire Mekong River Basin and surrounding areas are selected to be processed for the new flood forecasting system. An investigation for the reliability and daily availability of the GTS data shall be carried out during the 2009 flood season. Potentially, the MRC-RFMMC will have over 200 daily rainfall observations to calibrate the grid based rainfall estimates for input to the hydrologic models in the 2009 wet season.

NEW FLOOD FORECASTING SYSTEM

The new flood forecasting system consists of a suite of URBS Hydrologic models, and the ISIS Hydrodynamic Model coupled together in the Delft-FEWS Platform. The general overview of each tool is described briefly below.

URBS

The conceptual runoff routing model, URBS, is a hydrologic modelling program that enables the simulation of catchment storage and runoff response by a network of conceptual storages representing the stream network and reservoirs. It combines two hydrological modelling processes into one model:

- a rainfall runoff model, which converts the gross rainfall into net or excess rainfall;
- a runoff routing model, which takes the excess rainfall as input and converts it into flow.

During 2007, a set of 51 URBS models, covering over 740,000 km^2 and represented by over 2,244 sub-areas, were developed and calibrated. The Mekong River Basin was divided into four sections as shown in Figure 8. Forty eight of these models are runoff routing models which are linked together by three channel routing models from Chiang Saen to Kratie, the Tonle Sap system and from Kratie to Tan Chau/Chau Doc.

It should be noted that the models were calibrated using daily data from rainfall stations from the MRCs Hydrological Modelling System (HYMOS) database. Conversion of observed and forecast flows to heights is carried out by ratings in the form of look up table (fixed relationships between flows and heights) at selected locations. This conversion of modelled flows to forecast heights either via rating tables or a hydrodynamic model is another key element in producing accurate flood forecasts. Improved ratings will lead to significantly improved flood forecasts. There is some inconsistency in existing ratings which require further investigation (Malone, 2009).

ISIS HDYRODYNAMIC MODEL

ISIS is a generic 1D model for the simulation of unsteady flow in channel networks by providing an implicit numerical solver for the de Saint Venant equations. It has been developed jointly by Halcrow and Wallingford Software, both based in the United Kingdom. ISIS can be applied for a wide range of hydraulic problems, such as flood propagation, tidal flow and channel drainage. At selected intervals, it computes water levels and discharges on a non-staggered grid. Recently, ISIS has also been provided with a link to the 2D TUFLOW package, enabling the integrated modelling of flow in channel networks and through wide flood plains.

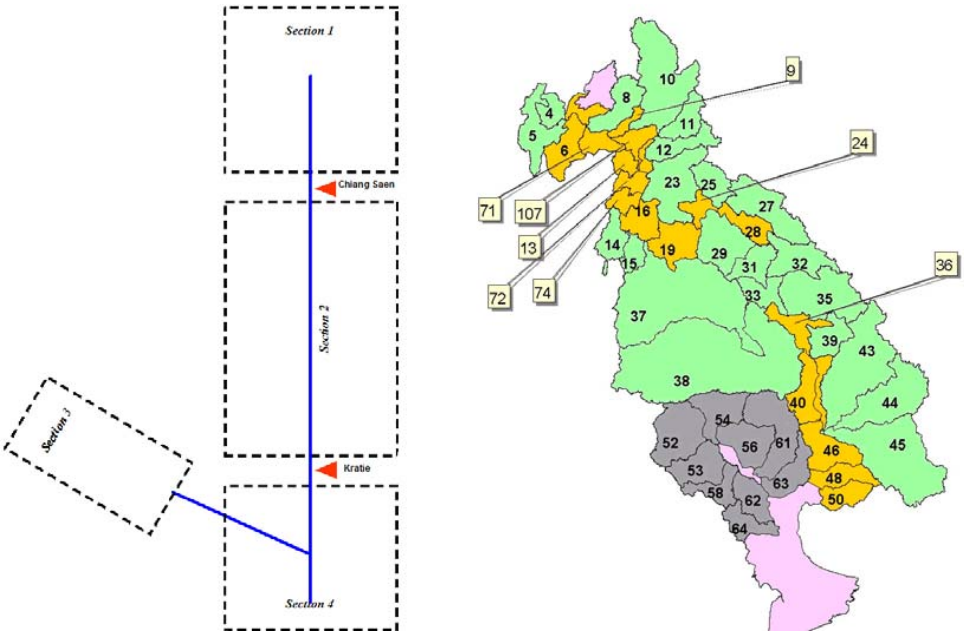


Figure 8. URBS Model

ISIS was introduced to the MRC under the Water Utilization Program (WUP) and now serves as part of the Decision Support Framework (DSF). The model covers the Mekong Basin from Kratie to the South China Sea, including the Tonle Sap Lake and Floodplain, the Cambodian floodplains and the Vietnamese Mekong Delta (Figure 9).

At the delivery of the model by Halcrow it was decided that further improvements had to be made in the model schematization and calibration. These were made in 2006 by the Southern Institute for Water Resources Research (SIWRR) in Ho Chi Minh City. Further improvements in the quality of the model are expected from a contract to be issued in 2008, based upon a review written by JBA Consulting (Mekong River Commission Secretariat (MRCS), 2008).

The ISIS model within the Delft-FEWS environment starts at Stung Treng instead of Kratie as in the DSF. Tributary inflows supplied to the model are obtained from the URBS. The extent of downstream boundaries of the model are beyond the influence of the flood flow, namely to the sea boundaries at the mouths of the Mekong (and the West Sea). Besides, the accuracy of the underlying Digital Elevation Model (DEM), the accuracy of a hydrodynamic model will be dependent upon the accuracy of the hydrologic inputs as well.

DELFT-FEWS

Delft-FEWS has been developed as a data management and modelling platform. On the one side, this platform is open to various data sources, supplying measured or forecasted weather

state variables, such as precipitation and temperature. On the other side the platform enables the generic coupling of a variety of hydrological/hydraulic flood routing models. The data management platform of Delft-FEWS has been equipped with generic tools providing a variety of data handling tasks, such as data validation, interpolation, aggregation and error correction in forecasts, including a variety of visualization and forecast dissemination options. One of the most important requirements is the ability to integrate both new and existing simulation models and data streams on the basis of an open-architecture design of the system. Such design will allow for the reuse of existing hydrological and hydraulic flood routing models that form the core of already pre-existing forecasting systems or that are already in use for flood management. Only minor adaptations in Delft-FEWS are required to plug existing sets of models into the novel framework (Verwey, 2006).

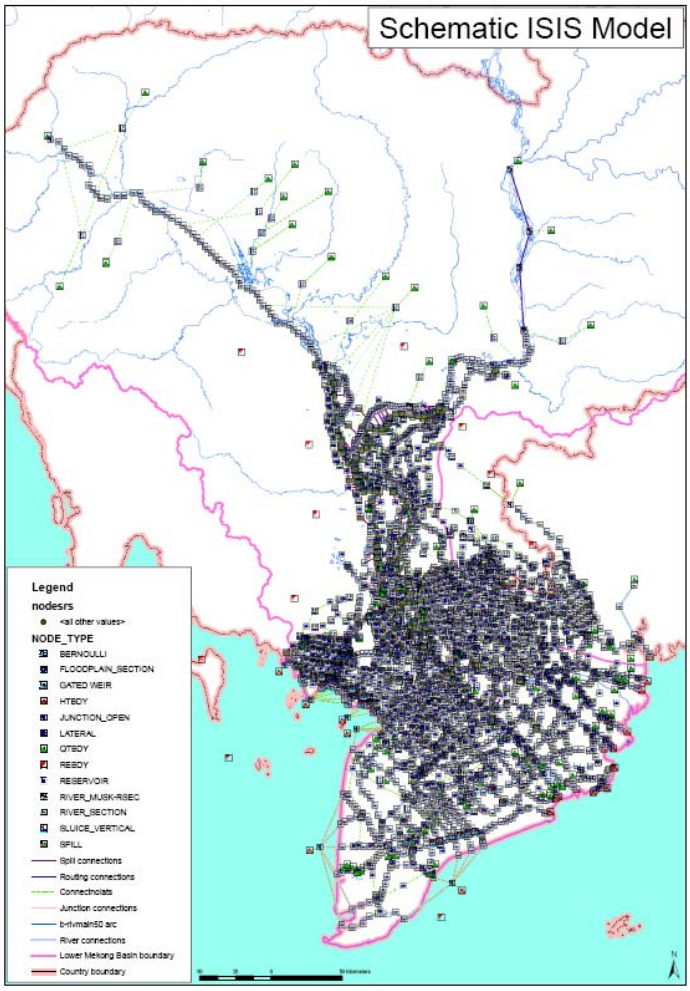


Figure 9. Current ISIS schematization for the Mekong Delta

The MRC's Mekong-FEWS collates rainfall and water level inputs, runs the set of URBS models, manages the model results and publishes the flood forecasts. The first version of the FEWS with the connection of URBS models (in Phase I) is a standalone application run on a Windows platform and has excellent utilities to manage and display rainfall and observed and forecast water level and flow data. It also incorporates an autoregressive moving average (ARMA) error correction module which is applied to the key locations along the mainstream.

Workflows in FEWS have also been defined for four sections (Upper to Chiang Saen,

Chiang Saen to Kratie, the Tonle Sap system and Kratie to Tan Chau/Chau Doc). However after the system performance of the first version was evaluated, it was decided that the mainstream routing model of section 2 be broken up into sections containing fewer stations to ascertain if this improves forecast stability and accuracy. Breaking up the Section 2 model into smaller sections improved the way matching and the ARMA error correction module was applied, leading to improve stability and accuracy in the forecasts. Hence, during March 2009, the mainstream routing model was divided into 4 sections: Chiang Saen to Luang Prabang, Luang Prabang to Nong Khai, Nong Khai to Pakse and Pakse to Kratie. The ARMA corrected output from one section becomes the input signal for the next mainstream model. Moreover the rating at Vientiane has been updated in the new version. Initial tests indicate that this break-up of section 2 results in improved forecasts at mainstream locations. In addition to breaking the routing model into small sections in the latest version of the FEWS, linkage between ISIS model and URBS model has been made inside FEWS as well. The performance of the improved models will be discussed in more details in the next section.

Apart from the modelling improvement/development work, FEWS itself has been moved to a client-server system which is now ready for testing during the 2009 flood season. The advantages of FEWS client-server system are that users in different offices are able to connect the system via MRC-RFMMC network, synchronizing with the central database (PostGresSQL) when they need data, run the system and view the results on the central database on their own machines.

ASSESSMENT OF SYSTEM PERFORMANCE

In order to evaluate the performance of URBS models as a new hydrological model for the flood forecasting system, their performance must be compared with that of SSARR model. The comparison was carried out over the three months period from July to September for one to five day forecasts at ten mainstream stations from Chiang Saen to Pakse. Forecasts at stations downstream from Stung Treng are not compared since they are derived using regression models in the current system.

The Mean Absolute Error (MAE) has been adopted as the major measure of performance since it is a reliable indicator of error magnitudes and is a robust measure. It is found from the results of assessment over the three months period for above-mentioned stations that 60% of forecasts made by URBS were more accurate than the forecasts made by SSARR. Significant improvements were found at Luang Prabang, Chiang Khan, Savannakhet and Mukdahan. The forecast accuracies at Chiang Saen, Nakhon Phanom, and Thakhek using URBS are comparable with SSARR while the forecasts made using SSARR at Pakse are marginally better than the URBS model. An assessment undertaken for a peak of August 2008 points to the same conclusion but the accuracies at above-mentioned locations were much better.

As described in the previous section, in March 2009 additional works were carried out to improve the performance of URBS model by breaking up the Section 2 model into four sub-sections as well as adjusting the rating at Vientiane. It was found that forecasts made by the new version of URBS model (version 2) are 86% better that those made by SSARR (26% increase from the first version). Improvements were found at all locations except at Pakse where the forecast using SSARR are still better.

Figure 10 compares the performances of the forecast at Vientiane made by SSARR, URBS v.1, and URBS v.2 between 10th and 15th August 2008 before and after the water levels reached the flood stage. It is clearly seen that the URBS v.2 remarkably outperformed both SSARR and the previous URBS v.1, particularly the predicted levels are most of the time fitted to the observed levels. When water levels were rising, SSARR tended to underestimate the water level beyond the two-day forecast, whilst URBS v.1 tended to overestimate the water level beyond the three-day forecast. However all models provide accurate forecasts during the flood recession.

It can be concluded from the overall spatial and temporal assessments as illustrated in Figure 11 that both versions of URBS perform better than SSARR over the assessment period. It is quite impressive that the forecast accuracies are much improved with the updated URBS v.2 model.

For stations downstream of Pakse, the forecasts made using URBS are poorer than the forecasts obtained from the regression models. This prompted the implementation the ISIS hydrodynamic model for areas downstream of Kratie with the assumption that the hydrodynamic model will possibly give better results than the current hydrological model in the southern part of Lower Mekong River Basin for the floodplains, Great Lake system and the Mekong Delta. The first test results with ISIS are promising, but evaluation of the results for the 2009 flood forecast have to be analysed to be able to draw any conclusion.

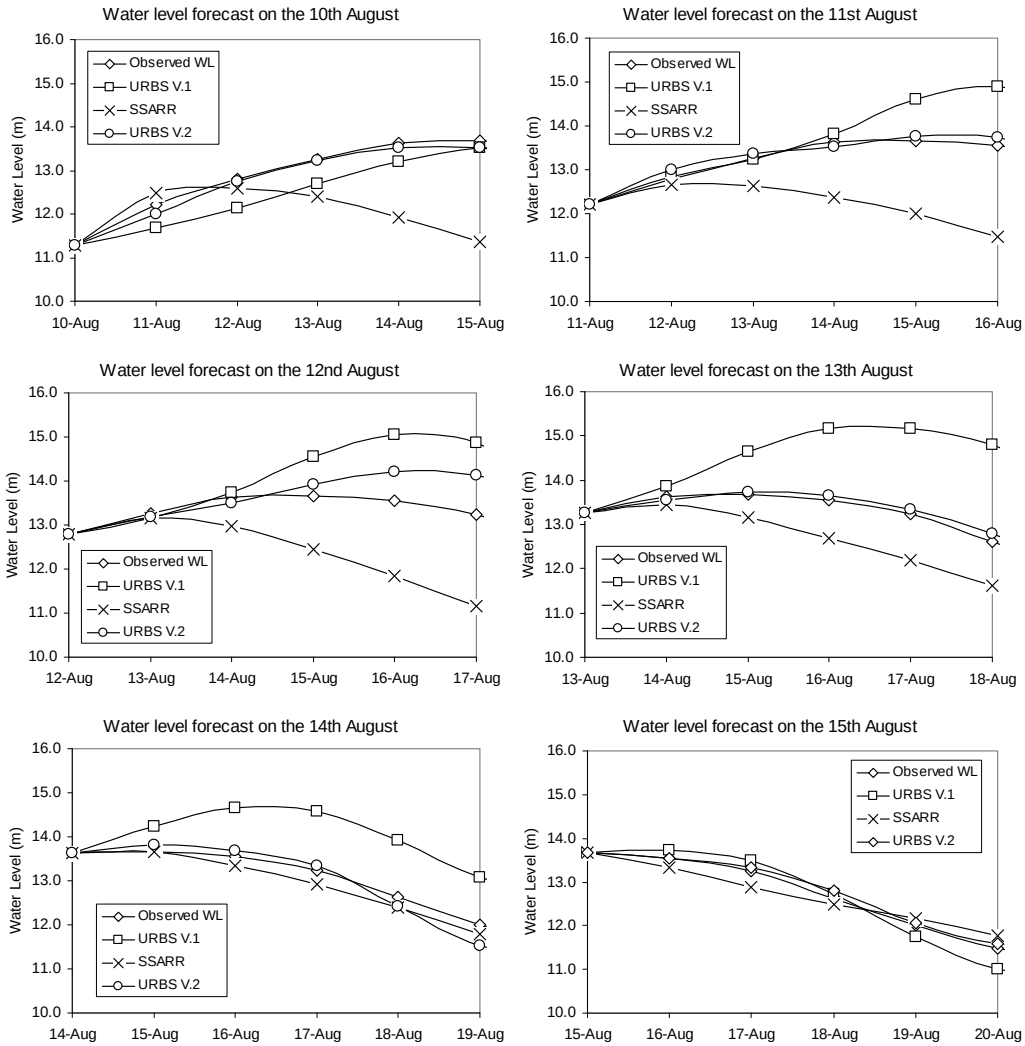
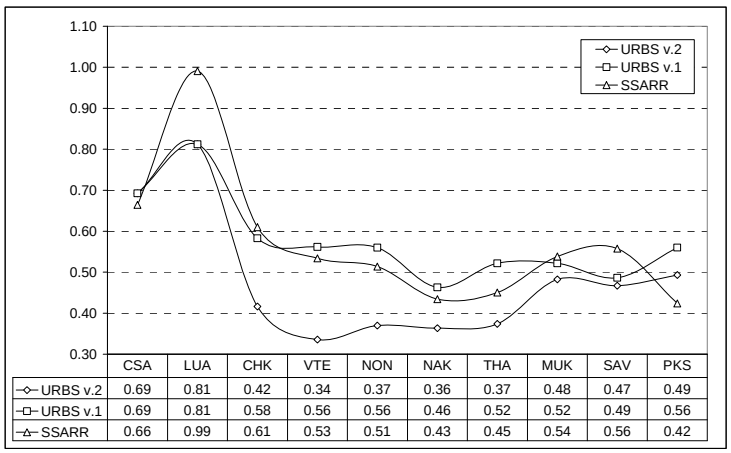


Figure 10. Performance of the one-to five day forecasts of water levels at Vientiane between 10th and 15th of August 2008

MEDIUM-TERM FLOOD FORECAST

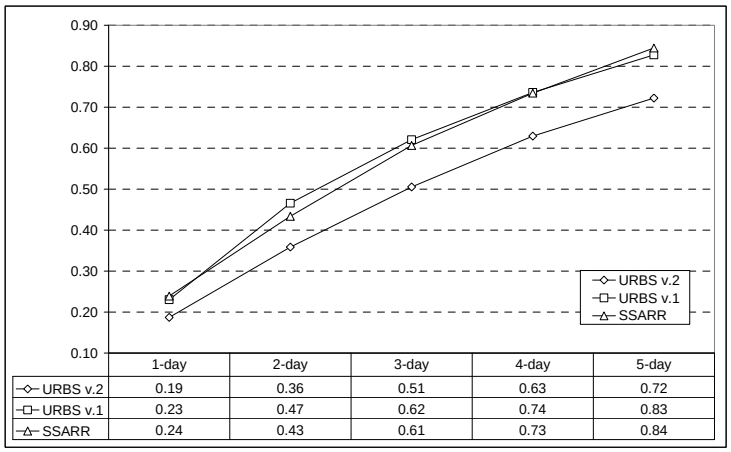
The May 2006 Road Map Mission (Malone, 2006) recognized that extension of the forecasts to medium-term and the introduction and development of improved hydrological models was a major step towards the improvement of flood forecasting services of the MRC-RFMMC. The requirements of the countries differ reflecting the different physical situations. In the Mekong basin, flood forecasts are defined in terms of lead times as follows:

Forecast	Lead times
Short-term	1 to 5 days
Medium-term	6 to 15 days
Long-term	Greater than 15 days



	CSA	LUA	CHK	VTE	NON	NAK	THA	MUK	SAV	PKS
URBS v.2	0.69	0.81	0.42	0.34	0.37	0.36	0.37	0.48	0.47	0.49
URBS v.1	0.69	0.81	0.58	0.56	0.56	0.46	0.52	0.52	0.49	0.56
SSARR	0.66	0.99	0.61	0.53	0.51	0.43	0.45	0.54	0.56	0.42

1. Average errors of 10 stations for 1-day to 5-day lead times over 3 months from July-September 2008



	1-day	2-day	3-day	4-day	5-day
URBS v.2	0.19	0.36	0.51	0.63	0.72
URBS v.1	0.23	0.47	0.62	0.74	0.83
SSARR	0.24	0.43	0.61	0.73	0.84

2. Average errors of 1-day to 5-day lead times between Chiang Saen and Pakse over 3 months from July-September 2008

Figure 11. Comparison between SSARR and URBS (v.1and v.2)

The current practice is to provide short term forecasts, one to five days, for 21 locations along the main stream. As demonstrated above these short term forecasts show improved accuracy in the new flood forecasting system.

Forecast rainfall is currently available for six days and coupled with in-stream travel times, this means that the new flood forecasting system is capable of producing medium-term forecasts (up to 10 days) for locations downstream of Kratie.

The performance assessment of the medium-term forecast made by URBS (with zero rainfall after six-day) over the three months in August 2008 reveals that there is an average error

increase of about 0.25 m from the five-day lead time forecast to the ten-day lead time forecast. It is also found that the gaps of error between each lead time beyond six days become smaller.

To extend the lead time beyond 10 days requires additional rainfall input beyond the six-day forecast currently available. Assuming zero rainfall, the present situation, is clearly incorrect in the context of a Mekong wet season and will lead to under-estimation of medium to long term forecasts (Malone, 2009). It is feasible that the forecast rainfall, and thus the forecast lead times, could be extended beyond six-days by incorporating a time series of historical catchment rainfall averages for each hydrologic model in the system. These series have already been derived during the model calibration and methods to incorporate them in FEWS may be investigated in near future.

Short-term forecasts, usually based on observed upstream water levels, can be accurately provided by regression models used by both the MRC and in riparian countries. To meet the medium to long term requirements of the riparian countries, forecasts must be based on forecast rainfall from the NWP and historically similar rainfall patterns. The inclusion of this forecast rainfall will provide increased lead times but also lead to increased uncertainty for the longer lead times.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The new Mekong Flood Forecasting System offers an increased ability to provide satisfactory and more accurate forecasts at more locations within the basin and, depending on the rainfall inputs, offers the possibility for longer lead times. It is considered that the new system is more user-friendly, reliable and robust because it is less dependent on missing data and provides a platform for the incorporation of new models. The new system is ready for the coming 2009 flood season although further investigation shall be made in the meantime in order to improve and strengthen the system performance even further.

The need for more accurate medium to long term flood forecasts for the Mekong River Basin has been recognized by the member countries as a core function of the MRC-RFMMC. The MRC-RFMMC recognizes these needs and strives to meet them by implementing an ongoing programme of continuous upgrades to data, models and systems, in conjunction with more highly trained and experienced forecasters.

Recommendations

A number of recommendations are listed as follows:

1. ongoing development, maintenance and the introduction of new sources of data, models and model types should be a feature linked to the requirement for ever increasing flood forecast accuracy of the MRC-RFMMC;
2. the MRC-RFMMC has been working to enhance the hydrometric network over the Lower Mekong River Basin (LMRB) leading to increasing numbers of real-time rain gauges. Although the gauge network should still be considered sparse and not spatially complete, there is a challenge to investigate how the model performs with the currently available gauge dataset;
3. it is recommended that the MRC-RFMMC investigate a correction/calibration method to match the SRE data set to ground truth data so that the rainfall estimates will be improved prior to be input to the forecasting system;
4. performance of the ISIS model in the Cambodian Floodplain and the Delta shall be closely monitored during the 2009 flood season and then compared with that of the Regression Model;
5. further evaluation for the system's performance of the medium to long term forecasts

using historically similar rainfall patterns must be investigated.

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FMMP COMPONENT 3

ENHANCING COOPERATION BETWEEN MEKONG RIVER COMMISSION (MRC) MEMBER COUNTRIES IN ADDRESSING TRANS-BOUNDARY FLOOD AND RELATED ISSUES

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ABSTRACT

The objective of Component 3 (FMMP-C3) of the Flood Mitigation and Management Programme (FMMP) is to strengthen cooperation and capacity of the National Mekong Committees (NMC) and line agencies in addressing and resolving differences and disputes in trans-boundary flood issues.

Under the FMMP-C3 a number of key documents was produced and outputs have been achieved. Among others, the three key working papers and the design and implementation of the Capacity Building Programme (CBP) – Phase I are the most important outputs and achievements of the component to date. The key working documents are Trans-boundary Flood Issues Identification, The Legal Aspects of the Mandate of the 1995 Mekong Agreement for Enhancing Cooperation in Addressing Trans-boundary Floods and Related Issues (LA-MA95), and An Explanatory Notes - Manual to the LA-MA95.

Capacity building programme aims at to provide tailor made training to the Mekong River Commission (MRC), NMCs and line agencies in addressing trans-boundary floods and related issues, which is also the ultimate goal of the FMMP-C3.

Implementation of the component started in mid 2007. It will be completed by the end of 2010 with significant financial support from the Government of the Netherlands. The Capacity Building Programme Implementation Plan - Phase 1 (CBP Phase 1) was finalised in December 2008. The implementation of CBP Phase 1 has started in March 2009 and will be completed in November 2009. Implementation of Phase 2 of the Capacity Building Programme schedules for 2010.

This paper introduces an overview of Component 3, key achievements and recommendations.

INTRODUCTION

In 2001, the Mekong River Commission (MRC) Council adopted the Flood Management and Mitigation (FMM) Strategy. The following year, the MRC developed a FMM Strategy Implementation Plan (FMMSIP), which provides an overall framework for implementing various components of the MRC Flood Management and Mitigation Programme (FMMP), including Component 3. This component promotes cooperation and mediation as a key strategy for addressing trans-boundary flood issues.

It follows the objective of the MRC Strategic Plan for 2006 – 2010: ‘to identify potential trans-boundary issues for negotiation, mediation and conflict prevention, and to develop mediation and conflict management capacity’.

It is very clear that the Mekong River Commission Secretariat (MRCS) has an important role in supporting the MRC Council, Joint Committee (JC) and the MRC Member Countries by

gathering, assessing, and analysing data, information, and report preparations in a routine manner. It is also specifically requested by the JC to conduct other forms of analyses, set up meetings, field trips, or to provide potential independent experts or organisations to assist in addressing development or conflict issues. Certainly, the role of the MRCS is important in facilitating the enhancement of cooperation and avoidance or mitigation of incidents that may give rise to differences and disputes.

In the process of identifying the Trans-Boundary Flood Issues (TBFI), the MRC Member Countries grouped the main constraints to better addressing issues, differences and disputes in three areas:

- *knowledge-related* constraints limit access to reliable information on structural development plans including standard design criteria and policies. Better access to and operation of appropriate tools would help to improve understanding of causes and effects;
- *policy, governance and institutional* constraints refer to differences in administrative, institutional and policy frameworks in the four Member Countries;
- inadequate *financial and economic* resources are another important constraint. In the Lao PDR, for example, joint studies of bank erosion require considerable funding for which budget allocation is insufficient.

The support required from MRC to the MRC Member Countries presented in two groups: technical and administrative support.

Technical support would focus on:

- information and knowledge generation and exchange to improve factual evidence of causes, effects and impacts. This includes science-based clarification and awareness raising, information exchange, joint fact-finding missions and studies, and harmonisation of policies and regulations;
- development and application of tools to reduce complexity so that causes and effects become sufficiently clear to allow effective response strategies to be identified. The suitability of tools would be demonstrated and tested within specific pilot study;
- capacity building in impact assessment to provide a framework and develop analytical capacity for value-based discussions on trade-offs between beneficial and non-beneficial impact. The underlying assumption here is trust and confidence among the parties involved.

Administrative support focuses on:

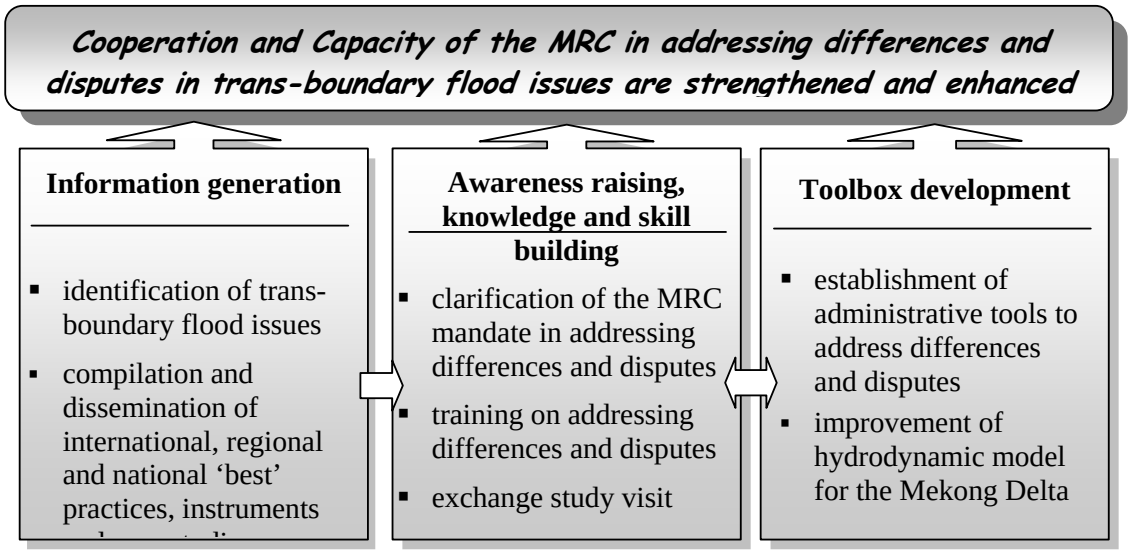
- ensuring adequate stakeholder participation with senior technical and administrative representatives of line agencies, including national and provincial levels if required;
- developing and agreeing on processes and procedures that provide sufficient scope for factual and information-based discussions resulting in strategies and actions;
- ensuring progress, continuity and sustained interest in the process through awareness raising, conflict prevention, management and funding.

From the above findings, Component 3 of the FMMP developed to strengthen cooperation and enhance the capacity of the MRC to address differences and disputes in trans-boundary flood issues.

FMMP-C3 has identified three main outputs: 1. ‘Information Generation’, 2. ‘Awareness Raising, Knowledge and Skills Building’ and 3. ‘Toolbox Development’ as presented in the following figures.

The outputs have been designed such, that the products of output 1 and output 3 will feed into the activities under output 2. By mid 2008, output 1 and 3 had largely been accomplished, creating suitable conditions for initiation of activities under output 2. The activities mentioned under output 2 are being carefully integrated as part of the training and reference materials for

the Capacity Building Programme.



Integrate Technical and Legal Aspects of Trans-Boundary Flood Issues, Differences and Disputes (TBIDD). Addressing TBIDDs is not only a legal, technical, social, economic, or political matter; it is the combined and concentrated effort of all disciplines, all levels of government, and all stakeholders (public and private). It is important to integrate not isolate technical and legal matters related to the identification, addressing and resolving trans-boundary water issues.

INTRODUCTION ON THREE WORKING DOCUMENTS

The three key working documents were prepared and endorsed by MRC Member Countries as working papers to support MRC, NMCs, and concerned line agencies to address the TBFIs. These working papers are: 1) trans-boundary Flood Issues Identification report (TBFII), 2) The Legal Aspects of the Mandate of the 1995 Mekong Agreement for Enhancing Cooperation in Addressing trans-boundary Floods and Related Issues (LA-MA95), and 3) an Explanatory Notes - Manual (EN-M) to the LA-MA95.

Trans-boundary flood issues in the Mekong River Basin

The MRC Member Countries, with assistance and facilitation from the FMMP, have jointly identified trans-boundary flood issues (TBFI) through a bottom-up and intensive participatory approach. The identification of TBFIs aims to build common and better understanding among the Member Countries regarding trans-boundary flood issues in the Mekong River Basin, as well as ways that the countries could or would like to address these.

The identification process of trans-boundary flood issues in 2006 followed a highly participatory bottom-up approach, which the consultation process started first with provincial, national and then bilateral and regional levels with the full involvement of National Mekong Committees and national agencies.

The report was prepared by W. Hundertmark, International consultant of FMMP-C3. It summarizes the results of regional consultations on trans-boundary flood issues in the Lower Mekong River Basin by Component 3 of the MRC Flood Management and Mitigation Programme (FMMP). Consultations were held to prepare for the successful implementation of

the component. During a regional workshop in October 2006, MRC Member Countries confirmed their support for enhanced cooperation activities. They also agreed that trans-boundary flood issues need to be identified before developing the work plan and activities of the component.

The adopted working definition of trans-boundary flood issues is: 'any existing or potential substantial adverse impact on the natural, economic or social environment within an area of a Riparian State resulting from a change of the water conditions during the flood season and/or during the occurrence of floods of the Mekong River System caused by a human activity, originating wholly or in part from within one or more areas of one or more other Riparian States' (WP TBFI report). In the TBFI report, the application of the term 'trans-boundary flood issues' includes both natural origin floods and floods caused or worsened by human influence or human interventions.

Six broad groups of trans-boundary flood issues related to:

- floodplain development within the Mekong Delta;
- upstream development in the Lower Mekong River Basin that has an impact on the Mekong Delta;
- upstream hydropower development in the Upper Mekong River Basin;
- hydropower project development and operation in the Se San, Srepok, and Se Kong river basins;
- bank protection and port development, sand excavation, dam-operation communications in the upper reaches of the Mekong mainstream;
- increased flooding on tributaries in northwest Cambodia.

Those groups were mutually identified by the MRC Member Countries based on the information provided in the national reports and the agreed working definition of trans-boundary flood issues.

Using the working definition of trans-boundary flood issues, the validity of each group was checked by identifying the main causes, effects and impact. The issues require specific response strategies and actions to be addressed by enhanced cooperation based on technical and administrative priorities, capacity and support needs.

Consultations with MRC Member Countries unanimously identified bilateral and multilateral arrangements as the preferred mechanisms. Strategies would have to:

- build on existing bilateral mechanism supported or facilitated by the MRC Secretariat in general and Component 3 in particular;
- share experiences and lessons learnt from bilateral mechanisms, expanding them to the multilateral and regional level where appropriate;
- strengthen multilateral mechanisms such as the Mekong dialogue partnership by providing suitable tools and services from the MRC Secretariat (relating to Upper Mekong River Basin developments and global concerns associated with climate change).

It was strongly suggested that trans-boundary flood issues must be managed in a coordinated manner, promoting inter-governmental and inter-agency cooperation while being based on integrated water resource management (IWRM) principles. With the involvement of the MRC Secretariat, the status of existing mechanisms will be raised and the technical profile and capabilities of members strengthened.

Support strategies will include technical and administrative aspects that respond to the specific needs of the main stakeholders and the contexts of MRC Member Countries. Important opportunities for cooperation exist within MRC programmes and through regional technical assistance being prepared by the Asian Development Bank and the World Bank with close MRC involvement.

Working Documents on The Legal Aspects of The Mandate of The 1995 Mekong Agreement for Enhancing Cooperation in Addressing Trans-boundary Floods and Related Issues (La-Ma95) and an Explanatory Note – Manual (En-M)

In the October 2007, FMMP published the MRC Joint Committee approved 'The Legal Aspects of the Mandate of the 1995 Mekong Agreement For Enhancing Cooperation in Addressing Trans-boundary Flood and Related Issues' (LA-MA95) prepared by George E. Radosevich, FMMP Senior International Legal Advisor.

The LA-MA95 is approved as the working paper (WP) to be used as a 'reference document' within the MRC and Member Countries to provide a common understanding and facilitate in addressing and resolving flood and related issues, differences and disputes under the framework provided in the 1995 Mekong Agreement. This WP is not intended to nor does it limit the interpretations of the Member Countries or their respective MOFAs on the legal issues and provisions of the MA95.

The WP developed out of the first efforts under FMMP to implement Component 3, beginning with national and regional consultations. At that time the title of Component 3 was 'Mediation of Trans-boundary Flood Issues.'. Upon review of the MA95 and the flood and related issues of the Mekong River Basin, it was concluded the original title was not a correct reflection of the key focus to be addressed in a mandate paper on the broader project objective of flood management and mitigation. Consequently, the title of Component 3 was agreed to be changed to 'Enhancing Cooperation in Addressing Trans-boundary Flood Issues' as a more accurate description of the MA95 intentions and expectations on addressing differences and disputes. That firstly tries to avoid or mitigate such circumstances through cooperation, and should harm or damage occur, then to apply a series of approaches set out in the MA95 and consistent with international law.

This document consists of five chapters and five annexes. Chapter 1 is a brief statement on the nature of trans-boundary differences and disputes, the nature of the Mekong River Basin and its international characteristics and key events leading up to the 1995 Mekong Agreement. This is followed by a brief discussion of the background and intent of the MA95. Chapter 2 analysis details the mandate of the MA95 and role of MRC in conflict prevention and dispute resolution. Chapter 3 elaborates the past and current role of the MRC in enhancing cooperation and preventing disputes through cooperation and conflict management mechanisms of the Mekong Agreement. Chapter 4 provides a brief background into the international law applicable to addressing riparian issues. The final Chapter proposes the steps and processes for addressing trans-boundary contentious issues, differences and disputes within the context of the 1995 Mekong Agreement, and briefly sets out the mechanisms within the MRC Secretariat to facilitate and coordinate mitigation and resolution of flood and related issues within structure of the MRC, e.g., Council and Joint Committee and its Member Countries.

Draft document of Explanatory Note – Manual (EN-M) on LA-MA95

The objectives and purposes of this explanatory note-manual are to produce a practical explanatory note /manual that addresses the resolving of flood and related water trans-boundary issues, differences and disputes (TBIDDs)[7] for the Lower Mekong River Basin riparian nations that is also applicable to the Upper Mekong River Basin riparian nations. This EN-M is a complimentary and supplementary reference document to the LA-MA95 manual to be used in conjunction with the LA-MA95 and not a stand-alone document. It provides a range of information and materials to compliment the LA-MA95 and supplement the more brief discussion in that document for practical use by the involved parties and for CBP training on

[7] The use of this acronym (TBIDD) in EN-M report is broader than defined and applied in the FMMP TBFI Identification Report of October 2007 in that the latter confined TBFIs to those caused through human interventions and did not include those caused by nature or exacerbated by human interventions.

this topic. This Explanatory Note-Manual, also prepared by Dr. Radosevich, will be referred to as EN-M.

The *purposes* of these two documents (EN-M and LA-MA95) are to facilitate understanding and cooperation amongst the concerned parties and all Lower Mekong River Basin riparian in identifying and avoiding or mitigating contentious trans-boundary issues and to address and resolve by peaceful and mutually acceptable means those TBFIs remaining or that become differences or disputes.

TBFIs include both those of natural origin and floods caused or worsened by human activities and/or interventions. Natural TBFIs may be identified and mitigated through cooperation, while floods caused or worsened by human activities and interventions may pose a contentious issue, difference and dispute, which needs addressing and resolving. The *focus of the two documents is mainly on man-made flood impact*, as these potentially cause differences and disputes between parties concerned.

These two documents will also be used in the FMMP CBP. One of the primary objectives of the FMMP is to enhance the capacity of the NMCs and relevant line agencies regarding various activities carried out under the five components of the project. Components 2 and 3 provide for the identification and classification of critical trans-boundary flood issues and locations in the Lower Mekong River Basin (LMRB) and how to implement the provisions of the LA-MA95 to promote cooperation in avoiding and mitigating trans-boundary flood harmful effects or addressing and resolving trans-boundary flood differences and disputes. The mandate set out in the LA-MA95 and other documents of the MRC (ROP, Procedures, etc.) was addressed in Working Paper No. 1, with the extension of going beyond just flood issues to include water related water and environmental TBIDDs since most approaches and mechanisms applicable under the LA-MA95 to flood issues are generally applicable to other matters covered by the treaty. Although the LA-MA95 is quite thorough and extensive on areas of cooperation and addressing and resolving issues, differences and disputes through the MRC institutional framework, it is widely acknowledged and practiced that many MRC Member Countries, initially at least, attempt to identify and seek less formal and low profile solutions to Trans-Boundary Issues (TBI) on a government-to-government or agency-to-agency basis before, if at all, raising the matter with the Joint Committee or Council. This is accepted practice and one of the options available to the MRC Member Countries as sovereign nations.

OVERVIEW AND STATUS OF THE CAPACITY BUILDING PROGRAMME

Purposes of the Capacity Building Programme are to build sustainable capacity for MRC, NMCs and line agencies in addressing trans-boundary floods and related issues, which is the ultimate goal of the FMMP-C3.

To assist FMMP-C3 in the design and conduct the trainings and ESV - Phase I implementation of CBP, MRCS FMMP has contracted International consultant UNESCO-IHE. UNESCO-IHE in close consultation with FMMP and NMCs has prepared a draft Implementation Plan - Phase I of the Capacity Building Programme (IP CBP). The MRC Member Countries, through Regional consultations in November 2008 have commented to the draft IP CBP. The document was endorsed for implementation in January 2009. The CBP is in line with MRC training and capacity building activities.

Design of the CBP

The CBP designed for three phases. Phase I has been started from December 2008 up to October 2009. Phase II is scheduled to be implemented in 2010. The CBP was designed to be developed gradually in phases to allow for adjustments based on in-depth evaluation. The implementation of the Phase 3 will go beyond the implementation framework of FMMP Phase I -2005-2010. Phase 3 plans to provide trainings at national level.

The CBP was designed for three target groups within MRCS, NMCs and line agencies working in the field of trans-boundary (flood) issues:

- *Group 1.* Policy and decision-makers; e.g. members of the MRC Joint Committee, vice-ministers and Directors General (DG) of relevant ministries, directors of line agencies, chairmen of the NMCs;
- *Group 2.* Mid-level professionals and academics who address the subject not only nationally but also regionally in organisations (e.g. ministries, line agencies, MRCS and NMCs) related to water, public works, foreign affairs, environment, and planning as well as academics who have the potential of becoming future trainers;
- *Group 3.* Operations / administration oriented professionals at the national level who mainly operate locally or nationally but who need to be aware of the trans-boundary dimensions and implications of basin developments and flood management.

In the first two phases of the programme, the first two target groups will be addressed simultaneously in order to build capacity at mid-level professional level and to create an enabling environment for this target group by addressing the policy and decision-making. The third target group will be trained during Phase 3.

Sustainability of the programme is further ensured through the training of future trainers, and the gradually involvement of the selected national training institutions. The programme uses innovative ways of delivery wherever relevant to encourage continuous learning to increase the number of participants and expert input. The programme is in line with MRC training and capacity building activities.

Objectives of the CBP

- Group 1: awareness raising and enhancing a conducive environment;
- Group 2: knowledge and build skills on the subject has been developed. Regional training specialists: knowledge and skills in the subject is sufficient to be able to delivered training in later stage;
- Group 3: awareness raising and having general knowledge and skills on the subject.

Implementation of the CBP- Phase 1

Main output - Phase 1:

- 10-15 policy decision makers made aware on the subject and internationally exposed;
- 25-30 mid-level professionals trained on the subject;
- part of the mid-level group trained gradually take over the programme in phases 2 and 3;
- quality assure training curriculum on the subject and made accessible for use in later phases;
- preparation of implementation plan for phases II and III of the CBP.

Design CBP – Phase 1. Phase 1 preparation: November 08 – February 2009; Phase 1 implementation: March 2009 – October 2009. Phase 1 consists of three training workshops, three exchange study visits, and group assignments to create a stimulating and challenging learning environment.

The following tasks have been and will be conducted under Phase 1: a) the preparation and documentation of all Phase 1 materials; b) the implementation of the Training Package and Study Exchange Visits; c) a review / evaluation of Phase 1; and d) a work plan for Phase 2 Implementation.

In Phase I, the first two target groups are addressed simultaneously in order to build capacity at mid-level professional level and to create an enabling environment for this target group by addressing policy and decision-making.

The training curriculums: the consultant has been developing appropriate teaching material and tutorials of high quality. The training materials consist of state-of-the art lecture notes, skills training exercises, simulations and other dynamic role plays, and additional readings taken from scientific literature that include relevant case studies. PowerPoint presentations and tailor made assignments with appropriate background materials have been developed and made available. The general structure of the training programme is characterized by a balance between theory applicable to this specific Mekong context, and practice of preventing and resolving conflicts in international as well as Mekong cases. The training workshops contain many references to international (including the UNESCO PCCP programme) and regional best practices, instruments, case studies, and MRC information and tools available or to be developed, such as the FMMP outputs as described earlier.

Training course 1. 'Water Resources Development and Flood Management in a Trans-boundary Context' (5 days) was successfully implemented in March 2009.

A group of 24 participants attended the first Training course and Mekong ESV. Those participants equally represented four countries: Thailand, Lao PDR, Cambodia and Viet Nam. Participants came from NMCs, line ministries and selected National Institutional. This training workshop focused on the Mekong system and its trans-boundary flood issues. The workshop also addresses concepts and approaches of Integrated Water Resources Management (IWRM) and flood management, with a particular focus on the Mekong River Basin. The training workshop provided an introduction to the general framework in which water-related conflict and cooperation might take place. It also aimed at levelling differences in background knowledge of the participants and developing a shared understanding of key concepts, including upstream-downstream interactions and asymmetries, water allocation and benefit sharing.

The Mekong Exchange Study Visit of 3 days to Viet Nam and Cambodia was successfully undertaken directly after the first training. The aim of the Mekong Exchange Study Visit is to provide practical knowledge and understanding of (potential) Mekong trans-boundary issues in an early phase of the capacity building programme. During the Mekong study visit trans-boundary sites in An Giang province of Viet Nam and Takeo province of Cambodia were visited. The understanding of national and regional reports on trans-boundary issues produced by each of the Member Countries were presented to participants to introduce potential TBF issues and create awareness and mutual understanding.

Training course 2. 'Trans-boundary Water Conflict Management and International Water Governance' (8 days) will be implemented in June 2009. This training workshop will start with a review of principles of international law and treaties relevant for the Mekong context such as the Mekong Agreement of 1995. It will also address international and regional best practices, instruments and case studies in the field of water conflict management. Examples of local and regional practice (MRC, 2008a) as well as examples drawn from other international river basins will be presented and discussed. The workshop then provides an intensive training on the different approaches and techniques to address water conflicts including negotiation techniques and dispute resolution taking into account the MRC mandate on differences and disputes (MRC, 2007c; 2008b). The objective is to learn to develop strategies of conflict anticipation and prevention. Participants will get acquainted with relevant methods and tools of conflict analysis from an interdisciplinary perspective.

Training course 3. 'Technical Tools to Support Trans-boundary Issues' (5 days) will be implemented in Vientiane in October 2009. This training workshop outlines how the technical tools available at MRC and in the countries can be used in the process of anticipating and resolving trans-boundary (flood) issues. Technical tools available comprise of models (like the hydrodynamic model developed as part of the Output 3 (Toolbox Development) and the Decision Support Framework (DSF), the Integrated Flood Risk Management (IFRM) guidelines, trans-boundary Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA), and tools for integrated assessments. Participants will learn how to use these methods and tools in various phases of conflict anticipation and resolution through lectures, discussion and a series of exercises to develop the necessary skills and to

practice them. Particularly in this training workshop where MRC tools play an important role, regional experts, including experts from the MRC, will be brought in as guest lecturers.

Implementation of the CBP - Phase 2: Scheduled for 2010

The implementation plans for the Phase 2 to be develop based on the outcomes of the review/evaluation of Phase I and the lessons learned and discussions with national universities. Phase 2 may have an estimated duration of 9 – 12 months. The target group consist of mid-level professionals and the selected Regional training specialists (RTS), one from each university. The selected RTS will gradually take over from the international training specialists the roles for facilitation and instruction in selected sessions and on dedicated topics. At the end of the implementation of Phase 2, a review /evaluation will be carried out. The outcomes provide inputs for the development of a Phase 3 work plan.

Implementation of the CBP - Phase 3: Scheduled after 2010

Phase 3 plans to provide trainings at national level. The target group will consist of people who are involved in practical operations and in related administrative functions at a national level. The training will be mainly delivered by regional and national resource persons, who have been trained under Phase 1 and Phase 2. On the basis of the Review/Evaluation of Phase 2, the duration of Phase 3 can be estimated. The funding of Phase 3 is envisaged under the MRC Regional Flood Management and Mitigation Centre (MRC-RFMMC) operations after 2010.

RELEVANCE TO OTHER MRC PROGRAMMES

It is important for other MRC projects and programmes to build the capacity of the NMCs, line agencies and others in Trans-boundary issues. The two Working Papers of TBFI and LA-MA95 could be used by any MRC programme and national members in their capacity building and training programmes.

This is important to note that the information, administrative tools, awareness, knowledge and capacity building, which has been generated and built under Component 3, many of them will go beyond just flood issues, and relate to broader aspects of trans-boundary water issues and problems. Those applicable to flood issues are most likely equally applicable to other water and related resource and associated environmental issues and problems.

The MRCS has developed a large number of tools and courses for trans-boundary environmental analysis as part of the Water Utilization Programme (WUP). The WUP finalized its activities in 2007. Some of the procedures developed under WUP will be supported by the Basin Development Plan Phase 2. The Training Course on the Trans-boundary Diagnostic Analysis (TDA) and the Strategic Action Program (SAP) are some of the important activities developed under WUP. The following Working Papers are relevant for mention:

- WP No. 1: On Trans-boundary Analysis, June 2003;
- WP No. 3: Suggested Indicators for Trans-boundary Analysis and on Environmental Flows, June 2002;
- WP No. 6: Modelling Socio-Economic Impacts, May 2002;
- WP No. 7: Impact Indicator, June 2002.

Most MRCS programmes have identified the need for trans-boundary impact assessment and for enhancing cooperation between the Member Countries. Under an initiative of the MRC's Environment Programme (EP) a support programme is being provided on trans-boundary Water Conflict Prevention and Management with support of USAID/ECO-Asia. This support programme has facilitated a number of regional workshops and trainings on Trans-

boundary Waters Conflict Prevention and Management. This is a general support to all programmes for MRCS, the NMCs and line agencies. The EP and FMMP work closely together in order to develop synergy in training and capacity building. While EP's support programme provides a more general approach in trans-boundary conflict prevention and management, the FMMP will focus much on subject matters and tools development relevant for enhancing cooperation between the MRC Member Countries in the field of flood management and mitigation. Courses and case studies developed under FMMP therefore will serve the EP support programme.

RECOMMENDATIONS:

Many relevant studies, documents and training courses developed under the WUP and other MRC programmes, have been developed and made available to MRCS and its Member Countries. The sustainability of these valuable documents is questioned however. How will these be integrated in the national processes from each member country? Will these tools be accessible to other line agencies and wider public or institutions?

It is recommended to consider the national institutes, colleges and universities, which could play an important role in enhancing materials, provide training and capacity building, aimed at improving awareness and knowledge to the public and targeted specialists in trans-boundary flood and water related issues.

Integrated Capacity Building Programme of MRC could be a recommended option to explore other opportunities for enhancing the sustainable use of these materials, which are at the heart of the MRC Member Countries Mekong Agreement 1995.

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FMMP COMPONENT 4

FLOOD EMERGENCY MANAGEMENT STRENGTHENING PEOPLE-CENTRED APPROACH IN INTEGRATED FLOOD RISK MANAGEMENT

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ABSTRACT

The paper describes Component 4 (FMMP-C4) of the Flood Management and Mitigation Program (FMMP) of the Mekong River Commission (MRC), which has been implemented by the Mekong River Commission Secretariat (MRCS) with technical support from the Asian Disaster Preparedness Centre (ADPC) and funding support from the 'Deutsche Gesellschaft für Technische Zusammenarbeit' (GTZ) on behalf of the Federal Ministry of Economic Cooperation and Development of Germany and the European Commission Humanitarian Aid Department (ECHO).

In response to the devastating Mekong flood that occurred in 2000, the MRC launched its FMMP, over a six year period from 2004 to 2010. The programme fully recognises both the positive and negative impacts of the Mekong annual floods and has the following objective: *'People's suffering and economic losses due to floods are prevented, minimized, or mitigated, while preserving the environmental benefits of floods'*. Component 4 is one of the five key components of the FMMP. Component 4 deals with strengthening the capacity of disaster management authorities at all levels, raising public awareness and trans-boundary province-to-province cooperation on emergency assistance,. With its non-structural measures this component of the FMMP forms an important part of Integrated Flood Risk Management (IFRM), which is being applied for the first time in the Lower Mekong River Basin (LMB).

Component 4 focuses on enhancing the 'competence of civil authorities at various levels, emergency managers and communities in flood preparedness and mitigation ', which will ultimately help facilitate the objective that 'Emergency management systems in the riparian countries are more effectively dealing with Mekong floods.'

The project has been providing assistance and technical support to disaster management (DM) authorities, particularly at the sub-national levels (provincial, district and commune) and in filling the gaps and needs of the existing system. The process started with Institutional Role Analysis and Improvement Identification that identified the gaps and needs.

Local DM authorities have taken the lead in the development and implementation of Flood Preparedness Programs (FPP) in which clear roles and responsibilities are defined for each line department of the Provincial and District Disaster Management Offices. Various innovative approaches to flood risk reduction were carried out in support to the FPP, including promoting local, national and regional knowledge sharing and trans-boundary province to province cooperation in flood emergency assistance, as well as ensuring the sustainability the FPP activities by integrating them into the local development planning process. Linkage of Component 4's activities with other FMMP Components is also highlighted.

The paper further explains Component 4 activities as a Component of FMMP that deals with flood preparedness and emergency management of local authorities and communities at the forefront of flood disasters. This people-centred approach is low-cost, effective, and relevant to local conditions in the LMB. Ownership is gradually evolving and sustainability is being

secured step-by step. It is recommended that once the model is well tested it could be replicated across the LMB, well beyond the border of the project target areas.

INTRODUCTION

One of important interventions identified in the MRC's FMM Strategy adopted by the MRC Council in November 2001 is capacity building and technology transfer in flood preparedness and emergency response. Past experience has revealed that unnecessary damage and losses due to flood disasters were mainly due to a lack of preparedness to prevent and respond to flood events.

The project entitled *'Flood Emergency Management Strengthening-FEMS', Component 4 of the MRC Flood Management and Mitigation Program (FMMP)'* has been implemented by the Mekong River Commission Secretariat (MRCS) with technical support from the Asian Disaster Preparedness Center (ADPC) and funding support from the 'Deutsche Gesellschaft für Technische Zusammenarbeit' (GTZ) on behalf of the Federal Ministry of Economic Cooperation and Development of Germany and the European Commission Humanitarian Aid Department (ECHO) since 2003. Component 4 focuses on enhancing the 'competence of civil authorities at various levels, emergency managers and communities in flood preparedness and mitigation', which will ultimately lead to the component objective of 'Emergency management systems in the Riparian countries more effectively dealing with Mekong floods.'

Since 2003 Component 4 has achieved fundamental results in setting in motion a process of flood preparedness programme development and implementation and enhancing the capacity of local authorities in support to this process. Starting from mid 2008 until December 2010 the on-going phase is expanding the target areas to all four MRC Member Countries with more emphasis on continuing the process initiated in the past phases and making more impact on the ground, as well as gradually building a solid framework for sustaining the system in the long run.

BACKGROUND

In response to the devastating Mekong flood that occurred in 2000, the Mekong River Commission (MRC) launched its Flood Management and Mitigation Program (FMMP), over a six year period from 2004 to 2010. The programme fully recognises both the positive and negative impacts of the Mekong annual floods and has the following objective: *'People's suffering and economic losses due to floods are prevented, minimized, or mitigated, while preserving the environmental benefits of floods'*.

Current limited capacities and resources at national and local levels for effective emergency management are apparent in different ways:

- limited capacity at national level and in particular at provincial and district level to understand, interpret and effectively use advanced flood forecasting and hazard information;
- limited exposure to good practices in flood preparedness planning;
- limited capacities for undertaking preparedness and mitigation planning and concerted implementation among disaster management authorities and their line departments at all levels;
- weak public awareness activities to inform/educate people how to prepare before floods, how to cope with floods when they occur and how to recover afterwards.

Important issues that remain to be solved include: *'how to get people ready for floods before they come'* and *'how to help people cope with floods'*. To deal with the Mekong floods

more effectively there is a need to strengthen the capacity of local disaster management authorities in flood preparedness and emergency response. Component 4 is one of the five key components of the FMMP dealing with capacity strengthening of disaster management authorities at provincial and districts levels. It forms an important part of the FMMP which is considered as one of the first Integrated Flood Risk Management (IFRM) programmes to be applied in the Lower Mekong River Basin (LMB).

Component 4 has six projects (four completed and two ongoing) implemented by the MRCS with technical support from ADPC and financial support from GTZ and ECHO.

The first Phase of GTZ funded project commenced in September 2004 and was completed in April 2008.The target areas under this phase are located in four provinces, two each in Cambodia (Kandal and Prey Veng provinces) and Viet Nam (An Giang and Dong Thap provinces). Since May 2008 the 2nd Phase has started and will be implemented until December 2010. Total number of target districts of the 2nd phase is 18 (6 in Cambodia including 4 of the 1st phase, 6 in Viet Nam including 4 of the 1st phase, 4 in Lao PDR and 2 in Thailand). A list of target districts is summarized in Table 1.

Table 1. List of target districts under Phase 2 GTZ-funded project

	CAMBODIA		VIET NAM		LAO PDR	THAILAND
Province	Kandal	Prey Veng	An Giang	Dong Thap	*Khammouane*	*Nakhon Phanom*
District	Lovea Em	Peam Chor	Chau Thanh	Tan Hong	*Hin Boun*	*Nakhon Phanom*
	Leuk Dek	Sithor Kandal	Tan Chau	Than Binh	*Tha Khek*	*Tha Uthen*
	Kien Svay	*Peam Ro*	*An Phu*	*Tam Nong*	*Mahaxay*	
					Nhommalath	

Remarks: Names in Italic are new districts.

The three completed ECHO funded projects were: 1) Phase I: '*Capacity Building for Preparedness Planning in the LMB using Flood Information Products'* was implemented during 2003-2004, under the 3rd Disaster Preparedness European Commission Humanitarian Aid Office (DIPECHO) Action Plan for South East Asia. This phase resulted in capacity building for flood preparedness planning and response through the use of flood information products by the MRC in Cambodia, the Lao PDR, Thailand and Viet Nam; 2) Phase II: '*Capacity Building for Planning and Implementation of Flood Preparedness Programme at Provincial and District Levels in the LMB*', was implemented during 2005-2006 under the DIPECHO 4th Action Plan for South East Asia to enhance capacity of the provincial and district DM committees for undertaking planning and implementation of flood preparedness programmes at their provincial and district levels in the pilot areas namely; Kratie and Kampong Cham in Cambodia, Can Tho and Tien Giang in Viet Nam and Champassack, Khammouane, Saravanh and Savannakhet provinces in the Lao PDR and 3) Phase III, '*Support to Implementation of Flood Preparedness Programs at Provincial, District and Commune Levels in the LMB* ', was implemented during 2007-2008 under the DIPECHO 5th Action Plan for South East Asia to enhance capacities for preparation and implementation of flood preparedness programs at the province, district and commune levels in the three selected provinces of the LMB in the pilot areas namely; Kratie in Cambodia, Tien Giang in Viet Nam and Khammouane in the Lao PDR.

The on-going Phase IV of the ECHO funded project '*Strengthen Implementation of the Flood Preparedness Program at Provincial, District and Commune Levels in the LMB'* is being implemented from August 2008 to November 2009 in Kratie and Svay Rieng in Cambodia, Tien Giang and Ben Tre in Viet Nam and Khammouane in Lao PDR. Figure 1 shows a map of the LMB with locations of the target districts. A list of target districts under ECHO IV project is summarized in Table 2.

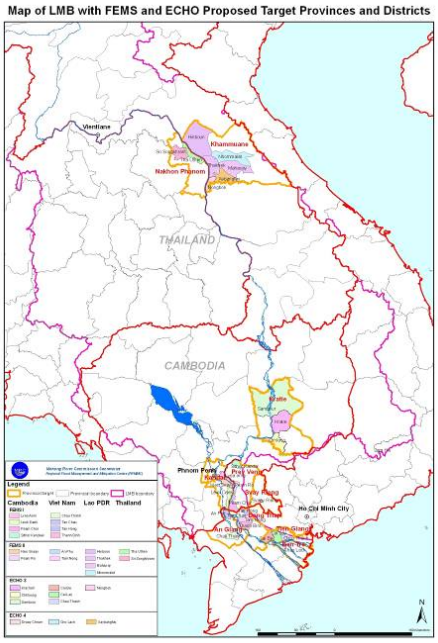

Figure 1. Map of the Lower Mekong River Basin showing the target districts

Table 2. List of target districts under the ECHO IV project

	CAMBODIA		VIET NAM		LAO PDR
Province	Kratie	Svay Rieng	Tien Giang	Ben Tre	Khammouane
District	Kratie	*Svay Chrum*	Chau Thanh	*Cho Lac*	Nong Bok
	Chhlong		Cai Lai		*Se Bangfai*
	Sambor		Cai Be		

Remarks: Names in Italic are new districts.

OBJECTIVES, APPROACH AND PRESENT STATUS OF THE COMPONENT

Component 4 focuses on enhancing the 'competence of civil authorities at various levels, emergency managers and communities in flood preparedness and mitigation ', which will ultimately help facilitate the component objective of *'Emergency management systems in the Riparian countries more effectively dealing with Mekong floods.'*

Integrated flood risk management is a comprehensive approach where equal emphasis is placed on mitigation, preparedness, relief and recovery through the involvement of all relevant sectors and stakeholders with the overall goal of reducing flood risk. Experience has shown that the most effective approach is to have a flood risk management programme incorporating the following elements:

1. *prevention:* preventing damage caused by floods by avoiding construction of houses and industries in present and future flood-prone areas; by adapting future developments to the risk of flooding; and by promoting appropriate land-use, agricultural and forestry practices;
2. *protection:* taking measures, both structural and non-structural, to reduce the likelihood of floods and/or the impact of floods in a specific location;
3. *preparedness:* readiness of authorities and population to prevent from, respond to and recover from the event of a flood;

4. *emergency response:* developing emergency response plans in the case of a flood;
5. *recovery and lessons learned:* returning to normal conditions as soon as possible and mitigating both the social and economic impacts on the affected population.

Component 4 of the FMMP aims at reducing the vulnerability and damage by strengthening the capacity of local authorities and population in the flood vulnerable communities to get ready for floods before they come and to respond to and recover from floods in an effective and efficient manner.

The main activities include flood preparedness program development and implementation, raising public awareness, sharing of knowledge and experience among concerned partners and stakeholders at local, national and regional levels and trans-boundary province-to-province cooperation on emergency assistance. To enhance long term sustainability local disaster management (DM) authorities have been actively participating in project implementation with facilitation and technical support from Component 4 projects. Under the current phase the national DM authorities are playing a dominant role in institutionalisation of key project activities aiming at duplicating them in other flood prone communities which are not covered by the projects.

DATA COLLECTION AND ANALYSIS

A study on 'Institutional Role Analysis and Improvement Identification' was conducted in March and April of 2005, in two target provinces of Kandal and Prey Veng. The outcomes of the study are; identification of roles and responsibilities of each Provincial Committee for Disaster Management (PCDM) member line department with respect to flood preparedness activities (before, during and after floods); and the gaps and needs in the existing system. The key gaps identified were:

- a lack of systematic flood preparedness planning processes at provincial and district levels;
- weak/limited coordination between PCDM and District Committee for Disaster Management (DCDM) member line departments (resulting in overlapping of activities with little information sharing);
- outdated flood data and flood records;
- a lack of flood maps;
- poor access to flood information;
- limited resources (equipment, funds, skilled personnel).

The needs were identified as:

- capacity building of PCDM and DCDM members in areas such as safe area management, damage and need assessment, flood early warning, etc.;
- public awareness raising on basic flood risk reduction and mitigation measures;
- clearly defined roles and responsibilities of each member department of PCDM and DCDM.

In Viet Nam the findings of institutional analysis study in An Giang Province and the previous similar study conducted in Dong Thap Province by OXFAM, recommended that a new and separate set of planning activities in Viet Nam be avoided but to go straight into implementation process of priority action areas identified under existing Annual Provincial and District Flood and Storm Control Plans, with respect to the project's objectives.

The institutional analysis study in both countries not only helps identify the gaps in the existing flood management planning process but also highlights the needs in order to improve various mechanisms such as coordination between the member agencies and more effective

ways in organizing the committees. It is one of the significant contributions of FEMS project towards the disaster risk reduction efforts in Cambodia and Viet Nam.

METHODOLOGY, APPROACH AND RESULTS

The project has been providing assistance and technical support to the DM authorities, particularly at the sub-national levels (provincial, district and commune) and in filling the gaps and needs of the existing system identified by institutional role analysis and improvement identification study.

Local DM authorities took the lead in the development and implementation of their Flood Preparedness Program (FPP) in which clear roles and responsibilities were defined for each line department of the Provincial and District Disaster Management Offices with respect to flood preparedness activities (before, during and after floods). Various innovative approaches to flood risk reduction were carried out in support to the FPP implementation.

All target districts in the selected provinces of Cambodia have implemented the priority sub-projects identified under the FPP, including:

- building capacity of Commune Disaster Management Committees on community-based flood management;
- improving skills of district and commune officials in damage and needs assessment;
- district resource inventory development;
- development of programme on meeting the needs of women-headed households;
- improved dissemination of flood early warning through installation of village and home flood marks;
- improvement of safe areas;
- orientation workshops for teachers and educators on flood risk reduction and raising awareness of school children in flood risk reduction through school flood safety campaign;
- public awareness activities (cultural performances, folk songs, production and distribution of a flood booklet, posters and leaflets on flood safety measures and protection against child drowning, dissemination and show of the film on Living with Floods and teacher's information kits, installation of a flood information board, etc.);
- training of trainers for provincial and district facilitation to link flood risk reduction activities into commune development/investment plan (in Cambodia).

In Viet Nam, as identified in the institutional analysis study the existing flood and storm control planning at provincial and district levels are already well in place. However there is a need to strengthen the capacity of district and commune levels in the implementation of the flood and storm control (FSC) plan. Therefore sub-priority projects were identified and carried out to strengthen the capacity and assist the implementation of the FSC plan. These projects included:

- search and rescue training for the district Red Cross;
- emergency kindergarten management training;
- swimming lessons for primary school children *as part of the Swimming Universalisation Program which is one of post 2000 flood program for Child Casualty Prevention enforced by the Government for the Mekong delta provinces in Viet Nam*;
- community-based flood management training;
- retrofitting of emergency kindergartens;
- public awareness activities (cultural performances, installation of billboards on flood safety measures, production and distribution of flood booklets, posters on flood safety measures, protection against child drowning and four on-site VCDs on Living with Floods, school flood safety kit),

- orientation of school teachers and organisation of School flood safety campaign.

To ensure that experiences on flood preparedness and emergency management are documented and shared several case studies were prepared and distributed. Furthermore a series of national workshops and national flood forum were held to promote sharing of experiences and lessons learnt among implementing and cooperating partners, international organisations, non-governmental organisations (NGO), donors, etc. It provided opportunity for DM authorities of provinces and districts under the projects to interact and share their knowledge with representatives from other flood prone provinces.

A regional workshop and regional flood forum brought together partners and stakeholders at regional level to share innovative approaches to flood risk reduction in the Mekong Basin. It was a rare occasion for the DM authorities and their line departments from the sub-national level to present their achievement as well as to learn new practices in FRR from other MRC Member Countries and the region.

Trans-boundary province-to-province cooperation has gained a new ground. Built on existing cross border cooperation (border trade, human and drug trafficking, security, etc.) the neighbouring provinces between Cambodia-Viet Nam and Lao PDR-Thailand have discussed and agreed to cooperate in flood preparedness and emergency management, i.e. between Kandal and An Giang provinces: 1) Joint search and rescue training; 2) exchange information on flood and storm forecast; 3) health care; and 4) Preparedness and prevention of avian influenza, insects and animal diseases during flood season and between Khammouane and Nakhon Phanom provinces: 1) Information sharing and exchange; 2) capacity building; 3) Exchange visits and academic seminars; and 4) disaster drills. The trans-boundary disaster management were included in the regular cooperation between Kandal and An Giang provinces at the provincial meeting held on 29 May 2007 between two provincial authorities led by the Governor of Kandal and the Chair of People's Committee of An Giang Province.

Recognising the limited financial and geographical coverage of the projects extra effort was invested to establish links with on-going planning processes in the country. In Cambodia, a Programme to Support Democratic Development through Decentralization and Deconcentration (PSDD), formerly known as Seila Programme, was identified for this purpose. The representatives from PSDD Office in the provinces under both GTZ and ECHO projects were invited to all FPP development workshops. The finalised provincial and district FPPs has been shared with PSDD provincial offices. PCDM and DCDM of the target provinces and districts have been working closely with PSDD to support the integration of flood/disaster risk reduction activities into the Commune Development Plan (CDP) and Commune Investment Plan (CIP).

This people-centred approach is low-cost, effective, and relevant to local conditions of the LMB. It is the heart of IFRM in which people are involved in the process, ownership is gradually evolving and sustainability is being enhanced step-by step. Key results of the past phases of Component 4 projects are as follows:

In Cambodia the provincial and district flood preparedness programs have been developed by the provincial Committee for Disaster Management (PCDM) and District Committee for Disaster Management (DCDM) in the target areas where the FPPs did not exist before. PCDM and DCDM have not been active in the past due to lack of clear and detailed roles and responsibilities, resources and capacity. The process of FPP development has clearly set the flood preparedness activities at sub-national level in motion. Facilitated by the project, the PCDM and DCDM have gone through a process of 'learning by doing' which has significantly enhanced capacity and skills of local authorities in the development and implementation of their FPP.

Change in attitude could be considered as significant project achievement. Before the project, local authorities perceived that flood management or disaster management only consists of emergency relief operations. With their participation in the FPP development and implementation the Disaster Management Organisations (DMO) have begun to understand that flood/disaster management is a range of activities to be undertaken before, during and after

flood/disaster events. They have alsoi realized that preparedness activities are important to minimize the impact of disasters and that flood risk reduction is one of the key components of sustainable development framework. This has helped promote and initiate an integration of flood risk reduction into local development planning. In Cambodia the integration of flood/disaster risk reduction into the CDP and CIP is now part of local planning process.

As a result of joint efforts in developing and implementing the FPP at sub-national levels, horizontal and vertical cooperation and coordination has significantly been improved from the national to local authorities and between the line agencies of government. Similarly, the cooperation and coordination between DM authorities at all levels with stakeholders working in disaster risk reduction and rural development areas are also increasingly enhanced.

Capacity of the DM authorities, especially, the local authorities in the target provinces and districts has been built and enhanced through activities undertaken by the project, including FPP development and implementation, training, public awareness activities, workshops, and involvement of local authorities in relevant events conducted under the project.

In Cambodia the CDP and CIP are well and widely recognized as part of the sustainable development framework, mainly concentrating on strengthening capacity and empowering commune authorities on socio-economic development. This commune planning process is led by the Ministry of Interior (MOI) and Ministry of Planning (MOP) at the national level. It is technically and financially supported by PSDD.

To ensure that flood risk reduction is properly and successfully integrated into local development planning, a lot of advocacy work has been carried out under the project. There has been an increasing involvement of national, provincial and district DM authorities and relevant line ministries and provincial and district line departments in the processes of local development planning, including facilitation of those who are concerned in processes of CDP/CIP, provision of training on flood risk reduction to PSDD facilitators and involvement of PSDD staff in relevant workshops organized under the project.

RELEVANCE FOR THE MEKONG RIVER BASIN

In general there are limited numbers of target areas covered by the projects. The target areas of past Component 4 projects cover only 3 out of 7 flood prone provinces and 7 out of 28 flood prone districts of 3 provinces in Cambodia. In Viet Nam only 2 out of 12 flood prone Mekong delta provinces and 4 districts out of 21 flood prone districts of 2 provinces are covered by the programme. Following the successful results of the last phases the MRC member countries requested to expand the activities of Component 4 to Lao PDR and Thailand. Some more new districts were therefore added under the current phase (2 new districts each in Cambodia and Viet Nam, 4 in Lao PDR and 2 in Thailand).

Due to lack of resources and limited time frame the project’s main purpose is to build a good example/model which can practically be replicated in other flood prone areas. Local provincial and district authorities will ultimately continue their effort to expand the flood preparedness and emergency management activities within and beyond their provincial/district borders with some assistance from the national DM authorities. Initial momentum has already been set and will be continued by the activities under the current phase.

By having a well planned flood preparedness program local authorities have realised that they can make use of their resources and capacities which have often been overlooked or underestimated. The effectiveness of FPP implementation has been increased due to clear division of roles and responsibilities of the local DM authorities and their line department members. New good practice has been initiated in the transfer of knowledge into other provinces beyond project areas. The experiences have expanded beyond the borders of the target provinces and districts when PCDM/DCDMs focal points (who are the leading member of the Secretariat) became resource persons and shared their knowledge and skills in FPP preparation with other provinces.

CONCLUSIONS AND RECOMMENDATIONS

Full participation of DM authorities at sub-national levels (provincial and district) and involvement and guidance from the national level has been key factor to success. It provides a good foundation for ownership and long-term sustainability. The project has played its roles as technical support provider and facilitator. In Cambodia the FPP process in the target areas have been set in motion which is being supported by the DM authorities and their line departments at provincial and district levels whose capacities have been strengthened. In Viet Nam the existing flood and storm control planning at provincial and district levels are already well in place. However there is a need to strengthen the capacity of district and commune levels in the implementation of the flood and storm control (FSC) plan. Remarkable achievements have been also the activities to raise public awareness on flood risk reduction, sharing knowledge and experiences, trans-boundary province-to-province cooperation and the initiation of integrating FRR into local development planning.

It is important that the momentum of the FPP process as well as its supporting mechanism be maintained. The investment and efforts made so far need to be continued and expanded beyond the border of the project target areas. It is the main objectives of current on-going Component 4's GTZ and ECHO funded projects to carry on the good work done in the past and continue to build sustainable foundation for future expansion of flood preparedness activities. It needs strong commitments from all concerned. There is a requirement for the national DM authorities to play a greater role in supporting local DM authorities and in providing favourable conditions to enable replications to take place. Networking and partnership among flood vulnerable provinces, districts and communes within one country and with their neighbouring countries would help facilitate knowledge sharing and strengthen close collaboration among the partners. The aim at creating a good model of flood/disaster resilient communities that could be replicated in the whole LMB is not far from reality.

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FMMP COMPONENT 5

FLOOD INFORMATION BASED LAND MANAGEMENT (FIBLM)

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ABSTRACT

The Flood Management and Mitigation Programme Component 5 (FMMP-C5) has commenced its Phase 2 by August 1, 2008 and will run until December 31, 2010. Phase 1(2004-2008) focused on the development of an approach to generate flood probability information for floodplains of the Lower Mekong River Basin (LMB), particularly flood probability maps in three pilot districts in Cambodia. Phase 2 focuses on the adaptation of the developed technical tools (software) by the respective line agencies of all four riparian countries (Cambodia, Laos, Thailand, Vietnam) for an improved 'Flood Information Based Land Management (FIBLM)'.

Given the different conditions in each of the four Member Countries of the Mekong River Commission (MRC) in terms of capacities and data available, the project supports each country to develop its own strategy and approach in flood probability based land management. The project initiates national discussions, facilitates the development of a national strategy, trains authorities (line agencies) and relevant land management related organizations in all four countries and supports the implementation of flood probability based land management in seven pilot districts (two in Cambodia, Laos and Vietnam and one in Thailand) along the Mekong and in the Mekong floodplains.

Current land management practices are an important factor contributing to a situation where the regular floods of the Mekong cause substantial damage to agriculture and infrastructure. More effective decision making in these fields, as well as disaster management, requires the provision of more relevant and accurate flood related information.

Improvements in land management by considering flood probability information do not only provide direct positive impacts through the reduction of damage to agriculture and infrastructure, but also indirect benefits through the avoidance of damage to the most vulnerable parts of the population living and working in the floodplains.

FMMP-C5 produces flood probability maps in a scale of 1: 10 000 or larger. Therefore the project helps to supply the decision making authorities (particularly provincial and district offices of line agencies) in the four participating countries with an urgently required planning tool of the right scale, which will help to avoid or at least minimize flood risks and damages along the Mekong River.

So far Flood Probability Maps have been only produced in the three pilot districts in Cambodia (FMMP-C5, Phase 1) and no experiences exist concerning the use of these maps in land management and land use planning. It is premature to expect the mapping carried out so far to be actively used by planning agencies, since the Cambodian pilot areas are not sufficiently extensive (approximately 15-50 km^2).

However, the current FMMP-C5 Training of Trainers (TOT) training programme, which addresses the data processing and the data using line agencies in all four countries, includes components designed to show how the maps used singly or in combination can be analyzed in a GIS application to answer complex planning questions relating to Land Management, Agriculture, Irrigation, Disaster Preparedness and Rural Infrastructure Development.

INTRODUCTION

The German contribution to the Flood Management and Mitigation Programme (FMMP) of the Mekong River Commission (MRC) Component 5 'Land Management' (FMMP-C5) contributes to the FMMP objective 'The civil and socio-economic losses due to floods and flooding are prevented, minimized or mitigated, while preserving the environmental benefits of floods' and more specifically to the objective of Component 5 'Land management in the Mekong floodplains is more effective, using reliable flood-related information'.

Given the FMMP-C5 summary output 'The professional competence of civil authorities at provincial, district and communal level is strengthened with regard to land management in floodplains', the FMMP-C5 approach focuses on the relevant authorities and land management related organizations at various levels of the riparian countries (Cambodia, Laos, Thailand, Vietnam), supporting them to use reliable flood-related information in land management.

Given the different conditions in each of the four MRC Member Countries in terms of capacities and data available, the project supports each country to develop its own strategy and approach in flood probability based land management. The project initiates national discussions, facilitates the development of a national strategy, trains authorities and relevant land management related organizations in all four countries and supports the implementation of flood probability based land management in seven pilot districts in the Mekong floodplains.

REVIEW OF FMMP-C5 (PHASE 1)

Phase 1 of FMMP-C5 (2004-2008) focused on the development of an approach to generate flood probability information for floodplains of the LMB, particularly flood probability maps in 3 pilot districts in Cambodia (Kaesler, 2006).

Figure 1 shows an outline of the steps used by the Land Management Component of FMMP in generating the information displayed in its flood probability maps. It indicates that in this approach three groups of data have been used as inputs:

- historical water level records of the main river covering the period of 1960 to 2006;
- recent observed water level records in the floodplains covering the period of 2003 to 2006;
- data from a topographic survey of features and overall ground levels in the floodplains specifically commissioned for this purpose in 2006.

In a first step, the two sets of water level records have been analyzed with regard to their statistical and hydrographic characteristics, with the results then serving to calculate a series of flood probability statistics. The statistical description of the seasonal floods of the main river is derived from historical water level records, which are available in form of daily readings starting in 1960. These data have been used to derive statistical descriptions of the floods using standard hydrological methods.

In contrast to the well-established system of hydrographic stations at the main river, there were almost no records of water levels on the floodplains, the only exception being data collected since 2003 in connection with a project supported by the U.S. Agency for International Development (USAID) Office of Foreign Disaster Assistance (OFDA). The aim of this project was to provide communities on the Cambodian floodplains with early warning information on approaching floods. As part of this undertaking a number of flood marks were installed by the Department of Hydrology and River Works (DHRW) in the villages participating in the project (Figure 2). During the flood season village volunteers took daily readings from these flood marks and transmitted them to the DHRW. Their records had been proven to be complete and very accurate.

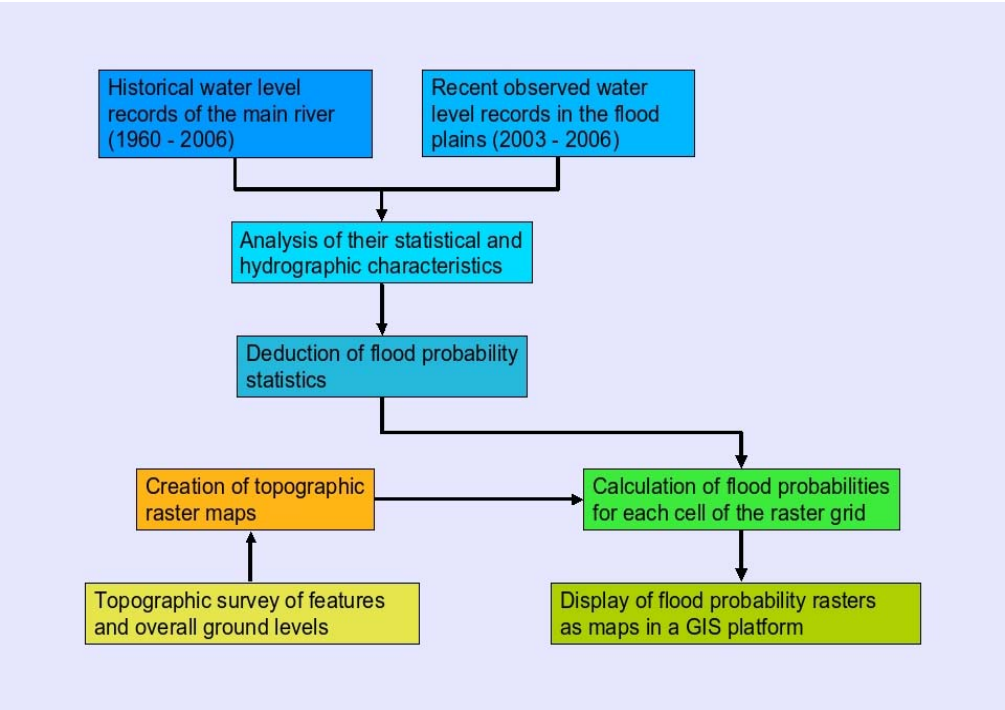

Figure 1. Outline of the approach used by Component 5 of FMMP to generate flood probability information and corresponding maps

Figure 2. Examples of village flood marks used to record water levels on the floodplains

The key step then was to relate these data about the flooding on the plains to the behaviour of the Mekong main stream. The aim was to use the correlation between the two sets of data to 'extrapolate' the limited records from the floodplains - only four flood seasons have been recorded so far - by employing the longer term statistical information from the main river. An empirical approach has been taken to determine the relationship between the levels in the river and on the plains, supported by consideration of the controls on the flow of floodwater across the plains.

In the areas selected for these calculations, the relationship between the main river and the water on the floodplains typically looks as shown in Figure 3, although with slight variations between the different sub-areas: The river starts diverting into the floodplains once it has reached point A (in this case about 5.7 m+MSL (mean sea level)). The water then fills up the plains relatively fast (A → B). At the peak of the flood season (between points B and C) the levels of the main river and the floodplains are connected and fluctuate together. When draining sets in, the two disconnect at point B, from whence draining continues relatively evenly towards point D. The inflow and outflow of the floodwaters take place to a large degree through different channels, which explains the Y-shaped form of the graph.

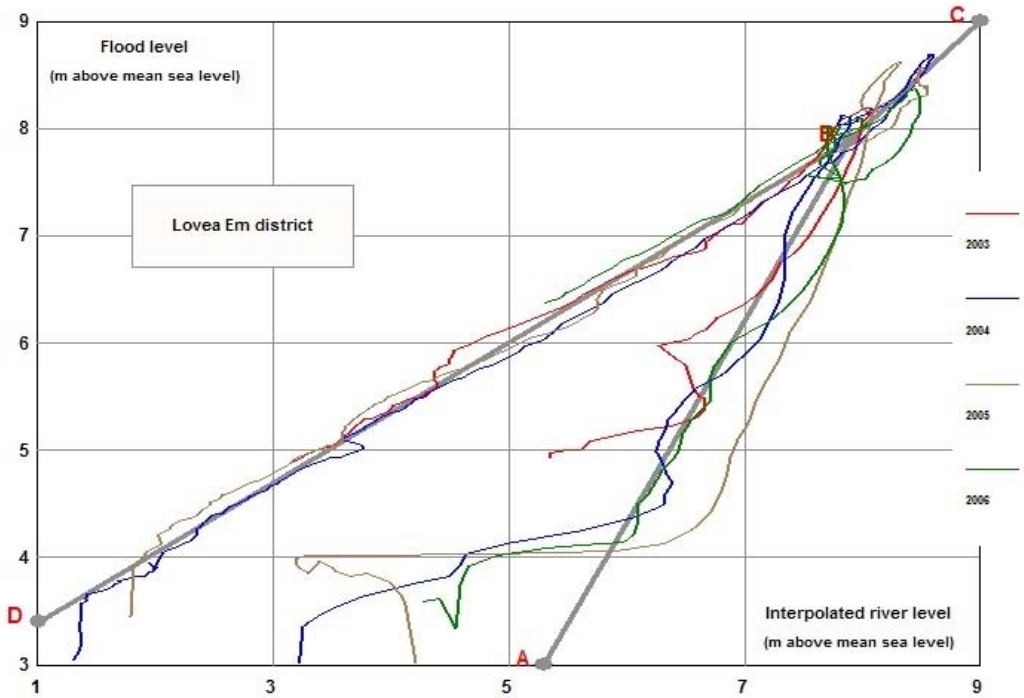

Figure 3. Example of the relationship between the river level and the flood level on the plains (main river data: interpolated records from the stations in Phnom Penh and Neak Luong; village level data: records from flood marks in Lovea Em district)

Once these relationships were established for selected sub-areas of the districts, the process of estimating flood levels and the timing of flood events could be started. The results were subsequently validated by verifying that the statistics were consistent with the observed water levels from the village flood marks, although this validation was limited by the fact that floods in recent years have not been extreme - neither particularly high nor low.

A second process then consisted in creating detailed topographic raster maps. The data for these maps came from a survey of features and overall ground levels in the floodplains specifically commissioned for this purpose in 2006. The need for such a specific survey arose from the fact that none of the available data sets (Digital Terrain Models (DTM), aerial

photography, etc.) were detailed enough for the envisaged purpose of providing information which could be used for planning exercises at district level and below.

The processing of the survey data was then standard procedure: They were first geo-referenced using the positions and heights of the control points and then referenced to a standard height datum (Ha Tien, 1960)[8]. The adjusted data were subsequently used to create a Triangulated Irregular Network (TIN) which was edited where necessary to correctly define features. The edited TIN finally formed the basis for the creation of topographic raster maps with a pixel size of 5 x 5 m. This resolution was found to be adequate to define small linear features like ditches and embankments while maintaining reasonable file sizes. See Figure 4 for an example of such a map.

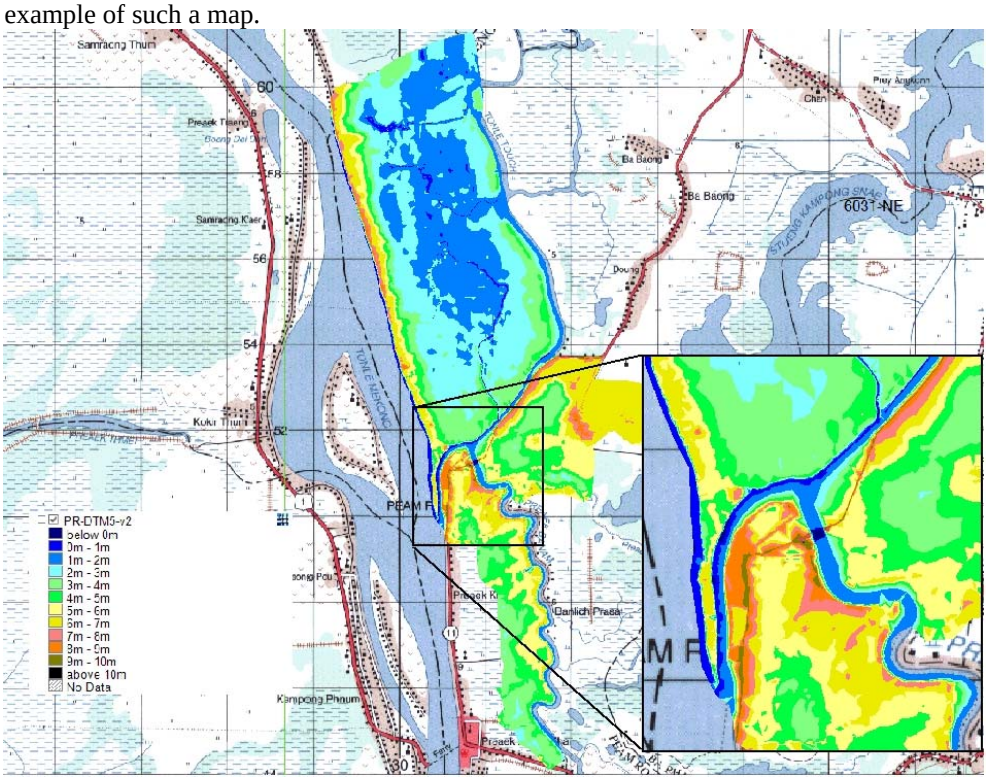

Figure 4.Example of a map based on a topographic raster file with a pixel size of 5 x 5 m (Peam Ro, Cambodia).

The next step then was to combine the earlier created information on the flood probability statistics with the topographic raster maps to calculate flood probability statistics for each cell of the raster grid. The Component has therefore developed a software programme called 'MapStats' that can execute this task. At its core is a Fortran Programme Dynamic Link Library (DLL) for the actual calculations while the user is provided with a graphical interface where choices can be made regarding the properties to be mapped. Figure 5 shows the overall structure of this process.

The options provided by the programme for selection are as follows:

- *area (district).*So far data are available for three districts in Cambodia (Phase 1): Lovea Em, Peam Ro, Leuk Dek. During the running Phase 2 data will be used for the 5 new districts in Laos (2), Thailand (1) and Vietnam (2);

[8] Vertical positions in the lower Mekong basin are still referenced to the Ha Tien 1960 datum (mean sea level), although this datum has in Vietnam been replaced by the Hon Dau 1992 datum. The vertical difference between Ha Tien 1960 and WGS84 is about 10 metres in the Lower Mekong River Basin, but this is not properly calibrated.

- *type of statistic.* The following statistics can be mapped:

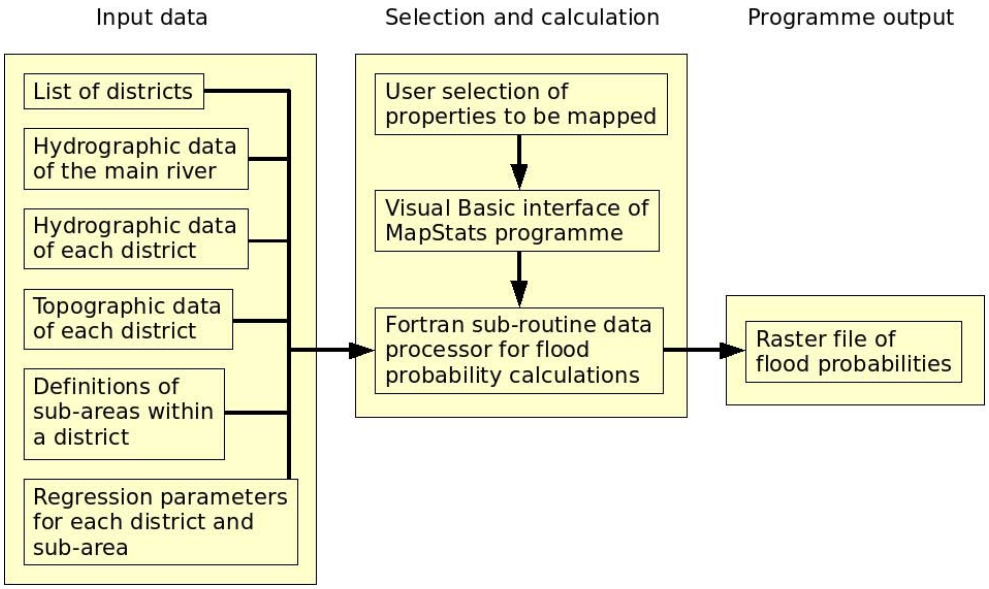

Figure 5. The flood probability calculation process of the MapStats programme

- maximum depth of flooding;
- probability of flooding;
- completion of draining;
- duration of flooding;
- *probability of exceedance.* Users can choose from the following levels: 1%, 5%, 10%, 20%, 30%, 50%, 70%, 80%, 90% and 95%. When 'Probability of flooding' is selected in the previous step these options are of course not available because in this case all probabilities will be in one output file;
- *classified results.* The results of the 'Probability of flooding' statistic are always classified by the programme according to the levels listed above. When 'Completion of draining' is selected there is an option to classify the results replacing day numbers with class numbers representing monthly or half-monthly increments. Similar options may in future versions of the programme be included for 'Maximum depth of flooding' (e.g. 0.5 meter increments) and 'Duration of flooding' (e.g. 10 day increments);
- *file name.* The programme provides a recommended name for the output raster file but users can replace this by one of their own choice. They can also select whether the file extension should be 'txt' to be compatible with ArcGIS or 'asc' for a programme like MapWindow GIS.

The resulting output raster files can then be displayed as maps in any GIS platform (e.g. ArcGIS, MapWindow GIS, Quantum GIS). As potential users of this information can not always be expected to have a license of ArcGIS, FMMP-C5 (Phase 1) has looked for a suitable low-cost (preferably free of charge) alternative and found it in form of 'MapWindow GIS' which is an open source application and set of programmable mapping components developed and maintained by a group of voluntary developers at Idaho State University. It is included in the Component's installer CD but can also be downloaded from http://www.mapwindow.org/.

OBJECTIVES AND APPROACH OF FMMP-C5 (PHASE 2)

Phase 2 (2008-2010) builds on the first phase, but based on the recommendations from the project progress review, the approach has however been changed. Instead of entirely focusing on technological development, the second phase is characterized by country specific approaches – in line with national land use planning practices – which are jointly developed and implemented by the respective national line agencies and FMMP-C5.

In addition, training is delivered and study tours as well as a regional workshop are foreseen to exchange knowledge and experience between the countries.

While Phase 1 was only conducted in Cambodia (2004-2008), the project's activities are now extended to all four countries during the second phase. They focus on two districts in Cambodia, Laos and Vietnam and one district in Thailand (Figure 6).

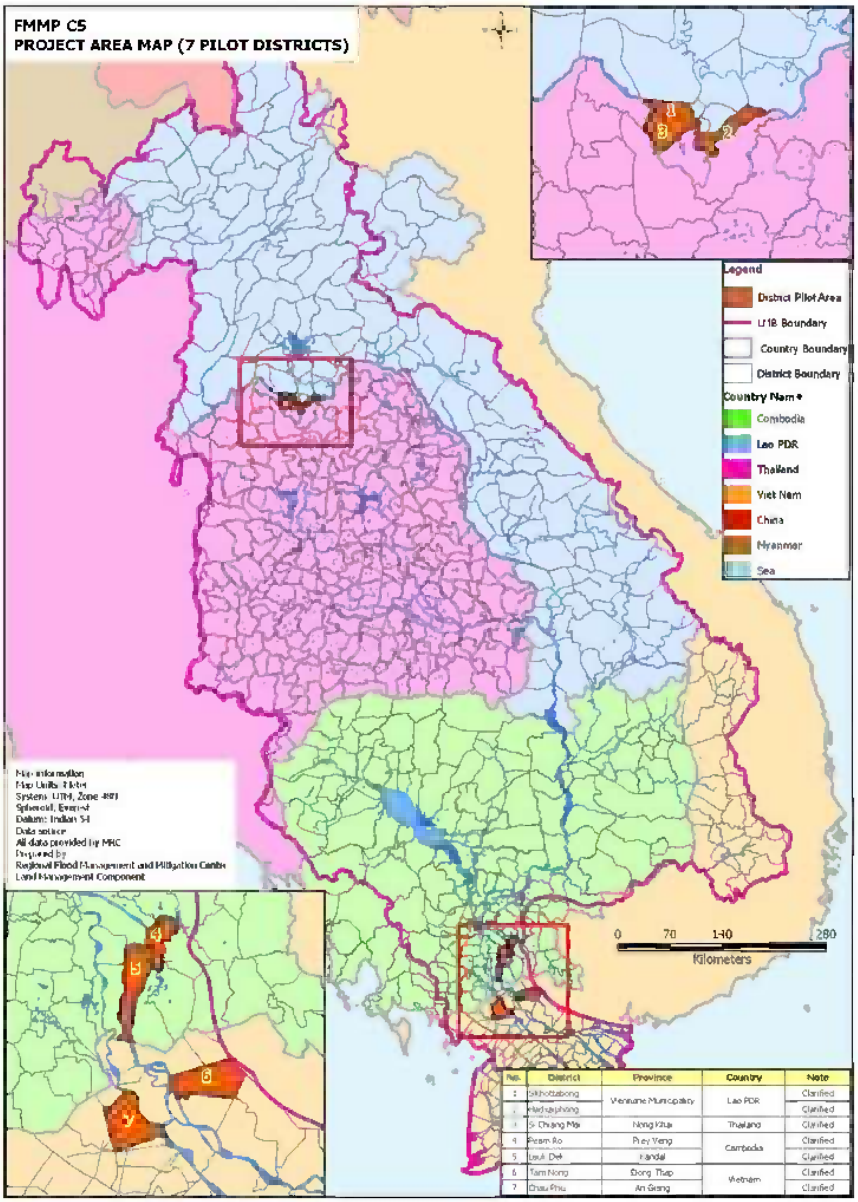

Figure 6. FMMP-C5 Project area map with the seven Pilot Districts

The specific pilot districts for the implementation of the FMMP-C5 approach were jointly identified by the countries and FMMP-C5 during the respective four national workshops, conducted in October 2008 and later confirmed during field visits in November 2008 and January 2009 under participation of the respective National Mekong Committees (NMC), Line Agencies and Community Leaders.

For technical reasons, the districts need to be located in the Mekong floodplains where the inundation is directly correlated to the water level of the mainstream. If there is no regression between local floods and the floods of the mainstream, the approach developed during the first phase cannot be applied.

The methodical approach for the implementation of FMMP-C5 is focusing on Flood Information Based Land Management (FIBLM/ Steps A to D).

According to the experiences of FMMP-C5 / Phase 1 (2004 – 2008), gained in three pilot districts in Cambodia, the FIBLM-approach for C5/ Phase 2 is the following:

A. preconditions for the Pilot-Districts, located in floodplains, to be chosen:

- topographic Digital Terrain Model (DTM) established;
- flood marks established;
- floodplain is connected to the Mekong main course supplied with an adjacent Hydro-Station;
- flood history (hydrographic data) is available for the pilot district area;
- the pilot districts are Land Management (LM) registered and Land Use Planning (LUP) is initiated (optional);

B. water level/ flood data collection/ early warning system (EWS):

- daily readings from flood marks in the floodplain communities/ villages (taken during the monsoon season by responsible villagers) are sent by Radio Transmitter or SMS to the hydrographic data processing agency Department of Hydrology and River Works (DHRW) or Department of Meteorology and Hydrology (DMH), Lao PDR or Department of Water Resources (DWR), Thailand or Southern Region Hydro-Meteorological Centre (SRHMC), Vietnam for review and analysis;
- according to their review and comparison with the Mekong Main River Stations the hydrographic data processing agency sends Flood Information and Forecasting directly back to the communities/villages by Radio Transmitter or SMS [= *Early Warning System/ EWS* according to MRC-Standard (= No warning/ Warning Stage/ Flooding stage)]. The communities/villages publicize this flood information on *billboards* at central locations/ community places in the floodplains and advertise it via *loudspeakers*.

C. data processing:

- at the hydrographic data processing agency the following data are processed in the MapStats-Program (Software, developed during FMMP-C5/ Phase 1):
  - topographic information (DTM);
  - water level data from the floodplains;
  - water level data from the hydro-station at the Mekong mainstream;
  - flood history/hydrographic data.

  The product based on these statistics is flood probability information for the floodplains;
- this flood probability Information is further used by the Map Windows-Program (a GIS-Software, available free of costs) or ArcGIS (if available at the hydrographic data processing agency) to produce *flood probability maps*, displaying the
  - probability of flooding;
  - maximum depth of flooding for a range of probabilities;
  - duration of flooding for a range of probabilities;
  - completion of drainage for a range of probabilities;

in a scale of 1:10 000 for the Pilot Districts, which is a sufficiently detailed scale for further use in Land Management and Land Use Planning.

D. use of flood probability maps and other Flood Information for Flood Information Based Land Management (FIBLM):

Line Agency Organizations, concerned with Planning in Land Management and Land Use, Infrastructure and Construction, Agriculture, Irrigation, Environment, Rural Development, Water Resource- and Disaster Management make use of Flood Probability Maps (and other Flood Information) to reduce and minimize the hazards and damages of flooding towards people and infrastructure in the floodplains, while at the same time the economic and ecological benefits of flooding are preserved or increased.

PRESENT STATUS OF FMMP-C5 (PHASE 2), DATA COLLECTION AND ANALYSIS, RESULTS

During the respective National Kick Off-Workshops for FMMP-C5 (Phase 2) in October 2008 the formation of a National Working Group for FMMP-C5 was initiated in all four participating countries and seven pilot districts were determined for the implementation of the FMMP-C5 approach.

As part of the identification of data requirements and data acquisition (topographic data/ topographic surveys, hydrographic data) as well as the availability of hydrological infrastructure (flood marks and hydro stations) the Terms of Reference (TOR) and work plans, elaborated by FMMP-C5 in close cooperation with the implementing Line Agencies in each MRC Member Countries, were clarified during field visits of all seven pilot districts in November 2008 and January 2009 under participation of the respective NMCs, Line Agencies and Community Leaders and are currently implemented in all 4 countries.

While detailed topographic surveys are required and conducted in Lao PDR, sufficient topographic data (= DEM/DTM) are available in Vietnam and Thailand. Still, for the latter two countries this has to be validated and confirmed during the data analysis process.

In those three countries a number of flood marks are being established in the pilot districts and communities are being trained concerning the data transmission of flood mark readings to the hydro-data processing agencies.

After the data compilation phase the data analysis and processing for the Flood Probability Map Establishment will commence in those three countries towards the end of the flooding season 2009, when the first flood mark reading-data sets are available. As a result Flood Probability Maps on a scale of 1:10 000 can be expected earliest at the beginning of 2010 for the five new pilot districts.

In Cambodia the FMMP-C5-approach, already established in Phase 1 (2004-2008), has to be refreshed and re-activated, since communities and the Department of Hydrology and Meteorology did not continue their mutual data exchange after the end of the former donor support (USAID and Cambodian Red Cross (CRC)) in 2007.

With FMMP-C5-support flood marks and billboards are currently renewed and communities are being trained concerning the transfer of the flood mark readings.

As part of the capacity building concerning its technical approach FMMP-C5 developed three user manuals and one report (on data processing and data use for Flood Probability Map Establishment, translated into the 4 riparian languages) and conducted TOT-Trainings (GIS, Data processing and Data use) in Phnom Penh/Cambodia for 13 participants (technical staff) from the Department of Hydrology and Meteorology and Line Agencies, concerned with Land Management, during February and March 2009.

In the other three MRC Member Countries such TOT-Trainings will be conducted at the beginning of 2010. As well a study tour to Cambodia will take place for Line Agency staff from Lao PDR, Thailand and Vietnam during 2009.

According to international standards of performance measurement, additional activities

aim to introduce results based monitoring as a contribution to overall quality management. The development and introduction of a monitoring system by GTZ-FMMP is linked to and in line with MRC activities of establishing its results-based M&E system.

The monitoring system will focus on the results as well as on the quality of the new approach (enhancing the capacities of relevant authorities and organizations).

RELEVANCE FOR THE MEKONG RIVER BASIN

Current land management practices are an important factor contributing to a situation where the regular floods of the Mekong cause substantial damage to agriculture and infrastructure. More effective decision making requires the provision of more relevant and accurate flood related information. While there have been some MRC activities aiming to improve flood mapping, the maps resulting from these exercises are at a scale of (best) 1:50,000 only, which is not enough for land use planning purposes.

FMMP-C5 produces flood probability maps in a scale of 1:10 000 or larger. Therefore the project helps to supply the decision making authorities (particularly provincial and district offices) in the four participating countries with an urgently required planning tool of the right scale, which will contribute to avoid or at least minimize flood risks and damages for communities living along the Mekong River.

Improvements in land management by considering flood probability information will not only provide direct positive impacts through the reduction of damage to agriculture and infrastructure, but also indirect benefits through the avoidance of damage to the most vulnerable parts of the population living and working in the floodplains.

Reference is made to the vulnerability assessment which is being carried out under Component 1 of FMMP. Inappropriate infrastructure alters the pattern of flows and thus affects especially the livelihoods of poorer households who tend to have fewer options in adjusting to these changes. It also alters the habitats of indigenous plants and animals, of which the floodplains have abundance and which do not only constitute important environmental assets but also provide important sources of food and raw material (like building material) for the local population. Reference can be made to the road and flood project of Component 2 of FMMP.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

While the FMMP-C5- methodology for mapping flood statistics in the Cambodian floodplains has been shown to be reliable for three pilot areas in Cambodia during Phase 1, some further adaptation (= country specific approaches) might be necessary to reflect different conditions in the other three MRC Member Countries. This will become clear when data from the five new districts in the other countries, where flood marks have been installed, become available at the end of 2009.

It is anticipated that the present methodology, with minor modification, can handle most cases where the flooding is largely uncontrolled. When there are flood control measures in place, such as drainage channels controlled by sluices or other dynamic structures, more elaborate modelling would be necessary to predict the depth, duration, and extent of flooding.

In any event, it is anticipated that some consolidation and extension of the software used in the statistical analysis would be beneficial, automating some of the tasks that are currently carried out manually in spreadsheets.

So far Flood Probability Maps have been only produced in the three pilot districts in Cambodia (FMMP-C5 Phase 1) and no experiences exist concerning the use of these maps in land management and land use planning. It is premature to expect the mapping carried out so far

to be actively used by planning agencies, since the Cambodian pilot areas are not sufficiently extensive (approximately 15-50 km^2).

However, the current FMMP-C5 TOT training programme, which addresses the data processing and the data using line agencies in all four countries, includes components designed to show how the maps used singly or in combination can be analyzed in a GIS application to answer complex planning questions relating to Land Management, Agriculture, Irrigation, Disaster Preparedness and Rural Infrastructure Development.

Recommendations

Extension of the map coverage and the sustainability of map production are important after the present Phase of Component 5 is completed. Establishment of flood marks, collation and processing of the data, and production of the maps should become a major function of a suitable line agency of government in the four MRC Member Countries.

Line Agencies who should be able to fulfil this role are: The Department of Hydrology and River Works (DHRW) in Cambodia, the Department of Meteorology and Hydrology (DMH) in Lao PDR, the Department of Water Resources (DWR) in Thailand and the Southern Region Hydro-Meteorological Centre (SRHMC) in Vietnam. They could call upon support from competent local consultants experienced in statistical analysis and GIS applications.

It is envisaged that these ‘data processing’ organizations would provide the Flood Probability Maps as a service to other, ‘data using’ agencies along with technical expertise in their interpretation and use. Dataflow and the distribution of Flood Probability Maps to the Line Agencies, for the use in Land Management, should be facilitated and supported by the respective National Working Group on FMMP-C5 and the respective NMCs in each of the four countries.

The ‘user’ organizations and line agencies should continue to receive training as ‘map users’, with increasing emphasis on their kind of land management planning issues.

All this would finally result in a more flood adapted, flood information based land management and land use planning, which will help to avoid or at least minimize flood risks and damages along the Mekong River.

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Kaesler, G. 2006. Outline of an approach to generate flood probability information and its possible use in land management. 6th Annual Mekong Flood Forum (AMFF-6), Mekong River Commission.

SESSION 3

PARALLEL PAPER PRESENTATIONS FROM THE MEKONG REGION ON THE FOUR TOPICS FOLLOWED BY PARALLEL GROUP DISCUSSIONS

Topic I

Optimal packages for flood management

Paper 3-1-1

INTEGRATED HYDROLOGIC, HYDRAULIC, AND DAMAGE ANALYSIS FOR SELECTION OF OPTIMAL FLOOD MANAGEMENT MEASURES

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ABSTRACT

The increased level of impact on life, property, infrastructure and the environment caused by flooding has resulted in the need for improved flood management. Over the recent decades, parts of the Yang River Basin (4,145 km^2), Thailand, have been transformed through a variety of changes in land use, including urbanisation, and a range of agricultural activities. The rapid rate of land use development has created important constraints on options for flood management that must be addressed. The main purpose of this study, which is part of an Integrated Flood Management Framework for the Yang River Basin, was to predict flood behaviour within the river system for various probabilities of occurrence, identify the flood management measures which accomplish a reduction in flood risk, and assess the damage due to catastrophic flooding. A synthetic land use-elevation curve has been derived to build a base for potential flood damage assessment in relation to land use patterns. Moreover, hydraulic model simulation results, the flood level-discharge-damage relationships can be established for certain design floods with different probabilities of occurrence. This results in a priority ranking of appropriate flood mitigation measures after which an optimal (tailor-made) flood management package can be determined. In this study, model simulations of the inundation processes at the floodplains of the Yang River were carried out for different events and specified probability, thus flood levels could be detected in flood prone areas. For this purpose, the process-based hydrological model Soil and Water Assessment Tool (SWAT), incorporating a physically based representation of the surface runoff has been coupled with the model 1D/2D SOBEK to identify the propagation of floods through rivers, channels and floodplains. The hydraulic effectiveness of the proposed flood management measures has been analysed by comparing the situation with and without flood control measures for various probabilities of flood occurrence. The extent to which the flooding would have been prevented by the flood control measures concerned has been determined. The results show that the green river is the most appropriate scenario since it can potentially reduce a 1% to a 10% per year flood event, with a reduction of peak discharges of respectively 14% and 9.2% compared to the natural flood storage. Finally, the suggested methods in this paper may result in the initiation of a sustainable framework of flood risk management, which could be a useful improvement of the present practice for the flood defence in the Chi River Basin.

INTRODUCTION

Flooding is a natural and recurring phenomenon of rivers and streams, which has resulted over time in the formation of natural floodplains. Consequently, human settlements and activities have always tended to use these floodplains as it occurred in the study area, the Yang River

Basin, Thailand, which has resulted in the potential for flood damage. The analysis of worldwide loss events shows that flood damage has been extremely severe in recent decades and it is evident that both the frequency and intensity of floods are increasing at many places around the world (Loster, 1999), as corresponding to the trend analyses which reveal that major flood disasters and the losses generated by them have increased drastically in recent years (Berz, 1999). The human and economic impact of hydrological (essentially floods) disasters from 1988 up to 2007 show that they are highly influenced by the occurrence of 'mega-disasters' affecting tens of millions of people and/or causing billion of dollars worth of economic damage (Scheuren et al., 2008). The potential for future flood damages may be reduced significantly by preventing inappropriate development in flood prone areas. To better understand the flood hazards and their impacts that threatens life, health and cause extensive property damage, and to identify ways to reduce those impacts, proposed solutions to flood hazard problems must be considered. In order to decide on an optimum solution of flood hazard problems, it is necessary to know the extent of damage caused by floods of different magnitudes. To meet this purpose, model simulation is one of the ways to simulate potential risks associated with floods of different probabilities of occurrence.

In this study, the process-based hydrological model Soil and Water Assessment Tool (SWAT) (Di Luzio et al., 2005; Neitsch et al., 2005[a]; Neitsch et al., 2005[b]), incorporating a representation of the surface runoff has been coupled with the model 1D/2D SOBEK to identify the propagation of floods through rivers, channels and floodplains (WL|Delft Hydraulics, 2004). Thereafter, a logical method of assessing such damage for use in the selection of appropriate flood damage reduction measures for a given area is determined. It is based on hydrological and hydraulic factors related to the river system and the area to be protected from floods, which can eventually be used to identify a suitable flood management package for the Chi River Basin. Accordingly, the selection of an alternative measure is made between natural flood storage and a green river measure, through a comparative study of alternatives, considering the most effective combination of structural and non-structural measures. In exploring part of an Integrated Flood Management Framework for the Yang River Basin, the intention is to predict flood behaviour within the river system for various probabilities of occurrence, identify the flood management measures which accomplish a reduction in flood risk, and assess the damage due to catastrophic flooding. The integrative character of the presented study is featured by the combination of land use information and raster-based digital elevation models (DEM), and data on flood characteristics, in order to obtain a damage estimate for various damage categories. As a result, the expected flood damage in the flood prone areas in the Yang River Basin is estimated.

METHODOLOGY

Study area

The Yang River Basin occupies 4,145 km^2 and is located in the Northeast of Thailand (Figure 1). The dominant land use is agriculture (mainly paddy fields), which covers about 60% of the area. Forest covers about 33%, and water bodies about 3%. Only 4% of the area is urbanised. Historically this area suffers from frequent and extensive flooding. The major flood events occurred in 1978, 1980, 1995, 2000, and 2001, which affected several parts of the Chi River Basin (Royal Irrigation Department (RID), 2005). Topographically, the Yang River Basin is characterized by the Range of Phu Phan. The surface elevation of the plain area ranges between 0-560 m+MSL. It lies in the tropical monsoon region and experiences on average 1,390 mm/year rainfall.

Integrated hydrologic and hydraulic modelling

A flood event is a hydrological event of great complexity. Models not only help in understanding this flood phenomenon, but they are essential for flood risk assessment of the current situation and for assessment of suggested changes in the flood prone area. Within the context of flood management, an integrated hydrologic and hydraulic modelling approach is used to evaluate the effect of certain flood mitigation measures on the extent of flooding and damages.

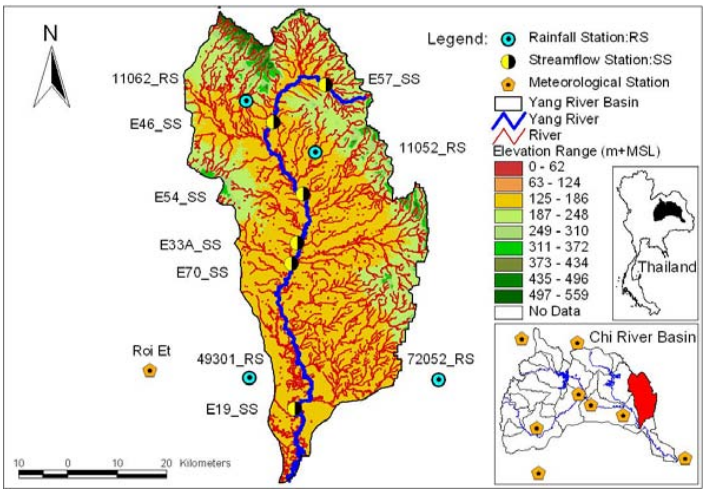


Figure 1. The Yang River Basin, as part of the Chi River Basin, Thailand, including instrumentation network

Hydrologic modelling

The process-based hydrological model SWAT (Soil and Water Assessment Tool) was used to simulate rainfall-runoff processes in the Yang River Basin. SWAT is a spatially semi-distributed, widely process-based hydrological model (Arnold et al., 1998). The hydrological processes in SWAT are based on the water balance equation:

$$\frac{dSW_t}{dt} = \frac{dSW_0}{dt} + \sum_{i=1}^{t}\left(P_i - Q_{surf} - E_a - w_{seep} - Q_{gw}\right) \quad (1)$$

where: $\frac{dSW_t}{dt}$ [mm d^{-1}] is the final soil water content, $\frac{dSW_0}{dt}$ [mm d^{-1}] is the initial soil water content on day i, t [d] is the time, P_i [mm d^{-1}] is the amount of rainfall on day i, Q_{surf} [mm d^{-1}] is the amount of surface runoff on day i, E_a [mm d^{-1}] is the amount of actual evapotranspiration on day i, w_{seep} [mm d^{-1}] is the amount of water entering the unsaturated zone from the soil profile on day i, and Q_{gw} [mm d^{-1}] is the amount of groundwater flow on day i. Four data layers comprise the data set used for the SWAT model, i.e. digital elevation model, land use, soils, and hydrometeorological data. Further details were discussed in Kuntiyawichai et al. (2009).

Hydraulic modelling

With the application of the model 1D/2D SOBEK for riverine flood simulations, a model of the Yang river system has been built and calibrated using the record of a large flood that occurred

in 2001, in order to identify the propagation of floods through rivers, channels and floodplains.

Water movement in the stream channel in 1D/2D SOBEK is described by a finite difference approximation, based upon a staggered grid approach as shown in Figure 2a. In the model 1D/2D SOBEK, the interactions between the 1D and the 2D schematisations are combined into a shared continuity equation at the grid points where water levels are defined as illustrated in Figure 2b (Frank et al., 2001).

$$\frac{dV_{i,j}(\zeta)}{dt} + \Delta y\left[(uh)_{i,j} - (uh)_{i-1,j}\right] + \Delta x\left[(vh)_{i,j} - (vh)_{i,j-1}\right] + \sum_{i=1}^{L(i,j)} Q_{kl} = 0 \qquad (2)$$

where: V [m^3] is the combined 1D2D volume, t [s] is time, u [m s^{-1}] is the 2D layer velocity in x direction, v [m s^{-1}] is the 2D layer velocity in y direction, h [m] is the total water height above the 2D bottom, ζ [m] is the water level above the plane of reference (the same for 1D and 2D), Δx [m] is the 2D grid size in x (or i) direction, Δy [m] is the 2D grid size in y (or j) direction, Q_{kl} [m^3 s^{-1}] is the 1D discharge flowing out of control volume through link kl, $L(i,j)$ is the number of 1D branches connected to 2D nodal point (i,j) and i, j, k, l is the integer numbers for 2D nodal point and 1D channel numbering.

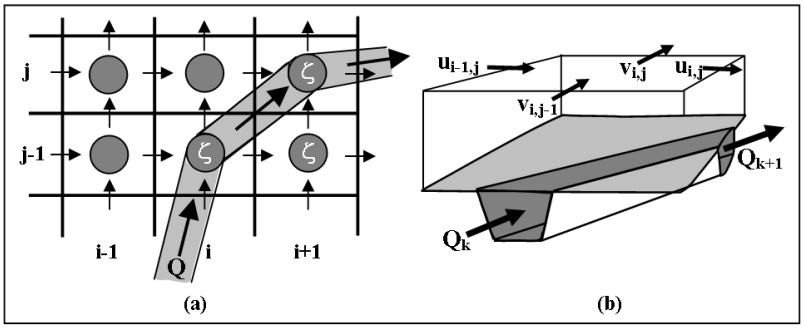


Figure 2. Schematisation of the hydraulic model: a) combined 1D/2D staggered grid; and b) combined continuity equation for 1D2D computations (adapted from Frank et al., 2001)

Hazard and risk

Flood risk is a measure of the seriousness of the flood hazard (International Commission on Irrigation and Drainage (ICID), 1999), and is a result of the combination of the flood hazard and the consequences of the flooding. Therefore, flood hazard and vulnerability maps are often required to produce flood risk maps. Mathematically, the risk of flooding is given by:

Flood risk = Probability of the flood event x Potential damages (3)

The hazard is the probability of the occurrence of a potentially damaging phenomenon within a given period of time and space (Tanavud et al., 2004). To perform a comprehensive analysis of flood hazards, the probability of occurrence is used to indicate different hazard levels, ranging between Class A and Class C. The following criteria were included in the analysis:

- Class A represents the inundated area due to the floods with a relatively high probability (chance of occurrence 20% per year);
- Class B refers to the inundated area comprised between boundary of Class A and the boundary of the inundated area related to the floods with a medium probability (chance of occurrence 10% per year);
- Class C identifies the inundated area comprised between the boundary of Class B and the

boundary of the inundated area related to the floods with a low probability or extreme events (chance of occurrence 1% per year).

A vulnerability or susceptibility analysis, which is directly related to its land use, enables identification of the densely populated and economically important areas at greatest risk from flooding. As a result, the analysis of the vulnerability will be useful for assessing the potential damage. In this study, the vulnerability was defined based on the sensitivity of a specific land use to potential flooding water by considering 4 classes of potential damages (classes D1 to D4, with D1 identifying major damage and D4 insignificant damage). Due to the fact that residential, commercial, and industrial areas generally are more valuable than institutional areas, dispersed settlements and small villages, and agricultural land, therefore vulnerability values varied between very high (4), high (3), moderate (2), and low (1). Higher vulnerability values were given to residential, commercial, and industrial areas, followed in descending order by institutional areas, dispersed settlements and small villages, and agricultural land (Table 1).

Table 1. Risk assessment matrix

					Potential damage			
					Insignificant (D4)	Minor (D3)	Moderate (D2)	Major (D1)
Flood hazard	Probability	Phenomenon	Likelihood	Score	1	2	3	4
	20% per year (Class C)	Is expected to occur in most circumstances	Highly likely	5	6	7	8	9
	10% per year (Class B)	Will probably occur	Likely	4	5	6	7	8
	1% per year (Class A)	Might occur at some time in the future	Possible	3	4	5	6	7

RESULTS AND DISCUSSION

Assessment of flood risk and damage, and mitigation options

To characterise the flood risk in the Yang River Basin and accurately identify potential mitigation measures, a comprehensive study has been undertaken. In this study, mainly inundation characteristics and land use data were used for the evaluation and calculation of flood damages, as well as the potential flood mitigation options. In the following, each of these components, which may have an influence on the damage will be described in more detail.

Risk mapping

The potential adverse consequences associated with different types of floods must be addressed through a flood risk map. In this study, an attempt has been made to establish a risk map. The total estimated risk for each flood risk category is determined by mapping the potential damage and flood hazard rating in accordance with the following relatively simple risk assessment matrix, which represents the degree of risk. The risk score for each risk dimension is determined by summing up the potential damage score and flood hazard rating numerical values in the risk assessment matrix. Using the matrix shown in Table 1, the risk classes are expressed as a single number that is used to help determine hazard mitigation priorities, i.e. the higher the value the higher the priority. The total estimated risk was classified in four categories, i.e. extremely high risk, high risk, medium risk, and low risk (Table 2). Then, the flood risk map was built, identifying four risk classes (R1 to R4), as shown in Figure 3. As a

result, the most plausible estimate of the area at risk of flood/flooding was eventually determined as given in Table 3.

Flood damage analysis

In this study, the flood damage analysis will be related to a combination of hydrological aspects about the probability of occurrence of different types of flood events, the hydraulic modelling information about inundation behaviour of floodwater in floodplains and the flood damage evaluation. For the flood damage analysis it is necessary to estimate the total direct damage, therefore the information on digital elevation data and land use are integrated and combined with the land use-elevation curve. Based on the local flood conditions, the expected damage by land use category can then be calculated as a fraction of the damages per land use type.

Table 2. Maximum and minimum values of the total estimated risk for each flood risk category

Total estimated risk values	Risk level	Further action
>7	R1: Extremely high risk	Immediate action required
6,7	R2: High risk	Action plan required
5	R3: Medium risk	Specific monitoring/procedures required
<5	R4: Low risk	Manage by routine procedures

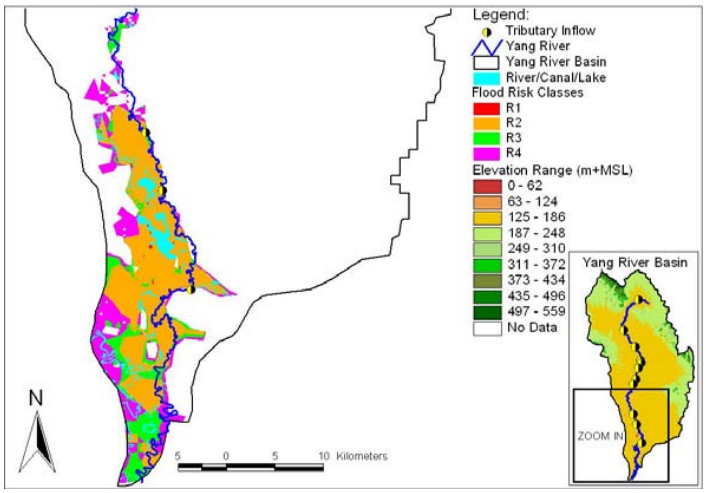


Figure 3. Flood risk map of the Yang River Basin

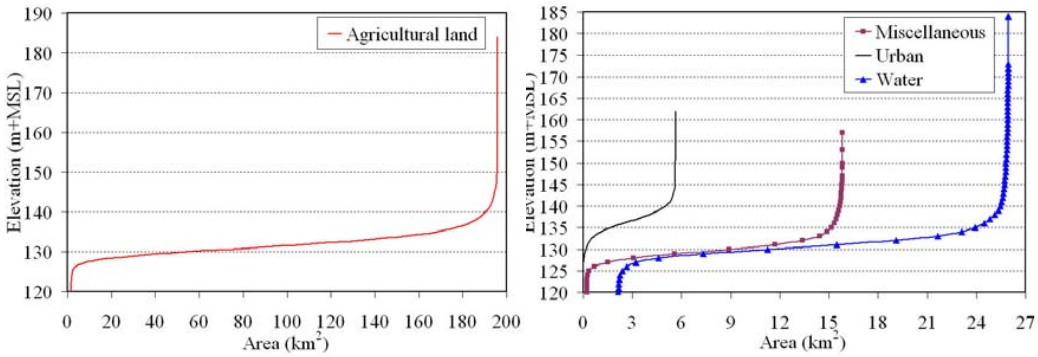
Table 3. Estimation of the area at risk for each risk dimension

	Risk level				Total area at risk (km^2)
	Extremely high risk (R1)	High risk (R2)	Medium risk (R3)	Low risk (R4)	
Area at risk (km^2)	<1	128	33	57	218

Land use-elevation curve

With the available information on flood prone areas, flood occurrence, probability and frequency, a full potential damage assessment for design flood scenarios can be made to determine a value of the expected loss and damage per flood event. A land use-elevation curve for the Yang River Basin as shown in Figure 4a and 4b can be established for the potential flood damage assessment in relation to several land use patterns. The classification of digital elevation data has been made and matched into each land use type by overlaying the digital land use map within the inundation extents due to a 1% per year flood event. In fact the type of

land use damage caused by flood events depends on the depth of the floodwaters; therefore, the grids which provide spatial information of flood depth from the inundation modelling were combined with land use-elevation curves by intersecting flood levels on the land use-elevation curve. Consequently, an estimate of the flood damage value per unit area/expected primary direct damages from flooding for each type of land use can then be determined.



(a) (b)

Figure 4. Land use-elevation curve: a) for agricultural land; and b) for miscellaneous, urban, and water

Evaluation of the proposed flood management measures

Evaluation of the proposed flood management measures to overcome or minimize the damages of flooding will be examined. The hydraulic effectiveness of the proposed flood mitigation measures compares the situation with and without flood control measures for different chances of occurrence, and calculates the area of inundation to which the flooding would have been prevented by the flood alleviation measure concerned. In order to fulfil this evaluation, an appropriate flood parameter (i.e. flood discharge and inundation extent) has to be determined in order to characterise the flooding in the area concerned.

Comparison of alternative flood mitigation measures

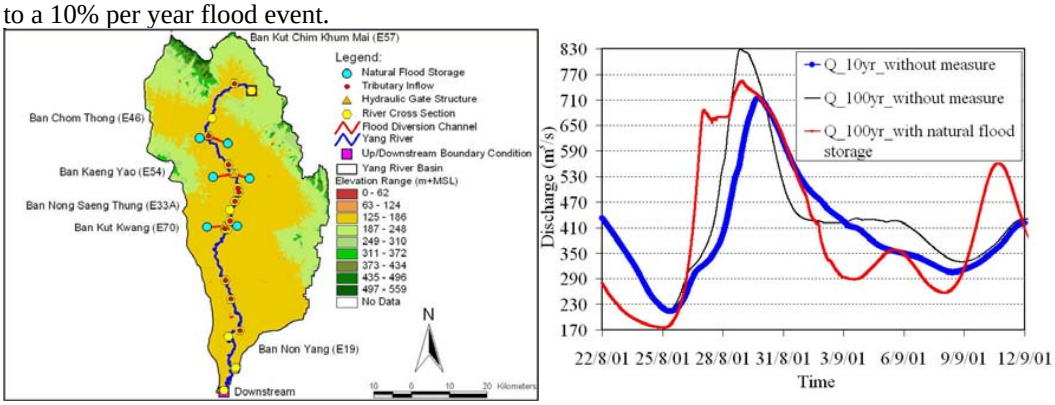
A comparison of floods, flooding, and various flood mitigation measures is necessary to evaluate their hydraulic effectiveness on a common basis. The target has been set as a criterion for selection of alternative flood alleviation measures to limit a 1% to a 10% per year flood event. Accordingly, two structural measures, i.e. natural flood storage and a green river channel, were proposed as it has to be supplemented to strengthen flood sustainability in the Yang River Basin. In the following the relevance of each of these measures will be briefly described.

Natural flood storage

The most effective way of protection against flooding is to delay the quantity of discharge by means of flood flow retention and partial water flow to detention areas to effectively reduce the peak flood discharge. Therefore, the study comprises the investigation of the upstream of the risk location that might be suitable for impounding water. As a result, a retarding basin has been supposed to be constructed to store floodwater from the Yang River (Figure 5a), thus preventing overflow of the Yang River. When the flood has ceased, the stored water can be drained back into the Yang River through the discharging gate.

Six locations were selected upstream of the risk location with the total area of approximately 18,700 ha (4.5% of the Yang River Basin). Figure 5b gives an illustration of the influence exerted by flood retention on the magnitude of a major flood peak. The peak

discharge was reduced with about 9.2%, close to the 10% per year flood event, which effectively mitigated the flood risk in the downstream part of the Yang River Basin from a 1% to a 10% per year flood event.



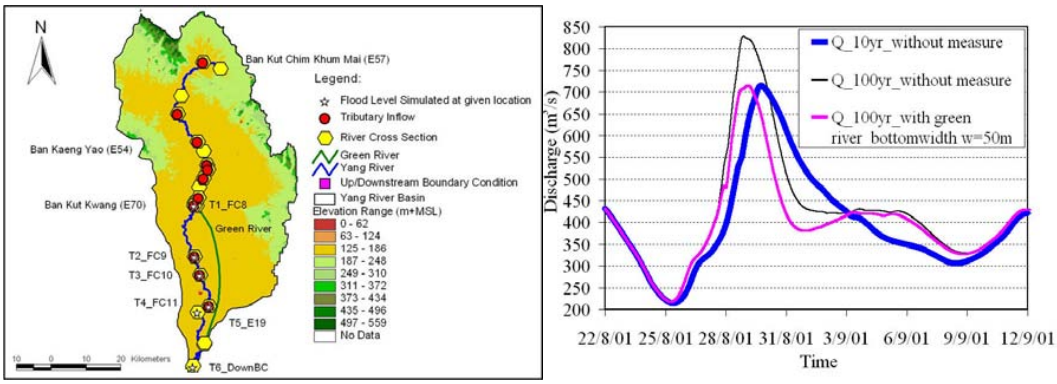
(a) (b)

Figure 5. Schematisation of the model 1D/2D SOBEK: a) potential natural flood storage areas; and b) discharge in the Yang River with and without flood diversion and natural flood storage

A green river measure

The floodplain of the Yang River is always flooded by the floods travelling down from streamflow station Ban Kut Kwang (E70) through the confluence of the Chi River (Figure 1). Flooding takes mainly place through overtopping of low-lying points in the river banks of the Yang River. Therefore, a green river scheme on the left bank through the floodplain to increase the discharge capacity during floods was proposed as one of the solutions to mitigate flooding problems. The floodwater will be diverted from the station E70 through the green river with 50 m channel bed width and 3 m maximum depth over a 50 km length, to a point 18 km away from the confluence of the Chi River, where it will re-enter the Yang River (Figure 6a).

Based on the results of the hydraulic simulations, there is a potential for a decrease in discharge of approximately 14%. The results clearly show that the discharge of the far more disruptive 1% per year flood event would be reduced to about the 10% per year flood event (Figure 6b).



(a) (b)

Figure 6. Schematisation of the model 1D/2D SOBEK: a) location of a green river; and b) discharge in the Yang River with and without green river for different dimensions

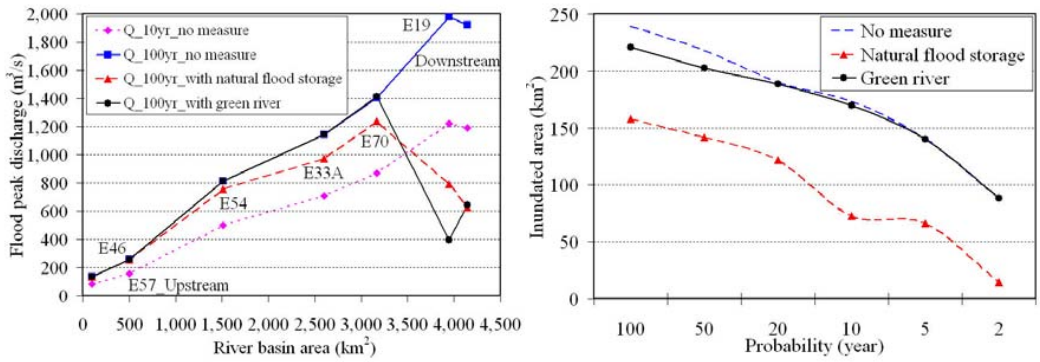
Comparison of flood characteristics of alternative flood mitigation measures

Based on comprehensive consideration of flood characteristics of alternative flood mitigation measures, it is obviously desirable to compare these schemes first of all based on hydrological

and hydraulic considerations, rather than on other factors, such as cost-effective analysis, environmental impact assessment, and socio-economic impact assessment, which were not included in this study. The evaluation results of all measures are specified in the following.

To provide a simplified method for the selection of alternative measures, the simulated flood peak discharge-river basin area along the Yang River for each flood mitigation option is considered as shown in Figure 7a. The slopes of the plotted curves in the portions between the river basin area of 3,170 km^2 (E70) and 3,950 km^2 (E19) indicate that the reduction of flood peaks by the proposed flood mitigation options is effective for the natural flood storage and green river. However, it is obvious that the decrease of flood peak discharge by the green river is larger than with the natural flood storage option.

The inundated area-reducing effects of different flood alleviation measures can also be estimated as shown in figure 7b. The curve enables a direct estimation of the amount of area at risk which is to be expected if a flood with a specific frequency of occurrence happens. In this study, a flood control work is able to ensure protection against floods with different chances of occurrence of 1%, 2%, 5%, 10%, 20% and 50% per year. The benefit of a scheme is given by the difference in the inundation areas for with and without scheme situations. It can be clearly noticed that even though the green river measure has a limited mitigation effect, it is more than the natural flood storage in view of inundation areas.



(a) (b)

Figure 7. Comparison of flood characteristics: a) flood peak discharges; and b) inundated area-probability curve for the downstream risk location of the Yang River Basin

Selection of alternative measures

For the selection of alternative measures, the proposed flood mitigation measures were put through a prioritisation process based on the criteria described above (Table 4). From a technical point of view, the natural flood storage measure is slightly better than a green river measure, since it is more effective to mitigate flood damage at the downstream risk location. However, the delineation of potential flood storage may affect many people, as many low-laying regions would be needed solely for the storage of floodwater. Also, in many cases using fertile land to store floodwater is not always looked upon favourably. Apparently, it will only transfer flood damage from one location to another and not solve the problem. By considering this evaluation table, it can be summarized that the green river measure can be considered as a first priority, as it can be multi-purposely used such as transportation, agriculture during non-flood times, etc.

Table 4. Identification of priority rank evaluated for proposed structural measures

Structural measures	Evaluation criteria	
	Peak reduction	Inundation area
Natural flood storage	Secondary	Primary
Green river	Primary	Secondary

CONCLUSIONS

In order to identify an optimal (tailor-made) flood management package, an integrated hydrological SWAT and 1D/2D SOBEK hydraulic model has been presented to predict flood behaviour of the Yang River System for various probabilities of occurrence.

Based on the modelling results a flood risk map for the Yang River Basin has been prepared by using the results of the flood propagation for various probabilities of flood occurrence and land use categories. Using a risk assessment matrix, the total estimated risk has been classified in four distinct risk categories, from R1 (extremely high risk) to R4 (low risk). In order to decide on an optimum solution of the flood hazard problem in this river system, the extent of damage caused by floods of different magnitudes has been identified. Therefore, the land use-elevation curve has been developed. By superimposing flood levels on the land use-elevation curve, damage level by land use category caused by a certain flood has been estimated as a fraction of the maximum damage.

Various appropriate flood mitigation options, which will reduce the social and economic impacts of flooding within the Yang River Basin up to the 1% per year flood event have been analysed. As a result, it was found that the green river option is superior to the other options for solving the regional flood/flooding problems.

Finally, the results of this study for the Yang River Basin, as one of the sub-basins of the Chi River Basin, provide the information and understanding necessary for systematically identifying effective flood management options, which can used as a principle for comprehensive flood management strategies in the whole Chi River Basin.

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Paper 3-1-2

CHARTING ICHARM'S STRATEGY FOR INTEGRATED FLOOD RISK MANAGEMENT IN THE LOWER MEKONG RIVER BASIN

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ABSTRACT

The International Centre for Water Hazard and Risk Management (ICHARM) was established in 2006 under the auspice of UNESCO as a Centre of Excellence in the area of water-related disaster risk management. The main objective of this paper is to charting ICHARM's Integrated Flood Risk Management (IFRM) strategy emphasising on the local conditions in the Lower Mekong River Basin. Recognizing risk as a factor of hazard, vulnerability and exposure (R = H x V x E), flood risk assessment and mapping is one pillar of the proposed strategy. It covers the identification and assessment of risks from floods and their consequences for the future development scenarios in the target areas. Promotion of Flood Hazard Maps is another key strategy of ICHARM, which is also useful for flood response such as evacuation. There is also a need of in depth study on hydrological events in the Lower Mekong River Basin as a part of the strategy. Another key element of the strategy is the study on climate change impact. The mitigation and adaptation strategy will focus mainly on flood preparedness indicators/standards and an approach to establish flood resilience communities with respect to socio-economic processes and human activities. More effective and accurate flood forecasting and warning is part of ICHARM's IFRM and is targeted to be achieved by introducing Integrated Flood Analysis System (IFAS) as one of the tools. IFAS is a concise flood-runoff analysis system, developed as a toolkit for more effective and efficient flood forecasting, and especially applicable for ungauged or poorly gauged basins. IFAS has implemented interfaces to input not only ground-based but satellite-based rainfall data, Geographic Information System (GIS) functions to construct flood-runoff models, a default runoff analysis model, and interfaces to display output results. In combination with the intended result outputs from ICHARM's ongoing research for tool development for generating near real-time satellite rainfall information and heavy rainfall area indication, the proposed approach is expected to deliver a more pragmatic IFRM system for the Lower Mekong Basin.

INTRODUCTION

The interactions amongst hydro-climatic, topographic, trans-boundary and socio-economic conditions in the Mekong River Basin often induce devastating floods, such as flooding in 2000, 2002 and again more recently in 2008, causing loss of lives of many residents and huge damages to riparian countries, especially in the Lower Mekong Basin. More than half of the Lower Mekong Basin residents are living with floods, and partly benefited through fisheries and agricultural gains in the flood plain (Mekong River Commission (MRC), 2003).

The International Centre for Water Hazard and Risk Management (ICHARM) was established in 2006 under the auspice of UNESCO as a Centre of Excellence in the area of water-related disaster risk management. The Asia-Pacific Water Forum (APWF) was also launched in 2006, with support from the Government of Japan and Asian Development Bank

(ADB). APWF's *KnowledgeHubs* initiative has been launched during the inauguration of the Singapore International Water Week, to promote knowledge networking for water security in the 21st Century. *KnowledgeHubs* are networks of internationally recognized institutions committed to generating and sharing water knowledge and capacity building in the Asia-Pacific region. ICHARM is serving as the regional water knowledge hub for disaster risk reduction and flood management.

ADB and ICHARM took the opportunity of the *KnowledgeHubs* launch to endorse and provide further direction to the design of a flood/drought Technical Assistance (TA) for the Lower Mekong River Basin. Technical assistance will be given to the Mekong River Commission Secretariat and its National Mekong Committee Secretariats in Cambodia, Lao PDR and Viet Nam, to develop flood and drought vulnerability indices for the Lower Mekong Basin, which has been identified as a priority requirement for preparing investment projects. The main objective of this paper is to charting ICHARM's Integrated Flood Risk Management (IFRM) strategy emphasising on the local conditions in the Lower Mekong River Basin (Asian Development Bank (ADB)/International Centre for Water Hazard and Risk Management (ICHARM), 2008).

TECHNICAL ASSISTANCE COMPONENTS

According to the project profile of the Technical Assistance (TA) proposed for the Japan Science Foundation (JSF) financing (draft of the 26 August 2008) prepared by ADB and ICHARM, the proposed TA has two components: (a) in-country project support; and (b) program quality support through regional cooperation (Asian Development Bank (ADB)/International Centre for Water Hazard and Risk Management (ICHARM), 2008).

In-country project support will be provided to the countries of the Lower Mekong Basin, particularly Cambodia, Lao PDR and Viet Nam. More countries are expected to participate in regional cooperation activities under the program quality support component. The TA will provide a package of advisory services and financial support to national executing and implementing agencies in the formulation and implementation of:

- flood management investment projects, strategies and programs, including the applications of flood hazard mapping;
- demonstration projects to improve flood forecasting and warning through a regional, satellite-supported flood alert system, utilizing advanced geophysical data integrating satellite, radar and ground observations;
- action research on innovative community-managed flood preparedness and disaster risk management practices;
- identification of 'no-regret' investments in flood management to accommodate climate change impacts;
- capacity development activities including training programs; and
- diagnostic assessments of executing and implementing organizations in preparation for long-term programs to build capacity and improve governance.

The Program Quality Support will improve knowledge networking and regional cooperation among interested developing member countries and development partners in the Asia-Pacific region. Technical assistance will be provided for the following:

- workshops and exchange visits among professionals to share experience in flood management;
- incorporating climate change adaptation effects into flood risk management;
- training to develop the capacity of River Basin Organizations (RBO) in flood risk management for Network of Asian River Basin Organizations (NARBO);
- training to incorporate flood risk management in cities, through existing city networks

such as CityNet;

- developing policy and institutional training elements for ICHARM's Masters Course on Disaster Management, with a link to local action research in the participating countries;
- organizing a pool of regional experts to improve flood management and emergency response services;
- developing a regional index for in-country water-related disaster preparedness with a view to introduce performance benchmarking and improvement through project investments and capacity development; and
- a comparative study of institutional arrangements for flood risk management in the region.

Considering the above components, the paper elaborates ICHARM's Integrated Flood Risk Management (IFRM) strategy emphasising on the local conditions in the Lower Mekong River Basin. Flood risk mapping is one pillar of the proposed strategy. It covers the identification and assessment of risks from floods and their consequences for the future development scenarios in the target areas. Promotion of Flood Hazard Maps, which are also useful for flood response such as evacuation, is another key strategy of ICHARM. There is also a need of in depth study on past and extreme hydrological events in the Lower Mekong River Basin as a part of the strategy. Another key element of the strategy is the study on climate change impact. The mitigation and adaptation strategy will focus mainly on flood preparedness indicators/standards and an approach to establish flood resilience communities with respect to socio-economic processes and human activities. More effective and accurate flood forecasting and warning is part of ICHARM's strategy and is targeted to be achieved by introducing Integrated Flood Analysis System (IFAS) as one of the tools.

In the following, the ICHARM's strategy for Technical Assistance toward integrated flood management in the Lower Mekong River Basin (LMB) is charted in four main themes.

THEME 1: FLOOD VULNERABILITY AND RISK MAPPING

The Mekong River Commission (MRC) needs quantitative information on flood vulnerability at the community level, including factors that affect vulnerability, to ensure that activities under the five components of MRCs Flood Management and Mitigation Programme (FMMP) are reflected in reduced flood risk and impacts at the community level. Such information would also be of use to non-governmental organisations (NGO), international organisations (IO) and national line agencies working in the flood and drought disaster risk reduction field (Mekong River Commission (MRC), 2007).

The focus of this theme is on flood vulnerability and disaster risk mapping. One of the most common and simple conceptual models is the Pressure and Release Model (PAR model), which is based upon the equation of 'Risk = Hazard × Vulnerability' (Wisner et al., 2004).

Recognizing risk as a factor of hazard, and vulnerability, it covers the identification and assessment of flood risk and vulnerability as follow:

- identifying hazards and vulnerabilities leading to flood risk and capacity to cope with it;
- flood risk assessment by combination of risk component indicators;
- estimating cost of the flood disaster risk reduction in flood prone area.

Flood risk depends not only on hazards and vulnerability, but also on exposure and capacity to cope with these hazards, making risk an inherently interdisciplinary issue. In order to reduce vulnerability, there needs to be integrated risk analysis, including consideration of relevant human behaviour, its motivations, constraints and consequences, and decision-making processes in face of risks. Moreover, the understanding of risk patterns and risk-management

decisions and their promotion require the integration and consideration of scales that go from the local through to the regional level.

Once the hazards, vulnerabilities and risks have been identified, a key task of decision makers is to establish the policies required for reducing the vulnerability and risk, and these include anticipating future events and, as far as possible, predicting the places affected, the timing and the scale of the phenomena and cost of the countermeasures to cope with them.

In this project, measurement of community-based flood risk is offered based on the PAR model, namely Flood Risk Index (FRI). Vulnerability is divided into four components hence Flood Risk Index considers five aspects; Hazard, Exposure, Basic Vulnerability, Capacity, Soft and Hard Countermeasures, which are named as Sub-indices. The basic equation of:

'R=H×V' is modified to calculate Flood Risk Index, which is expressed as (Kannami, 2008):

$$\text{Flood Risk Index (FRIc)} = \frac{\text{Hazard} \times \text{Exposure} \times \text{Basic Vulnerability}}{\text{Capacity (Soft countermeasures} + \text{Hard countermeasures)}}$$

It is targeted to extend this risk assessment and mapping for the future development in Lower Mekong Area as well. Presumably, not only the local policy makers and disaster managers are interested in wider concepts of risk mapping, but also ADB too can use it for sustainable development plans and investment assessments in the region.

Moreover, it will help design a standard flood preparedness procedure to assure a positive spiral installed into community management system in LMB. In order to design a flood disaster preparedness procedure, the following steps may have to be included:

1. form a community flood defence committee to maintain and improve the community-based disaster management. It should start from community itself, forming a committee made up of all the key-players including community leaders, public officers, volunteers and residents who do the real labour work;
2. identify the goal of the locality. The goal may be decided by the committee, such as no human losses by any floods while constructing a sustainable flood-safe community, while conserving the current ecological system;
3. design a set of rules of procedure for the community to reach the goal. The committee shall design a standard set of rules for the flood preparedness plan and also the system to routinely implement, record, review, improve and again implement to complete the plan-do-check-action cycle. This is an important and difficult step necessarily carried out by participatory process with strong support of worldwide preparedness knowledge base;
4. identify the annual objectives for improvement. Once an initial rule is established and routine procedure is being exercised, the committee should decide the short term objectives for improvement that may include concrete targets such as development of some residential area in a flood proof design in accordance with a flood risk map issued, the improvement of particular evacuation routes, the annual flood management training participated by more than 10% of community population etc.;
5. plan and materialize the administrative, technical and financial actions to achieve the annual objectives. The concrete actions should be decided to achieve the annual objective. This requires the local government to provide the necessary resources for implementation for the actions committed. This is why the committee is required to have the local government leaders as members;
6. establish a linkage with the national/provincial level administration. This step will ensure the integrated emergency operation in nation–wise, in the case of large scale catastrophic disasters. At the same time, it ensures legal and financial agreement for support with the national/provincial level administration;
7. prepare the regular internal and external review process and re-licensing of the flood preparedness (Takeuchi, 2008).

THEME 2: IN-DEPTH HYDROLOGICAL ANALYSES

In order to achieve effective flood risk forecasting for poorly gauged sub-basins in the Lower Mekong River Basin, the feasibility of using a currently available distributed hydrological model and satellite-based precipitation datasets coupled with a simple statistical approach is considered as a part of TA. The physically based distributed hydrological model, YHyM/BTOP model, will be used for this to simulate at any grid for the whole Mekong River Basin, including poorly gauged basins. In ICHARM, historical discharge data for the past 29 years were reconstructed and archived with validation using ground-based observed hydro-meteorological data with other public domain datasets as input. A preliminary study on the real-time flood risk assessment interpreted from the percentile of simulated discharge from the discharge database referring observed river discharge is consequently conducted utilising satellite-based precipitation datasets Global Satellite Mapping of Precipitation (GSMaP) and Tropical Rainfall Measuring Mission (TRMM) Multi-satellite Precipitation Analysis (TMPA) data. Simulated discharge by the YHyM/BTOP model using satellite-based precipitation generally represents the trend of observed discharge well and the possibility of real-time flood risk assessment was well demonstrated (Magome et al., 2007).

The YHyM is an integrated hydrological simulation system, which consists of core 'BTOP model' and other advanced sub models, as described below. These sub modules are meso-scale precipitation module, a potential evaporation module, a snow accumulation/melt module, frozen soil module, sub-surface model, sediment movement module, inundation module, water quality model and water use/control module (dam, irrigation), and each sub-module can either be activated/deactivated based on the overall objective of model application. In this particular application, the potential evaporation and snow accumulation/melt models are used together with the core model for the hydrological simulation of Mekong River Basin.

The core 'BTOP model' is formed by incorporating a topographic model, runoff generation model, flow routing model and parameter identification module. The runoff generation concept used is an extension of the original TOPMODEL (Beven et al., 1979, 1992) to large river basins. This extension was made by redefining the topographical index by using an effective contributing area per unit grid cell area instead of the upstream river basin area per unit contour length and introducing a concept of mean groundwater travel distance. Furthermore, transmissivity parameter was replaced by a groundwater dischargeability function, which can provide a link between hill slope hydrology and macro hydrology. Yet the BTOP model uses all the original TOPMODEL equations in their basic form (Takeuchi et al., 2007). For the routing model, Muskingum-Cunge Method and simplified routing technique based on Manning's equation are available in the latest version (Takeuchi et al., 1999; Ao et al., 2000).

Moreover, ICHARM has been engaged in several other further studies about the effect of climate change on water-related disasters using General/Regional Circulation Models (GCM/RCM) rainfall data. It is possible to provide change in the flood/drought risk map for the future (for instance next 30 years) in the region using modelling tools developed at ICHARM.

THEME 3: INTEGRATED FLOOD ANALYSIS SYSTEM (IFAS)

ICHARM has developed a concise flood-runoff analysis system as a toolkit for more effective and efficient flood forecasting in developing countries (Sugiura et al., 2008). It can be used for low flow modelling too. This system is called 'Integrated Flood Analysis System (IFAS)'. IFAS has implements interfaces to input not only ground-based but satellite-based rainfall data, incorporates GIS functions to construct flood-runoff models, a default runoff analysis model, and interfaces to display results (Figure 1). ICHARM hope that this system will be useful for the immediate and efficient implementation of flood forecasting and warning systems in LMB.

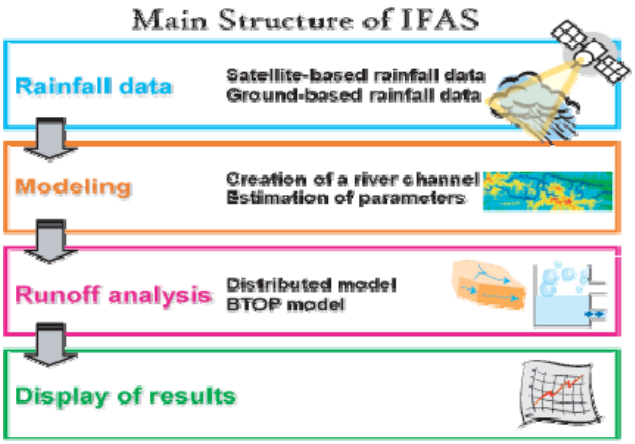

Figure 1. Main structure and outline of the Integrated Flood Analysis System (IFAS)

To do runoff calculation for flood forecasting, it is essential to have real-time rainfall data (or semi-real-time rainfall data). Products of global rainfall information observed by earth observing satellites are currently available on the Internet. However, in addition to 1 hour time resolution, satellite-based rainfall has a distribution delay time of several hours, and, at present, it can be applied only to large basins with at least half a day lag-time to occur a flood from a particular rain event. The following are some advantages of using IFAS:

1. *utilization of satellite-based rainfall as an input data*

   Real-time satellite-based rainfall information which covers almost the whole world is provided from NASA, NOAA, JAXA, etc (Table 1). Thus, in principle, satellite-based rainfall data could be downloadable even to a personal computer connected to the Internet, which can substitute ground-based rainfall gauges to some extent.

Table 1. Products of satellite-based rainfall data

Product name	3B42RT	CMORPH	QMORPH	GSMaP
Builder	NASA/GSFC	NOAA/CPC	NOAA/CPC	JAXA/EORC
Coverage	60N ~ 60S			
Spatial resolution	0.25°	0.25°	0.25°	0.1°
Time resolution	3 hours	3 hours	30 minutes	1 hour
Delay of delivery	10 hours	15 hours	2.5 hours	4 hours
Coordinate system	WGS			
Data archive	Dec. 1997 ~	Dec. 2002 ~	Recent 2 days	Dec. 2007 ~
Data source	TRMM/TMI Aqua/AMSR-E AMSU-B DMSP/SSM/I IR	Aqua/AMSR-E AMSU-B DMSP/SSM/I TRMM/TMI IR		TRMM/TMI Aqua/AMSR-E ADEOS-II/AMSR SSM/I IR AMSU-B

2. *implementation of modification function of satellite-based rainfall*

   In past studies, it has been found that satellite-based rainfall data are underestimated compared with ground-based rainfall, especially during heavy rainfall conditions. ICHARM has developed a modification method of GSMaP data, focusing on the movement of rainfall area (Shiraishi et al., 2008), and this function has already been effectively implemented in IFAS (Figure 2).

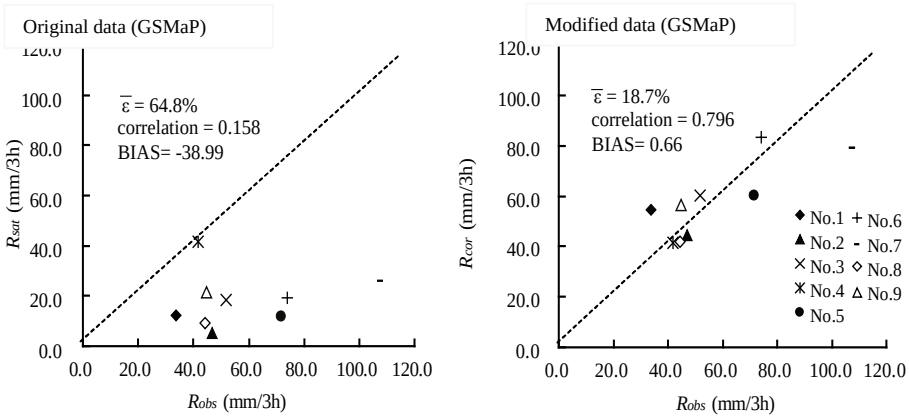

Figure 2. Example of modification of satellite-based rainfall data (for Yoshino River Basin in Japan)

3. *implementation of multi-runoff analysis engines*
   IFAS has a function of multi-engine analysis. A runoff analysis engine is a physics-based distributed hydrological model. Most of parameters are related to physical basin condition of land use and soil type, which are globally available in public. Guideline parameters are prepared based on past simulation results, therefore, the application can be extended to any poorly gauged basins easily.
4. *implementation of a model creation function*
   IFAS has a function to create runoff model and to estimate parameters using the GIS data of elevation, land use, soil type, etc. With this function, runoff analysis can be applied to basins with insufficient hydrological and geophysical information.
5. *iisualization of flood forecasting results*
   IFAS has interfaces to display output results in graphical format on digital maps. Users can easily identify the risk of flood by observing and promptly assessing the readily visualized simulation results.

THEME 4: INUNDATION MODELLING

This theme focuses on flood hazard and risk assessment of the Mekong River Delta (Cambodia & Vietnam) under Scenarios of Global Warming. A detailed 2D-FEM model (Hai et al., 2008) was applied in ICHARM for the simulation of inundation flows of year 2007. In this simulation, 100-m resolution DEM data of Mekong delta in Cambodia were used with hydrographical data simulated by YHyM (BTOPMC) model, like discharges at Kratie in upstream part of main Mekong River, and the other 12 tributaries at upper Tonle Sap Lake. The simulation output was uploaded to Google-Earth interface, making the modelling and presentation process much comprehensible to the general public. Moving boundary conditions for inundated areas around Tonle Sap Lake were imposed and the effects of roads, dikes and other man-made structures were introduced in simulation. This result showed that the 2D-FEM model can be effectively integrated with the other ongoing hydrological modelling procedures at ICHARM targeting Flood Forecasting and Warning Systems, like in IFAS (Integrated Flood Analysis System).

The topographic data used in the model are derived from the 100 m x 100 m grid resolution Digital Elevation Map (DEM) (provided by Technical Support Division – Mekong River Commission), which covers the Mekong floodplain from Kratie, Tonle Sap Lake and its vicinities in Cambodia to the South China Sea including parts of coastal areas of Mekong Delta in Vietnam. This DEM data set has been generated by MRCS Technical Support Division. As

for inside river areas, Hydrographic Atlas sound-bathymetry data (cross-sections data) of Mekong, Bassac, Tonle Sap rivers and Tonle Sap Lake were used.

At present, we are in the processes of preparation of input data for the 2D-FEM model to simulate flood inundation of year 2000. The bed elevations of grids in the DEM data were used to interpolate the elevations of FEM nodes in the floodplain domain, while more precise sound-bathymetry data of the main rivers as bed elevations were utilized to interpolate the elevations of FEM nodes in the domain of the main rivers. In addition, a bilinear interpolation algorithm was used to interpolate the elevations of the FEM nodes in the floodplain areas, and a nearest-point interpolation algorithm was applied to interpolate the elevations of the FEM nodes in the main river areas. Water levels and discharges at Kratie, tributaries around the Tonle Sap Lake and water levels at estuaries are use as hydrological boundary conditions (Hai et al., 2008).

The simulated results in Cambodia area produced valuable hydrologic data for the basin areas, especially for those without gauging, and the ongoing modelling procedures are expected to derive further insight and additional data that can be used to evaluate the effects of basin management on flooding and agricultural water use.

EXPECTED RESULT

The TA is expected to result in (i) a regional index for in-country water-related disaster preparedness, and a regional flood alert system; (ii) improved flood management strategies and investment projects; (iii) demonstration projects to improve flood forecasting and warning, including community-managed flood preparedness and disaster risk management practices; (iv) improved capacity in flood management of project executing and implementing agencies in the participating countries; (v) enhanced policy and institutional modules of ICHARM's Master's course program on disaster management; and a (vi) an organized pool of regional experts for flood management emergency response.

ACKNOWLEDGMENT

The authors gratefully acknowledge Asian Development Bank and Mekong River Commission for opportunity and support of this paper.

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Paper 3-1-3

RISK-BASED FLOOD MANAGEMENT FOR ADAPTING TO CLIMATE CHANGE

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ABSTRACT

This paper introduces the latest efforts in implementing adaptation measures to climate change, with a particular focus on water-related disasters taken by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), Japan. Based on consideration on negative impacts of climate change, our challenge is focused on developing new ways of thinking about adaptation measures to water-related disasters with the objective of adapting our society to climate change. As a result of the challenge, a road map has been prepared, which shows the staged implementation of structural measures, and was used as road map to prioritize zones and to examine whether it was possible for those low-priority zones to allocate risks and strengthen non-structural measures in these zones. This approach can also be applied to the developing countries which have an insufficient safety-level and currently ongoing projects to sort out what needs to be done.

INTRODUCTION

When we consider climate change from the perspective of managing water-related disasters, our concern is that the growing risk of sea level rise and increases in rainfall intensity would bring about an extremely hazardous situation. For this reason, in spite of our full recognition of the need for mitigation measures to promote reduction of greenhouse gas emissions, it is necessary to start thinking about adapting to future climate change, because even if reduction in greenhouse gas emissions becomes successful, climate change will still inevitably occur. Therefore, it is necessary to start adapting our society to climate change as soon as possible.

It is time to discuss new ways of thinking about adaptation measures to water-related disasters with the objective of adapting our society to climate change. It is a purpose this paper to make a proposal based on the latest discussions held in Japan on a specific risk-based program.

INTENSIFYING EXTERNAL FORECE AND ITS IMPACT BASED ON CLIMATE CHANGE

Climate-change phenomena in Japan

According to our analysis of recorded data and summarized, climate-change phenomena were actually taking place in Japan. For example, the number of days with the daily precipitation of 200 mm or more was counted which is generally considered as a level that may give rise to floods in Japan. The results of the analysis showed, in Figure 1, that whereas it was 3.5 days a

year about 70 years ago, it had increased to 5.1 days a year for the latest figures. The number of occurrences of the hourly rainfall of 100 mm or more, which is considered as a heavy rainstorm, was 1.7 times as many as 20 years ago, 2 times as many as 10 years ago, and 3.6 times for the latest figures. The increase is more than double the level of 20 years ago, in Figure 2.

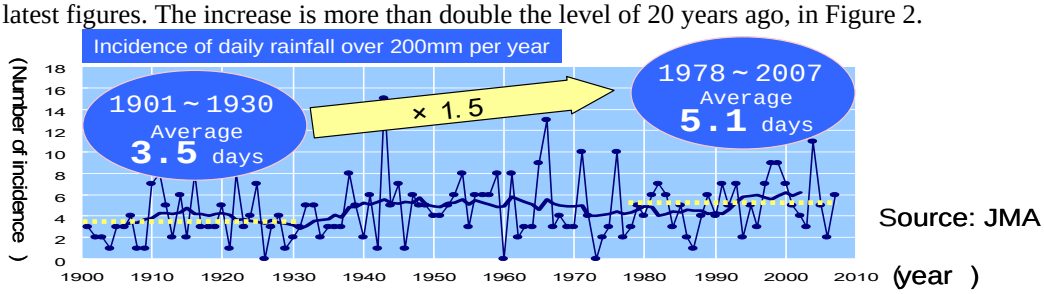

Figure 1. Incidence of heavy daily rainfall in Japan

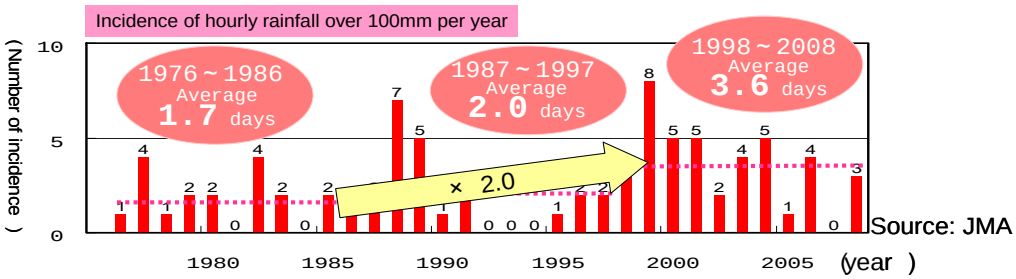

Figure 2. Incidence of heavy hourly rainfall in Japan

Analysis on climate change's effect on increase in the impacts of water-related disasters

As explained in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), the rise in temperature from climate change causes melting of glaciers and Antarctic ice sheets, thermal expansion of sea water, and increase in evapotranspiration. Ultimately, it increases the intensity of the impacts of water-related disasters, giving rise to more frequent storm surges, coastal erosions and floods and aggravating the damage from debris flow and landslides, in Figure 3.

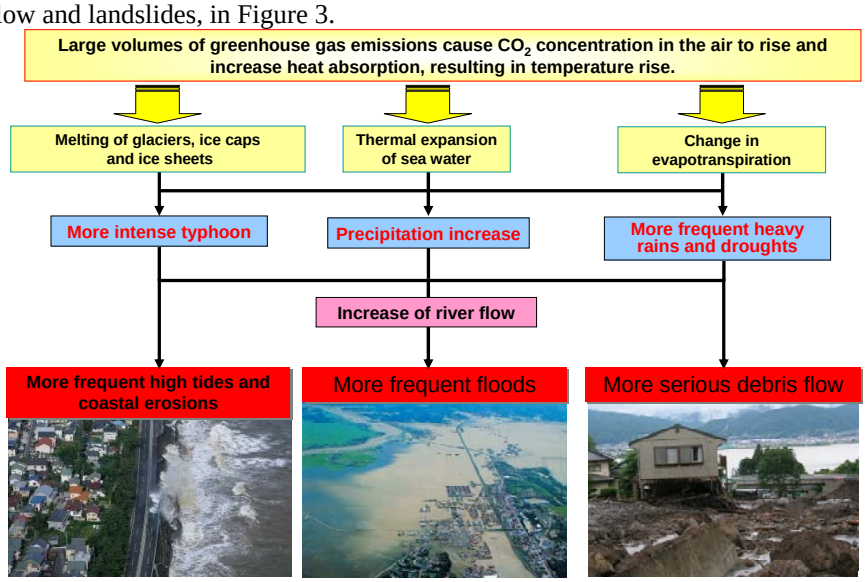

Figure 3. Basic concept for tackling in increasing risks

Forecast of future climate change

Using the calculations of General Circulation Model 20 (GCM20), we obtained the mean values of the maximum daily precipitation in the year during a period 20 years in the past and during the same period 100 years into the future, based on A1B scenario (Emphasis on the balance among various energy sources). The results showed that rainfall intensity will increase nationwide, as shown on the slide, and that the future rainfall intensity in northern Japan, in particular, will increase by more than 20%.

An increase in rainfall intensity means a decrease in flood control safety level, which is calculated based on the current precipitation levels. For example, if the current flood control plan is designed to withstand a major flood that might occur once in 100 years, the increase in precipitation would make the flood control plan good only for a major flood that might occur once in 25 to 50 years. In other words, the flood control safety level would decline substantially.

ADAPTATION STRATEGIES AGAINST WATER-RELATED DISASTERS

System of adaptation measures

In responding to climate change, it is important to promote mitigation measures. At the same time, it is necessary to work promptly on implementing adaptation measures. Adaptation measures against water-related disasters include the use of dams, levees, and other structures; measures tied in with community development; measures focused on emergency response; and improved monitoring of the adverse effects of climate change. It is necessary to take a multi-stratified approach of combining these measures. It is also necessary to couple adaptation measures with risk assessment and to arrive at the optimum combination of measures that offers the greatest efficiency and effectiveness, in Figure 4.

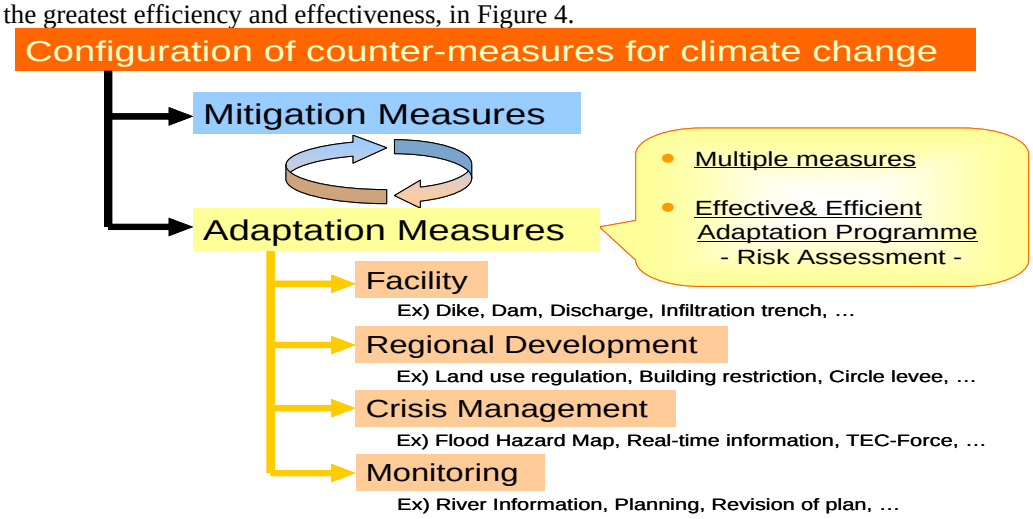

Figure 4. System of adaptation measures for climate change

Basic Policy for Adapting to Future Increase in Risk (Multi-stratified Flood Management). To give you some more explanations on the image of our adaptation measures, a river with a target flood control safety level of 1/150 is expected in 100 years' time to have its flood control safety level drop to 1/40. In this case, damage from major floods will become frequent, but considering the socioeconomic conditions, it is not realistic to raise the target flood control safety level to 1/150 in the face of future climate change. Therefore, to manage future increases in river discharge, it is necessary to implement existing structural measures such as

channel improvement and construction of flood control facilities and further promote projects in drainage basins. At the same time, this should be combined, in a multi-stratified approach, with emergency measures to contain flood damage in case a flood occurs as well as regulation and guidance on land use and development (Figure 5).

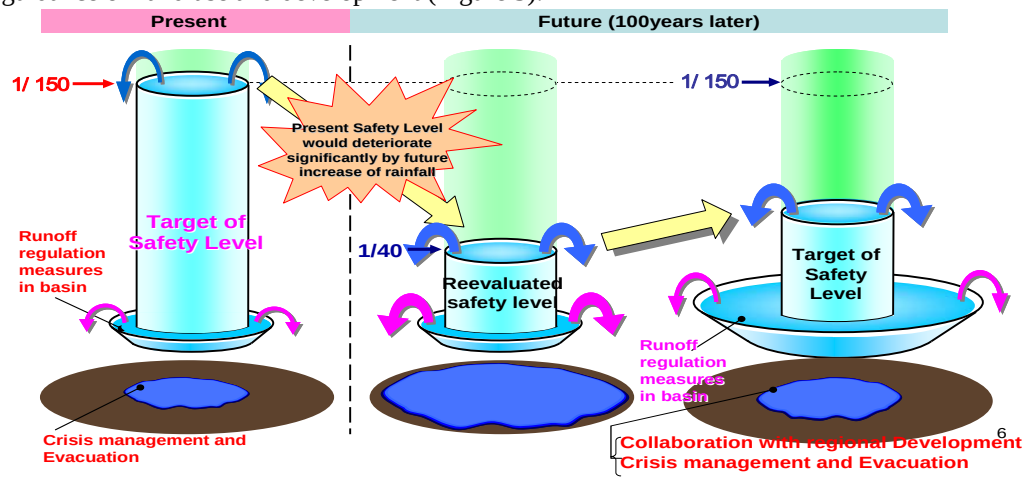

Figure 5. Multiple measures in flood management for adapting to future increase in risk

PROPOSAL FOR A NEW FLOOD CONTROL PROGRAM BASED ON RISK ASSESSMENT

Priority items in risk assessment

When considering flood control measures within a drainage area, it is important to identify and comparatively assess the risk level within that drainage area.

We considered a range of foreseeable, measurable damage, and ultimately picked out four kinds of damage, namely, the number of deaths, the number of stranded people, economic damage, and infrastructure, as being the most important.

Among these four, the top priority is to prevent loss of lives. Therefore, we need to concentrate on ensuring that there are no blocks with the risk of death.

Secondly, we minimize the economic damage. From among a range of measures at our disposal, it is necessary to choose the ones that can efficiently mitigate damage.

When structural measures are not sufficient to prevent loss of lives or people from becoming stranded, it may be necessary to implement emergency measures, such as evacuation and advance preparations, as well as to provide regulation and guidance on land use.

This new flood control programme utilizes risk assessment and explores the optimum solution by effectively combining a range of measures.

Utilization of risk map

When performing a risk assessment, we take into consideration the increasing future climate change, and carry out analysis of floods of various magnitudes that may occur at different precipitations. Risk assessment is then performed for each index, and risk maps are created from the assessments (Figure 6).

Specifically, we use the data on the forecast of future climate change as reference. In this case study on the drainage area of the lower Arakawa River, we calculate floods based on the assumption of 20% increase in rainfall. This is necessary to understand the limitations of the currently implemented measures. The results indicate that the four indices of the number of

deaths, the number of stranded people, economic damage and infrastructure, which have a notable effect from the increase in rainfall, to be the most appropriate indices for evaluation.

Measures for preventing any loss of lives

In considering the adaptation measures, we examine the four priority items and come to a conclusion that preventing any loss of lives is the most important. Now its measures are necessary to be considered. In this case study, there is a risk of a substantial number of deaths in R2 and R1. We need to execute measures to remedy this situation.

Specifically, we reinforce levees alongside the two zones to prevent damage from the anticipated levee breach. Since these measures are still insufficient, we build dams and reservoirs upstream.

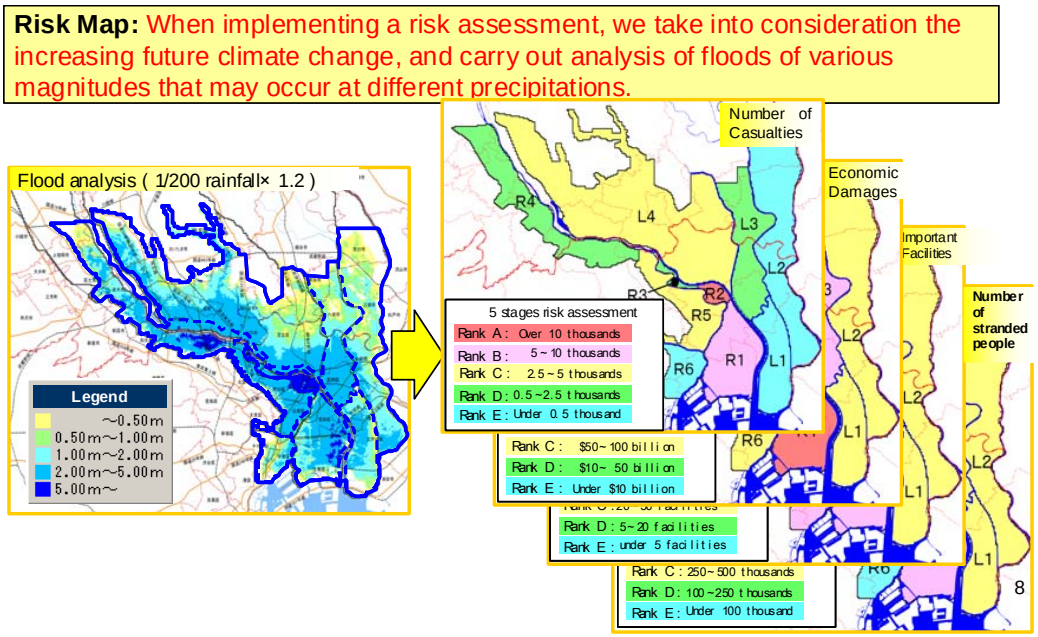

Figure 6. Case study of risk map utilization of Arakawa River

Measures for minimizing damage

We also consider measures for minimizing economic damage. Since there is concentration of assets in the lower drainage area, the economic damage would be considerable particularly in R1, R5 and L4 zones. Therefore, we examine measures for mitigating damage in these zones. We reinforce levees in these zones and replace bridges to increase discharge capacity.

Effectiveness of the optimum measures

An assessment on the combined effect of the various structural measures we have discussed shows that the maximum water depth will decrease substantially even in R2 zone where loss of lives was anticipated. The inundated area in L2 on the left bank and the upper drainage area will also decrease markedly (Figure 7).

Risk assessment that takes into consideration the measures' effectiveness over time

The contents of our discussions, together with the measures' effectiveness over time, are summarized in a road map.

The road map illustrates the zones requiring particular attention, the priority and non-priority zones, the timeline for specific measures, the effect of those measures, and non-structural measures in zones that require further action.

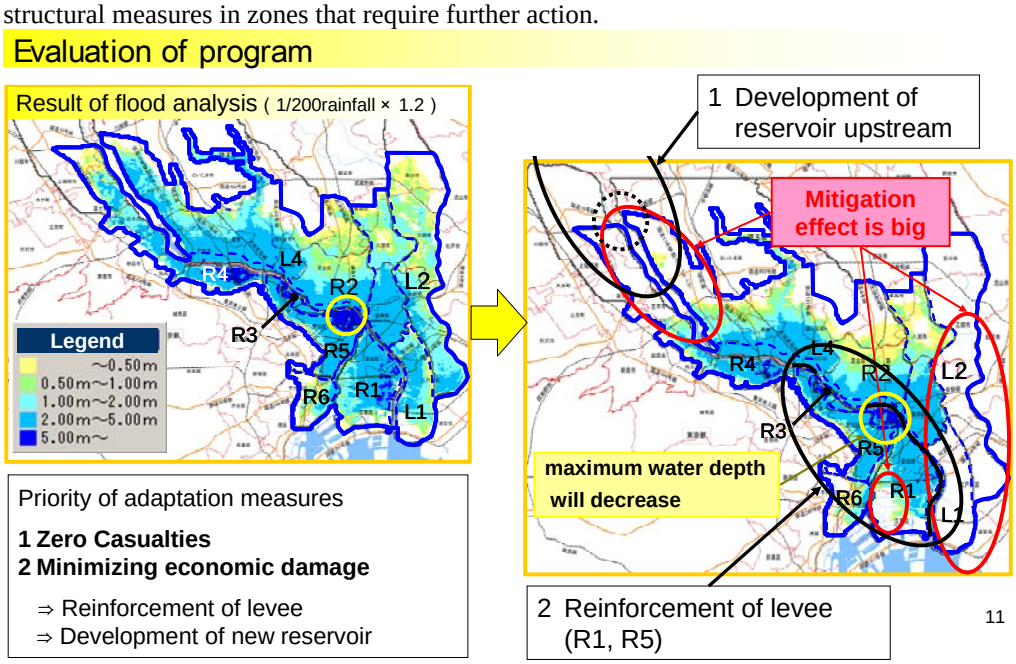

Figure 7. Evaluation of program based on the result of the case study

Adaptation measures in zones with remaining hazards

When structural measures are not enough to eliminate the adverse impact, we may concentrate non-structural measures on specific locations to minimize damage as much as possible.

Specifically, concrete measures should be implemented by considering the types of anticipated flooding. When there is a need to reduce the number of stranded people, for example, we would need to focus on emergency measures and work on reinforcing the evacuation programme.

An assessment may also be made on the level of preparedness, which may include preparation and distribution of hazard maps and other public awareness activities. It is, however, difficult to evaluate such activities in terms of numerical data.

Non-structural measures may include land use regulation and guidance over the long term. This shows that the risk assessment may afford long-term use of the data gained from the assessment.

CONCLUSIONS

We can summarize the findings from our case study, as follows:

- up to now, our flood control projects have focused on setting the target discharge for each river. We need to change that to a new approach whereby we assess the possible damage in the entire drainage area that may occur from floods of varying magnitudes;
- until now, we evaluated the effect of individual flood control projects. We will also need

to change this to an approach where we introduce risk assessment and evaluate the effect on mitigating the risks of floods in the entire drainage area;

- our road map shows the staged implementation of structural measures, and was used the road map to identify low-priority zones and to examine whether it was possible for those low-priority zones to share risks. This approach can also be applied to the currently ongoing projects to sort out what needs to be done. It allows us to set well-defined, concrete programs for minimizing damage by combining structural measures on the rivers, various projects in the drainage basins, and emergency measures;
- in areas where structural measures are not sufficient to mitigate risks, we need to assess the vulnerabilities, which should be reflected on hazard maps and land use regulations;
- because of the significant uncertainty of future climate change, it is necessary to conduct continuous monitoring, review climate change forecasts based on the results of the monitoring, and respond flexibly to the revised forecasts;
- contributing to the world by transferring of new technology and Japanese expertise, policy, technology, such as Integrated Flood Analysis System (IFAS), developed by the International Centre for Water Hazard and Risk Management (ICHARM).

By radically changing the existing flood control plan and drawing up a more effective, risk-based plan, regional communities can be strengthened to withstand future floods of variable magnitudes.

Based on this case study, similar studies on other rivers in Japan are planned to be conducted, and through accumulation of these studies, to actually institute a system.

This new approach can widely use as it can be applied to rivers with limited levee construction as well such as developing countries. It is essential to further improve in this approach through exchanging information with other countries.

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Topic II

Recent developments in flood forecasting and early warning

Paper 3-2-1

FLASH FLOODS, HYDROMETOROLOGICAL FORECASTING AND WARNING SYSTEMS IN VIET NAM

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ABSTRACT

Located in a monsoon tropic humid area, being contiguous to the South China Sea and the West–North of the Pacific Ocean, Viet Nam not only has diversified climate and plentiful resources but also has many natural disasters, especially floods, flash floods and typhoons.

In Viet Nam, flash floods are considered severe disasters that occur suddenly, having high flood intensity, high amplitude and huge damages. These floods usually occur in the small and medium river basins in the Northern mountainous and the Central part of Viet Nam. According to surveys carried out from 1996 up to now, flash floods occur more frequently in Viet Nam, the number of flash floods per year has increased year by year, causing tremendous damages on people's lives and the environment.

This paper presents an overview on Hydro-meteorological station networks, database, types of forecasting bulletin and methods currently used in the Hydro-meteorological forecasting systems in Viet Nam. Simultaneously, it also presents the flash flood forecasting and warning system in Nam La - Nam Pan and its operation results from 2000 up to now and the flash flood project, which has been executing since 2006. All restrictions need to be overcome and developmental orientations of hydro-meteorological forecasting works in general and flash flood warning and forecasting works in particular are also mentioned in the conclusions.

GENERAL INTRODUCTION

Generally, the natural topography of Viet Nam can be categorized as follows:

- Northern Viet Nam is divided by high mountain ranges located in Northwest-Southeast direction. The topographical elevation lowers from the Northwest to the Southeast and to the sea side. Delta areas of the Red River and Thai Binh river and the coastal area have the low natural elevation (97.4% of the area has elevation <9,0 m + MSL (mean sea level). (Figure 1);
- Central and Highlands region has the elevation sloping from the West to the East, with the Truong Son range in the West and lowland having sand dunes in the coastline area;
- Southern Viet Nam has relatively flat topography with low elevation.

Viet Nam is located in the tropical zone with monsoons and high rainfall. Viet Nam is subject to the dual effect of the continental tropical climate and sea tropical climate. Therefore, the very heavy rains usually occur in Viet Nam. And forest destruction results in the reduction of the forest cover at upstream areas.

- in Viet Nam, the annual average amount of rainfall is 1,960 mm;
- Bac Quang is the highest rainfall place with annual average amount of 4,760 mm;
- the lowest place is Phan Rang with the only amount of 650 mm per year;
- 70% to 80% of the amount of rainfall and runoff occurred on 3 to 6 months in the rainy

and flood season;

- in dry season months, the amount of rainfall and runoff holds only 20% to 30%. Some months take only 1% to 2%.

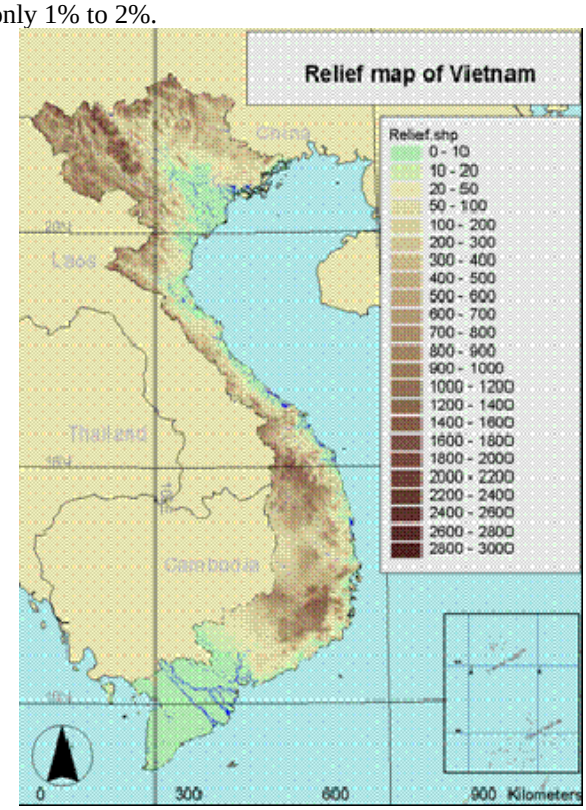

Figure 1. Relief map of Viet Nam

In annual average, there are about 8 typhoon and Tropical low pressure events in Viet Nam each year, most of them occurring in July to November.

Annually, in main rivers of Viet Nam, there are 4 to 12 flood events occurring mainly in 3 months in flood season: from July to October in the North; from September to November in the Central. Particularly, There are 2 to 3 flood events occurring in Cuu Long River but lasting from July to end of November and causing serious inundation state in Cuu Long delta area.

The changing level of water flow is substantial in Viet Nam. The maximum of the discharge is 10 times to 30 times larger than the annual average value and hundreds of times larger than the minimum value. In general, in any main river system in Viet Nam, flood and inundation are always the biggest threat to people‘s life and social-economic activity.

Flash floods are considered the severe floods that occur suddenly having high flood intensity, high amplitude and huge damages. These floods usually occur in the small and medium river basins in the mountainous and midlands of Viet Nam.

In recent years, because of effects of global climate changes and El Nĩno – Southern Oscillation (ENSO) phenomena, hydro-meteorological natural disasters in general and heavy rainfall, typhoon, flood in particular unfold more and more complicatedly and have an abnormal sign on effect scale, range of impact. The intensity and rate of natural disasters have an increasing trend. Especially, in recent years, heavy rainfall, flash flood, landslide have occurred more and more frequently. In some areas, they have occurred in many years continuously and many times in one year.

Along with the social-economic development in the country, the serious damages causing by natural disasters rises millions US$. In 10 years (1996-2005), the damages causing by only

flash flood and landslide rises rapidly over VND 600 billion (Vietnamese Dong, approximately US$ 40 million), as follows:

Dead:	423 persons
Injured:	194 persons
Households directly affected:	5,000 units
Inundated paddy fields:	34,000 ha
Destroyed subsidiary crops:	16,000 ha
Inundated premature paddy:	4,000 ha
Cows and buffaloes killed:	600 head
Land eroded and swept away:	2,600,000 m^3
Destroyed sluices and bridges:	500 units

SITUATIONS IN THE LAST 3 YEARS (2006 - 2008):

In 2006, there were 9 flash floods. Although flash floods didn't occur as seriously as those previous years, they caused 77 people died and missing, 32 injured, and total economic loss of VND 400 billion. (Figure 2)

Figure 2. Bridge and village were damaged by a flash flood in Yen Bai Province in 2006

In 2007, there were 17 flash floods. Although flash floods didn't occur as seriously as those previous years, they caused 38 people died and missing, 06 injured, and total economic loss of VND 29.2 billion (Figure 3).

Figure 3. Irrigation canal and bridge crossing Dak Bla River were damaged by a flash flood in November 2007

In 2008, there were 21 flash floods that caused 192 dead and missing people, 154 injured people. Total estimated economic losses: 2,311 billion VND. Among that, the flash floods and

landslides after the Storm No.4 (Kammuri) from 6-9 August caused serious damages for Northern mountainous province including: Lao Cai (Figure 4), Yen Bai, Ha Giang, Tuyen Quang, Phu Tho, Thai Nguyen, Lang Son, Cao Bang, Dien Bien, Bac Kan. There were 153 dead and missing people, and 113 injured people. The total estimated economic losses: 2,042 billion VND.

Figure 4. Landslide and flash flood after storm Kammuri in Lao Cai in August 2008

RECENT SITUATION OF FLASH FLOODS IN VIET NAM

Flash floods usually occur in water catchments of rivers and streams in the mountainous areas. The mountainous areas have the geographical features that are favourable for flash floods such as complicated terrain structure, high slope of the water catchments and the riverbeds, and the weak stability of the surface land due to the strong weathering process. This strong weathering process results from the distinguished contrary between different seasons and strong destruction of the vegetation cover that creates the easily flash flood affected areas and big land slides can occur and obstruct the water flows.

The rains that cause flash floods usually have high intensity and last in some hours in an area from tens to hundreds km^2. Therefore, flash floods in the branch rivers or streams are not synchronous with the floods in the main rivers.

According to surveys carried out from 1960 up to now, flash floods occur frequently in Viet Nam. Recently, the number of flash floods per year has increased year by year (Figure 5). There were flash floods causing huge damage such as the flash flood in Huong Son (Ha Tinh Province) in 1989; the flash floods in Muong Lay and Lai Chau townlet (Lai Chau Province) in 1990 and 1991; the flash floods in Son La townlet (Son La Province) and Song Ma district (Thanh Hoa Province) in 1991; the flash flood in Truong Son mountain range in Quang Tri province in 1992; the flash floods in Central Viet Nam from 1992 to 1995; the flash floods in Ham Tan in Binh Thuan province in July 1999, the flash floods in Yen Bai province in September 2005; the flash floods in Lao Cai, Yen Bai, Ha Giang, Tuyen Quang, Phu Tho, Thai Nguyen, Lang Son, Cao Bang, Dien Bien, Bac Kan provinces in Augest 2008 and other provinces in the mountainous areas of the North Viet Nam such as Lang Son, Cao Bang, Yen Bai, Tuyen Quang, Thai Nguyen, and Bac Can. These floods caused huge damage to human life and property. The map of areas occurred flash floods in Viet Nam in 1990 - 2005 is shown in Figure 5.

The surveys carried out recently show that the number of flash floods per year in Viet Nam is increasing year by year (*1998:18; 1999: 15; 2002:15; 2007: 18; 2008: 21*).

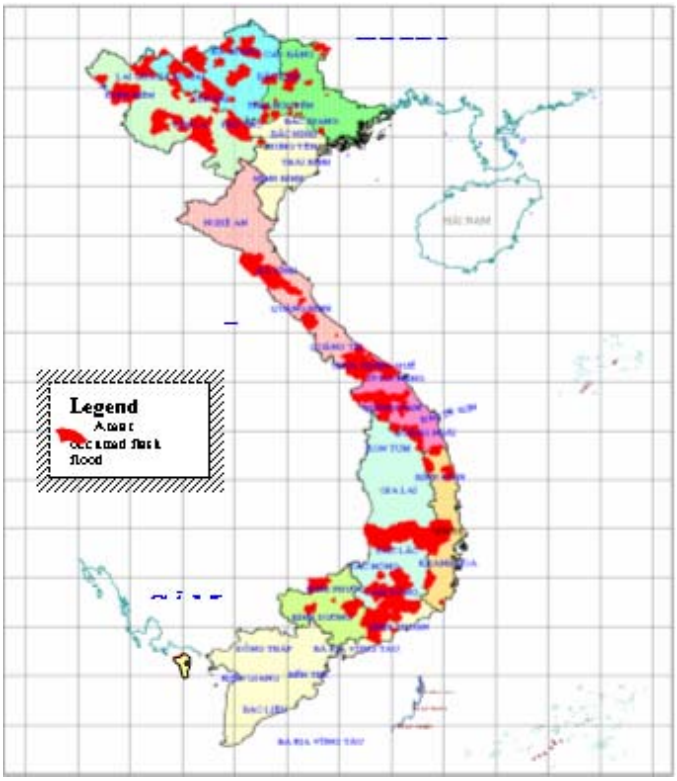

Figure 5: Map of areas with flash floods in Viet Nam in 1990 – 2005

GENERAL ASPECTS OF WEATHER THAT CAUSE FLASH FLOODS IN VIET NAM

- *the northwest of the North:*
  - the low northern cyclone or low cyclone located in the low pressure range of the northwest-southeast axis stretches to the North. It operates with strong intensity, and from low to high;
  - low cyclone or low pressure range exists in the South of China, combining with cold front or being pushed down by high air pressure, and causing rain;
  - the tropical conversion range has cyclone, combining with air front or other weather topographies;
  - storm or tropical depression stopped after hit the mainland, move towards the west direction and causing rain;
- *the northeast of the North:*
  - storm or tropical depression combines with cold front;
  - the west low, hot furrow combining with cold front or the Pacific Ocean high pressure edge flows into;
  - operation of air front;
  - operation of the tropical conversion;
- *the central coastal areas:*
  - due to the move of the tropical conversion range from low latitude to high latitude at the end of July;
  - the operation of cold front from the North;
  - storm and tropical depression;
  - combination of the above factors;

- *the central highland areas:*
  - storm and tropical depression;
  - combination of the above factors.

CHARACTERISTICS OF RIVERS AND STREAMS

Most of the rivers in North Viet Nam are very high sloping. Therefore, the flood is accumulated rapidly with high velocity and huge destruction force.

Most of the rivers in the Central Viet Nam, in the East side of the Truong Son mountain range and in the eastern area of the South Viet Nam rise from the high mountain range in the western area and flow to the South China Sea. Most of the river in this region are short and usually have no transition sections. The floodwater from the upstream areas with high slope flocks into the river sections with low slope in plain areas, causing high intensity floods and severe inundation.

Zoning of potential flash flood areas

In mountainous areas of the Northern Viet Nam, flash flood usually occurs from July to October and most of the flash floods occur in June and July, early months of the rain season, after these two months the flash floods occur in Southern Viet Nam. In the Central Viet Nam and the Central Highlands, flash flood usually occurs from October to December (most of the flash floods in the Southern Viet Nam occur in October) (Figure5).

Areas with potential of flash floods

In Northern Viet Nam:

- In the left side of Da River:
  - A large area of the Nam Mu River;
  - Than Uyen, Phong Tho, and Mu Cang Chai Districts in the mountain sides of the Hoang Lien Son mountain range.
- In the right side of the Thao River:
  - The upstream area of the Thia Channel, Yen Bai Province.
- In the right side of the Lo River:
  - Nac Channel in Vinh Tuy District, Ha Giang Province
- Pho Yen, Dai Tu, Dinh Ca and Vo Nhai Districts, Thai Nguyen Province;
- The basins of the small rivers and streams in Cao Bang, Tuyen Quang, Lang Son, Quang Ninh and Hoa Binh Provinces.

In Central Viet Nam and the Central Highlands:

- In the right side of the Ca River:
  - The Ngan Sau River and Ngan Pho River, Ha Tinh Province;
- In the right side of the Gianh River, Quang Binh Province:
  - Rao Nam River;
  - Upstream area of the Dinh River;
- Upstream area of the Tra Khuc River, Quang Ngai province;
- Upstream areas of the Cai Phan Rang, Luy and Ca Ty Rivers, Binh Thuan Province;
- Upstream are of the Srepok, Se San Rivers, Dac Lac and Kon Tum Provinces.

In the eastern area of Southern Viet Nam:

- Upstream areas of the La Nga and Be Rivers, Dong Nai Province.

ORGANIZATION STRUCTURE AND OPERATIONAL HYDRO-METEOROLOGICAL FORECASTING IN VIET NAM

Organization

Operational Hydro-meteorological forecast and warning is a task assigned to Ministry of Natural Resource and Environment by the Government.

In order to serve well the mission of preventing and mitigating natural disasters and meet all social-economic development requirements, the Hydrometeorological Service, an agency under the Ministry of Natural Resource and Environment has organized one Hydrometeorological Forecasting and forecast serving system from central to provinces. This system operates all year round, especially be strengthened in flood season. It includes3 levels as follows:

- *Central level:* the National Centre for Hydrometeorological Forecasting;
- *Regional level:* 9 Regional Hydrometeorological Centres;
- *Province level:* 54 Provincial Hydrometeorological Forecasting Centres.

Data/information collection, processing for operational forecasts

Hydro-meteorological data have been received from National and International Telegraphic Station Networks. The National Telegraphic Station Network included 133 synoptic stations, 78 rainfall stations, 204 hydrologic stations, 21 ocean-meteorological stations, 6 weather radar stations, 3 low resolution satellite image receiving stations, 1 high resolution geostationary meteorological satellite (GMS) and National Oceanic and Atmospheric Administration (NOAA) satellite image receiving station. All observed data has been transmitted from observation stations to regional Hydro-meteorological Centres by telephone or computer networks. After that, the data has been transmitted to the National Centre for Hydro-meteorological Forecasting by computer networks. In the National Centre for Hydro-Meteorological Forecasting, the data has been encoded, processed, and organized to make a database for forecast serving and load up to networks to serve Hydro-meteorological agencies and related agencies.

Forecasting

Forecast is made year round in the form of three types: short-term, medium-term, and long-term forecast.

Short-term forecast:

- short-term weather forecast with the lead time of 1 to 2 days for the whole country is issued daily: Temperature, precipitation, relative humidity, windy and cloud thickness. The weather bulletins are made for major cities, all land-parts and sea-parts of Viet Nam and surrounding areas;
- tropical cyclone and monsoon forecast: Tropical storm, depression, and monsoon are dangerous weather phenomena that usually cause serious damages to people' life and properties in Viet Nam, especially, to fisherman and people living in coastline areas. Typhoon, depression, and monsoon forecasting bulletins are supplied from 2 to 8 times per day. Forecasting parameters are storm/depressions track, intensity, time of landing and possible affected areas, possibility of rain and surge;
- rainfall forecasts with the lead time of 2 - 3 days are made and used as inputs for hydrological forecasts;
- short-term hydrological forecast: During the rainy season from June to December the river flow and stage of main rivers are made daily forecast with the lead time of 24 to 48 hrs rivers in the North, 12 to 24 hrs for rivers in the central part, and 5 days for the lower

delta Mekong, respectively. In case river stage exceeds the alert level II, information on flood situation and forecast is disseminated twice a day and three times per day if it exceeds the alert level III, and in emergency case 2 to 4 times per day.

Medium-long-range forecast

Medium-Long-term: five-daily, monthly and seasonal hydro-meteorological forecasting bulletins have been supplied periodically one time per five days, one time per month in all year. Temperature, rainfall, water level, discharge, and possibility of drought and lack of water are major forecasting factors in main rivers.

FLASH FLOOD WARNING AND FORECASTING

Flash floods are generally difficult to warn or forecasted because of their short time concentration, massive destruction power and sudden occurrence at the night time. At present, the National Centre for hydro-meteorological forecasting undertakes warning by two modes: a/ General warning and forecasting, b/ automatic warning.

General warning and forecasting

Flash flood warning and forecasting is made daily for the areas with high risk of flash flood occurrence in three steps:

- to detect and forecast development of heavy rain causing weather pattern in integration with basin's hydrological condition and coverage;
- to give warning on possible flash flood within a small area based on the predicted rainfall;
- to give warning based on heavy rain and analysis of observed rainfall map (This map is synthesized from rainfall measured on station network and rainfall calculated from satellite images and weather radar, see an example in Figure 6).

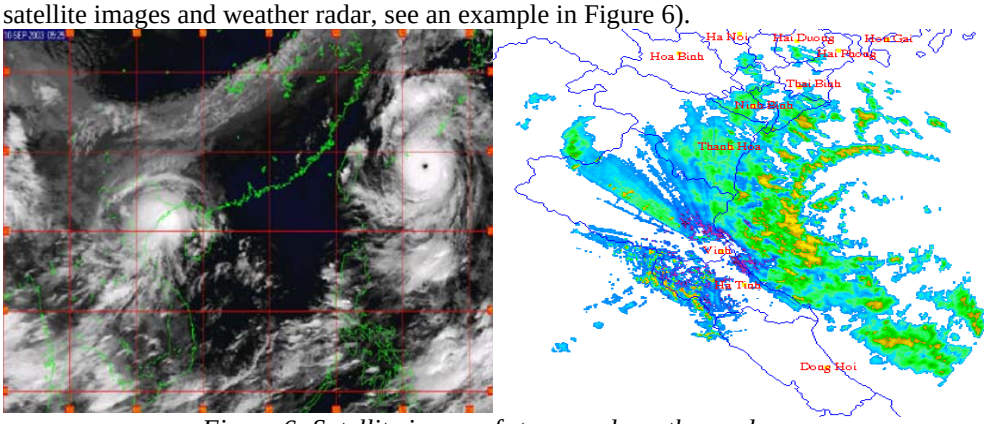

Figure 6: Satellite image of storm and weather radar

Automatic warning

Projest Nam La - Nam Pan flash flood warning and forecasting system

In 2000, Viet Nam has established the first flash flood warning and forecasting system in Nam La - Nam Pan. This system has been maintained and developed up to now (Figure 7). This system has been established in two basins Nam La and Nam Pan, Son La province. The area of the Nam La basin is 455 km2, the Nam Pan basin is 418 km2. Flash floods usually occur with frequency of 1 time per 2 to 5 years in these areas.

Figure 7. Flash flood warning and forecasting system on Nam La - Nam Pan rivers

Structure of the system

The Nam La - Nam Pan flash flood warning and forecasting system has been established with automatic station network including 5 rainfall stations, 2 meteorological stations, 10 water level and rainfall stations, 2 centres for receiving and processing data and issuing forecasting bulletins. (One has set up in Son La town and one has set up at the National centre for Hydro-meteorological forecasting in Ha Noi). This system has 3 automatic flash flood warning stations in Son La town, Ban Ai and Hat Lot. One centre with function of decision-making about preventing methods, managing and implementing flash flood preventing activities is located at the people's committee of Son La Province (Committee of Flood and Typhoon Control of Son La Province) and one centre with function of implementing directly is situated at People's committee of Mai Son Town (Committee of Flood and Typhoon Control of Mai Son District).

Data measurement and transition activities

The Nam La - Nam Pan flash flood warning and forecasting system operates regularly from May to end of October. Measured data are stored at the stations and directly transmitted from station network to regional centre at Son La Town. After that, they are transmitted to the National centre for Hydro-meteorological forecasting. In normal weather condition data is transmitted one time per 3 hours, one time per hour in case of having dangerous weather patterns causing heavy rainfall in the Northwest area and one time per 10 minutes when heavy rainfall in Son La province is forecasted.

Flash flood warning and forecasting regulation

Step 1. The National centre for Hydro-meteorological forecasting and Son La regional centre monitor, discover and forecast all dangerous weather patterns causing heavy rainfall and flood on Northwest area. It is changed to regime of receiving and transmitting one time per hour. Simultaneously, warning bulletins about appearing possibility of flash flood on the basin are made and sent to the committee of flood and typhoon control of Son La province.

Step 2. If heavy rainfall in Son La province is forecasted, it is changed to regime of receiving and transmitting one time per 10 minutes and the software changes automatically from green to red in rainfall stations at which the rainfall intensity is larger than 10 mm per minute and in hydrological station at which flood amplitude larger than 2 meter. Simultaneously, flash flood calculating and forecasting software using Tank model work automatically and give

forecasting results one time per 10 minutes at positions of Son La, Ban Ai and Hat Lot.

Step 3. Analyzing results, issuing flash flood forecasting bulletins and sending to the Committee of flood and typhoon control of Son La province.

Step 4. The Committee of flood and typhoon control of Son La province makes a decision of preventing methods and command for the warning and forecasting stations, provincial broadcasting and television and the committee of flood and typhoon control of Mai Son Town to implement these preventing methods.

Results of system operation

The system has operated well and it is maintained frequently. However, no flash flood has occurred since 2000 within Nam La - Nam Pan River Basin.

During big floods on the Da River occurred on 2-3 August 2001 and 10-12 August 2002 respectively the system was put into alert but no flash flood occurred, no station reached the threshold in terms of rain intensity and water level rate.

Restrictions of the system:

- no weather radar to measure precipitation over the Nam La - Nam Pan River Basin has been installed in Son La yet;
- still unable to transfer/ receive rainfall and flooding information to/from the area strongly dissected where torrential rains often occur.

Project warning flash floods executing since 2006

The project on warning for flash floods has two purposes:

- drawing up of flash flood map (Figure 8) with scale 1:25,000 and 1:50,000;
- establishing flash flood warning systems in 37 river basins of 11 provinces.

After the huge flash flood occurred in Yen Bai Province, established the flash flood forecasting and warning system using automatic rain gauges with alarm signal when flash flood occur is an important task (Figures 9 and 10). Setting of the standard rainfall in 3 warning levels:

- *Warning Level I.* Heavy rain, preparing for all contingencies;
- *Warning Level II.* Continuing heavy rain, prepare for evacuation;
- *Warning Level III.* The rainfall reaches the threshold that causes flash flood, urgent evacuation.

The Hydrologic Engineering Centre model is being applied to simulate flash floods.

ASSESSMENT OF CURRENT MEASURES FOR FLASH FLOOD CONTROL

Viet Nam suffers from many kinds of natural disasters, including typhoons, tropical depressions, etc. Heavy rain, flooding and flash floods occur frequently, causing considerable damage to properties and massive loss of human life.

Structural measures:

- plant and protect protective forests in the upstream; encourage all economic sectors to involve in forest development process and enhance forest coverage;
- continue constructing reservoirs for flood discharge and provide water for preventing drought to downstream. Invest in construction, improve its strength to prevent land slide and erosion; ensure reservoir safely in flood season;

- the flood drainage way free of obstruction;
- construction of structures to protect infrastructures and livelihood areas;
- bridges over rivers and streams should have wide enough aperture for flood discharge.

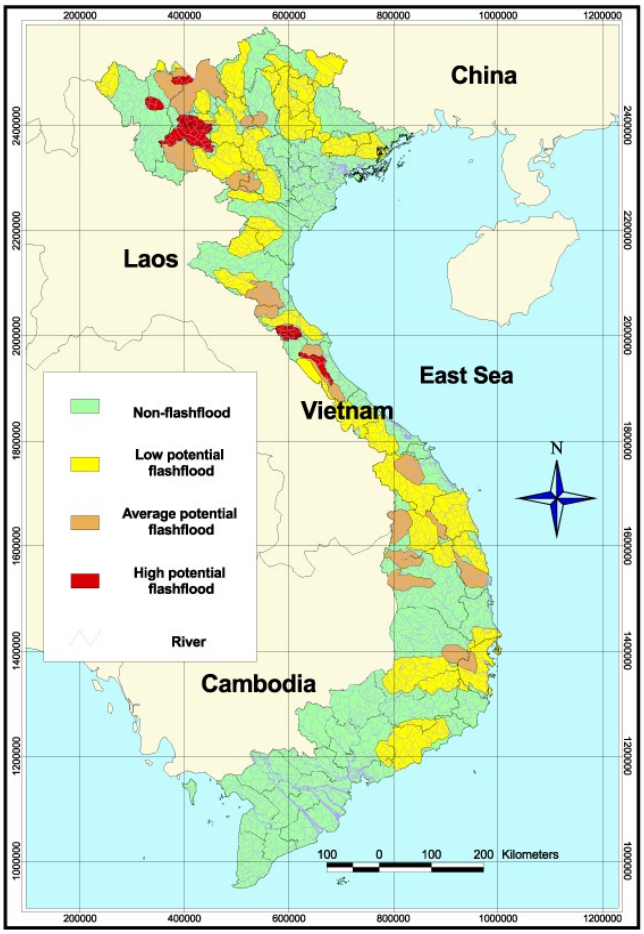

Figure 8. Map of flash flood affected areas in Viet Nam

Non-structural measures:

- continue studying and developing indicators for identifying flash flood and landslide high risk areas; compile technical documents; organize trainings on disaster preparedness. Develop flash flood risk map;
- improvement of hydro-meteorological station network;
- improvement of Flash flood warning and forecasting system;
- conduct survey and statistics at residential areas, villages, households in affected areas where are under the direct influence of flash flood and landslide (near the streams, river, mountain side that have thin coverage and high risk of landslide). Relocation of people out of flash flood areas. Set up warning signs at dangerous areas so that people can be proactive in prevent and response;
- install simple and on-the-spot rainfall gauge and provide usage instructions guidelines. In the short term, deploy in some important villages;
- organize on-the-spot and local rescue team to response to emergencies;
- residential planning and steer the plan implementation process; evacuate people from villages which are in high risk areas of flash flood, landslide to safe areas.

Figure 9: Equipment of automatic rainfall gauge made in Viet Nam

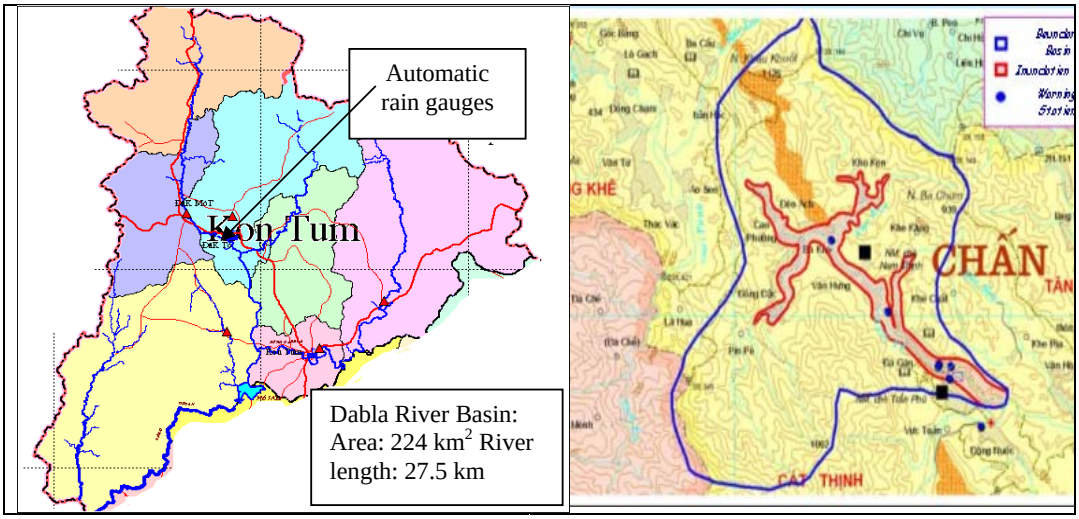

Figure 10: Flash flood warning system in Kon Tum and Yen Bai provinces

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Paper 3-2-2

RECENT DEVELOPMENT IN FLOOD FORECASTING AND EARLY WARNING

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ABSTRACT

The Department of Hydrology and River Works (DHRW) is responsible for hydrological data collection and flood forecasting for the whole country. Flood forecasting conducts from July to October every year along the mainstream of Mekong River, Bassac River and Tonle Sap River in Cambodia for 3 days ahead by using the method of station correlation. The DHRW receives the near real time data before 7:00 hour by SMS in 2008 through the HydMet Software and phone call. Then DHRW also exchanges data and information between the countries in the Mekong River Basin through the Mekong River Commission Secretariat (MRCS) by e-mail or HydMet software. Flood bulletins are send to the mass media, line agencies concerned and the end-users by fax around 9:00 hour, about 45 users per day in year 2008. When a serious or peak flood occurs, the Ministry of Water Resources and Meteorology (MOWRAM) declares the warning of the flood and weather situation to the people by TVs, radios, journalists, etc.

Under the Office of U.S. Foreign Disaster Assistance (OFDA) - Mekong River Commission (MRC) Flood Management and Mitigation Project (FMMP), DHRW also used to provide flood forecasting and transfer flood information for 3 days ahead to 40 flood vulnerable villages in Cambodia around noon, but the activities stopped since 2007 due to resources constraints. Under Component 5 of the FMMP, DHRW has re-established the flood mark in the Peam Ro and Leuk Dek districts and continued to make flood forecasting from late 2008.

DHRW is facing both financial and human resources constraints to implement activities under its responsibility. More work needs to be done, but more resources are also needed to fulfil the tasks.

HYDROLOGICAL NETWORK IN CAMBODIA

The Department of Hydrology and River Works of Ministry of Water Resources and Meteorology is responsible for flood forecasting and hydrological monitoring network in Cambodia. There are water level stations, discharge stations and water quality stations. The equipment that we use for water level station is staff gauge, slope gauge, automatic recorder (bubble sensor, float and radar sensor). The hydrological network in Cambodia was shown in Figure 1 and the water quality monitoring network shown in Figure 2.

WATER LEVEL DATA TRANSFER

There are three types of water level data transfer to the Department of Hydrology and River Works: daily, weekly and 6 monthly as shown in Figure 3.

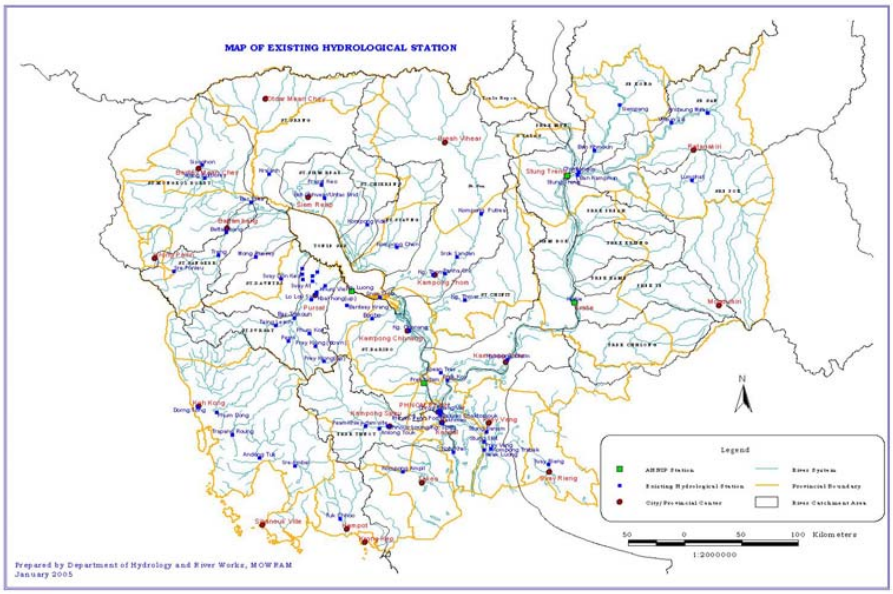


Figure 1. Map of existing hydrological stations

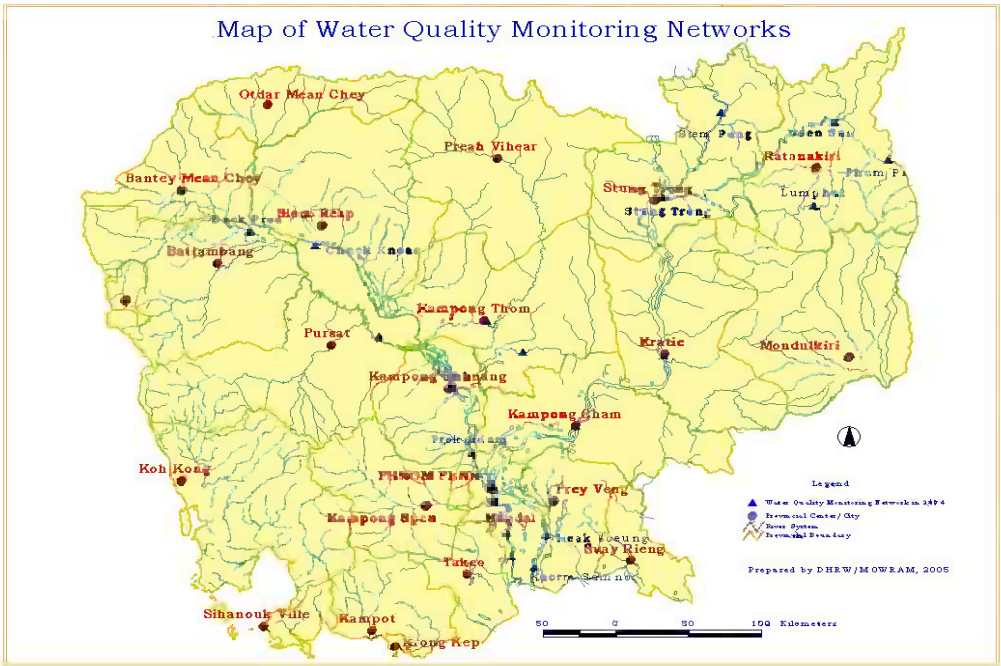


Figure 2. Map of water quality monitoring network

Daily data transfer for flood forecasting

During the flood season from July to October, the DHRW made the flood forecasting for seven stations along the mainstream of Mekong, Bassac and Tonle Sap rivers. So, it needs the water level and rainfall data every day of those seven stations such as: 1) Mekong-Stung Treng; 2). Mekong-Kratie; 3) Mekong-Kompong Cham; 4) Mekong-Neak Loung; 5) Bassac-Chaktomuk; 6) Bassac-Koh Khel; and 7) Tonle Sap-Prek Kdam and additional data of three stations such as

8) Tonle Sap-Phnom Penh Port; 9) Se San-Veunsai; and 10) Sre Pork-Lumphat.

The data were transferred to DHRW every day before 7:00 hour by SMS through (HydMet) software or Telephone call to observers of the field station.

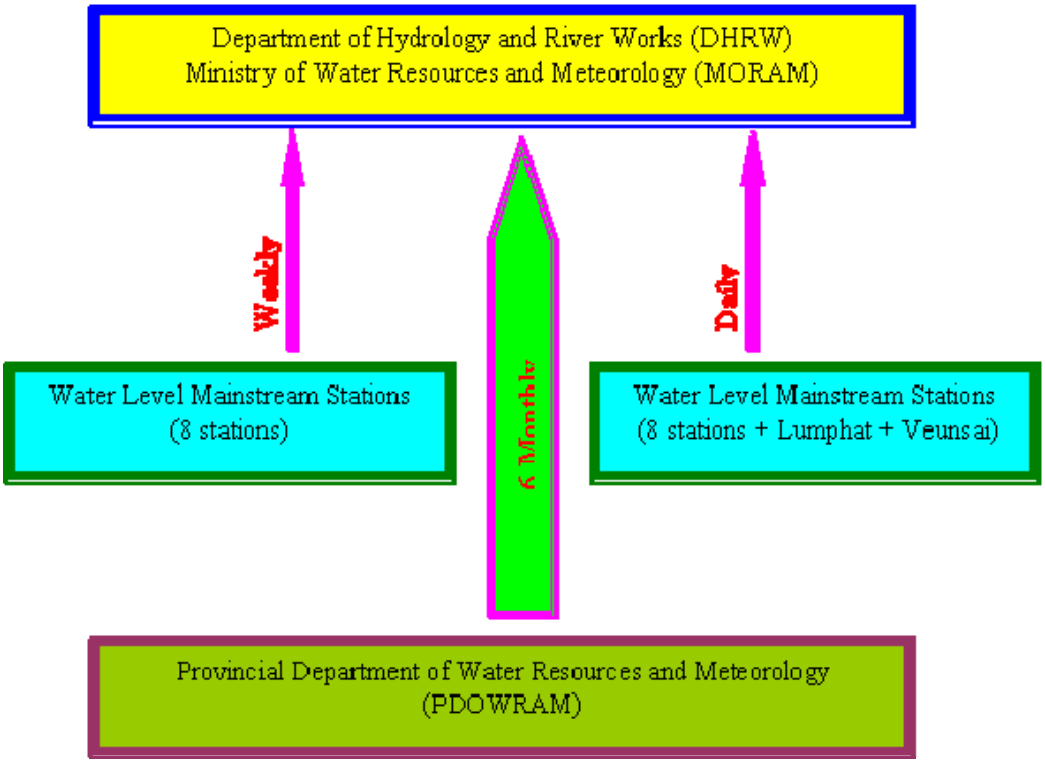


Figure 3. Data Transfer from stations or provinces to DHRW of MOWRAM

Weekly data transfer for river monitoring

During the dray season from November to June, DHRW made the river monitoring by receiving data every Monday from the 8 water level stations along the mainstream of Mekong, Bassac and Tonle Sap river such as: 1) Mekong-Stung Treng; 2). Mekong-Kratie; 3) Mekong-Kompong Cham; 4) Mekong-Neak Loung; 5) Bassac-Chaktomuk; 6) Bassac-Koh Khel; 7) Tonle Sap-Phnom Penh Port; and 8) Tonle Sap-Prek Kdam.

The data were transferred to DHRW by Telephone call to observers of the field station.

Monthly data transfer

DHRW received the water level data from each the Provincial Department of Water Resources and Meteorology as two times per year, so the data were sent to DHRW every 6 monthly to input to the Hydrological Modelling System (HYMOS) data base.

RECENT FLOOD FORECASTING AND EARLY WARNING

Flood forecasting and warning in the mainstream

The flood forecasting aims at ‘getting people ready for floods before they come’. MOWRAM

didn't forecast the flash flood. MOWRAM is responsible for making announcement of weather and flood warning in the country.

As soon as data and information are received from the near real time stations, it is reported to the MOWRAM leaders as well as to the concern agencies and FMMP of the Mekong River Commission Secretariat (MRCS) by fax/e-mail. Then the data is entered into a computer base flood forecasting system for checking, analyzing, processing and producing forecasts for 3 days ahead by using the method of station correlation. Finally, Flood Forecasting Bulletin is printed and approved then send by fax before 10 AM to the 45 end-users which are namely line agencies, TVs, Radio, Journalists, non-governmental organisations (NGO), etc. The data flow and the flood forecasting tool were shown in Figures 4 and 5.

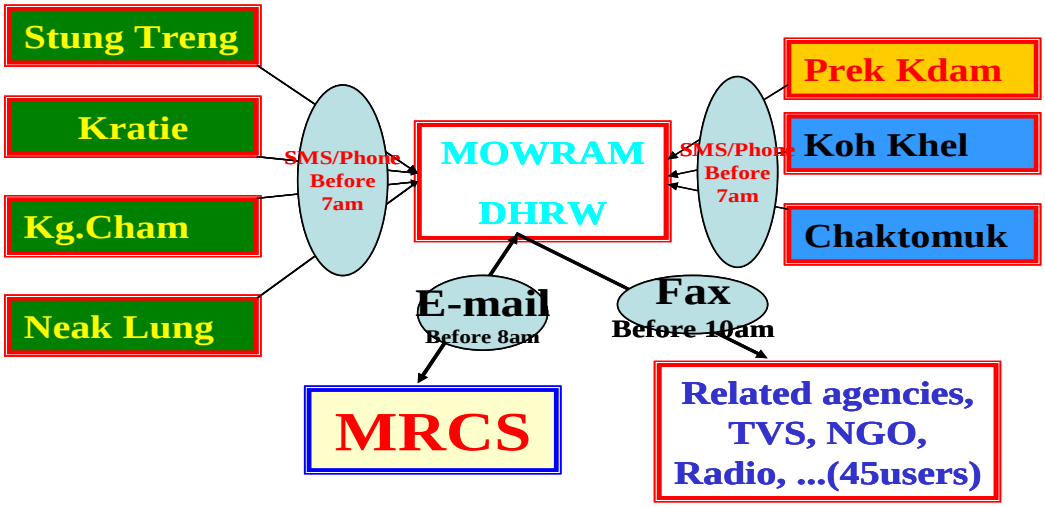


Figure 4. Data flow for flood forecasting

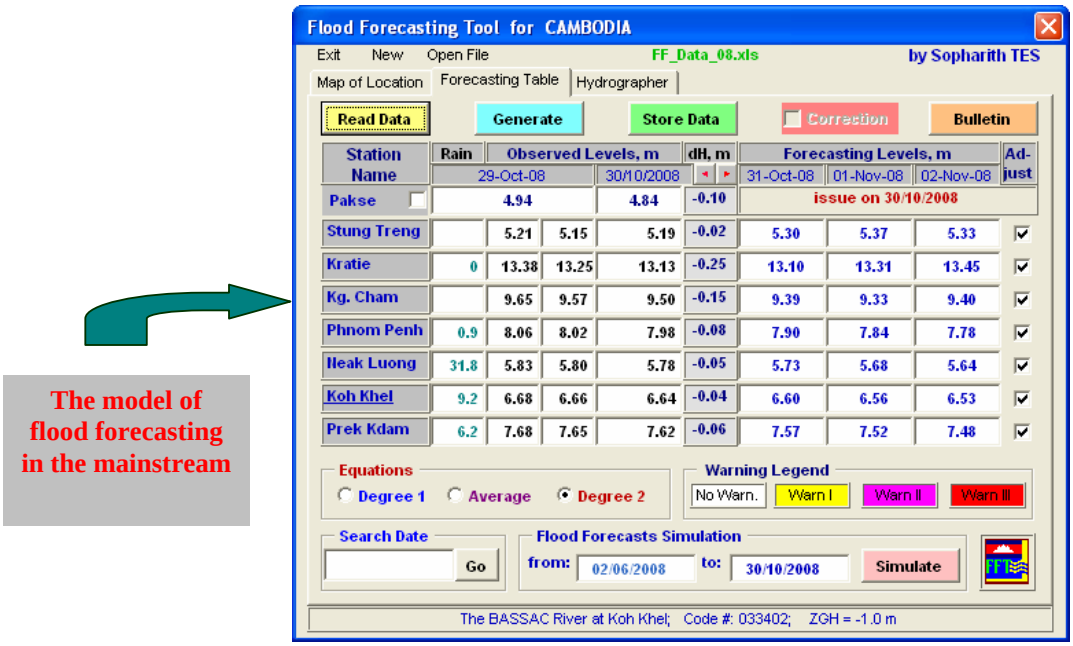


Figure 5. Flood forecasting tool

The flood forecasting tool can be shown the comparison between the observation and simulation such as graph, value and statistical analysis for forecasting in 1 day, 2 days and 3 days of each station were shown in Figures 6 and 7 respectively.

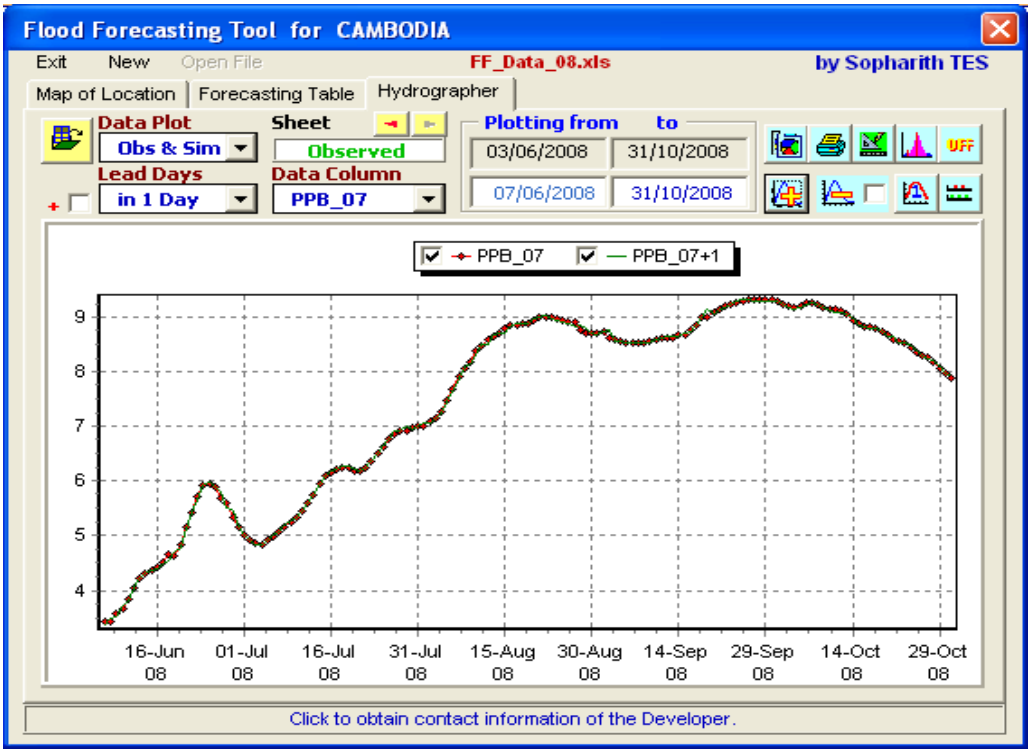
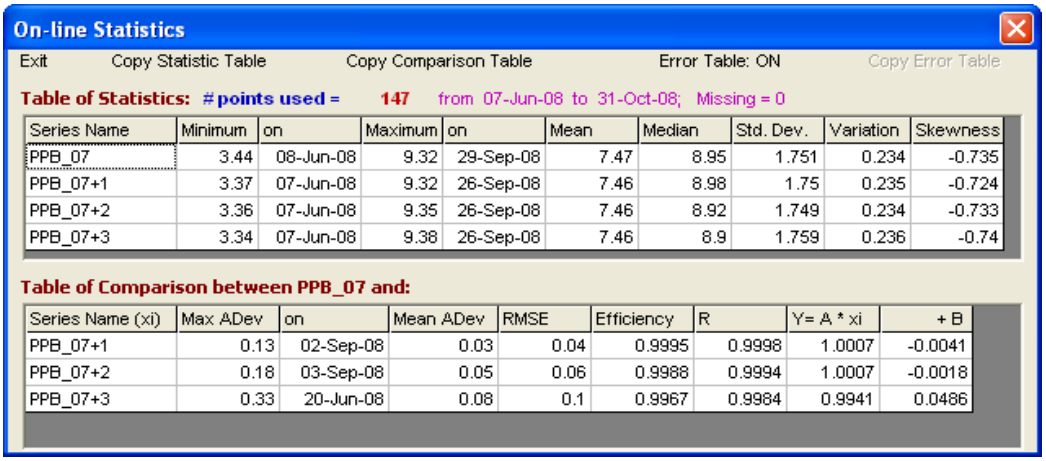


Figure 6. Comparison between the observation and simulation at Bassac-Chaktomuk Station



On-line Statistics

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Table of Statistics: # points used = 147 from 07-Jun-08 to 31-Oct-08; Missing = 0

Series Name	Minimum	on	Maximum	on	Mean	Median	Std. Dev.	Variation	Skewness
PPB_07	3.44	08-Jun-08	9.32	29-Sep-08	7.47	8.95	1.751	0.234	-0.735
PPB_07+1	3.37	07-Jun-08	9.32	26-Sep-08	7.46	8.98	1.75	0.235	-0.724
PPB_07+2	3.36	07-Jun-08	9.35	26-Sep-08	7.46	8.92	1.749	0.234	-0.733
PPB_07+3	3.34	07-Jun-08	9.38	26-Sep-08	7.46	8.9	1.759	0.236	-0.74

Table of Comparison between PPB_07 and:

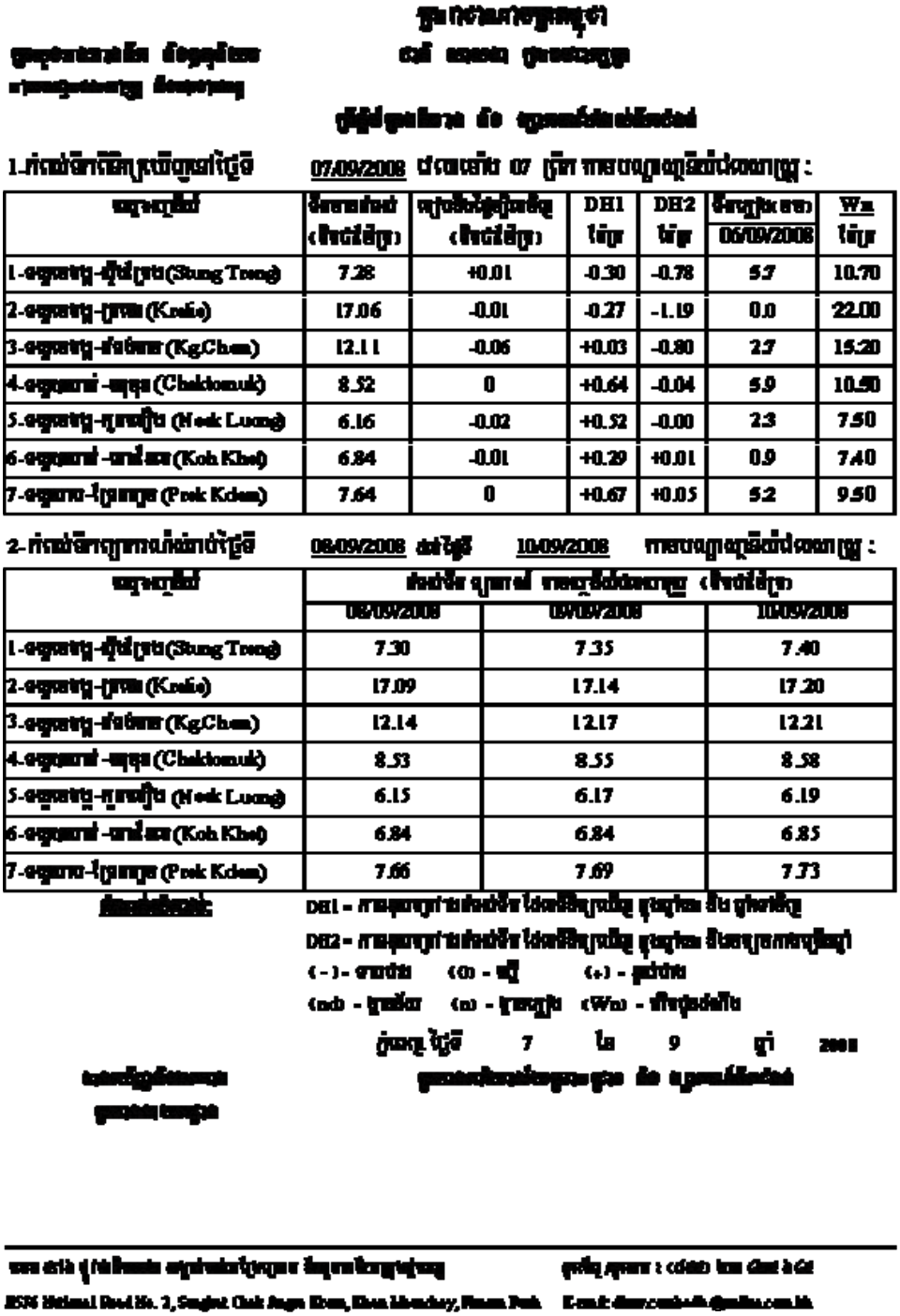
Series Name (xi)	Max ADev	on	Mean ADev	RMSE	Efficiency	R	Y= A * xi	+ B
PPB_07+1	0.13	02-Sep-08	0.03	0.04	0.9995	0.9998	1.0007	-0.0041
PPB_07+2	0.18	03-Sep-08	0.05	0.06	0.9988	0.9994	1.0007	-0.0018
PPB_07+3	0.33	20-Jun-08	0.08	0.1	0.9967	0.9984	0.9941	0.0486

Figure 7. Statistical analysis between observation and simulation of 1 day, 2 days and 3 days at Bassac-Chaktomuk station

Flood forecasting and early warning

DHRW cooperated with the FMMP/MRCS as well as the Cambodian Red Cross (CRC), National Disaster Management (NDM) and American Red Cross to make the flood forecasting in the floodplain of 40 villages of flood marks for flood early warning to local community in

2005-2006 (Figure 8). The flood forecasting was stopped forecast since 2007 because there were not any water level data reading sent to DHRW. Under the Flood Management and Mitigation Programme, Component 5. Flood information based land management (FMMP-C5), they will renew the flood marks of Peam Ro and Leuk Dek districts for improving hydrological data, produce flood maps and make flood forecasting to these two districts from 2009-2010.



1.-[illegible] (Stung Treng)	7.28	+0.01	-0.30	-0.78	5.7	10.70
2.-[illegible] (Kratie)	17.06	-0.01	-0.27	-1.19	0.0	22.00
3.-[illegible] (KgCham)	12.11	-0.06	+0.03	-0.80	2.7	15.20
4.-[illegible] (Chaktomuk)	8.52	0	+0.64	-0.04	5.9	10.50
5.-[illegible] (Neak Luong)	6.16	-0.02	+0.52	-0.00	2.3	7.50
6.-[illegible] (Koh Khel)	6.84	-0.01	+0.29	+0.01	0.9	7.40
7.-[illegible] (Prek Kdam)	7.64	0	+0.67	+0.05	5.2	9.50

1.-[illegible] (Stung Treng)	7.30	7.35	7.40
2.-[illegible] (Kratie)	17.09	17.14	17.20
3.-[illegible] (KgCham)	12.14	12.17	12.21
4.-[illegible] (Chaktomuk)	8.53	8.55	8.58
5.-[illegible] (Neak Luong)	6.15	6.17	6.19
6.-[illegible] (Koh Khel)	6.84	6.84	6.85
7.-[illegible] (Prek Kdam)	7.66	7.69	7.73

Figure 8. Information and flood forecasting bulletin

The water level reached to DHRW around 11:00 hour by headquarter offices of NCDM and CRC via an e-mail, then the data were input the model for flood forecasting, after that the flood bulletin product were sent back to them by e-mail for taking further action. The detail information of data flow shown in Figure 9.

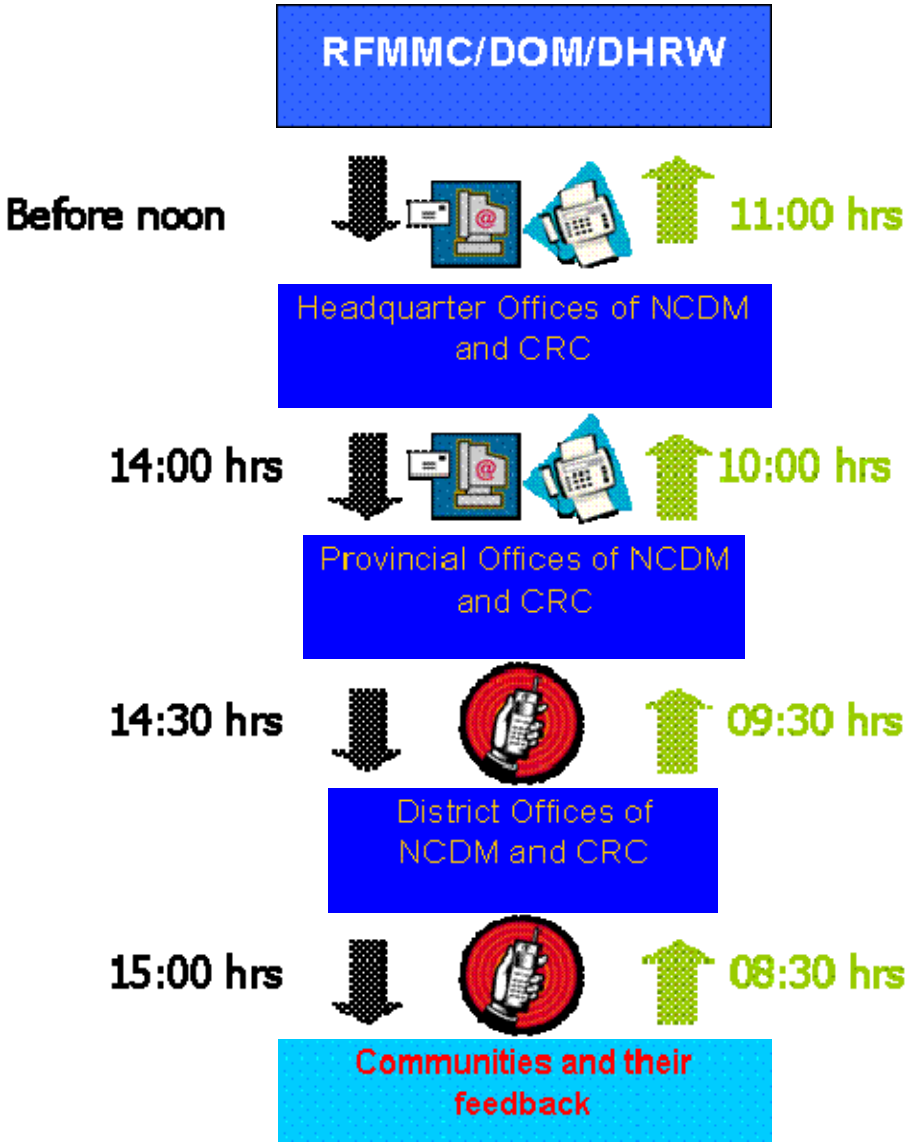


Figure 9. Data flow from floodplain of 40 villages of flood marks

Result of the comparison between the observation and the flood forecasting in the floodplain

The flood forecasting in day 1 is can be reliable because the forecasted result fitted to the observed data as shown in Figure 10. But the forecasting in day 2 and day 3 are less accuracy than day 1.

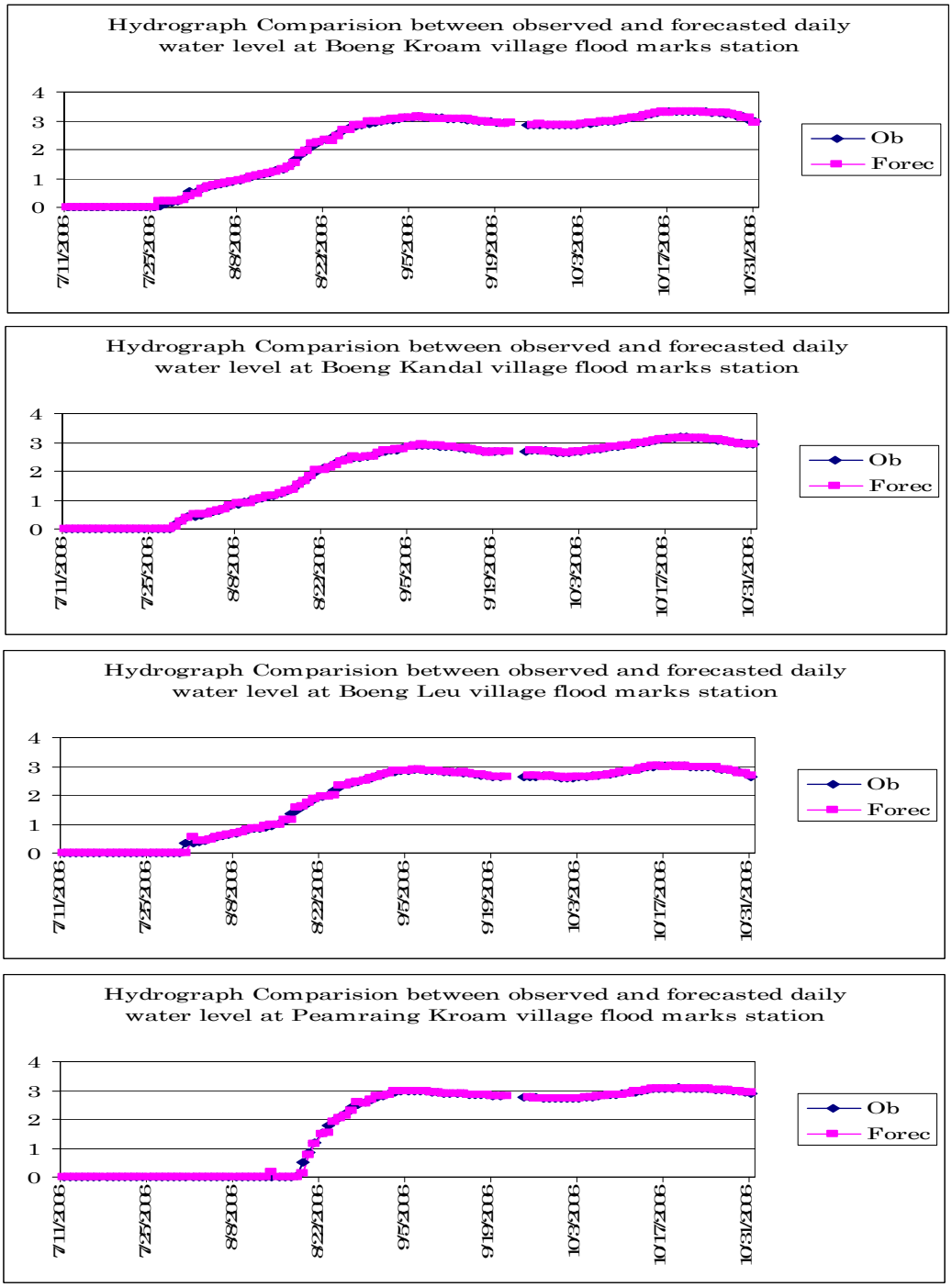


Figure 10. Some results of comparison between observation and flood forecasting of 1 day

LESSONS LEARNED

There are some challenges to make good the flood forecasting due to the delayed of hydro-meteorological data in upstream countries, unknown the dam released of water in upstream

countries, data transmission delayed in the country, communication problem sometimes, equipment working not properly, etc.

To improve the flood forecasting it need to solve the above problem, increase the frequency of sending real time data during extreme flood, hydrological network should be improved and capacity building for DHRW as well as the provincial staff too.

CONCLUSION

The hydrological data provides the basis for planning, development and operation of water resources project. The comprehensive water resources management requires a series of hydrological data. The hydrological phenomena should be observed and measured in according to the standard practices. The data must also be recorded at enough to enable an accurate assessment of water resources. Any observation missed will be lost forever and inaccurate observations can not be repeated. The inadequate data can seriously affect development costs in the future. The unreliable data may result in cost increase for a project and can lead to project failure or shorten its useful life span.

Paper 3-2-3

HELP-DESK FOR INTEGRATED FLOOD MANAGEMENT: SUPPORTING RIVER BASINS IN IMPLEMENTING AN INTEGRATED APPROACH

WOLFGANG GRABS, MASAHIKO MURASE, JOACHIM SAALMUELLER, AVINASH TYAGI AND DAISUKE YAMASHITA

World Meteorological Organization, Associated Programme on Flood Management, Technical Support Unit, Geneva, Switzerland

ABSTRACT

To minimize loss of life and livelihoods from flooding, *and* to make at the same time most efficient use of flood plains for sustainable development, the concept of Integrated Flood Management (IFM) has emerged over recent years as the central approach in addressing flood issues in a sustainable and balanced way. The application of the concept in development practice of flood-affected countries and river basins, however, is a challenge for policy makers, development planners and flood managers alike. At this stage, an un-biased development partner in this specific area with operational capacities to respond to needs in implementing an integrated approach to flood management is required.

The Associated Programme on Flood Management (APFM) based in the Secretariat of the World Meteorological Organization (WMO) and operating through funding and expert services from its partners has been promoting over the past years the Integrated Flood Management approach and has embarked on the development and operation of a HelpDesk for Integrated Flood Management (IFM). This HelpDesk is a facility that will provide guidance on flood management policy, strategy, capacity building and institutional development related to flood issues to countries that want to adopt an integrated approach to flood management. River Basin Organizations form an essential part of the target group that the HelpDesk seeks to address. The HelpDesk is hosted by the World Meteorological Organization and functions through a decentralized network of technical partner institutions that form the 'HelpDesk Support Base'. This group is currently comprised of some 26 institutions engaged in flood and water resources management, including major international centres of excellence. The HelpDesk is scheduled to be officially launched on 17 June 2009. Further information is provided under: www.floodmanagement.info.

INTRODUCTION

Integrated Flood Management (IFM) integrates land and water resources development in a river basin within the context of Integrated Water Resources Management (IWRM), with a view to maximizing the efficient use of flood plains and minimizing loss of lives, livelihoods and infrastructure. Integrated Water Resources Management is based on the recognition that a single intervention has implications for the system as a whole. Consequently, integrated management results in multiple benefits that may be achieved from a single intervention.

For flood management to be carried out within the context of IWRM, river basins should be considered as integrated systems. Consequently, the aim of IFM is to put in place well-functioning integrated measures for flood management. Therefore, linkages between various relevant sectors are essential in the implementation of IFM practices.

The Associated Programme on Flood Management (APFM) is a joint effort of the World

Meteorological Organization (WMO) and the Global Water Partnership (GWP) that since 2001 has developed into being an eminent platform for advancing the case of integrated flood management. There has been a sustained global interest in these activities that continues to be supported by its financial partners and a host of collaborating institutions and organizations worldwide. The current fundamental challenge is to enable countries to incorporate these principles into policy and practice.

In an effort to provide demand-driven support for the implementation of integrated flood management policies, concepts and practices, the HelpDesk for IFM (hereafter, 'IFM HelpDesk') has been developed that will be formally launched in June 2009 with full functionality being expected by mid-2010. Governance of the IFM HelpDesk is provided by the APFM Advisory and Management Committees where major stake- and shareholders are represented.

Typical user-groups for the IFM-HelpDesk include: National, provincial or local government agencies involved in decision making in flood management; River Basin Organizations; Intergovernmental, Bi- and Multilateral Organizations involved in Technical and Financial Cooperation; Non-Governmental Organizations in particular those working with flood affected communities; Voluntary Organizations and Community-based Organizations ; and Universities.

IFM HELPDESK FUNCTIONS AND SERVICE DELIVERY

The IFM HelpDesk is a facility that is tailored to provide guidance on flood management policy, strategy, and institutional development related to flood issues to countries that want to adopt the concept of IFM. It is based on an increasing network of supporting partnerships with specialized institutions in various aspects of Flood Management with respect to the knowledge base implied by the IFM HelpDesk. Close partnership is maintained with countries and their specific needs in flood management. The added value of the IFM HelpDesk is the provision of balanced, independent and quality assured flood management policy guidance that provides the basis for the field-implementation of IFM principles and practices. It is noteworthy that the continued operation of the IFM HelpDesk will steadily increase the knowledge base available for users as the functions are dynamic in nature rather than static and the contents are continually upgraded.

Technically, the IFM HelpDesk is being hosted within WMO Headquarters that through its Technical Support Unit provides for the necessary infrastructure to further develop, maintain and provide essential services through IFM HelpDesk functionalities.

As an overview, the IFM HelpDesk will:

- provide quick access to relevant flood management information;
- provide guidance for implementation of activities for integrated flood management in countries or river basins in developing long-term flood management policies, strategies and institutional arrangements;
- serve as a link between flood management practitioners and decision-makers and required multi-disciplinary scientific expertise and best practice in various fields such as hydrology/river engineering, legal and institutional development, ecology, sociology and development economics, etc.;
- provide a continuous and sustainable capacity development mechanism in support of IFM implementation.

It should be noted that the functions of the IFM HelpDesk do not include disaster assistance or flood emergency response/operations. The basic working mechanism of the IFM HelpDesk is illustrated in Figure 1. The IFM HelpDesk is the centre-piece linking relevant

institutions of countries in need of technical guidance for IFM implementation with required expertise and partners.

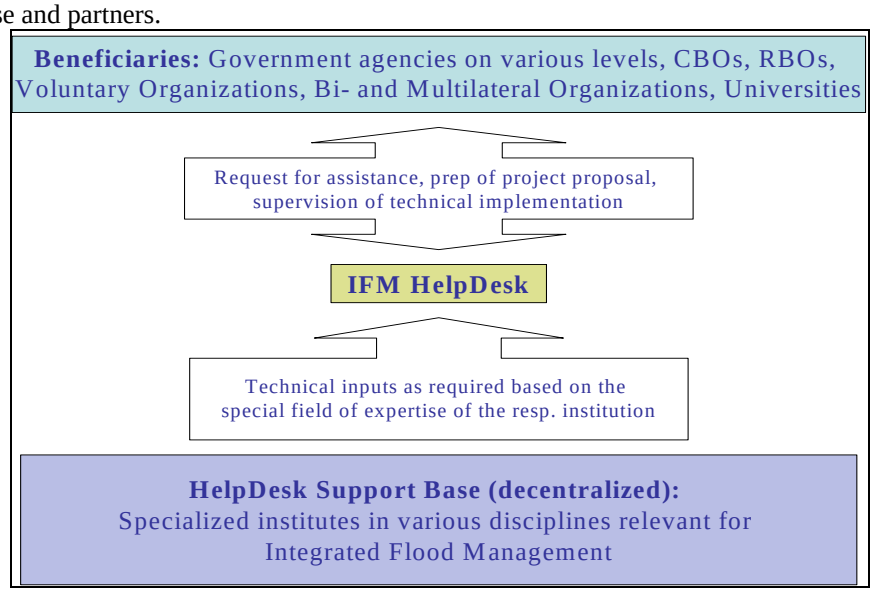


Figure 12. Simplified working mechanism of the IFM HelpDesk

As illustrated in Figure 2, the HelpDesk is planned to function in two modes: The Self-Help mode and the interactive Get-Help mode.

The Self-Help mode contains information useful in support for the implementation of the IFM approach. It is based on an internet platform and complemented by alternative means of information dissemination. It is expected that the majority of users would be able to find initial guidance through this mode. The Self-Help mode consists of:

- question and answer bank;
- flood management tools;
- the reference centre on flood management[9];
- virtual discussion groups.

The Get-Help mode is an inter-active section within the IFM HelpDesk. This section is coordinated by staff of the Technical Support Unit of the APFM and advisory support is provided mainly by the IFM HelpDesk Support Base that consists of a network of dedicated supporting partners working with expertise in various aspects of flood management. Major support aspects relate to strategic advice on flood management policy, strategy and project formulation as well as capacity development for Integrated Flood Management. The following Service Categories are currently being established:

- *service category I* : assistance for flood management policy, law and strategy;
- *service category II* : capacity development;
- *service category III* : rapid guidance on technical tools and advisory material.

To continually maintain and upgrade the contents of the IFM HelpDesk and to provide support for the Self-Help mode a network of dedicated institutions and partners to put the process into practice provide essential supporting services. The request from institutions in need of specialist guidance for example on issues related to incorporating adaptive management principles into structural design or on flood data analysis for factoring climate variability and change scenarios or on legal provisions and institutional design for putting IFM into practice are

[9]Components available at http://www.apfm.info/database.htm

addressed through this network, wherever required. Given the extensive demand for IFM guidance and technical support, budget, extra-budgetary resources may also be required to sustain the operation of the IFM HelpDesk in addition to support provided through core budgetary resources of WMO. For this, financial partners are approached.

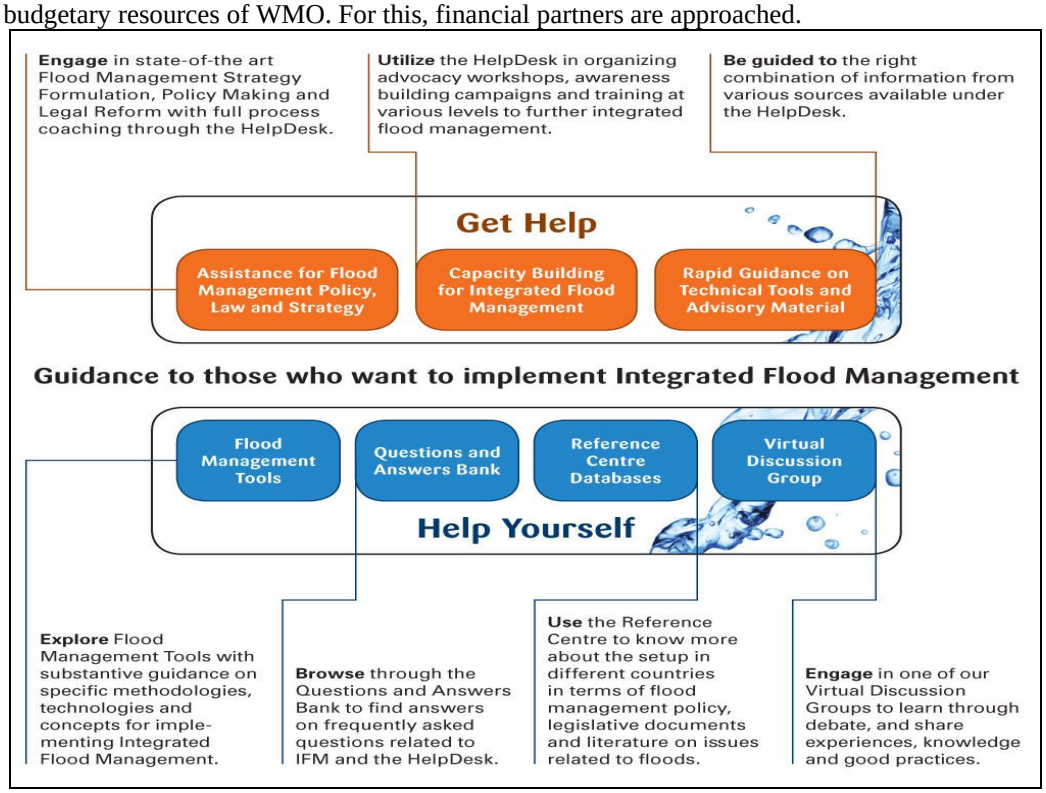


Figure 2. Service delivery through the IFM HelpDesk

CONCLUSIONS

The IFM HelpDesk is an innovative inter-active and web-based approach to bridge requirements for the implementation of Integrated Flood Management practices with guidance, technical tools and expert advisory services to help implementing Integrated Flood Management concepts and practices. Activities undertaken in the Associated Programme on Flood Management and through projects and programs of the Hydrology and Water Resources Branch of the World Meteorological Organization in collaboration with its partner countries and specialized institutions are the main sources for the continued expansion of the knowledge base that is the underlying basis of the IFM HelpDesk.

REFERENCES

Associated Programme on Flood Management, Integrated Flood Management concept paper, APFM Technical Document No.1, second edition (Geneva: Associated Programme on Flood Management, World Meteorological Organization, 2004)
http://www.apfm.info/pdf/concept_paper_e.pdf

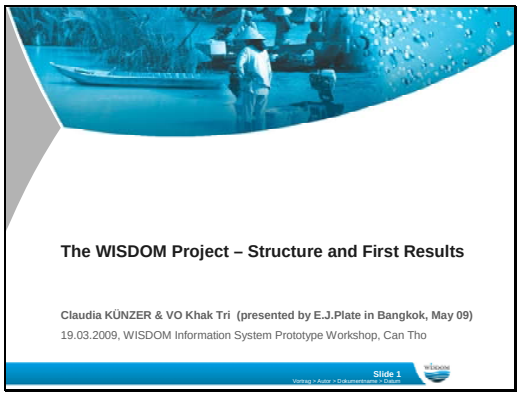
More publications are available at http://www.apfm.info/publications.htm

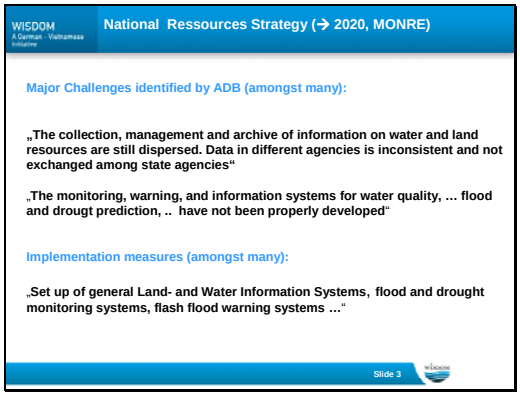
Presentation

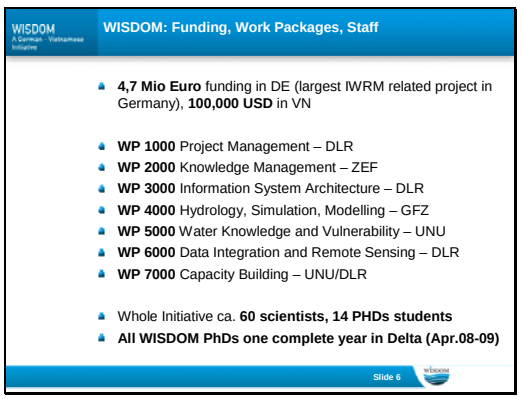
THE WISDOM PROJECT – STRUCTURE AND FIRST RESULTS

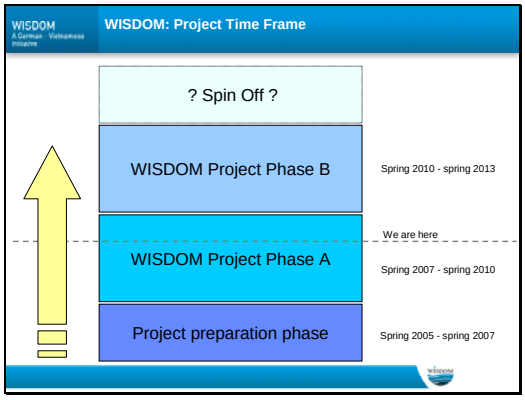
ERICH PLATE

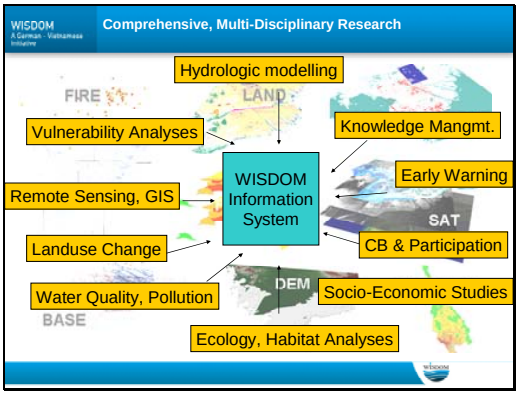
Institut für Wasser und Gewässerentwicklung, Bereich Wasserwirtschaft und Kulturtechnik Universität Karlsruhe, Germany



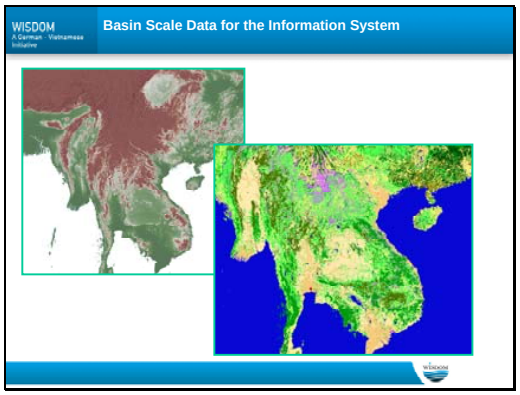


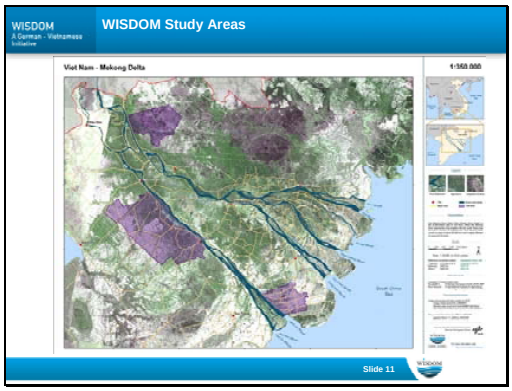


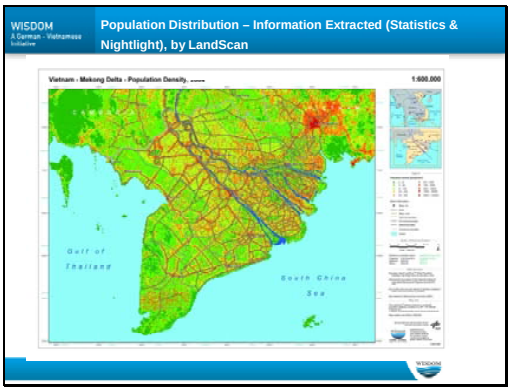

WISDOM
WISDOM: Project Time Frame
? Spin Off ?
WISDOM Project Phase B
Spring 2010 - spring 2013
We are here
WISDOM Project Phase A
Spring 2007 - spring 2010
Project preparation phase
Spring 2005 - spring 2007

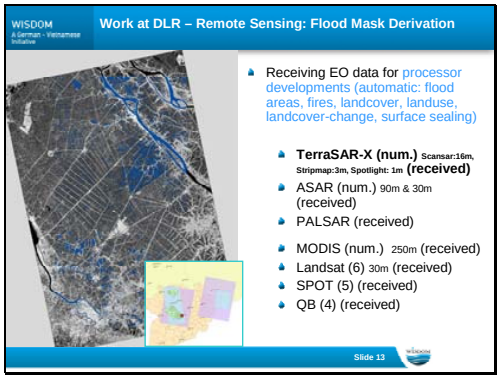

WISDOM
Comprehensive, Multi-Disciplinary Research
Hydrologic modelling
FIRE
LAND
Vulnerability Analyses
Knowledge Mangmt.
Early Warning
Remote Sensing, GIS
WISDOM Information System
SAT
Landuse Change
CB & Participation
DEM
Water Quality, Pollution
Socio-Economic Studies
BASE
Ecology, Habitat Analyses

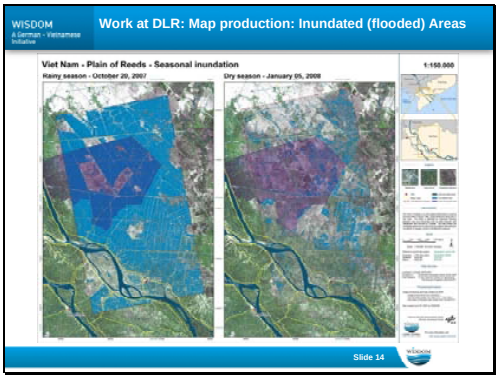
WISDOM
WISDOM adresses 3 Scales, Scientific Work:
1: MEKONG BASIN (incl. riparian upstream countries) (MRC, NGOs ...)
2: MEKONG DELTA (MONRE, (diff. departments), MARD, MOST, MOT ..)
3: Field Survey Sites: Can Tho, Dong Thap, Tra Cu (DONRE, DARD, DOST, CERWASS..)

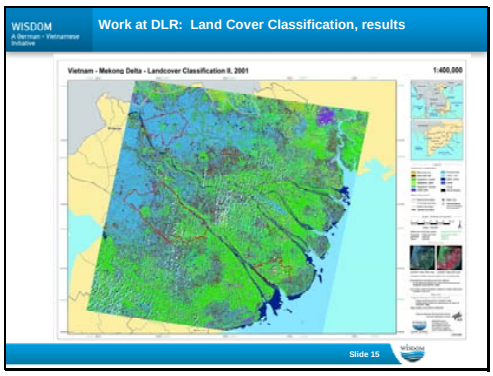

WISDOM
Basin Scale Data for the Information System

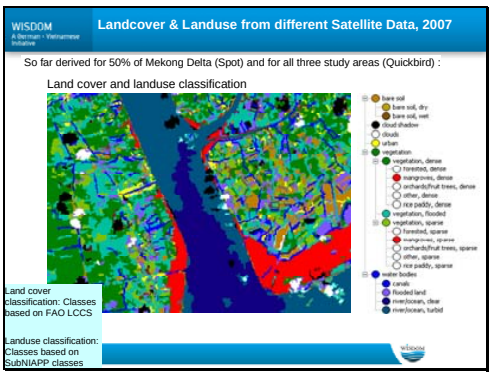

WISDOM
WISDOM Study Areas
Viet Nam - Mekong Delta
Slide 11

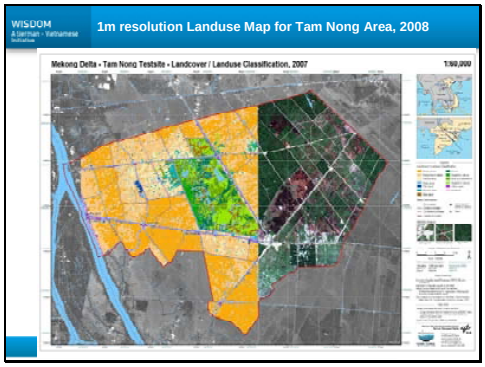

WISDOM
Population Distribution – Information Extracted (Statistics & Nightlight), by LandScan
Vietnam - Mekong Delta - Population Density
Gulf of Thailand
South China Sea

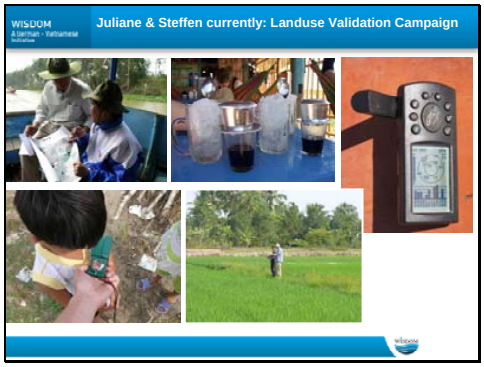

WISDOM
A German - Vietnamese Initiative
Work at DLR – Remote Sensing: Flood Mask Derivation
Receiving EO data for processor developments (automatic: flood areas, fires, landcover, landuse, landcover-change, surface sealing)
TerraSAR-X (num.) Scansar:16m, Stripmap:3m, Spotlight: 1m (received)
ASAR (num.) 90m & 30m (received)
PALSAR (received)
MODIS (num.) 250m (received)
Landsat (6) 30m (received)
SPOT (5) (received)
QB (4) (received)
Slide 13

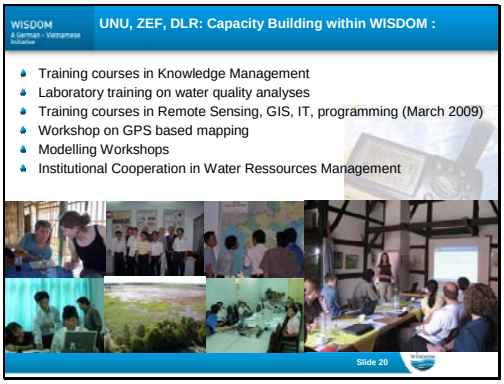

WISDOM
A German - Vietnamese Initiative
Work at DLR: Map production: Inundated (flooded) Areas
Viet Nam - Plain of Reeds - Seasonal inundation
Rainy season - October 20, 2007
Dry season - January 05, 2008
1:150.000
Slide 14

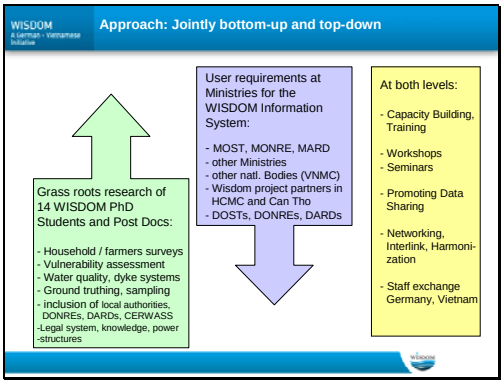

WISDOM
A German - Vietnamese Initiative
Work at DLR: Land Cover Classification, results
Vietnam - Mekong Delta - Landcover Classification II. 2001
1:400.000
Slide 15

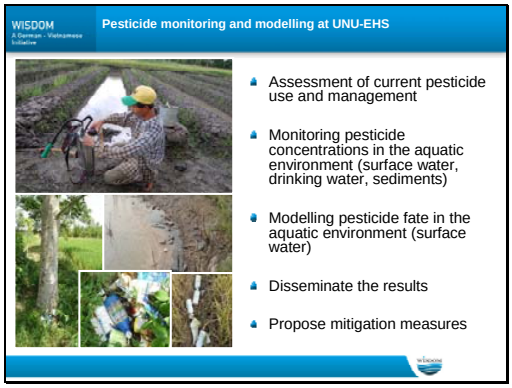

WISDOM
A German - Vietnamese Initiative
Landcover & Landuse from different Satellite Data, 2007
So far derived for 50% of Mekong Delta (Spot) and for all three study areas (Quickbird) :
Land cover and landuse classification
Land cover classification: Classes based on FAO LCCS
Landuse classification: Classes based on SubNIAPP classes

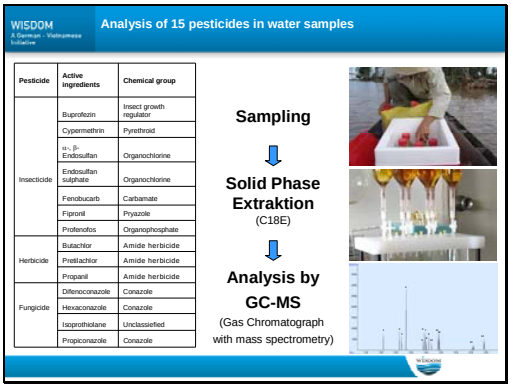

WISDOM
A German - Vietnamese Initiative
1m resolution Landuse Map for Tam Nong Area, 2008
Mekong Delta - Tam Nong Testsite - Landcover / Landuse Classification, 2007
1:10,000


WISDOM
A German - Vietnamese Initiative
Juliane & Steffen currently: Landuse Validation Campaign







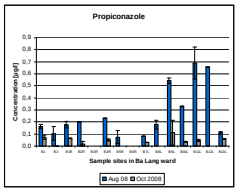


Pesticide	Active ingredients	Chemical group
Insecticide	Buprofezin	Insect growth regulator
	Cypermethrin	Pyrethroid
	α- β-Endosulfan	Organochlorine
	Endosulfan sulphate	Organochlorine
	Fenobucarb	Carbamate
	Fipronil	Pryazole
	Profenofos	Organophosphate
Herbicide	Butachlor	Amide herbicide
	Pretilachlor	Amide herbicide
	Propanil	Amide herbicide
Fungicide	Difenoconazole	Conazole
	Hexaconazole	Conazole
	Isoprothiolane	Unclassiefied
	Propiconazole	Conazole

WISDOM A German - Vietnamese Initiative

First results of interviews and chemical analysis

- Lack of awareness for protection of human health and aquatic environment among farmers
- Inappropriate management of pesticide related waste



- First analytical results available for Aug – Nov 2008 (rainy season) for surface water
- 3 fungicides detected
- highest level 0.78 µg/l
- Results for the dry season will be available soon

WISDOM A German - Vietnamese Initiative

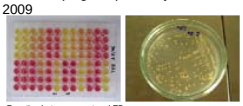
Work at INRES, University of Bonn, at CTU , and in HCMC

Endocrine disruptors research:
hormone like substances may influence the hormon system of animals and humans

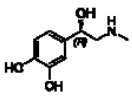
Development of standardized tests for the analysis of endocrine disruptors in Vietnam

Sampling in Dong Thap and Can THo

Field campaigns April / May 2008 and June 2008 – September 2009



Reaction between yeast and EDs



Slide 26

WISDOM A German - Vietnamese Initiative

50 Measuring points, weekly measurements, one year

WISDOM A German - Vietnamese Initiative

Work at INRES: ED Analyses First Results

- In water: 0,2-10 ng/l (similar to Germany)
- Concentrations in Can Tho higher than in Dong Thap
- Difference to Germany: no waste water treatment
- Methodology: living yeasts are used for ED analysis
- Unexpected: several samples inactivated the yeasts although low concentration of ED in the water

Slide 28

WISDOM A German - Vietnamese Initiative

Work at UNU-EHS – Vulnerability

Vulnerability assessment:

- Gathering **flood impact** data (flood fatalities, impacts on critical infrastructure)
- Analysis of major **socio-economic trends** in the provinces of the Mekong Delta (e.g. urbanisation, poverty, education)
- Goal: to derive **vulnerabilty indicators** and **parameter sets** for vulnerability / risk definition

Slide 29

WISDOM A German - Vietnamese Initiative

Work at UNU-EHS – Vulnerability: First results

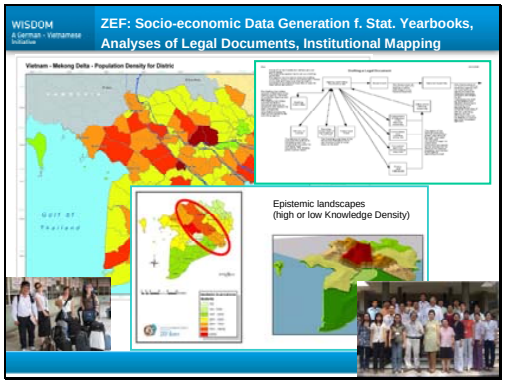
Official / government level:

- Genrally, Vuln. created through lack of planning coherencies
- Long term future planning needed. E.g. new industry planned in places, where according to scenarios flooding will increase. Lack of perception about future changes and needed procedures
- Hazards that have not been experienced = limited awareness. Climate change as a term is known. Now, transfer to scenarios or actions is an urgent need and adressed through NTPs

Household level:

- Changes in dyke system create disparities: e.g. suddenly cannot fish anymore (location from floodplain on top of the dyke)
- Decreased livelihood assets increase vulnerability
- Urban households: less flood fatalities and severe impacts, only Dong Thap: 250 fatalities during last big flood.

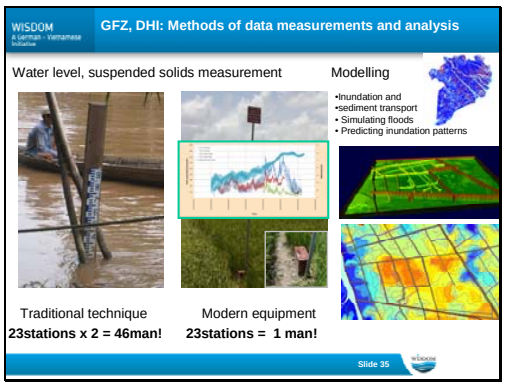
Slide 30

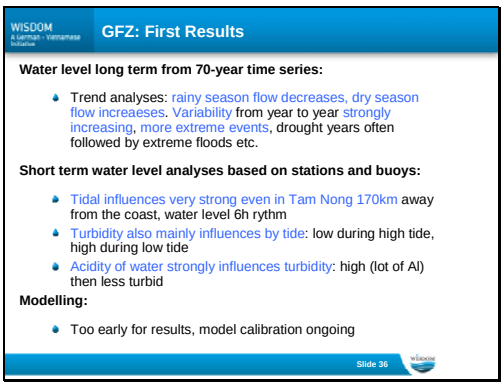

WISDOM
ZEF: Socio-economic Data Generation f. Stat. Yearbooks, Analyses of Legal Documents, Institutional Mapping
Epistemic landscapes
(high or low Knowledge Density)

WISDOM
ZEF: Socio-economic Findings
Institutional mapping:
> 200 educational and research institutes in water sector alone in South
Assessment of the capacity and staff situation in water related research
Legal Situation:
1998: first law on water ressources.
Numerous laws, decrees, regulations at different scales, ongoing reform process → thus: real overview difficult to achieve
Currently: case study in Can Tho on legal framework in water sector

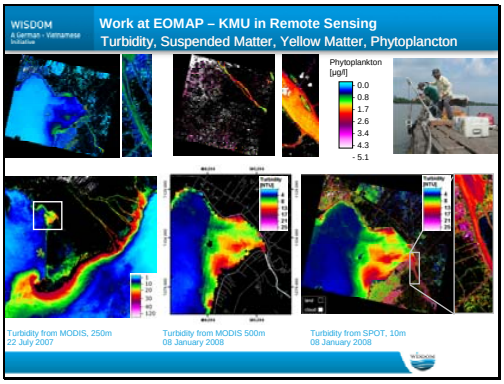
WISDOM
ZEF: Socio-economic Findings
Knowledge Management:
Demand for tools and methods to increase knowledge exchange between research and governmental organizations
Detailed assessment of knowledge dissemination (publications, websités, thesis', blogs etc.) of water related reserach
Three KM workshops undertaken with staff from different fields
Policy and Planning:
Comparison of water management within two different dyke systems (governmental and cooperative)
Policy analysis of drinking water supply in rural Can Tho

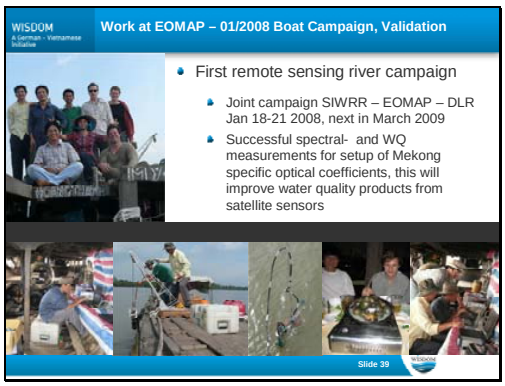
WISDOM
Work at GFZ, DHI –Field Campaigns May 2008 - Sept 2008
Detailed and precise field survey of dike lines for inundation simulation
Water level measurements with Field Units and GPS buoys (mm, sec)
Slide 34

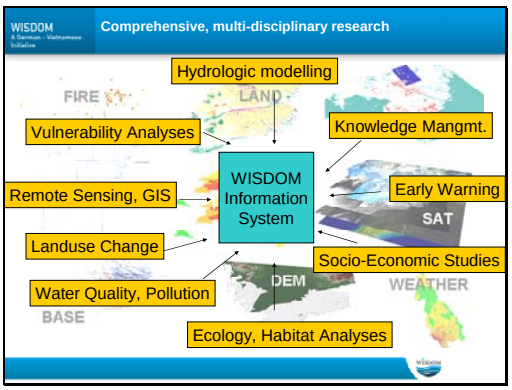

WISDOM
GFZ, DHI: Methods of data measurements and analysis
Water level, suspended solids measurement
Modelling
•Inundation and
•sediment transport
• Simulating floods
• Predicting inundation patterns
Traditional technique
23stations x 2 = 46man!
Modern equipment
23stations = 1 man!
Slide 35

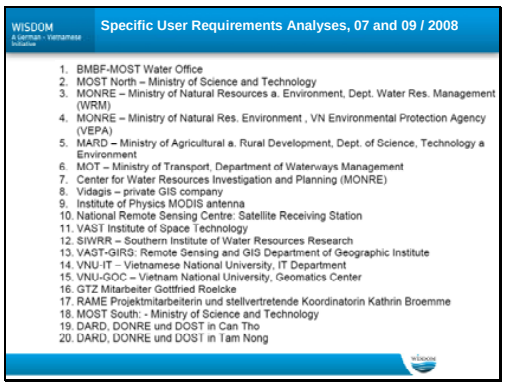

WISDOM
GFZ: First Results
Water level long term from 70-year time series:
Trend analyses: rainy season flow decreases, dry season flow increaeses. Variability from year to year strongly increasing, more extreme events, drought years often followed by extreme floods etc.
Short term water level analyses based on stations and buoys:
Tidal influences very strong even in Tam Nong 170km away from the coast, water level 6h rythm
Turbidity also mainly influences by tide: low during high tide, high during low tide
Acidity of water strongly influences turbidity: high (lot of Al) then less turbid
Modelling:
Too early for results, model calibration ongoing
Slide 36

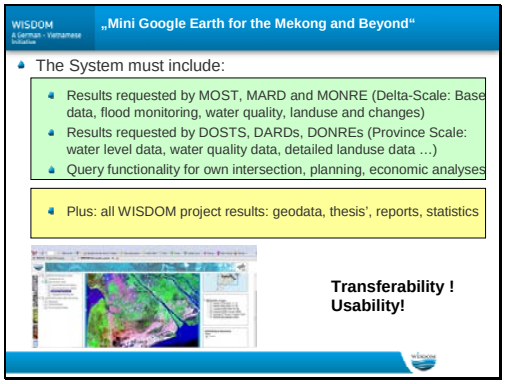
WISDOM
A German - Vietnamese Initiative
GFZ: Fieldwork impressions
Slide 37

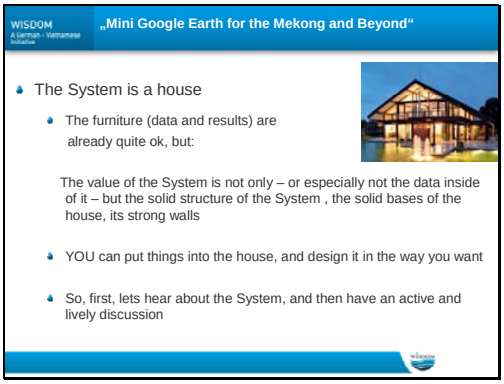

WISDOM
A German - Vietnamese Initiative
Work at EOMAP – KMU in Remote Sensing
Turbidity, Suspended Matter, Yellow Matter, Phytoplancton
Phytoplankton [µg/l]
0.0
0.8
1.7
2.6
3.4
4.3
- 5.1
Turbidity from MODIS, 250m
22 July 2007
Turbidity from MODIS 500m
08 January 2008
Turbidity from SPOT, 10m
08 January 2008


WISDOM
A German - Vietnamese Initiative
Work at EOMAP – 01/2008 Boat Campaign, Validation
First remote sensing river campaign
Joint campaign SIWRR – EOMAP – DLR Jan 18-21 2008, next in March 2009
Successful spectral- and WQ measurements for setup of Mekong specific optical coefficients, this will improve water quality products from satellite sensors
Slide 39


WISDOM
A German - Vietnamese Initiative
Comprehensive, multi-disciplinary research
Hydrologic modelling
FIRE
LAND
Vulnerability Analyses
Knowledge Mangmt.
Remote Sensing, GIS
WISDOM Information System
Early Warning
SAT
Landuse Change
Socio-Economic Studies
Water Quality, Pollution
DEM
WEATHER
BASE
Ecology, Habitat Analyses


WISDOM
A German - Vietnamese Initiative
Specific User Requirements Analyses, 07 and 09 / 2008
1. BMBF-MOST Water Office
2. MOST North – Ministry of Science and Technology
3. MONRE – Ministry of Natural Resources a. Environment, Dept. Water Res. Management (WRM)
4. MONRE – Ministry of Natural Res. Environment , VN Environmental Protection Agency (VEPA)
5. MARD – Ministry of Agricultural a. Rural Development, Dept. of Science, Technology a Environment
6. MOT – Ministry of Transport, Department of Waterways Management
7. Center for Water Resources Investigation and Planning (MONRE)
8. Vidagis – private GIS company
9. Institute of Physics MODIS antenna
10. National Remote Sensing Centre: Satellite Receiving Station
11. VAST Institute of Space Technology
12. SIWRR – Southern Institute of Water Resources Research
13. VAST-GIRS: Remote Sensing and GIS Department of Geographic Institute
14. VNU-IT – Vietnamese National University, IT Department
15. VNU-GOC – Vietnam National University, Geomatics Center
16. GTZ Mitarbeiter Gottfried Roelcke
17. RAME Projektmitarbeiterin und stellvertretende Koordinatorin Kathrin Broemme
18. MOST South: - Ministry of Science and Technology
19. DARD, DONRE und DOST in Can Tho
20. DARD, DONRE und DOST in Tam Nong


WISDOM
A German - Vietnamese Initiative
„Mini Google Earth for the Mekong and Beyond“
The System must include:
Results requested by MOST, MARD and MONRE (Delta-Scale: Base data, flood monitoring, water quality, landuse and changes)
Results requested by DOSTS, DARDs, DONREs (Province Scale: water level data, water quality data, detailed landuse data …)
Query functionality for own intersection, planning, economic analyses
Plus: all WISDOM project results: geodata, thesis', reports, statistics
Transferability !
Usability!


WISDOM
A German - Vietnamese Initiative
„Mini Google Earth for the Mekong and Beyond“
The System is a house
The furniture (data and results) are already quite ok, but:
The value of the System is not only – or especially not the data inside of it – but the solid structure of the System , the solid bases of the house, its strong walls
YOU can put things into the house, and design it in the way you want
So, first, lets hear about the System, and then have an active and lively discussion

WISDOM
A German - Vietnamese Initiative
Good Atmosphere: 60 People Growing together, Increasing Synergies, Interdisciplinarity successful

WISDOM
A German - Vietnamese Initiative
Thank You
www.wisdom.caf.dlr.de
claudia.kuenzer@dlr.de
Slide 46

Topic IV

Successful flood risk management approaches

Paper 3-4-1

SUCCESSFUL FLOOD RISK MANAGEMENT APPROACHES IN CAMBODIA

KHUN SOKHA

National Committee for Disaster Management, Phnom Penh, Cambodia

ABSTRACT

The National Committee for Disaster Management (NCDM) was established in 1995 to serve as the coordinating body for all disaster management related activities of the government. Flood risk management is one of the activities implemented under its mandate. It is recognized as the primary agency for managing emergencies and building the resilience of communities to natural disasters. It is composed of representatives from 17 ministries and four officials from other government offices. The NCDM does not only lead in responding to emergency situations but is also implementing prevention and mitigation strategies to reduce the impact of disasters on life, livelihoods and infrastructure. Its goal is to build an effective system for disaster prevention, effective disaster response and rapid disaster recovery. A secretariat coordinates all activities and is the main contact for all other disaster related work. The entire membership meets every July, right before the onset of the rainy season.

The NCDM is mandated to issue necessary guidelines and aid in formulation of policies, recommend or facilitate requests for legislation, budgets and support for emergencies and preparedness work, coordinate with International Non-Governmental Organisations (INGO), local Non-Governmental Organisations (NGO) and other institutions working on Disaster Risk Management (DRM) in the country. The NCDM sits and/or leads network groups on disaster management in the country.

In 2007, the NCDM drafted a new strategic plan which is aligned with the Hyogo Framework of Action (HFA), the document signed by 167 countries at the World Conference on Risk Reduction (WCRR) in Kobe, Japan. The two year strategic plan details NCDM's strategies for strengthening partnerships, building capacity and building institutional capacity for DRM.

At the moment, the NCDM coordinates disaster related programs among which, is Community-Based Disaster Risk Management (CBDRM). As part of its strategy to institutionalize CBDRM, the NCDM worked with various NGOs to establish disaster management committees at the provincial, district, commune and village levels in target provinces, building capacity of local authorities and communities through various training.

The NCDM works closely with other partners such as the Asian Disaster Preparedness Centre (ADPC) and specifically its Partnerships for Disaster Reduction - Southeast Asia (PDR-SEA) program, which provides technical support.

More work need to be done by NCDM within its mandate and this require more resources.

INTRODUCTION

The occurrence of regular flood and drought in Cambodia, often within the same year, makes the country among the most disaster prone in Southeast Asia. Eighty percent (80%) of Cambodia's 14 million population is dependent on agriculture and fisheries, both of which suffer the brunt of drought and flood, threatening the lives of already vulnerable communities.

Cambodian food security depends heavily on the cycle of the Tonle Sap and Mekong

Rivers. The waters feed agricultural plains and provide fish - the country's main source of protein. Because of widespread poverty (food insecurity and lack of livelihood), even a slow and relatively predictable flood or drought phenomenon increases the vulnerability of many poor families.

Previously, a more typical response to regular drought and flooding involved the temporary provisions in the communities, in the form of food, shelter, health services, water and sanitation. However, increasingly, over the years, there has been a realization among NGOs and the government that while emergency response is important, it is more sustainable and effective to establish preparedness, mitigation and prevention mechanisms at all levels.

The communities and local governments have increasingly played a more active role in disaster management work, recognizing that the communities are a repository of information and experience and are in the best position to identify needs and appropriate mechanisms for prevention and mitigation.

Acknowledging that addressing disaster in Cambodia needs a multi-sectoral and institutionalized approach, the government of Cambodia, through the initiatives of the National Committee on Disaster Management (NCDM) and the Asian Disaster Preparedness Centre (ADPC) PDR-SEA program, commissioned this exercise to provide an overview of existing initiatives and to assist in identifying gaps and emerging areas for development in community based disaster risk reduction and management in the country. This report will be presented at a meeting of NGO and government representatives, who will produce a manifesto - a set of recommendations to be presented to H.E. Prime Minister Hun Sen for his endorsement and support.

This report is a summary of project documents and questionnaires submitted for the various Community Based Disaster Risk Reduction (CBDRR) and Disaster Risk Management (DRM) activities such as the Strategic National Action Plan (SNAP) and the Community Based Disaster Risk Management (CBDRM) award. The secondary data collected from the NGOs and other sources were supported by interviews and email exchanges with project staff.

THE DISASTER SITUATION IN CAMBODIA

Cambodia is one of the five countries that straddle the Mekong River and many of the river's arteries cut across the country. This and the fact that Cambodia's landscape is that of rolling plains and low lands make it susceptible to flooding. There are two types of flooding that occur, one being flash floods; swift but damaging occurrences, usually following heavy downpour in parts of the country. Flash floods have been observed in the provinces of Battambang, Kampong Chnang, Kampong Speu, Kampong Thom, Kampot, Kandal, Pursat and Rattanakiri. The much slower but prolonged flooding observed in the provinces of Kampong Cham, Kratie, Kandal, Prey Veng, Stung Treng, Svay Rieng and Takeo is caused by the swelling of the Tonle Sap, the Mekong and their tributaries, due to accumulated rainfall. The year 2000 saw the worst flooding in recent history, with a total estimated damage of US$ 150 million. It affected more than 3 million people in 22 of the 24 provinces of the country, displacing 85,000 families and killing 182.

Drought in Cambodia is characterized by the loss of water sources caused by early end or delays in expected seasonal rainfall. While not as severe as floods in terms impact, it affects farming, particularly rice growing communities who only rely on rain or river fed irrigation. Extended drought increases indebtedness of families and causes widespread food shortage. The worst drought incident was in 2002 where around two million people were affected, causing a total damage of US$ 38 million.

Fishing and farming are heavily dependent on the predictability of the weather and the amount of water it brings. For many, the rise in water levels signals the beginning of farming season, more fishing grounds or new migration routes. However, with the changing environmental patterns, dry spells are earlier or longer and rains have been unpredictable.

Despite the influx of recent investment and the rise in the price of land, Cambodia is still a poor country with 85% of more than 13 millions of its population are farmer. This means that families and communities are still vulnerable to disaster and are least likely to recover from its impacts.

COMMUNITY BASED DISASTER RISK MANAGEMENT (CBDRM) INITIATIVES IN CAMBODIA

Government agencies

National Committee for Disaster Management (NCDM)

The National Committee for Disaster Management (NCDM) was established in 1995 to serve as the coordinating body for all disaster management related activities of the government. It is recognized as the primary agency for managing emergencies and building the resilience of communities to natural disasters. It is composed of representatives from 17 ministries and four officials from other government offices. The NCDM does not only lead in responding to emergency situations but is also implementing prevention and mitigation strategies to reduce the impact of disasters on life, livelihoods and infrastructure. Its goal is to build an effective system for disaster prevention, effective disaster response and rapid disaster recovery. A Secretariat coordinates all activities and is the main contact for all other disaster related work. The entire membership meets every July, right before the onset of the rainy season.

The NCDM is mandated to issue necessary guidelines and aid in formulation of policies, recommend or facilitate requests for legislation, budgets and support for emergencies and preparedness work, coordinate with International Non-Governmental Organisations (INGO), local Non-Governmental Organisations (NGO) and other institutions working on DRM in the country. The NCDM sits and/or leads network groups on disaster management in the country.

In 2007, the NCDM drafted a new strategic plan which is aligned with the Hyogo Framework of Action (HFA), the document signed by 167 countries at the World Conference on Risk Reduction (WCRR) in Kobe, Japan. The two year strategic plan details NCDMs strategies for strengthening partnerships, building capacity and building institutional capacity for DRM.

At the moment, the NCDM coordinates and cooperate in disaster related programs among which, is CBDRM. As part of its strategy to institutionalize CBDRM, the NCDM worked with various NGOs to establish disaster management committees at the provincial, district commune and village levels in target provinces, building capacity of local authorities and communities through various training.

The NCDM works closely with the Asian Disaster Preparedness Centre (ADPC) and specifically its Partnerships for Disaster Reduction – Southeast Asia (PDR-SEA) program, and produce the Strategic National Action Plan (SNAP) which provides technical support.

Cambodian Red Cross (CRC)

The Disaster Management Department of the Cambodian Red Cross (CRC) was established in 1994. With lessons from the flooding of 1996, the CRC piloted its Community-based Disaster Preparedness Program (CBDP) in late 1998. It began with addressing flood hazards and was developed further to include drought impacts.

The goal of the CBDP program is ‘to reduce the impact of disasters on the most vulnerable people affected by disasters in Cambodia’. The objectives are; ‘to develop the capacity of the CRC to effectively prepare for, and to respond to, natural disasters affecting Cambodia’, and ‘to successfully implement natural disaster prevention and mitigation strategies at the community level, through its network of Red Cross Volunteers (RCV)’.

The CRC’s CBDP has among the widest coverage in the country spanning 9 provinces,

23 districts, 94 communes and 317 villages. The current phase of the CBDP focuses on Kratie, Prey Veng, Pursat and Svar Rieng provinces. Activities in the filed include the development of Hazard Vulnerability Capacity Assessments (HVCA), Village Disaster Reduction Plans (VDRP) and implementation of disaster risk reduction (DRR) measures. At the moment, 27 villages have developed their HVCAs and there are plans to increase this number to 40 villages. A number of commune councils have committed to incorporating the VDRPs into their commune development plans (CDP) and more commune councils in the target provinces will be encouraged to do the same.

Currently in its inception stage, the Disaster Response Preparedness project aims to strengthen the capacity of the CRC to efficiently meet the basic needs of people and communities affected by disaster. This is a capacity building project for the CRC, looking at strengthening its internal structure and its coordination with its external partners by clarifying roles and responsibilities. The DRP will also be integrated into the CBDP activities across the country.

The CRC is in direct partnership with the NCDM and works closely with most NGOs in the field. It's strength lies in the field based staff and local volunteers.

Networks

There are currently four networks in the country, simultaneously implementing DRM programs. These networks do not necessarily implement community based activities but members or their local partners either have a field presence or are working at the provincial level. There may be existing overlaps in programs and target areas but there are also distinct specializations that support local level activities.

The NCDM is itself a network of ministries. As was mentioned, the NCDM is the recognized government focal point for DRM related activities. It has the following membership:

- Ministry of Interior;
- Ministry of Defence;
- Ministry of Environment;
- Ministry of Economy and Finance;
- Ministry of Public Works and Transport;
- Ministry of Agriculture, Forestry and Fisheries;
- Ministry of Health;
- Ministry of Information;
- Ministry of Education, Youth and Sports;
- Ministry of Cults and Religious Affairs;
- Ministry of Rural Development;
- Ministry of Industry, Mines and Energy;
- Ministry of Women's Affairs and Veterans;
- Ministry of Social Affairs, Vocational Training and Youth Rehabilitation;
- Ministry of Posts and Telecommunications;
- Ministry of Water Resources and Meteorology;
- Ministry of Tourism;
- Ministry of Land Management, Urban Planning and Construction;
- Secretary of State for Civil Aviation;
- High Command of Armed Forces.

Each of these member ministries will take the lead in developing policies conduct disaster management activities covered by their jurisdiction. The representatives from this group every July to plan and coordinate responses and clarify roles right before the expected arrival of the rainy season.

In a recent national consultation, a suggestion was made to form a technical group from among the member ministries to provide technical expertise and bring focus CBDRM within the ministries.

Additionally, the NCDM coordinates a working group for emergency response and rehabilitation work. Members include NGOs, the International Federation of Red Cross (IFRC) and CRC, the UN Disaster Management team and representatives from health, agriculture and rural development, among others. This group is further broken into subgroups to focus on emergency response, food security, health, small scale infrastructure on water and sanitation and preparedness and mitigation.

The United Nations Disaster Management Team (UNDMT) is composed of representatives from the UN Food and Agriculture Organization (FAO), United Nations Development program (UNDP), United Nations Children's Fund (UNICEF), UNFPA, World Food Program (WFP) and World Health Organization (WHO) in the country. The WFP coordinates this group, which is responsible to the UN Country Team.

Another network is the Humanitarian Accountability Network (HANet), which primarily promotes accountability in the humanitarian sector. This group is currently chaired by ARE and it counts World Vision, Oxfam GB, IFRC, CRC, CONCERN and other local NGOs among its embers. This is a Forum for facilitating and promoting accountability among practitioners, advocating for standards and good practices.

CBDRM activities of non-government organizations

ActionAid

ActionAid is an international organization working to fight poverty and promote human rights particularly women's rights, education, food, human security during conflicts and emergencies, just and democratic governance and the right to life and dignity in the face of HIV/AIDS. It began working in Cambodia in 1999 but only established its office in Phnom Penh in 1994.

It's program *Strengthening community resilience to flood and drought in Cambodia*, seeks to build the capacity of community members and local authorities to understand and prepare for flood and drought. The project works with partner NGOs to reach its target of 48 villages in Kratie, Svay Rieng and Bantey Meancheay provinces over a course of 15 months.

Project activities include the capacity building and training of Commune Committee on Disaster Management (CCDM), VDC, youth volunteers and school teachers. Awareness training activities are conducted with 16 primary schools. Technical training on disaster preparedness, mitigation and management, community development processes as well as project orientation seminars are also conducted with local authorities and local leaders.

ActionAid's program includes an information and awareness raising component that reaches to the larger village population as well as in the school curriculum. Local groups and local authorities are trained to conduct vulnerability and hazard assessments and develop village development plans. To support this, there is a conscious effort to strengthen the relationship and coordination with the local and national level structures on CBDRM.

CARE

CARE is also an international organization that strives to work with the most vulnerable individuals and households to identify resources, experiences and address poverty through sustainable solutions. The main activities of CARE in Cambodia include education, health, rural development and emergency response.

Under CARE's Rural Development Program, there are presently two CBDRM related projects namely, Integrated Rural Development and Disaster Management and Community Led Innovations in Disaster Preparedness. The first program is implemented in Svay Rieng and Prey Veng provinces while the second is in Prey Veng Province only. These two programs build on

the previous Disaster Preparedness Planning program started in 2004. The main activities of the previous project included capacity building of local authorities through action planning exercises. Mitigation through savings scheme was also developed then. The action plans included.

The Integrated program, which began in June 2006, aims to have functional drought and flood preparation and mitigation action plans and established accessible information exchange networks in at least 75% of the target villages. In this phase, roles and responsibilities of the village implementation committees (VIC) are clarified. Coordination with local and national authorities will also be strengthened.

The Community Led Innovations in Disaster Preparedness project builds community capacity for flood and drought preparedness and management. Drought emergency needs assessments, indigenous early warning systems and small scale mitigation infrastructure operation are among the activities under this project.

CONCERN Worldwide

Concern Worldwide has been in Cambodia since 1991. Its mission is to strengthen the ability of poor and most vulnerable people to exercise their rights and make informed choices to achieve a better quality of life without compromising the environment, with the government meeting its obligation to respect, protect and fulfil the rights of the Cambodian people.

The Disaster Risk Reduction project is one component of CONCERN's Supportive Initiatives Livelihood Improvement (SILIC) program. DRR work is conducted through 18 local partner NGOs and include awareness raising, support for 23 small scale mitigation infrastructure systems benefiting 3,938 vulnerable families.

Concern has had a number of achievements from previous project cycles including, supporting community infrastructure projects, responding to emergencies and supporting replanting of rice paddies. Future plans include DRR training of partner NGOs, completion of risk vulnerability assessments with communities, developing action plans and strengthening coordination and increasing capacity of local authorities and local partners in implementing CBDRM.

Church World Service (CWS)

The Church World Service has been in Cambodia since 1979 delivering relief and implementing development programs. It aims to develop the capacity of the most vulnerable to meet their basic needs sustainably and participate in the emerging democracy. CWS works with local partners and community organizations focusing on building technical and institutional capacity.

CWS has just completed its Community Based Disaster Risk Reduction project in nine villages in Svay Rieng province, with the support of the ADB and ADPC and MOWRAM. This was a project piloting Disaster Risk Reduction which ran from July 2006-September 2007 whose main achievement was the development of a three year Action Plan for Disaster Risk reduction. The current project, Provincial Partnership for Disaster Risk Reduction builds on the activities (action planning, training, establishment of CCDMs and VCDMs) previous project and focuses on supporting the PCDM of Svay Rieng province in implementing the action plan.

There are plans to expand the target areas to four more provinces but at the moment, these are still subject to funding.

Lutheran World Federation (LWF)

The Lutheran World Federation (LWF) is a church based international organization which responds to challenges and consequences of human suffering and poverty. It was established in Cambodia in 1979, with the overall goal of empowering rural community manage development processes, advocate for their rights and improve their options for sustainable livelihoods.

From 2003-2007, LWF implemented Community Based Disaster Management projects in some 300 villages across the provinces of Kampong Spey, Kampong Chhnang and Battambang. It partnered with Dan Church Aid and CWS as well as partners from their Integrated Rural Development Through Empowerment projects. They also worked with the NCDM and the CRC in facilitating the local planning processes ensuring that CBDRM becomes a component of local development plans. Other activities include organizing village disaster volunteers, building the capacity of the PCDMs, DCDMs, CCs through training. Information and awareness raising activities such distribution of IEC materials were also conducted. Small scale community infrastructure for mitigation purposes was supported.

The current project focuses capacity building through training of trainers on CBDRM, conducting more CBDRM training and organizing a CBDRM forum while continuing to strengthen coordination with other NGOs and the local infrastructure.

Oxfam International

Oxfam International is a global group of independent organizations dedicated to overcoming poverty and fighting injustice all over the world. In Cambodia, the lead agency for the humanitarian program is Oxfam Great Britain. Other active Oxfams in Cambodia include Oxfam America, Oxfam Hongkong, Oxfam Quebec, Oxfam Australia, Oxfam Novib and Oxfam Solidarite.

The OI CBDRR program works through partners in Kratie (Community Based Flood Preparedness), Kampong Speu (Community Based Drought Preparedness and Mitigation) and Svay Rieng (Community Based Disaster Risk Reduction). Oxfam also responds to emergencies such as flash floods, recently in Kratie in 2006 and Preah Vihear in late 2007. Common in the three programs is the aim of reducing risk, increasing resilience (to drought and flood) and capacity building of communities, partners, staff and local authorities for implementing CBDRR strategies. Oxfam and its partners work closely with the NCDM and its counterpart structures at the local level.

Activities at the local level include village needs assessments, formulation of village DRR plans, capacity building on disaster management, gender, leadership, accountability, community mobilization and climate change, among others. Oxfam has also supported the construction of infrastructure such as flood gates, water catchments and latrines. Since January 2005, the joint Oxfam program has invested more than US$ 1.3 million in CBDRR and emergencies and have directly benefitted 16, 636 households and 28,666 households indirectly.

Plan International

Plan International first established in presence in Cambodia in 2002, setting up an office in Siem Reap. Plan works with children, their families, communities, organizations and local governments to implement programs at grassroots level in health, education, water and sanitation, income generation and cross-cultural communication.

Recently, Plan initiated a DRR capacity building program for its staff, partners in the community and children in school. This is a relatively new area for Plan which eventually hopes to integrate DRR in its programs. At the moment, Plan is building its relationship with organizations, network and government agencies working on DRR to help them build their capacity for future programming.

World Vision

World Vision is a Christian humanitarian organization dedicated to working with children, families and their communities worldwide to reach their full potential by tackling the causes of poverty and injustice. For many years, WV has responded to emergencies in the country but has recently decided to develop a long term strategy for disaster management.

Under the Humanitarian and Emergency Affairs (HEA) Program the Community Disaster Mitigation Project (CDMP) seeks to improve the coping capacity of two districts from Kampong Chhnang and Takeo provinces. For this project, WV works closely with CCDMs to improve their understanding of their roles and build their capacity by providing training on DM, CBDRM, report and proposal writing, accountability and Local capacity for Peace. Information on floods, droughts, avian influenza and environment preservation are shared with communities. To support community learning, WV organized cross visits between the CCDMs from the two provinces. Further, self help groups were formed, trained both to support the communities and support the CCDM in its work.

WV plans to eventually integrate disaster management into the Area Development Plans (ADP). There are currently 20 ADPs across six provinces and Phnom Penh city.

ZOA Refugee Care

ZOA-Refugee Care supports refugees, internally displaced people (IDP), returnees and others affected by conflict or natural disaster in their transition from instability and lack of basic needs towards a situation in which conditions enable a process of structural development have been (re-)established.

From 2004-2006, ZOA implemented a program geared towards reducing the impact of droughts in Oddar Meanchey province. Among its achievements were the selection and training of village disaster management councils (VDMC), participatory risk assessments and formulation of DRR plans. ZOA also worked closely with NCDM to provide training to the CCDM and the PCDM of Oddar Meanchey.

Other drought mitigation activities include the construction of irrigation ponds, wells and forms of water catchment, distribution of farming implements and drought resistant rice varieties and cash crops. The MOWRAM also came to provide training on drought early warning systems.

The current program aims to build the capacity of communities to reduce the impact of disaster, particularly drought, expanding the program to seven communes in Oddar Meanchey province. Another 33 VDMCs were formed and trained (CBDRM and hazard, vulnerability and capacity assessments) leading to the development of more village disaster management plans. Three more CCDMs were formed and further training was conducted for the new councils as well as refresher training (by NCDM and MOWRAM) for the previous CCDMs and the PCDM.

Further, ZOA provided tractors and other farming implements, distributed rice seeds and supported the construction of drought mitigation structures.

Future plans include further capacity building activities at all levels and increasing agricultural yields through crop diversity.

TRENDS AND GAPS IN THE IMPLEMENTATION OF CBDRM

Geographical coverage

CBDRM projects are currently being implemented in 12 out of 23 provinces. Svay Rieng (flood and drought) has the most number of CBDRM projects with four followed by Kampong Chhnang (flash floods) with three. Other provinces have one or two programs present.

What is important to note is that there are provinces which are considered high priority in the flood and drought vulnerability maps (World Food Programme (WFP), 2004) but do not have a CBDRM program. Such is the case for Kandal province which has areas registered as high priority for flood and drought as well as some incidence of flash floods in the recent years.

The province of Stung Treng, while only ranked third priority, appears to have a wider area of vulnerable communities but does not have any CBDRM activity.

Kampot and Rattanakiri have registered flash flood incidents but do not have any

CBDRM activities as well.

The province of Prey Veng ranks first and second priority (covering most of the province) for both flood and drought but currently has only one NGO/CBDRM program.

Another important point to note is that there are nine provinces which experience both flood and drought throughout the year. These are the provinces of Bantey Mencheay, Kampong Cham, Kampong Speu, Kampong Thom, Kandal, Kratie, Prey Veng, Preah Vihear and Takeo. Four of these provinces have one CBDRM program while three provinces have two CBDRM ongoing programs.

Programming

Beneficiaries are generally among the most vulnerable, including farming and fishing communities. Because of the mapping and assessment exercises, the communities themselves are able to identify the most in need, considering children, elderly, poorest households, people with disabilities, etc. This has made the distribution of support (in emergency situations) much more coordinated and participatory.

All CBDRM programs currently prioritize capacity building of committees for disaster management at the provincial, commune and village level. All NGOs have invested heavily in training and capacity building activities on CBDRM for authorities, partners and communities.

There is increasing involvement of formal structures such as the PCDMs, CCDMs and VCDMs. This is the more sustainable way to leave knowledge, technology and mandate for CBDRM in the future. There is a felt need in building these structures, evident in the capacity building components of all CBDRM programs.

Most CBDRM programs in the drought context also provide small scale infrastructure (water catchments) construction and farming implements and materials.

No skills training for alternative or secondary source of livelihood so far.

Emerging hazards

Most CBDRM programs are currently focusing on flood and drought prone areas. There are a few NGOs who are implementing Avian Influenza programs but have not incorporated into the CBDRM program.

Increasingly, with the change in environmental patterns, communities have raised their concern about the changes in the seasons. Rains have either come early or late, prolonging or cutting short the dry season. This has implications not only on agriculture and food security but also on the preparedness measures in the community. This could spell more frequent or prolonged droughts and flooding, where the scale may be unpredictable.

LESSONS AND RECOMMENDATIONS

Institutionalization of CBDRM

Despite the capacity building activities, many NGOs still feel that there is insufficient leadership and participation from the CDMs at all levels. This means that capacity building will have to continue and new strategies need to be thought out. Aside from technical skills, local leaders have to be learn basic project operations and management, which includes proposal writing, reporting and fundraising, among many. While some NGOs may feel that absorbing local leaders/government employees into their programs builds capacity, this does not guarantee transfer of knowledge in the community as this staff do not tend to go back to local service.

Institutional capacity building needs to be approached from a wider angle. The NCDM, being the focal point for all CBDRM and all disaster related activities in the country, currently does not have enough staff and budget. Firstly, the NCDM needs to be strengthened as an

institution so that it can lead in CBDRM activities on the ground. It has to have the capacity to consistently manage and hold accountable its counterparts at the local level. Staffing at the Secretariat needs to be reinforced and NCDMs access to national coffers needs to be improved.

The role of the NGOs

There seems to be no structures for CBDRM where there are no NGOs. It is to be noted that the NGOs have led in organizing local CDMs and in almost all the activities on the ground. Many 'volunteers' (VCDM, RCV, etc.) receive allowances (*per diem*) which may be understood as payment for their participation, if not by them, by the community members or by the commune council members. To encourage community ownership and continuation of programs, the NGOs need to present clear and transparent exit strategies from the beginning.

For those NGOs who are present in the same provinces, there needs to be coordination of programs on the ground so that non-project areas are covered and duplication of project partners and target areas are avoided.

To improve effectiveness in the field, NGOs (humanitarian actors) should see each other as a resource, making use of each other's specializations, i.e. water and sanitation, health, etc.

Sustaining community participation

Community capacities need to be strengthened through continuous training, building on eventual handover of responsibilities and leadership. Development plans in the community need to folded into larger plans at the provincial and district level.

Recommendations from the national consultation

The NCDM, together with the ADPC organized a national consultation for institutionalizing CBDRM. It was attended my NCDM member agencies and NGOs implementing CBDRM programs. The following are the recommendations from the workshop:

- link disaster preparedness program and development project Ensure good communication between local authorities, organizations and disaster management at all level;
- focus more on livelihoods protection and strengthening;
- acknowledge and address the fact that food security is a primary concern for many rural households before, during and after a disaster (immediate and longer-term);
- factor in the significant linkages between Common Property Resources (CPR) and Natural Resource Management (NRM) with disaster risk reduction;
- early Warning Systems should be fully integrated into relevant development planning and programming rather than 'stand alone';
- mainstream DRR into national and local development planning (Commune council) rather than 'stand alone' DRR projects;
- improve the sharing of field experiences amongst DRR practitioners (in Cambodia and regionally) - in particular for Cambodian staff and local authorities;
- raise the profile of DRR amongst development actors and increase Cambodia DRR staff exposure to practical 'new' ideas and solutions;
- access to longer funding cycles to enable DRR initiatives to be properly and fully integrated into development planning/programming;
- in project design stage, consider involvement of, or linkages with, the National Committee for Disaster Management (NCDM);
- focus on the development of Village Disaster Reduction plan rather than one structural mitigation measure (Micro-project);
- greater, and genuine, participation of vulnerable communities and local authorities in project design (and M&E).

Paper 3-4-2

ASSESSMENT OF INTEGRATED FLOOD MANAGEMENT STRATEGIES IN THE LOWER DONG NAI – SAI GON RIVER BASIN, VIET NAM

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ABSTRACT

The paper presents a comprehensive study on integrated flood management strategies in the Lower Dong Nai-Sai Gon River Basin situated in the southwest of Vietnam. The basin has the country's highest economic development rate. It houses Vietnam's largest population centre (Ho Chi Minh City) and has the largest concentration of industrial output. As a typical flat and low-lying riverine-estuarine transition area, it is flood prone and faces increasing damages as a result of re-occurring flood events, both from rivers as well as storm surges from the sea. In general, the existing flood defence structures with a relatively low safety standard are small and situated in a scattered order over the river basin. In the past the area experienced large scale flooding, which brought about serious damages to private houses and properties, public facilities, agricultural crops and livestock.

Flood management strategies in Ho Chi Minh City should initially be based on a 'holistic approach'. This approach considers the catchment as a whole, not only in terms of the geographical and functional interdependencies involved, but also the inter-relationships between land and water. Not just economic developments are considered, but also socio, environmental and institutional developments. The development of flood management strategies should be implemented by associating water-related sciences, environmental sciences with social sciences as well as by coordinating and combining physical and mathematical modelling tools, involving experts in all sections and public participants.

Firstly, the flood damages and impacts are assessed by using results of a 1-D hydrodynamic model (SOBEK). Different (steady-state) scenarios for future flooding situations have been taken into account, considering both upstream runoff as well as tidal dynamics. Secondly, flood management strategies have been developed on the basis of the above-mentioned assessment results. Various starting points for flood management strategies for different geographic areas have been defined, such as: 'keep floods away from people', 'keep people away from floods' and 'accept floods and clean up afterwards'. In total eight different strategies have been defined, based on three conceptual approaches: (i) different principles of structural measures; (ii) compatibility between structural and non-structural measures; and (iii) spatial distribution and pre-feasibility of various measures. Thirdly, the proposed strategies have been assessed and compared by using a specific set of criteria in order to determine preferred strategies, which could be suitable for further analysis. The strategies can be roughly divided into three main categories: favourable, less favourable and non-favourable. The advise on favourable strategies is composed by taking existing environmental conditions (ecologically, socially and economically) of the study basin into consideration. The 'storage and confinement' strategy has been evaluated to be the most promising solution.

The flood issues in the Lower Dong Nai-Sai Gon River Basin can be substantially

managed and mitigated by some promising integrated management strategies, which are the combination of various structural measures and their appropriate non-structural measures.

INTRODUCTION

The Lower Dong Nai - Sai Gon River System (Figure 1) is situated in the southwest of Vietnam and has the country's highest economic development rate. It houses Vietnam's largest population centre (Ho Chi Minh City) and has the largest concentration of industrial outputs. At the same time, the river basin continues to diversify its agricultural sector with products ranging from basic staples like rice and maize to raw materials for the local industry (Claudia et al., 2001). As a typical flat and low-lying riverine-estuarine transition area, it is flood prone and faces increasing damages as a result of re-occurring flooding events, from rivers as well as storm surges from the sea and as a result of local precipitation (Figure 1). In general, the existing flood defence structures are small and situated in a scattered order over the river basin (Japan International Cooperation Agency (JICA), 1996). The dike systems are discontinuous and contain a relatively low safety standard (Sub-Institute for Water Resources Planning (SIWRP), 2001). Upstream of Ho Chi Minh City, two large reservoirs have been developed in the recent past (Dau Tieng and Tri An). In the past the area experienced some exceptional floods, with return periods ranging from 1 - 25%, which caused serious damages to private houses and properties, public facilities, agricultural crops and livestock (Table 1). During the flood season, the drainage possibilities of different rural and urban areas are severely affected, since the drainage system has no sufficient capacity to adequately discharge the flood waters and it is not well maintained.

Despite many efforts from various governmental agencies on different levels, floods and their consequences still remain as one of the biggest issues in the Lower Dong Nai - Sai Gon River Basin. To solve the flood problems substantially is a challenging task, which needs broad and profound studies.

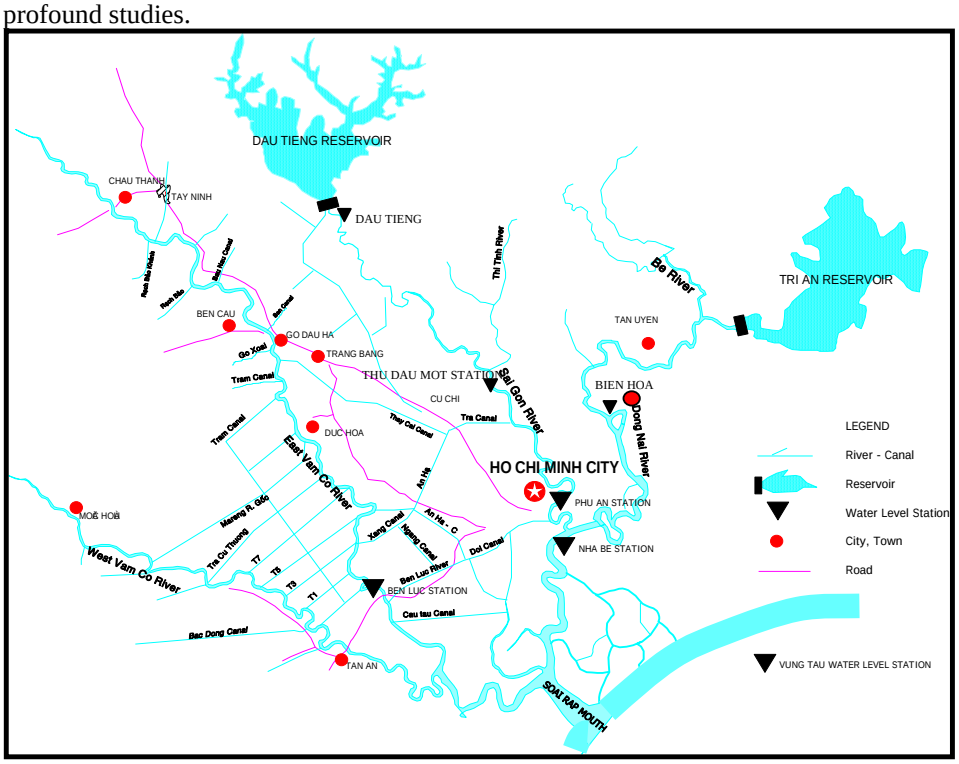

Figure 1. The Lower Dong Nai – Sai Gon River System

Table 1.Historical flood damages (Japan International Cooperation Agency (JICA), 1996 and Sub-Institute for Water Resources Planning (SIWRP), 2001).

Year (Frequency)	Damages			
	Houses (unit)	Roads (km)	Paddy crops (ha)	Cereals
1952 (1%)	7,598	13	31,270	120
1978 (10%)	1,834	20.5	8,110	203
2000 (25%)	1,100	32	6,500	100

The objective of this paper is to develop and assess various flood management strategies to reduce flooding risks, potential damages and losses in the Lower Dong Nai - Sai Gon River Basin and to explore their pre-feasibility by analyzing hydraulical, environmental and economical impacts in a broad scope.

METHODOLOGY AND APPROACH

Flood management strategies in Ho Chi Minh City should initially be based on a 'holistic approach'. This approach considers the catchment as a whole, not only in terms of the geographical and functional interdependencies involved, but also the inter-relationships between land and water. Not just economic developments are considered, but also socio, environmental and institutional developments. The development of flood management strategies should be implemented by associating water-related sciences, environmental sciences with social sciences as well as by coordinating and combining physical and mathematical modelling tools, involving experts in all sections and public participants.

The flood management strategies in the Lower Dong Nai-Sai Gon River System have been developed within a contemporary concept which states that 'Floods cannot and should not be eliminated, and every future flood-related development should be compatible with the entire environmental system of the Lower Dong Nai - Sai Gon River System. Flood management strategies should cover all potential flood stages and should be developed to efficiently respond before, during and after floods'.

Flood management strategies have to comply with relevant aspects of social-economic, physical and ecological conditions in the Lower Dong Nai - Sai Gon River System. Therefore, various starting points for different geographic areas have been defined (Figure 3) (Petry, 2002):

- 'keep the floods away from people';
- 'keep people away from floods';
- 'accept floods and clean up afterwards'.

After analysing flooding risks, potential damages and losses for future flood situations (based on historic GIS data), flood management strategies have been derived, primarily based on the combination and complementarity of structural and non-structural measures, taking effectiveness and technical and socioeconomic pre-feasibility into consideration (Green et al., 2000).

In order to explore the flooding situations in the Lower Sai Gon - Dong Nai River Basin, 12 different scenarios have been defined (Table 2). These scenarios include different upstream (discharge) and downstream (tidal level) boundary conditions, considering the effects of climate change and other recent and future developments in the study area. A 1-D hydrodynamic model (SOBEK-RURAL) (see model schematisation in Figure 2) has been employed to simulate the

hydraulic impacts of the flood management strategies. Flood scenario No. 10, which corresponds to the upstream (discharge of 0.1 exceedance frequency) and downstream (high tide + sea level rise) boundary conditions and mid-term future developments in the study basin.

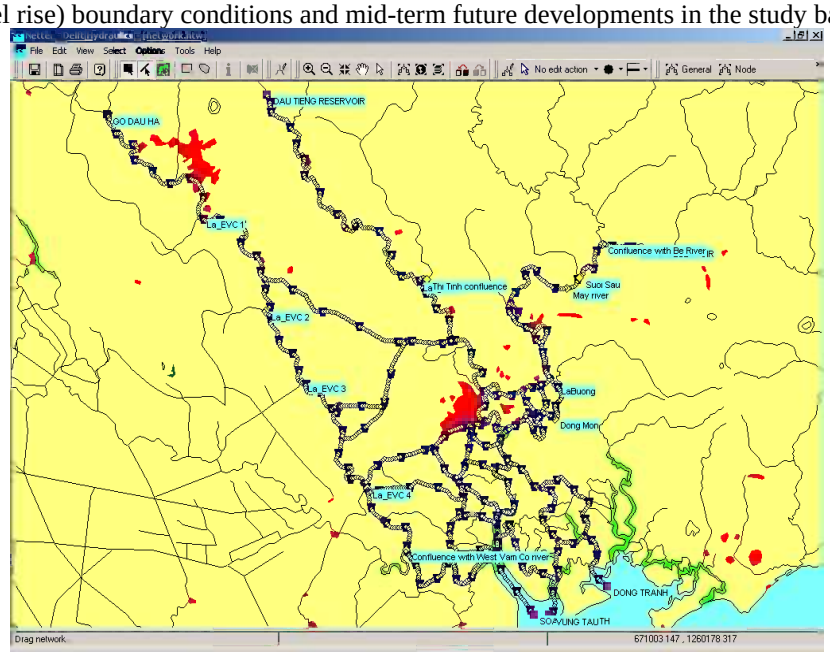

Figure 2. SOBEK schematization of the Lower Dong Nai - Sai Gon River Basin

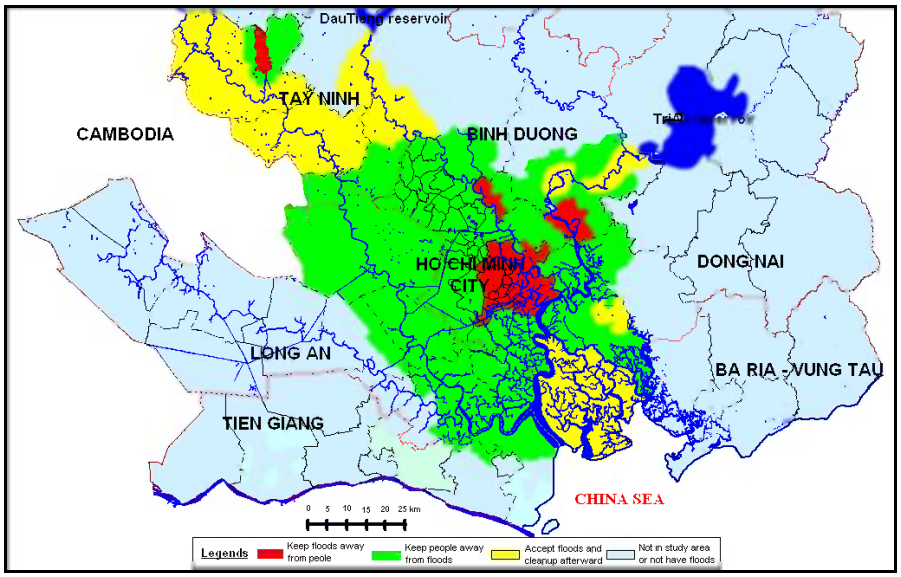

Figure 3. Zoning of starting points for the development of various flood management strategies

The purpose of structural measures is to keep floodwater away from people. The implementation of structural measures will modify the flow of floodwater and alter the physical characteristics of the floods (Petry, 2002). They comprise ‘discharge control’, ‘water level control’ and ‘embankment and levees’ measures.

Non-structural approaches, as defined by the International Commission on Irrigation and Drainage (ICID) (1999), comprise activities, which are planned to eliminate or mitigate adverse effects of flooding without involving the construction of flow-modifying structures (i.e. land use

planning, preparedness and emergency and relief).

Table 2. Measures selected for various flood management strategies

Tide level	Tide water level exceedance frequency	Flood discharge exceedance frequency		
		1%	0.5%	0.1%
High tide (or spring tide)	*100%*	Scenario 01	Scenario 05	Scenario 09
High tide + sea level rise	*100%*	Scenario 02	Scenario 06	Scenario 10
High tide of 2%	*2%*	Scenario 03	Scenario 07	Scenario 11
Storm surge	*0.1%*	Scenario 04	Scenario 08	Scenario 12

RESULTS

In total eight different strategies have been defined (Table 3), based on three conceptual approaches:

- different principles of structural measures (discharge control, water level control and confinement);
- compatibility between structural and non-structural measures;
- spatial distribution and feasibility of various measures.

Table 3. Measures selected for various flood management strategies

No	Measure	Strategy							
		1	2	3	4	5	6	7	8
I.	*Structural measures*								
1.	Reservoirs and discharge control works in Dong Nai River	X				X	X		X
2.	Reservoirs and discharge control works in Sai Gon River	X				X	X		X
3.	Detention areas in East Vam Co River	X				X	X		X
4.	Dike - embankment system for entire river system		X						
5.	Dike - embankment system for important areas (*)					X	X	X	X
6.	Floodplain excavation for the river system			X			X	X	
7.	River channel widening for the river system				X			X	X
II.	*Non-structural measures*								
1.	*Land use planning (floodplain management)*								
a.	Floodplain regulation	O	O	X	X	O	X	X	O
b.	Zoning and land use by-laws	O	O	X	X	O	X	X	O
c.	Building codes								
2.	*Preparedness*								
a.	Flood forecasting	X	O			X	X		X
b.	Emergency response planning and training								
c.	Local social structure strengthening								
d.	Public participation	X	X	X	X	X	X	X	X
e.	Flood proofing		O				O	O	
3.	*Emergency and relief*								
a.	Flood emergency response planning								
b.	Response measures	X	X	X	X	X	X	X	X
c.	Flood fighting		X			X	X	X	
d.	Recovery measures	O	O	O	O	O	X	O	O

Note: X: Compulsory for the strategy O: Optional for the strategy
(*) Important areas: Ho Chi Minh City, Bien Hoa City, Thu Dau Mot town and some small towns.

The various strategies have been assessed and compared with a specific set of criteria, derived from studies like Hooijer et al. (2002) and Silva et al. (2001) (i.e. costs, excavation

works, land use, environmental impacts, implementation time, etc.) in order to determine preferred strategies, which could be suitable for further analysis. The quantitative and qualitative assessment results for the eight proposed strategies are presented in Table 4.

Table 4. Assessment results for flood management strategies

No	Crirterion	Unit	Strategy							
			1	2	3	4	5	6	7	8
1	*Effectiveness (ΔH)*									
a	Sai Gon river									
	River zone	metre	0.27	na	0.55	0.67	0.27	1.04	1.56	0.89
	Transition zone	metre	0.65	na	0.02	0.04	0.65	0.67	0.18	0.54
	Tidal zone	metre	0.70	na	0	0	0.71	0.69	0	0.64
b	Dong Nai river									
	River zone	metre	2.72	na	0.64	0.94	2.72	3.40	1.68	3.44
	Transition zone	metre	1.18	na	0.05	0.1	1.18	1.19	0.10	1.09
	Tidal zone	metre	0.18	na	0	0	0.19	0.18	0	0.18
c	East Vam Co river									
	River zone	metre	0.52	na	0.18	0.45	0.52	0.68	0.64	0.81
	Transition zone	metre	0.12	na	0.03	0.04	0.26	0.26	0.02	0.20
	Tidal zone	metre	0.02	na	0	0	0.08	0.08	0	0.08
2	*Absolute Costs*	million US$	1,845	866	915	581	1,983	2,900	1,630	2,560
3	*Excavation work*	million m^3	3.0	174	129	98.5	27.5	157	401	126
4	*Embankment work*	million m^3	2.1	121			19.2	19.2	121	19.2
5	*Land use or land occupation*									
a	Rural	km^2	346 *(86)*	27	129	9.5	346 (86)	475 (86)	166	356 (86)
b	Urban and sub-urban	km^2	-	5	-	-	5	5	5	5
6	*Technical feasibility*		++	++	+	+	++	+	+	+
7	*Environmental impacts*		+	*	-	-	+	*	-	*
8	*Time*		++	++	++	++	++	++	++	++

Note: na: not applicable 346 (*86*) Italic text represents for the temporary land use or occupation

i. 'Effectiveness' is presented by average values of water level reduction (in metre)
ii. 'Absolute Costs' are calculated in Present Value, with an assumed discount rate of 10% (for the period from 2005 to 2050).
iii. 'Technical feasibility': (++) most feasible; (+) feasible; (*) moderate; (-) less feasible; (- -) not feasible
iv. 'Environmental impacts': (++) very positive; (+) positive; (*) moderate; (-) negative (- -); very negative
v. 'Time until the desired effect occurs': (++) very short; (+) short; (*) moderate; (-) long time; (- -) very long time

The strategies can be roughly divided into three categories: favourable, less favourable and non-favourable. The advise on favourable strategies is composed by taking existing environmental conditions (ecologically, socially and economically) of the study area into consideration. The 'storage and confinement' strategy (no. 5 with reservoirs, detention, dikes and embankments, and various non-structural measures) seems the most promising solution to mitigate flooding in Lower Dong Nai - Sai Gon River System (Figure 4 and Table 4).

In addition, it can be concluded that all non-structural measures can be applied for each strategy in practice. For this study, in order to distinguish the characteristics of each strategy, relevant and closely related non-structural measures accompany certain structural measures. For example, the 'reservoir building' measure should accompany the 'flood forecasting' measure, and the 'floodplain excavation' measure should be associated with 'land use planning' measures.

Table 5 presents more detailed information for the criterion ‘environmental impacts’. The information was obtained from a Japan International Cooperation Agency (JICA) study (1996) and literature (Petry and Boeriu, 2005 and Douben, 2006).

The ‘Initial Environmental Examination’ (IEE) is carried out instead of a detailed ‘Environmental Assessment’ as a result of lacking data. However, the IEE roughly reveals that the ‘reservoir building’ measure might give an overall positive impact, whilst ‘dredging and excavation works’ implicate an overall negative impact and the ‘dike-embankment system’ might give a moderate impact to the existing environmental system. These qualifications however, should be considered as a very rough estimation of potential environmental impacts. The actual environmental consequences of a flood management strategy can only be quantified after a detailed and thorough analysis.

Table 5. Initial Environmental Examination for proposed structural measures

Measure	Positive impact	Negative impact	Overall environmental evaluation
Reservoir	• flood reduction • food security (increase of agricultural production) • domestic water supply • hydropower supply • fisheries	• loss of land (360 km2) • resettlement (41,500 people) • loss of wild lands and wildlife habitat • scouring of river bed below dams • decrease in floodplain agriculture • conflict demands for water use	*‘Positive’*
Dredging and excavation works	• reduction flood water levels • soil material for construction	• affect sensitive habitats or valuable fisheries resources • alteration of bottom surface, which may be unfavourable to flora and fauna • upland disposal of dredging material could modify terrestrial habitat • impacts of possible land disposal on surface run-off • sediment pattern changes	*‘Negative’*
Dike – Embankment system	Protection by keeping people away from floods and tidal movements	• separation of river environment into 2 sides - outside and inside river • frequent improvement as a results of section failure, settlement • reduction of natural storage for floodwaters • flow of water in tributaries constrained • exacerbation flood problems for other parts of rivers • increase flow velocities, reduced shelter in the channel bed	*‘Moderate’*

DISCUSSION

The assessment results indicate that the implementation of the ‘storage and confinement’ strategy (no. 5) will reduce peak water levels significantly for a flood event that occurs with 0.1% exceedance frequency, as well as the consequences of flooding, hence potential losses and damages. Although considerable reductions occur of flooding impacts in the riverine and transition zones will be achieved, in many developed areas such as Ho Chi Minh City and Bien Hoa City, the pre-established protection levels still are not met fully. Additional measures (e.g.

drainage works, local dike and embankment systems) need to be studied and implemented as well.

Ho Chi Minh City is located in the transition and tidal zones of the rivers. Therefore, improvement and implementation of a continuous dike-embankment system with appropriate sluices and gates are certainly needed to protect the area against floods with 0.1% exceedance frequency and to satisfy the principle of 'Keeping floods away from people'. The continuous dike-embankment system will also need to be implemented in some other important areas, such as Bien Hoa City and Thu Dau Mot town.

Along the Sai Gon, Dong Nai and East Vam Co rivers, in which important agricultural areas are located, it is proposed to build embankment systems to protect these areas against floods with 1% exceedance frequency. In remaining agricultural areas in floodplains, it is proposed to locally build summer-embankment systems to protect these areas against annual floods, with full consideration of the functions of floodplains in- and outside the summer-embankment system during floods. Appropriate sluices and gates need to be built in order to drain inundation water back into the river.

Local heavy rainfall also significantly contributes to urban inundations, and therefore exacerbates the adverse inundation consequences during and after floods. Hence, effective drainage systems, accompanied by pumping stations are necessary.

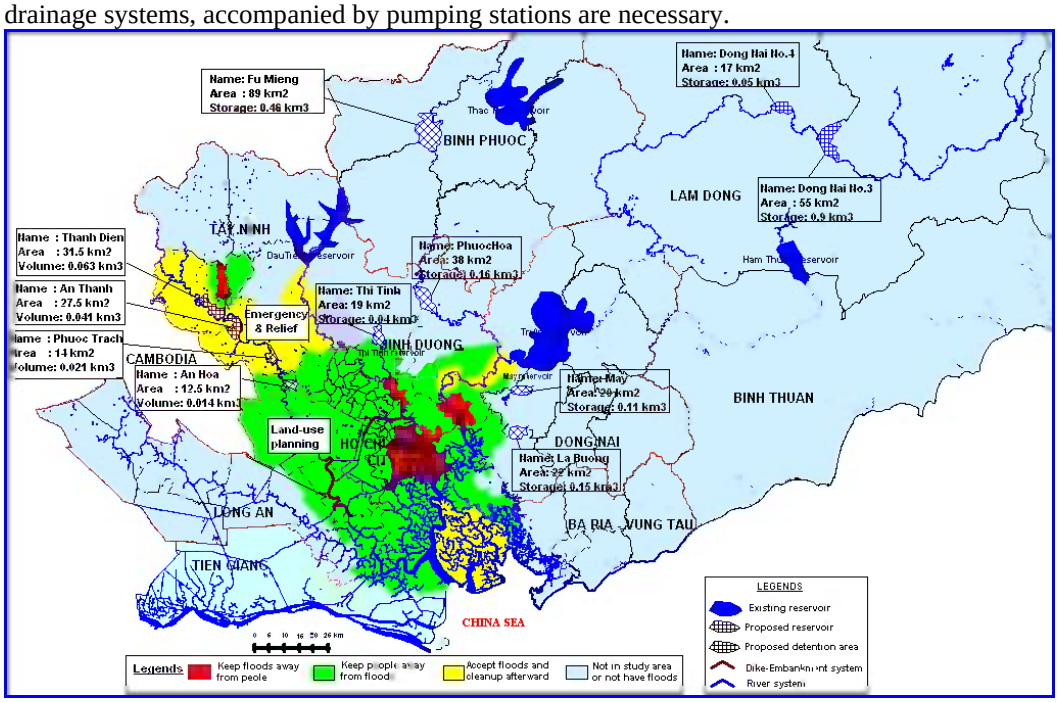

Figure 4. Spatial presentation of Strategy 5 'storage and confinement'.

The implementation of non-structural measures is required to satisfy the principle of 'Keeping people away from floods' and 'Accept floods and clean up afterwards'. They will play a main role for flood management strategies in many areas, where the above mentioned structural measures do not solve flooding issues substantially, are not justified by cost-benefit analysis and/or are not preferred due to adverse environmental consequences. Flood forecasting and warning, flood emergency response planning and flood response measures will need to be implemented all over the river zones. However, their performance (including maintenance) should be optimised in the river and transition zones, where most of the rural and urban areas are located, in order to minimise the potential damages and losses. Land use planning measures will be used for the rural and sub-urban areas as well.

As a result of lacking environmental system data, together with non-accurate hydrological

data, the inter-relationships between land and water can be considered as the most important uncertainty of the study. Therefore, further (implementation) studies should consider the basin as a whole, not only in terms of the geographical and functional interdependencies involved, but also the inter-relationships between land and water as well as socio-economic and institutional development.

CONCLUSIONS

A comprehensive study on integrated flood management strategies in the Lower Dong Nai - Sai Gon River System is presented. Flooding issues in these basins might be substantially managed and mitigated by some promising integrated management strategies, which are a combination of various structural measures and appropriate non-structural measures. Despite of some constraints and limitations, the paper will certainly contribute to the ongoing development of flood management studies in the Lower Dong Nai - Sai Gon River System.

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Paper 3-4-3

BEST PRACTICE GUIDELINES FOR FLOOD RISK ASSESSMENT IN THE LOWER MEKONG RIVER BASIN

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ABSTRACT

As part of Component 2 of the Flood Mitigation and Management Program (FMMP) of the Mekong River Commission (MRC) guidelines for flood risk assessment have been developed. This paper summarizes the contents of these best practice guidelines for flood risk assessment and presents examples of results of flood risk assessments (FRA) for a case study area in the Lower Mekong River Basin. Within the FRA there needs to be insight in the flood hazards (flood levels and their probability of occurrence), the flood damages and both need to be combined to estimate the level of risk. A sound knowledge of the flood hazards, potential damages and risks is fundamental for the development of a balanced mix of measures aiming at the reduction of the risks.

INTRODUCTION

Component 2 of the Mekong River Commission (MRC) Flood Mitigation and Management Program (FMMP) aims, among others, at the development of guidelines for the preparation of flood risk management plans and for the evaluation of the impacts of flood risk management measures. A good knowledge of the flood hazards, potential damages and risks is fundamental for the development of a balanced mix of measures aiming at the reduction of the risks. The paper presents the best practice guidelines of flood risk assessment as developed in the FMMP-C2 for application in the MRC Member States for the Lower Mekong River Basin (LMB). The guidelines are intended for policy makers, basin planners, practitioners involved in flood risk management related projects and those active in dialogues regarding trans-boundary impacts of projects. The best practice guideline was prepared on the basis of a review of other guidelines and best practice documents in the field of flood risk management (e.g. the EU Floodsite and Excimap projects) and existing guidelines and flood risk assessments for the LMB countries. The objective of this paper is to summarize the main contents of the guidelines and show examples of the application of flood risk assessment for case study areas in the Lower Mekong Basin.

Integrated flood risk management (IFRM) is an approach to identify, analyse, evaluate, control and manage the flood risks in a given system. Flood risk assessment (FRA) is part of IFRM and involves the identification of hazards, damages and risks for a given system or area. As such, FRA provides a basis for evaluation of the acceptability of a risk level and the analysis of the effects of risk reduction measures. The general steps in flood risk assessment are shown

in Figure 1 and discussed below. The first step is the definition of the system and area studied and the collection of relevant data for this area (e.g. data basic regarding elevation of the terrain and the hydraulic processes). Flood hazard analysis is the second step and it includes an analysis of meteorological events that may eventually lead to flooding. In connection with the characteristics of the respective watershed the hydrological hazards (peak discharges, volumes) are assessed that may create the flooding. In connection with the characteristics of river channel and floodplain the flood hazard can be determined in terms of inundation area, depth etcetera. The results can be eventually displayed by means of flood (hazard) maps. The third step is the analysis of potential damages in the areas prone to flooding based on socio-economic data and a vulnerability / damage model. In the final step the risk is determined by combining the results of the flood hazard analysis, that gives insight in the probability of a certain hazard, and the results of the damage assessment. These results can be displayed in different forms, e.g. by means of risk maps, graphs or risk numbers that give insight in the yearly expected damage.

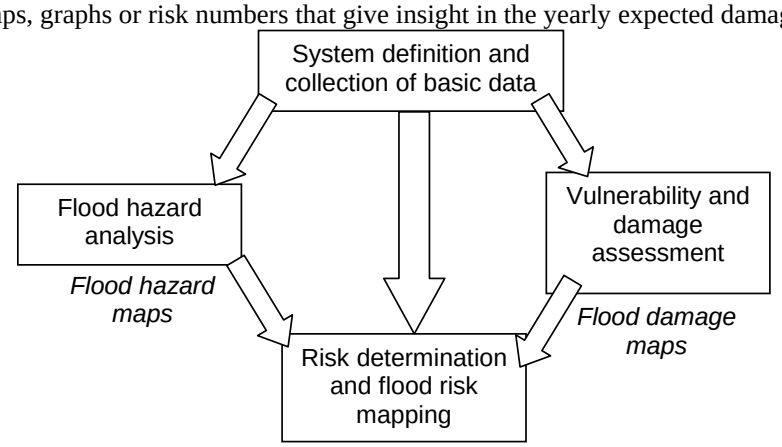

Figure 13. General scheme for flood risk assessment

The following sections describe the contents of flood hazard analysis, flood damage assessment and risk assessment. To illustrate the potential outputs of the steps examples are included from the results of assessments that were made for the so-called focal areas as part of stage 1 of the FMMP project (Royal Haskoning et al., 2008). Analyses were made for areas in Thailand, Lao PDR, Vietnam and Cambodia and in this article examples of the results for the latter country are presented. Section 5 summarizes concluding remarks regarding the guidelines, their application and their further development.

FLOOD HAZARD ASSESSMENT

In general the flood hazard assessment starts with an initial assessment of flood types in the area. Within the LMB several flood types can occur including: tributary floods, main stream floods, combined floods, floods in Cambodian flood plain, and floods in the Mekong delta. To develop an appropriate assessment of flood hazards the following steps have to be followed.

Data collection and analysis. This includes data gathering, data storage and validation (checking) of the data. Relevant data sources include: soil, land use and elevation maps, meteorological data (rainfall, evaporation), hydrological data (water levels, discharges), hydraulic infrastructure, river geometry (cross sections) and historical flood data (flood marks). Data storage should preferably be done in a GIS (geographic information system) environment. An important step that is often forgotten is data validation. The guidelines describe how the steps can be filled in for various situations that vary regarding the type of flooding (e.g. tributary floods, delta floods etc.) and the available data sources (e.g. rainfall data, observed

flows, regional flood statistics).

Hydraulic modelling. In general hydraulic data will only be available for a limited number of points/locations in an area. A hydraulic model is needed to assess data on the flooding, e.g. the water depth, for a larger area, and it uses physical laws and area-specific input information to do so. The guidelines describe which kind of modelling approaches can be chosen for several flood types and geographic situations. For example, for the Mekong delta the hydrodynamic ISIS software has been used to simulate the flows and water depths for several locations in the delta. A hydraulic model is also useful to evaluate the effects of measures on the hydraulics and flood depths in the area.

Flood frequency analysis involves the calculation of the frequency or probability of a flood with a certain magnitude. Information on flooding probabilities is needed to assess the level of risk. Depending on the type of flood considered, the available time series of data, the flood frequency analysis can be done in different ways. It can be based on observed flows, or local rainfall statistics in combination with a runoff model. The guidelines describe several techniques and indicate for which situations these can be utilized.

Flood hazard mapping. The results of flood hazard assessments for different return periods can be translated to flood maps. It is therefore needed that the model results for water levels at several (point) locations are included in a georeferenced data table. This table can be attached to an elevation map of the area. By combining information on the water levels and the terrain elevation and using interpolation techniques flood maps can be created. These show the extent of the flooded area and the local flood depth. Figure 2 shows an example of a flood depth map for the trans-boundary area of Cambodia and Vietnam.

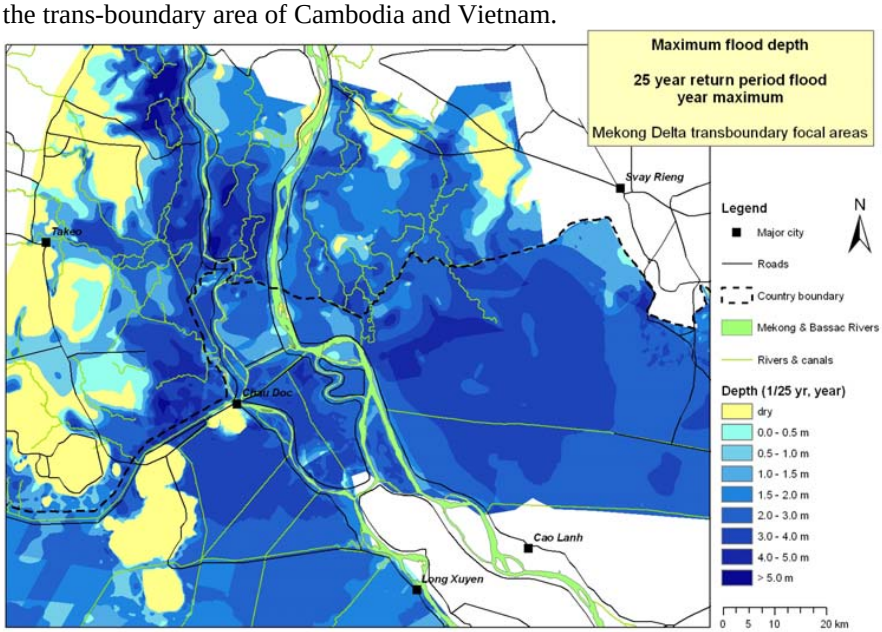

Figure 14. Flood depth map for the trans-boundary area of Cambodia and Vietnam for the 25 year return period

FLOOD DAMAGE ASSESSMENT

The consequences of a flood encompass multiple types of damage. An overview of different types of damages / consequences is given in Table 1. The damage is divided into tangible and intangible damage, depending on whether or not the losses can be assessed in monetary values. Another distinction is made between the direct damage, caused by physical contact with

floodwaters, and damage indirectly following from the flood. Indirect damages are damages caused by disruption of physical and economic linkages of the economy, and the extra costs of emergency and other actions taken to prevent flood damage and other losses, see e.g. (Parker *et al.*, 1987). This includes, for example, the loss of production of companies affected by the flooding, induced production losses of their suppliers and customers, the costs of traffic disruption or the costs of emergency services. Flooding in the Mekong basin causes not only damages, but benefits as well. These include beneficial effects for fishery, agricultural production and biodiversity. For a complete assessment these would have to be included as well.

Table 5. Classification of flood damages

	Tangible	Intangible
Direct	Physical damage to: • housing, structure and assets • infrastructure and public utilities • agriculture	• loss of life • health effects • environmental damages
Indirect	• temporary relocation • cleaning & sanitation • loss of income • industrial production losses • others	• societal disruption • increased vulnerability of survivors

The general approach for the assessment of direct damage is shown in Figure 3 and to estimate the flood damage there needs to be insight in the following factors:

- the flood characteristics (depth, velocity, duration, affected area, etc.)
- the number and type of land use functions affected and their value;
- the susceptibility of land use functions against flooding.

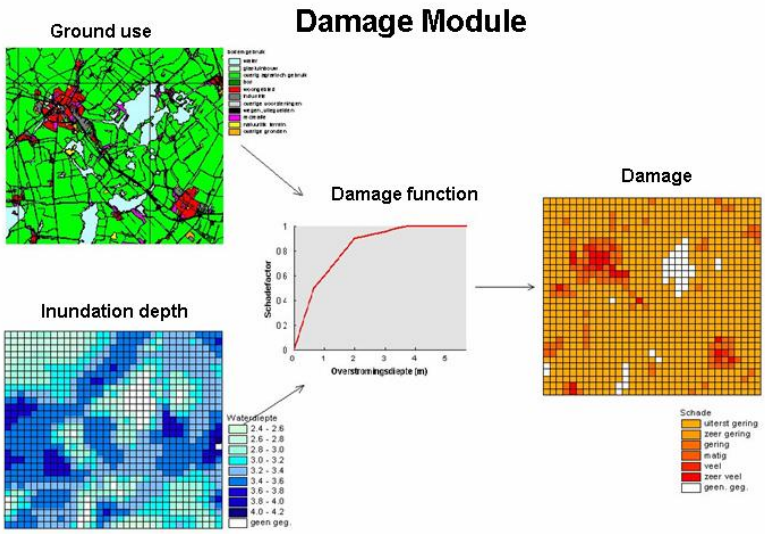

Figure 15. General approach for damage estimation

Generally, a so-called (stage) damage function is used to relate the level of damage to the flood characteristics. These functions have been developed in different countries, see e.g. (Penning-Rowsell and Chatterton, 1977; Dutta *et al*., 2003; Jonkman et al., 2008) for further background. Most damage functions take into account water depth as the main factor. However, for some damage types, e.g. damage to paddies, it is also important to take into account the

duration of the flooding and / or the season when the flooding occurs.

For the assessment of damage for the LMB two approaches are distinguished. The first approach is the *absolute approach* and the damage functions describe the relationship between the water level and the absolute damage value for a larger area, e.g. a district. The relationship between water level and damage to individual objects is not known. This approach is particularly applicable when damage data is only available for a larger area in combination with general information on historical flood levels in the river. The second approach is the *relative approach* and in this approach the damage function gives the relationship between water depth and the damage as a fraction or percentage of the maximum damage value. Relative damage functions can be derived if more detailed survey information on local water depths and damage to individual houses, or smaller units of infrastructure and agricultural land use are available. Examples of the two types of damage functions that were derived in stage 1 of the FMMP-C2 project are shown in Figure 4. Which of the two approaches is used depends on the availability of information and resources and the scope and desired level of detail of the analysis. As part of the damage assessment also a choice has to be made regarding which damage categories are included in the analysis. In general, those categories are analysed that are expected to determine the largest part of the damage. For the case study areas this concerned damage to housing, agriculture and infrastructure.

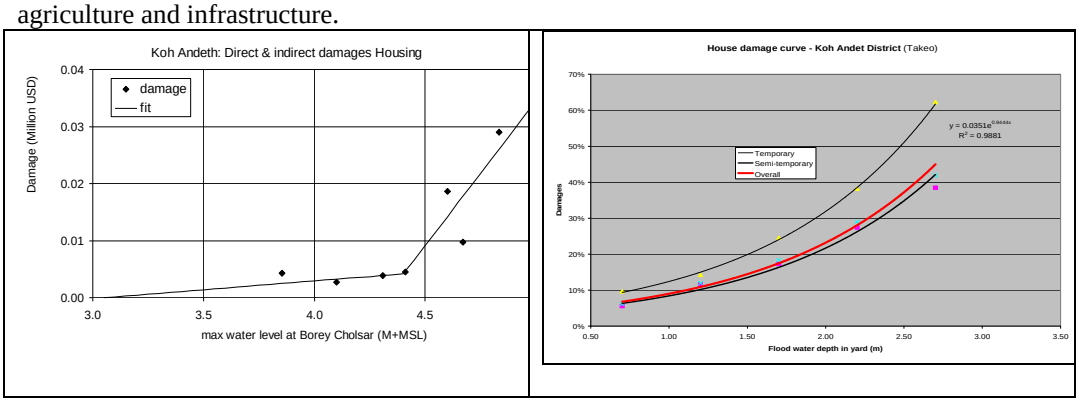

Figure 16. Absolute (left) and relative (right) damage functions for housing for the area Koh Andet in Cambodia

Various approaches are available for the assessment of indirect damages. In some countries approaches have been developed that include a model of the linkages in the economic system. Within stage 1 of the FMMP project the indirect damage has been assessed by means of surveys. Consequently the indirect damages have been related to the direct damages and a ratio between the two types of damage has been derived. The guidelines further describe how the damage functions can be elaborated and further elaborate on necessary steps such as the processing of flood data, economic aspects in the analysis (e.g. conversion from current to fixed prices).

To enable consistent damage assessments, standardized computer models for damage assessment have been developed in several countries. Examples are the HAZUS model developed in the United States and the Damage and Casualties Assessment (DACA) Module developed in the Netherlands. The application of the DACA model to parts of the Lower Mekong Basin has been investigated for an area in Thailand (Leenders et al., 2009). The development of such a computer model becomes particularly attractive when a) large amounts of underlying (GIS) data is available; b) there is good information to derive damage functions and these functions are applicable to various regions; c) a large number of calculations has to be made.

The results of the damage assessment can be presented in different ways. Possible outputs are numbers, such as the total damage number or the damage by category, or damage maps that indicate the level of damage for different areas. As an example the results are presented for the

Koh Andet area in Cambodia. Table 2 displays the damages for events with different probabilities. As an example of a damage map Figure 5 shows the damage to paddies by commune for the flowing with a 100 year return period. In the guidelines it is described in detail how several types of flood damage maps can be created by combining information on the flood hazards, land use and damage functions.

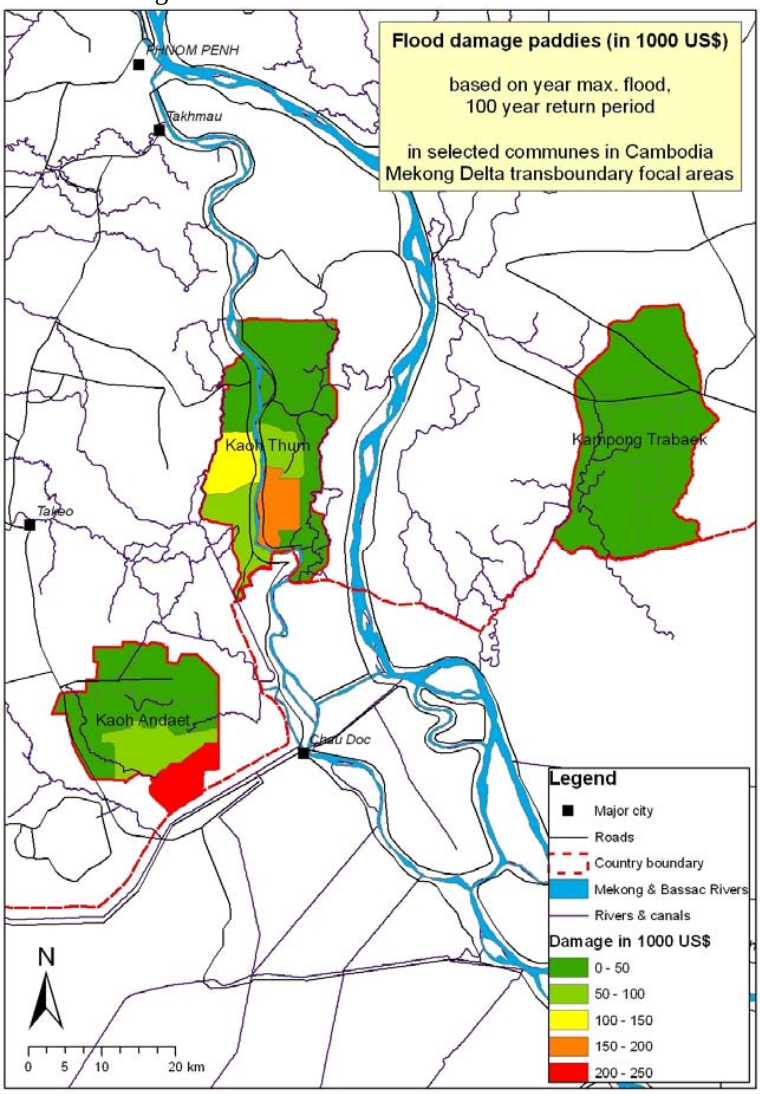

Figure 17. Damage map for paddies for flooding with a 100 year return period for case study areas in Cambodia (map is based on the relative damage functions)

Table 6. Damage data for different return periods for Koh Andet district. Damage is shown in million US$

Damage	Probability (1/year)			
	1%	5%	10%	50%
Housing	0.05	0.04	0.03	0.00
Infrastructure and relief	1.14	0.75	0.69	0.10
Agriculture	2.15	1.58	1.48	0.35
Total	3.35	2.37	2.20	0.45

In addition to the direct and indirect damages that can be expressed by means of monetary values, other damage types could be relevant for the analysis as well. The guidelines summarize existing approaches for the estimation of loss of life and health effects.

RISK ASSESSMENT

In the risk assessment the results of the hazard and damage assessments are combined. Flood risk is generally defined as the product of the probability of flooding and damage, but other ways of presenting the risk are possible. Often information is available for the economic damage for a limited number of flood scenarios that cover a range of probabilities (see table 2). The relationship between the damage value and the probability can be plotted in a graph, which is also called the probability-damage curve. Figure 6 gives an example of the probability damage curve for three case study areas in Cambodia (see Figure 5 for locations of the areas). Alternatively it is also possible to plot an equivalent relationship between the return period and the damage level, as the return period equals 1 / probability.

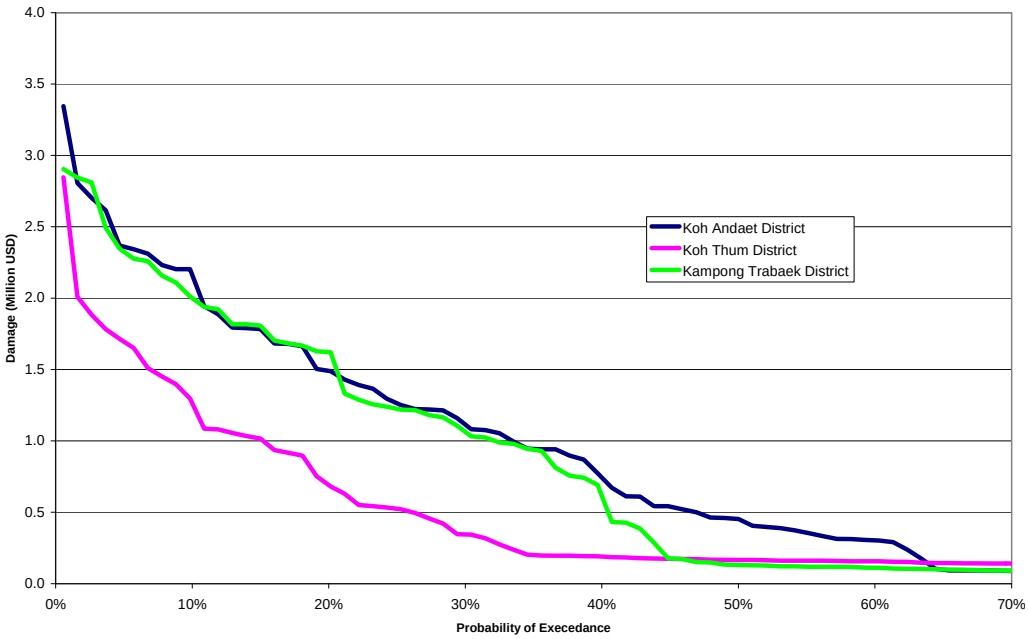

Figure 18. Probability damage curve for three Cambodian districts

The risk/expected damage can be determined by calculating the area under the curve that shows the relationship between probability of exceedance and the damage. The risk value is also referred to as the (yearly) expected value of economic damages and it has the unit of US$ per year. For the Koh Andet case study area the risk value equals US$ 0.77 million per year. The results of the risk calculations can also be visualized. Figure 7 shows the results for the flood risk calculations for the focal areas in Cambodia in Vietnam. The size of the circle shows the magnitude of the risk for the district and within the circle the distribution over the three damage categories (housing, infrastructure & relief, agriculture) is shown. It becomes clear that the risk values and the distribution of risk over the damage categories vary between districts. For Koh Andet the largest part of the risk is determined by the category agriculture.

The results of the risk assessment can be used to evaluate the effects of measures on the risk. Basically there are two types of measures, i.e. measures to reduce the probability and

measures to reduce the consequences. Figure 8 shows these two types and schematically shows the effects on the probability - damage curve. Based on the results a cost benefit analysis of measures can be carried out in which the investments in measures are compared with the benefits (i.e. the reduction of the risk). A related technique is the economic optimization and it provides insight in the optimal level of risk reduction. The guidelines provide more information on cost-benefit analysis and optimization and it is also discussed how the risk to life can be evaluated.

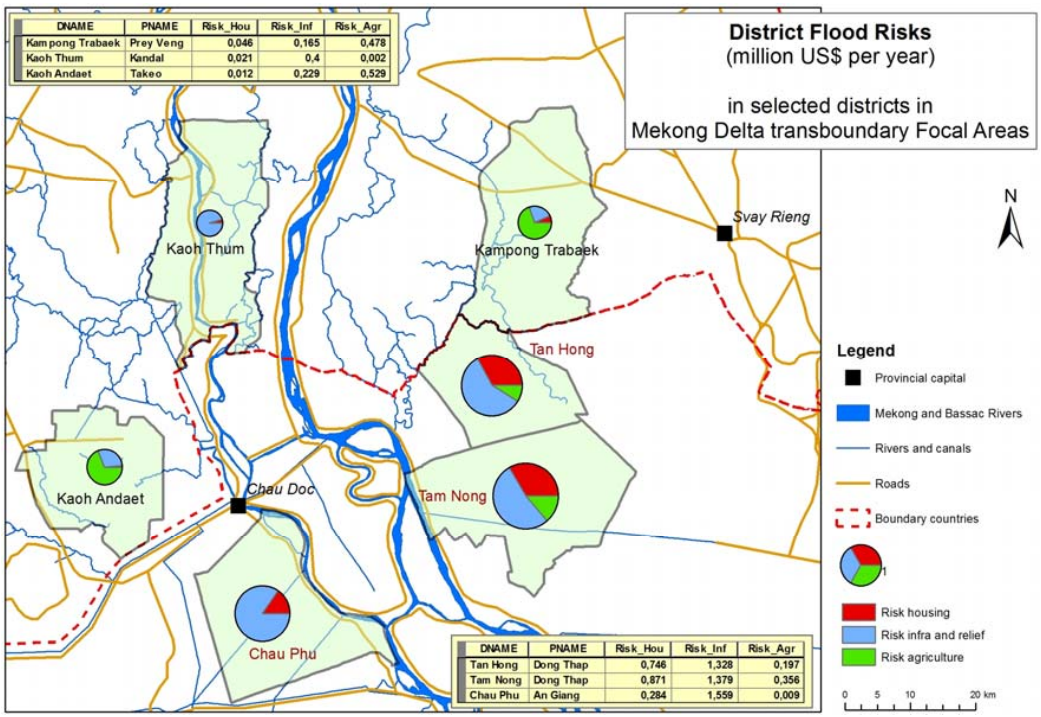

Figure 19. Flood risks by district for selected areas in Cambodia and Vietnam

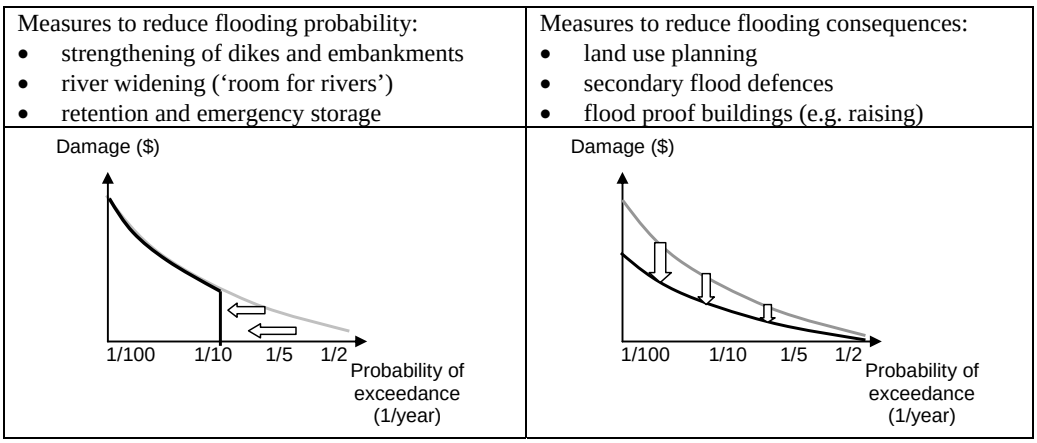

Figure 20. Effects of measures on flood risk.

CONCLUDING REMARKS

The best practice guidelines are intended to enable a consistent and uniform approach for flood risk assessment for the Lower Mekong Basin. The guidelines describe the theory and make the

connection to the practice in the LMB by including examples of results of flood hazard-, damage- and risk assessments for a case study area. These guidelines do not fully prescribe the methods and models for the steps in the risk assessment. Rather they provide the general principles and give an overview of the steps that need to be made for a complete risk assessment. The exact elaboration and application of the risk assessment will highly depend on the local situation. In this context the type of flooding will be an important aspect as the main flood and damage characteristics differ between the types of flooding that can occur in the Lower Mekong Basin. For all steps in the risk assessment the availability of resources, the (spatial) scope of the analysis and the desired level of detail of the output and its application in risk evaluation are important factors. The exact elaboration of the steps in the risk assessment process will thus rely on the above aspects. In these guidelines first guidance is given on useful approaches for several situations.

For a further development of the guidelines and the risk assessment process in the Lower Mekong Basin it is recommended to apply the guidelines to (new) case study areas in various parts of the Lower Mekong Basin. In addition it could be investigated if approaches and models could be further harmonized for the LMB and to what extent the development of standardized and automated approaches, e.g. for damage assessment, is feasible and needed.

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SESSION 4

SUMMARY OF DAY 1, PLENARY PAPER PRESENTATIONS, DISCUSSIONS

Report

SUMMARY OF DAY 1

NICOLAAS BAKKER

Chief Technical Adviser, Flood Management and Mitigation Programme (FMMP), Mekong River Commission (MRC), Phnom Penh, Cambodia

Inaugural session:

- *Mr. Jeremy Bird:* provided a practical overview of historic floods in the LMB, a clarification of the 2008 flood event in Vientiane, and the lessons leaned, which led to an Action Plan for FMMP. Even though the accuracy of forecasts during the 2008 flood event were adequate, dissemination and communication of the forecasts could be improved;
- *Dr. Siripong Hungspreug:* TNMC is satisfied with the progress made with the implementation of the FMMP. A better balance between upstream and downstream country involvement is required. Member Countries are fully committed to the important work of the MRC;
- *Mr. Martien Beek:* referring to the recent FMMP Review Mission the RNE is satisfied with the results, and is willing to consider a phase 2 of FMMP, provided that there will be a joint interest with the Member Countries and other donors;
- *Ms. Sezin Tokar:* highlighted the global attention by OFDA of flood impacts on livelihoods. Expressed also interest in continuing the existing cooperation;
- *Mr. Timo Menniken:* stressed the strong point of FMMP with respect to integration. Expressed that GTZ is interested in future cooperation;
- *Dr. Hatda Pich AN:* presented an overview of AMFF-6, and the follow-up of the recommendations of previous forums. Most of the recommendations have been implemented
- *Mr. Nicolaas Bakker:* provided a summary outline of FMMP, and the Objectives and Expected Outcomes of the AMFF-7.

Country reports and presentations of Dialogue Partners:

- the 2008 mainstream floods in the Cambodian floodplain and the Viet Nam Mekong Delta were beneficial floods;
- river floods have caused some USD 135 million damage in Lao PDR and NE Thailand. No excessive mainstream discharge from China was recorded;
- flash floods caused damages in Lao PDR, Thailand and Viet Nam;
- since the introduction of the Flash Floods and Landslides Early Warning System in Thailand there have been no casualties.;
- China expressed its appreciation for the work of MRC, as well as its commitment to further cooperation;
- Vietnam has established the Disaster Management Center under DDMFSC;
- activation of an important water level recording station along the mainstream near the border of Myanmar and China will be considered;
- sustainability of ongoing activities is essential.

2008 Mekong Flood Report:

- special attention has been paid to the benefits and damages of floods;
- the impact of the tropical storm Kummuri has been analysed and a report has been shared with participants.

Session 2: Towards Integrated Flood Risk Management in the Mekong Basin

- Component 1: the new Mekong Flood Forecasting system has proven its usefulness;
- Component 2: the progress is well on track;
- Component 3: a challenging set of activities was presented;
- Component 4: the progress of this component was reported. The recent experiences with river and flash floods have stressed the importance of this component;
- Component 5: this component is intended to develop village early warning systems in combination flood probability mapping in order to provide flood information for land management offices.

Session 3: Parallel Paper Presentations from the Mekong Region on the Topics I, II and IV Followed by Parallel Group Discussions:

- in each topic 3 papers were presented, generally describing the local conditions and interesting developments;
- for each session the reports will be presented by reporters during the Closing Session.

Paper 4-1

FLOOD HAZARD MAPPING IN NAN RIVER, THAILAND

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MANZUL K. HAZARIKA AND LAL SAMARAKOON

GeoInformatics Center of Asian Institute of Technology (AIT), Bangkok, Thailand

ABSTRACT

Although Thailand is not so prone to flooding compared to other countries in the Southeast Asia region, the country is usually faced with flooding problems every year with increasing severity attributed to climate change, including global warming. Many structural measures have been developed to overcome this problem. However, it is realized that structural measures have failed to prevent flooding completely due to unprecedented and unpredictable flooding events. Some flood protection structures, such as levees tend to increase the flood hazard levels with possible breach due to over-stressing resulting in increased damage. Under the circumstances, non-structural measures are explored more towards sustainable mitigation. Flood hazard mapping through modelling, which helps analyse a variety of possible scenarios, has been the focus of this study. Nan municipality area in Nan province, Thailand, was selected for the study considering the severity of the past occurrences.

The one dimensional steady flow module of Hydrologic Engineering Centre's River Analysis System (HEC-RAS) was utilized for the study. The requisite geo-spatial modelling of the flood plain was carried out by implementing Hydrologic Engineering Centre's Geo River Analysis System (HEC-GeoRAS) module in the ArcView environment and using a Triangulated Irregular Network (TIN) model. The land use map of the study area was used for necessary hydraulic characterization of the study area. The 2006 severe flood event pertaining to which field records are available was chosen for model calibration. Having successfully calibrated the model with acceptable correspondence between model results and field records a number of scenarios were analysed utilizing the modelling technique which integrates remote sensing, Geographic Information System (GIS), and Global Positioning System (GPS) technologies targeting effective and sustainable mitigation strategies.

INTRODUCTION

Flood events are a part of nature. They occur every year in many parts of the world claiming human lives and causing a large scale of property damages. Statistics indicate that the scale of flood damage around the world is steadily increasing, and further that flood damage accounts for a significant proportion of total damage caused by natural disaster. According to the report of the Disaster Prevention and Mitigation Department of Thailand, there were 106 flood events in Thailand occurred during the decade 1997-2006. The numbers of dead and injured people are up to 1,332 and 1,967 persons, respectively. Although the trend of the number of events was not clear, the number of casualties tends to increase. In 2006, the number of flood events accounted for only 6% of the total flood events from 1997-2006 but the numbers of flood deaths and injured people were as high as 34% and 74% of the totals of that period. The total losses value for the 2006 flood event was up to 300 million US dollar.

Nan province, located in the northern region of Thailand, was one of the fifty-eight

provinces affected by the 2006 flood and still faces to flood problem causing losses of lives and damages of properties almost every year. A study was undertaken, therefore, with an objective to map the flood hazard using a one-dimensional flood simulation model, HEC-RAS, incorporating remote sensing and GIS technologies.

STUDY AREA

Figure 1 shows the location map of the study area. It is located in Nan River Basin, which is one of twenty-five main river basins of Thailand. The study area covers an area of about 280 km^2 of Nan and Phupiang municipalities. It is within latitudes 18º 38' 50" - 18º 50' 20" and longitudes of 100º 42' 50" - 100º 50' 20". Topographically, it is a plain area surrounded by mountains. The elevation in this area varies from 186 metres to 374 metres from the mean sea level.

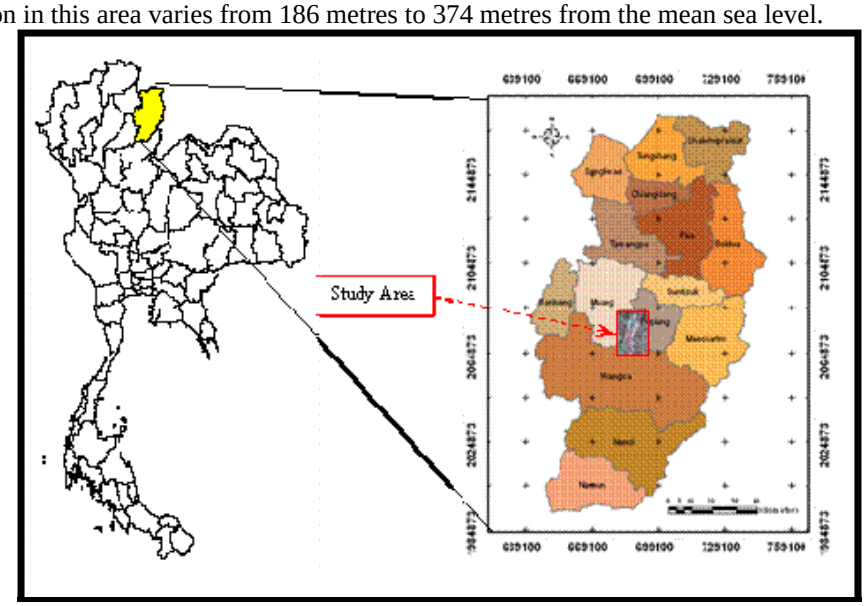

Figure 1. Study area

DATA USED

Data used for this study are:

- the water level and discharge data of Nan River at N1 gauging stations located in Nan municipality. These are the daily average data for a period of thirty-one years from 1978 to 2008 (Source: The Hydrology and Water Management Centre for Upper Northern Region, Royal irrigation Department, Thailand);
- rating table at N1 gauging station (Source: The Hydrology and Water Management Centre for Upper Northern Region, Royal irrigation Department, Thailand);
- contours of the study area at 2 meter elevation interval (Source: Royal Irrigation Department, Thailand);
- river river bed cross section data of Nan River at 500 meter surveyed interval (Source: The Regional Irrigation Office 2, Royal Irrigation Department, Thailand);
- GPS surveyed data collected in the study area along Nan River;
- ALOS/AVNIR-2 image acquired on January 18, 2008. (Source: Japan Aerospace Exploration Agency, Japan):
- land use data of the study area (Source: Land development Department, Thailand);

- river network, road network, and administrative boundary.

METHODOLOGY

The methodology consists of three phases; preparation, execution and verification, and hazard mapping phase. A flow chart of the methodology is shown in Figure 2.

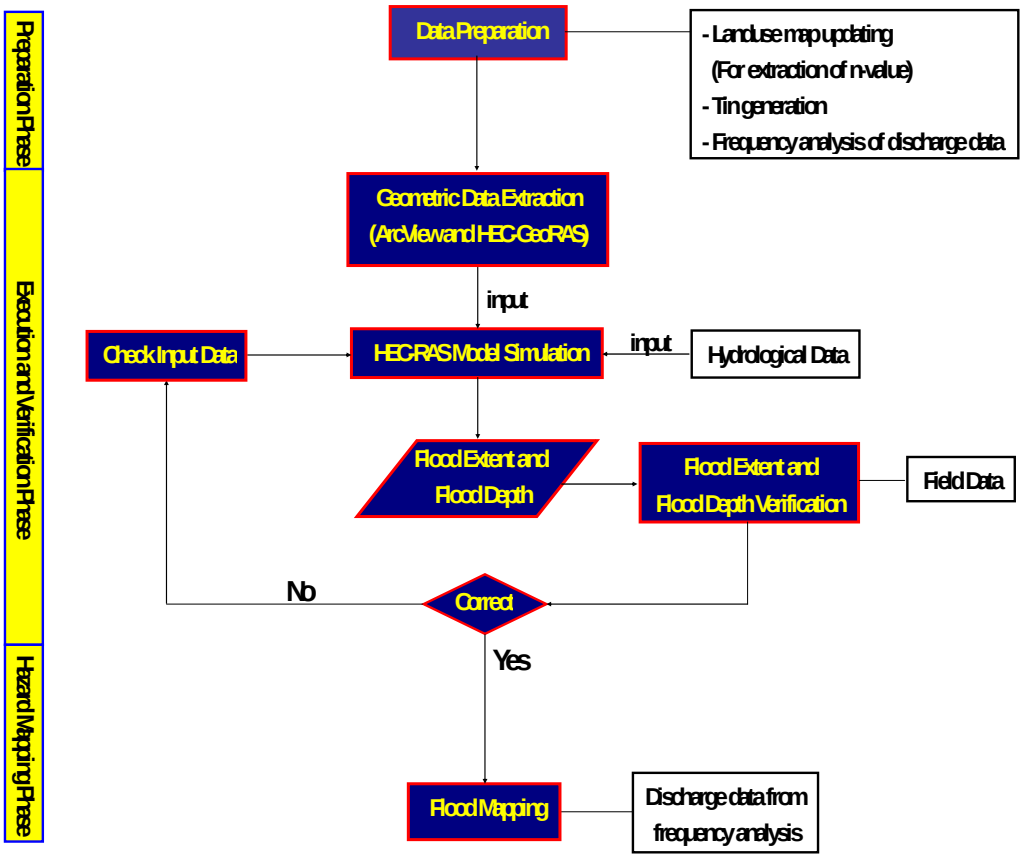

Figure 2. Flowchart of the methodology

Preparation phase

The objective of this phase was to prepare the necessary data for flood model simulation. The land use map of the study area, which was composed in 2003, was updated with the satellite image acquired on 18 January, 2008. The Triangulated Irregular Network (TIN) model was generated from contour data. The maximum discharge of Nan River at N1 gauging station located in the study area was prepared for frequency analysis.

Execution and verification phase

The objective of this phase was to generate the flood map of 2006 flood event and verify it with field observation data. In this phase the geometric data of the study area, i.e. the stream centreline, cross-section cut lines, main channel banks, flow path centrelines, reach lengths, and Manning's roughness coefficient values were extracted from the TIN and land use themes prepared in the first phase. The ArcView program and the HEC-GeoRAS module were used to extract the geometric data and export to the RAS GIS Import File in the HEC-RAS import file

format. This file was then imported in HEC-RAS model. The correction of geometric data such as adjusting the location of river banks, filtering the number of cross section point, etc. was then performed in HEC-RAS model. After the correction, the maximum daily average discharge of year 2006 and the boundary conditions of the simulation were input to simulate the flood event of this year. The results of the simulation were the flood extent and flood depth. The model was then calibrated with the available field data.

Hazard mapping phase

Once the model results were verified, the discharge values corresponding to each return period from the frequency analysis in the first phase were input in the model to simulate flood in the same calibrated geometric data and boundary conditions. In this study the discharge for 10-year, 20-year, and 50-year return period were used for flood hazard mapping.

RESULTS AND DISCUSSION

Verification of model output

The result of flood simulation of 2006 flood event was used for verification of the model. The first step of verification of flood depth was done by comparing the simulated water surface elevation of 2006 flood event at N1 gauging station with the water surface elevation from rating tables of this gauging station as shown in Figure 3. The comparison shows the very good correspondence of the water surface from both sources.

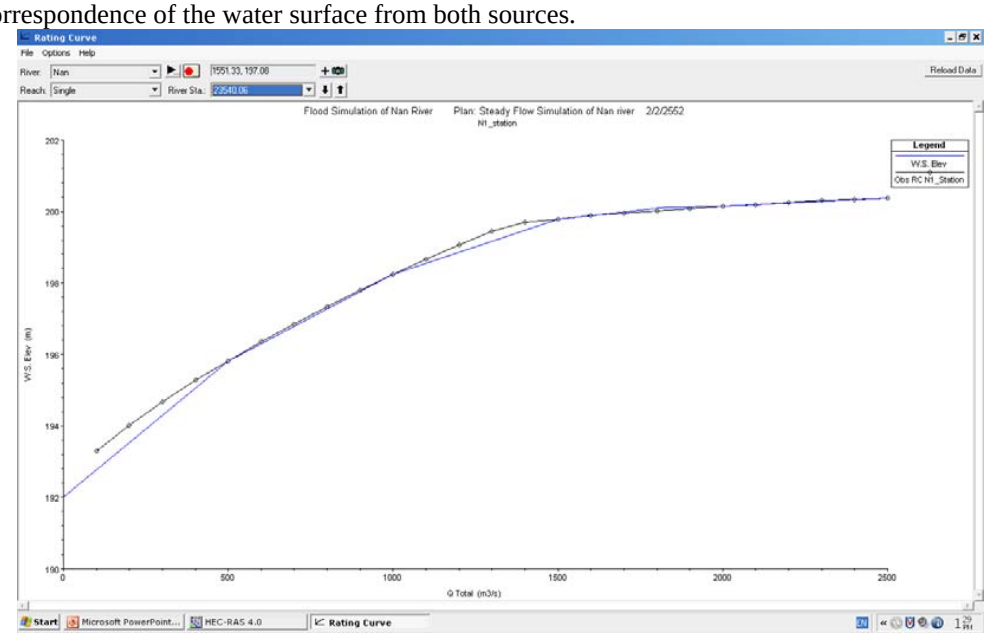

Figure 3. Comparison of water surface elevation at N1 gauging station

To confirm that the simulation result was accurate over the entire study area, field verification for the flood depth was done at several locations in the study area as shown in Figure 4. The flood depth in the study area of this flood event varies from 0.0 to 9.0 meter. The comparison of flood depth shown in Figure 5 indicates that flood depths at several points of field investigation are good correspond with the model flood depths while some points show a large difference. The result closely matched by a difference of 12 cm at point number 12 and differed by 181 cm at location number 13. The result of some field verification points also

confirms the accuracy of the simulated flood extent. Since the flood extent map received from Nan Municipality office indicated no flooding at locations 8 and 12 while the results of the simulation and field investigation indicated flooding at those location, this verified that the model was accurate enough for flood hazard mapping.

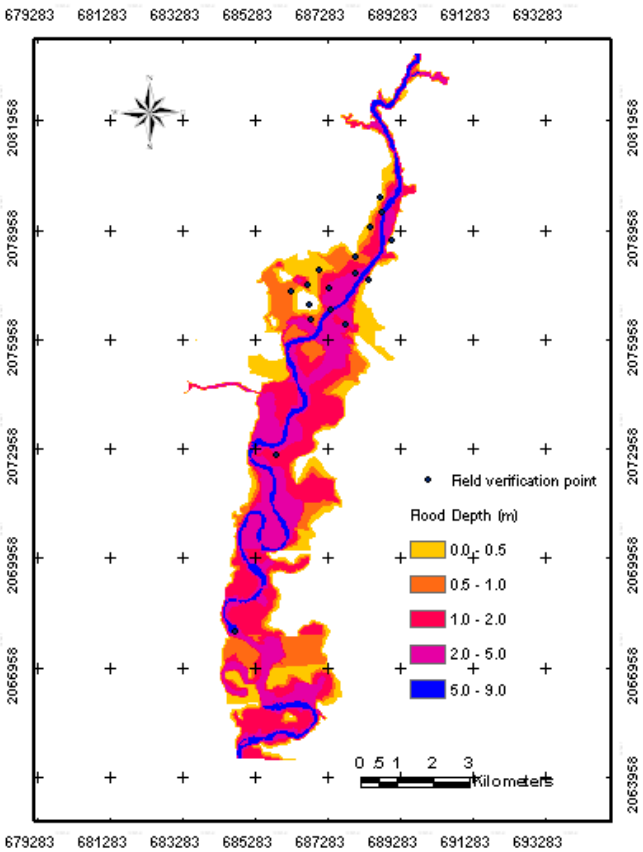

Figure 4. Flood depth verification points

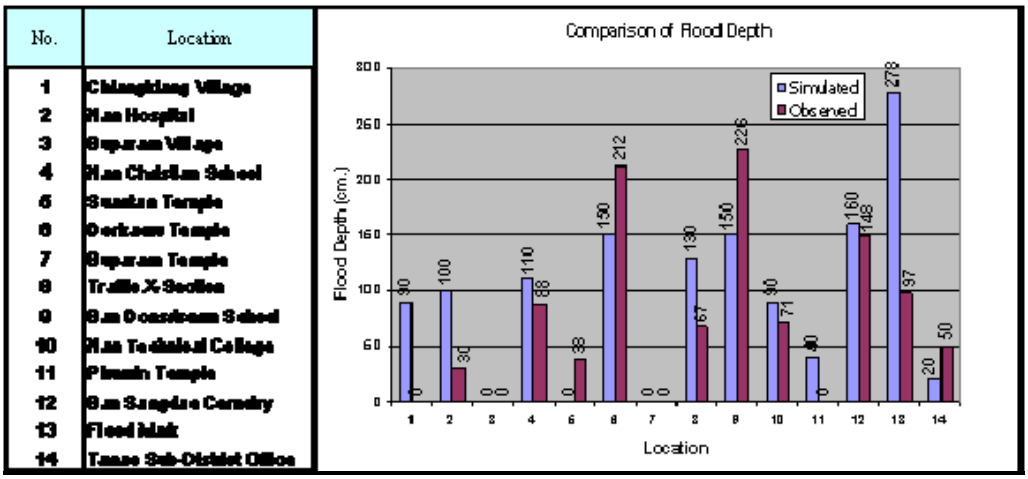

Figure 5. Comparison of simulated flood depth and field investigated flood depth

Flood hazard mapping

Once the model was calibrated, the discharge values for the 10-year, 20-year, and 50-year return period flood events were input in the model for flood hazard mapping. The results of mapping for 10-year, 20-year, and 50-year return period flood events are shown in Figure 6, 7, and 8, respectively. The total inundation area and the maximum flood depth for each return period flood event are summarized in Table 1. It is seen that the difference of the flood area is decreased when the return period increases while the difference of depth is in increase. This implies that the increase of discharge has more effect in flood depth than flood extent. This may be because of the characteristic of flood area as it was surrounded by mountains so that the flood was limited in a horizontal direction but was not in a vertical direction.

Table 1. Summary of the flood area and the maximum flood depth

RETURN PERIOD	FLOOD AREA (KM^2)	AREA DIFFERENCE (%)	MAX. FLOOD DEPTH (M)	DEPTH DIFFERENCE (%)
10-year	32.9	-	8.79	-
20-year	36.8	12.1	9.33	0.54
30-year	40. 1	9.8	9.96	0.63

CONCLUSIONS

HEC-RAS together with HEC-GeoRAS utility was successfully utilized for flood hazard mapping in Nan Province, Thailand. Having established the model with records of historical flooding event record of year 1999, flood hazard maps corresponding to 10 yr, 20 yr and 50 yr return periods were prepared.

These flood hazard maps will be utilized in flood warning system of this province in order that the authorities responsible for flood warning can provide timely and reliable flood warning and flood information to the people in this area so that they will be able to evacuate themselves on time.

ACKNOWLEDGEMENT

The authors wish to thank the Japan Aerospace Exploration Agency (JAXA) for providing financial support through Mini-Projects for providing with the data used in this study.

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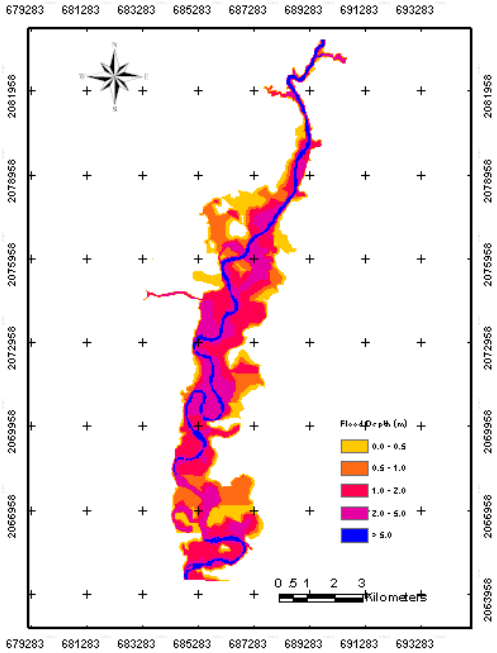

Figure 6. 10-yr return period flood hazard map

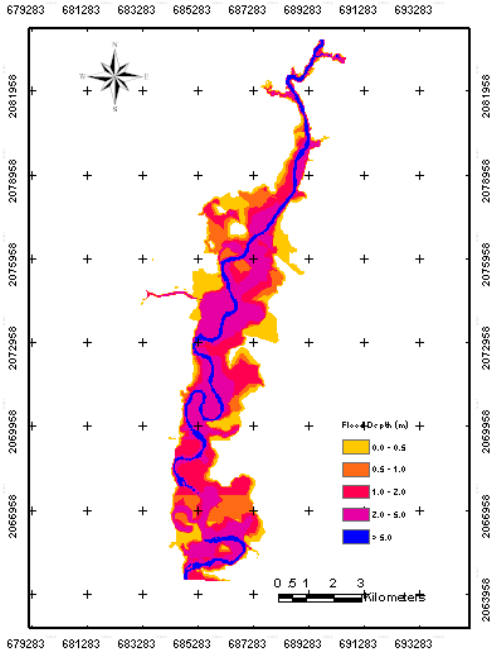

Figure 7. 20-yr return period flood hazard map

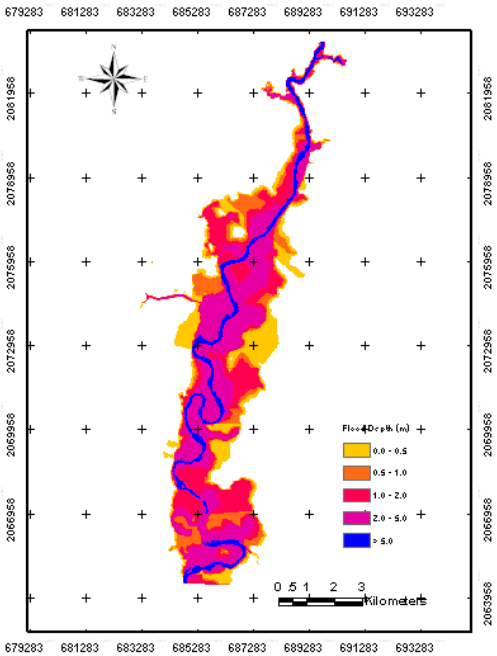

Figure 8. 50-yr return period flood hazard map

Paper 4-2

STATISTICAL ENSEMBLE FLOOD FORECASTING FOR THE MEKONG RIVER

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ABSTRACT

The existing flood forecasting method of Mekong River Commission (MRC) is based on a physical hydrological model, as has been described by Tanaka or Plate and Insigsiengmay, which according to Apirumanekul yields forecasts of limited accuracy. To overcome the shortcomings of the existing model, we are in the process of developing a data based forecast model using a mix of auto-regression, statistical analysis and physical modelling. The present paper is concerned with exploring the possibilities of a statistical approach, derived on the basis only of time series of flow gages. It is used to develop exploratory ensemble forecasts for the Mekong in Lao PDR and Thailand.

INTRODUCTION

In development of hydraulic river models one faces the problem of large numbers of uncertainties. How much these influence the usefulness of the models depends on the intended application? For design purposes, models for river flow must permit to study the consequences of a design, i.e. it is necessary to be able to assess effects of different design features for situations that will occur only after designs are realized in hydraulic works. Models should therefore produce an acceptable representation of reality. Accuracy is of secondary importance, as long as possible extreme cases are properly taken into consideration. At the other end of the scale are forecasting models. For them reliability and accuracy within narrow limits are of primary importance, no matter how it is obtained. Naturally, a model which accurately reflects natural conditions, and which has exactly known rainfall fields as inputs has a very good chance of providing good forecasts. However, such conditions hardly ever exist, and due to uncertainties of data and model parameters, large error margins must be accepted for long term forecasts. Consequently, a statistical model which directly uses the available data base may also give results with similar error bounds. It is the objective of this study to explore the forecast capability of data based statistical models for the Mekong. As first approximation, a forecast model based only on time series of stream gages is developed in this paper. It is based on an optimized linear regression analysis.

For optimizing the forecasts QF, let the parameters of the forecasting model be identified by the symbols α, β, γ.. Let time be $t = i \cdot \Delta t$ (expressed in discrete intervals Δt with i=1, 2, i_{max}). $T = k \cdot \Delta t$ is the forecast time, and QF(i+k) is the forecasted quantity for time t + T. We then write the variance Z (i.e. the objective function) for each forecast time step k:

$$Z(\alpha,\beta,\gamma.\,|\,k) = \sum_{i=0}^{i\,max}\left[QO(i+k) - QF(i+k\,|\,\alpha,\beta,\gamma..)\right]^2 \tag{1}$$

This function is to be minimized for each forecast time step k, i.e. we have to determine that set of parameters $\alpha, \beta, \gamma, ..$… which satisfies the condition:

$$Z^*(\alpha,\beta,\gamma..\,|\,k) = \min_{A,B,...} \sum_{i=0}^{i\,max}\left[QO(i+k) - QF(i+k\,|\,\alpha,\beta,\gamma..)\right]^2 \tag{2}$$

where QO(i+k) is the observed quantity after time T. The parameter set should be valid for the whole period of forecast, although it also may depend on seasons. As result one gets one set of parameters for each value of k.

A measure of the quality of the forecast is obtained if one compares the optimum variance defined by Eq. 2 with the variance obtained from the simple assumption that the value to be forecasted for time t + T is the same as the value at time t. In Plate et al., (2007) it was shown that this criterion is more demanding than the traditional use of the Nash-Sutcliffe (Nash and Sutcliffe, 1970) criterion. For this forecast, the corresponding variance for each forecast interval is:

$$ZC(k) = \sum_{i=0}^{i\,max}\left[QO(i+k) - QO(i)\right]^2 \tag{3}$$

from which we obtain a measure for the forecast quality:

$$QC(k) = \frac{Z^*(\alpha,\beta,\gamma...\,|\,k)}{ZC(k)} \tag{4}$$

If this ratio is smaller than 1, the forecast model yields better results than the assumption of no change, if it is larger than 1, no benefits are obtained from the model. The optimization schedule of Eq. 2 depends on the structure of the model which yields QF(i+k).

THEORY

Continuity equation for forecasting

Stochastic forecasting models generally provide purely empirical forecasts. They are based on past records of the variables to be forecast. The simplest models use the recorded time series for the gage for which a forecast is wanted. Let this gage be identified by index j. A more complex approach used here includes upstream information. It is based on the fact that when we make a forecast for k, say k=5, days ahead in a river which has upstream gages with k days flow time to the gage under consideration (index j), then the part of the flow coming from upstream of gage j for times t = k days ahead is known. Only the flow generated during the forecast time interval in the stretch between this upstream station and our gage needs to be forecasted.

Starting point for the statistical model is the general continuity equation. Assume that at some discrete time t= i Δt we observe simultaneously the flow in a river at many gages, which are identified by index j. Let j identify the station for which a forecast is to be made, and let stations be numbered in sequence j +m, with m =0,1,2…. m_{max} , with the station farthest

upstream having index $j+m_{max}$. Assume that the stations are located, in terms of flow time, 1 time step apart. We wish to make a forecast for k time intervals t, i.e. for a general forecast time $T_F = k\,\Delta t$. For this purpose we write the continuity equation as recursion equation:

$$Q_j(i+k) = Q_{j+1}(i+k-1) + QI_j(i+k) - QO_j(i+k) \text{ with } j = 1,2,3\ldots j_{max} \tag{5}$$

where $Q_{j+1}(i+k-1)$ is the discharge at station j+1 at time (i+k-1) Δt and the other two terms on the right form the difference between inflow and outflow in the stretch between stations j and j+1 during interval between (i+k) Δt and (i+k-1) Δt . Let the differences $QI_j(i+k) - QO_j(i+k-1)$ be called $DQ_j(i+k)$, so that:

$$DQ_j(i+k) = Q_j(i+k) - Q_{j+1}(i+k-1) \tag{6}$$

The notation becomes simpler if we always centre the equation on the station for which a forecast is to be made, by letting this station have index j = 0. By repeated applications of Eqs. 5 and 6 we obtain the set of equations (in index notation):

$$Q_0(i+k) = Q_k(i) + \sum_{m=0}^{k-1} DQ_m(i+k-m) \tag{7}$$

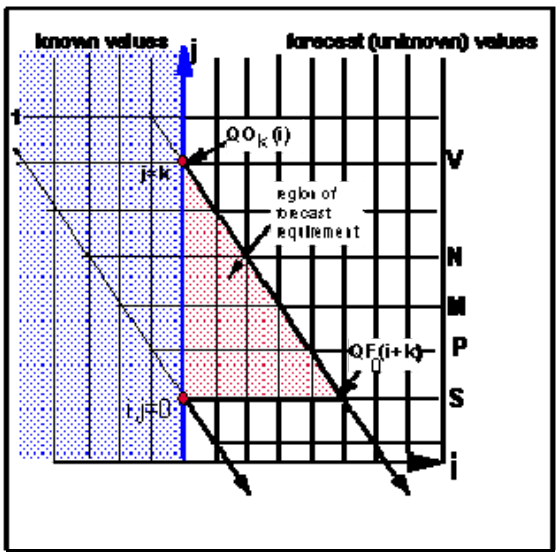

Figure 1. Space time relationship for forecasting

In this way, the continuity equation is prepared for real time forecasting. It must consist of one part which is known from records available up to the present time, and a second part, (the sum on the right) which has to be forecasted.

The relationship between space j and time i is indicated in Figure 1. At time t information in the blue section is known, i.e. at time t all inflows generated upstream of gage j+k are already known and included in readings of gage j+k. Consequently, Eq. 7 can be used for forecasting, when $Q_0(i+j)$ is substituted with $QF_0(i+j)$, and $DQ_m(i+k)$ with $DQF_m(i+k)$, so that:

$$QF_0(i+k) = QO_k(i) + \sum_{m=0}^{k-1} DQF_m(i+k-m) \tag{8}$$

The actual value $QO_0(i+k)$ of the forecast at time $k\,\Delta t$ differs by an error term $\varepsilon(i+k)$ from the forecasted value $QF_0(i+k)$. We get:

$$QO_0(i+k) = QF_0(i+k) + \varepsilon_{0,k}(i+k) \tag{9}$$

Obviously, it is the purpose of optimization to minimize error term ε in accordance with Eq. 2.

Method of solution

Step 1: The procedure used in this paper starts with the use of Eq. 6 to 8 to calculate time series of terms $DQ_m(i+1)$ for all stations m.

Step 2: $DQ_m(i+1)$ is analysed, as a first approximation, as a random variable, which is to be regressed against known parts of the time series for all stations. Assume that there exists a linear correlation, valid for all i, of $DQ_m(i+1)$) with known parts of the time series. Inspection of Figure 1 suggests the use of differences $DQ_m(i-1)$ as approximations for $DQ_m(i+1)$ for each station m. However, for longer forecasting times the nearest station alone is not sufficient, one wants to include also effects of stations which are further upstream – in particular, it is known that the value $Q_k(i)$ is already known for a forecast up to time $k\,\Delta t$. Consequently, the terms $DQ_m(i+k)$ are regressed against all differences upstream between station 0 and station k by means of a linear multi-regression analysis. The result is:

$$DQF_m(i+k) = \alpha_m(k) + \beta_m(k)\cdot Q_k(i) + \sum_{j=1}^{k} \gamma_j(k)\cdot DQ_j(i-1) \tag{10}$$

The final result is obtained if these terms are summarized according to Eq. 8. In the end, this reduces to:

$$QF_0(i+k) = \alpha_0(k) + \beta_0(k)\cdot QO_k(i) + \sum_{j=1}^{k} \sigma_{0,j}(k)\cdot DQ_j(i-1)\} \tag{11}$$

Where the coefficients $\alpha_0(k), \beta_0(k)$ ... are sums of all the coefficients associated with the same terms in Eq. 10. Fully developed Eq. 11 yields:

$$QF_0(i+1) = \alpha_0(1) + \beta_0(1)\cdot QO_1(i) + \sigma_{0,1}(1)\cdot DQ_1(i-1)$$

$$QF_0(i+2) = \alpha_0(2) + \beta_0(2)\cdot QO_2(i) + \sigma_{0,1}(2)\cdot DQ_1(i-1) + \sigma_{0,2}(2)\cdot DQ_2(i-1)$$

$$QF_0(i+3) = \alpha_0(3) + \beta_0(3)\cdot QO_3(i) + \sigma_{0,1}(3)\cdot DQ_1(i-1) + \sigma_{0,2}(3)\cdot DQ_2(i-1) + \sigma_{0,3}(3)\cdot DQ_3(i-1)$$

An application of this method to the data of the Mekong gages upstream of Stung Treng is given in the application section.

Step 3: For ensemble forecasting on statistical basis Eq. 11 is used as forecast equation. The difference between the forecasted value and the actual value is the error term according to Eq. 9, which can be analyzed further by finding its empirical probability distribution. In this way one can, through a frequency analysis of the error terms, obtain bands about the forecasted value, which are specified by the probability distribution $P(\varepsilon)$. Probability of $P(\varepsilon_{80})$ =80% means that 80% of all values are lower than the forecast plus ε_{80}.

APPLICATION OF THE ANALYSIS TO THE MEKONG

Mekong forecast procedure

The statistical method outlined above is applied to the middle reach of the Mekong between Vientiane and Stung Treng. The sequence of the gauging stations is indicated in Figure 1 by means of the letters on the right side of the diagram.

The flood wave takes approximately 5 days travel time from V = Vientiane to S = Stung Treng after passing through N = Nakhon Phanom, M = Mukdahan and P = Pakse, the intermediate flow gauging stations. The travel time of flood wave is normally one day from one gauging station to another except for Viantiane to Nakhon Phanom where it is 2 days. The flood wave travel time computed by various approaches is given by Plate (2007). In the course of travel from Vientiane to Stung Treng, the flood wave is increased by contributions from lateral rivers mainly draining the mountain range between Lao PDR and Vietnam. The major contributing sub-catchments are sub-catchment of Nam Sane, Nam Nhiep, Nam Cading and Nam Hinboun Rivers which join Mekong River between Vientiane and Nakhon Phanom. The second major lateral contribution in the Mekong river flood wave comes from Se Kong River which joins the Mekong River upstream of Stung Treng. Apart from these two major contributions from lateral rivers, both right and left side tributaries in the reach between Mukdahan and Pakse make a significant contribution to the flow, among them River Nam Mun, which drains a large area in Thailand and joins the Mekong River in the reach between Mukdahan and Pakse.

The basic idea in this forecast approach is moving back in time and simultaneously in space applying the continuity equation according to Eq. 11 for flood forecasting. As an example for the 5 days flood forecast for Stung Treng as station (j) at time (i+5) - written for short as (i+5,j) - the current day discharge at Vientiane (i,j+5), is taken, where it was pre-estimated that the discharge of Vientiane takes five days to reach Stung Treng. Obviously in the Vientiane discharge there will be additions of discharges from lateral tributaries during the flood passage time interval of 5 days. These lateral inflows are estimated separately for each reach by means of multiple linear regressions. Thus, the lateral inflow between Vientiane (i j+5) and Nakhon Phanom (i+2, j+3) is estimated as dependent variable by multiple regression both with the (known) discharge at Vientiane (i,j+5) and with the (known) previous flow difference of Vientiane (i-2, j+5) and Nakhon Phanom (i, j+3) as independent variables. The lateral flow contributed by rivers between Nakhon Phanom (i+2, j+3) and Mukdahan (i+3, j+2) as dependent variable is estimated by multiple regression with discharges Vientiane (i, j+5), with the discharge differences between Nakhon Phanom (i+2, j+3) and Mukdahan (i+3, j+2) , the differences between Vientiane (i-2, j+5) and Nakhon Phanom (i, j+3), and the differences between Nakhon Phanom (i-1, j+3) and Mukdahan (i, j+2). Incoming lateral flows into the reach between Mukdahan and Pakse, and into the reach from Pakse to Stung Treng are estimated in the same manner by multiple linear regressions. According to Eq. 11 all these estimated lateral flows are added to the Vientiane (i, j+5) flow to obtain a 5 days flow forecast for Stung Treng (i+5, j).

The flood flows of Mukdahan, Pakse and Stung Treng are forecasted for the last 15 flood seasons. Time leads of flood forecasts are 1, 2, 3 and 5 days for Stung Treng, 1, 2 and 4 days for Pakse and 1 and 3 days in the case of Mukdahan. These forecasted flows are compared with actual observed flows, and then flood forecast accuracy is estimated by means of Eq. 4. The patterns of errors in these forecasts with different time leads are observed and an error correction routine is introduced separately for Mukdahan, Pakse and Stung Treng. In each of these three gauges it has been noted that flood forecast error is a function of flood accession, recession and certain threshold flow values. Normally the flood forecast errors are positive in flood accession and negative in flood recession above certain critical discharge values. To compensate the effect of this regularity an error correction routine is developed. This error

correction routine is based on multiple if-else conditioning which determines if the current discharge (above a critical threshold level) falls in the rising or falling limb of the flood hydrograph. If these 'if-else' conditions are fulfilled then the error correction routine adds or subtracts certain pre-estimated values to compensate for a bias in the errors. The results of flood forecast after the applications are again compared with actual observed values and accuracy coefficients according to Eq. 4 are calculated again. The results indicated that the error correction routine to some extent increases the accuracy of overall flood forecast.

The remaining errors in the forecast are distributed statistically into error bands about the forecasted values, according to the probability distribution (pdf) of the errors. The actual observed flows and their respective forecasts are separated into several intervals. The error pdfs are found to be significantly different for different discharge classes. For example, the flow at Stung Treng varies from 1,000 to70,000 m^3/s. This whole range of flow and their respective forecasts are separated into 14 intervals from 5,000 to 10,000, 10,000 to 15,000 m^3/s. The 50%, 80% and 95% bands of ensemble realizations are introduced along with crisp forecast value with which flow forecast is changed from crisp value to band of certain reliability value or confidence level.

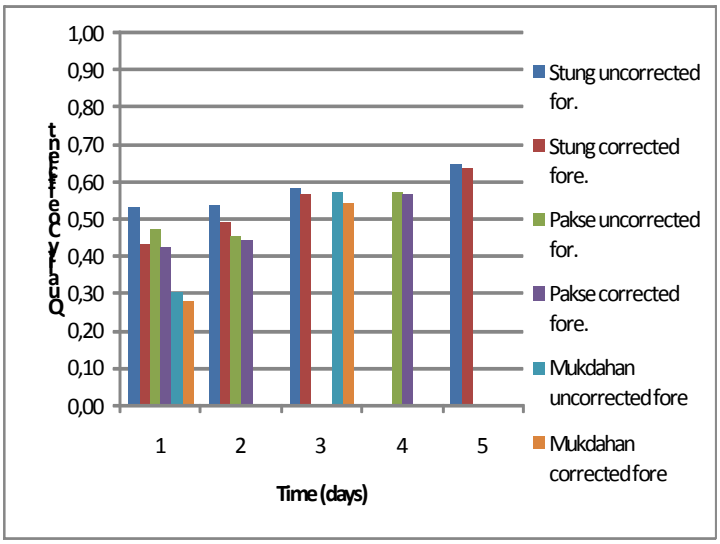

Figure 2. Forecast accuracy for year 1991-2005 at Mukdahan, Pakse and Stung Treng

Results

The flood forecast accuracy as illustrated by coefficient QC(k) according to Eq. 4, at Mukdahan, Pakse and Stung Treng from year 1991 to 2005 before and after the application of error correction routine is shown in the Figure 2. The accuracy of forecast ranges from 0.3 to 0.6 as per quality coefficient given in Eq. 4. The accuracy decreases with increase in lead time of forecast. If one realizes that the variance according to Eq. 3 also increases very much with lead time, it can be seen from Figure 2 that the forecast based on statistical approaches decreases in value after 2 days. This is an indication that the continuity is much disrupted by the occurrence of extremely heavy rains of short duration, which tend to make forecasts over long times very inaccurate.

Flood forecasts with error correction routine for the year 2005 for Mukdahan and Stung Treng are plotted against observed flows in Figures 3 and 4. At the bottom we also show the errors according to Eq. 9. These figures show that the accuracy of flood forecast by the statistical method is much reduced whenever there is a strong increase of the flood before high flood peaks, especially for forecasts with lead times of more than 1 day. In particular the 3 day forecast of Stung Treng obtained by this approach (Figure 4 right) is quite inaccurate due to the

fact of extensive rainfall storms occurring after the issuance of forecast.

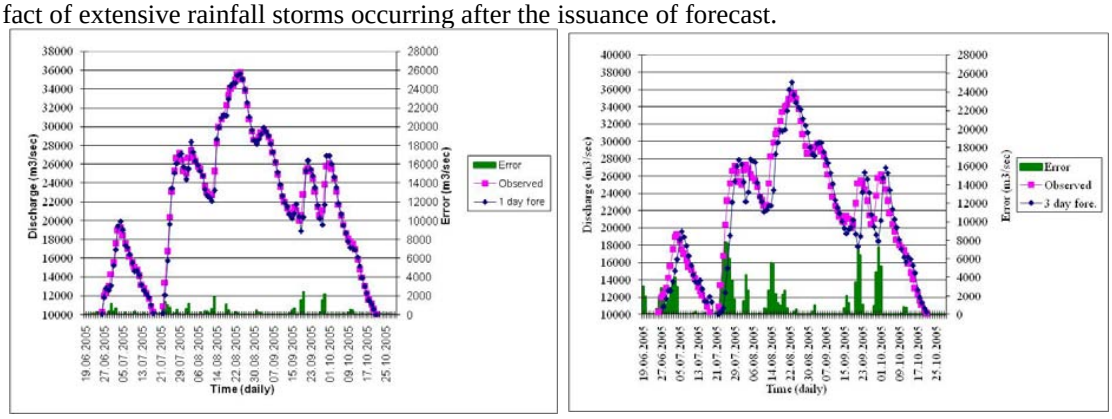

Figure 3. Forecast for season 2005 at Mukdahan: left: with 1 day lead time, right: with 3 days lead time

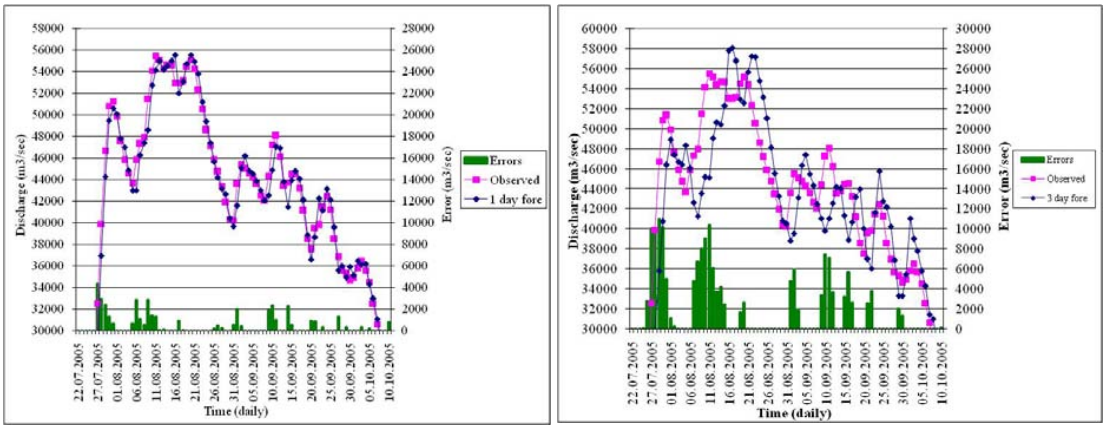

Figure 4. Forecast for season 2005 at Stung Treng: left: with 1 day lead time, right: with 3 days lead time

An empirical probability analysis of the error terms was made from which the error bounds for exceedance intervals of 20% and 5% were determined. These are found to depend on the magnitude of the observed discharge. Therefore the probability distributions (pdf) of errors of forecast for Mukdahan, Pakse and Stung Treng, had to be obtained by sorting the observed flows and respective forecast errors into various classes, as is plotted in Figures 5 and 6 for Mukdahan and in Figures 7 and 8 for Stung Treng, both in terms of discharges (left side of Figures) and in terms of water levels (right side). The results clearly show the tendency of forecasting errors to increase with discharges in the ascending branches, but stay constant or even reduce for discharges near the peak.

The 5-day forecast trajectories obtained by the stochastic method are shown in Figures 9 and 10. On the left in the figures the onset and peak flood flows are plotted against the forecast for Mukdahan and Stung Treng. There are total of 4 forecasts for day 1 to day 4 with lead times of 1 to 5 days. For example the first forecast in Mukdahan is made on 16.08.2005 for next 3 days. The forecast is repeated on 17th, 18th and 19$^{th.}$ The forecast is following closely the observed flows on the first and second days but the difference between observed and forecast for 3 day lead time increases very much. The case for Stung Treng is similar as shown in Figure 10. To improve the usefulness of the stochastic forecast information, ensembles of realizations are added in the crisp forecasts.

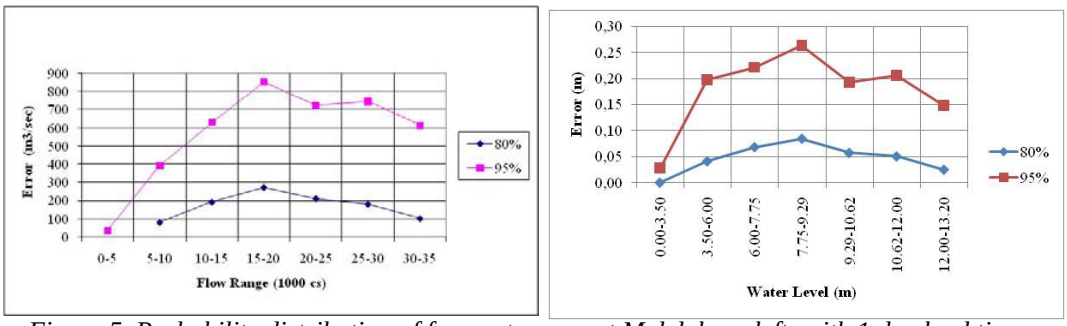

Figure 5. Probability distribution of forecast errors at Mukdahan: left: with 1 day lead time forecast error in m^3/s, right: with 1 day lead time forecast error in m

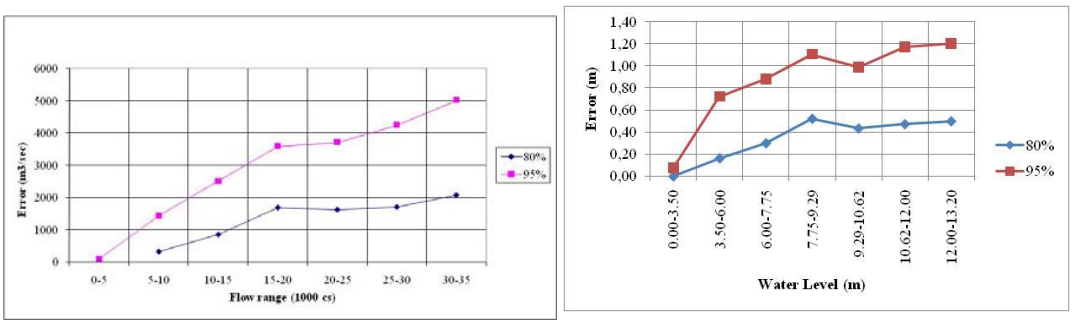

Figure 6. Probability distribution of forecast errors at Mukdahan: left: with 3 day lead time forecast error in m^3/s, right: with 3 days lead time forecast error in m

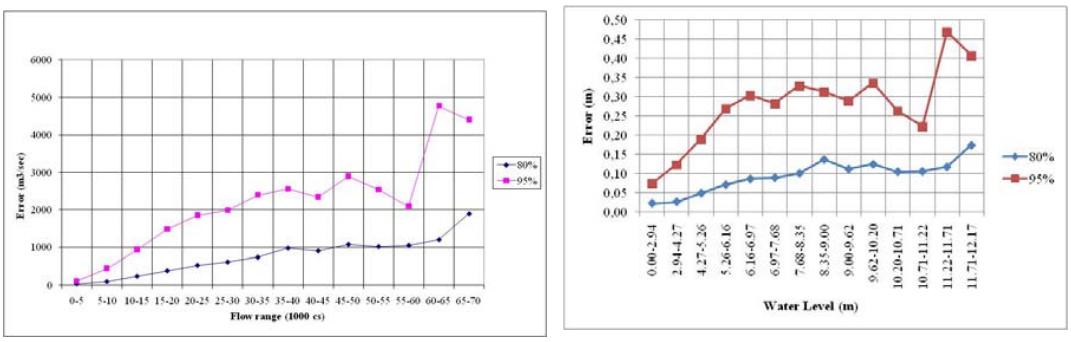

Figure 7. Probability distribution of forecast errors at Stung Treng: left: with 1 day lead time forecast error in m^3/s, right: with 1 day lead time forecast error in m

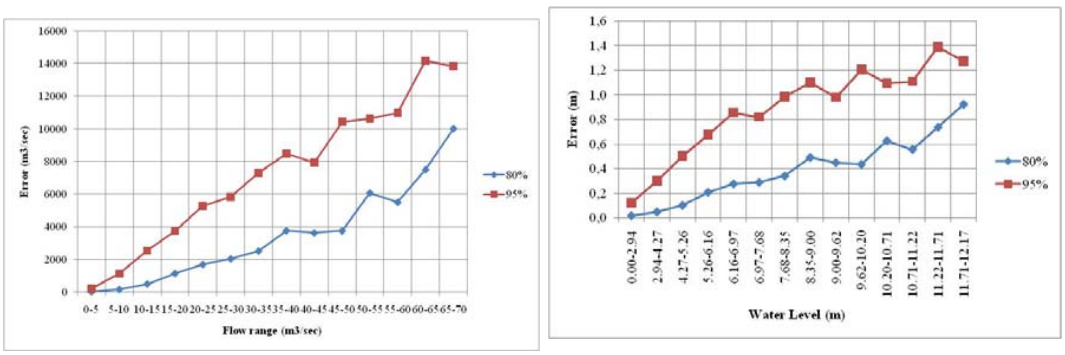

Figure 8. Probability distribution of forecast errors at Stung Treng: left: with 3 day lead time forecast error in m^3/s, right: with 3 days lead time forecast error in m

These 80% and 95% ensemble of realizations along with the crisp forecast are shown on the right side of Figures 9 and 10 for Mukdahan and Stung Treng. The differences of observed flows and 80% ensemble are much narrower than that of ensemble of realization of 95%, but in the ensemble of 80% there remain some values above the domain of 80% ensemble. On the other hand although most of the observed values remain below the 95% curve of ensemble realization but this 95% realization ensemble gets lot wider in the peak flows.

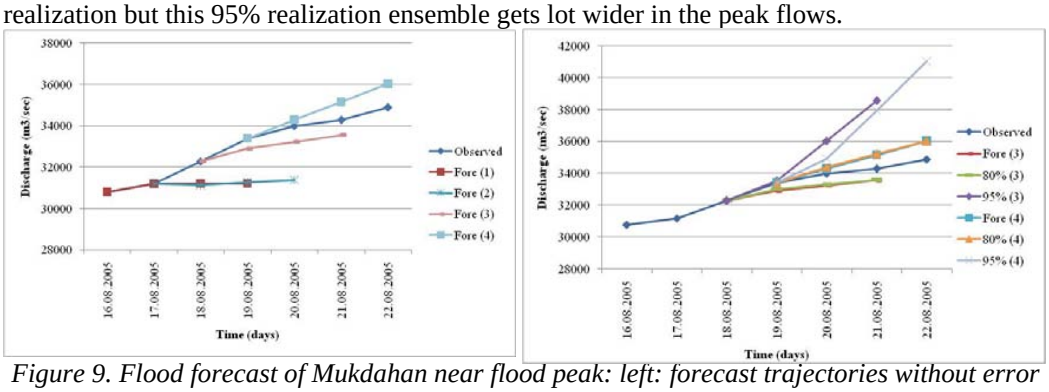

Figure 9. Flood forecast of Mukdahan near flood peak: left: forecast trajectories without error bands right: with 80% and 95% bands of ensemble of realizations included

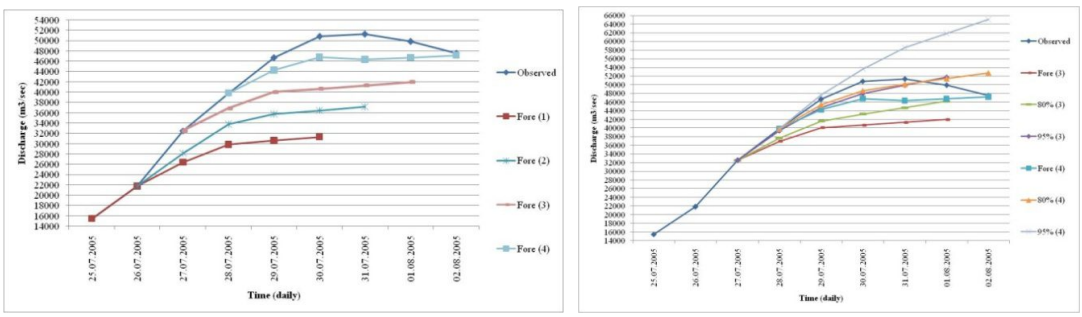

Figure 10. Flood forecast of Stung Treng near flood peak: left: forecast trajectories without error bands right: with 80% and 95% bands of ensemble of realizations.

CONCLUSIONS

A statistical analysis of the possibility of flood forecasting for the Mekong river has shown that upstream of Cambodia a forecast by means of statistical methods based only on river gages is likely to be feasible for one or two day forecasts. For longer times, the forecast is significantly impaired by the strong influence of lateral tributaries to the Mekong; in particular from the mountains of Lao PDR and Vietnam. This is of course well known. It results in wide error bands. The significance of this seems to be that the rainfall of any one day can be so large that it strongly affects the forecast for more than one day ahead for stations downstream up to Stung Treng - so much as to rendering them entirely worthless

Our results show that the error band increases significantly with the magnitude of the discharges. In some cases a forecast probability is useful, and statistical analysis can give error bounds. For some technical applications of the forecast it is helpful know exceedances with certain probabilities attached, similar to the production of ensemble forecasts in meteorological weather forecasting. For such applications, stochastic analysis may be extended to longer forecasting times, in particular if general seasonal information on climate can be incorporated. Although it seems to be possible (and further statistical analysis has shown this to be so), that the incorporation of known rainfalls into the stochastic model can improve the performance of the models, it will never be possible to make a longer range forecast without meteorological

forecasts. This is a problem which not only affects statistical models; it will also be a problem for any type of forecast model. It therefore is necessary that one concentrates on the meteorological input, if one wants to improve longer range forecasts for the stations in Lao PDR and Thailand.

On the other hand, the flood discharges and water levels in the Mekong in Cambodia and Vietnam are likely to be less dependent on the real time rainfall, as flow times from the rainfall intensive areas are longer, and because hydraulic features are more dominant. In particular when the Mekong River overtops its banks, it is not possible to make forecasts of flood level spreading without additional information concerning water levels, which may be obtained from satellite images. The capabilities of the German - Vietnam joint program WISDOM for this kind of forecast improvement are to be further explored in the near future.

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Paper 4-3

DEVELOPMENT OF TRANSBOUNDARY COOPERATION IN THE RHINE RIVER BASIN

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ABSTRACT

The Rhine River Basin is located in (parts of) the territory of eight countries. Within the Rhine River Basin there is a long standing cooperation among the riparian countries. Originally the cooperation focussed on navigation, but later on other issues came up, especially water quality control and flood management. Under the umbrella of the European Water Framework Directive of 2000 the cooperation has substantially been strengthened and the riparian countries in the European River Basins will jointly have to make River Basin Plans. These plans will have to be ready in draft during this year. The plans have a strong focus on environmental aspects.

In 2007 the Flood Directive was added to the Water Framework Directive. Under this directive the riparian states have to take into account flood management as well.

The paper will highlight the various relevant aspects of trans-boundary cooperation in the Rhine River Basin.

INTRODUCTION

The Rhine River Basin is located in (parts of) the territory of eight countries. Together with the Danube River it is one of the largest rivers in Europe. Within the Rhine River Basin there is a long standing cooperation among the riparian countries. Originally the cooperation focussed on navigation, but later on other issues came up, especially water quality control and flood management. For many years the cooperation has been based on joint interest and on a voluntary basis. However, under the umbrella of the European Water Framework Directive of 2000 the cooperation has substantially been strengthened and the riparian countries in the European River Basins will jointly have to make River Basin Plans. The River Basin Plans will have to be ready in draft during this year. The plans have a strong focus on environmental aspects. In 2007 the Flood Directive was added to the Water Framework Directive. Under this directive the riparian countries have to take into account flood management as well and have to make Flood Management Plans. These plans have to be ready by the end of 2015.

The paper will highlight the relevant issues with respect to water management and flood protection in the Rhine River Basin. Attention will be paid to the need for and development of trans-boundary cooperation and the impacts of the European Water Directive and Flood Directive on the trans-boundary issues and cooperation in the Rhine River Basin.

BACKGROUND

The Rhine River originates in Switzerland, with tributaries originating in the basin states: Switzerland, Germany, France and the Netherlands. In addition its entire river basin covers parts of the territory of Austria, Lichtenstein, Luxembourg and Belgium (Figure 1). The Rhine flows through Germany and the Netherlands to the North Sea. The river has a length of over 1,300 km

and its basin covers a surface of 185,000 km^2. The Rhine is both a rainfed and a meltwater river. The relatively high summer water levels are due to the regulating effect of the snowfields in Switzerland. In this period the surplus precipitation downstream of Basel is low. In December the situation is just the reverse, when the river is fed by the precipitation surplus in the river basin downstream of Basel (van Boetzelaer and Schultz, 2005a).

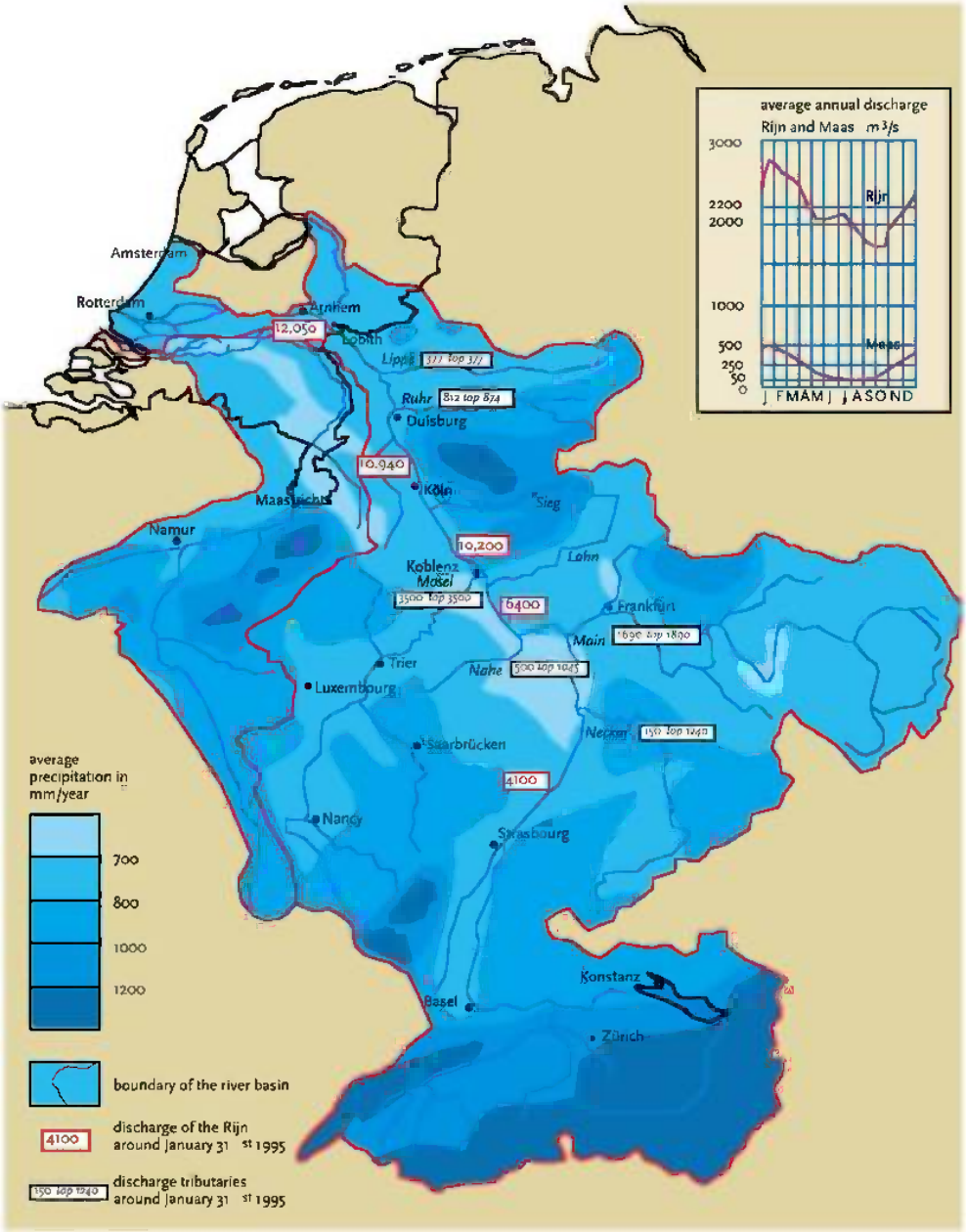

Figure 1. The Rhine and Meuse river basin (Van de Ven, 2004)

As an international trade route, shipping has always been important. Over the course of history, cultures and societies developed in the river basin, attracted and influenced by the way the river could be used for many purposes: political border, military defence, trade, industry, hydropower, agriculture, fisheries, extraction of building materials, domestic use, and more recently recreation and nature development (De Bruin, 2009).

Between 1000 and 1250 many man induced changes occurred in the downstream river system. For example several branches were dammed up. There are no direct records of river floods before 1200. This is logical because, at that time, the river and its branches were largely non-diked. The overtopping of the banks by the river was not considered a disaster. The first river flood that has been recorded in historical sources is the bursting of the Noorder Lekdijk in the Netherlands in 1233 (Van Boetzelaer and Schultz, 2005a). Since the 13th century high discharges and related high water levels occur regularly. Over the centuries they have caused many cases of flooding. Especially in the Netherlands the possible impacts of floods have increased over the years due to land subsidence, population growth and the increase in value of buildings and infrastructure (De Bruin and Schultz, 2004). Over the centuries various measures have been taken and approaches followed to protect the lowlands against flooding up to certain levels of safety. Nowadays the whole part of the river basin in the Netherlands is flood prone and is protected by dikes with a relatively high level of safety (Technical Advisory Committee on Water Defences, 2000) (Figure 2). For the last years a discussion has come up on the influence of climate change on very high discharges and related water levels. There is a scenario that by the end of this century extremely high water levels might occur more often due to a substantial increase in high discharges (Van Boetzelaer and Schultz, 2005b).

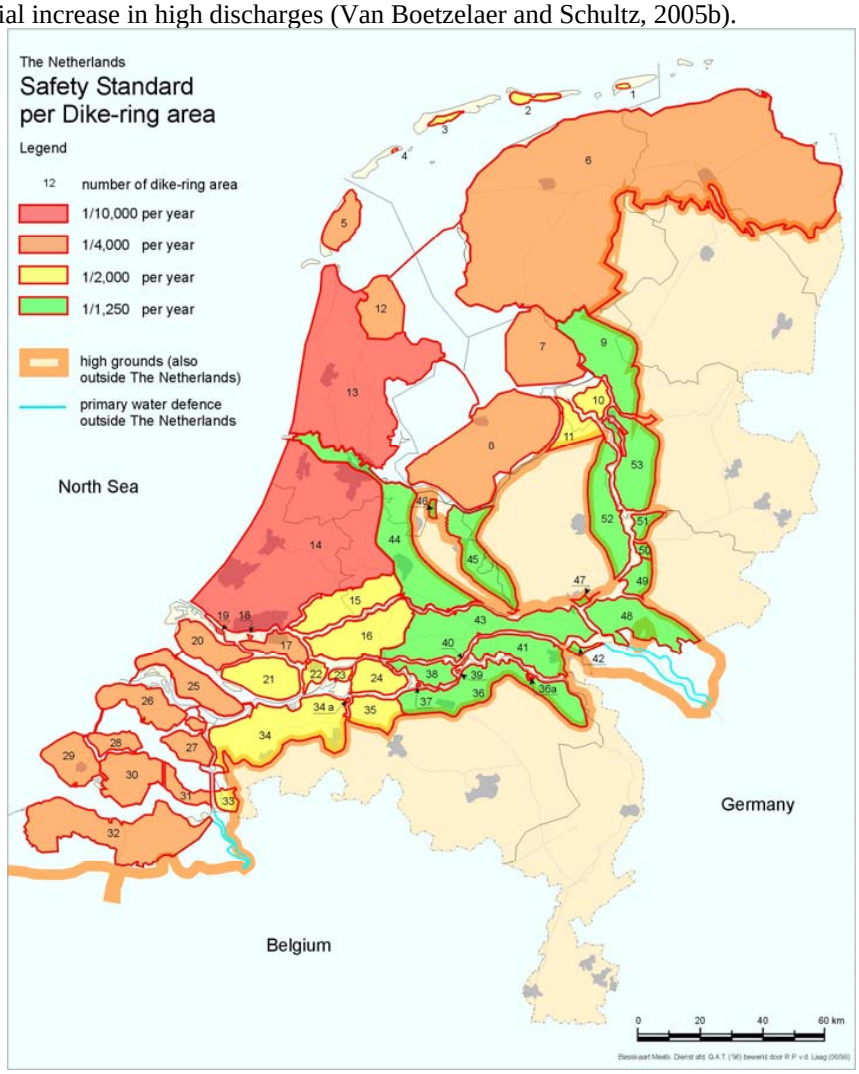

Figure 2. Dike ring areas and standards
(Technical Advisory Committee on Water Defences, 2000)

STAGES IN WATER (RESOURCES) MANAGEMENT

Through the history water management in the Rhine River Basin has gone through different stages. In the Netherlands part of the Rhine River Basin first water management activities aimed at reclaiming lowlands by small-scale drainage systems. Due to the resulting subsidence providing safety against flooding followed this. This was initially realised by making artificial mounds where people in the flood prone areas lived on. In a later stage dikes were built in combination with drainage systems to remove the excess water from the endiked areas (De Bruin and Schultz, 2004). In the whole basin the start concerned primarily agricultural water management, which implied more or less controlled discharge of excess water during winter. Later it also included provision of irrigation water. As a consequence storage became required, also in light of provision of hydropower. Due to this a significant number of dams were built. Especially in relation to ship transport sluices and weirs were built as well (Figure 3).

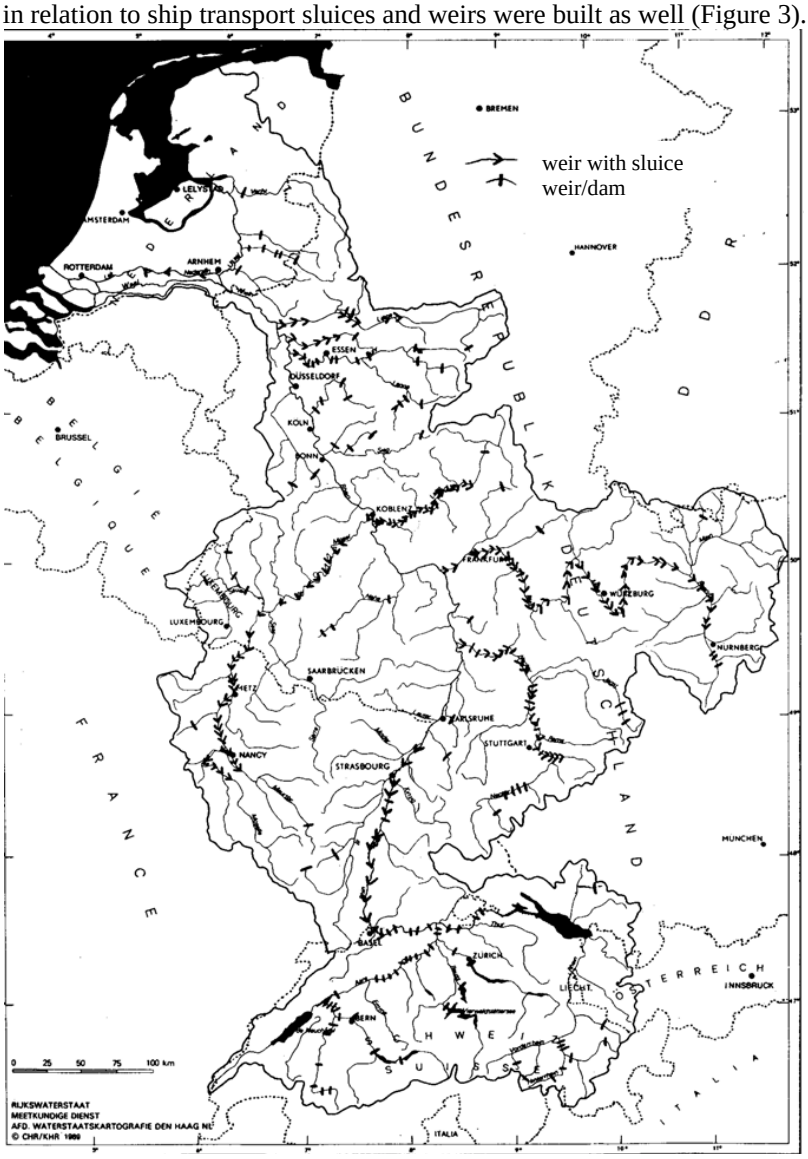

Figure 3. Rhine River Basin with its dams, sluices and weirs

In the twentieth century, a wide variety of water quality problems developed, which drew much attention in the seventieth and eightieth. In the ninetieth, attention was drawn to a wider concept of water management, called integrated water management. In this concept, account is taken of all functions waters fulfil, including those of nature and environment, so that these functions can be secured on the long-term. In the beginning of the twenty-first century the countries in the Rhine River Basin are still in this phase. However, in studies for future development even the approach is based on 'integrated environment management'. In this approach the developments in land use, water management, flood protection and environment are better integrated.

NEED FOR INTEGRATED WATER RESOURCES MANAGEMENT

Since the last decades there is an increasing interest in and focus on Integrated Water Resources Management (IWRM), although in practice almost no country is really applying it.

As far as IWRM with respect to food production and sustainable rural development is concerned the issues that play a role in the Rhine River Basin are especially, drainage, irrigation, rural drinking water supply and sanitation, flood management and flood protection, but also issues like application of fertilisers and pesticides, manure due to cattle breeding and other rural sources of pollution. As far as drainage is concerned the quality of the drainage water should not result in an exceedance of acceptable water quality levels of the receiving water bodies (Schultz, 2006).

As far as IWRM with respect to urban and industrial areas is concerned the issues that play a role in the Rhine River Basin are especially drinking water supply, sanitation, treatment of wastewater, urban drainage, flood protection, and water needs of the green areas. As far as water management is concerned these areas may discharge their surplus water directly to the river, or to the canal system in the surrounding rural area. Especially in the latter case due attention would have to be given to the different discharge patterns of the rural and urban area.

During the past years there have been quite some debates regarding the possible impacts of climate change on respectively:

- rise of the mean sea level;
- change in river regimes and increase in peak discharges of rivers;
- increase in average annual rainfall and in peak rainfalls;
- increase in droughts.

With exception of the last item these developments may increase the risk of flooding of flood prone areas. However, although such developments may occur, it has to be realized that the possible changes in design standards for water management and flood protection schemes due to the impacts of climate change are generally in the order of magnitude of 10 - 30% over the forthcoming 100 year. Locally there may be exceptions that can have more far reaching consequences, for example when drainage by gravity would have to be replaced by drainage by pumping. Therefore the effects of climate change are generally such that in the modernization of water management and flood protection schemes - which normally takes place every 25 to 50 years - the impacts of such changes can be easily accommodated.

If we, however, look at the increase in population and increase in value of public and private property - houses, buildings, infrastructure, public facilities, public and private property – and in certain cases the man induced land subsidence in the lowland, flood prone areas, in the Rhine River Basin then such increases are much more significant than the possible impacts of climate change. Therefore, compared to the issue of climate change, these increases would have to significantly dominate decision-making on water management and flood protection measures. So far this has generally not been the case, but the understanding that these processes would indeed have to play a major role is rapidly growing and not only the issue of flood

protection, but the much broader approach to flood management, which may be considered as a substantial element in IWRM, is getting increasing attention (Schultz, 2001, 2008 and German National ICID Committee, 2005).

We have to realise, however, that we will never be able to achieve complete control of the water resources. Nature has its extremes beyond the design criteria of our water management and flood protection schemes. What will be of utmost importance is that we better integrate land use planning with water management and flood protection. In the recent cases of flooding of New Orleans, along the Danube River and at many other places in the world the floods had a chance of occurrence of about 1/100 per year or less. We cannot really call this extreme floods, while they are expected to occur at least almost in ones' lifetime. The problem is that we increasingly are living and building in flood prone areas, often without implementing appropriate packages of structural and non-structural flood management measures. In fact in such cases the managing of the water resource is not really the problem, but the management of the land use. We still see that with respect to this political and economic considerations are domination decision-making and not really IWRM.

HOW TO ACHIEVE IWRM IN PRACTICE?

The above sections show, that especially because of population growth, the higher standard of living, urbanisation and industrialisation there is an increasing competition for water and an increased need to make use of this valuable resource in a sustainable way and to protect the lowland areas against flooding. How to achieve this in practice is not easy to answer. In fact we have to analyse who can decide on such issues. In Figure 4 a general picture is given of who are in charge and who are contributing to rural water management and flood protection. For urban water management a similar figure can be made, although in this case the municipal government will generally be in charge for the municipal water management.

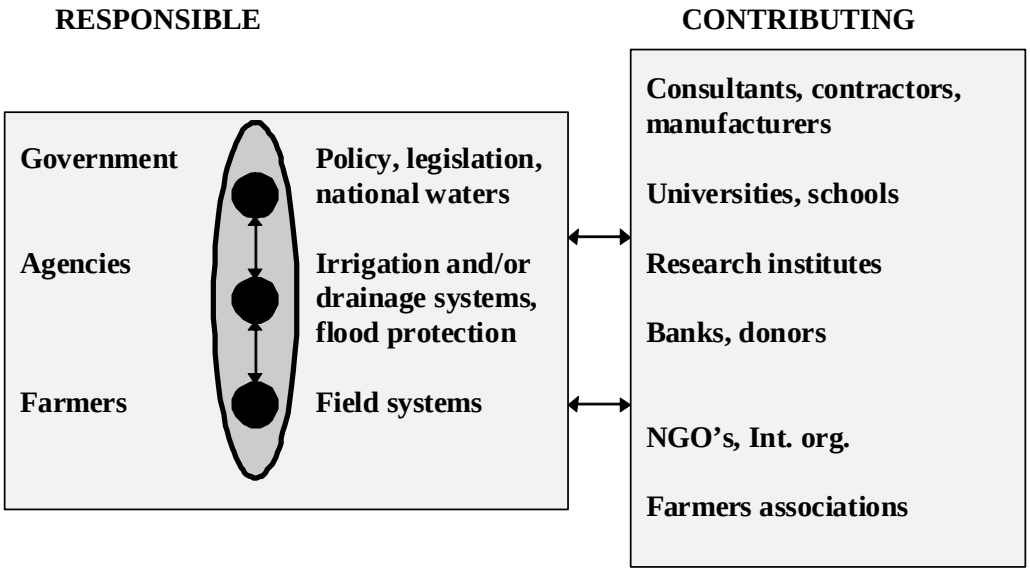

Figure 4. Indicative schematisation of actors in rural water management and flood protection (after Schultz, 2001)

Basically within a country the responsibility rest with three parties: the government, irrigation and/or drainage agencies and farmers/municipalities, each party with its own role and responsibility. In case of flood protection generally the agencies will be in charge as well.

For river basins that are shared by several countries these countries would need to agree on IWRM at river basin level and the policies, approaches and actions at country, regional and local level will have to fit in the overall river basin approach. This puts a very strong responsibility with the National Governments, especially with respect to policy making and legislation. In Europe we are in the middle of this process. Coming years it will become clear whether we will be able to achieve IWRM at river basin level, especially for the Rhine and Danube rivers, which basins are shared by several riparian countries. However, this will be not enough. Within a country the government at different levels (National, Provincial ad Local), the agencies and the farmers/municipalities will have to agree on each role and responsibility within a sustainable framework. That is the real challenge. A special complication is the multiple land use that exists nowadays in most of the sub-basins, implying that responsibilities and costs will have to be shared among different types of land use and users as well. While societies are changing over time one may expect that this will need more or less continuous consultation and negotiation in a never ending process. Therefore no general recipe can be given and solutions will be strongly dependent on the local physical and socio-economic conditions (Schultz, 2006).

Why is IWRM needed and why will it increasingly be needed? In fact this question can be easily answered, especially for the river basins with a large percentage of cultivated land and/or densely populated urban areas. It is required because of the increasing need for fresh water at an acceptable quality for the different purposes and the fulfilment of this need in a sustainable way. In fact we are in Europe in a privileged position, while our population density (32 persons/km^2) is below the average global level (46 persons/km^2), population growth is relatively small, our standard of living is relatively high and our economic development follows a gradual process.

DEVELOPMENT OF THE COOPERATION IN THE RHINE RIVER BASIN

The oldest formal cooperation with respect to the Rhine concerned free shipping and was developed by the inauguration of the international Central Commission for Navigation on the Rhine (CCNR), founded in 1832. This organisation is the oldest still-functioning international river commission in the world. It acts in the interests of free and safe shipping and trade on the navigable Rhine between Switzerland and the North Sea (De Bruin, 2009).

Due to the increasing pollution in the 1960s and 1970s solutions were needed, requiring a new international strategy. The International Commission for preventing Pollution of the Rhine (ICPR) was founded in 1963. This is an advisory body on cross-border policies, originally focusing on pollution control. Later, flood control and ecological restoration were included in a new and expanded mandate. Reflecting this broader mandate is its updated name in 1999: the International Commission for the Protection of the Rhine (ICPR).

A third international commission in the Rhine River Basin, founded in 1970, has a mainly scientific charter: the Commission for the Hydrology of the Rhine (CHR). Its mission is: to acquire knowledge of the hydrology of the Rhine basin through joint research and publications and to contribute to the solution of cross-border problems through the formulation of information systems and models (e.g., CHR Rhine GIS and the Rhine Alarm model).

The emphasis in the 20th century on navigation and hydropower eliminated the fishery (based on migratory fish) and harmed the ecosystem. Pollution of the Rhine endangered water quality for households, industry and the environment. The pollution of the river became politically unacceptable in 1971. Since that year, trans-boundary co-operation and harmonization has begun to redress the problems. The efforts aimed to reduce pollution, to rehabilitate the ecosystem and to improve flood protection.

Mutual understanding and trust are key issues in the co-operation process. They create the conditions for formulating common policies and frameworks to surmount trans-boundary problems. Harmonization and co-operation are paving the road to balanced, sustainable development in the Rhine River Basin.

When water quality criteria were being formulated, discussions in the ICPR reflected the opposing positions of upstream and downstream countries. However, an international inventory of wastewater treatment and sanitation plans in 1972 created mutual understanding about the problems being addressed in the individual Rhine Basin Countries. Due to the mistrust between the individual Rhine Basin Countries and other members of the European Union in the 1970s, the Convention for the protection of the Rhine against chemical pollution contains detailed procedures. The Sandoz disaster (an accidental poisonous chemical spill at Basle) of 1 November 1986 changed this agreement almost overnight. Instead of the troublesome negotiations on emission standards, the Rhine Basin Countries agreed that every country should reduce the actual pollution due to 47 dangerous and problematic substances by 50% in the period 1985-1995. The countries were free to select the most effective way to realise this aim. With that decision they did put the chemical convention and EU-directive aside. The agreement does not really have a legal status, but it is a political commitment. It is based on mutual trust and has paid off. A report to the Conference of Ministers (January 1998) concluded that the Rhine target values had been reached for 39 substances. The concentrations of the other 8 substances were still above the target values. The ministers decided to strengthen efforts to reduce these substances also.

The Sandoz incident resulted in the Rhine Action Plan (RAP), adopted by the ministers in 1987. This plan contained the following phased activities:

- measures to prevent accidents, by constructing storage capacity near large industries in a way that accidents such as Sandoz could not happen again;
- a reduction of the 1985 pollution level by 50% over the following 10 years;
- the rehabilitation and restoration of the Rhine River. This objective concentrated on three issues:
  - higher species such as salmon should return to the Rhine by the year 2000;
  - the future quality of Rhine water would have to be such that domestic water could (again) be produced with simple production methods;
  - the pollution of sediments had to be reduced to such a low level that the sediment could be applied on the land or dumped into the sea without negative impact on aquatic organisms;

  In addition measures to improve the ecological situation of the North Sea were added and adopted.

The measures with respect to the North Sea were added to the RAP in 1990 on behalf of the North Sea States who are not a member of the ICPR (like United Kingdom and Denmark). The purpose was to ensure that the marine environment would benefit from the RAP-objectives. Today, nearly 10 years after the year 2000 goal of the RAP has passed, it is clear that the effectuation of the RAP has been successful.

Over many decades, the system of flood protection works (dikes, or levees) has been improved and extended in all the Rhine Basin Countries. Also the design criteria have been adapted to safer norms.

In the mid 1990s, nature intervened. High floods were generated by intense rainfall in the entire Rhine River Basin in December 1993 and January/February 1995. Both events resulted in floods, statistically 1 in 150 years. The 1993 and 1995 floods along the Rhine gave a new opportunity to enlarge trans-boundary cooperation. In 1995, large areas along the Rhine were inundated, the confined floodplain was everywhere completely submerged, and at those stretches where the floodplain is not confined, damage was caused to houses and infrastructure. It led to social disruption on a large scale, which was unusual for the population of the Rhine basin. Dikes in the Netherlands were even on the point of collapse. Where they had not yet been adapted to the new standards, the situation became critical. As a precautionary measure, in the directly threatened flood prone zone, about 240,000 people (and more than one million cattle) were evacuated. But fortunately, critical sections of the flood protection system did not breach

so the adjacent land remained dry. People returned to their homes but insisted on quick action.

The ministers of the Rhine Basin Countries declared a number of measures to reduce the future risk posed by floods (Declaration of Arles, France). They decided to make maximum use of existing international institutions, to assure a rapid and integrated approach. Accordingly, they charged the ICPR with the development of strategies for flood protection referring to the RAP as an example of what was required. In concert with the various river management organisations in the Rhine Basin Countries, the ICPR produced a strategy paper for flood protection in December 1995. The ministerial conference of January 1998 approved that paper: the Flood Action Plan (FAP):

- the Plan was to be implemented over a period of 20 years, being basin oriented;
- it had an allocated budget of € 12 billion to work on flood reduction measures;
- the plan should deliver a reduction of flood related damages by 25% in 2020;
- the plan should restore floodplains and improve water storage everywhere;
- the plan should reduce the flood height during extreme flood events in the Upper Rhine by 0.70 m in 2020.

EUROPEAN WATER FRAMEWORK DIRECTIVE

Since the acceptance of the European Water Framework Directive (EWFD) on 23 October 2000 all member countries have committed themselves to apply IWRM in practice within the framework of a river basin approach (European Commission, 2000). The purpose of the EWFD is formulated in Article 1:

The purpose of this Directive is to establish a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater which:

(a) prevents further deterioration and protects and enhances the status of aquatic ecosystems and, with regard to their water needs, terrestrial ecosystems and wetlands directly depending on the aquatic ecosystems;

(b) promotes sustainable water use based on a long-term protection of available water resources;

(c) aims at enhanced protection and improvement of the aquatic environment, inter alia, through specific measures for the progressive reduction of discharges, emissions and losses of priority substances and the cessation or phasing-out of discharges, emissions and losses of the priority hazardous substances;

(d) ensures the progressive reduction of pollution of groundwater and prevents its further pollution;

(e) contributes to mitigating the effects of floods and droughts and thereby contributes to:

- *the provision of the sufficient supply of good quality surface water and groundwater as needed for sustainable, balanced and equitable water use,*
- *a significant reduction in pollution of groundwater,*
- *the protection of territorial and marine waters;*
- *achieving the objectives of relevant international agreements, including those which aim to prevent and eliminate pollution of the marine environment, by Community action under Article 16(3) to cease or phase out discharges, emissions and losses of priority hazardous substances, with the ultimate aim of achieving concentrations in the marine environment near background values for naturally occurring substances and close to zero for man-made synthetic substances.*

In fact the focus of the EWFD is on the protection of water and not on the need for water use in the riparian countries. In addition to this for quite a period the EWFD did not fully concern IWRM, while flood management was not yet covered under it. However, following the

initiative taken under the Netherlands Chairmanship in the second half of 2004, also flood management came on the European political agenda. This has resulted in the adoption of Directive 2007/60/EC of 23 October 2007 on the assessment and management of flood risks (European Parliament and the Council of the European Union, 2007).

As said in Europe we have observed substantial pollution problems and, especially during the past years, substantial cases of flooding. On the other hand urbanisation is still on going in combination with a decline of the number of the rural population due to the increase in farm sizes or the change to cultivation of higher value crops, like vegetables. All these processes result in an increasing need for IWRM and in fact in the longer run for integrated environment management, by integrating the land use and IWRM policies and planning mechanisms. To what extent the European countries will be able to achieve this is an open question. They first have to try to achieve IWRM in practice as a result of the full implementation of the EWFD. A start has been made with the preparation of the plans at river basin, national and sub-basin level. This set of plans and the adaptation of the legal frameworks have to be ready within a few years. This will really be a challenge for the member countries, but when they will be successful the benefits will be substantial.

With respect to the flood directive, especially interesting is Chapter III, Item 4. Chapter III describes the preparation of Flood Risk Management Plans by the member countries. These plans would have to be ready by 22 December 2015. In Item 4 is stated:

In the interests of solidarity, flood risk management plans established in one Member State shall not include measures which, by their extent and impact, significantly increase flood risks upstream or downstream of other countries in the same river basin or sub-basin, unless these measures have been coordinated and an agreed solution has been found among the Member States concerned in the framework of Article 8.

Article 8 provides the details with respect to the conditions of the plans in relation to the territory that they cover, especially with respect to within one country or within several countries.

CONCLUDING REMARKS

History has shown that again and again new measures have to be taken in answer to new developments, droughts, cases of flooding, or unforeseen consequences of former interventions. There is no reason to suppose that in the future such reactions and activities will come to an end. Even if we achieve an IWRM approach it will not be static. Anticipating future developments - rather than only reacting to them - will be the challenge. New developments will have to be reckoned with and there is no prospect of a permanent situation. For the Rhine Basin Countries it will be of increasing importance to continue and expand their cooperation with respect to developments in land use, water management, flood protection and protection of the environment.

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Paper 4-4

HYDROLOGICAL RISK ZONE MAPPING IN DONG THAP PROVINCE FOR DEVELOPING AGRICULTURAL INSURANCE

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ABSTRACT

Untimely flooding during specific phases of agricultural production is a major risk to rice production and other crops in the Mekong Delta. Hydrological risk zone mapping addresses the need for relative flood risk analysis in insurance pricing for first and second-generation agricultural insurance products. Risk zone mapping produces a set of maps and interpretations of flood hazard zone delineations. In developed insurance sectors, these illustrations are known as flood insurance rate maps.

For an insurance product to be market sustainable, and to preserve suitable incentives for producers to mitigate losses during a flood event, an insurance pricing model requires identification of the relative risk. Therefore, it is necessary to know which areas are more or less at risk for different levels of flood severity. Because the impacts of flood events are not uniform over space and time and depend on complex and changing hydrological systems, historical analysis of flood loss relative to indexed measures of the risk fails to capture either the actual current flood risk or the spatial distribution of that risk.

INTRODUCTION

The flood risk mapping has been carried out on the Dong Thap Province in the north-western part of the Mekong Delta in Vietnam. The hydraulic model used for the study covers the entire Mekong Delta. This is due to the complex interaction of rivers, canals, embankments and hydraulic structures that form the hydraulic network of the Mekong Delta. The key hydrological variable to be indexed for the risk mapping study is the water level at Tan Chau hydrological station. This variable appears to be a good indicator of flooding in the lower Mekong Delta farming system.

Flood hazard risk contours generated in this study are based upon specific values of this index. Flood risk maps provide a visual representation of the spatial relationship of flood risk in a given area. For this study the maps are being used to identify areas in Dong Thap Province which are at risk from early flooding.

The study is very important to identify impediments to developing sustainable agricultural insurance in Viet Nam and propose policy options, provide feasible models for informal agricultural risk mitigation and formal agricultural insurance for pilot testing and identify major risks that farmers face. Findings will be used to aid in the design of appropriate insurance products

BACKGROUND AND DESCRIPTION OF THE PROBLEM

Dong Thap Province covers an area of 334,407 hectares. The population of Dong Thap Province in 2005 was 1,654,680 and the majority of the population is dependent upon

agriculture for their livelihood, with rice production the principle activity.

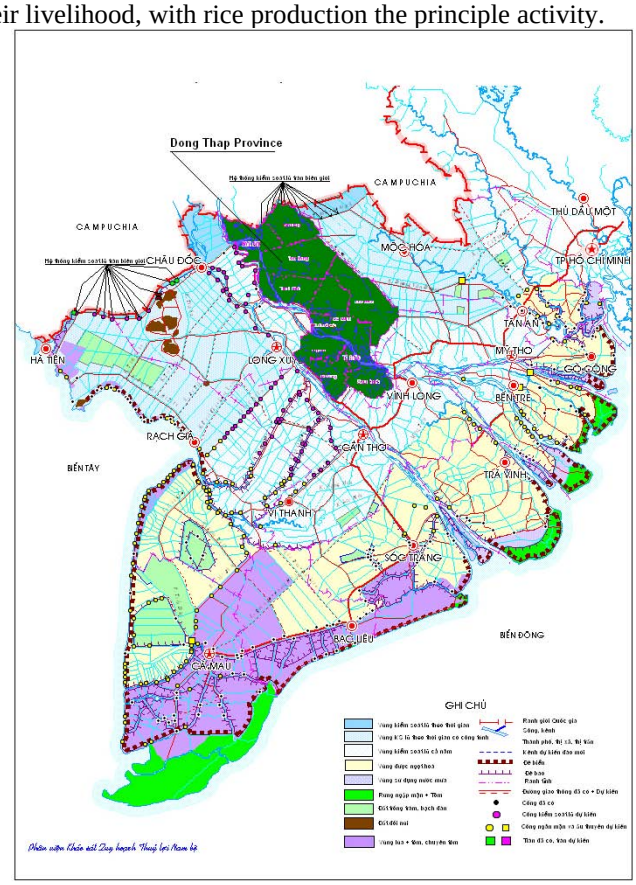

Figure 1. Location map of Dong Thap Province in the Mekong Delta of Viet Nam

The land elevation in Dong Thap Province ranges between 1.5 - 2.5 m+MSL (mean sea level). Annual flooding starts in June and lasts until November, and during this time more than 300,000 hectares becomes inundated.

METHODOLOGY

Hydrological risk zone mapping requires developing numerical models that dynamically describe hydraulic characteristics (i.e. water level, flow, velocity, etc.) for a defined topographical region. Numerical models used to develop flood hazard delineations incorporate historic and current meteorological, hydrological, and hydraulic data, as well as relevant information about natural and man-made physical features including and the location and characteristics of flood control works. The output from the engineering models is used to produce risk maps for the defined region.

When the environment in the defined region changes either by natural or human causes, the hydrological risk maps must be revised and updated. Consequently, the underlying numerical models need to be capable of incorporating and simulating the effect of changes to a number of variables over defined periods.

Models and model results used for risk mapping must also be verified. Ideally, the results of the risk zone mapping for each study area should be collaborated and verified by some independent means such as by calibrating to known flood events with reliable data records or if available, satellite imagery of known flood events.

Common features on a typical flood risk zone map may include:

- natural and man-made physical features, such as rivers, other waterways, major highways, secondary roads, canals, and flood control devices;
- base flood elevations (BFE) or depths. This corresponds to areas subject to inundation by a flood event with a 1% Annual Exceedance Probability (AEP), or a 1 in 100 year flood event;
- flood insurance risk zones;
- elevation reference marks established by survey;
- relevant administrative boundaries.

Risk mapping is a continual process, building on new information as it becomes available. Consequently, the entire modelling effort must be flexible and capable of responding quickly to incorporate new information or to needed changes in the underlying simulation algorithms.

DATA ANALYSIS AND SCENARIOS DEVELOPMENT

The key *hydrological variable* to be indexed for the risk mapping study is the water level at Tan Chau hydrological station. Tan Chau station is located on the Mekong River (Song Tien) on the upstream border of Dong Thap Province. This variable appears to be a good indicator of flooding in the lower Mekong Delta farming system. Flood hazard risk contours generated in this study are based upon specific values of this index. However, the hydraulic modelling effort requires consideration of complex interactions of hydraulic influences even outside Dong Thap Province.

For this study the hydraulic model VRSAP was run for the period between the 1 June and the 30 July. This includes the period of analysis from the 20 June to the 5 July. The model simulation started at the 1 June to minimize computational instabilities during the period of analysis. There are 24 scenarios to be considered for this study, based on different flow APE, tidal conditions and rainfall APE (Table 1).

The period of analysis for constructing the index and for generating flood risk maps is from June 20 – July 5 (critical window in Figure 2). The identification of this period is based on analysis of hydrological data from Tan Chau station, surveys of key stakeholders and consideration of insurability conditions. This period corresponds to the spring-summer rice harvest when early flooding has a serious impact on the ability of farm households to complete the harvest and manage other vulnerable assets.

Table 2 displays harvest data from the 2005 spring-summer rice crop for four provinces within Dong Thap Province. The 2005 flood was considered a ‘normal’ flood year as there was no early flood peak that disturbed the harvesting of the rice crop. The table shows the typical harvest schedule for the spring-summer rice harvest in Dong Thap Province

RESULTS

Flood risk maps provide a visual representation of the spatial relationship of flood risk in a given area. For this study the maps are being used to identify areas in Dong Thap Province which are at risk from early flooding.

Water level maps were created for Dong Thap Province from the output of the VRSAP hydraulic model. The calculated daily maximum water levels at the nodes within Dong Thap Province were input to a Graphical Information System (GIS) format so that spatial analysis of the results could be undertaken.

Table 1. Probable risk scenarios

Simulation number	Scenarios Id	Flow APE (%)	Tidal condition	Rainfall APE (%)
1	*Sc5_1*	5	Average	50
2	*Sc5_2*	5	Average	20
3	*Sc5_3*	5	Max	50
4	*Sc5_4*	5	Max	20
5	*Sc10_1*	10	Average	50
6	*Sc10_2*	10	Average	20
7	*Sc10_3*	10	Max	50
8	*Sc10_4*	10	Max	20
9	*Sc15_1*	15	Average	50
10	*Sc15_2*	15	Average	20
11	*Sc15_3*	15	Max	50
12	*Sc15_4*	15	Max	20
13	*Sc20_1*	20	Average	50
14	*Sc20_2*	20	Average	20
15	*Sc20_3*	20	Max	50
16	*Sc20_4*	20	Max	20
17	*Sc25_1*	25	Average	50
18	*Sc25_2*	25	Average	20
19	*Sc25_3*	25	Max	50
20	*Sc25_4*	25	Max	20
21	*Sc30_1*	30	Average	50
22	*Sc30_2*	30	Average	20
23	*Sc30_3*	30	Max	50
24	*Sc30_4*	30	Max	20

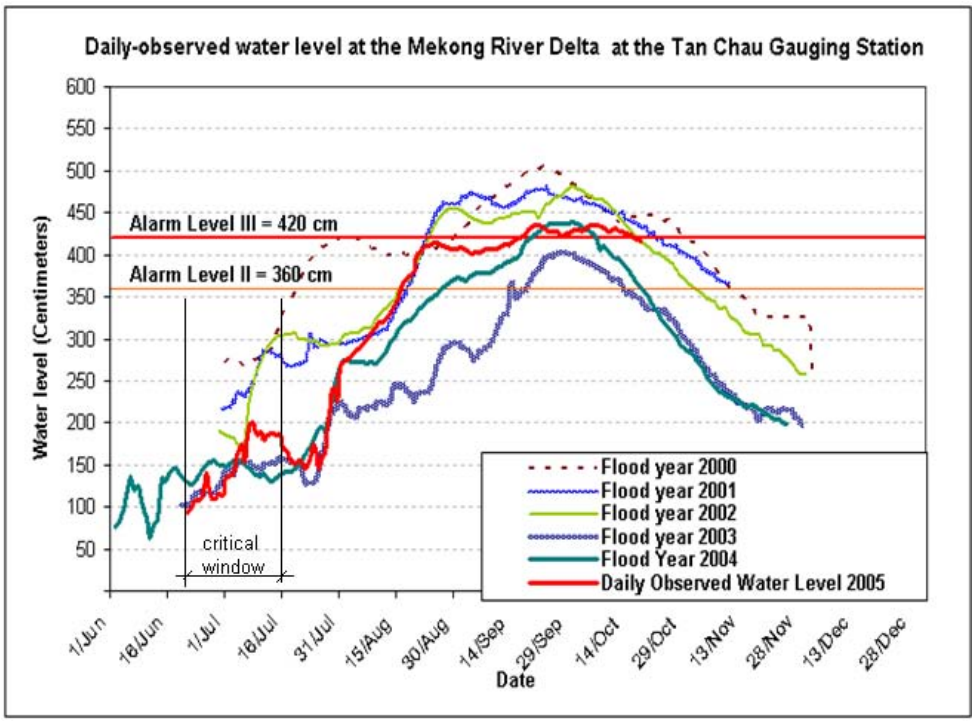

Figure 2. Critical window for generating flood risk maps and observed water level at Tan Chau Station

Table 2. Percentage completion of 2005 rice harvest in Dong Thap Province

Date	Crop area (ha) harvested by district			
	Hồng Ngự	Tam Nông	Thanh Bình	Cao Lãnh
June 25 – 2005	5,050	1,470	212	15,620
% of total	26%	5%	1%	60%
July 5- 2005	13,700	13,000	14,200	19,600
% of total	71%	45%	70%	75%
July 15 – 2005	16,088	21,582	15,567	24,057
% of total	84%	75%	76%	92%
July 25 – 2005	16,528	28,793	20,280	26,139
% of total	86%	99%	99%	100%
August 5 – 2005	178,889	28,793	20,420	26,139
% of total	100%	100%	100%	100%

Inundation maps are required to relate the calculated water level on any given day during the study period and the underlying Digital Elevation Map (DEM) presented in Figure 4. Inundation maps are created by subtracting the DEM from the calculated water level to produce a grid of values, which represent the depth of inundation across Dong Thap Province. A sample of inundation map is given in Figure 5.

Risk maps. The critical value of 0.5 m was chosen as it is believed to be an inundation depth where the damage to the rice crop and the ability to harvest becomes critical to the yield. For values less than 0.5 m, a value of 0 was assigned which represents that the area was at a lower risk from early flood events while for values greater than 0.5 m a value of 1 was assigned which represents that the area was at a greater risk from early flood events. A sample of risk map is shown in Figure 6.

Inundation maps for the 25 June and flood risk maps for the 25 June and 1 July have been produced of Dong Thap Province for each scenario and are included in the Maps section of the report. GIS data of the maps have also been supplied digitally in ESRI shape file format.

Figure 3 relates the calculated water level at Tan Chau to the number of areas identified with an average depth of inundation greater than or equal to 0.5 m for the 25 June. The results suggest that there is a good correlation between the water level at Tan Chau and the number of areas flooded and that Tan Chau may be possible to use as a flood index for Dong Thap Province. Figure 3 shows the districts where areas had an average inundation greater than or equal to 0.5 m for the modelled scenarios. The districts where flooding occurred were Cao Lanh, Hong Ngu, Tam Nong, Tan Hong, Thanh Binh and Thap Muoi. As can be seen in Figure 6 and the produced inundation maps and flood risk maps, Tam Nong and Tan Hong were the two districts that were most affected in the modelling. The supplied ESRI shape files contain tabulated and graphical results of the minimum, maximum and average depth of inundation in each identified area for each modelled scenario.

CONCLUSIONS AND RECOMMENDATIONS

The study is very important to identify impediments to developing sustainable agricultural insurance in Viet Nam and propose policy options, provide feasible models for informal agricultural risk mitigation and formal agricultural insurance for pilot testing and to identify major risks that farmers face. Findings will be used to aid in the design of appropriate insurance products.

The product of project is education to determine if effective risk transfer markets for catastrophic natural disaster risk can be started in Vietnam. Pilot programs are about demonstration and replication.

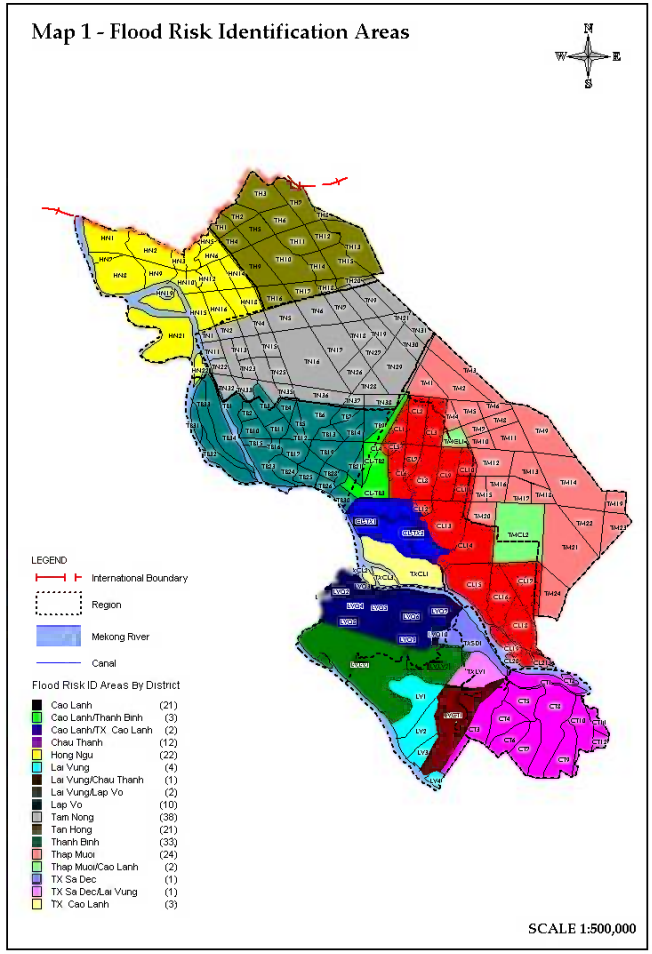

Figure 3. Flood risk identification areas

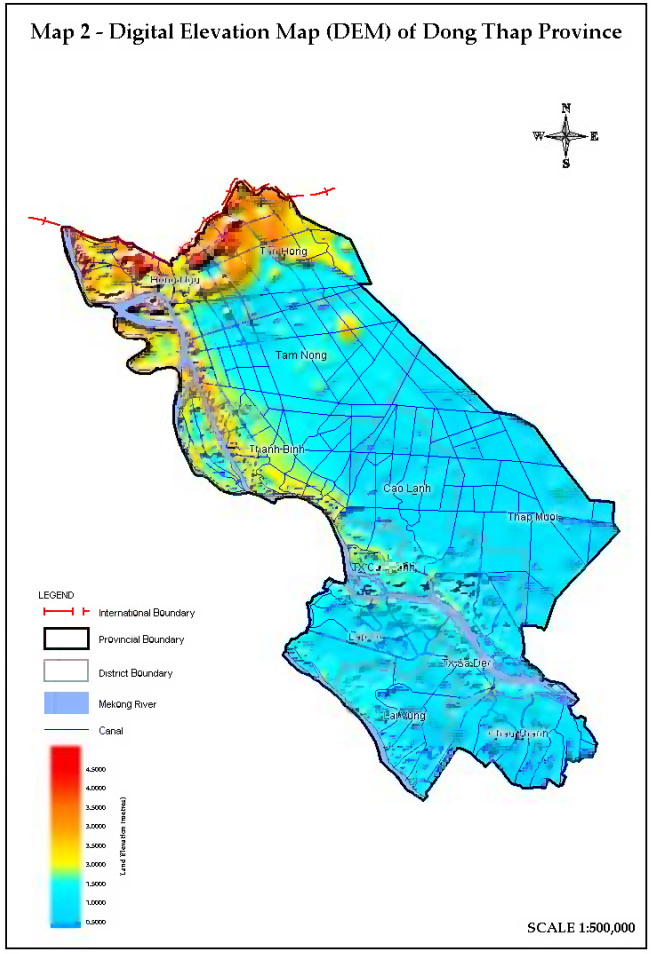

Figure 4. Digital elevation map of Dong Thap

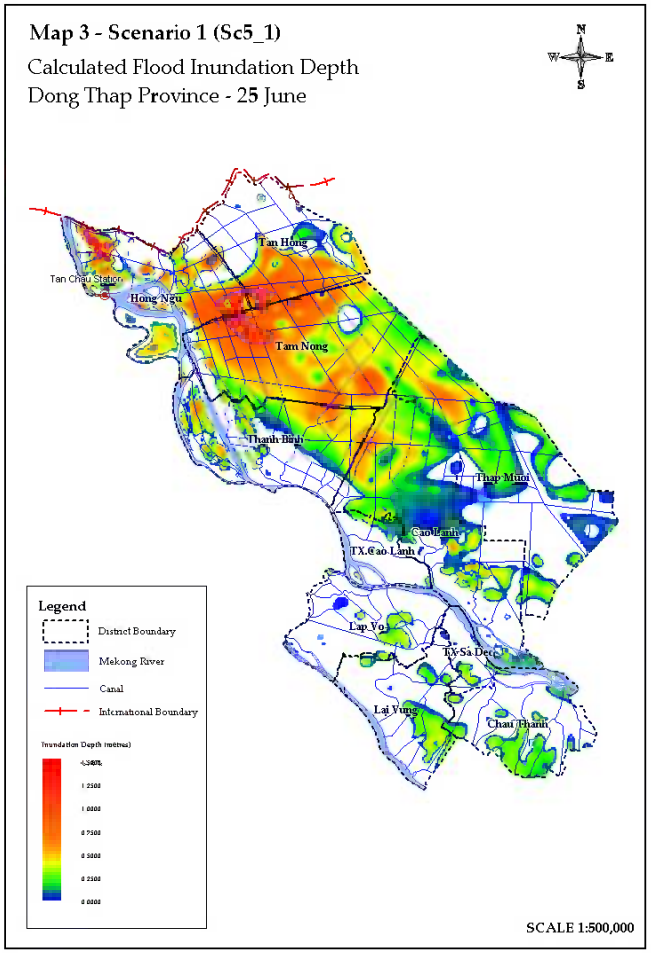

Figure 5. Sample of inundation map

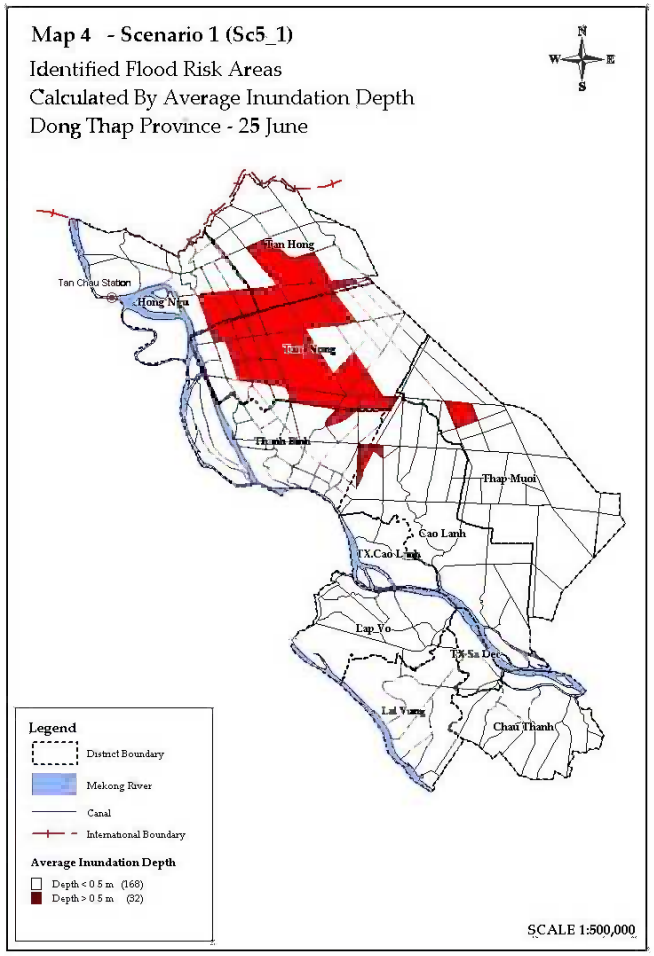

Figure 6. Sample of risk map

In order to apply these concepts in Vietnam it would having these type of risk transfer products help change some other government social policy and provide a linkage mechanism from the bank for indemnity based insurance and risk mitigation payments as well.

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SESSION 5

PARALLEL PAPER PRESENTATIONS BY INTERNATIONAL SPECIALISTS FOLLOWED BY PARALLEL GROUP DISCUSSIONS

Topic II

Recent developments in flood forecasting and early warning

Paper 5-2-1

THE WAY FORWARD IN HYDRODYNAMIC FLOOD MODELLING IN THE MEKONG RIVER BASIN

ADRI VERWEY

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ABSTRACT

Significant progress has been made in the Mekong River Basin in the understanding of the physical processes of flood wave propagation. These processes take place both in channels and on the floodplains as overland flow. As long as the flow is confined to the channels, the processes are predominantly of a one-dimensional (1D) nature and can rather accurately be described by the de Saint Venant equations. Such flows have been studied successfully by numerical models which can be used to study the effects of changes in geometry, operation rules, changing environmental and infrastructural conditions, such as climate changes, water demands, the construction of reservoirs, etc.

The description becomes more complex, however, when part of the flow occurs in floodplains. This is more the rule than the exception in the case of flood wave propagation, in particular during extreme events. 1D model descriptions face a number of limitations in describing such flow situations, discussed as follows:

- it is not always clear which flow paths the floods will follow as these depend on the magnitude of inflows and on the spatial distribution of terrain levels. During a model schematization the overall distribution of elevations cannot always be analyzed to provide sufficient insight in the paths that floods may follow. However, a 1D schematization requires such insight before simulations are made and if paths have not been foreseen in the 1D model schematization the model cannot simulate flow along such paths;
- a common method in 1D simulation to describe flow over floodplains is the cell approach. However, this is a very simplified way of dealing with the flow processes. In the first place, the exchange of flood water with neighbouring cells is described in a very crude way by replacing the flow over terrain by a head loss description, either based upon averaged equivalent channel flow conditions or on a simplified hydraulic structure equivalent. In the second place, the flow direction in the cell is changing spatially and this process cannot be represented by the 1D description.

The member countries of the Mekong River Commission (MRC) may deal with rather complex decisions to be made, in particular when discussing trans-border problems. This requires trust in the hydrodynamic simulation models that form part of the basis for such decisions. Currently, this trust is based upon the accepted ISIS hydrodynamic model as the current state-of-the-art at MRC. With improved simulation tools being developed and improved data coming in gradually, it is wise to keep an open eye on the possibilities of achieving a better physical description of the processes taking place. Such way forward in simulation modelling would form a more solid basis for scenario evaluations.

The last decade has shown significant progress in the joint modelling of 1D and two dimensional (2D) flood wave propagation processes. This presentation is discussing the various approaches in the combined 1D and 2D numerical modelling of flood wave propagation, in particular the ways in which the process descriptions are best integrated. It also deals with the

data requirements for such models, demonstrating the possibilities and limitations of current state-of-the-art data collection.

Data collection in the Mekong River Basin is progressing, including the improved data collection of elevation information. As such information becomes available at MRC, also the need arises to further develop the simulation models making use of this information. Progress will only be possible if integrated 1D/2D simulation models are developed. This paper discusses at least two of such applications in the Mekong River Basin and a variety of integrated 1D/2D models applied world wide.

INTRODUCTION

Significant progress has been made in the Mekong River Basin in the understanding of the physical processes of flood wave propagation. These processes take place both in channels and on the floodplains as overland flow. As long as the flow is confined to the channels, the processes are predominantly of a one-dimensional (1D) nature and can rather accurately be described by the de Saint Venant equations. Such flows have been studied successfully by numerical models which can be used to study the effects of changes in geometry, operation rules, changing environmental and infrastructural conditions, such as climate changes, water demands, the construction of reservoirs, etc.

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Data collection in the Mekong River Basin is progressing, including the improved data collection of elevation information. As such information becomes available at MRC, also the need arises to further develop the simulation models making use of this information. Progress will only be possible if integrated 1D/2D simulation models are developed. This paper discusses at least two of such applications in the Mekong River Basin and a variety of integrated 1D/2D models applied world wide.

STRENGTHS AND WEAKNESSES OF 1D MODEL SCHEMATIZATIONS

When flow in a channel follows distinct flow paths which are more or less the same for the full range of water levels, the flow processes are well described by the de Saint Venant equations (de Saint Venant, 1871), presented in a slightly adapted form as:

$$\frac{\partial A_t}{\partial t} + \frac{\partial Q}{\partial x} = q_{lat} \tag{1}$$

$$\frac{1}{gA}\left\{ \frac{\partial Q}{\partial t} + \frac{\partial}{\partial x}\left(\frac{Q^2}{A}\right) \right\} + \frac{\partial \zeta}{\partial x} + \frac{Q|Q|}{K^2} = 0 \tag{2}$$

where $\boldsymbol{A_t}$ is the cross-sectional area representative for storage over a control volume (m^2), $\boldsymbol{t}$ the time (s), $\boldsymbol{Q}$ the discharge (m^3/s), $\boldsymbol{x}$ the position along the channel axis (m), $\boldsymbol{q_{lat}}$ the lateral discharge per unit length of channel (m^2/s), $\boldsymbol{A}$ the flow conveying cross-sectional area (m^2), $\boldsymbol{\zeta}$ the water level above a selected horizontal reference plane (m) and $\boldsymbol{K}$ the channel conveyance (m^3/s).

Although these equations were derived nearly 140 years ago, their formulation remained unchanged, as it describes the processes accurately if the correct schematization principles are followed in the derivation of the parameter values and the full equations are being applied. Even in the case of strongly meandering channels the equations do not need correction terms, at least as long as the flow remains within the banks.

The application of correct schematization principles means, for example, that:

- the x-axis follows the talweg of the channel;
- the water level is the same across the section;
- the parameter A_t correctly describes the storage between successive computational grid points along the channel;
- the conveyance parameter takes into account the variation of roughness parameters across the section and uses the correct concept of hydraulic radius (e.g. Stelling and Verwey, 2005);
- all terms of the equation are included in the solution method.

As long as the flow remains within banks, the derivation of these parameter values is rather straightforward and in most cases these values follow directly from cross-section information. The situation changes, however, as soon as over bank flow occurs. This phenomenon is very common in the modelling of floods. The applicability of the 1D equations can be stretched to describe flow into the flood plains as long as some schematization principles are followed, such as:

- derive the parameter values A_t from the flood plain and channel bed digital elevation data rather than from cross-sections and make sure that the integrated A_t along the vertical axis (water depth) represents correctly the storage capacity of the channel between successive cross-sections at all water levels;

- derive the conveyance parameter values to take even more into account the variation of roughness across the channel section as well as the flow shortcuts over the flood plain compared to the route along the talweg. This last issue can be taken care of by integrating the conveyance parameter with a correction factor for the length of the various flow paths across the section.

How far can the use of the 1D equations be stretched? There are some basic assumptions that are easily violated for flow over flood plains. In the first place there are many situations where the water level in the flood plain differs from that in the main channel, e.g. by the presence of natural or man-made levees. In the second place, at main channel locations, where velocities are highest, the shortcutting flow over the flood plain may give different flow directions over the vertical. This situation is poorly described by the 1D equations.

Flood plain cells

The deviations from 1D flow are even more pronounced in the case of large flood plains, leading to flow shortcuts between various river channels and even various river basins. This is the case in the Plain of Reeds and in the Cambodian Mekong flood plain. To cope with such situation in a 1D model schematization, the concept of flood plain cell was introduced.

One of the first applications described in literature is the model developed for the Lower Mekong River Basin by SOGREAH (UNESCO/SOGREAH, 1964; Zanobetti et al., 1970). Although this model has been used successfully to develop insight into the flood processes, in particular the role of Tonle Sap, the concept has a number of shortcomings, commented as follows:

- the cell is often described as a storage element, with exchange of flow with neighbouring flood cells or channels simplified to flow over hydraulic structures. The parameters describing this process can only be derived in a crude way and are difficult to calibrate. Moreover, for storage description it is assumed that the water level is horizontal over the cell. This concept was applied, for example, for the Cambodian flood plain ISIS model schematization developed as part of the Decision Support Framework (DSF) for MRC;
- as an alternative concept, flow through the flood plain cells may be described as channel flow. However, also in this case it is hard to define reasonable parameters describing this flow, such as representative cross-sections. Its application also implies the risk of double counting of storage and conveyance. Moreover, the flow directions cannot be represented well as the complex flow over the flood plain is bound to follow pre-defined paths. An additional problem is that the head losses computed along the selected channel directions often differ from the head losses that would follow from a more detailed 2D schematization. Alternatively, for more or less correct head losses following from external conditions, the distribution of flows would be computed incorrectly;
- it expects from the modeller an insight into possible flood routes, which are dependent upon local variations in topography and local obstructions.

In the latest version of the ISIS model for the Lower Mekong River Basin a number of flood plain cells based upon storage cells has been replaced by smaller cells based upon the conveyance concept. Although this adaptation has improved the descriptive capability of the model there is scope for further improvement.

EXTENSION OF A 1D MODEL TO AN INTEGRATED 1D2D MODEL

More accurate modelling is possible by replacing the flood plain cell description by a full 2D schematization. This approach has the following advantages:

- possible flow paths do not have to be defined beforehand as part of the model schematization, as these follow directly from the terrain digital elevation model (DEM). In this way flow paths are detected by the model itself and present themselves automatically in the model application (Figures 2,3);
- head losses over the flood plain are described more accurately, including the spatial distribution of flows;
- the role of embankments and their overtopping can be introduced relatively easily.

The main reason for this relatively recent interest in the combination of 1D and 2D schematizations is the increased computing power of PCs and notebooks. A modeller usually would like to investigate each office day a number of simulated scenarios and until recently this was only possible for complex hydraulic networks, such as that for the Lower Mekong River Basin, by setting up a model based upon a purely 1D schematization. Although mainframe computers and parallel processing machines could have been applied to decrease the turn-around time for simulations, these have never become very popular in river basin applications.

Currently, a number of approaches have been developed to combine 1D and 2D schematization principles in one single model. There are two distinct ways of dealing with this integration:

- in one approach the 1D and 2D model domains are separated by vertical interfaces. 2D grid cells are placed adjacent to 1D grid cells and exchange water between 1D and 2D domains via a vertical section. Over the past decade a number of developments have taken place following this approach. Examples are the coupling of MIKE 11 and MIKE 21 in the DHI suite of flood modelling products and the coupling of ISIS and TUFLOW in the Wallingford suite;
- in another approach the 2D model domains are placed on top of the 1D model domains and the exchange of water takes place via horizontal sections. This last approach has been followed by Deltares in the development of their modelling suite SOBEK.

The Deltares approach has a number of distinct advantages over the first approach, such as:

- it is very easy to extend an existing 1D model with the 2D component, as the 2D elements are simply placed on top of the 1D elements;
- for all process descriptions their place of schematization within the 1D or the 2D domain follows logically from the nature of that process: typical channel flow and flow through and over hydraulic structures is schematized by 1D elements; flow over flood plains as 2D elements and flow blocking elements such as roads, highways, railways and levees are logically schematized by higher elevated 2D grid cells;
- it is relatively easy for the system to generate connection points between both domains, just on the basis of the geometric position of the 1D and 2D grid cells;
- 2D grid cells can be set with relatively large dimensions, as there is no need to follow the curvature of river bends precisely. As a result, the simulation can run much faster;
- in the way it has been arranged in SOBEK there is no need to exchange flows as it is sufficient to set a water level compatibility condition at the connection points between both domains and flows between grid cells are generated automatically;
- in addition, all equations generated to describe the 1D and 2D processes are solved simultaneously through consistent implicit numerical formulations. The coupling via a horizontal interface facilitates this arrangement;
- in SOBEK the 1D and 2D modelling domains have been implemented in the same user interface. This facilitates the generation of a good understanding of the physical processes represented by the model. At any time and at any location, the consistency and interrelation of these processes in both domains can be judged.

VARIOUS APPLICATIONS OF SOBEK 1D2D

Flood modelling in the Netherlands

In the Netherlands, the SOBEK concept has been applied to study a wide range of flooding scenarios, such as the effect of dike or levee failure around polders, the detailing of evacuation scenarios, flood damage assessment, climate change scenarios, etc. The alertness on these issues in the Netherlands is partly the result of the 1953 flooding of extensive parts of the Rhine and Scheldt Delta (Figure 1) with a death toll of nearly 2000.

A further impulse was given by the river flood threats in 1993 and 1995, which led in 1995 to the evacuation of nearly 250,000 people. Although the levees did not breach due to emergency operations, the economic damage could have been as much as € 18 billion. These figures indicate the need to develop and apply good modelling tools to simulate flood scenarios.

Figure 1. Dike breach in the Netherlands, February 1953

One such simulation is shown in Figure 2, demonstrating the application of SOBEK 1D2D to the area of Zuid Beveland, in the south-western part of the Netherlands. For a number of breaches in the primary dikes, the simulation clearly shows the effects of flood wave propagation through the breaches and the effect of the secondary dikes that were constructed over the past centuries. These dikes remained in place when their function became redundant to some extent with the extension of the reclaimed land and the construction of new dikes. The simulations compared reasonably well with historic observations from 1953.

The strength of the integrated 1D2D concept is that both overland flow and the flow in channels within the reclaimed land are well represented. Due to the larger flow depth in

channels, flood waves propagate faster here than overland. Pure 2D models cannot represent this phenomenon well. However, the integrated 1D and 2D schematization concept arrives at simulating flood propagation overland and in channels, including their interaction, very well.

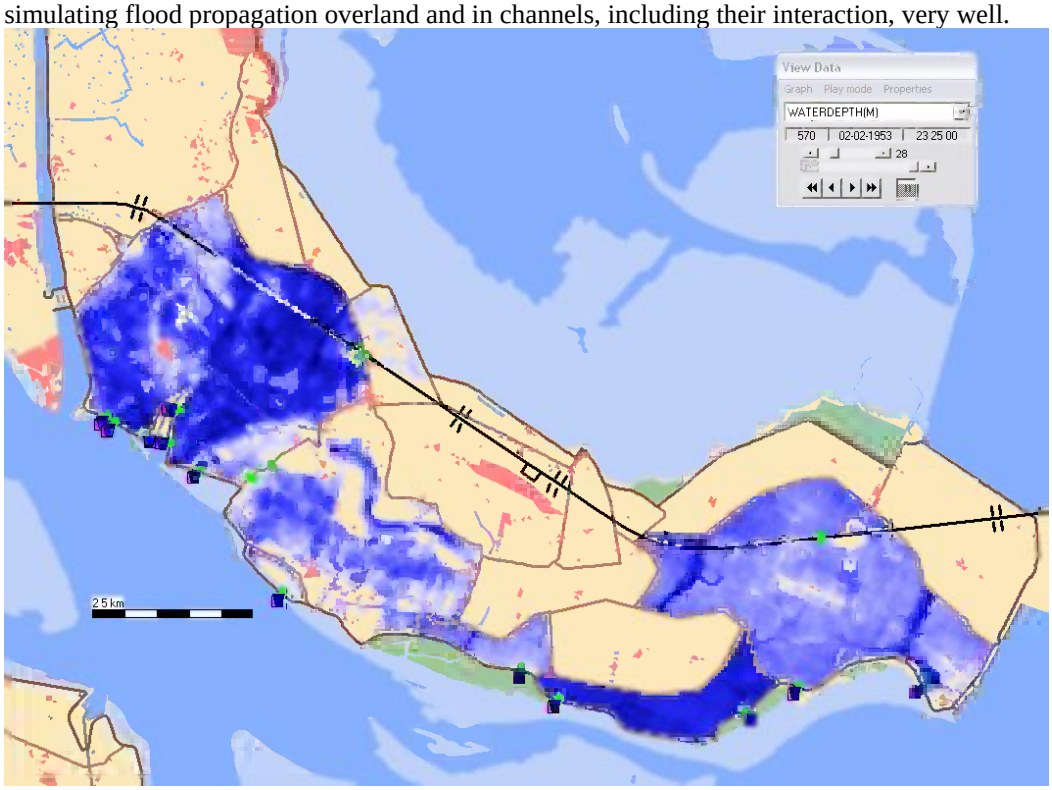

Figure 2. Simulation of flooding of Zuid Beveland, the Netherlands

Flood forecasting along Mae Nam Chi and Mae Nam Mun in Thailand

The Royal Irrigation Department (RID) in Thailand commissioned in 2007 a flood forecasting project along Mae Nam Chi and Mae Nam Mun to TEAM Consulting Engineering and Management Co in Thailand with Deltares, the Netherlands, as subcontractor. The forecasting system has been based upon Delft-FEWS as flood forecasting platform and SOBEK as the modelling system for the simulation of flood wave propagation along the rivers. For detailing of the flood forecasts at Ubon Ratchathani the 1D schematization of SOBEK was extended with a 2D schematization of the city area of Ubon Ratchathani.

Such coupling of a detailed 2D schematization of a vulnerable area has the advantage that the local flooding, generated by the high water levels in Mae Nam Mun, is represented with all its details of local flood passage ways and local obstructions such as local levees, land fills and local roads. Without such detailed 2D schematization is would not be possible to demonstrate the effects of local shortcuts between two sections of Mae Nam Mun, as shown in Figure 3.

THE WAY FORWARD IN THE MEKONG RIVER BASIN

Over the past years MRC has made efforts to improve the ISIS model for the Lower Mekong River Basin. Such a model is useful, though it must be realised that a model is just an abstraction of reality and not reality itself. The art of modelling is to arrive at a model which represents reality as closely as possible. Such achievement is limited by the following contributing factors:

- detailing of the model schematisation;
- quality of the underlying data;
- skill of the modelling team; and
- limitations of the 1D modelling concepts, as discussed earlier in this paper.

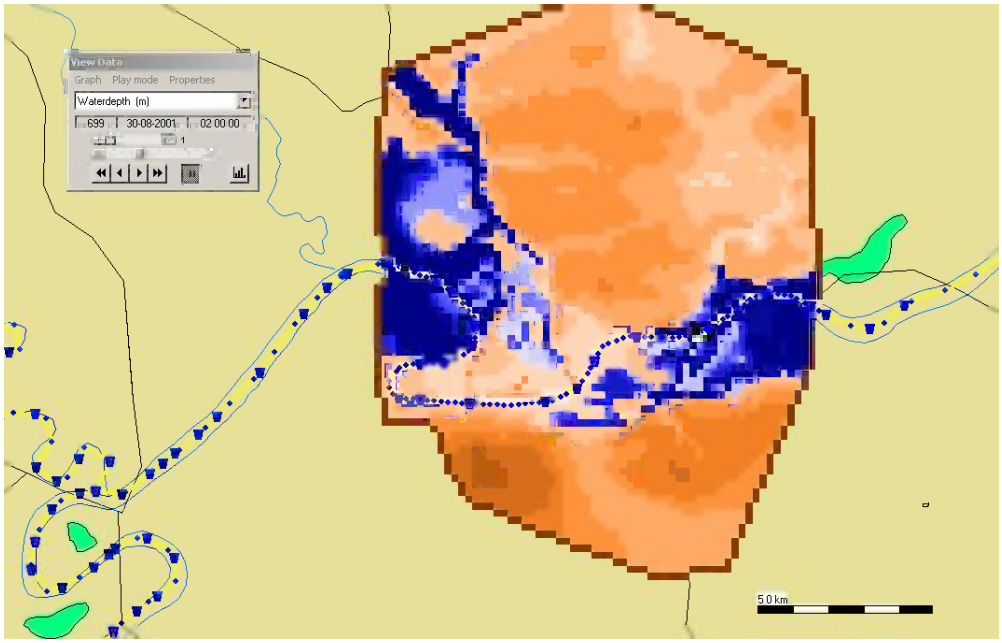

Figure 3. Detailed SOBEK 1D2D simulation of flooding in Ubon Ratchathani, Thailand

For the ISIS model, further improvement of underlying data used is still possible. For example, there is still scope to further improve the topographic data used. Recently, Vietnam has resurveyed the topography of its Mekong Delta and this information can still be processed in the model database. In Cambodia, new and more detailed topographic surveys would also lead to an improved model schematization. Moreover, the quality of the model calibration set could be advanced by the improved monitoring of rating curves at Kratie and Kampong Cham.

However, further improvement of the quality of underlying model data will soon lead to the insight that the 1D schematization concepts applied in the currently available ISIS instrument appear as new limiting factors in model improvement. Only by moving to the integrated 1D2D flood modelling concept, full use can be made of such new data and even improve the models based upon the currently available data.

But even with the current quality of data in the Lower Mekong River Basin, the use of integrated 1D2D modelling concepts would remove a number of uncertainties in the quality of flood propagation models and avoid lengthy discussion on the quality of some of the 1D schematization concepts being used.

In the same way, for other areas in the Mekong River Basin, the integrated 1D2D flood modelling would lead to improved models and to discussions focussing on the quality of underlying topographic data, their consistency, etc.

CONCLUDING REMARKS

So far, flood modelling in the Mekong River Basin is nearly exclusively based upon one-dimensional (1D) schematization concepts. With the continuously increasing computing power of PCs and notebooks the integration of 1D and 2D schematization methods has been

introduced and applied world wide.

The modelling system SOBEK of Deltares is likely the most successful introduction of such integrated concept and has proven its value of this concept in many countries of Europe, the USA, Australia and various countries in Asia, such as China, Taiwan, Hong Kong, Singapore, Indonesia, Thailand, etc.

Despite the problems MRC is facing with the quality of data in the vast area of the Basin, the introduction of integrated 1D2D modelling schematizations will already now benefit the quality of models developed for their flood simulations and even more so if the quality of data can be improved with new surveys.

Therefore, it is recommended to start as soon as possible with the application of integrated 1D2D modelling concepts for flood wave propagation simulation in the Mekong River Basin.

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Paper 5-2-2

REAL-TIME HYDROMETEOROLOGICAL OBSERVATION NETWORKS - DEVELOPMENT POSSIBILITIES FOR THE EARLY WARNING SYSTEM OF THE MEKONG RIVER BASIN

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ABSTRACT

Manual surface measurements have traditionally formed the basis for hydrometeorological observation networks. Although automation and real-time data communication has gradually increased, sufficient area coverage for minimizing uncertainties associated with spatial averaging of hydrometeorological variables is still relatively rare. The limited availability of real-time precipitation data for the Mekong River left bank (eastern) sub-basins of Lao PDR has been found to reduce the accuracy of flood forecasting. Also, the usage of surface data from Upper Mekong River Basin could be developed for better five-day water-level forecasts. During disasters like flash floods the lack of real-time hydrometeorological information for forecasting and advisory service contributes to unnecessary economic losses and human casualties. Therefore, a need to further develop hydrometeorological observation networks exists.

Longer lead times and improved input accuracy for flood forecasting can be reached by increasing observations of atmospheric water i.e. measuring water before it precipitates on a river basin. As tropical storms and typhoons arriving from the South China Sea cause the most severe flooding situations in the Mekong River Basin, enhanced observations, tracking and modelling of these storms is recommended for accurate medium-term flood forecasts.

In addition to satellite and aircraft observations, a very low frequency (VLF) long-range lightning detection network could be used to monitor convective activity and estimate rainfall associated with tropical systems over data-sparse sea areas. If suitable aircraft are available, dropsondes could enable even more detailed observations of tropical storms and their surrounding environment. Assimilation of any of these datasets into numerical weather prediction (NWP) models tends to improve both the storm track and precipitation forecasts. Weather radars play an important role in storm tracking and nowcasting over coastal and inland areas. Compared to conventional single polarization radars modern dual polarization weather radars can improve quantitative precipitation estimates (QPE) through hydrometeor classification and better data quality. Improving short term forecasts by assimilation of wind observations into NWP models such as the Fifth Generation Mesoscale Model (MM5) from weather radars is becoming evermore widespread. Finally, NWP model forecasts are used as input for medium term hydrological forecast models, while weather radar derived QPEs are combined with surface observations for improved nowcast input.

In our paper, we summarize recent findings related to operational applicability of these methods for improving hydrometeorological forecasts. Moreover, we discuss hydrometeorological observation system issues related to spatial configuration and overall performance.

INTRODUCTION

The Mekong River along with its numerous tributaries forms a significant international river basin. Its main stream stretches along for approximately 4800 km, while draining an area of around 795,000 km^2 (Mekong River Commission (MRC), 2005). The Upper Mekong River Basin (UMB) - represents around 1/4 of the entire river basin, draining the Chinese provinces of Qinghai, Xizang (Tibet) and Yunnan as well as parts of northern Myanmar. The Lower Mekong River Basin (LMB) covers the remainder of total catchment area with over 50 million people in four riparian countries (Thailand, Lao PDR, Viet Nam and Cambodia). This region is annually affected by tropical storms of varying intensities originating from the east or southeast. Three major causes for flooding in the LMB can be broadly be identified as 1) annual monsoon precipitation resulting in large scale river fed floods, 2) intense tropical depressions, storms and typhoons creating flash floods particularly in mountainous regions, and large scale river fed floods 3) floods caused by coastal storm surges in the Mekong Delta.

FOCUS OF THIS PAPER

Many geophysical phenomena like atmospheric storms do not respect artificial boundaries, such as national borders - floods in this sense make no exception. Often in context of operational hydrology however, the approach is often limited to certain natural drainage area. Although this is perfectly legitimate and justifiable, it is in our view however beneficial to expand these boundaries. Whilst considering the entire hydrological cycle as a single entity we can focus on the phenomenon that cause floods to begin with. By also focusing on the origins of these phenomenon's we can hope to provide more accurate and extended lead times for efficient flood forecasting. Therefore, we suggest that observations of the atmospheric part of the water cycle are given appropriate priority and importance in any serious attempts at improving flood forecasting accuracy and lead times. Since a large majority of tropical storms causing hazardous floods within the Mekong River Basin (MRB) originate from the South China Sea (SCS), we focus our discussion on the following target areas:

- the South China Sea and the Philippines, i.e. observations along the early route of most tropical storms and typhoons;
- the coastal or otherwise tropical storm prone provinces of Viet Nam and China, located either on or in the vicinity of the storm tracks having a potential to affect the Mekong River Basin;
- those regions within the Mekong River Basin with clear observational gaps, e.g. the poorly gauged eastern sub-basins of Lao PDR.

OBSERVATIONS AS PART OF THE FORECASTING SYSTEM

National hydrometeorological forecasting centres use various types of observational data, including surface observations (e.g. precipitation gauge, river gauge or weather station data), measurements of the upper atmosphere (like radiosonde or aircraft measurements) as well as various remote sensed data sets (e.g. satellite, weather radar, wind profiler data). Figure 1 shows an overview of a hydrometeorological forecasting system using such data, consisting of one or several numerical weather prediction (NWP) model(s) and hydrological model(s).

Modern assimilation techniques can accept observations performed during a system specific time frame, a so called assimilation window. As an example the global analysis performed every 6 hours (at 00, 06, 12, 18 UTC) by the Japanese Meteorological Agency (JMA) uses a 6 hour window of ± 3h (Japanese Meteorological Agency (JMA), 2007). The currently quite popular 4D-Var assimilation technique is capable of accepting both conventional

observation data and many types of more advanced data e.g. radar-rain gauge analyzed precipitation sums. Furthermore, with 4D-Var it is possible to assimilate observations made at actual unsynchronized observation times.

Whereas meteorological data assimilation has a history of over 30 years, the operational data assimilation in hydrology can still be considered as being in its early infancy (e.g. Walker et al., 2003; Beven, 2007; Seo et al., 2009). Therefore, there are still many open areas of research. For example, a considerable amount of effort (e.g. Reichle et al., 2001; McLaughlin, 2002; Komma et al., 2008) have been placed on studying the possibility of utilizing space borne remote sensing products for directly assimilating near-surface soil moisture estimates to hydrological forecast models. However, as Walker et al. (2003), quite appropriately point out; applying ever more complex data assimilation techniques involving distributed surface and sub-surface data creates a trade-off, where computational feasibility needs to be weighed against perceived benefits. These kinds of approaches can not be at the moment and likely in the very near future considered as a viable option for improving the performance of operational flood forecasting models. It is therefore, in terms of hydrological forecasting in our view relevant to concentrate on utilizing more traditional approaches.

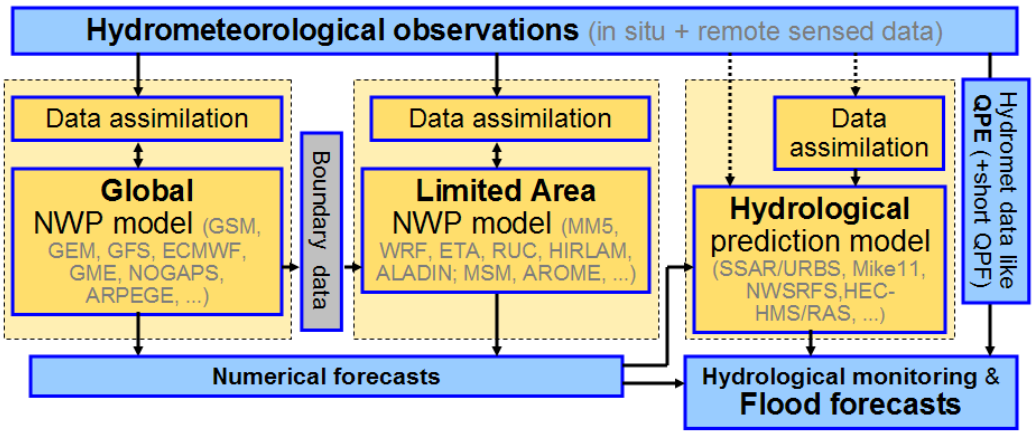

Figure 1. From hydrometeorological observations to flood forecasts.

In practice three broad categories for data assimilation can be identified; 1) error forecasting, where model output variables (generally speaking either river stage or discharge) are updated according to observed model residuals, 2) Kalman filtering or variational data assimilation, whereby all model system state variables and/or model parameters are restructured up to and prior to the time of forecast based on the relationship between observed hydrometeorological variables and discharge during an analysis window, 3) ensemble Kalman filtering whereby an ensemble of possible model states is integrated forward in time using a nonlinear forward model which replicates the noise typically caused by uncertainties in model forcing variables, system states, model structural errors and non-optimal parameterization. (Seo et al., 2003; Goswami et al., 2005; Reichle, 2008).

The combined use of Kalman filtering and error forecasting has been proven to be both very cost-effective and powerful in terms of improving hydrological forecast skill (e.g. Madsen and Skotner, 2005). Since, both of these assimilation approaches are heavily dependent on timely observations feeds, the argument for expanding and improving the real-time surface hydrometeorological observations network within the MRB can not be over emphasized. This along with a need to acquiring powerful, efficient and modern modelling systems has been acknowledged as a key limitation in current forecasting activities at Regional Flood Management and Mitigation Centre of the Mekong River Commission MRC-RFMMC), and a priority target for improvements during previous Annual Mekong Flood Forums (AMFF) (e.g. Pengel et al., 2008).

ON THECURRENT STATUS AND DEVELOMENT POSSIBILITIES OF HYDROMETEOROLOGICAL OBSERVATION NETWORKS

Surface and upper air measurements - look downwind and within the Mekong basin

Hydrological observations and modelling have traditionally been based on manual hydro-meteorological surface measurements. In meteorological observations, surface weather stations and radio sounding networks are considered core, whereas in hydrology this is extended to include hydrometric observations. Although automation and real-time data communication has gradually increased, sufficient area coverage for minimizing uncertainties associated with spatial averaging of hydrometeorological variables is still quite rare.

In October 2008, the World Meteorological Organization (WMO) performed its Annual Global Monitoring of data availability. The traditional hydrometeorological observations from key global observation networks were collected by the main data collection centres of the world, Global Telecommunication System (GTS). Figure 2a shows the availability of 00 UTC and 12 UTC atmospheric upper-level pressure, temperature, humidity and wind reports (Part A of coded report FM-35 TEMP) in the South-East Asia. Figure 2b depicts the availability of key surface weather reports (FM-12- SYNOP) for the same area (World Meteorological Organisation, 2009). With the exception of China and Viet Nam, the availability of radio sounding data, in particular downwind over the SCS and Philippines was found to be poor. No upper-level sounding stations are located on any of the islands of the Central SCS. Moreover, it appears likely that the forecasting community of the MRB has very limited possibilities to monitor the important lower tropospheric humidity flow of south westerly monsoons, indicated by e.g. the silent stations of Myanmar.

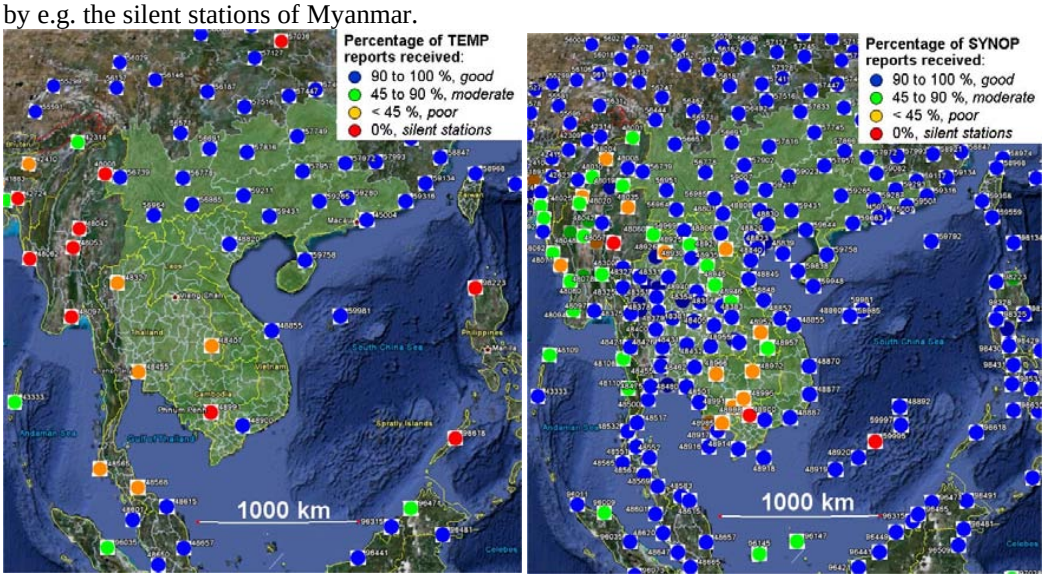

Figure 2. a) Availability of 00 and 12 UTC radio sounding reports (Part A of TEMP) from the South-East Asia during the WMO Annual Global Monitoring 1-15 Oct. 2008 (left figure). b) Availability of 00, 06, 12 and 18 UTC surface weather reports (SYNOP) during the same monitoring period (right figure, World Meteorological Organisation (WMO), 2009).

The availability of surface weather reports from the key synoptic weather stations in the MRB and the surrounding countries can be seen in Figure 1b. Although regional campaigns like HYCOS-Mekong and national updates have resulted in important network developments (Solangkuon, 2008; Saravuth et al., 2008), the availability of weather reports from Cambodia, Lao PDR and Myanmar still appear to be poor or moderate. This indicates problems either at the

observation sites or in data communication to GTS. It is important to acknowledge that within the MRB, this surface data is important for operational hydrological monitoring and forecasting. Moreover, this data as well as radio sounding data are used by both global and regional forecasting and monitoring centres to produce products that are used daily by the national hydrometeorological services of the MRB. The findings of the WMO thus indicate that the observations, if performed, cannot be fully utilized by international data users like global forecasting centres. This in-turn has a direct effect on regional weather forecast quality and an indirect effect on flood forecast quality for the MRB.

Lightning data in the estimation of convective rainfall

Numerous studies have looked at the relationship between lightning and rainfall on the storm-scale (Table 1, Kempf and Krider, 2003; this reference has similar comparison table for ground based precipitation gauges). These studies used both satellite-based radar reflectivity/rain gauges for rainfall estimation, and ground-based/satellite-based lightning detection networks for lightning detection. Table 1 demostrates that mean rain volume per cloud-to-ground (CG) flash is quite variable on shorter time and space scales, such as the storm-scale. However, the variability is greatly reduced when only examining isolated continental thunderstorms (Table 1) or oceanic storms (Pessi and Businger, 2009). Both rain gauge and radar reflectivity studies show values within a factor of 3-4 for isolated continental thunderstorms (Table 1).

Pessi and Businger (2009) compared convective rainfall rates obtained from the Precipitation Radar (PR) on the Tropical Rainfall Measuring Mission (TRMM) satellite with CG lightning flash rates obtained from Vaisala's Long Range Lightning Detection Network (LLDN) and total (cloud plus CG) lightning flash rates obtained from TRMM's Lightning Imaging Sensor (LIS). They found correlation coefficients of 0.96 and 0.92 when comparing hourly convective rainfall rates and lightning rates for central North Pacific summer and winter thunderstorms, respectively. Kuligowski and Scofield (2004) have shown that incorporating Vaisala's National Lightning Detection Network (NLDN) CG lightning data into the Self-Calibrating Multivariate Precipitation Retrieval (SCaMPR) algorithm improved convective rainfall estimates. SCaMPR automatically calibrates precipitation estimates from GOES IR-based predictors to microwave rain rates from the Special Sensor Microwave/Imager (SSM/I) and Advanced Microwave Sounding Unit (AMSU) satellites.

Table 1. Mean rain volume per CG flash on the storm-scale for studies using radar reflectivity for rainfall estimation (Table 1b in Kempf and Krider, 2003).

Study using radar	Location	Mean rain volume per CG flash (m^3 per flash)	Comments
Isolated thunderstorms			
Buechler et al. (1990)	Southeastern U.S.	$3.8 * 10^4$	21 isolated storms
Tapia et al. (1998)	Florida, USA	$4.3 * 10^4$	22 isolated storms
Soula et al. (1998)	Spain	$3.1 * 10^4$	1 storm causing a flash flood
Soula and Chauzy (2001)	France	$7.2 * 10^4$	4 isolated storms
Seity et al. (2001)	France	$6.8 * 10^4$	21 isolated storms over land
MCSs and large storm systems			
Williams et al. (1992)	Darwin, Australia	$5 * 10^5$ $5 * 10^6$	Continental regime Monsoon regime
Holle et al. (1994)	Central U.S.	$7.7 * 10^5$	MCS

Possibilities of weather radar networks

The quality and usefulness of radar data is often compared to gauge data and satellite techniques; the present consensus is that they are not competitive but complementary approaches. Key application areas of weather radar systems in operational hydrology include early warning systems such as storm hazard assessment with flood forecasting, warning, and control (Cluckie and Collier, 1991). Even though aloft radar measurements do not always represent rainfall intensity at the surface, the outstanding spatial resolution makes radar data attractive.

Radar data is well suited to real-time flood forecasting applications, but they have also been used for assessing water resources and providing a basis for engineering design. This is very true in areas where rain gauge network is sparse (Meischner, 2004). In addition to QPE one of the most important applications of the weather radar is nowcasting so called quantitative precipitation forecast (QPF) up to 6 hours. Contrary to typical NWP models, which typically take about 6 hours before they show reasonably good forecast skill, nowcasting techniques typically provide the best forecast skill within the first 30-60 minutes with decreasing skill out to six hours. These extrapolation techniques are especially important for flash flood forecasting, and guidance (Collier, 2000; Collier and Krzysztofowicz, 2000).

Attenuation using shorter wave lengths has been traditionally considered as a serious limitation for C-band weather radars in climates of intense rain. With the modern operational dual polarization weather radar this traditional problem can be avoided. Dual polarization C-band weather radar provides precipitation fields at high spatial resolution (Bringi and Chandrasekhar, 2001). With the transition of dual polarization techniques from laboratory into production weather radar systems, such as the Vaisala WRM200, many weather services that traditionally used S-band systems are now reconsidering to use polarization C-band systems instead. The cost issue is often the primary motivation. Optimal siting forms the basis for ideal, cost-effective C-band radar network configuration. An installed C-band system is 1/2 to 1/3 the price of an S-band system having comparable antenna gain and transmitter power. Therefore, over complex terrain where mountains create blockages for the radar measurements, good radar coverage of flash flood prone sub-basins can be much better guaranteed by locating two or three C-band dual polarization weather radars instead of just one S-band radar. Dual polarization C Band weather radars, equipped with advanced signal processing techniques, offer new methods to mitigate attenuation, which has previously been seen as a major limitation for broader use of short wave lengths technology in climates of intense precipitation (Keränen et al., 2008).

NWP models are moving towards a super-fine resolution of a couple of kilometres. From this perspective radar data assimilation has exciting potential for improving forecasts in high resolution (Salonen et al., 2008). Therefore, new mesoscale NWP models need high resolution wind and moisture observations for initialisation, which radar networks are well placed to deliver (Meischner, 2004). Wind is one of the primary prognostic variables in NWP models. Assimilation of weather radar based radial wind observations has also shown clear improvements in mesoscale precipitation forecast skill. This can partly be attributed to better descriptions of air flow related to atmospheric convection.

DISCUSSION AND CONLUSIONS

Keeping the entire hydrological cycle in mind, we suggest that longer lead times and improved input accuracy for flood forecasting can be reached by increasing observations of atmospheric water - i.e. measuring water before it precipitates on a river basin. As tropical storms and typhoons arriving from the South China Sea cause the most severe flooding situations in the MRB, enhanced observations, tracking and modelling of these storms is recommended for accurate medium-term flood forecasts.

In conclusion, we propose the following actions to target the observational weaknesses of the Mekong River Basin EWS (Figure 3).

Figure 3. Key action points in targeting the observational weaknesses of the Mekong River Basin EWS.

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Paper 5-2-3

ENHANCED DISCHARGE MEASUREMENTS IN IRRIGATION CANALS USING MULTI-FREQUENCY ACOUSTICS

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ABSTRACT

The application of acoustic Doppler technology for water velocity measurements initiated in the late 1970's as an oceanographic application and has evolved into a reliable standard for discharge measurements throughout the world. The increased demand and pricing for water resources has also created the demand for increased precision and accuracy for water users particularly in the irrigation industry. SonTek's Next Generation RiverSurveyor products, the S5 and M9, present end users with a new discharge measurement instrument that is easy to use yet highly robust in its data collection and processing. Typical discharge measurements with the S5 or M9 take only a fraction of the effort when compared to traditional gauging instruments. Multiple frequencies present users a high resolution velocity profile, as well as an extended bottom tracking range. Using the new system, the built-in echo-sounder and multiple frequencies allow the system two options to define cross-sectional area that are extremely accurately regardless of depth. The echo-sounder measures directly below the instrument to measure exact transect profile; this feature eliminates extrapolation errors of the traditional acoustic Doppler profilers by accurately defining discharge cross-sectional area, a key component when calculating discharge. The Next Generation RiverSurveyor has been used in irrigation districts in the South-western US, as well as throughout the world. Case studies will be presented analyzing a wide range of gauging scenarios, while highlighting the benefits of the technological advancement.

INTRODUCTION

The use of hydro-acoustic instruments to directly measure discharge in medium to shallow rivers and canals has been around for more than two decades. In the past, this technology was developed from instrumentation originally designed for oceanographic applications. Specialized software and floating platforms have extended the usability of these instruments in open channels; however, there were limitations caused by instruments operating at a single frequency that reduced the dynamic measurement range of the instrument. A recent advance in commercial microelectronics has greatly increased the capability of these devices intended for discharge measurements, including the ability to operate at multiple frequencies.

Taking into account the increasing demand for water resources and the continuing concerns of the long term impact of global climate change has presented many end users the need to for better accounting of water uses. Currently, in Australia there is a 10 year - hundreds of millions of dollars initiative for metering non-urban flow. Closer to home, the State of California has passed a number of Propositions, Proposition 50 for example, that would allocate tens of millions of dollars for the water resource monitoring and water use efficiency. In every case, these initiatives were developed with the idea to move from the old mechanical technologies to the newer highly accurate and precise technologies.

The importance of a good measurement is fundamental in the management and development of data; without good data the user can make poor and uninformed decisions. A good measurement is driven by site selection, the user's knowledge of "how to" make a proper measurement and measurement instrument capabilities. Typically a good site is easily accessible and has a well defined cross-section or transect. Velocity profiles should be well distributed and flowing perpendicular to the cross-section to be measured. The user "know how" is a key factor for making a discharge measurement and more often than not the user's knowledge of the instrument and the characteristics of the surrounding area guide the user to making an accurate measurement. Instrument capabilities are an important factor in accurately describing flow velocities which is translated into a discharge measurement by multiplying by discharge area. Describing all instrument characteristics is beyond the scope of this paper; however this paper will describe the latest developments in hydro acoustics and presents 5 case studies applying the RiverSurveyor.

NEXT GENERATION RIVERSURVEYOR TECHNOLOGY - KEY DEVELOPMENTS

Multi - frequency Acoustic Doppler Profiler ADP

There are several key developments for the RiverSurveyor that will provide discharge measurement end users with increased accuracy and precision as well as ease of use. The application of multi-frequencies to the ADP gives the user increased accuracy and precision on shallow to deep measurements without changes modes or configurations. Figure 21 and 2 display schematics for the 5-beam S5 and the 9-beam M9, respectively.

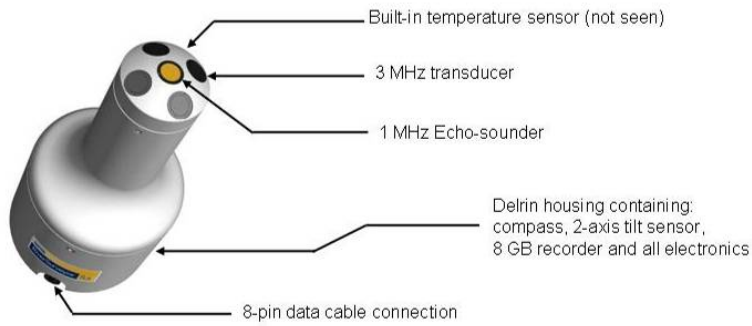

Figure 21. S5 RiverSurveyor ADP

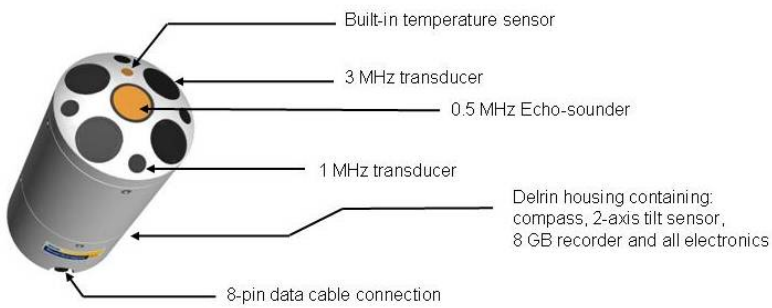

Figure 22. M9 RiverSurveyor ADP

The S5 uses a 1 MHz echo sounder for depth measurement with 4 - 3.0 MHz transducers for bottoming tracking and velocity profiling. The M9 utilizes a 0.5 MHz vertical beam with 4 - 3.0 MHz and 4 - 1.0 MHz transducers for bottom tracking and velocity profiling. In all cases the velocity profiling transducers are configured using a Janus 25° slant angle. The new multi frequency design compounded with increased profiling and depth measurements present the users significant improvements for discharge measurements. Table 7 displays depth and velocity profiling ranges

Table 7. Summary of transducer frequencies and profiling ranges for the S5 and M9

ADP type	Velocity profiling frequencies (MHZ)	Vertical beam frequency (MHZ)	Velocity profiling range		Depth measurement range	
			M	ft	m	Ft
S5	3.0	1.0	0.06 - 5.00	0.20 – 16	0.20 - 15	0.60 -49
M9	3.0/1.0	0.5	0.06 - 30.	0.20 – 98	0.20 - 80	0.20 – 262

Power and communications

The RiverSurveyor Power and Communications Module (PCM) provides integrated solutions for power, communications and navigational information. Each system is supplied with 2 rechargeable battery packs each provide the system power for 6+ hours. In addition, the unit has the capability for short or long range communications as well as GPS solutions. Figure 23 displays a drawing of the PCM and Figure 24 displays the SonTek Hydroboard, which provides quick mounts for the ADP and PCM and is light weight enough for one man operation.

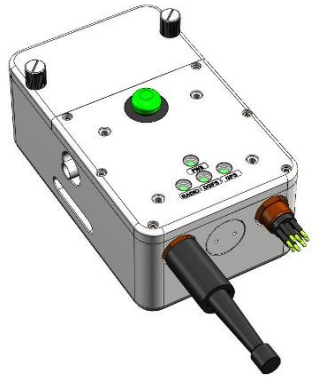

Figure 23. RiverSurveyor PCM

The PCM uses Bluetooth technology for short-range communications while a 900 MHz spread spectrum radio is used for the long range communications. Short range communications utilizes a laptop which has a range up to 200 m or 650 ft or a mobile phone platform that has a range up to 60 m or 200 ft. The spread spectrum radio has a range to approximately 1,600 m or 1 mile. Table 8 presents a summary of communications options and corresponding range.

Table 8. Summary of communications options and corresponding ranges

Communications type	Range
Bluetooth	Mobile 60 m (200 ft), Laptop PC 200 m (650 ft)
900 MHz Spread Spectrum	1600 m (1 mile)

Figure 24. SonTek RiverSurveyor assembled on SonTek Hydroboard

Additional Differential Global Positioning Satellites (DGPS) (sub metre accuracy) and Real-time Kinematic RTK-GPS (sub 3 cm accuracy) solutions are integrated into the PCM to provide highly accurate navigation data. These options provide end users a wide range of options for telemetry and present useful and accurate solutions for navigation that are ideal for moving bed situations. Table 9 presents a summary of GPS type and accuracy.

Table 9. Summary of GPS options and corresponding accuracy

Integrated GPS option	Accuracy	
	m	ft
Differential GPS (DGPS)	< 1m	< 3.3
Real-time kinematic GPS (RTK)	≤3 cm	≤ 0.01

Ease of use

The Next Generation RiverSurveyor was developed with the user in mind; after a brief set-up there are on only five steps to complete a discharge measurement. Figure 25 presents the steps involved in the discharge measurement process. The software design allows the user to measure discharge from shallow to deep water without changing modes or cell sizes, settings automatically change by recognizing water depth and optimal resolution for the discharge measurement. In addition, the data are stored in the ADP making the measurement process stable and flexible. This is an important improvement as it allows the user to connect and disconnect from the ADP and still collect data. Previously all data were stored on the laptop with communications drops due range would require a complete re-start for data collection. Additionally, all Bottom Tracking, GPS and depth data are collected. This allows the user multiple options for discharge calculation during post processing.

Figure 25. Five steps in completing a discharge measurement[10]

CASE STUDIES - RIVERSURVEYOR APPLICATIONS

This section will provide a series of case studies explaining the use of the RiverSurveyor in a wide variety of conditions. The case studies include five canals near Yuma, Arizona area that were either a United States Geological Survey (USGS) or Imperial Irrigation District (IID) gauged/rated sites. All measurements applied USGS protocols and were conducted on January 15 and 16. Figure 26 presents gauging sites used in this paper.

Figure 26. Locations of gauging sites for case studies

Table 10 presents a summary of the data collected in the field. The table provides details for Track and Depth References used for the measurements. It can be observed from the data that overall system performance was excellent with covariance measurements ranging between 0.004 - 0.044 (or 0.4 - 4.4%) while the difference from gauged values ranged from -3.5 - +0.4%. It is important to consider that rating curves for the site were developed using different instruments.

[10] Note: Figure above is from the Mobile Platform; while the presentation on the laptop PC is slightly different the steps in the process are exactly the same.

Table 10. Summary of data collected in the Lower Colorado River Basin

Station	Q_{RS}		Track/depth	STD DEV		COV	Q_{GAUGE}		% Difference
	m^3/s	ft^3/s		M^3/s	ft^3/s		m^3/s	ft^3/s	
All American Station 60	130	4,580	RTK*/VB+	0.54	18.9	0.004	134	4,740	-3.5
Gila Gravity Main	25.3	857	Bottom track/beam	0.37	12.9	0.015	24.2	854	+0.4
Reservation Main	2.78	98.0	VTG#/VB+	0.12	4.29	0.044	2.83	100	-2.0
Wellton Mohawk Main	13.3	469	RTK*/VB+	0.17	6.08	0.013	13.3	470	---
Wellton Mohawk Drain	5.32	188	RTK*/VB+	0.09	3.14	0.017	5.30	187	---

*RTK refers to Real Time Kinematic GPS
+VB refers to Vertical Beam
#VTG refers to the VTG GPS string using a differential GPS correction

Figure 27 presents a graphical summary of the M9 data collected on the All American Canal - Station 60. The graph in the top portion of the figure compares Bottom Track (BT) and Vertical Beam (VB) data. The Depth Reference data shows good agreement; however the VB better represents the trapezoidal canal, while BT has the tendency to round off corners due to depth determination being the average of the 4 beams in a 25° Janus configuration. The middle graph presents Track Reference data which also provides good agreement. The bottom graph presents velocity profile information across the measured transaction; note the cell velocities go from blue (slow) to red (fast). Overall performance of this site was optimal. It is important to observe that the RiverSurveyor measurement for the site was 3.5% less the gauged value. Observations made at the site indicate that instruments used in development of the rating curve had a much higher standard deviation (on the order of 10-fold or more) than the RiverSurveyor measurements conducted at the site.

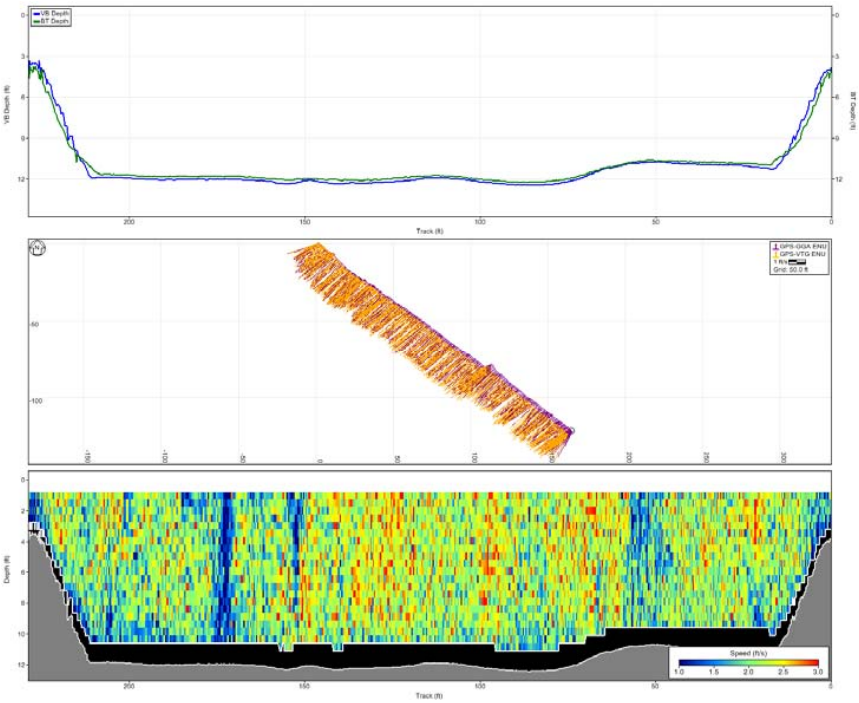

Figure 27. Data View - All American Canal Station 60

Figure 28 displays M9 data collected Gila Gravity Main Canal. The Gila Gravity Main Canal is a considerably smaller trapezoidal concrete channel than the All American Canal Station 60, however performance was similar recording a covariance of 0.015 (precision) for the four transects with a 0.4% difference from gauge rating. Depth Reference data was good with only slight variations observed in BT and VB data, while the same conclusions can be applied to Track Reference information. The bottom graph in Figure 28 displays velocity profile data (cell velocity data). It can be observed in this data that cell sizes on the left and right margins are larger that the cells in the middle of the transect. This can be explained by the M9 shifting from the 3 MHz transducers to the 1 MHz transducers, cell size and frequency hoping are done automatically based on depth.

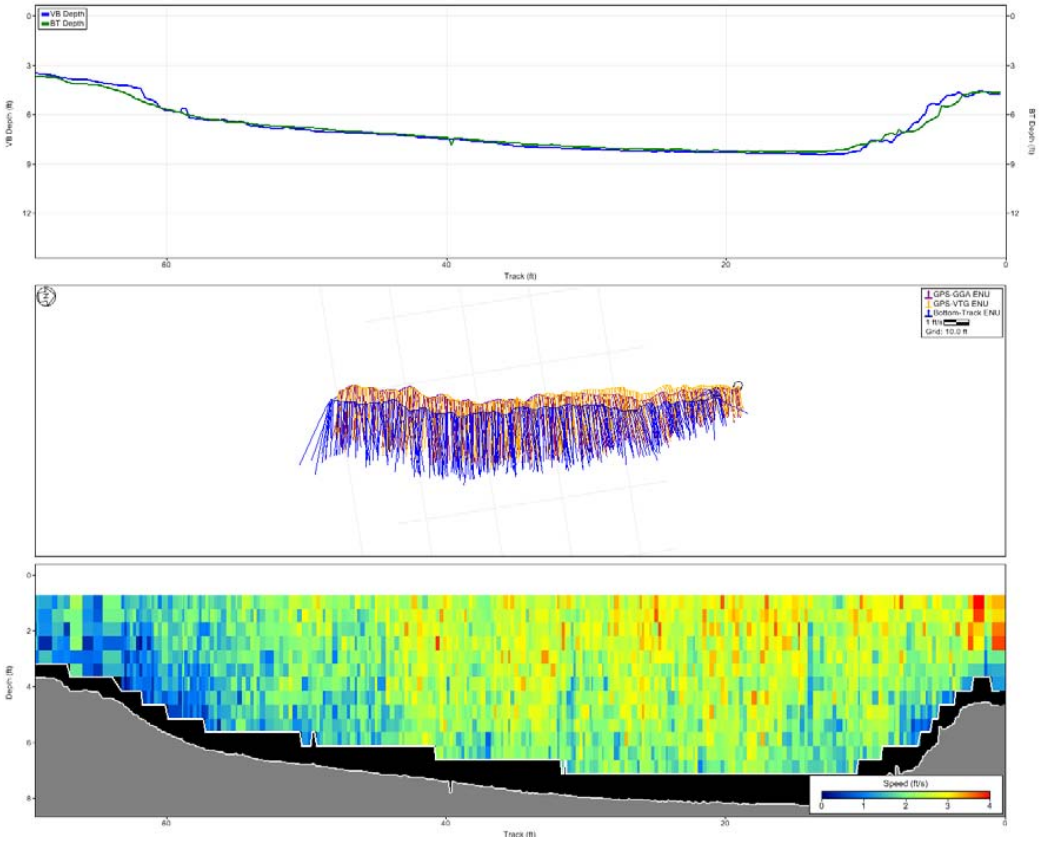

Figure 28. Data View - Gila Gravity Canal

Figure 29 highlights the S5 data from the Reservation Main Canal (USGS Station 09522500). The S5 collected almost equivalent data for Depth and Track Reference data for the earthen channel. BT data was not used in this case as the Reservation Main Canal is an earthen canal with deposits fine sediments on the bottom of the canal which proposes a potential problem for a moving bed. RTK GPS was not utilized for this paper in an effort to evaluate the performance of the VTG Track data in small to medium sized canals. Overall performance was good with a 0.044 value for Covariance and a -2.0% difference with the rated value. Observations can be made from the bottom graph as velocity profiling cell sizes changed automatically from smaller sizes (5 cm) on the edges to larger cell sizes (15 cm) in the middle of the transect as depth of the canal increased.

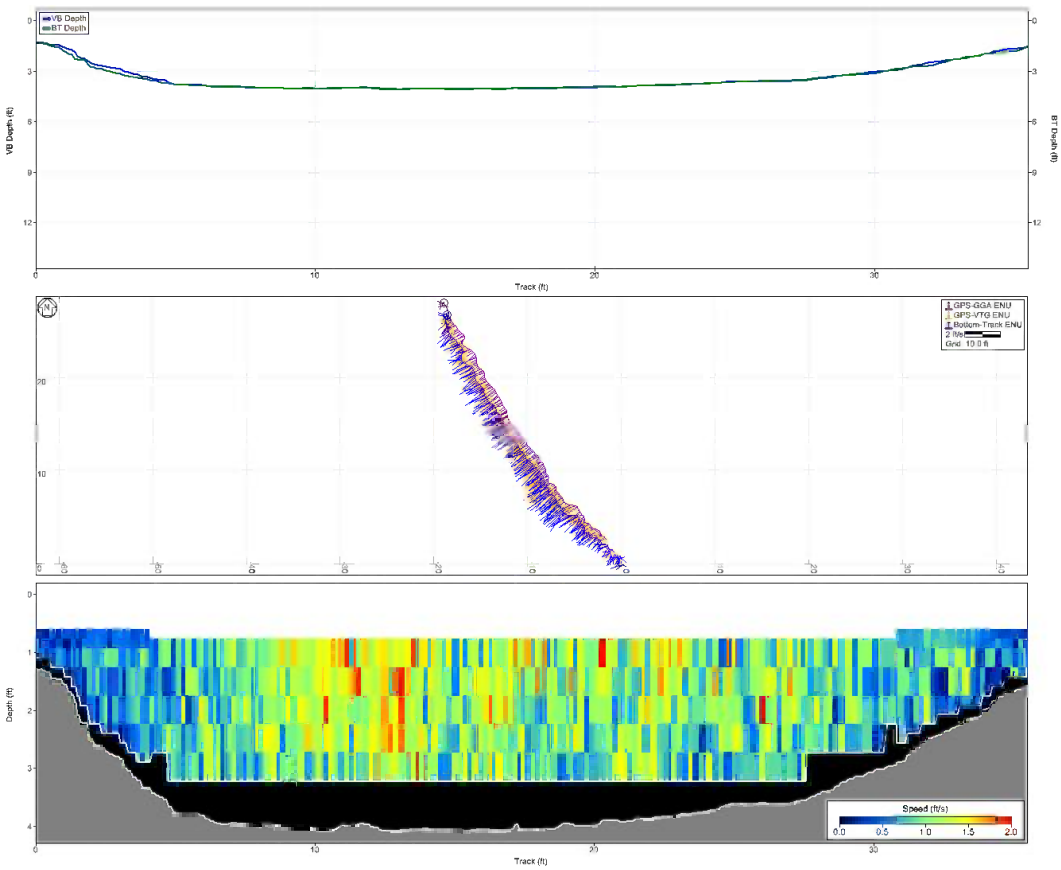

Figure 29. Data View - Reservation Main

Figure 30 presents the data collected at the Wellton Mohawk Main Canal using RTK GPS for Track Reference and the VB for Depth Reference. Results of gaugings for the trapezoidal concrete canal were identical to the rated value 13.3 m^3/s (470 cfs) with a standard deviation of 0.17 m^3/s (6.08 cfs) and a covariance of 0.013. Observations of the data indicate that the left edge has a significant build-up of sediments, approximately 1 m (3 ft) with the highest velocities measured on the right edge of the canal. The Depth Reference data had slight discrepancies and this can be attributed to the steep walled trapezoidal canal and the depth calculation of the beam data and corresponding calculation. All Track Reference data were consistent with each other indicating that all data were valid for this gauging. It can be observed from the bottom graph that at approximately 2.4 m (8 ft) of depth, the S5 automatically shifted from 5 cm cell size to a 15 cm cell size.

Figure 31 presents data collected at the Wellton Mohawk Drain. Depth Reference data was good with only slight differences observed in the BT and VB data. However Tack Reference data shows a major discrepancy between the GPS data and the BT data. The BT data indicates the track moving upstream while the GPS data presents a fairly straight line closing the transect. BT data indicates the presence of a moving bed therefore this data is not valid for the discharge measurement. Using the RTK GPS track information and VB data for Depth Reference the S5 data matched the rated values, with the S5 data presenting a standard deviation of 0.09 m^3/s (3.14 cfs) (covariance of 0.017). Observations at the site indicated the presence of thick algae attached the bottom of the concrete lined channel. These algae would bias the Track data, making it appear that the rover is moving upstream; this also would bias the velocity data by decreasing the water velocity measurements and therefore decreasing the overall measured discharge.

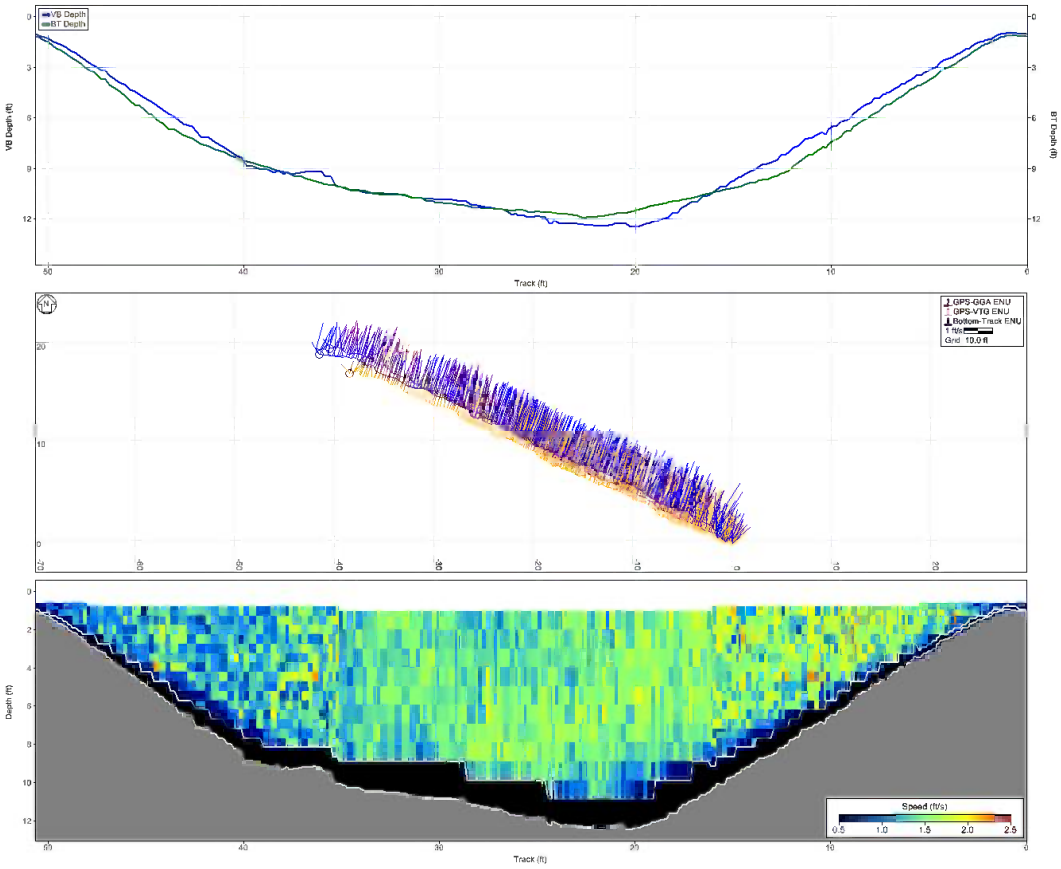

Figure 30. Data View - Wellton Mohawk Main

CONCLUSIONS

The case studies presented above indicate the RiverSurveyor is highly accurate when comparing discharge measurements to rated values of the USGS and IID, overall percent differences range from -3.5 to +0.4%. In addition, that data presented demonstrates a high level of precision of the measurements with covariance ranging from 0.004 to 0.044. The multiple Track and Depth data provide valuable information about the measured sites, such as sediment build up, velocity profile data and detection of moving beds.

The system provides a high degree of flexibility, collecting multiple Track and Depth data references which allow the user many options in post processing and discharge measurement calculations. The examples above described combining the vertical beam with RTK GPS, Beam and VTG GPS data to determine discharge. Best case scenario would be to always have RTK GPS information available in order to make viable measurements in the case of moving bed sites which are typical of flooding events, plant growth and other potential complications.

The system is easy to use with site set-up and preparation taking less than 10 minutes, which includes obtaining an RTK lock. Data collection follows the 5 steps described above while the RiverSurveyor applies automatic cell size adjustments based on water depth, this allows users to focus on the process of data collection and not instrument configuration.

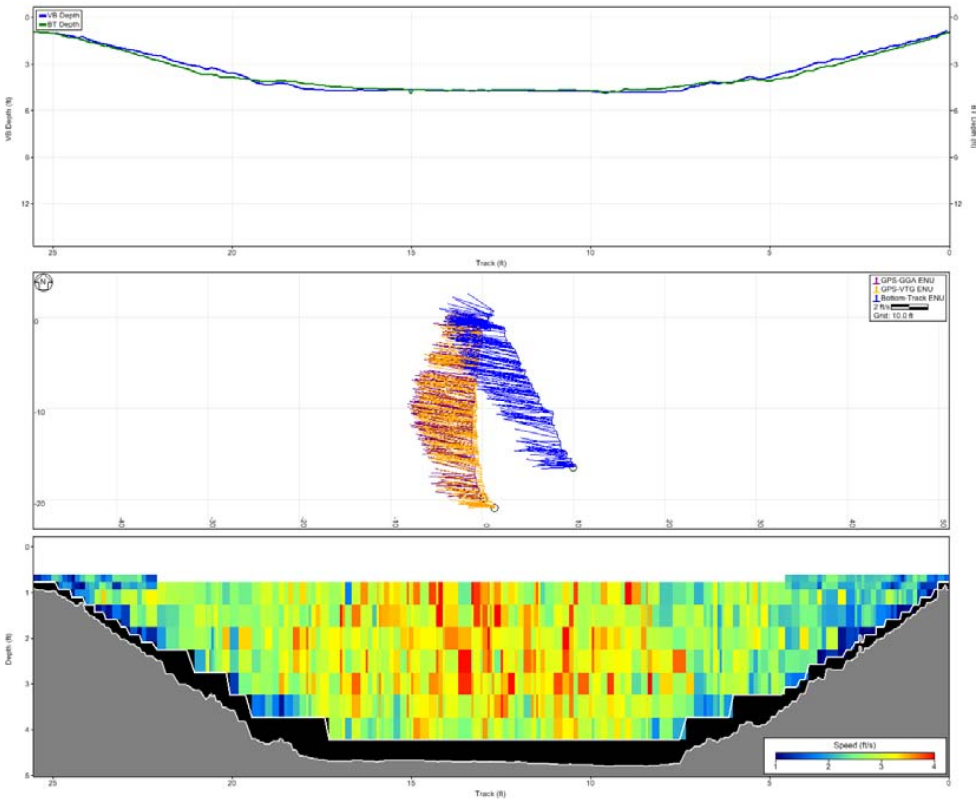

Figure 31. Data View - Wellton Mohawk Drain

Paper 5-2-4

STATUS OF MRC HYDRO-METEOROLOGICAL NETWORK FOR RIVER MONITORING

SOMPONG BOONPRASERT

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ABSTRACT

The Mekong River Commission Secretariat (MRCS) at present operates 17 hydro-meteorological stations (AHNIP) along the Mekong mainstream. Two stations are in Southern China, namely Jinghong and Man An (in tributary) stations. Fifteen other stations are located in the four member countries. The stations automatically record river water level and rainfall at hourly interval and generally transmit the recorded data one time a day via GSM system in the morning to four national data terminals and then to MRCS headquarter in Vientiane as well as to the Regional Flood Management and Mitigation Centre (MRC-RFMMC) of the Mekong River Commission (MRC) in Phnom Penh. During July, August and September more frequent data transmission is made to suit MRC-RFMMC requirement in flood forecasting. For tributaries of the Mekong River, 30 new hydro-met stations (Mekong HYCOS) have been under installation which is expected to be completed in 2009. The Mekong HYCOS stations are designed to automatically collect water level and rainfall data at 15-minute interval and transmit recorded data at one hour interval via General Packet Radio Service (GPRS) system. Also under the Mekong HYCOS, additional two stations for navigation purpose are located in coastal sea of Viet Nam to record sea water level. MRCS has a plan to upgrade the equipments of AHNIP stations of the four MRC Member Countries to that of Mekong HYCOS, aiming for integration of all stations into a single MRC Hydro-meteorological Network. The network integration is planned to be completed by 2010. With the new Mekong HYCOS, all key tributaries can be monitored thus enhancing a better near real-time river monitoring and flood forecasting for the mainstream and tributary basins of the Lower Mekong River Basin.

MRC HYDRO-METEOROLOGICAL DATA COLLECTION CONTEXT

A good understanding of the physical conditions of the major rivers in the basin is fundamental to the effective application of Integrated Water Resource Management (IWRM) principles. MRC through the Hydro-meteorological Data Component of Information and Knowledge Management Programme (IKMP), seeks to maintain the ongoing collection of critical time series data and to further the understanding of the physical condition of the mainstream and major tributaries in the Mekong River Basin through appropriate data collection activities. A large challenge is the technical coordination of the collection of a very wide range of data types, achieving time critical data collection and acquisition in cooperation with a variety of institutions across the basin.

The benefits that the MRC currently provides with respect to regional hydro-meteorological data collection concentrated on (i) trans-boundary/international data sharing and use and (ii) provision of data for monitoring and modelling analyses including flood forecasting.

For hydro-meteorological data observation, there are currently two hydro-meteorological systems: (i) the Appropriate Hydrological Network Improvement Project (AHNIP) system and

(ii) the Mekong HYCOS -Hydrological Cycle Observing System.

MRCS keeps improving its data assembly and dissemination roles by paying great effort in securing financial and technical support, capacity building, support of human resources, creating awareness and understanding for the need for data exchange and sharing, equipment, putting real time data on the website, reconciling water levels to a common datum, increasing the number of stations of the hydro-meteorological network to improve coverage, reliability and accuracy, assuring data quality assurance and standardization, provision of metadata and version control, and improvements in data access and communication.

THE APPROPRIATE HYDROLOGICAL NETWORK IMPROVEMENT PROJECT (AHNIP)

The AHNIP was established in April 2001 with funding from the Australian Government. Until March 2006 the project improved existing hydrological stations along the Mekong mainstream, all of which were then equipped with a telemetry system to support MRC capability for real-time flood forecasting and early warning. The AHNIP system was implemented with the aim of supporting the establishment of the MRC flood forecasting and early warning system, which is presently carried out by the MRC-RFMMC. The project was extended to August 2007. The extended activities of AHNIP covered (i) interim replacement of field equipment and support of AHNIP objectives; (ii) development of an MRC Information and Knowledge Management Policy; and (iii) formulation of the Project Document for the technical upgrade of the AHNIP Network and the integration with the Mekong HYCOS Network.

The main outputs of AHNIP are (1) Improvement of 17 hydrological stations along the mainstream of Lancang/Mekong River to report near real time data to the MRCS and MRC member countries for the purpose of water and related resources management, with an emphasis on trans-boundary issues under the framework of Water Utilisation Plan of the MRC; (2) Strengthen capacity in the MRCS and member countries in managing, operating and maintaining a real time hydro-meteorological network and sharing the data.

Mekong HYCOS-Hydrological Cycle Observing System

The Mekong HYCOS is another project of the MRC Hydro-meteorological network aiming at strengthening both the technical and institutional capacity for hydrological and meteorological monitoring in the Mekong Basin. It complements the existing hydro-meteorological network (AHNIP) and provides reliable real-time data from the Mekong mainstream and its major tributaries. The Mekong HYCOS project also forms a regional component of the global WHYCOS[11] programme. The Mekong HYCOS will serve as a priority data acquisition system for the flood forecasting and early warning system of the MRC-RFMMC.

The Mekong HYCOS project will install, in the four Member Countries, a total number of 30 water level and rain gauging stations and two tidal measuring stations (for navigation purposes). They are considered as Lots 1 and 2 projects (Tables 1 and 2, and Figure 1). The 17 AHNIP stations will be finally upgraded with HYCOS equipments and considered as Lot3 of the Mekong HYCOS project (Table 3 and Figure 1). Meteorological parameters other than water level and rainfall are not proposed at this stage. According to the project document, the identification and prioritization of the monitoring station locations were decided through dialogue amongst the project national collaborators and the MRCS. Mekong HYCOS implementation has been ongoing since September 2006. The project is expected to be completed by the end of 2009.

[11] The World Hydrological Cycle Observing System (WHYCOS) is a WMO programme aiming at improving the basic observation activities, strengthening the international cooperation and promoting free exchange of data in the field of hydrology. It is guided by the WHYCOS International Advisory Group (WIAG). (ref. www.whycos.org)

Table 1. List of Mekong-HYCOS stations (Lot 1)

Updated 01 April 2009

N°	Station Code	Station	River	Coordinates (WGS 84)		Country	Parameter	WL Sensor	Telemetry	Power supply	Date of Equipment installed		Remarks
				Latitude	Longitude						Phase 1 (2008)	Phase 2 (2009)	
1	033401	Chaktomuk	Bassac	11.563	104.935	Cambodia	WL/T/BV	Bubble	GPRS (Mobitel)	Solar Panel	15-Jul	19-Mar	SimCard Replaced (Postpaid to Prepaid)
2	440102	Voeun Sai	Sesan	13.968	106.885	Cambodia	WL/R/T/BV	Bubble	GPRS (Mobitel)	Solar Panel		21-Mar	
3	450101	Lumphat	Sre Pok	13.501	106.971	Cambodia	WL/R/T/BV	Bubble	GPRS (Mobitel)	Solar Panel		22-Mar	
4	430102	Siempang	Sekong	14.118	106.389	Cambodia	WL/R/T/BV	Bubble	GPRS (Mobitel)	Solar Panel		23-Mar	
5	610101	Kompong Thom	Stung San	12.715	104.888	Cambodia	WL/R/T/BV	Radar	GPRS (Mobitel)	Solar Panel	16-Jul	20-Mar	SimCard replaced (postpaid to prepaid)
6	550102	Battambang	Sangker	13.092	103.200	Cambodia	WL/R/T/BV	Radar	GPRS (Mobitel)	Solar Panel		18-Mar	
7	230113	Phiengluang	Nam Ngum	19.568	103.071	Lao PDR	WL/R/T/BV	Bubble	GPRS (ETL)	Solar Panel		9-Mar	
8	120101	Ban Mixai	Nam Khan	19.786	102.183	Lao PDR	WL/R/T/BV	Bubble	GPRS (ETL)	Solar Panel	23-Jul		
9	100102	Muong Ngoy	Nam Ou	20.570	102.617	Lao PDR	WL/R/T/BV	Radar	GPRS (ETL)	Solar Panel		6-Mar	
10	320107	Mahaxai	Se Bang Fai	17.419	105.196	Lao PDR	WL/R/T/BV	Bubble	GPRS (ETL)	Solar Panel		4-Mar	
11	430106	Ban Veunkhen	Se Kong	14.819	106.806	Lao PDR	WL/R/T/BV	Bubble	GPRS (ETL)	Solar Panel	26-Jul		
12	011901	Vientiane KM4	Mekong	17.931	102.616	Lao PDR	WL/R/T/BV	Bubble	GPRS (ETL)	Solar Panel	21-Jul		
13	050115	Ban Mai Bua Daeng	Nam Kok	20.025	99.960	Thailand	WL/R/T/BV	Bubble	GPRS (AIS)	Solar Panel	31-Jul		
14	050115	Ban Tha Kok Doeng	Nam Sonkhram	17.866	103.775	Thailand	WL/R/T/BV	Radar	GPRS (AIS)	Solar Panel			
15	150101	Wang Saphung	Nam Loei	17.300	101.776	Thailand	WL/R/T/BV	Bubble	GPRS (AIS)	Solar Panel			
16	440201	Kontum	Dak Bla	14.347	108.034	Viet Nam	WL/R/T/BV	Bubble	GPRS (Mobifone)	Electricity			
17	450701	Duc Xuyen	Krong Kno	12.296	107.976	Viet Nam	WL/R/T/BV	Bubble or Radar	GPRS (Mobifone)	Solar Panel			
18	451305	Ban Don	Se Re Pok	12.898	107.784	Viet Nam	WL/R/T/BV	Shaft Encoder	GPRS (Mobifone)	Electricity			
19	019804	My Thuan	Mekong	10.275	105.926	Viet Nam	WL/R/T/BV	Shaft Encoder	GPRS (Mobifone)	Solar Panel			
20	039803	Can Tho	Bassac	10.053	105.787	Viet Nam	WL/R/T/BV	Shaft Encoder	GPRS (Mobifone)	Electricity	7-Jul		
21	019826	Vam Kenh	Mekong	10.274	106.737	Viet Nam	WL/R/T/BV	Shaft Encoder	GPRS (Mobifone)	Solar Panel	9-Jul		
22	039814	Dinh An	Bassac	9.533	106.363	Viet Nam	WL/T/BV	Radar	GPRS (Mobifone)	Solar Panel	12-Jul		
23	019829	Cau tieu	Mekong	10.566	106.083	Viet Nam	WL/T/BV	Radar	GPRS (Mobifone)	Solar Panel	10-Jul		

Note : WL = Water Level, R = Rainfall, T = Air Temperature inside the shelter and BV = Batery Voltage

Table 2. List of Mekong-HYCOS stations (Lot 2)

Updated 01 April 2009

N°	Station code	Station	River	Coordinates (WGS 84)		Country	Parameter	WL sensor	Telemetry	Power supply	Date of Equipment installed	
				Latitude	Longitude						Phase 1 (2008)	Phase 2 (2009)
1	640102	Kompong Speu	Prek Thnot	11.456	104.496	Cambodia	WL/R/T/BV	Radar	GPRS (Camshin)		Solar Panel	16-Mar-09
2	530101	Sisophon	Sisophon	13.584	102.979	Cambodia	WL/R/T/BV	Bubble	GPRS (Camshin)	Solar Panel		Postponed due to the delay of civil work
3	350105	Sopnam	Se Bang Hieng	16.687	106.215	Lao PDR	WL/R/T/BV	Bubble	GPRS (ETL)	Solar Panel		27-Mar-09
4	270502	Ban Nape	Nam Phao	18.305	105.073	Lao PDR	WL/R/T/BV	Radar	GPRS (ETL)	Solar Panel		31-Mar-09
5	350101	Ban Kengdone	Se Bang Hieng	16.187	105.313	Lao PDR	WL/R/T/BV	Bubble	GPRS (ETL)	Solar Panel		26-Mar-09
6	320101	Se Bangfai	Se Bang Fai	17.077	104.985	Lao PDR	WL/R/T/BV	Radar	GPRS (ETL)	Solar Panel		30-31 March and 01 April 2009 (Installation of equipment was failed)
7	070103	Thoeng	Nam Mae Ing	19.689	100.187	Thailand	WL/R/T/BV	Radar	GPRS (AIS)	Solar Panel		
8	290113	Ban Had Paeng	Nam Sonkhram	17.676	104.287	Thailand	WL/R/T/BV	Bubble	GPRS (AIS)	Solar Panel		
9	450502	Giang Son	Krong Ana	12.510	108.183	Viet Nam	WL/R/T/BV	Radar	GPRS (Mobifone)	Solar Panel		

Note : WL = Water Level, R = Rainfall, T = Air Temperature inside the shelter and BV = Batery Voltage

Table 3. List of AHNIP stations (Lot 3)

Updated 01 April 2009

N°	Lot and item	Station	River	Coordinates (WGS 84)		Country	Parameter	WL Sensor	Telemetry	Power supply	Date of Equipment installed	
				Latitude	Longitude						Phase 1 (2008)	Phase 2 (2009)
1	3 – 1	Stung Streng	Mekong	13.545	106.017	Cambodia	WL/R	Bubble	GSM (Camshin)	Solar Panel		
2	3 – 1	Kratie	Mekong	12.240	105.987	Cambodia	WL/R	Bubble	GSM (Camshin)	Solar Panel		
3	3 – 1	Prek Kdam	Ton le Sap	11.813	104.804	Cambodia	WL/R	Shaft encoder	GSM (Camshin)	Solar Panel		
4	3 – 1	Kompong Luong	Ton le Sap	12.575	104.215	Cambodia	WL/R	Shaft encoder	GSM (Camshin)	Solar Panel		
5	3 – 2	Luang Prabang	Mekong	19.892	102.137	Laos	WL/R	Bubble	GSM (ETL)	Electricity		
6	3 – 2	Pakse	Mekong	15.117	105.800	Laos	WL/R	Bubble	GPRS (ETL)	Solar Panel		Integration to HYCOS equipment on 26 March 09
7	3 – 3	Chiang Saen	Mekong	20.273	100.083	Thailand	WL/R	Bubble	GSM (AIS)	Electricity		
8	3 – 3	Chiang Khan	Mekong	17.897	101.668	Thailand	WL/R	Bubble	GSM (AIS)	Electricity		
9	3 – 3	Nong Khai	Mekong	17.877	102.720	Thailand	WL/R	Shaft encoder	GSM (AIS)	Electricity		
10	3 – 3	Nakhon Phanom	Mekong	17.398	104.803	Thailand	WL/R	Bubble	GSM (AIS)	Electricity		
11	3 – 3	Mukdahan	Mekong	16.540	104.737	Thailand	WL/R	Bubble	GSM (AIS)	Electricity		
12	3 – 3	Khong Chiam	Mekong	15.318	105.500	Thailand	WL/R	Bubble	GSM (AIS)	Electricity		
13	3 – 4	Tan Chau	Mekong	10.803	105.243	Viet Nam	WL/R	Shaft encoder	GSM (Mobifone)	Electricity		
14	3 – 4	Chau Doc	Bassac	10.707	105.133	Viet Nam	WL/R	Shaft encoder	GSM (Mobifone)	Electricity		
15	3 – 4	Vam Nao	Vam Nao	10.575	105.357	Viet Nam	WL/R	Shaft encoder	GSM (Mobifone)	Electricity		

Note : WL = Water Level R = Rainfall

Figure 32. Locations of MRC Hydro-meteorological Stations

Principles of data recording and data flow

The AHNIP stations record water level and rainfall at hourly interval. The water level is sensed by water level sensors which are either bubble system or floating device with shaft encoder.

Rainfall sensor is an automatic rainfall recorder of TB3 model. The sensors send the readings every hour to data logger. The logger will send data to a national data terminal when it receives a phone call (under GSM network) from the terminal telephone (Figure 2). The data is transmitted by means of data channel in a similar manner to SMS (Short Message Service) provided by the Telephone Service Provider. The station calling is generally made every day around 8:00 am. Once the data is received at the national terminal, it is further sent to MRCS FTP and MRC-RFMMC FTP as well via internet facility. Computer software is used for calling/receiving data and sending to FTP. During flood period, more frequent data transmission is made. For the months of August and September the data will be transmitted three to four times per day for the purpose of water level monitoring and flood forecasting.

In addition to the two technologies applied by AHNIP for water level reading, the Mekong HYCOS also use the radar sensor where appropriate. All the sensors are configured for reading at 15-minute intervals. The data transmission (see also Figure 2) is automatically made at hourly intervals to national FTP, then to MRCS and MRC-RFMMC FTPs through a General Packet Radio Service (GPRS) system. By this the near real-time (lag time of one hour) water level and rainfall data arrive at the designated FTPs automatically without the field station calling, thus easing the operation at the national terminal.

Although the Mekong HYCOS has just recently begun operating, it has already been seen to reduce the work of the national data terminal operators, as the system works automatically. And as the GPRS technology is widely available and the price for telephone service is low, the system operation is financially viable in the long term.

System integration

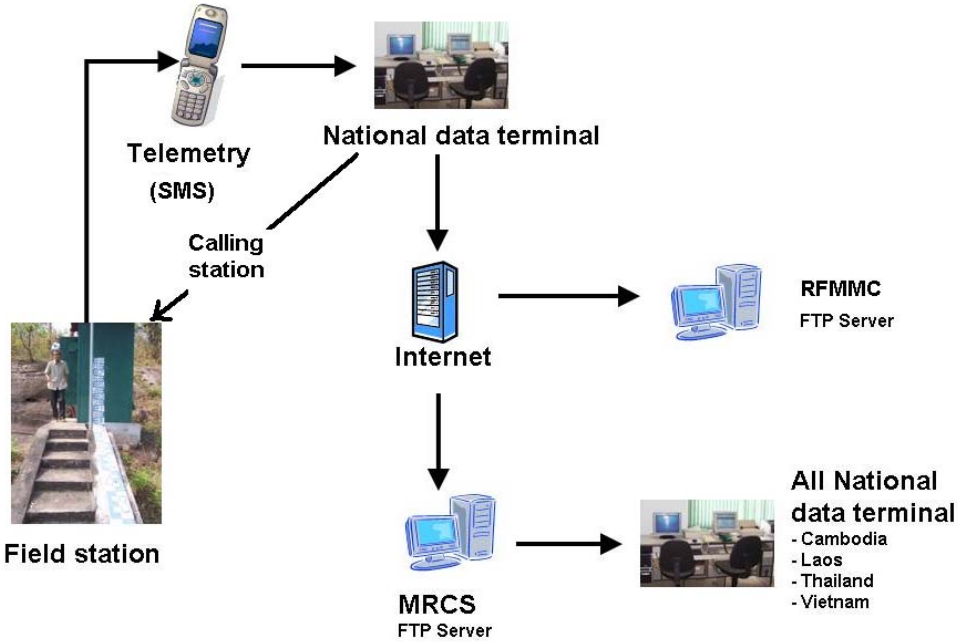
The AHNIP system has so far experienced a number of technical shortcomings, which affect the reliability of data transmission and overall performance. The upgrading of the AHNIP equipment was already realized in 2007, during the project extension. Essentially, it was planned to replace all the AHNIP equipment. And it was also proposed that the future equipment and data flow of AHNIP was similar to Mekong HYCOS. Under the IKMP work plan 2009, the upgrading to Mekong HYCOS equipment will occur. This is to provide for an integration of all hydro-meteorological stations into one single MRC Hydro-meteorological network. The integration as such will increase ease and convenience for operation and maintenance of the system. Once the integrated system is fully operational, data acquisition, storage, processing, and dissemination will be systematized leading to the establishment of MRC Hydro-met database and information system. The network integration is planned to be completed by 2010. With the new Mekong HYCOS, key tributaries can be monitored thus enhancing river monitoring and flood forecasting.

The hydro-met database will contribute to the data acquisition system of MRC-RFMMC which requires real-time observed data for river and flood forecasting. The archived data will be quality-assured having version control and Meta data attached to each data set for further application.

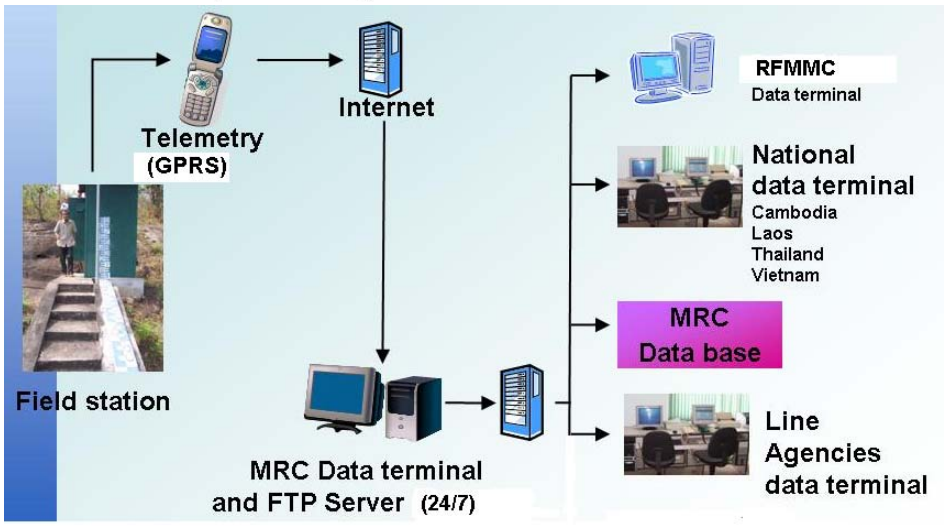
SIGNIFICANCE OF THE MRC INTEGRATED HYDRO-METEOROLOGICAL NETWORK

The MRC hydro-meteorological integrated network will establish an efficient, reliable and accurate hydrometeorological data collection and transmission system at basin level, while also strengthening relevant national and regional capacities. The network covers mainstream and main tributaries of the Mekong river system. The obtained data and information will be shared between the MRCs four Member Countries of Cambodia, Lao PDR, Thailand and Viet Nam. The MRC, through RFMMC, applies the monitored water level and rainfall data to river water level and flood forecasting. The forecast products are disseminated daily to target users directly via email and to the public via the MRC web site. In the 2008 flood crisis (due to the Kummari

storm in August), the MRC forecast was found to be successfully close to the observed data (the water level difference in the order of 20 cm). The mainstream hydro-meteorological stations help contribute to this successful forecast. With the full integration of all mainstream and tributary stations, a much better coverage of rainfall and water level data can be achieved. This integrated network would allow for accurate forecasts with suitable lead time, sufficient for flood preparedness activity at local communities. The accurate flood hydrograph forecasts will also be used, among other things, as key input for the forecasting flood extent and depth, which certainly will be of practical use in the flood disaster preparedness at the grass-root level.



a) AHNIP System



b) Mekong-HYCOS System

Note : After full system integration , the Mekong-HYCOS data flow will be totally applied.

Figure 2. Data flow

The significance of this MRC core data-gathering network extends beyond the requirement of the MRC-RFMMC. The network, as one component of the information system of the MRC (MRC-IS), under the Technical Support Division (TSD) will assist the MRC to perform the core tasks under the 1995 Mekong Agreement, through various MRC Programmes (FMMP, NAP, BDP, EP, Fisheries, etc.). It will provide timely hydrological data for the recalibration of hydrological modelling, implementation in the river monitoring and water management of the Mekong River, environmental monitoring, wetlands studies and management, river navigation, basin development plan, etc.

Topic IV

Successful flood risk management approaches

Paper 5-4-1

AN INTEGRATED APPROACH TO FLOOD RISK MAPPING FOR FLOOD DETENTION AREAS - A CASE STUDY OF DAY RIVER FLOOD DIVERSION AREA IN THE RED RIVER DELTA, VIET NAM

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ABSTRACT

The risk from natural disasters is an integration of the factors (parameters) of hazard and vulnerability. Population growth in disaster-prone areas in conjunction with socioeconomic development and environmental changes results to the increasing severity of impacts of natural disasters. Worldwide statistics show that flood events are not only increasing but the number of people killed by floods and the associated socioeconomic losses are also rising. It is, therefore, essential to find adaptive solutions for flood risk reduction in flood-prone areas. Comprehensive flood risk mapping can be applied as one of non-structural measures for that purpose.

This paper presented an integrated approach to flood risk mapping for flood detention areas with the case study of the Day River Flood Diversion Area (DRFDA) in the Red River Delta (RRD), Viet Nam. The comprehensive food risk maps were developed based on the integration of impact parameters of flood hazard and flood vulnerability. Flood hazard was an integration of hazard-related indicators such as depth, duration and velocity of floodwater, whereas flood vulnerability was a combination of economic, social, and environmental aspects. The economic vulnerability to flood was estimated based on land-uses such as residential buildings, special public uses, public infrastructures, and agriculture. The social vulnerability to flood was assessed based on population density, flood risk perception, spiritual values, and income level. The environmental vulnerability to flood, on the other hand, took into account the pollution sources, erosion potentials, and open spaces. The influential factors to flood risk were analyzed through the mechanism of weighted contribution to flood risk, and analyses of impact level of the factors were also implemented. These comprehensive flood risk maps would support to decision-makers and concerned authorities for formulating strategies for flood preparedness and mitigation in the study area and could particularly help local residents in actively reducing flood risk by them.

INTRODUCTION

Natural disasters cause much poverty, especially in developing countries where low-income economies are greatly stress by their recurrence. Statistics show that around 70 percent of all global disasters are linked to hydro-meteorological events. Flooding is one of the greatest natural disasters known to humankind (Associated Program on Flood Management (APFM), 2004). There is an alarming increasing trend in the number of people affected by natural disasters with an average of 147 million per year (1981 - 1990) rising to 211 million per year (1991 - 2000) with flooding alone accounting for over two-thirds of those affected and causing over one-third of the total estimated costs (Pilon, 2003). Population growth in flood-prone areas in conjunction with socioeconomic development and environmental changes results to the increasing severity of impacts of floods. Especially today, climate change leads to extreme

floods occur more frequently and global warming results in sea level rise more severely. These increase the comprehensive flood risk in the flood-prone areas.

Viet Nam is one of countries that are most effected by global warming due to deforestation, industrialization, urbanization, and with a long coastline. The Red River Delta in the North of Viet Nam is also most vulnerable to climate change because of lowland and joins the Gulf of Tonkin that suffers tropical typhoons every year from Pacific Ocean. An analysis of historical data of floods and sea level in the Red River Delta showed that flood trend would increase by from 10.4 to 20.9% and sea level rise would be 19.2 cm for scenario 2100 (Dang and Babel, 2009). It is, therefore, essential to find adaptive solutions for flood risk reduction in flood-prone areas. Comprehensive flood risk mapping can be applied as one of non-structural measures for that purpose. Modern flood mitigation is increasingly non-structural. Well-established, traditional non-structural measures such as zoning, building code, flood proofing, early detection and warning, emergency planning, flood insurance, etc. appear today as indispensable complements to structural engineering solutions (Simonovic, 2002).

The risk from natural disasters is an integration of the parameters of hazard and vulnerability. Flood hazard map, which can provide information including the past flood track records, flood anticipation, potential evacuation routes, evacuation places etc. to the local residents, are indispensable for emergency response and for long-term flood disaster management (Osti et al., 2008). Vulnerability map can be described as a natural hazard map which shows the degree of ability to cope with and respond to specific natural hazard events. The vulnerability map shows not only the degree of vulnerability of an area, but also the reasons for that vulnerability. That is very useful to find the adaptive ways to reduce the vulnerability of a particular area due to the vulnerability map can present where changes could be introduced. In case of high vulnerability is caused mainly by low preparedness and high exposure, one can concentrate on these two aspects in order to decrease vulnerability (Weichselgartner, 2001).

The aim of this paper is to present an integrated approach to flood risk mapping for flood detention areas with the case study of the DRFDA in the RRD, Viet Nam. These comprehensive flood risk maps will support to decision-makers and concerned authorities for formulating strategies for flood preparedness and mitigation in the study area and will particularly help local residents in actively reducing flood risk by them.

THE STUDY AREA

The DRFDA located in the RRD of Viet Nam as described in Figure 33 was selected to apply a new approach to comprehensive flood risk mapping with scenario of flood diversion 1971. The DRFDA is one of important components of flood control system in the RRD, it was established since 1937 and has mission to protect 18.56 million people living in the delta including Hanoi Capital. The measure of flood diverting from Red River to Day River is the final resort to lessen floodwater level for Hanoi and downstream areas of RRD, this measure is only used in the case of emergency such as when upstream reservoirs are full or dam breaks or control gate failures.

The DRFDA involves two main flood detention zones - the Head Zone and Middle Zone as shown in Figure 33 - where were applied to comprehensive flood risk mapping. The Head Zone is called Van Coc storage area comprises 11 communes of Phuc Tho district and Dan Phuong district. The Head Zone is directly connected with Red River through flood diversion structures including Upper Hat Mon and Lower Hat Mon spillways, and Van Coc sluice with 26 control gates. Downstream of Head Zone is regulated by Day Dam with 6 control gates. The Middle Zone is called Chuong My - My Duc storage area which includes 57 communes of two districts: Chuong My and My Duc. If flood diversion measure is implemented, floodwater is first discharged from Red River to the Head Zone until it is full, after that floodwater is then released to Middle Zone by control gates of Day Dam.

In the past there were several occasions of extreme flood events that floodwaters had to be diverted from the Red River into the Day River (Ky, 2000). However, flood diversion

measure has not been used since 1985 due to upstream reservoirs has constructed for flood control purpose, this has resulted in local people ignore the sense of flood risk because they feel safe, consequently decreasing flood risk perception in the area. Furthermore, rapidly population growth and economic development in the flood detention zones lead to increase vulnerability to flooding. Thus, if public awareness about flood risk is not improved properly and timely, any flood diversion into the areas will become a disaster.

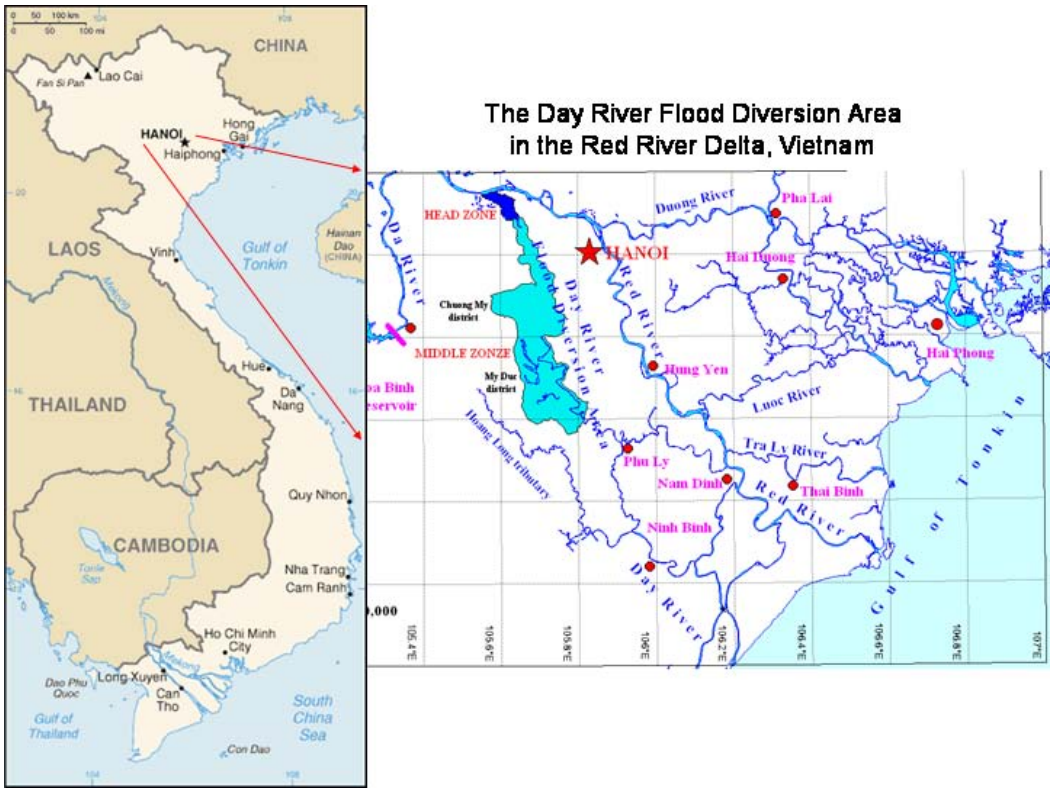

Figure 33. The study area

METHODOLOGY

A new approach to comprehensive flood risk mapping was proposed apply for the study area that includes collection, processing and integration of interdisciplinary information related to flood risk such as flood hazard, and economic, social, environmental vulnerability to flooding. The flood hazard information was computed by 1-D and 2-D hydrodynamic models (Mike 11 and Mike 21), while flood vulnerability information was extracted and processed by Geographic Information System (GIS) and remote sensing techniques. The Digital Elevation Model (DEM) 90 m of flood detention areas involving the Head Zone and the Middle Zone shown in Figure 33 was used in the 2-D hydrodynamic modelling for flood simulation, and the socio-economic maps were also divided into grids as 90 m by 90 m for assessing flood vulnerability in detention areas.

The comprehensive food risk maps were developed for the Head Zone and the Middle Zone based on the integration of impact factors of flood hazard and flood vulnerability. Flood hazard was an integration of hazard-related indicators such as depth, duration and velocity of floodwater, whereas flood vulnerability was a combination of economic, social, and environmental aspects. The economic vulnerability to flood was estimated based on land-uses

such as residential buildings, special public uses, public infrastructures, and agriculture. The social vulnerability to flood was assessed based on population density, flood risk perception, spiritual values, and income level. The environmental vulnerability to flood took into account the pollution sources, erosion potentials, and open spaces. The influential parameters to flood risk were analyzed through the mechanism of weighted contribution to flood risk, and analyses of influential level of the parameters were also implemented.

The functions for computation of flood risk index, flood hazard index, and flood vulnerability index are described as follows:

- Flood Risk Index (FRI) was an integration from two risk components:

  FRI = FHI * FVI (1)

- FHI: the Flood Hazard Index, was resulted in from three hazard subcomponents:

  FHI = Depth Index * De Weight + Duration Index * Du Weight
  + Velocity Index * Ve Weight (2)

- FVI: Flood Vulnerability Index, was a weighted summation from three subcomponents of vulnerability:

  FVI = EcVI * Ec Weight + SoVI * So Weight + EnVI * En Weight (3)

- EcVI: the Economic Vulnerability Index, was defined as:

  Residential Building Index * Ec1 Weight + Special Public Use Index * Ec2 Weight + Public Infrastructure Index * Ec3 Weight + Agricultural Land-use Index * Ec4 Weight (4)

- SoVI: the Social Vulnerability Index, was defined as:

  Population Index * So1 Weight + Flood Risk Perception Index * So2 Weight
  + Spirit Value Index * So3 Weight + Income Index * So4 Weight (5)

- EnVI: the Environmental Vulnerability Index, was defined as:

  Pollution Index * En1 Weight + Erosion Index * En2 Weight
  + Open Space Index * En3 Weight (6)

The weights and indices of parameters mentioned above were referred from Dang et al. (2009). The processing and mapping for flood risk, flood hazard, and flood vulnerability were implemented with supporting by ArcGIS software.

MULTI-PARAMETER FLOOD-HAZARD MAPPING

Flood hazard of particular area depends on many parameters such as depth, duration, velocity of floodwater, impulse (water level multiplied by velocity), rate of rise of water level, warning time, as well as frequency of occurrence (Alkeman, 2003; Tingsanchali and Karim, 2006). In this study, three parameters involving depth, duration and velocity of floodwater were considered in flood hazard mapping. Figure 34 is a presentation of flood hazard integrated for the Head Zone. Flood scenario used for flood hazard mapping herein is the historical flood event 1971 that had been diverted from Red River to the DRFDA. First, flood was diverted from the Red River to the Head Zone until its storage was full and then was discharged to the

Middle Zone before flowing down to Day River and finally gone to the sea.

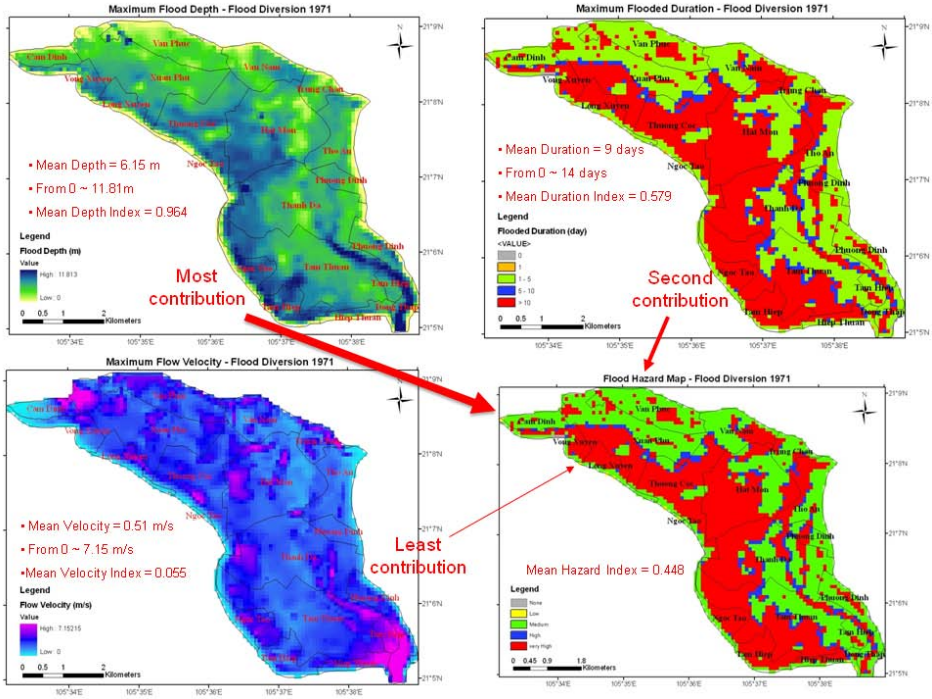

Figure 34. Multi-parameter flood hazard map in the Head Zone with scenario of flood diversion 1971

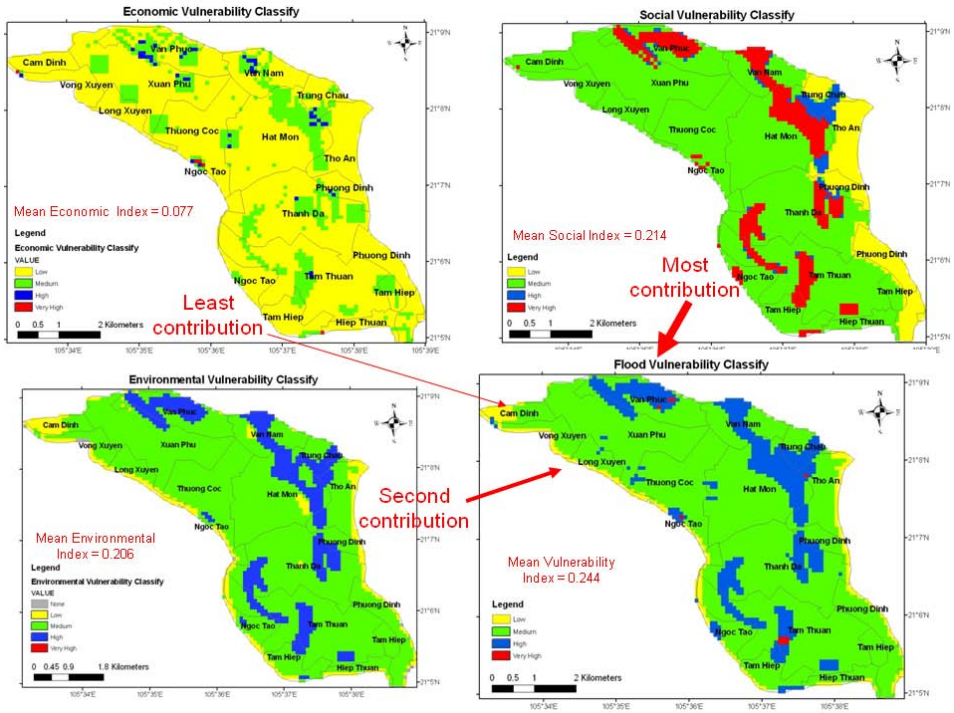

Figure 35. Multi-parameter flood-vulnerability map in the Head Zone with scenario of flood diversion 1971

The 2-D hydrodynamic model was applied to simulate flood propagation in flood detention zones including the Head Zone and the Middle Zone. Output of the model showed hazard-related information which is called hazard indicators such as depth, duration and velocity of floodwater. The hazard indicators were then classified into five categories such as none, low, medium, high, and very high before they were converted to indicator-indices. The hazard index was a weighted summation from indicator-indices multiplied by indicator-weights as shown in Equation 2. Each flood cell of 90m by 90 was presented by a value of hazard index, and the Mean Hazard Index (MHI) was computed averagely in particular zone. The MHI presents an average value of overall flood dangers threatening to a flood-prone area and it is also used to evaluate and compare the flood hazard level in each flood detention zone. The MHI of the Head Zone was calculated as 0.448 while that of Middle Zone was as 0.444, both zones were therefore in similar situation in term of flood hazard. Analysis of contribution level of indicators to flood hazard through Regional Mean Indices (RMI) of indicators showed that in the Head Zone the depth indicator most influenced to magnitude of flood hazard index (RMI = 0.964), the duration indicator was the second contribution (RMI = 0.579), and velocity indicator was least one (RMI = 0.005). However, flood duration mightily shaped spatial distribution of flood hazard classification as depicted in Figure 34. In the Middle Zone the most impacted indicator of flood hazard is the duration (RMI = 0.629), the second was the depth indicator (RMI = 0.592), and velocity was found least influence (RMI = 0.039). Moreover, maximum velocity distribution maps in the flood detention zones presented obviously the floodway during flood diverting that differentiates with normal flow regime in the river. These finding is very important to formulate the plan for flood risk reduction in the study area.

MULTI-PARAMETER FLOOD-VULNERABILITY MAPPING

Flood vulnerability is one important component beside hazard component contributing flood risk, therefore, flood vulnerability mapping are needed as a foundation for comprehensive flood risk mapping. Flood vulnerability maps were overlaid by three subcomponent maps such as economic, social, and environmental vulnerability as described in Equation 3. Figure 35 showed the presentation of flood vulnerability mapping in the Head Zone. The economic vulnerability maps were done based on weighted computation of land-use areas such as residential building, special public uses, public infrastructure, and agriculture (Equation 4); while the social vulnerability maps were integrated from parameter maps such as population density, flood risk perception of local residents, spiritual values, and income level (Equation 5); environmental vulnerability maps were established through weighted overlay of indicator maps such as pollution, erosion, and open spaces (Equation 6). The RMI of economic, social and environmental vulnerability were assessed and named as Mean Economic Index, Mean Social Index, and Mean Environmental Index, respectively, as presented in Figure 35. A representative value of multi-parameter flood-vulnerability of a flood detention zone was defined by the Mean Vulnerability Index (MVI).

From integration of flood vulnerability maps for flood detention zones, the MVI for both the Head Zone and the Middle Zone were found as same value of 0.244. However, in the Head Zone the social vulnerability (RMI = 0.214) and environmental vulnerability (RMI = 0.206) most contributed to flood vulnerability and were set at the medium level. In the Middle Zone the social vulnerability was estimated at high level with RMI of 0.413 that was more prominent than environmental vulnerability with RMI of 0.142. The economic vulnerability in both zones contributed to flood vulnerability at low level, namely RMI were 0.077 and 0.053 for the Head Zone and the Middle Zone, respectively. This is due to properties and assets of local people are planed to evacuate to the safe places before flood coming; and the effected areas of economic vulnerability were smaller than that of social and environmental vulnerability. Agriculture and public infrastructure were estimated as essential parameters contributing to economic vulnerability due to their land-use areas were very large. The study area is rural, most local

residents are working in agriculture have low income, therefore, the index of income indicator exposed in social vulnerability with very high level such as RMI of 0.898 and 0.916 for the Head Zone and Middle Zone, respectively. In addition, flood risk perception was very poor in the Middle Zone leading to the index was also very high (RMI = 0.779) in social vulnerability. Potential erosion was momentous in environmental vulnerability, especially in the Head Zone with RMI = 0.934. Thus, in strategy for flood preparedness and mitigation in the study area, the measures for decreasing social and environmental vulnerability are appreciated. Especially, improving flood risk perception for people in the Middle Zone is extremely necessary.

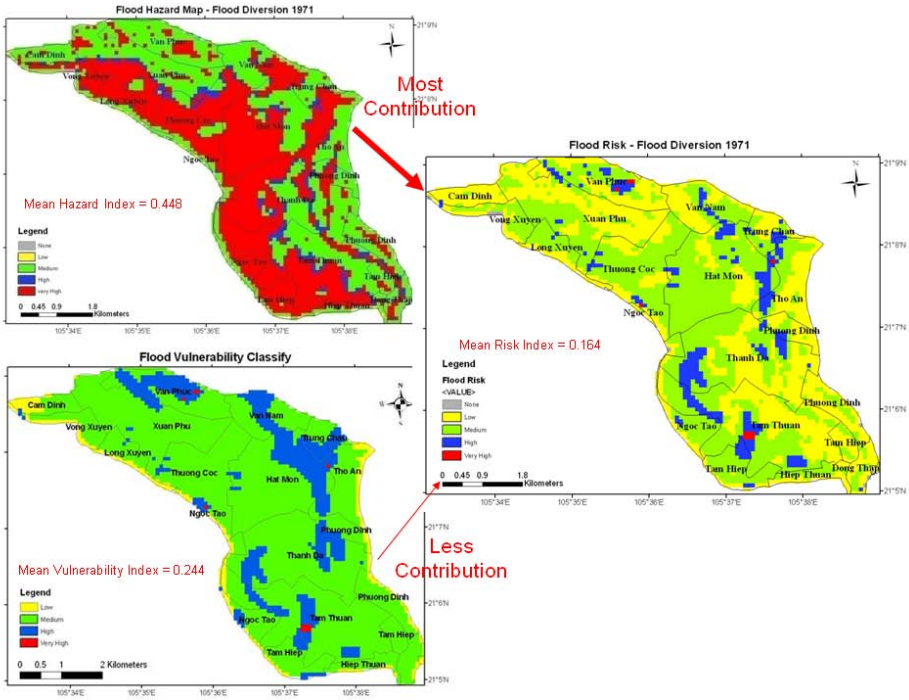

Figure 36. Comprehensive flood risk map in the Head Zone with scenario of flood diversion 1971

COMPREHENSIVE FLOOD-RISK MAPPING

Once multi-parameter flood hazard and vulnerability maps were completed, the next important task was to integrate comprehensive flood-risk maps based on those parameter maps. The function was used as depicted in Equation 1. For each flood cell (90 m by 90 m), the flood risk index only exists when both flood hazard index and flood vulnerability index exposed, otherwise the flood risk index in the cell gets ‘zero’. The level of overall potential damage of flood causing for a detention area was proposed to consider through the Mean Risk Index (MRI) which is averaged from flood risk indices of all flood cells in the area. Figure 36 and Figure 37 are examples of comprehensive flood risk maps that were developed for the case of flood diversion 1971 in the Head Zone and the Middle Zone of the study area.

The analyses of impact level of risk components contributing to flood risk showed that hazard component most contribute to flood risk in both the Head Zone (Figure 36) and the Middle Zone (Figure 37), and was followed by vulnerability component. Impact levels of flood hazard and flood vulnerability on flood risk were considered through MHI and MVI. In the both zones, the MHI were much greater than the MVI, namely, in the Head Zone the MHI was 0.448 while the MVI was 0.244; in the Middle Zone the MHI was 0.444 whereas the MVI got 0.244. The comprehensive flood risk level for each flood detention zone was examined through value

of MRI that is 0.164 and 0.181 for the Head Zone and the Middle Zone, respectively. Thus, flood risk of the Middle Zone was more severe than that of the Head Zone although MVI of those two zones got the same value (0.244) and MHI of both zones were similar (0.444 for the Head Zone compared with 0.448 for the Middle Zone). The flood risk map in Figure 37 showed some specific locations with very high flood risk level that were the result from noticeable social vulnerability based on the cooperation of high population density, poor flood risk perception, and low income in local area. It is proposed that adaptive measures should be sought to apply for reducing these social vulnerability in the Middle Zone.

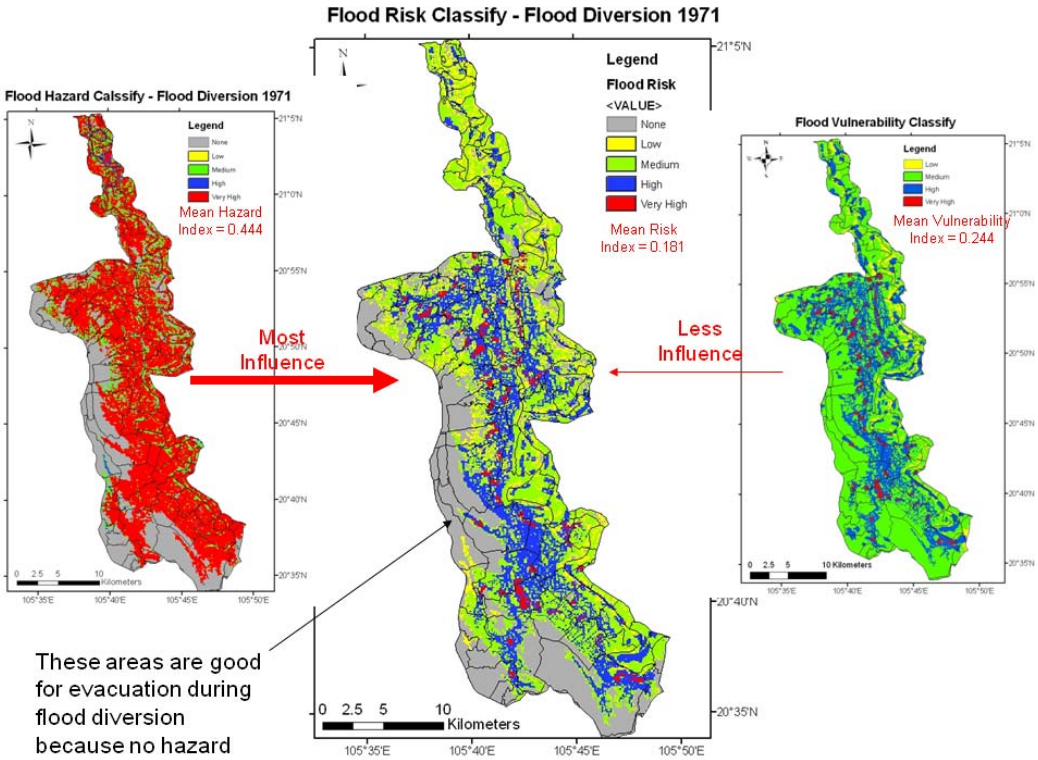

Figure 37. Comprehensive flood risk map in the Middle Zone with scenario of flood diversion 1971

CONCLUSIONS

The maps of flood hazard, vulnerability, and risk were displayed through flood hazard, vulnerability, and risk indices. Flood risk was defined by two principal components such as flood hazard and flood vulnerability. Hazard component was more prominent in contribution of magnitude of flood risk (MRI) whereas vulnerability component mainly shaped the area distribution of flood risk in the study area. Flood hazard depended on indicators related to the danger of flood to human and properties, while flood vulnerability depended on various parameters related to socio-economic environment representing for capacity against to flood threatening. Flood depth and duration were found the most important parameters in strategy for flood hazard reduction which can be done by structural measures. Concerning to flood vulnerability which could be decreased by adaptively non-structural solutions, the social issues were most significant in the Middle Zone, while social and environmental aspects were most influential in the Head Zone. Comprehensive flood risk maps showed the safe areas for evacuation and floodway during flood diversion, the findings could support to spatial planning

and land-use management as non-structural measure for flood preparedness and mitigation. The comprehensive flood risk maps would support to decision-makers and concerned authorities for formulating strategies for flood preparedness and mitigation in the study area and could particularly help local residents in actively reducing flood risk by them.

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Paper 5-4-2

FLOOD DAMAGE ASSESSMENT INTEGRATING GEOSPATIAL TECHNOLOGIES. A CASE STUDY IN HUE, VIET NAM

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ABSTRACT

Viet Nam which has more than 3,000 km of coastal line is received with many tropical storms from East Sea every year. Storms of destructive nature causing considerable damage, generally, strike the central part of Viet Nam; namely three provinces, HaTinh, Thua Thien Hue and QuangNam. The 1999 event has been the worst as regards to storms and associated flooding in Viet Nam causing significant damages. Particularly, in Hue, since 1999, hundreds of people have lost their lives and the property damage comes amounts to thousands of billions Viet Nam dong. With climate change scenarios, it is anticipated that similar events of low frequency could revisit the country with devastating effects. Having identified the effectiveness of the modern day geospatial technologies such as remote sensing, GIS, and GPS, in hazard, vulnerability and risk analyses as well as risk management, it is aimed to delineate the flooding extents and map the elements at risk towards increased awareness, preparedness and sustainable development.

With their proven advantage on the detection of water bodies, RADAR satellite imageries acquired during the 1999 extreme event and images of the same kind acquired during dry seasons were made use of to extract the flood area extent by both Red-Green-Blue composition and image classification after filtering speckle noise and image enhancement. Multi spectral optical satellite imageries were used for land cover and land use classification by the supervised classified technique. A field visit was made in this conjunction for observing the ground truth. Finally, a GIS analysis was carried out for a quantitative analysis and assessment of damage. Damage curve models corresponding to the identified land use land cover classes were assumed for the purpose. Attributing total damage costs for the different land cover land use classes the total damage was arrived at, demonstrating a methodology for assessing the flood damage with the integration of geospatial technologies and tools.

INTRODUCTION

The flooding event which affected Viet Nam in late 1999 has been recorded as the worst flooding event the country had experienced in a century. The floods were caused by a series of storms that brought heavy rain to the central part of the country in October and November. The first storm to hit was Tropical Storm Eve on October 19 and the main event occurred from November 1 - 6. In total 793 people lost their lives and 55,000 were made homeless. The floods brought US$ 290 million of damage to the region and caused a further US$ 490 million of economic losses. It is estimated that 1.7 million people in the central Provinces of Viet Nam were affected by the floods.

Important is the fact that Viet Nam gets lashed by typhoons and tropical storms every year, mostly along the central coast. Further, unprecedented occurrences of rainfall events linked with climate and which led to flooding have also been reported in the recent past resulting in loss of life and considerable damage to property. These indicate the need for efforts

in efficient and effective flood risk management strategies towards human security as well as reduction of damage. A study was thus formulated to estimate the impact of flood hazard in Thua Thien Hue by using modern day geospatial technologies assisting the local government in the development of a soft engineering methodology for mitigating flood damages.

STUDY AREA

Thua Thien Hue Province is located at the central part of Viet Nam (Figure 1). It is made up of four zones; mountain area, hills, plains and lagoons separated from sea and sandbank. Mountainous area covers more than half the total surface of the province with a height varying from 500 to 1480 meters. Hills cover one third of the area of the province between the mountains and the plains with heights varying from 20 to 200 metres. Plains cover about a tenth of the surface area with height of only up to 20 m+MSL (mean sea level). Lagoons separated from the sea by sandbanks. These are between the hills which occupy the remaining 5% of the surface area of the province. Thua Thien Hue has an annual precipitation of around 3,200 mm of about 70% of which is distributed from September to December.

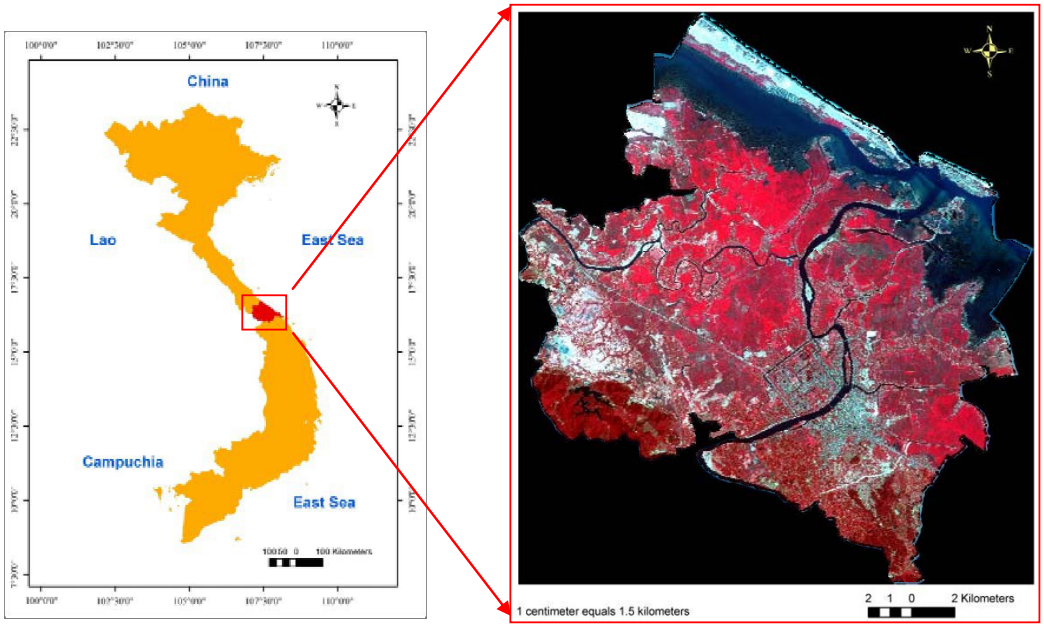

Figure 1. Location map of the study area

Hue city which is the capital of Thua Thien Hue province falls in the Basin of Huong River. Eastern of Thua Thien Hue is covered by East Sea and opposite direction it is hugged by TruongSon Mountains. Being frequently affected by strong tropical storms from the East Sea and because of its low altitude topography, this city was chosen for the study.

METHODOLOGY

The methodology adopted in the study is shown in Figure 2 in the form of a flowchart.

The RADARSAT satellite data acquired during and after the 1999 extreme flooding event were processed to extract the flood extent. These images were processed for speckle reduction by applying the enhanced frost filter (Lopes and Nezry, 1990) while simultaneously preserving texture information. The enhanced frost filter is an adaptation of the frost filter and similarly

uses local statistics (coefficient of variation) within individual filter windows. The low convolution filter (Haralick et al, 1987) was then applied to smooth the low frequency components of the image such as water, wetland, etc. The above filtering techniques have been checked by Dutra and Sant Anna (1995). Subsequently, Red-Green-Blue composite as well as classified image were produced for extracting the flood area extent. K-Means unsupervised classification technique was used for the classification (Tou and Gonzalez, 1974). This technique calculates initial class means evenly distributed in the data space then iteratively clusters the pixels into the nearest class using a minimum distance technique. The objective function is the Sums of Squares Distances - errors (*equation 1*) between each pixel and its assigned cluster centre where C(x) is the mean of the cluster that pixel x is assigned to. Minimizing the $SS_{distances}$ is equivalent to minimizing the Mean Square Error.

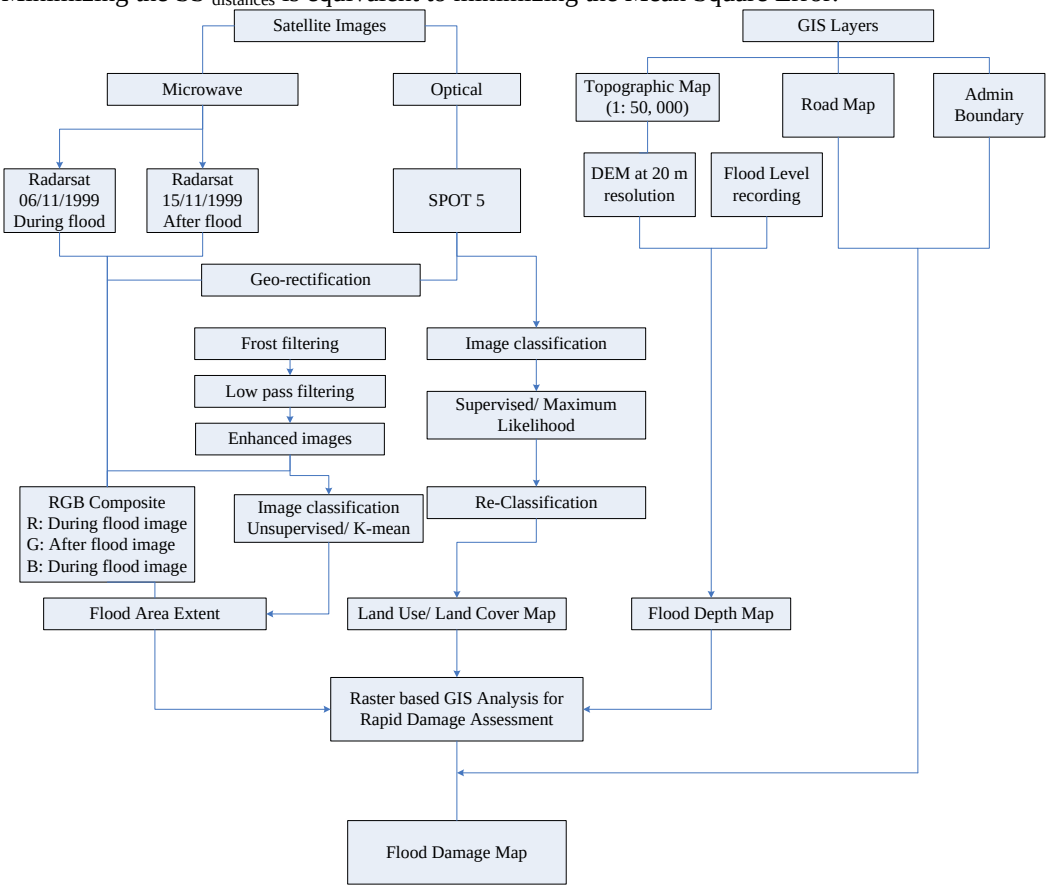

Figure 2. Flow Chart depicting the Methodology adopted in the Study

$$SS_{distances} = \sum_{\forall x} [x - C(x)]^2 \quad (1)$$

The multi-spectral SPOT image covering the study area was used to prepare the land use map; the supervised classification technique with the maximum likelihood algorithm was applied. Necessary ground truth data were incorporated. During the field visits, residents of the area were also interviewed regarding the water levels during the 1999 flood event. Recordings on the same made by the meteorological department were also obtained. These data on flood depth were then utilized together with the digital elevation model created from the topographic data at a resolution of 20 m by 20 m for preparing the flood depth map of the study area.

Finally, a GIS analysis was carried out developing a methodology in ArcGIS environment

for rapid flood damage assessment. The raster based model developed for the purpose was based on the land use information. The produced vector theme was therefore rasterized at a pixel size of 20 m by 20 m corresponding to the prepared flood map. A duplicate raster data set was created with an attribution of logical maximum cell damage costs depending on the land use categories producing the maximum cell damage cost map.

The versatile raster GIS tools were then conveniently utilized to identify the flood depth and water level at each cell location and thereby to attribute each cell with the associated damage factor from the damage curves producing the damage factor map. Appropriate damage models were assumed in the absence of developed damage curves. The intended damage map of the area in question was produced by raster multiplication of the damage factor map and the max cell damage cost map. The total damage caused by the event of concern was finally obtained by summing up the derived cell damage costs.

RESULTS AND DISCUSSION

Flood area extent map from the RGB composite

The flood area extent map prepared by the traditional method of RGB compositing the RADAR image is shown in Figure 3. Having assigned the red, R, and blue, B, colour guns with the image during flood and the green, G, colour gun with the image after flood, the flood area extent appears in the colour shown in the legend. The advantage of this method is the rapid extraction of the flooding area extent.

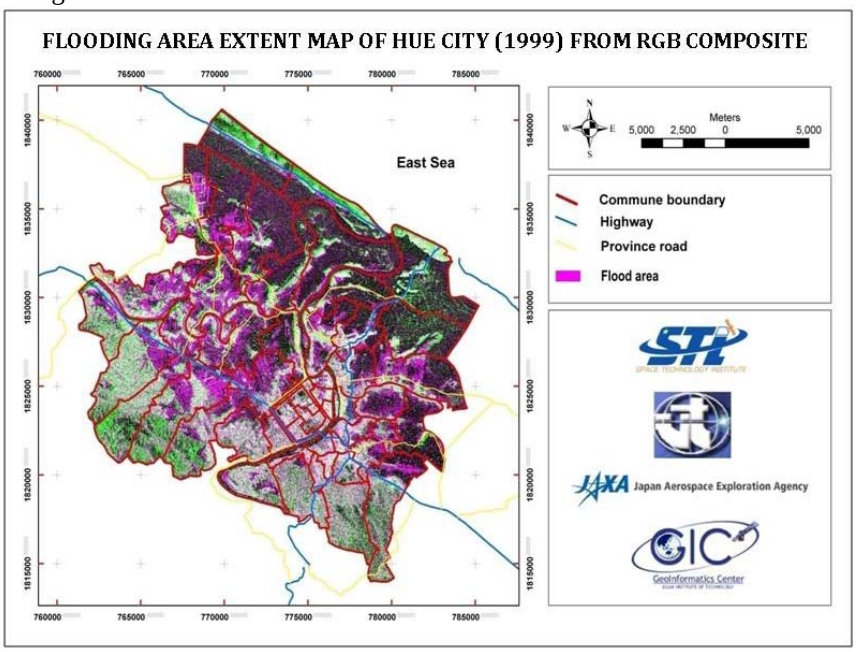

Figure 3. Flooding area extent map of Hue City (1999) from RGB Composite

Flood area extent map from image classification

Figure 4 shows the flooding area extent map obtained through image classification. Although the method is time consuming, is compromised with the quality of the output. Extraction of flooding area, particularly in the urban areas, is enhanced by this technique. The flooded area extent as obtained makes the reasons clear for the devastations it had caused inundating almost the whole of the Hue City.

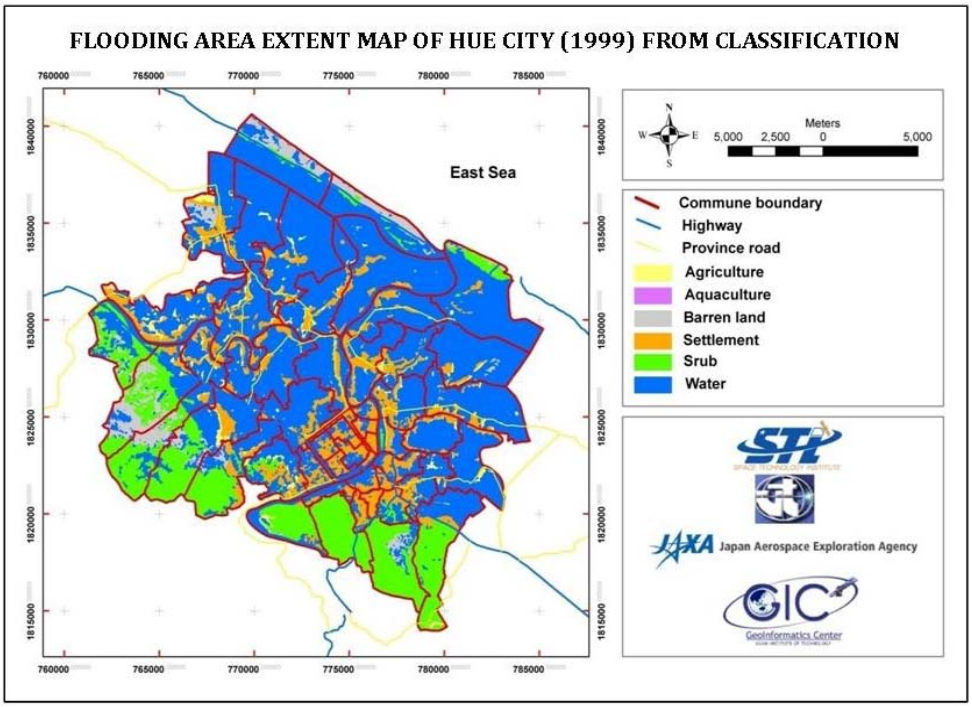

Figure 4. Flooding area extent map of Hue City (1999) from classification

Land Use Map

Figure 5 shows the land use map of Hue city derived from the SPOT 5 image. Six main land use classes identified were agriculture, aquaculture, barren land, settlement, shrub and water.

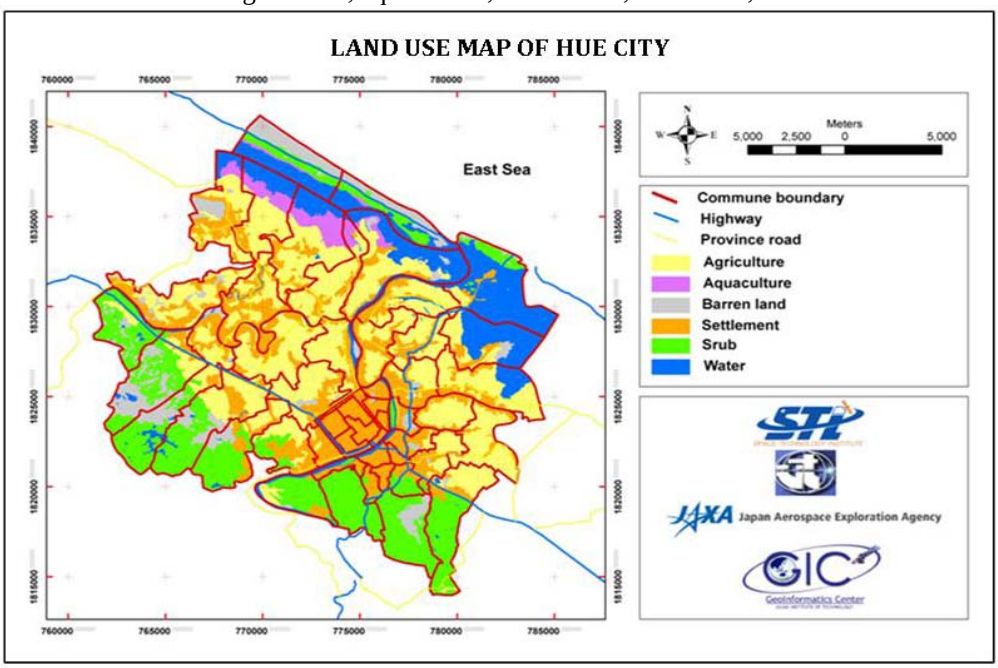

Figure 5. Land use map of Hue City

Flood damage map of Hue city corresponding to the 1999 flooding event

The flood damage map derived from the GIS analysis is shown in Figure 6. Based on the land use type and the assumed damage models a majority of the area is identified to be falling under damage cost range of 2 to 4 million of Vietnam Dong. With the actual damage curves, the developed methodology could easily be implemented to arrive at the intended damage estimate rapidly.

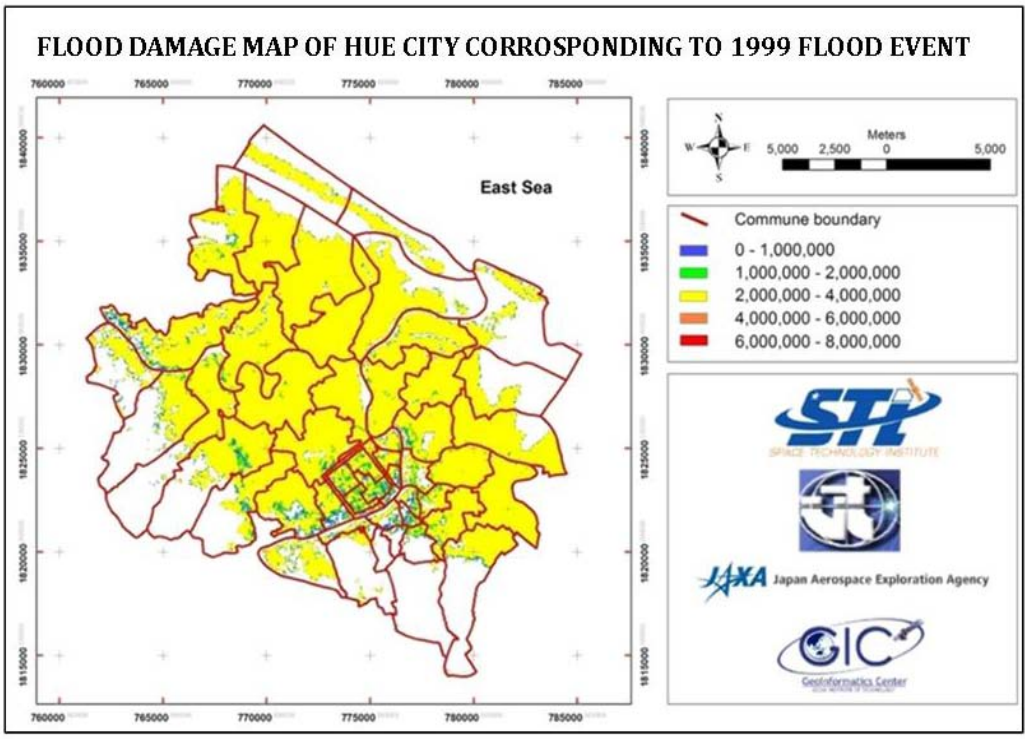

Figure 6. Flood damage map of Hue City corresponding to 1999 flood event

CONCLUSIONS

With its proven advantages the RADAR remote sensing technology was successfully utilized to extract rapidly the flood area extent in the worst flood hit city in Viet Nam. The conventional RGB composition and image classification techniques were made use of. It is found that the flood area extraction using RADAR data by creating RGB composite though simple is less accurate compared to that extracted by the classification technique.

The study has also output a methodology for rapid flood damage assessment the ArcGIS environment based on the land use information.

ACKNOWLEDGEMENT

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Paper 5-4-3

DEVELOPMENT OF A 1D HYDRAULIC MODEL FOR FLOOD INUNDATION MAPPING ALONG THE ANABRANCHED MEKONG RIVER, SIPHANDONE, LAO PDR, AS AFFECTED BY RECENT LAND USE CHANGES

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ABSTRACT

Development of a suitable digital elevation model (DEM) of the bathymetry of a remote river channel, which could then be used for hydraulic modeling, was challenging. This paper presents a method to derive a pseudo-bathymetry using a SPOT (Satellite Pour l'Observation de la Terre) images for channels within an anabranching network of the Mekong River where there were no surveyed bathymetric data. The derived information was then integrated with the available bathymetry from a hydrographic atlas to create a complete DEM of a complex anabranching river networks. A one dimensional (1D) hydraulic model - Hydrological Engineering Centre River Analysis System (HEC-RAS) - was applied to calculate the wetted section throughout a multi-channel network where a detailed DEM was available for the date of the SPOT image and for the in-bank discharge that day recorded at Pakse. The wetted sections obtained from the HEC-RAS model were compared to those in the SPOT image to identify the acceptability of the modelled results. Land cover maps for the last decade showed significant changes in the land cover pattern. The HEC-RAS model then was run for overbank flood flow conditions and the effect of spatial and temporal changes in land cover roughness were determined. It was found that the lateral extent of flooding was not significantly affected by the land cover changes (leading to the hydraulic roughness changes) but the reduction in flow resistance as natural forest was cleared might lead to faster near-bank flows and increased bank erosion.

INTRODUCTION

Many numerical hydraulic models have been developed to explore different aspects of natural channelized river flows. Perhaps the most important input data for a numerical hydraulic model is the geometry of a channel system. However, the geometry data are not always available at a sufficient resolution and indeed, in some cases, there may be no channel geometry data. Collet *et al.* (2000) developed an approach to determine bathymetric maps using SPOT (Satellite Pour l'Observation de la Terre) images to estimate water depths. However, this particular model was developed in the case of non-turbid water. It is still a significant challenge to apply remote-sensing techniques to explore the bathymetry of a deep, highly turbulent, turbid river.

In recent times, the land cover along the Mekong River, especially in the Siphandone wetlands, Lao PDR has changed significantly from dry forest and mixed forest to dry scrub and agriculture, especially rice paddy. Such changes result in alteration of the hydraulic natures of the flow during the flooding period within the study area and may have significant impact on the downstream channels as well. However, the influence of land cover change on the flooding pattern is not clear, especially in the case of a multi-channel network with a combined bedrock and alluvial river bed. In addition, apart from the choice of the dimensionality of a model, the selected roughness values of the riparian land surfaces are important for estimating the flooding

pattern during overbank discharges. The roughness values mainly are influenced by the land cover pattern which can be derived from satellite images (Wilson and Atkinson, 2007).

According to previous studies, there are still uncertainties about the suitability of hydraulic models of different dimensionality for modelling flooding extent. Even though HEC-RAS is a one dimensional (1D) hydraulic model, it may be used effectively to calculate the water surface elevation (WSEle) at each cross-section and therefore in principle can be used to estimate the flooding pattern along a multi-channel network (Horrit and Bates, 2002). A 1D hydraulic model is most suitable in those situations where input data are limited in both quality and quantity, as is the case with poorly gauged rivers in developing countries.

This study is done to: (i) develop a semi-quantitative bathymetry of a complex anabranching river network; (ii) calculate the hydraulic roughness at each cross-section along the multi-channel network; and, (iii) determine the planview of the wetted multi-channel network during low discharge and the flooding patterns resulting from an extreme high discharge by using a 1D hydraulic model (HEC-RAS) in the case of different scenarios of land cover change.

STUDY AREA AND SPATIAL MATERIAL

A mixed bedrock – alluvial anabranching river network of the Mekong River located in the Siphandone wetlands, Lao PDR (Figure 38) was chosen for this study. Within the Siphandone wetlands, a multi-channel network can be found in the north (Box b, Figure 38) while in the south, a complex anabranching river network can be observed. Because no discharge data were collected at any gauging station near the study area, the discharge recorded from the Pakse gauging station was used as upstream boundary condition for the 1D hydraulic models. Two stage board records at Channoi and Hatxaykhoun were used to constrain the upstream and downstream boundary conditions of a 1D hydraulic model of the studied multi-channel network, respectively.

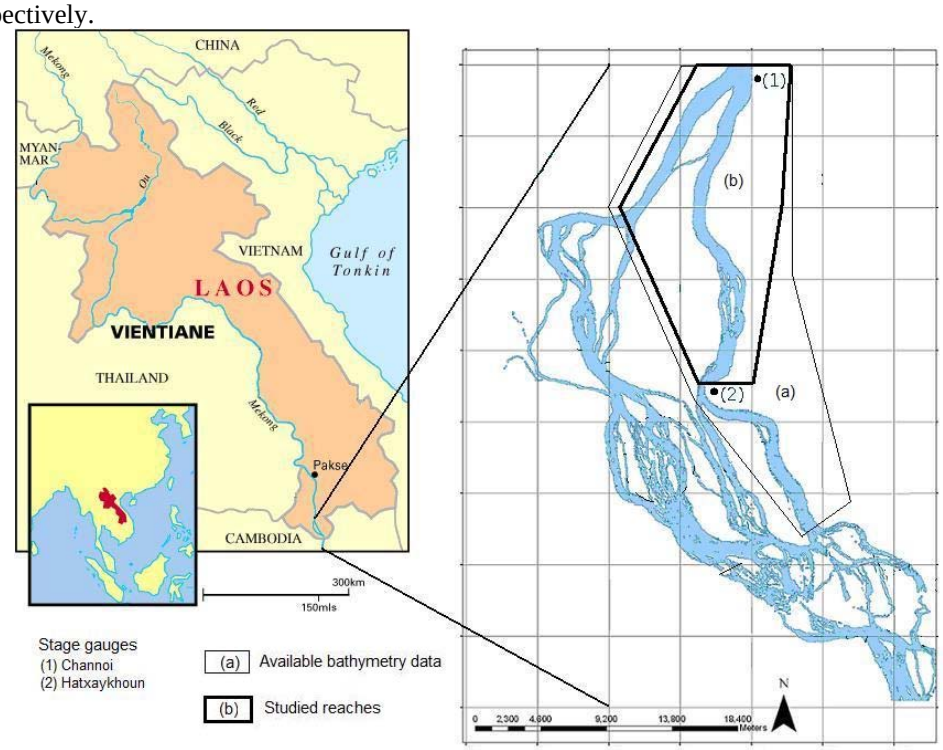


Figure 38. The Siphandone wetlands, Lao PDR

The SPOT images (20 m resolution) taken on 3 March, 2001 and 18 February, 2005 were used to acquire the spatial changes of the land cover pattern over a 4-year period. However, both SPOT 2001 and 2005 did not cover the entry channel at Channoi therefore the SPOT image taken on 30 March, 2003 was used to calculate the hydraulic roughness at each cross-section and therefore applied to validate results obtained from the HEC-RAS model. In addition, to classify the land cover pattern on the SPOT images, a land cover map produced by the Mekong River Commission (MRC) in 2006 was used. Furthermore, the DEM of the study area was available according to: (i) The available DEM (30 m resolution) partly covering the Siphandone wetlands (including bathymetric data), and (ii) the Shuttle Radar Topography Mission (SRTM) data (90 m resolution) to create a new DEM which covered the land surface of the whole Siphandone wetlands.

METHODOLOGY

To create a pseudo-bathymetry of the riverbed where there were no available bathymetric data, a SPOT image was used with reference to the digital Hydrographic Atlas (dHA) sounding data (Box (a), Figure 38). A semi-quantitative approach describing the river bathymetry within the river network was developed by matching the SPOT image reflectance band data with the available measured bathymetric data. To simplify the applied method, the assumption was that where the water column was deepest in the main channels, the flow velocity would be higher and the total suspended sediment concentration would be higher, which resulted in less reflectance (*i.e.* darker colour in the image) at the water surface (WS). The following classification of the water depth was proposed: very deep water (11 - 20 m), deep water (6 - 11 m), average (4 - 6 m) and shallow water (0 - 4 m).

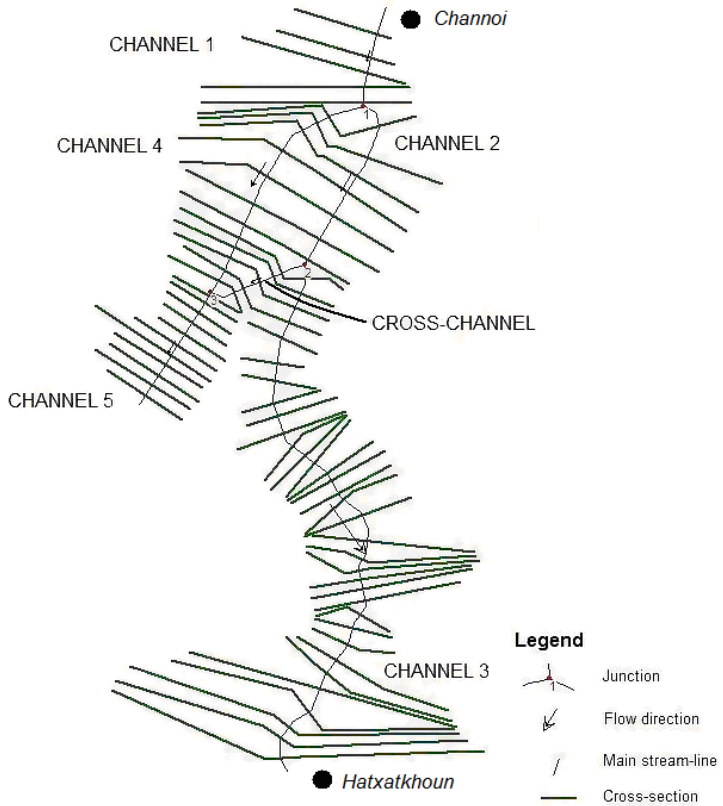


Figure 39. Cross-section alignment developed for both low and flooding discharge scenarios

To classify different land cover patterns in the study area during the studied period, the available data (*i.e.* a digital land cover map and the SPOT images taken in 2001 and 2005) were analyzed using the supervised classification technique.

For the low discharge scenario (6,450 m^3s^{-1}), with the interpolated top-width derived from the SPOT image (taken in 2003), the WSEle at the first cross-section of channel 1 and the last ones of channel 3 and 5 were 84.09 m+MSL (mean sea level), 80.30 m+MSL and 80.98 m+MSL, respectively. During the flooding period, there was no specific information which could help to determine the WS slopes of channels within the multi-channel network. According to the local people, with the peak discharge (56,000 m^3s^{-1}) in 1978, the WSEle's at Channoi and Hatxaykhoun were about 2.50 m and 2.00 m above the left bank respectively. With the elevation of the left bank in Channoi and Hatxaykhoun of about 86.00 m+MSL and 85.50 m+MSL, the WSEle's at each location were about 88.50 m+MSL and 87.80 m+MSL, respectively. In addition, it is assumed that the water surface slope along the multi-channel network in the flooding period was similar; the WSEle at the end of Channel 5 was estimated at 88.00 m+MSL. The WSEle's at each location in two scenarios were summarised in Table 11.

Table 11. Boundary conditions of the multi-channel network at different scenarios of the entry discharge

Channel	WSELe (M+MSL)	
	Low discharge	Flooding discharge
Channel 1 (Upstream boundary condition)	84.09	88.50
Channel 3 (Downstream boundary condition)	80.30	87.50
Channel 5 (Downstream boundary condition)	80.98	88.00

Zavadil *et al.* (2007) used the ratio of cross-sectional areas of the first cross-section of each downstream channel to examine the changes of geometry of the multi-channel network at each confluence. In this paper, such the ratio was used as an indicator to identify the splitting discharge at each junction. In other words, the ratio of splitting discharge at each junction was defined by the ratio of cross-sectional areas between the first cross-sections of the two channels downstream.

To calibrate the HEC-RAS model in the low discharge scenario (Figure 40), the top-width at each cross-section was identified according to the SPOT image. By using Winxspro, a software package designed to analyze stream channel cross section data for geometric and hydraulic parameters, the WSEle and cross-sectional area at each cross-section corresponding to the top-width were identified. In addition, the initial values for the WS slope between cross-sections were identified according to the average WS slope of each channel which was the ratio of the difference in the WSEle and the distance between the first and last cross-section of a channel. The Manning's *n* roughness parameter was calculated at each cross-section in MS Excel according to the Manning's equation and then applied in HEC-RAS. The hydraulic nature at each cross-section was modelled using HEC-RAS. If the differences of simulated WSEle's between the last cross-section of the upstream channel and the first two cross-sections of the two downstream channels were acceptable (less than or equal to 0.003 m), the water-way along the multi-channel network was identified; otherwise, the WS slope at each channel in MS Excel was adjusted (to match the SPOT channel width and to minimize the differences of the WSEle's of the cross-sections at the junctions) leading to the change of the hydraulic roughness at each cross-section and the simulated water-way.

In the flooding scenario (Figure 41), to identify the hydraulic roughness value at each cross-section in MS Excel, an initial WS slope ($S = 4.5 \times 10^{-5}$) was applied to all channels. The WSEle at each cross-section was calculated from the downstream to the upstream cross-section of each channel according to the initial slope. With the defined WSEle, the cross-sectional area and top-width at each cross-section were identified by using Winxspro. The Manning's *n* at each cross-section was calculated (in MS Excel) and applied in HEC-RAS. If the differences of

the WSEle's between the last cross-section of the upstream channel and the first two cross-sections of the two downstream channels were acceptable (less than or equal to 0.003 m), the flooding pattern along the multi-channel network was identified; otherwise, the initial WS slope along the channels would be adjusted.

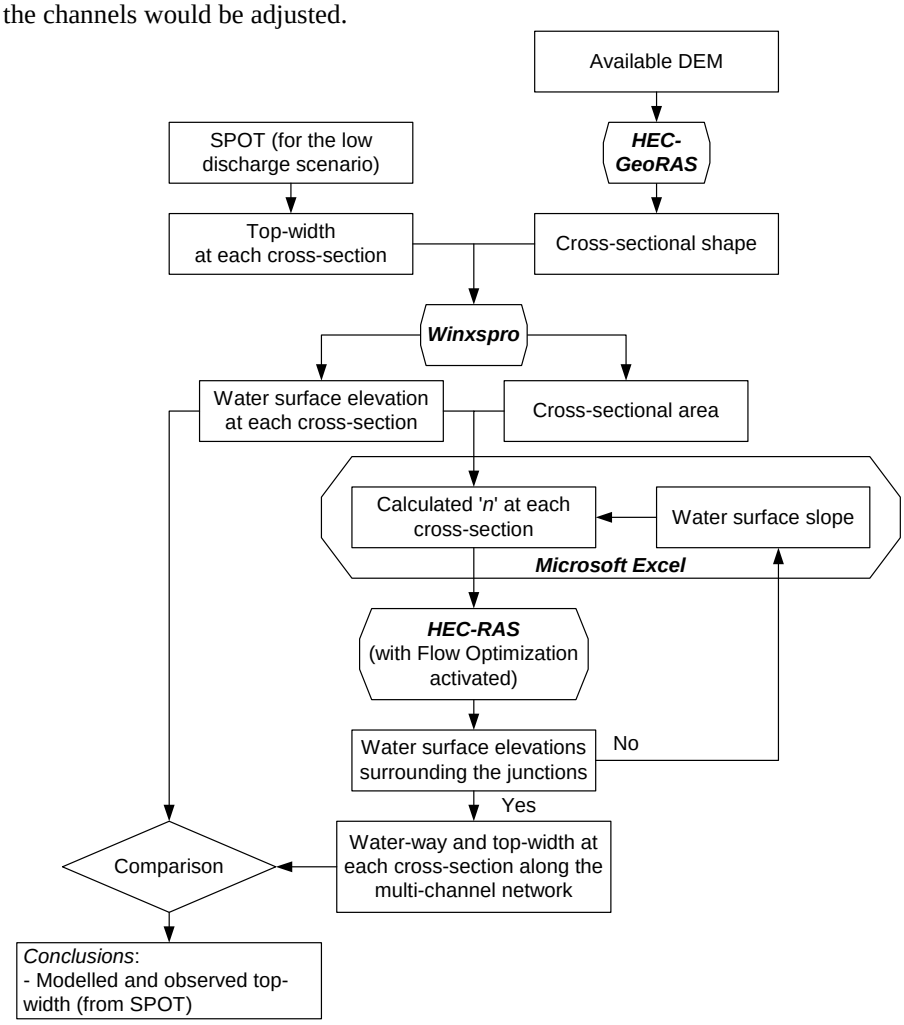


Figure 40. Routine to calibrate the HEC-RAS model for the low discharge scenario

To account for rapid changes of the land cover within the study area, three scenarios of land cover pattern were developed to model the flooding patterns. The first scenario (scenario 1) was of the current land cover pattern for the year 2005. The second and third scenarios were hypothetical cases in which all areas were covered by dry forest and rice paddy, respectively.

RESULTS

Land cover change over the Siphandone wetlands

Within the study area, the main land cover types (*i.e.* outcrops of rock and sand bars, dry shrub, bamboo/mixed forest, dry forest and rice field) could be recognized in both of the two SPOT images (taken in 2001 and 2005) (Figure 42). Between the two dates, the spatial pattern of the location and the proportion of each land cover type over the study area have changed significantly. Significant changes had occurred in the areas of dry forest and bamboo/mixed

forest; dry forest had been cut mainly for commercial purposes and had not been re-planted but replaced by degraded forest of bamboo/mixed forest or dry scrub. This feature was most noticeable in the west of the study area. In the east of the study area, apart from the change of dry forest into bamboo/mixed forest, more rice fields could be found as well. In addition, the land cover change could also be recognized by an increasing proportion of dry scrub from 2001 to 2005. The wetted-area was slightly different due to different entry discharges of the multi-channel network at the time the SPOT images were taken.

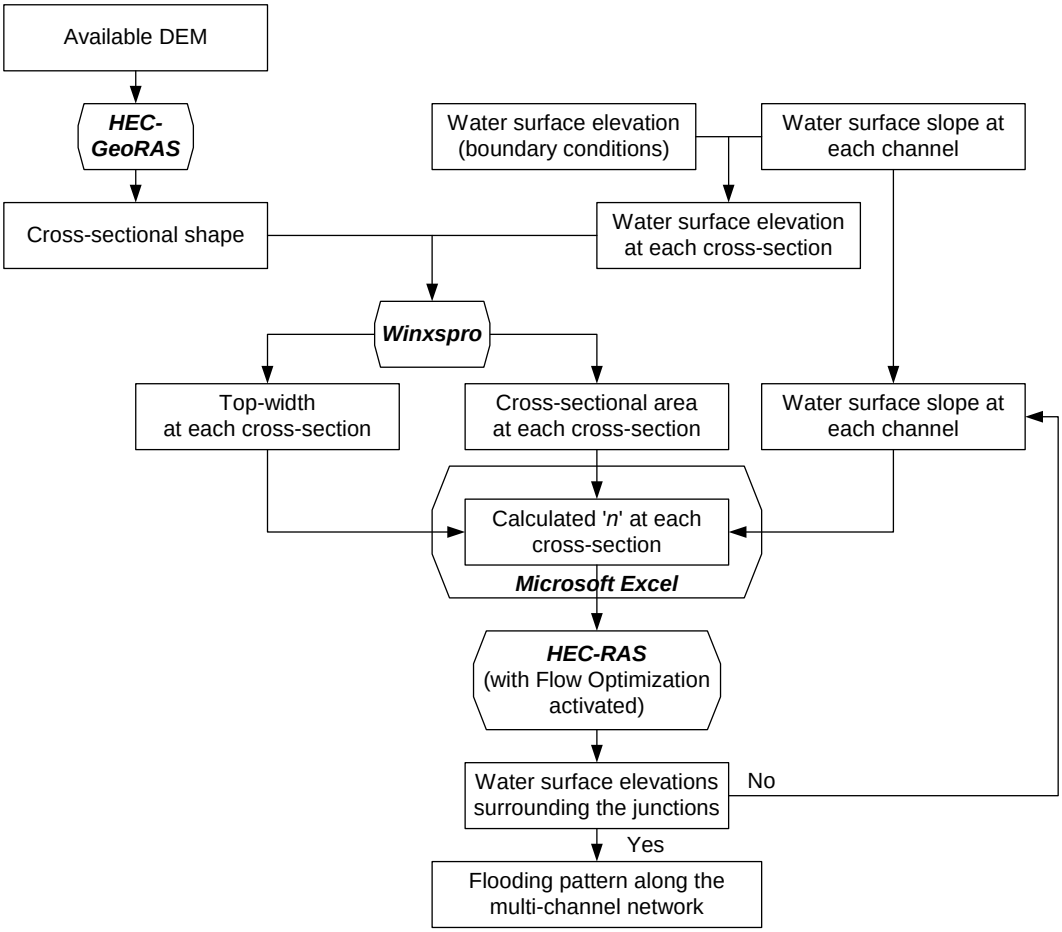
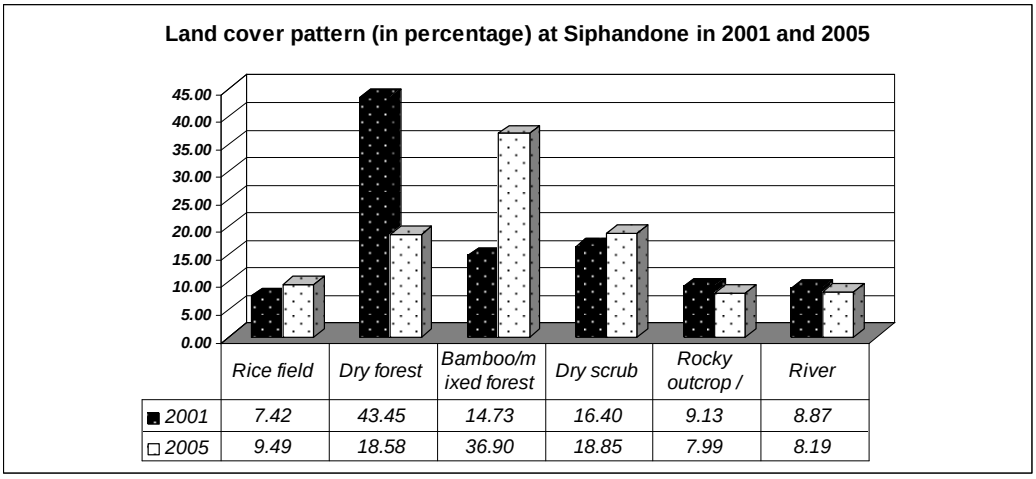


Figure 41. Routine to calibrate the HEC-RAS model for the flooding scenario

The integrated DEM

There were about one-hundred pairs of points (created by interpreting the SPOT image and derived from the dHA) available to develop a relationship between spectral reflectance and bathymetry. The correlation coefficient, R^2 = 0.742, for the relationship (between the reflective combination of the three bands in SPOT and the range of water depth) confirmed that the ranges of water depth derived from the SPOT image were relevant to the range of classified depths derived from the dHA. The newly developed DEM (with the integration of the available DEM. SRTM, dHA and SPOT) is presented in Figure 6. There are some errors (presented in ellipses) but these are few and mostly remote from the river network and require correction in due course.



	Rice field	Dry forest	Bamboo/mixed forest	Dry scrub	Rocky outcrop /	River
2001	7.42	43.45	14.73	16.40	9.13	8.87
2005	9.49	18.58	36.90	18.85	7.99	8.19

Figure 42. Percentage of each land cover type of the year 2001 and 2005

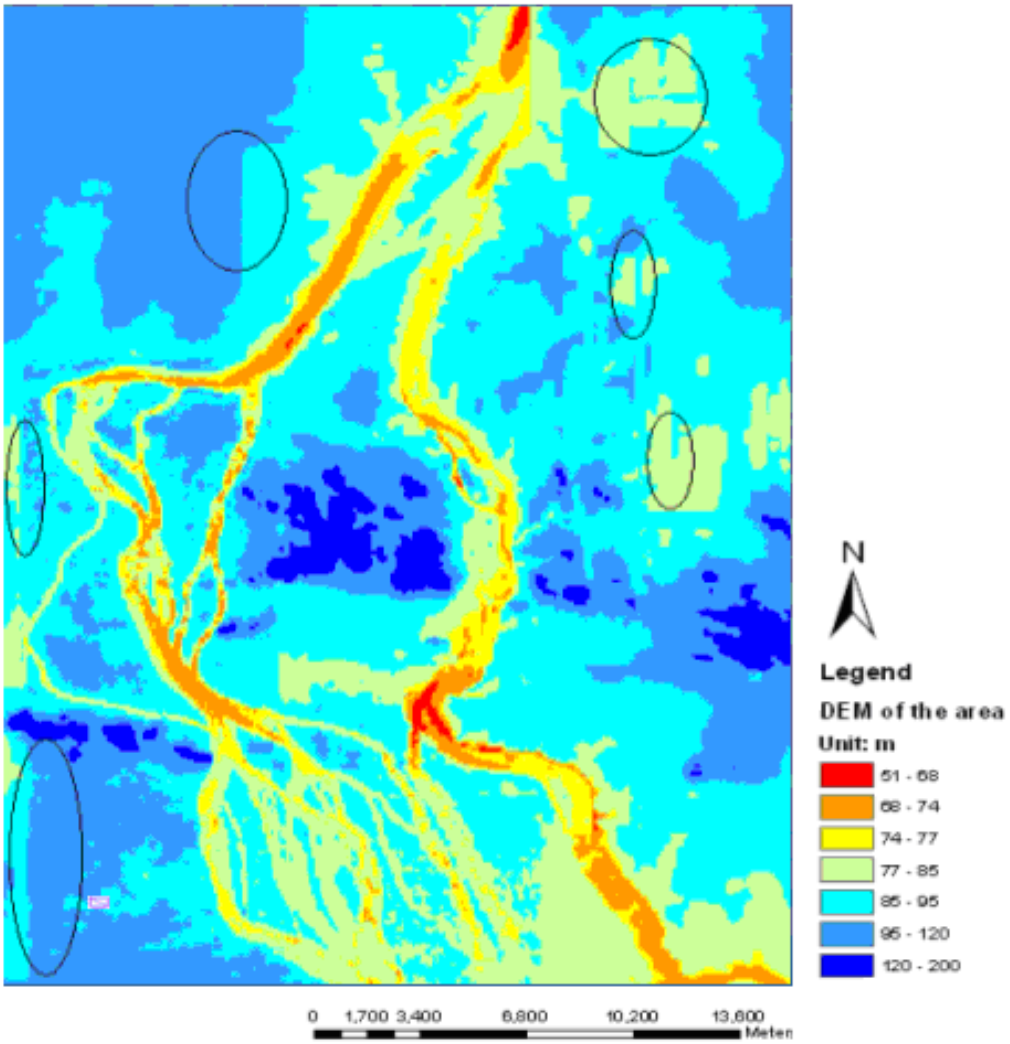


Figure 43. The newly developed DEM of the Siphandone wetlands, Lao PDR

The application of HEC-RAS for the multi-channel river network

Figure 7 illustrates the distribution of the in-channel hydraulic roughness (Manning's *n*) at each cross-section along the multi-channel network. It can be seen that the Manning's *n* coefficients along channel 4 and 5 was higher than those along channel 2 and 3. The comparison between the SPOT image and the modelled wetted section in HEC-RAS is presented in Figure 8; in this figure, the positive percentage indicates that the wetted area in the SPOT image was wider than in the HEC-RAS results and the negative percentage indicates the wetted area in HEC-RAS was wider than in the SPOT image. The differences between the modelled top-width and the SPOT image was within the range of (-27%: +17%) and most of the significant differences came from Channel 3. WSEle at the first cross-sections of each channel and the splitting discharge ratio at each bifurcation are presented in Table 12.

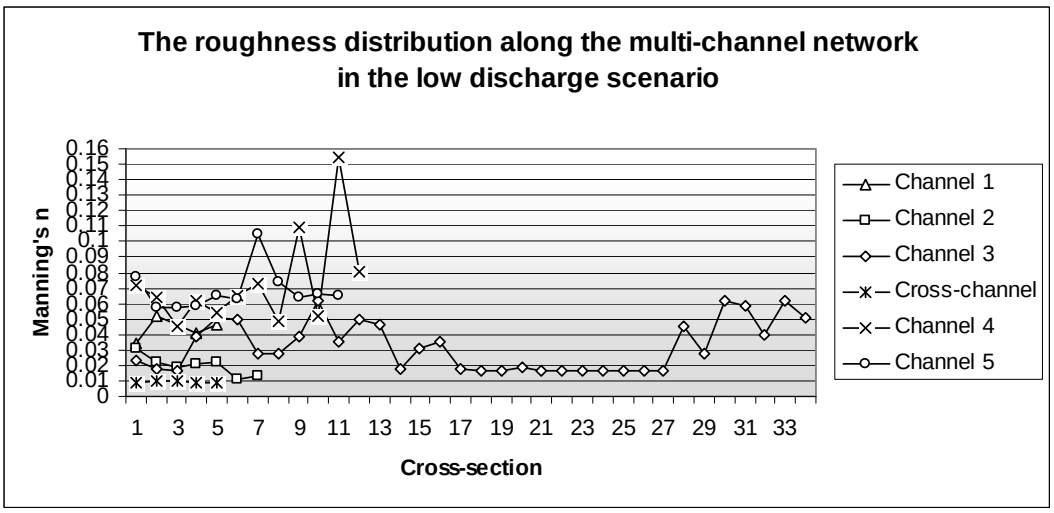


Figure 44. The hydraulic roughness distribution along the multi-channel network in the low discharge scenario

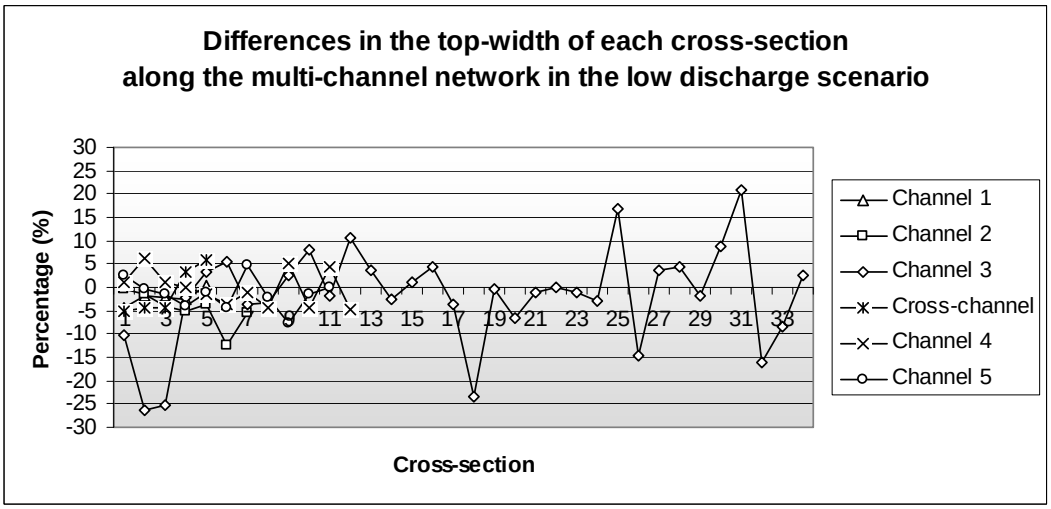


Figure 45. Comparison between the top-width derived from the HEC-RAS result versus SPOT image in the low discharge scenario

For the flooding scenario, each cross-section was divided into three main parts, including two sections of the floodplain and a channel section. To identify the hydraulic roughness of the floodplain sections, the land cover map produced by the MRC in 2006 was used and the referenced hydraulic roughness values of each land cover type were identified according to literature (Table 13).

Table 12. Water surface elevation at first cross-sections and the entry discharge of each channel

Channel	WSEle (m+MSL)	Discharge (m^3s^{-1})	Ratio of splitting discharge at the junction (%)	
			Junction 1	Junction 2
Channel 1	84.09	6,450		
Channel 2	83.92	3,278	50.8	
Channel 3	83.41	3,119		95.1
Cross-channel	83.40	159		4.9
Channel 4	83.93	3,172	49.2	
Channel 5	82.89	3,331		

Table 13. Roughness value of each riparian land cover type in the Siphandone wetlands.

No.	Land cover type	Referenced roughness
1	Outcrops of rock and sand bar (low flow only)	0.050 (**)
2	Dry shrub	0.300 (*)
3	Bamboo/mixed forest	0.200 (**)
4	Dry forest	0.800 (*)
5	Rice field	0.220 (*)

(*) Marsik and Waylen (2006); (**) Arcement and Schneider (2008).

Figure 46 illustrates the hydraulic roughness distribution along the channels of the multi-channel network and Figure 47 shows the flooding pattern for the current land cover scenario with WSEle at the upstream boundary condition found to be 89.09 m+MSL, which was 0.59 m above the predefined boundary condition. The hydraulic roughness at all cross-sections in the flooding scenario was lower than in the low discharge scenario, except the hydraulic roughness along the cross-channel because in the cross-channel the WS slope increased when the upstream boundary discharge increased. With different scenarios of land cover change, the simulated WSEle at each channel was similar therefore the flooding extents were not different according to land cover change. However, the land cover change led to change of hydraulic roughness of the floodplain and therefore resulted in the change of the velocity of the floodplains (Figure 48) leading to changes of discharge flowing through the floodplain. In fact, there were no significant differences in flooding area according to different land cover scenarios.

DISCUSSION

The SPOT image can be used together with the measured bathymetry to create a pseudo-bathymetry of a large river network where there was no measured data and should be similar according to the hydraulic properties and sediment transport pattern to the neighbour channels. However, in the case of a highly turbulent channel, the obtained result might be able to reflect ranges of the bathymetry with a certain level of uncertainty. The pseudo-bathymetric data has not been used in the hydraulic modelling reported in the ‘Results’. The approach needs to be further studied so that it can be used to develop a more precise pseudo-bathymetry of a large river network and therefore useful for a 1D hydraulic modelling. To advance this aspect of the study, it is planned to use the pseudo-bathymetry DEM to extend the hydraulic model further to the south. For the present, the HEC-RAS model has been developed for the northern multi-channel network alone (Box b, Figure 38) using the dHA and the DEM developed by the MRC.

By using MS Excel and Winxspro, the hydraulic roughness (within the channel) at each cross-section could be identified and the wetted section along the multi-channel network identified for low discharge by using HEC-RAS and matching the water levels to the SPOT image. Once this procedure was developed successfully, the similar procedure was applied to the less-well constrained flooding scenario. Even though the Flow Optimization function (to minimize any hydraulic jump or drop by adjusting the splitting ratio at each junction) in HEC-RAS was used to identify the ratio of splitting discharge at each junction, the ratios of the cross-sectional areas of the first cross-sections after each junction were used to provide guidance on splitting the discharges proportionately to the area ratios for both low and flooding flows.

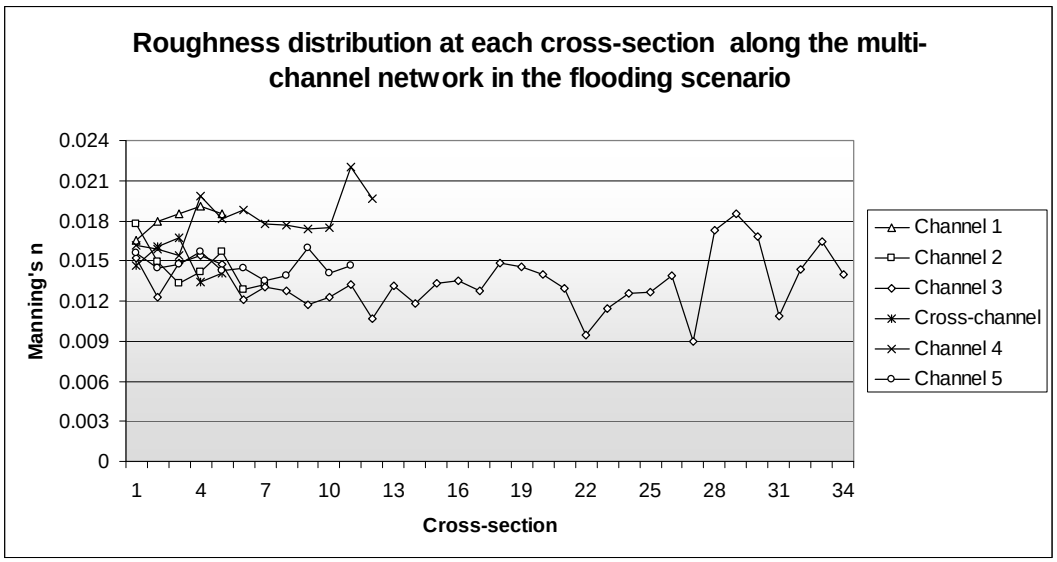


Figure 46. Hydraulic roughness distribution along the multi-channel network in the flooding scenario

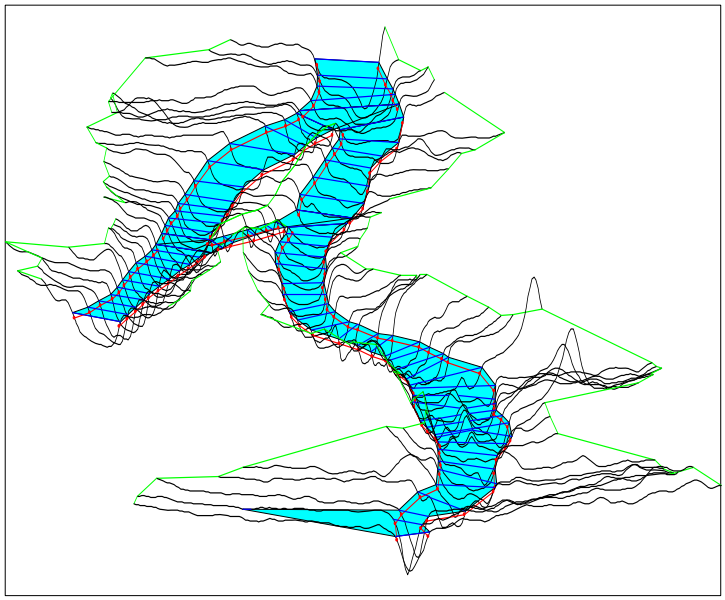


Figure 47. Flooding pattern according to three scenarios of the land cover pattern. Blue colour is the modelled channelized flow, the green lines indicate expected floodplain and red lines indicate the channel banks

The hydraulic roughness along channel 4 and 5 was higher than that of channel 2 and 3 in both scenarios of the entry discharge. Such differences might be explained by differences in the physical roughness of each channel bed; a topographically-rough bedrock channel might have higher hydraulic roughness than one with an alluvial fill within the bedrock channel. The hydraulic roughness of the cross-channel remains low, as the cross-channel is largely alluvial.

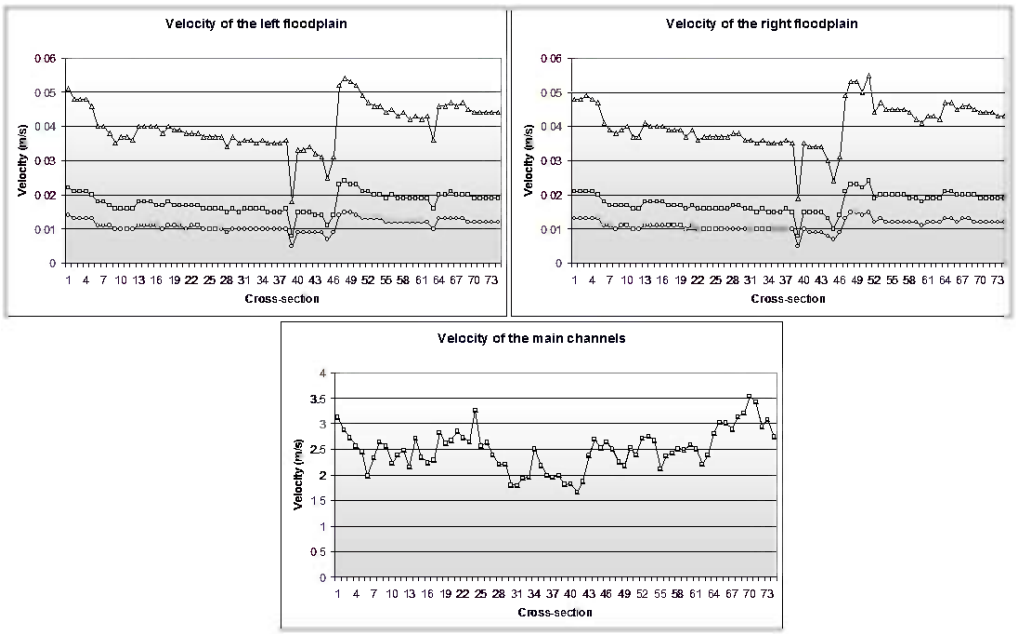


Figure 48. Velocity of the left-floodplain, channel and right-floodplain in different scenarios of the land cover pattern along the multi-channel network; square-symbol represents the present-day hydraulic roughness of the floodplain while triangle- and round-symbol represent the hypothetical cases where all areas were covered by rice paddy and dry forest, respectively

With different scenarios of the land cover pattern, even though the flow velocity along the floodplain changed significantly, the flow velocities within the main channels were similar when comparing the simulations for the three land cover patterns. In addition, the proportion of discharge flowing through the floodplain was small compared to that of the channels. Given the spatial resolution in the GIS model, land cover change had no effect on flooding extent but the presence of riparian vegetation slowed the main channel flow slightly so increasing water levels slightly. Additional unsteady flow simulations are required to investigate the effects of land use change on the dynamic progress of the annual peak flow and flooding patterns. Future work will also consider the changes in proportions of the land uses inundated given the effects of climate change scenarios on river discharge.

CONCLUSIONS

The SPOT image can be used to derive the pseudo-bathymetry of the river network based on the supervised classification technique. Due to the limitation of the information extracted from the SPOT images in the context of determining water depths, the results do not show a continuous range of bathymetry values but are rather grouped semi-quantitatively to create a pseudo-bathymetry that replicates the known range of bathymetric values. The approach potentially is valuable especially in the case of a complex anabranching river network where not all channels

can be observed in the field.

The ratio of cross-sectional areas (defined according to the available dHA) after a bifurcation can be used to set the initial ratio of splitting discharge in the case of lack of field discharge data in individual channels. Subsequently, using MS Excel and Winxspro, the optimized hydraulic roughness at each cross-section along the network can be identified iteratively. Consequently, the HEC-RAS model can be used to simulate the multi-channel network with different upstream boundary discharges and limited additional parameter information.

Land cover change does not have significant impacts on the flooding extent over the study area. In addition, the land cover change along the floodplain does not have any impact on the velocity of the channel itself but the velocity of the floodplain (*i.e.* the lower the roughness floodplain, the faster the flow in the floodplain). Such the consequent changes of the flow rate according to the land cover change could cause major modifications of geomorphological features within the river network.

ACKNOWLEDGEMENT

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Paper 5-4-4

FLOOD RISK APPROACH AND USE OF THE DACA INSTRUMENT IN THE LOWER MEKONG RIVER BASIN

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ABSTRACT

Economic activities in flood-prone areas are increasing around the world. At the same time we face changing weather conditions and a rising sea level as a result of climatic change. If no measures are carried out, both probability and impact of floods will increase severely. In the Netherlands flood hazard and flood damage are combined in a risk-approach using a cost-benefit analysis for proposed measures. In this approach, risk is defined as the product of probability of flooding and impact of flooding.

In this paper a tool is presented that can provide insight in the impact of potential floodings for various user defined scenarios. The tool does this by taking into account the spatial distribution of land cover and its economic value, as well as the characteristics of potential flooding scenarios. By dividing the assessment over direct damage, production losses and indirect damage a clear picture of the origin of the damage can be given.

The tool is called DACA - Damage and Casualties Assessment. It was implemented in a pilot project in the Chiang Rai region of northern Thailand. DACA is based on the Dutch 'HIS-SSM'[12] which is a mandatory part of impact assessments for large infrastructural works in the Netherlands.

The paper illustrates the use of DACA in flood management and mitigation planning. DACA can support assessment of the effects of land developments on the total flood risk in a certain area. It is shown that by using DACA the economic benefits of measures to mitigate or prevent flooding can be evaluated. As such DACA can be used in land use planning.

The paper also presents an analysis on the Strengths, Weaknesses, Opportunities, and Threats of DACA in the Lower Mekong River Basin by delegates from Thailand, Vietnam, Lao PDR and Cambodia. The users explain that DACA is both practical and useful for their work in flood management and land use planning. They also indicate that the quality of the results will depend on the quality of the economic figures. It is mainly the amount of economic data that they see as a threat for implementation.

The paper concludes with remarks on how to improve DACA, with respect to the economic dataset and valuation and opportunities for future use and implementation of the tool in the Lower Mekong River Basin.

INTRODUCTION

Every year, large areas in the Lower Mekong River Basin (LMB) are flooded. This does not mean that huge damage occurs every year. In parts of the LMB, people even speak of 'beautiful floods', when it comes at the right time, to provide sufficient water and soil nutrients for crops, while causing little damage. However all too often floods are less harmless. Alone in this millennium three large floods (2000, 2001 and again in 2002) occurred and caused losses of life

[12] HIS-SSM stands for the Damage and Casualties tool in the Netherlands

and huge property damages to the four riparian countries of the LMB.

Today the vulnerability of the LMB to floods is still increasing. Conservative prognoses anticipate a population growth from 60 million today to over a 100 million in 2025. More and more flood-prone areas are being developed for new settlements and cultivation. If the economic development in the region will continue to grow at the rate it has been doing the past decades, economic value at risk will increase by a landslide.

Currently there is a considerable amount of studies, data-gathering and modelling efforts carried out and ongoing in the LMB countries. However, a practical tool to quantify the effects of floods in terms of damage and casualties is still lacking. This paper presents a Damage and Casualties Tool (DACA) that was developed for this purpose. A prototype of DACA was developed for the Chiang Rai Region in northern Thailand. The tool is based on the Dutch damage and casualties assessment tool 'HIS-SSM'. HIS-SSM stands for *'Hoogwater Informatie Systeem, Schade en Slachtoffer Module'*. In the Netherlands, by law all infrastructural measures of national importance require an assessment to consider positive and negative effects of a proposed measure on safety, economy and quality of life. The effects of floods on safety and economy are determined using 'HIS-SSM'.

Besides the development of DACA, the paper describes how it can be used and how various users valued the tool in a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis. Please mind that the DACA tool as it is today is a prototype. The results presented in this paper are first estimates of damage using the prototype to show the working of DACA in damage assessment and its use in flood risk assessment, rather than to present detailed numbers for the actual flood risk in the area. Before full implementation the database needs to be tested, adapted and updated.

DESCRIPTION OF DACA

DACA is a software package that can be installed on a standard PC with windows operating system and an access database. DACA determines the present value of expected annual losses for different flood scenarios, including damage on agricultural yields, damage to infrastructure, industrial activities and houses. The instrument supports cost-benefit analyses that include the assessment of damage in flood-prone areas under different prevention and mitigation strategies. In other words it can be used to answer questions such as:

- what is the present flood risk in this region?
- what are the expected benefits if measures are taken?

The Dutch 'HIS-SSM' was adapted to the user defined needs of DACA in the area of Chiang Rai (Leenders et al., 2009a). The dataset on landcover and economical valuation were adapted to the situation of our study area. The use of DACA in damage assessment in the Chiang Rai region is shown in Figure 1. DACA requires a flood scenario as an input. This flood scenario is expressed as a flood map. In DACA this flood map is converted to a damage map, by combining it with data on land cover and an economic dataset of damage functions and maximum damage values. As an output of DACA we obtain a total damage for the given flood scenario, a table of damage per category of land cover and a map of the damage.

In DACA the damages are estimated for several damage categories, representing a landcover type (e.g housing, agriculture, etc).DACA considers three types of damage:

- direct damage within the flooded area: This comprises physical damage to buildings, inventories, terrain and infrastructure;
- direct damage within the flooded area as caused by business interruption and economic damage by production loss;
- indirect damage: Economic damages outside the flooded area due to loss of production. For example transportation routes through the flooded area cannot be used or production

stops due to lack of supplies from industry within the flooded area.

For each damage category and type of damage, the economical damage (expressed in Baht) is calculated by Equation 1.

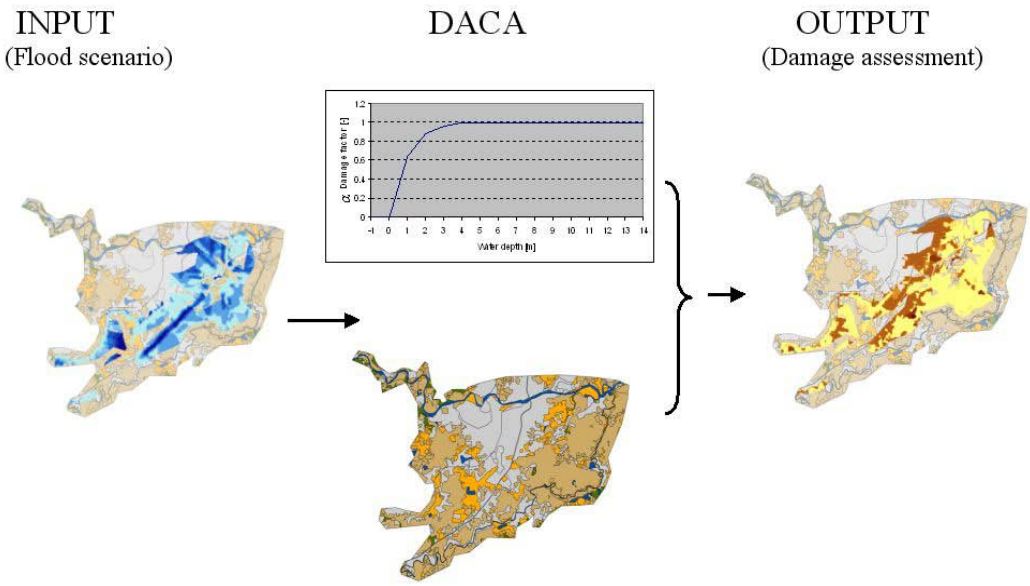


Figure 1. Process of damage assessment using DACA

$$S = \sum_{i=1}^{n} \alpha_i n_i S_i \qquad \text{(Equation 1)}$$

where α_i is the 'damage factor' for category i , n_i is the area (m^2) in category i and S_i is the maximum damage per area unit (m^2) in category i. Each category (i) represents a landcover type. The damage-factor α_i represents the effect of hydraulic conditions and is affected by the maximum water depth and flow velocity. The damage factor α_i is calculated using a damage function (Kok et al., 2005). Figure 2 gives an example of such a damage function. A damage function scales damages between 0 and 1, with a damage factor (α). If the damage factor is 0 there is no damage, if the factor is 1 there is maximum damage.

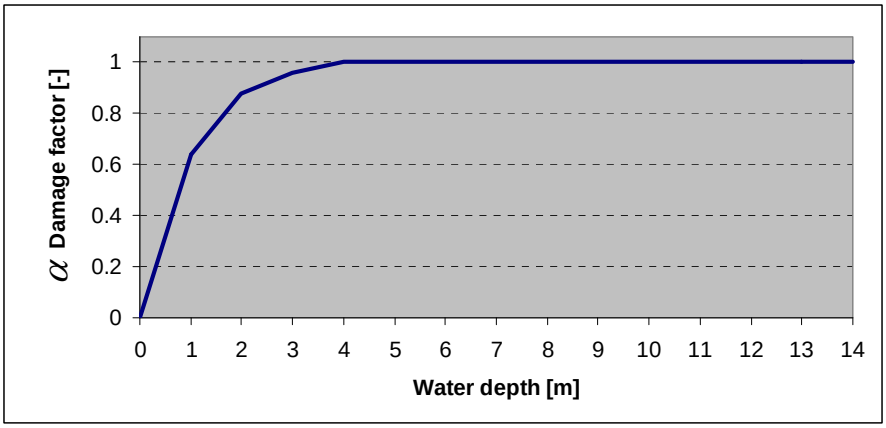


Figure 2. Example of damage function where a damage factor α, is related to water depth

DAMAGE ASSESSMENT

The use of the prototype of DACA is demonstrated with three flood scenarios in the study area of Chiang Rai. Upon implementation, users can add their own flood scenarios to determine damage. Figure 3 shows the flood extent of the flood that occurred in 2002 around Chiang Rai.
The flooding around Chiang Rai is mainly caused by overland flow from the Nam Mae Korn and the Nam Mae Lao. Flooding around Chiang Rai as a result of high water level at the Nam Mae Kok is not common. The catchment area of Nam Mae Lao is 3000 km^2 and that of Nam Mae Korn is 170 km^2. During the first part of the rainy season (May to July) the soil absorbs the rain, but in August and September the soil is saturated and heavy flash floods may occur. As the slope of the two rivers is rather steep, flooding due to backwater from the Nam Mae Kok is not noticed. (provincial office Royal Irrigation Department Chiang Rai, pers. comm.).

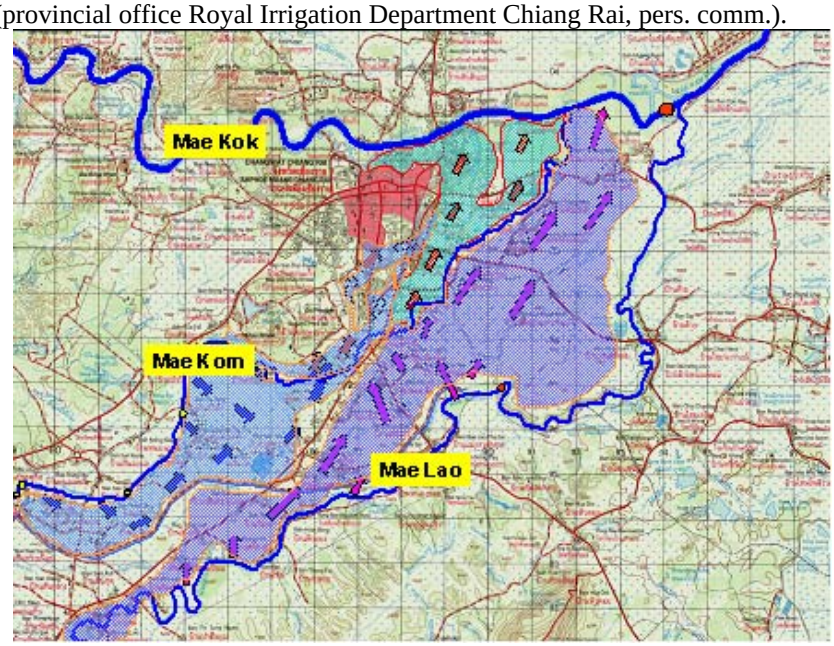


Figure 3. River systems and flood extent of 2002 flood around Chiang Rai

Three flood scenarios were determined with a return period of five years (T5), 25 years (T25) and 100 years (T100). The procedure of flood mapping for the water depth is described by Leenders et al., (2009a, 2009b). The flow velocity is based on the slope of the terrain and expert judgement. Figure 4 shows the maps of the water depth in the three flood scenarios.

The flooded area in the T5, T25 and T100 scenario doesn't differ much, nor the water depth or flow velocity (Table 1). The flooded area does not differ much between the scenarios because in the methodology the flood extent of the flood of 2002 is used to determine the extent of the flood. The reason for the low differences in flood depth between the scenarios can be explained by the use of a 30-year dataset to estimate a 100 year event and to the location of the measurement station Ban Tha Sai in the Nam Mae Lao.. It is very likely that in case of a flood with a return period higher than 25 years the Nam Mae Lao starts flooding upstream from the measurement station. This implies indeed that the hydrographs of T25 and T100 at the measurement station do not differ much from each other, nor the flood map of T25 and T100. As such the scenarios of T5 and T25 are more reliable than the scenario T100.

Table 2 shows the total damage as calculated for each flood scenario. These damage values are very large (50 Baht is about 1 Euro). Figure 5 presents the map of the damage for the T5 flood scenario. The urban parts can be easily recognized by their larger damages (darker colours).

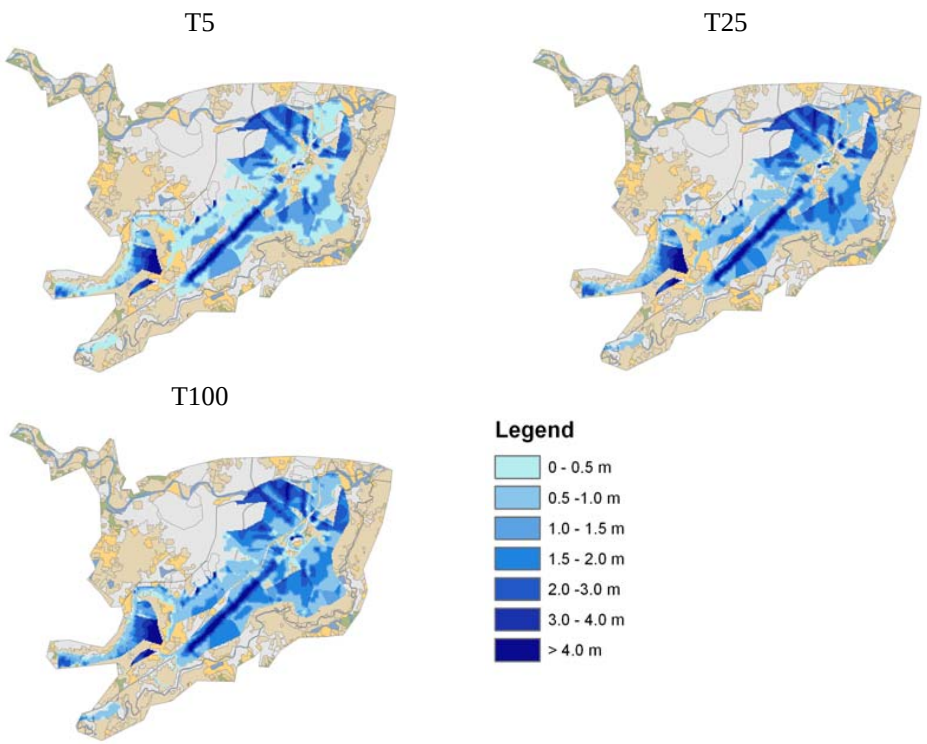


Figure 4. Flood map of water depth for the T5, T25 and T100 flood scenario.

Table 1. Flood characteristics of each flood scenario

		T5	T25	T100
Flooded area	Km^2	38.8	38.8	41.7
Water depth				
Minimum	M	0.05	0.35	0.06
Maximum	M	6.72	7.02	7.17
Mean	M	1.28	1.58	1.62
Flow velocity				
Minimum	m/s	0.41	0.45	0.47
Maximum	m/s	2.18	2.36	2.49
Mean	m/s	1.03	1.13	1.18

Table 2. Total damage of three flood scenarios calculated with DACA

Scenario	Return period [year]	Total damage [Baht]
T5	5	2.54E+11
T25	25	3.18E+11
T100	100	3.52E+11

FLOOD RISK ASSESSMENT

Flood risk was determined based on three flood scenarios for the area of Chiang Rai (Figure 4). Flood risk is defined as the total sum of probabilities of floods multiplied by their impacts (Equation 2). Probability refers to the statistical probability that a flood of certain return period occurs, while impact refers to the consequences of a flood, the latter being determined for instance using DACA.

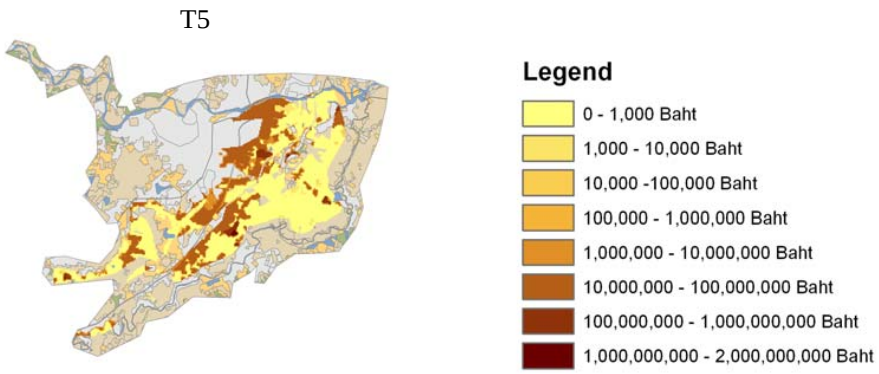


Figure 5. Map of damage for T5 flood scenario

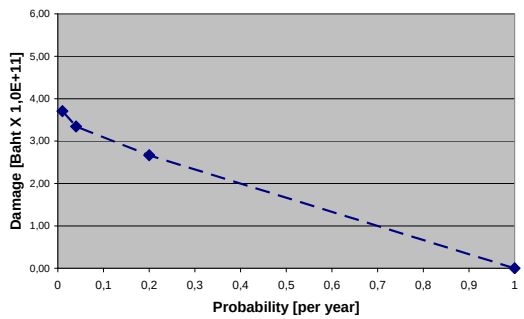
$$\textit{Flood risk} = \int \textit{Probability} * \textit{Impact} \qquad \text{(Equation 2)}$$

Flood risk reduction may be induced by either:

- reducing the probability of flood occurrence: for instance by creating extra discharge capacity in the river by widening or deepening of the river beds or when a flood is prevented by constructions of dykes and embankments;
- reducing the impact of a flood: for instance by constructing a compartmentalization dike or when people are encouraged to reduce the effect of a flood by preparing themselves properly. This may be the result of a solid early warning system;
- both a reduction on the probability of the occurrence and the impact of floods.

Figure 6A presents a graph of the estimated damage, presented in Table 2, versus the probability the flood occurs in the study area of Chiang Rai.

A. Damage versus probability for study area



B. Flood risk in study area

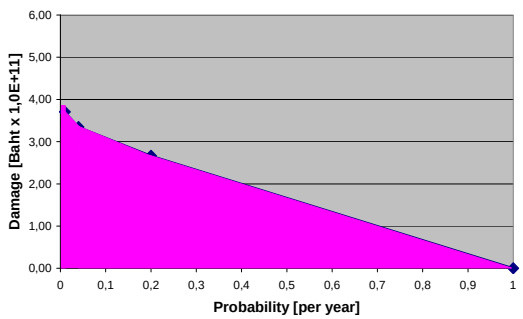


Figure 6. Graphs of estimated damage versus the probability of a flood per year for three flood scenarios in Chiang Rai (in the graph it is assumed there is no damage resulting from a one year flood event

The area underneath the curve of Figure 6A, gives the flood risk (Figure 6B). We can calculate this by using Equation 3. Mind that these 'flood risk curves' are specific for an area and cannot be copied from one area to the other.

$$FR = \frac{1}{100} \cdot D\,(\text{"1/100"}) + \left(\frac{1}{25} - \frac{1}{100}\right) \cdot \left(\frac{D\text{"}(1/100\text{"}) + D\text{"}(1/25\text{"})}{2}\right) + \left(\frac{1}{5} - \frac{1}{25}\right) \cdot \left(\frac{D\text{"}(1/25\text{"}) + D\text{"}(1/5\text{"})}{2}\right) + \left(\frac{1}{1} - \frac{1}{5}\right) \cdot \left(\frac{D\text{"}(1/5\text{"}) + D\text{"}(1/1\text{"})}{2}\right) \quad \text{(Equation 3)}$$

where:

FR	= Flood risk per annum (Baht/year)
1/100, etc.	= Probability of flood (1/year)
D('1/100'), etc.	= Damage with a probability of 1/100 year, etc. (Baht)

The flood risk that is calculated with Equation 3 for the study area of Chiang Rai is 161 billion Baht per year.

THE EFFECT OF MEASURES ON FLOOD RISK

The effect of measures on flood risk can also be assessed with DACA. For this purpose the flood risk needs to be assessed for a set of flood scenarios with and without a measure carried out. Let's assume that in the area of Chiang Rai infrastructural measures are considered to be constructed that reduce the frequency of flooding from once a year to once in 5 years (for example a dike along the Nam Mae Lao). Figure 7A illustrates the risk in the situation in which no measures are carried out, Figure 7B illustrates the risk in the situation in which the measures are carried out and there is only damage when water levels with a return period of five years or more occur.

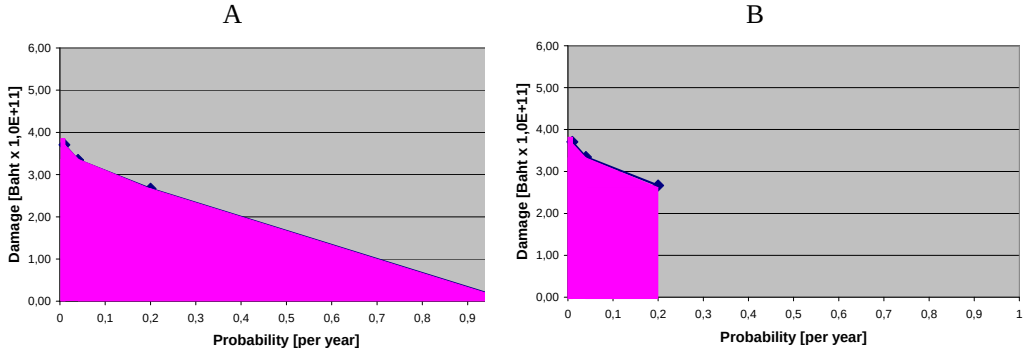


Figure 7. Graphs of estimated damage to return period for three flood scenarios in Chiang Rai

Applying Equation 3 to Figure 7B results in a flood risk of 59.4 billion Baht per year. This means that by conducting measures that prevent the area from being flooded to once every 5 years, a hundred billion Baht flood damage per year would be prevented. In a cost-benefit analysis of flood mitigation measures this prevented damage is regarded as a benefit of the flood mitigation measure. In this example the benefits of the flood mitigation measure are about a 100 billion Baht per year. To compare this value with the costs to construct the measure we need to express the value of 100 billion Baht per year to its present value (Equation 4). Present value is the value on a given date of a future payment or series of future payments, discounted to reflect the time value of money and other factors such as investment risk.

$$PV = FR * \left(1 - \frac{1}{(1+r)^n}\right) * \frac{1}{r} \qquad \text{(Equation 4)}$$

where:
PV = present value (Baht)
FR = flood risk per annum (Baht per year)
r = discount rate (%)
n = number of years

If we were to say that the construction of this flood mitigation measure would hold for 25 years and we use a discount rate of 4%, the present value of these benefits would amount to 1.59 zillion Baht. In other words, if construction of the measure would cost less than 1.59 zillion Baht the investments would be cost-efficient.

Again this is just an example of the use of DACA for flood risk management and actually the procedure that Dutch policy makers follow in decision making on infrastructural measures larger than € 25 million. The prototype of DACA, as developed in this project, should not yet be used for such decision making with its current dataset. For implementation in the regions of the LMB, the database needs to be tested, adapted and updated. Once the database is tested, adapted and updated, DACA can be used for ex-ante decision making in flood management.

SENSITIVITY ANALYSIS

The sensitivity of flood risk in the area of Chiang Rai was determined for variations in water depth, flood statistics and economic valuation. Table 3 presents the results of the sensitivity analysis. The changes in flood risk, compared to the flood risk as was calculated in paragraph 'FLOOD RISK ASSESSMENT' was taken as an indicator to reflect the sensitivity (161 billion Baht per year). Three examples were considered:

1. effect of water depth; what if the water depth in a given flood scenario is not correct?: In this example the water depth of scenario T100 is increased with 1.0 m. The water depth in the scenarios T5 and T25 were not changed;
2. effect of flood statistics; what if the flood statistics are not correct? In this example the return period of the flood scenarios is set to 1, 2, 10 and 100 years (Example 2A) or 1, 2, 10 and 50 years (Example 2B) instead of 1, 5, 25 and a 100 years;
3. effect of economic valuation; what if the economic valuation is not correct? In this example the set of maximum damage values that was used in the prototype is changed. In Example 3A a set of maximum damages values is used in which the damage values for urban areas are 50 times smaller. Example 3B uses a set of damage values in which the damage values of the categories, but the urban categories is 50 times larger.

Example 1 shows that a change in water depth in the T100 has little effect on the flood risk in the area. Apparently a low frequency flood that occurs statistically once every 100 years does not contribute much to the total flood risk in the area. This implies that to determine the flood risk for the area of Chiang Rai, it is of most importance that the high frequency flood scenarios are best described. This is also shown in Example 2. If the T100 scenario has in fact a return period of 50 years, the flood risk increases significantly. Example 3 shows the importance of a good estimation of the maximum damage values for the urban areas. As the maximum damage values are large in urban areas, it is important that these are estimated well (Example 3A). In the study area, the damage to agriculture does not contribute as much to flood risk as the damage to urban area. When the damage values of agricultural land use are increased 50 times, the increase in flood risk is only 5% (Example 3B). Whereas a reduction of maximum damage values of 50 times in urban areas, the flood risk is also reduced a factor 50. Thus, to

determine flood risk in the area of Chiang Rai, it is important to have a good economic valuation in urban areas.

Table 3. Effects of changes in flood scenarios of example 1 on flood risk

	Description	Flood risk	Effect on flood risk
		[Billion Baht/year]	[in % of flood risk in reference case]
Reference		161	
Example 1	1 meter added water depth of T100 scenario,	173	103%
Example 2A	Return periods of 1, 2, 10 and 100 years	164	102%
Example 2B	Return periods of 1, 2, 10 and 50 years	185	115%
Example 3A	Max damage values of urban land cover divided by 50	3.4	2%
Example 3B	Max. damage values of land cover, but urban multiplied by 50.	169	105%

SWOT ANALYSIS

From 6-9 January a 4-day workshop on the use of DACA was held with delegates from Thailand, Vietnam, Lao PDR and Cambodia. At the workshop, the participants ran and tested the DACA instrument. The possibilities of improving DACA and expanding it to other regions were discussed. The last day of the workshop an analysis on Strengths, Weaknesses, Opportunities and Threats of the DACA-instrument was done.

In the SWOT analysis the delegates concluded that the DACA instrument could be of great value when implemented on a large scale. The users explain that DACA is both practical and useful for their work in flood management and land use planning. Especially the working of the software and its interface were considered to be easy and handy, as well as the brief calculation time required for a full damage assessment. However, it was recognized that the topic of damage assessment and determining flood risk are far from easy. Assistance to implement and use such instrument is appreciated. To develop a database which is good and generally adopted takes time, an amount of data and expertise. Furthermore, to run DACA with representative flood scenarios is also considered to be an expertise. It is also indicated that the quality of the results will depend on the quality of the economic figures. It is mainly the amount of economic data that is regarded as a threat for implementation.

From the authors' point of view, it should be mentioned that the instrument should be regarded as a tool that facilitates the current method of damage analysis. DACA doesn't need more information than currently is applied and generally accepted in a country as Thailand or any other country in the Lower Mekong River Basin. Notion is that by filling in the database people become more aware of the difficulties and extent of damage assessment. These difficulties are not subject to the tool, but to the topic. The tool gives insight in the data that should be taken into account.

CONCLUSIONS AND RECOMMENDATIONS

The objective of this project was to develop a Damage and Casualties Tool (DACA) and implement it in an area in the Lower Mekong River Basin. For this the Dutch 'HIS-SSM' was adapted. The adaptation and demonstration have been carried out successfully and a full-functioning DACA was demonstrated during a four-day training in Bangkok. On the basis of development and demonstration we conclude that:

1. there are various governmental agencies involved when developing an instrument for damage assessment in Thailand. When scope is broadened to the region even more

agencies and institutes become involved. From our experience in development and demonstration we find that DACA functions as a unifying incentive where various expertises of organisations and institutions are joined together;

2. DACA can be used to support the justification of investments in flood risk management in Thailand. The flood damage assessment method used in DACA is in conformity with Thai government administration;
3. the prototype of DACA that was developed should not be used for decision making with its current dataset. Before full implementation the database needs to be tested, adapted and updated. This holds for both the database on the land cover dataset and the database on economic valuation. The land cover dataset for example could be improved with a more detailed description of the urban areas. This could be done by using data from the department of Public Works, Town and Country. The economic dataset could be improved with results of an economic survey that is done in the area of Chiang Rai, within the Programme 'Flood Management and Mitigation Strategy' of the Mekong River Commission. From our study it appeared that especially the economic damage values for urban areas have major impact on the total damage. Once the database is tested, adapted and updated, the DACA prototype can be used for ex-ante decision making in flood management for the Chiang Rai region;
4. with some adaptations DACA can be extended to other flood prone areas in the Lower Mekong River Basin. Participants of the Bangkok training indicated that DACA could be a valuable tool for all countries in the Lower Mekong River Basin. Reasons they put forward are the following:
   - DACA assesses damage in a spatially distributed fashion that takes into account the spatial distribution of land utilities, as well as specified characteristics of flood scenarios (water depth and flow velocity). It also is possible to group the damage per spatial unit, for example administrative unit once the damage is calculated;
   - DACA can assess damage per damage category. This way the contribution of each damage category to the total damage is easy to derive;
   - the method that DACA uses to determine damage is transparent and easy to adapt. Within the interface it is possible to derive how damage is determined. If necessary the method can be adapted by adapting a damage function and/or a maximum damage value for a damage category;
   - DACA can be used as a tool within flood risk assessment;
   - DACA can be used to assess the benefits of flood measures.

Main recommendation is to proceed in the development of DACA for Thailand as well as for the entire Lower Mekong River Basin. This could include further development towards implementation for the Thai administration as well as a full scale feasibility study for the implementation of DACA in Lower Mekong River Basin. Such development would thrive when all potential financiers and stakeholders in flood risk and flood risk management are involved and their expertise and interests are unified. We therefore suggest that DACA is used not only as damage assessment tool but also as the umbrella towards effective collaboration between stakeholders in flood risk management.

PROJECT CONSORTIUM

DACA was developed by HKV$_{\text{CONSULTANTS}}$ in collaboration with the International Institute for Geo-information Science and Earth Observation (ITC). The interface and database architecture was made available by the Dutch Ministry of Water. In addition to these organisations, the following organisations participated in the project: (listed in alphabetical order): Asian Disaster and Preparedness Centre, Bangkok; Asian Institute of Technology, Bangkok; Department of

Water Resources, Thai Ministry of Natural resources and Environment; Department of Disaster Prevention and Mitigation, Thai Ministry of Interior; Department of Public works, Town and Country Planning, Thai Ministry of Interior; Mekong River Commission, Flood Management and Mitigation Program; National Mekong Committees of Loa PDR, Cambodia, Vietnam and Thailand (delegates); Royal Irrigation Department, Thai Ministry of Agriculture.

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SESSION 7

CONCLUDING SESSION

Reports presented during the concluding session

Report plenary session 1

LESSONS LEARNED FROM 2008 FLOODING AND NATIONAL AND MRC-RFMMC EXPERIENCES WITH INTEGRATED FLOOD RISK MANAGEMENT

RAPPORTEUR: HAK SOCHEAT

National Coordinator Flood Management and Mitigation Programme (FMMP), Cambodia National Mekong Committee, Phnom Penh, Cambodia

Country Flood Report for 2008 Cambodia by Mr. Sok Bun Heng, National Flood Expert of CNMC-NFU:

- Mekong River System in Cambodia, flooded area in 2008;
- population density;
- production (1998-2008): rice 7.1 million tones, crops 3.5 million tones, fish 365,000 tones;
- flood damage (1996-2008), in 2008 only flash flood damage on 18,907 ha crops;
- hydrograph of some stations in Cambodia;
- in 2008 (mainstream-normal flood, flash flood: some damage);
- relevant works of CNMC and LAs with the four -topics of the Forum.

Lessons learned - sustainability, longer time forecast leading time, data collection, flash flood is more destructive.

Recommendations - capacity building-flash flood, clarify tasks on data collection and data quality improvement, Strengthening capacity of National Flood Forecasting Institutes, installation of more hydro-meteorological stations.

Country Flood Report for 2008 Lao PDR by Mr. Virana Sonnasinh, National Flood Expert of LNMC-NFU:

- country background - area 202,000 km^2, 97% in river basin, population 4.905 million, average flow 5,270 m^3/s, average flow 35%;
- overview of hydro-meteo condition in 2008 - Luangprabang, Xiengkhouang, Borikhamxay, Khammounan, Vientiane Province and Vientiane Capital (most of the provinces affected by flash flood);
- flooding in urban cities affected by storm Kummuri with rainfall of around 180 mm, lost in damage 180 Billion Kip;
- institutional arrangement for flood management and mitigation – National Disaster Management Committee (13 members) and Water Resources and Environment Administration (6 entities as member);
- flood forecasting, warning and dissemination.

Lesson learned:

- the flooding in Vientiane capital in 2008 was severe and exceeded the historical highest record in 1966
- the timely flood forecasting and dissemination provided by Department of Meteorology and Hydrology was helpful for making arrangements and preparing measures by each level of Government Line Agencies in Lao PDR
- lack of tools for flood victims evacuation such as boats, rescue teams no means of access to flooded areas

- improvements of data coverage are particularly needed over north of Luangprabang in Lao PDR in favour of accurate flood forecasting along the Mekong River. Awareness on utilize meteorological/hydrological information to users and disasters prevention to flood risk community need to be improved;
- the strong political commitment is very crucial for successful large-scale flood preparedness;
- unplanned urban development and spontaneous settlements escalate flood damage and losses;
- no standard format for assessing flood damages results in the misuse of the resources.

Recommendations:

- the standard format for assessing flood damage and losses need to be developed both for assessing direct and indirect damages in favour of better flood management and mitigation, resources allocation in particular;
- the community based flood risk management should be strengthened. the community self reliance for flood management and mitigation is proved to be effective, the disaster management committee should focus on building capacity of the local community in flood preparedness and emergency responses;
- in order to improve the flood forecasting and warning, the review of hydromet network coverage is needed to ensure sufficient data input for forecasting analysis;
- the urban development should consider the flood implication and the spontaneous settlement should be controlled;
- the MRC Flood Management and Mitigation Programme should consider orienting its activities to benefit the local level by providing a supportive role in building the capacity of local authority and community in flood management and mitigation;
- the MRC flood forecasting and dissemination should focus on establishing the link with the national flood forecasting agency, so that the MRCS as the knowledge based river basin organization can provide its products to benefit the flood forecasting at the national level.

Country Flood Report for 2008 Thailand by Mr. Supapap Patsinghassnee and Ms. Srisunee Wuthiwongyouthin:

- general situation - average of annual rainfall 1,581 mm, average runoff 213,800 MCM and flow to Mekong River 65,000 MCM;
- water resources situation in 2008 - Climate Data rainfall 1,643 mm, N-E Thailand 1,638 mm, Isohyets of N-E Thailand and Graph of water level;
- significant flood events in 2008 - heavy rain on 11-31 August 2008, 11 August 270 mm caused flood in 7 provinces, 298 districts, 2,310 villages, 6 people dead in NK Phanom and Nong Khai, series of storms (Mekkhala, Noul and heavy rainfall) caused flash floods and flood in several provinces in total in 2008 65 provinces of 584 districts in Thailand affected by flood;
- the 2008 basic aid to the people affected by flood
- impact of 2008 flooding - 65 provinces affected with lost of US$ 72 million which was higher than 2007 US$ 23 million, around 95 people dead;
- responses to flood events in Thailand - put in place preventive measures (develop data, install early warning system), in 2008 warning 64 times to 168 villages, to ensure proper water resources management - establishment of water operation centre (Mekkhala Centre), National Water Resources Committee, Draft of Water Act.

Lesson learned - lack of action plan, lack of evaluation of water resources management plan, lack of integrated database system and lack of promotion/support.

Conclusion - the calamity of flood brought suffering in 65 provinces, 4,494,189 people of

1,197,253 households and agriculture area about 4,837 km^2. Flood disaster suffered about 67 people casualties. The cost of damage was US$ 72 million (December was damaged about US$ 28 million, about 39% of total cost of damage in the year 2008). Aid from many institutes and private sectors.

Recommendation - due to some problems of water resource concern in many sectors the process of resolving flood disaster is performed by many agencies as follows from their authority and it is limited due to many legal issues, which implies that there is no leading role of water resource law that causes the resolving operation to become less effective. Therefore the water act should be supported more seriously. To increase flood management, there must be an agency that takes direct responsibility to plan and coordinate with the related organizations at community, basin and national level.

Country Flood Report for 2008 Viet Nam by Dr. Trinh Hoang Ngan, National Flood Expert of VNMC-NFU:

- map of location of the Mekong River Basin in Viet Nam and potential flood risks- 5 SAs 1V, 4V, 7V and 8V (highland) and 10V (low-land);
- table of brief overview of past flood extremes - 1904, 1937, 1961, 1966 and 2000 with frequency of 30 years (1966 Lao-Thai and 2000 Cambodia-Viet Nam);
- main cause of flooding in Mekong Delta - rainfall, river flooding, local rainfall and river basin deforestation;
- overview of 2008 flood and flooding in Mekong Delta and Central Highland (SA 10V it was a positive flood but in SA 7V flash flooding occurred in some places and cost some damage to properties and human);
- table and graph of rainfall distribution and flood characteristic of SA 10V and 7V were shown with indication of negative and positive impact.

Lesson learned - flood is mainly good for food security and biodiversity (natural resources), need good flood forecasting and warning to mitigate flooding, need flood preparedness plan, need to maintain close cooperation with MRC-RFMMC, adopt national strategy for natural disaster prevention response and mitigate. Comments and suggestion were made to the 4 topics of the forum, for Topic I need to identify and prioritize flood issues in LMB countries and develop management programme, for Topic II, marine software was used by French expert, Vespa-Belgium and MIKE 11, for Topic III, Viet Nam uses Win-Win approach by open discussion, promote and strengthen bilateral cooperation, share relevant information and date and building capacity and for Topic IV, using and improving non-structural measures promote knowledge and awareness to living with flood and structural measures (flood control works in Mekong Delta).

Recommendations - meeting between riparian forecasting agencies and MRC-RFMMC should be made before and after flood season, a networking system of forecasting agencies should be established, extreme flood in mid August 2008 in Lao-Thai as a lesson learned and if it happens again a meeting of forecasters and scientists should be organized at MRC-RFMMC.

Conclusion - floods and flooding in the Mekong Delta can be managed and mitigated by both structural and non-structural measures, but the world climate change (sea water level rising) might be able having serious challenge for the Delta. Flash flood still occurred in the SA-7V therefore flash flood forecast should be applied and improved.

Dialogue Partner Report China by Dr. Zhong Yong and Dr. Li Bo:

- Chinese representative acknowledged the importance of the Lancang - Mekong River (politics, economy and historical and cultural);
- he expressed appreciation for being invited to the forum as an excellent platform for sharing experience in flood management especially on flood forecasting and warning;
- situation of cooperation between MWR and MRC - good cooperation since 2002 for

mutual benefit on data sharing, 29 August 2008 signed new cooperation agreement and hope to continue;

- the flood management of Lancang River - the main measures adopted to manage the flood - establishing a standing agency at each level, establishment of flood warning system, non stopping monitoring, set up good data collecting machine, all hydrological projects must have flood prevention plan (security first);
- the 2008 Flood Review of the Mekong River - based on statistical analysis of measured data from hydrological stations in Lancang River the extreme flood occurred in mid August 2008 in Lao and Thailand was mainly caused by abnormal regional rainstorm not from the upstream project;
- Ministry of Water Resources appreciated the MRCS to clarify this issue in its flood situation report August 2008;
- the previous achievements marked good friendship and sincere approach of the two parties and these need to be strengthened further.

Floods of Mekong River Basin 2008 in Myanmar Territory by Dr. U Hla Myint Thein and Dr. U Sein Tun:

- map of Mekong River Basin in Myanmar was shown with general description of Mekong River Basin (21,000 km^2) and its 6 major tributaries;
- overview of flood in 2008, especially in Wang Pong Port, Kiang Lat Sub-township and Tachileik;
- a number of pictures on flood management, flood damage and flood intervention;
- flood warning and management (Wang Pong Port and Township Authorities);
- some damage on crops but not severe and no casualties, positive impact;
- future needs - initiate and improve flood forecasting and warning and management for specific areas, more cooperation with MRC is considered more effective in this matter in the region.

2008 Annual Mekong Flood Report by Dr. Janejira Tospornsampan and Dr. Peter Adamson:

Dr. Janejira Tospornsampan covered on 4 major sections - the annual theme, benefits and costs of the annual Mekong flood, review of hydrological aspects of the flood season, brief summary of each of the four annual country reports, and, lessons learnt and recommendations and covered also the overview of 2008 flood season in the whole Lower Mekong River Basin. Benefits of floods for fisheries and agriculture.

An indicative distribution of average annual regional flood costs of US$ 76 million over the MRC Member Countries was shown, as well as the 2000 and 2008 Mekong floods – proportional and total damage. Finally the relative costs and benefits of the annual Mekong floods were shown.

Overview:

- the 2008 flood season across the LMB illustrated a common feature of the *regional flood hydrology*;
- in 2008 it were the northern parts between the Chinese border and Vientiane that witnessed flood levels not seen for almost 50 years, while further downstream in Cambodia and Viet Nam discharges and water levels were average at best;
- volumes of flood runoff, discharges and water levels in the northern part of the region up until mid July had been average but an intensification of the SW Monsoon saw repeated tropical storms and higher flood runoff;
- the storm situation then intensified dramatically during the first week of August with the passage of tropical storm Kammuri across the northern provinces of Lao PDR. Volumes of flood runoff in the large northern Lao tributaries such as the Nam Ou and Nam Khan increased to extreme levels;

- maximum discharges at Luang Prabang and Vientiane/Nong Khai occurred on the 14th and 15th of the month and were in the region of 23,000 m^3/s or 50% above the annual average;
- the associated water levels were comparable to those of 1966, when both city centres were flooded;
- some urban flooding again occurred at Luang Prabang since water levels were elevated due to backwater effects on the Nam Khan upstream of the Mekong confluence;
- at Vientiane large-scale urban flooding was avoided principally due to the sandbagging of the river bank adjacent to the central business district, but large areas of suburbs and peri-urban the area were flooded to depths locally exceeding 1.5 m;
- these conditions soon dissipated downstream of Vientiane/Nong Khai, flows at Pakse and Kratie coming close to those for an average flood season overall, while water levels in the delta at Tan Chau and Chau Doc were below average throughout most of the season .

Lessons learnt and recommendations:

- the performance of the MRC-RFMMC's flood forecasting models and expertise generally performed reasonably well, though obviously room for improvement is recognized;
- the major constraint to accuracy over lead times in excess of 2 to 3 days is the emerging conclusion that the storm rainfalls indicated by satellite images are probably too low and that the network available for ground truthing needs to be improved in key areas of Lao PDR in particular;
- the lessons and recommendations from four countries generally repeat those of earlier years and focus on such issues as strengthening community based flood risk management and self reliance and building capacity within local communities with regard to flood preparedness and emergency response;
- a need is also recognized to improve the channels of communication between the local communities and the relevant flood forecasting, mitigation and response agencies.

Plenary Panel Discussion Facilitated by Dr. An Pich Hatda:

- *Question from the floor:* In August 2008 storm hit the region especially Lao PDR and Thailand affected strongly, were there any forecasts on it and how come the forecasts to the countries?
  Answer from panel: there was a forecast that the storm will land in Viet Nam and headed to Lao PDR and Thailand. In Viet Nam there was a well prepared forecast but for Lao PDR and Thailand it was a bit hard to deal with flash flood caused by the storm. MRC-RFMMC traced the storm and informed to the countries by its bulletin;
- *Question:* as presented by Dr. Ngan, Vietnamese Expert, in SA 7V there was no link to WRM of MRCS's BDP, the Dirctor of MRCS's Planning Department asked the presenter to explain and pass all information to his staff? The Director also proposed the continuation of Hua Khong water level station.
  Answer: there will be a private discussion during lunch. Lao PDR and Myanmar representatives welcome the proposal but express concern over the accessibility and security;
- *Question:* as observed the graph of Lao PDR the water level was very simple, can this graph be used in other countries?
  Answer: it depends on the countries if one want to use it Lao will happy to share.
- *Chairman Comments:* most of the countries presented on damage and benefits of flood but in different format, we should have a common format to present this. Community involvement and tributary water level stations are needed. We need to integrate agencies concern to avoid duplication and waste of fund. Flash flood damage is severe. Thailand has enough technical capacity to share with others how to reduce the damages both to properties and human. Expressed appreciation over the Chinese contribution and support

towards integrated flood management in the whole Mekong Basin, last flood event in August 2008, we have enough information we can make clarification to the public, therefore we need more cooperation on data and information sharing.

Report plenary session 2

TOWARDS INTEGRATED FLOOD RISK MANAGEMENT IN THE MEKONG RIVER BASIN

RAPPORTEUR: NGUYEN ANH DUC

National FMMP Coordinator, Viet Nam National Mekong Committee, Ha Noi, Viet Nam

There were five papers in Session 2, presenting 5 components of the Flood Management and Mitigation Programme (FMMP) of the Mekong River Commission.

1). FMMP-C1: Short and medium-term flood forecasting at the MRC Regional Flood Management and Mitigation Centre by Janejira Tospornsampan, Terry Malone, Bob Pengel, Phung Katry and Hatda Pich An. The paper was presented by Dr. Janejira Tospornsampan:

- introduction on the newly developed MRCs Flood Forecasting System (FFS): configuration – performance;
- new MRCs FFS:
  - combination of URBS (Unified River Basin Simulator) and ISIS Hydrodynamic Model. Currently FFS ver. 1.0 (URBS from Chiang Saen to Chau Doc) & Near future: Ver. 2.0:URBS (Chiang Saen – Stung Streng) & ISIS (Stung Streng – Chau Doc);
  - more accurate forecasts, more user-friendly, reliable and robust (compared to the previous SSARR model);
  - new FFS is capable of producing medium-term forecasts (up to 10 days);
  - ready for the coming 2009 flood season;
  - needs: medium-term to long term forecast; upgrade data, models and systems; more highly trained and experienced forecasters.

2). FMMP- C2: Structural measures and flood proofing by Pham Thi Van Lan and Nicolaas Bakker. The paper was presented by Ms. Pham Thi Van Lan:

- introduction on FMMP-C2; overview implementation and key outputs of the 2 main projects; relevance;
- 'Roads and Floods' project (completed):
  key outputs are 3 sets of Best Practice Guidelines for the Integrated Planning, Environmental Assessment and Technical Design for Roads in the Mekong Floodplains of Cambodia and Viet Nam.
- Structural Measures and Flood Proofing' project (on-going):
  - implementation: inception, Stage 1 and Stage 2;
  - key outputs and activities: (i) sets of Best Practice Guidelines for IFRM ; (ii) implementation of demonstration projects and preparation of the list of priority investment projects; (iii) capacity building in IFRM practices;
- relevance:
  - other MRC's programmes: Basin Development Plan Programme, Fisheries Programme, Agriculture, Irrigation and Forestry Programme, Environment Programme, Integrated Capacity Building Programme.

3). FMMP-C3: Enhancing cooperation between Mekong River Commission (MRC) and MRC Member Countries in addressing trans-boundary flood and related issues byPham Thi Van Lan and Nicolaas Bakker. The paper was presented by Ms. Pham Thi Van Lan:

- introduction on FMMP-C3 and Overview implementation and key products;
- key products: 3 working papers (completed):
  - trans-boundary flood issues identification report (TBFI) (1st WP);
  - legal aspects of the Mandate of the 1995 Mekong Agreement for Enhancing Cooperation in Addressing trans-boundary Floods and Related Issues (LA-MA95) (2nd WP);
  - an explanatory note - Manual (EN-M) to the LA-MA 95 (3rd WP): *Could be useful for MRC programmes and national members in addressing trans-boundary water issues;*
  - Capacity Building Programme (on-going): key part of FMMP-C3, designed for three different target groups: *High Level Decision Makers - Mid Level Professionals and Academics - Operations/administration oriented professionals.*

4). FMMP-C4: Flood emergency management strengthening. People-centred approach in integrated flood risk management by Mr. Thanongdeth Insisiengmay:

- introduction on FMMP-C4: background – objectives – methodology, approach and results – relevance;
- bottom-up approach – non-structural measures;
- pilot districts: Cambodia (10), Laos (6), Thailand (2), Viet Nam (12);
- stressing on the People-Centred Approach in Integrated Flood Risk Management: building capacities of the National, Provincial and District Authorities in the Lower Mekong River Basin. This approach is expected to be replicated after being well tested.

5). FMMP-C5: Flood information based land management (FIBLM) by Dr. Martin Falke:

- 2 parts: Review of C5 Phase 1 and and introduction of FMMP C5 - Phase 2;
- review of C5 phase 1:
  - creation of reliable Flood Probability Maps for subsequent use in Land Management by the relevant authorities and organisations;
  - experiences and lessons learned 3 pilot districts in CPC (2004-2008);
  - the C 5- methodology for mapping flood statistics has been shown to be reliable for three pilot areas in the Cambodian flood plains during C 5- Phase 1;
- introduction of C5 phase 2:
  - flood Information Based Land Management (FIBLM) Scheme/Approach;
  - pilot districts: Cambodia (2), Laos (2), Thailand (1), Viet Nam (2);
  - relevance for the Mekong river basin;
  - it is anticipated that the present methodology, with minor modification, can handle most cases where the flooding is largely uncontrolled.

Group discussions:

- FMMP-C1: Flood Forecasting System: Concerns on accuracy of data (NOAA, Radar, etc.);
- FMMP-C2:
  - Best Practice Guidelines: Application, sustainability, etc.;
  - demonstration projects: Progress;
- FMMP-C3: working papers are advised to be the training materials.
- FMMP-C4: similarity to India, lessons learnt.

Report plenary session 4

SUMMARY OF DAY 1, PLENARY PAPER PRESENTATION, DISCUSSIONS

RAPPORTEUR: BURACHAT BUASUWAN

Senior Policy and Planning Analyst/National Coordinator Flood Management and Mitigation Programme, Thai National Mekong Committee, Department of Water Resources, Bangkok, Thailand

Summary of Day 1 of AMFF-7 by Nicolaas Bakker:

- Inaugural session:
  - *Mr. Jeremy Bird:* overview of historic floods in the LMB, a clarification of the 2008 flood event in Vientiane, and the lessons leaned. The 2008 flood event were adequate, dissemination and communication of the forecasts could be improved;
  - *Dr. Siripong Hungspreug:* A better balance between upstream and downstream country involvement is required. Member Countries are fully committed to the important work of the MRC;
  - *Mr. Martien Beek:* referring to the recent FMMP Review Mission the RNE is satisfied with the results, and is willing to consider a phase 2 of FMMP;
  - *Ms. Sezin Tokar:* highlighted the global attention by OFDA of flood impacts on livelihoods. Expressed also interest in continuing the existing cooperation;
  - *Mr. Timo Menniken:* stressed the strong point of FMMP with respect to integration. Expressed that GTZ is interested in future cooperation.;
  - *Dr. Hatda Pich AN:* Presented an overview of AMFF-6, and the follow-up of the recommendations of previous forums. Most of the recommendations have been implemented;
  - *Mr. Nicolaas Bakker:* Provided a summary outline of FMMP, and the Objectives and Expected Outcomes of the AMFF-7.
- *Session 1:* Lessons Learned from 2008 Flooding and National and MRC-RFMMC Experiences with Integrated Flood Risk Management'
  There were six reports from the each countries of the Mekong River and One report from RFMMC
- *Session 2:* Towards Integrated Flood Risk Management in the Mekong River Basin
  They presented the activities of the five Components of the Flood Management and Mitigation Programme of the MRC
- *Session 3:* Parallel Sessions
  There were the three Topics.

  There were four papers presented in the session:
- *first report:* Flood hazard mapping in Nan River, Thailand by Somchit Ammatsan:
  - the country usually faces with flood problems every year;
  - the study area is located in Nan River Basin in the upper reach of Nan River. Cover the area of Nan municipality and Phupiang Municipality in Nan province. Topographically, It is the plain area surrounded by mountains;
  - the data were hydrological data, topographic data and vector layers;
  - methodology were three phases and used HEC-RAS and HEC-GeoRAS provided the flood hazard mapping for 10yr, 20yr, and 50yr flood events;
  - Conclusion: HEC-RAS together with HEC-GeoRAS utility was successfully utilized for flood hazard mapping in Nan Province, Thailand;

- flood hazard maps corresponding to 10 yr, 20 yr and 50 yr return period flood events were prepared. These flood hazard maps will be utilized in flood warning system of this province;

- *second report:* Statistical ensemble flood forecasting for the Mekong River by Muhammad K. Shahzad:
  - *fist step:* Conclusions SSARR model needs improvement, and can be improved by better filtering of rainfall data, rainfall input at present causes large oscillations;
  - *second step:* Statistical Analysis of Discharges Conclusion. On the average better results from statistical model. Closer inspection shows this to be caused by SSARR model having large fluctuations due to rainfall input variability. Improvement obtained due to better rainfall weighting;
  - *third step:* correlating discharge differences between two stations with rainfall and regression with different rainfall averages, Analysis Unit hydrograph;
  - *fourth step:* Using approaches from step 3 to generate system model for the upstream system;
  - *fifth step:* Including hydrological approaches to lake and channel hydraulics;
  - Conclusions: the objective of a forecasting model is:
    - to make a crisp forecast, as an expected value;
    - to produce an error band for the range of possible deviations from the crisp value;
    - to minimize the error band by entering as much conceptual information based on the physics into the model as is significant.
    - An objective benchmark must be established by means of which forecast quality can be judged:
      - SSARR model not suitable, neither is Nash-Sutcliffe;
      - efficiency criterion based on last known value and no change;
    - basic physical information comes from the condition of continuity. This leads to a first order approach of regression analysis for the region between the Chinese border and the border of Cambodia:
      - regression of time series upstream and downstream improves on SSARR but not enough to matter;
      - regression of discharges with earlier discharges at the same station is no improvement;
      - regression with discharges upstream up to stations with flow times = forecast time yields some improvements and allows to construct probabilizy distributions;
    - further improvement must include rainfall information:
      - correlation of runoff increase between stations with daily rainfall;
      - correlation of runoff increase between stations with 5 day averages of days before forecast;
      - further concepts include time delay between rainfall and runoff (unit hydrograph).

- *third report.* Development of trans-boundary cooperation in the Rhine River Basin by Bart Schultz:
  - over the centuries many cases of flooding, oldest record of a flooding is from 1233;
  - especially in the Netherlands impacts of floods have increased due to subsidence, population growth and increase in value of buildings and infrastructure;
  - stages in Water Resources Management;
  - developments in 20th Century;
  - in 1990s attention to integrated water management;

- in study ‘integrated environment management’. In this approach developments in land use, water management, flood protection and environment will be better integrated;
- impacts of Climate Change: Change 10 – 30% per century;
- change in Land Use: Change 100 – 1,000% per century;
- history of the shared river basins;
- history of the cooperation in Rhine Basin;
- history of the impact of pollution;
- impact of 1993 and 1995 Floods: *International Commission for preventing Pollution of the Rhine: development of strategy paper for flood protection* (December 1995);
- in January 1998: *Flood Action Plan (FAP);*
- European Water Framework Directive (accepted at 23 October 2000);
- European Flood Directive of 23 October 2007 on the assessment and management of flood risks;
- Flood Risk Management Plans ready by 22 December 2015;
- Concluding remarks:
  - history has shown that again and again new measures have to be taken in answer to new developments. There is no reason to suppose that in this will come to an end;
  - anticipating future developments - rather than only reacting to them – will be the challenge;
  - for the Rhine Basin Countries it will be of increasing importance to continue and expand their cooperation with respect to developments in land use, water management, flood protection and protection of the environment;

- *fourth report:* Hydrological risk zone mapping in Dong Thap Province for developing agricultural insurance by Dang Thanh Lam:
  - the Flooding in Dong Thap Province;
  - the Flood Management for Living with Flood;
  - hydraulic structures;
  - recent flood damage;
  - the 4 steps of the approach to natural hazard risk and the development of agricultural insurance in Vietnam;
  - agriculture insurance’s needs;
  - methodology and analysis;
- conclusions and recommendations:
  - hydraulic model is well calibrated;
  - Long-time series data for statistical analysis;
  - reliable data set from MRCs and National Agencies to generate flood maps;
  - instant water level at Tan Chau for flood management decision;
  - official water level data at Tan Chau are issued by Southern Hydro-Meteorological Station after validated;
  - measurement precision meet national standard;
  - the study is very important to identify impediments to developing sustainable agricultural insurance in Viet Nam and propose policy option, provide feasible models for informal agricultural risk mitigation and formal agricultural insurance for pilot testing and identify major risks that farmers face;
  - findings will be used to aid in the design of appropriate insurance products;
  - the product of project is education to determine if effective risk transfer markets for catastrophic natural disaster risk can be started in Vietnam;

* would have these type of risk transfer products help change some other government social policy and provide a linkage mechanism from the bank for indemnity based insurance and risk mitigation payments as well.

Report on Topic I

OPTIMAL PACKAGES FOR FLOOD MANAGEMENT

RAPPORTEUR: SOK BUN HENG

National Flood Expert, Cambodia National Mekong Committee, Phnom Penh, Cambodia

Presentation 1: Integrated hydrologic, hydraulic, and damage analysis for selection of optimal flood management measures by Mr. Kittiwet Kuntiyawichai:

- flood occurring in the Yang River Basin (area = 4,145 km^2) caused by monsoon rains and tropical cyclones every 2 - 3 years and occur 2 - 3 times/year. The most severe floods occurred in 1978, 1980, 1995, 2000, and 2001. Therefore flood prevention and mitigation is needed;
- relationship between hydrological and hydraulic models and physical aspects in Yang River Basin;
- rainfall runoff and water balance simulation using SWAT, flood simulation using 1D/2D SOBEK;
- integrated hydrologic and hydraulic modelling approach can evaluate the effect of flood mitigation measures on flooding and damages;
- schematic chart to transfer data from SOBEK and SWAT format to FEWS format and to produce flood and flood risk maps;
- two measures for flood mitigation:
  - natural flood storage to delay discharge quantity (peak);
  - green river to decrease discharge (inundated area);
- results provide information and understanding for identifying more desirable and effective flood management options by which flood management will improve and serves as base for comprehensive flood management strategies;
- however, for better flood management, more factors should be considered.

Presentation 2: Charting ICHARM'S strategy for integrated flood risk management (IFRM) in the Lower Mekong River Basin (LMB) by Mr. Ali Chavoshian

The paper covers the identification and assessment of risk from flood and other consequences for the future development in the target area. The two components of the proposed TA prepared by ADB and ICHARM are in-country project support and program quality support through regional cooperation:

- *in-country project support will provide TA to the countries of the Lower Mekong River Basin:*
  - flood management investment projects, strategies and programs, applications of flood hazard mapping;
  - demonstration projects to improve flood forecasting and warning:
  - action research on innovative community-managed flood preparedness and disaster risk management practices;
  - identification of 'no-regret' investments in flood management to accommodate climate change impacts;
  - capacity development activities;
  - diagnostic assessments of executing and implementing organizations;
- the Program Quality Support through regional cooperation in the region will provide for the following:

- workshops and exchange visits;
- incorporating climate change adaptation effects into flood risk management;
- training to develop the capacity of river basin organizations in flood risk management and to incorporate flood risk management in cities, through existing city networks such as CityNet;
- policy development and institutional training for ICHARM's Masters Course on Disaster Management;
- organizing a pool of regional experts to improve flood management and emergency response services;
- developing a regional index for in-country water-related disaster preparedness;
- a comparative study of institutional arrangements for flood risk management in the region.

The ICHARM's strategy for Technical Assistance towards integrated flood management in the LMB is charted in four main themes:

- in-depth hydrological analysis;
- integrated flood analysis system (IFAS);
- inundation modelling;
- flood vulnerability and risk mapping.

With the intended result output from ICHARM ongoing research for tool development for generating near real-time satellite rainfall information and heavy rainfall area identification, the proposed approach is expected to deliver a more pragmatic IFRM system for the LMB.

Presentation 3: Risk based Flood Management for adapting to Climate Change by Mr. Eiji Otsuki:

- recent change in climate:
  - daily rainfall over 200 mm is significantly increasing;
  - hourly rainfall over 100 mm is increasing;
- review impacts on water related disaster:
  - more frequent high tides and coastal erosions;
  - more frequent floods;
- projection of future climate change:
  - rainfall after 100years is projected to increase 10 to 30%;
  - increasing rate in northern area is bigger;
  - increasing rainfall intensity will make the flood safety level significantly lower than present;
- basic concept for tackling in increasing risks:
  - mitigation measures;
  - adaptation measures (facility-dike, dam, regional development-land use regulation, building restriction, crisis management-flood hazard map, real-time information, monitoring-river information, planning);
- challenge new flood management program based on risk assessment:
  - implementing a risk assessment taking into consideration the increasing future climate change, and carry out analysis of floods of various magnitudes that may occur at different precipitations. When structural measures are not enough to eliminate the hazards, we may concentrate non-structural measures;
- conclusion:
  - change flood control target from secure of necessary river flow to disaster risk in basin for various size of possible floods;

- introduction of flood risk assessment as basic procedure in flood management program;
- clear prioritizing of each measure and risk allocation put into the time-oriented road map;
- strengthen non-structure measures for areas which still remain problematic;
- monitoring, regularly review, adaptive response.

Results of Parallel Group Discussion

Formulation of recommendation on the Topic: Optimal packages for flood management:

- enanbling environment has to be created in terms of institutional arrangements and legal support;
- IFM should follow a Road Map. Iit should have a multi sector approach. Optimal flood management should balance the environmental needs, flood protection needs, interest of all livelihood groups related to water and mitigation of adverse effects;
- IFM should start with basin/regional approach and be country specific;
- intensive capacity building to enhance the knowledge base making use of locally available knowledge and experience;
- IFM should be a national development agenda;
- easy accessibility and sharing of data and information is a necessary condition for IFM.

Report on Topic II

RECENT DEVELOPMENTS IN FLOOD FORECASTING AND EARLY WARNING

RAPPORTEUR: TRINH HOANG NGAN

National Flood Expert, Vietnam National Mekong Committee, Ho Chi Minh City, Viet Nam

Four presentations have been presented in the session on Topic II.

Presentation 1: The way forward in hydrodynamic flood modelling in the Mekong River Basin introduced by Mr. Adri Verwey:

- Mr. Adri Verwey, a famous modeller from Detares, the Netherlands, provided an overview of numerical model applications for simulation of the hydraulic regime of the Mekong River flow, especially in floodplains as the Mekong Delta. The limitations of 1D models in describing such flow situations were clearly indicated;
- to overcome of the limitations of 1D models, the author introduced the various approaches in the combined 1D and 2D numerical modelling of flood wave propagation, in particular the ways in which the process descriptions are best integrated;
- the presentation also dealt with the data requirements for such models, demonstrating the possibilities and limitations of current state-of-the-art data collection.

Presentation 2: Real-time hydro meteorological observation networks - development possibilities for the early warning system of the Mekong River Basin presented by Mr. P.J. Airaksinen:

- Mr. P.J. Airaksinen from Finland summarized the recent observations and findings related to operational applicability of the methods for improving hydro meteorological forecasts. In addition, the presenter also shared and discussed hydro meteorological observation system issues related to spatial configuration and overall performance of the network;
- the manuals for surface measurements have traditionally formed the basis for hydro meteorological observation networks. However, the limited availability of real-time precipitation data for the Mekong River left bank (eastern) sub-catchments of Lao PDR has reduced the accuracy of flood forecasting;
- longer lead times and improved input accuracy for flood forecasting can be reached by increasing observations of atmospheric water i.e. measuring water before it precipitates on a river basin;
- satellite and aircraft observations, a very low frequency (VLF) long-range lightning detection network could be used to monitor convective activity and estimate rainfall associated with tropical systems over data-sparse sea areas;
- the numerical weather prediction (NWP) models such as the Fifth Generation Mesoscale Model (MM5) from weather radar forecasts are used as input for medium term hydrological forecast models, while weather radar derived quantitative precipitation estimates (QPE) are combined with surface observations for improved forecast input.

Presentation 3: Enhanced discharge measurements in irrigation canals using multi-frequency acoustics presented by Mr. Mike Cook:

Dr. Mike Cook introduced the new equipment for survey purposes as the ‘Next Generation RiverSurveyor’ that has been used in the South-western US, as well as throughout

the world. The following items were summarized:

- initially an oceanographic application;
- reliable standard for discharge measurements;
- world water issues (demand and pricing models);
- multi-frequency Acoustics.

The presenter is devoted to analyze a wide range of gauging scenarios and highlighted the benefits of the technological advancement. It is potential equipment for surveying.

Presentation 4: Status of MRC Hydro-meteorological network for river monitoring reported by Dr. Sompong Boonprasert:

- Dr. Boonprasert, Senior Hydrologist, IKMP, presented the status of MRC Hydro-meteorological network for river monitoring. The progress of implementation of the AHNIP and Mekong HYCOS has been reported;
- he believes that with the new Mekong HYCOS, all key tributaries can be monitored thus enhancing a better near real-time river monitoring and flood forecasting for the mainstream and tributary basins of the Lower Mekong River Basin.

Network integration:

- the future equipment and data flow of AHNIP will be the same as Mekong HYCOS. The integration will increase ease and convenience for operation and maintenance of the system;
- Under IKMP work plan 2009, upgrading the AHNIP equipment. Planned to be completed by 2010.

Report on Topic III

EFFECTIVE APPROACHES TOWARDS TRANS-BOUNDARY FLOOD MANAGEMENT

RAPPORTEUR: PHONEPASEUTH PHOULIPHANH

Acting Director of Division/National FMMP Coordinator, Planning and Cooperation Division, Lao National Mekong Committee Secretariat (LNMCS), Prime Minister's Office, Vientiane, Lao PDR

There were no papers submitted for this Topic. Based on the discussion that was held, the following was formulated:

- learn from best practices of sharing benefits and reduction of damage among member countries. Approach these issues in a broader context;
- enhance and strengthen cooperation in different sectors;
- increase increments over long term periods;
- mobilize commitment of stakeholders would have to be prefered above imposing of laws and regulations.

Report on Topic IV

SUCCESSFUL FLOOD RISK MANAGEMENT APPROACHES

RAPPORTEUR: VIRANA SONNASINH

National Flood Expert, Lao PDR National Mekong Committee Secretariat, Prime Minister's Office, Vientiane, Lao PDR

Summary of discussion:

- an overview of CBDRR initiatives in Cambodia;
- assessment of IFMS in the lower Dong Nai - Sai Gon River Basin, Viet Nam;
- best practice guidelines for FRA in LMB;
- an integral approach to flood risk mapping for flood detention areas, Red River Delta, Viet Nam;
- flood damage assessment integrating geospatial technologies, a case study of Hue, Viet Nam;
- development of 1D hydraulic model for flood inundation mapping along anabranch Mekong River, Siphandone, Lao PDR;
- FRA and use of DACA instrument in LMB.

Recommendations:

- communication of technical information and products in simple form for various audiences;
- non structural measures for flood management and mitigation should be emphasized;
- multi purpose water management structures from flood management to hydropower generation;
- the flood risk management should consider the basin-wide approach rather than local areas;
- stakeholder participation in developing and implementing flood risk management;
- flash flood is common in the region , the accuracy of forecast should be considered and there is a need for flash flood risk identification;
- awareness of flood risk management should be considered in the national development planning cycle.
- structural measures can not be avoided;
- locally appropriate and sustainable, and culturally acceptable measures for flood risk management within basin-wide approach;
- the effort should be made for flood risk management rather than flood control;
- MRC play a major role supporting the inter agency coordination and data and information exchange, sharing experiences regarding flood risk management;
- need for a methodology for comprehensive flood damage assessment (direct and indirect);
- participation of civil society, communities and all stakeholders at all stages of flood risk management activities.

Special presentation

IMPORTANCE OF INTEGRATED FLOOD RISK MANAGEMENT PACKAGES. EXPERIENCES FROM PRACTICES IN BANGLADESH

M.A.QUASSEM

Former Director General. Water Resource Planning Organization, Ministry of Water Resources, Dhaka, Bangladesh

ABSTRACT

Bangladesh, like the Mekong delta, is a delta which has been formed by the mighty Ganges, Brahmaputra and Meghna (GBM) complex. Like the Mekong River Commission (MRC) countries, as well as many South Asian countries, extreme floods are the most prominent natural disaster in Bangladesh. This key-note paper will present our experience in Bangladesh which, too, has similarities with many South Asian countries.

BANGLADESH AND FLOOD

Bangladesh, like the Mekong Delta, is a delta which has been formed by the Ganges, the Brahmaputra and the Meghna (GBM) complex with an area of about 144,000 km^2 and a population of about 150 million. It is a country with 310 rivers with a total length of about 24,000 km, innumerable channels criss-crossing the country; and, a high-intensity seasonally-concentrated rainfall - 1,200 mm in North-West to 5,500 mm in North-East (Figure 1). It has 57 trans-boundary rivers - 54 from India and 3 from Myanmar. Bangladesh receives runoff from a river basin of 1.72 million km^2, around 12 times its land area. About 50% of the land lies within 6-7 m+MSL (Mean Sea Level), 25 - 30% of the area is inundated by normal flood ('barshaa')

and about 68% is vulnerable to flood. About 92% of the flood discharge enters Bangladesh from outside territories (Figure 2).

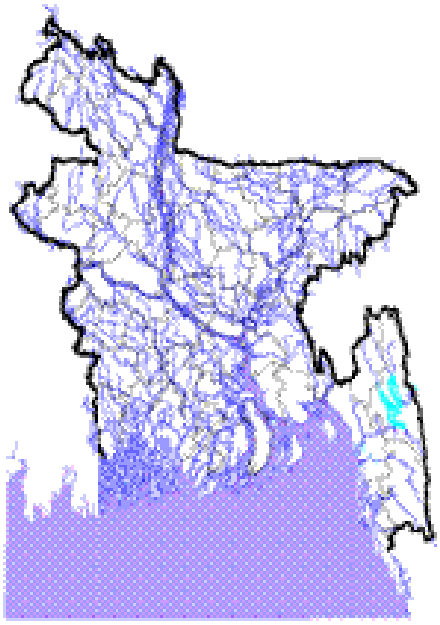

Figure 1. Bangladesh - criss-crossed by big and small rivers and channels

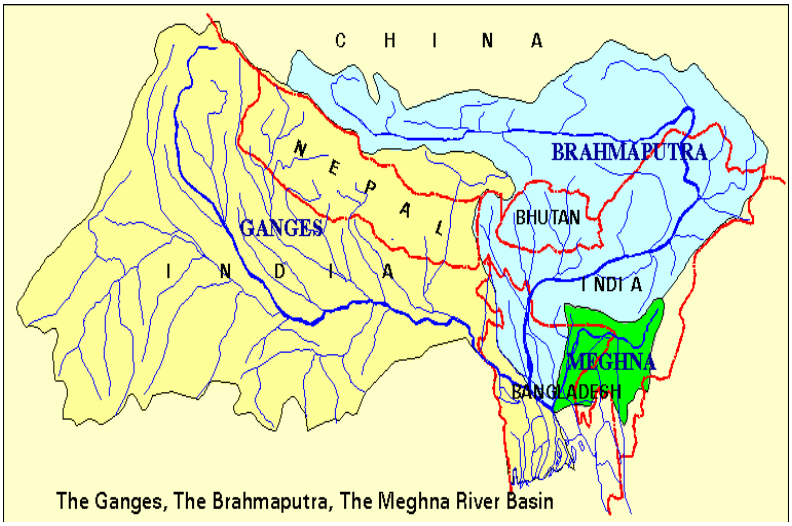

Figure 2. Catchment area of the Ganges, the Brahmaputra and the Meghna

Like the Mekong River Commission (MRC) countries, as well as many South Asian countries, extreme floods are the most prominent natural disaster in Bangladesh. This key-note paper will present our experience in Bangladesh which, too, has similarities with many South Asian countries.

I would like to begin with our perspective of 'flood'. 'Borshakaal' (rainy season) is one of the six seasons in Bangladesh. It is characterized by intense rainfall, high water levels in rivers, and natural inundation of low lying areas. This is called 'Borshaa' (the Bengali synonym of 'normal flood'). 'Borshaa' or normal flood is a regular phenomenon and is regarded as a blessing as the land benefits from the supply of silt carried by the GBM rivers. 'Borshaa' has

always been a source of livelihood, and was integrated with our rural life style, agricultural practices, fish culture, forestry, flora and fauna; wetland functions, ecological balance; and regulated our social and cultural life. In rural Bangladesh, life had been uncomfortable if there was no 'Borshaa'.

When the water level rises unusually high during 'Borshakaal' (rainy season) and inundates lands more than the 'Borshaa' (normal flood) does, we call it 'Bannya' (the Bengali synonym of damaging flood), which causes loss of life, property, crops; and disrupts normal business, communication and transportation system. We get 'Bannya' (floods) from rivers, torrentials in hilly areas (flash flood), local intense rainfall (rainfed flood) and flood due to storm surges. Previously, the abnormal floods were less frequent, but now it is more often, once in about every three years. The worst hit is the poorer section of the population (Figure 3).

Figure 3. Worst hit by flood is the poor

Flood damages due to a devastating flood goes up to even US$ 20-25 million. Flood damages relate to flood protection, drainage, irrigation, communication and housing infrastructure, agricultural crops, fisheries, livestock, forestry, commerce and business, etc. Flood due to storm surges takes heavy toll of human life. Human deaths by snake-bites are not unusual during the flood time.

In recent times, flood in Bangladesh has taken a new dimension i.e. urban flooding. The population density in the cities and urban areas is increasing fast due to migrants from rural areas who usually settle down in low-lying areas within the cities or in the periphery. Rapid changes are taking place in land use; investments in infrastructure and economic activities are increasing fast. Urbanization has decreased percolation and increased the runoff has reduced the drainage capacity; indiscriminate filling up of ditches, ponds and lowlands has decreased the retention reservoirs - all contributing to increasing the occurrence and intensity of urban flood hazards (Figure 4).

INTEGRATED FLOOD RISK MANAGEMENT PACKAGE

An integrated flood risk management package consists of a combination or mix of the following three elements - sequentially one following the other:

1. preventive measures;
2. flood forecasting and warning;
3. disaster management measures.

Figure 4. Dhaka - the capital city under flood water

The first element is the construction of flood preventive infrastructure for reduction of the probability of flooding and reduction of the vulnerability of flood prone areas. Flood preventive infrastructure is constructed on the basis of a design flood level for a certain flood return interval period. Statistically, these infrastructures are vulnerable to floods beyond the design level, which may happen once within the design return interval period; and even in two consecutive years. So the risk of flood in any year remains - threatening life and property. Here lies the importance of the second element of an integrated flood risk management package i.e. the need for a flood forecasting and early warning system - to make people and the relevant disaster management agencies aware of the expected disaster, take possible precautionary measures and for preparedness to deal with the aftermath. With the rise in level of concerns and development of technology, of late, the second element has attracted focus. Then comes the third element i.e. the disaster management measures to rescue and provide relief to the flood victims after the flood disaster occurs (Figure 5).

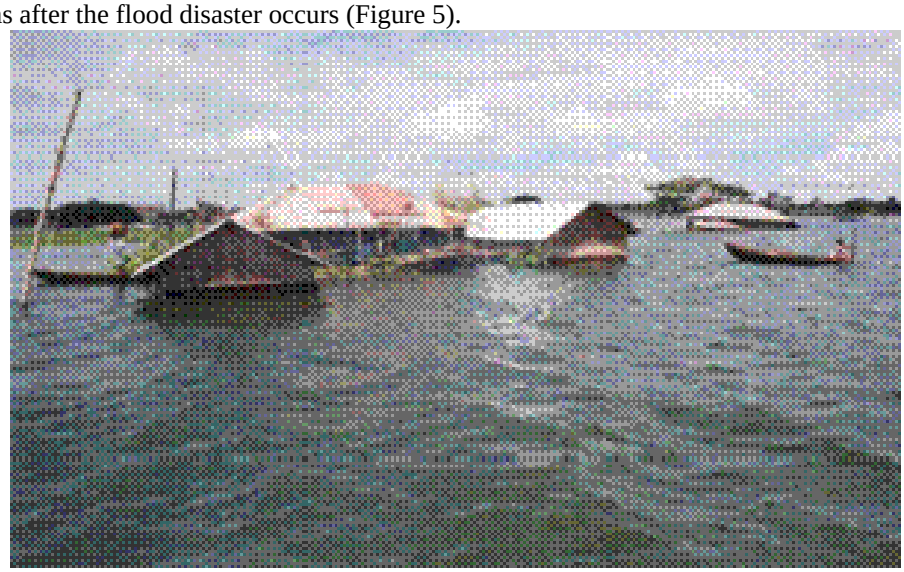

Figure 5. Houses go under flood water

Preventive measures

Bangladesh Water Development Board (BWDB) is the key organization for planning, implementation, operation and maintenance of flood protection infrastructure. Major flood preventive measures include:

- earthen embankments with provision of drainage sluices;
- flood walls - in densely populated parts of the capital, where enough land for construction of embankment is not available;
- revetment works for bank protection against severe river erosion;
- construction of spurs / groynes.

The principles followed in designing the preventive measures include:

- total exclusion of flood water from the protected area (construction of polders), particularly in the south-west and the south east parts of Bangladesh, which are subject to saline water intrusion, and tidal surges. We have 113 polders in this region;
- exclusion (part of the year) of flood water during the cropping season to protect the crops from damage, particularly in the north-west part of the country by construction of submersible embankments;
- compartmentalization of flood areas and controlled flooding – which was tried on pilot basis but did not work;
- embankments along the big rivers in the central part of the country (Figure 6).

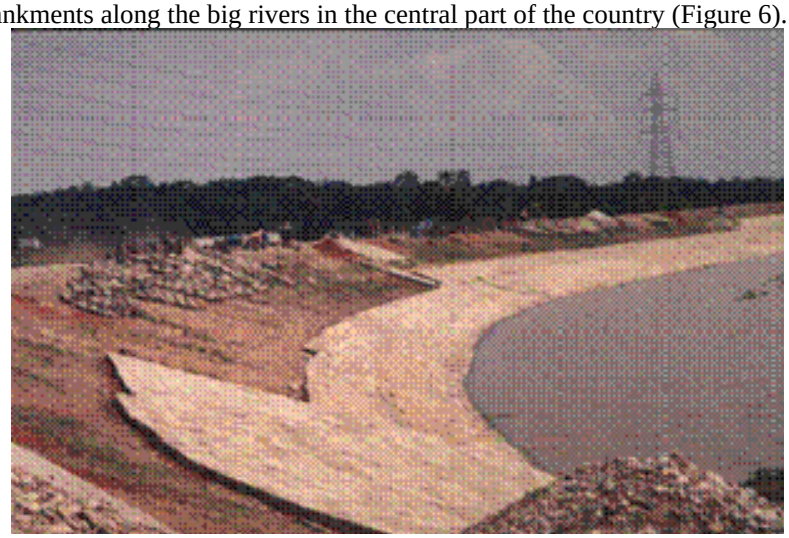

Figure 6. Revetment works under construction to protect Dhaka Embankment

Flood protection infrastructure those have been constructed so far in Bangladesh is shown in Table 1.

Table 1. Flood protection infrastructure which have been constructed so far in Bangladesh

Item	Total	Unit
Embankment	10,100	km
Drainage channel	4,000	km
Hydraulic structures	14,110	Nos.
River closures	1,302	Nos.
Spur/groyne	220	Nos.
Bank revetment	522	km
Area benefitted	6.0 million	ha
Town protected	20	Nos.

Maintenance of the infrastructure, particularly the embankments, is a problem - primarily due to lack of sufficient funds and secondly due to lack of stakeholders participation. By our National Water Policy (1999), beneficiaries of flood protection schemes need not pay any levy for maintenance of infrastructure. Imposition of flood control tax is difficult without a national consensus at political level. Institutional arrangement for maintenance of such huge infrastructure - lying in remote corners of the country - only with government efforts is difficult. Consequently, during 'Borshakaal' (flood season), sometimes breaches occur in embankments. The National Water Policy emphasizes on participatory approach to project planning and implementation to ensure ownership of the projects by the beneficiaries and handing over of small projects to the beneficiaries; as well as joint management of big projects by the government and the beneficiaries - to ensure sustainable operation and maintenance (Figure 7). The government as well as the developing partners has good focus on this aspect, but it's not an easy task.

Figure 7. Discussion with local leaders in a village

Flood forecasting and early warning

The Flood Forecasting and Early Warning Centre - to make people and the relevant disaster management agencies aware of the expected disaster and to take possible precautionary measures against damages and for preparedness to deal with the aftermath - was established in 1972 under the Ministry of Water Resources. Since the devastating floods of 1987 and 1988, forecasting systems have considerably been strengthened. There are 73 monitoring stations for water level data collection, 56 rainfall data collection station, 35 meteorological stations. Little is known on flash flood behaviour due to lack of data and information on the river basins. Building knowledge on flash floods and finding a mechanism, methodology and facilities for flash flood forecasting and preparedness is necessary. Data collection network all over the country is not considered as sufficient. We receive limited data on water level and rainfall forecast from India, Nepal and China. This exchange takes place through bi-lateral agreements with the Governments of India, China and Nepal. The data are received by the Bangladesh Flood forecasting and Early Warning Office by e-mail directly from the relevant Agency of India, Nepal and China. Co-operation and co-ordination of the co-riparian countries is an important and essential element of our flood forecasting and warning system and there is room for improving this. Immediate concerns for accurate flood forecasting and early warning are:

- expansion of the data collection network;
- data quality, frequency and transmission;
- relate river stage forecast with important structures;
- finer resolution DEM for accurate flood-depth mapping;
- increased forecast lead time;
- flash flood forecast.

There is regular weather forecast on the electronic and the print media (Figure 8). In case of emergency, the electronic media makes frequent announcements about the weather, the impending catastrophe and the need for taking immediate shelter. Nevertheless, the challenge for dissemination of flood warning remains - as very often, the vulnerable communities in remote areas, particularly the poor, do not receive the forecasts well in advance. They do not have direct access to mass communication channels. Local government agencies have limited resources and facilities to pass on flood warnings to communities at the grassroots level. Pilot studies are being conducted to find out best possible means for timely dissemination of flood information to the vulnerable communities.

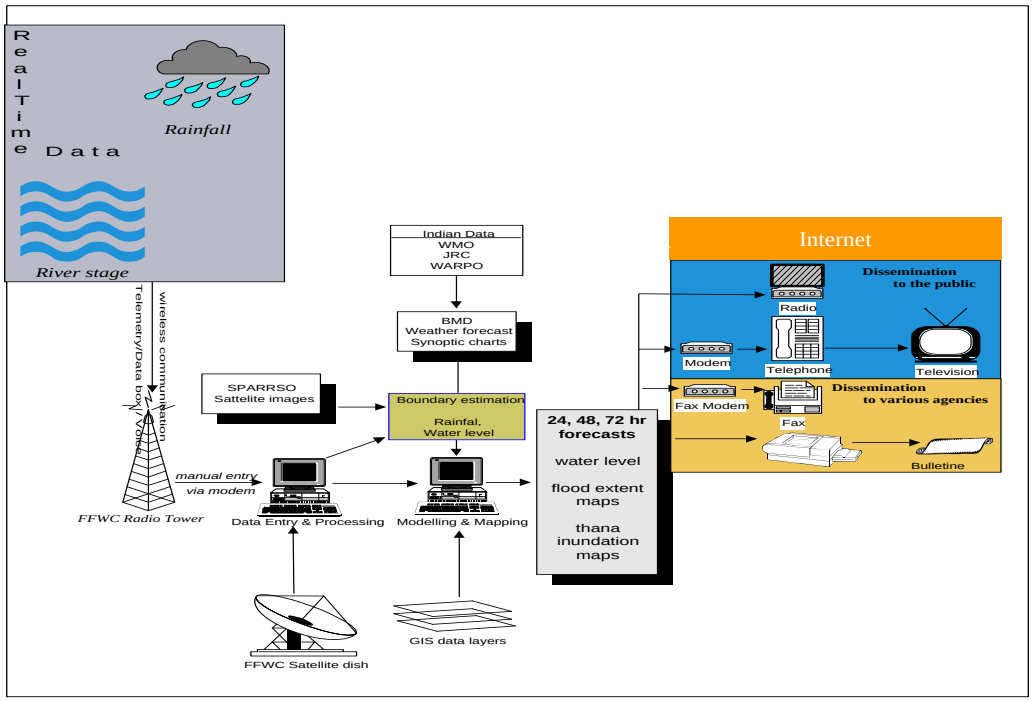

Figure 8. Present flood forecasting and warning system

Public response to forecast and warning is mixed. Most people in rural areas, particularly the poor, do not take the warning seriously, particularly if they have experienced false warnings in the past. They feel they are capable of coping with the flood as they have done in the past. There are people who view flood as a kind of fate against which they can do little (Figure 9).

Historically, people in Bangladesh and in South Asia pursued the concept of 'live with flood'. They built flood proof houses against normal floods, flood defence infrastructure, adjusted the cropping calendar, facilitate flood release capacity, prevent water borne diseases, use indigenous innovative methods of communication system (for example connecting country boats, bamboo 'Shanko' to cross rivers and channels), crop drying (using roads/highways), emergency accommodation ('Macha'), raised patch of land for emergency shelter for livestock, etc. In recent years, those who can afford are raising the level of existing homesteads and newly constructed houses.

Figure 9. Emergency protective works

Flood preparedness includes a number of technical as well as non-technical measures. The technical measures include preparation of a Contingency plan in advance for the most vulnerable infrastructure in the flood prone areas, temporary measures for protection of important hard points (Spur/groyne), protection of embankment in vulnerable reaches; and storing of necessary construction materials (sand filled geo-synthetic bags, bamboo, bullah, tarza, etc.) for emergency protective works at vulnerable sites.

The non-technical measures include preparation of a contingency plan for evacuation of people to safe places and shelters, keeping all logistics ready for operation during emergency, transmission of repeated flood warning and the necessary safety instructions over electronic media at national level and by announcement with microphones locally (Figure 10).

Figure 10. Announcement with microphone locally

Flood disaster management

Bangladesh has developed a good disaster management system, which is monitored by a National Disaster Management Council (NDMC) headed by the Hon'ble Prime Minister and an

Inter-Ministerial Disaster Management Co-ordination Committee (IMDMCC) headed by the Minister for Food and Disaster. Disaster Management Bureau (DMB) co-ordinates the activities among various agencies. Disaster management is monitored and controlled at the regional level and executed at the field level (sub-regional and local levels) by Disaster Management Committees headed by the Administration Chief at each level.

The vision of the Government of Bangladesh (GOB) on disaster management is 'to reduce the vulnerability of people, especially the poor, to the effects of natural, environmental and human induced hazards to a manageable and acceptable humanitarian level'. Disaster Management (DM) Regulatory Framework includes Disaster Management Act, DM Policy, National Plan for DM, Standing Orders on DM, DM Guideline Templates.

Tasks of the relevant government agencies are generally clarified and good coordination exist among them in carrying their tasks and in the sharing of data and information both at local and national levels. There are many international and national non governmental organisations (NGO) who have disaster management wing who help in planning and training local people about disaster management and work with the government in times of a disaster.

Bangladesh Armed Forces Division (AFD) plays a significant role in all disaster management activities and they have assigned tasks by Standing Order (Figure 11). AFD runs a 'Disaster Management and Relief Monitoring Cell' at the Prime Minister's Office which maintain close coordination with Disaster Management Bureau and other line agencies. AFD representatives play a major role as member of the National Disaster Management committees and District Disaster Management Committee. Army also plays a crucial role in relief operations including rescuing and distributing food to remote and not-easy-to-access places.

Figure 11. Bangladesh Army Chief in relief operation

Role of public participation

In this connection, I should highlight the important role, which the population play in flood disaster management. This role flows from the history and tradition of volunteering service in the region. During the great flood of 1998, BBC forecasted that about two million people will die. The government and the people took that as a flood forecast and warning. The government did its part well. The sufferings of the people - particularly of the poor - from the catastrophe was significantly reduced because the entire population mobilized themselves to help and support the affected people in flood hit areas. Individuals, informal groups, community based organizations, NGOs, professional groups, businessmen, journalists, student groups from colleges and universities took self-motivated initiatives to form relief squads (medical squads by

Medical students) to collect money, food, candles, emergency medicines, cloths and distributed it among the flood victims of their own as well as other localities. These efforts go side by side with the official (government) efforts. The government appreciates and is supportive of the voluntary public efforts. The volunteers mostly with food, medicine and clothes go to the affected areas, contact the local Co-ordination Office and take their suggestion for their operation. Local administration helps by arranging transportation if the target area is remote and transportation availability is difficult. Usually, the law and order situation during this period remains in order.

A FEW PERTINENT QUESTIONS

So long I have given a general comprehensive picture how *integrated flood risk management package works in Bangladesh***.** Before I conclude, it may be interesting if I specifically but briefly address a few pertinent questions which may come up with many of you.

What GIS data are available in Bangladesh?

Geographic Information System (GIS) data is available in different sectoral agencies for their specific purposes. A detailed inventory of GIS related data processed by various organizations were stored in the National Water Resources Database (NWRD). The available GIS data include data on administrative boundaries at various levels, roads, rivers, water bodies, topography, planning units and river basin boundaries, navigation routes, power lines and sub-stations, project information, railways and airways, hydrological stations (water level, discharge, salinity, sediment, groundwater level, groundwater quality), agro-ecological zones, crop suitability, drought maps, land type and soil association, meteorological stations of climate, rainfall and evaporation, industrial discharge and natural disasters, forest location with different attributes (Figure 12).

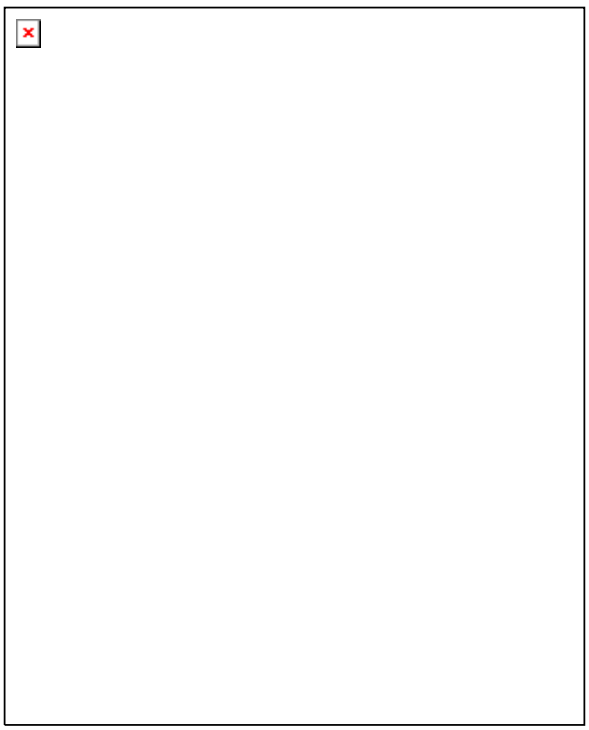

Figure 12. Satellite map of 2007 flood (August) in Bangladesh

Is there an accurate DEM (Digital Elevation Model)?

A national DEM (300 m x 300 m) for most parts of the country except the forest and hill areas was developed in 1995. The base data of the DEM was captured from BWDB 4' = 1 mile map, Irrigation Planning Map (1:40000) of 1959. Although the pixel size of the DEM was chosen as 300 m x 300 m, the input data resolution was from a 500 m template grid, which limits the accuracy of this DEM. This low resolution DEM is considered too coarse to produce an accurate flood depth forecasting. However, apart from the National DEM there are a number of DEMs with higher resolution developed for accurate flood forecasting, from recent surveys done under various projects for specific areas and the capital city of Dhaka. Local consulting firms have developed high resolution DEMs for donors like World Food Programme (WFP) and the Red Cross for specific flood areas.

How is flood mapping used as an effective tool by disaster agencies?

Flood mapping needs accurate information of DEM along with the water level situation in floodplains. The Flood Forecasting and Early Warning Centre (FFWC) simulates the water level conditions using a numerical hydrodynamic model system named MIKE 11 developed at Danish Hydraulic Institute. With the results of model and DEM data FFWC maps the flooded area of the country mainly during the monsoon season, which is used for flood forecasting at national level. Although the low resolution DEM (input data resolution 500 m grid) is too coarse to produce an accurate inundation map, nevertheless, it can give a gross idea about places under water and thus helps the disaster agencies locating the requirement for rehabilitation. World Food Programme (WFP) uses flood maps in identifying the most flood-vulnerable areas so that they have in place the relief and rehabilitation ready for those areas. The Red Cross has also done such mapping to know the most vulnerable areas so that they have a definite strategy to face the flood disaster.

How good are the data collected about direct and indirect damages?

Flood damages relate to loss of life and damage to infrastructure, agricultural crops, fisheries, livestock, forestry, commerce and business, etc. - which belong to a number of government agencies. Flood damage report on behalf of the government at national level is compiled by the Disaster Management Bureau. They collect the damage reports from the District Commissioner's Office at regional level in a prescribed format. However, the relevant basic data and information are collected in prescribed form of each agency by their staff working at the field level whose copy is forwarded to District Commissioner's Office. The assessment methodology is guess-estimate by the concerned officer and the local level public functionaries. That's why the damage assessment may vary when done by different agencies. The damage report of the cyclone (Sidr) in 2007 prepared by the Government was estimated at US$ 2.1 billion , while the World Bank estimate was US$ 1.6 billion. The damage reports are known to be usually over-estimated. Lack of comprehensive assessment of damages and the economic loss is a constraint for the decision makers in the government as well as among the development partners. Of late, a project with the assistance of development partners is in progress to establish an internationally accepted procedure to assess disaster damages.

Investment in FF and EW

Flood Forecasting (FF) and Early Warning (EW) is done, as has been mentioned earlier by the Directorate of FF and EW under the Ministry of Water Resources. There are only a few people doing the job of analysing, processing and forecasting in this Office. There expenditure is not much. But this Office receives data and information from other offices (Department of

Hydrology, SPARSO, Disaster Management Bureau, etc.) that collect the data and information and the hardware belongs to those agencies. Expenditures for FF and EW are also done by them. The government does not have a Head of Account specific for FF and EW, from where funds flow to various agencies for the purpose can be identified. But it can be said that there is a constraint of funding that does not allow expanding the network of data collection, developing high resolution DEM for the whole country, improving the forecasting model and the forecasting system for long-time forecasting with accuracy. Most of the development and improvement of the FF and EW system took place with development partner's assistance.

Finally, I may conclude that we do not eliminate the risk of flooding, we only try to reduce the risk and the damage, make the people aware of the impending catastrophe, and help the relevant agencies for preparedness to manage the aftermath.

SUMMARY OF PROCEEDINGS AND RECOMMENDATIONS FOR FOLLOW-UP OF THE 7th ANNUAL MEKONG FLOOD FORUM (AMFF-7)

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INTRODUCTION

Flood management and mitigation is of increasing concern for the authorities and citizens of many countries with flood prone areas. Flood vulnerability is generally increasing due to the population growth and the increasing value of public and private property in such areas, as well as due to land subsidence and impacts of climate change. The MRC Regional Flood Management and Mitigation Centre (MRC-RFMMC) of the Mekong River Commission (MRC) and the MRC Member Countries - Cambodia, Lao PDR, Thailand and Viet Nam – are putting major efforts in modernising and improving their flood management approaches and measures and are directing towards integrated flood risk management.

In light of these developments in the Mekong River Basin (MRB), during the preparation of the 7th Annual Mekong Flood Forum (AMFF-7) there was a commonly felt need to select as a theme for the Forum *Integrated flood risk management in the Mekong River Basin*. Stakeholders from the MRC Member Countries, MRC Dialogue Partners (China and Myanmar), donor agencies, MRC Programmes, scientists from the MRB and the international community, international and national civil society organisations, and local communities were expected to join the Forum, as it has become kind of a common practice. In order to enable a proper presentation and discussion of the various relevant aspects under the theme, it was decided to focus on four topics:

I Optimal packages for flood management;
II Recent developments in flood forecasting and early warning;
III Effective approaches towards trans-boundary flood management;
IV Successful flood risk management approaches.

Measures with respect to flood management and flood protection are generally categorised in structural and non-structural measures. The structural measures concern: dams, dikes, storm-surge barriers, etc. In fact they concern physical provisions to reduce the risk of flooding. Non-structural measures concern: food forecasting, flood warning, flood mapping, evacuation plans, land use zoning, etc. In practice one may expect that for a particular river basin an optimal (tailor made) package consisting of a balanced set of structural and non-structural measures has been, or will be developed. Therefore under Topic I papers were invited that present methods and experiences to develop optimal packages for flood management.

The meteorology, the weather forecast and the conditions in the river basin create the basis for producing flood forecasting and early warning. An efficient data collection, processing and retrieval system for real or near-real time meteorological and weather forecast data will be of utmost importance to enable an adequate input to the river flow modelling and finally the issuing of forecasts. In case of the Mekong River Basin most of the data are collected by the agencies in the riparian countries, while forecasts for the mainstream of the Mekong River are prepared by the MRC-RFMMC as well as by most of the riparian countries. This requires a good compatibility of the data, based on agreed accuracy and protocols. From the MRC-RFMMC short-term and reliable medium term forecasts (6 – 10 days) are expected. These forecasts need to be based on up to date technology for data collection, processing, retrieval and

subsequent river modelling, with a focus on flood forecasting, related to the risks in the flood prone areas. With respect to this a wide range of new developments may be observed regarding weather models, remote sensing techniques, global positioning systems, geographic information systems, automation in data collection, transmission, storage and retrieval, etc. The applicability of new developments for the interrelated database and flood forecasting systems in the conditions of the Mekong River Basin were an important aspect of Topic II.

The Mekong River Basin covers parts of six countries, which implies the importance of coherent approaches in river management. This will especially be of importance during extreme conditions of floods and droughts, while under such conditions measures taken in one country may easily have a negative impact in the downstream country. Under certain conditions measures in a downstream country may even have impacts in an upstream country. In the context of Component 3 on *Enhancing Regional Cooperation in Addressing Trans-boundary Flood Issues* of the Flood Management and Mitigation Programme (FMMP) of the MRC-RFMMC experience is being obtained in enhancing regional cooperation. In light of this it will be of importance to present such experiences, both for the Mekong River Basins, as well as for other trans-boundary river basins in the World. Therefore papers on experiences with effective approaches towards trans-boundary flood management were invited under Topic III.

The MRC Member Countries, Dialogue Partners, International Organisations, Consultants, Communities and Civil Society Organisations have obtained an impressive treasure trove of experiences with successful flood risk management approaches. These experiences are increasingly documented. None the least in the proceedings of the previous Forums. These experiences may concern the effectiveness of flood forecasting and early warning, the effectiveness of communication and measures taken during and after the event of a flood, and the measures to be taken to reduce the risk of flooding in future. For Topic IV the focus was on successful flood risk management approaches in the various river basins of the World. Papers would preferably have to be prepared in such a way that the experiences might be of use in the Mekong River Basin.

This has resulted in a set up of the programme along the following main lines:

- presentation of a summary of the 6th Forum (AMFF-6) on the theme *Integrated approaches and applicable systems for medium-term flood forecasting and early warning in the Mekong River Basin,* on the follow-up of the recommendations of the first six Forums as well as on the set-up and expectations with respect to the 7th Forum;
- presentations on *Lessons learned from 2008 floods and flooding and National and MRC-RFMMC experiences with integrated flood risk management in the Mekong River Basin* by the MRC Member Countries and Dialogue Partners, as well as by the MRC-RFMMC;
- presentations by staff and consultants of MRC-RFMMC on the five components of the FMMP;
- the above presentations were followed by parallel paper presentations with primarily papers from the region on Topics I, II and IV. The presentations were followed by discussions. Unfortunately there were no papers submitted on Topic III. However a discussion was held on this topic;
- the initial observations and results of the plenary and parallel sessions were presented by the Chief Technical Advisor and briefly discussed in the plenary session at the start of the second day. In addition four papers were presented, one on each topic;
- after the plenary session the participants split in two groups for respectively Topics II and IV. The two groups started with the presentation of papers that were predominantly prepared by international experts. This was followed by discussions, which together with the papers as presented during the previous parallel sessions on the topics resulted in reports by the rapporteurs with conclusions and recommendations on each of the four topics;
- these reports on the plenary and the parallel sessions were presented in the concluding session as well as a draft summary report. In addition a special presentation was given by

Dr. M.A. Quassem, former Director General. Water Resource Planning Organization, Ministry of Water Resources, Dhaka, Bangladesh, on *Importance of integrated flood risk management packages. Experiences from practices in Bangladesh*. At the end of this session the Forum Statement was adopted. It is published separately in these proceedings.

SOME GENERAL POINTS

The Forum was held on 13 and 14 May 2009 in Bangkok, Thailand. About 120 participants coming from the MRC Member Countries and Dialogue Partners, organisations working in the MRB, international organisations, civil society organisations, institutions and companies, attended it. There were 34 presentations in the plenary and parallel sessions and 6 booths in the exhibition.

Definitions, abbreviations and acronyms

World wide the terms of flood and flooding may have a different meaning. Therefore the definitions as used in the Forum were:

- *flood: natural abundance of water in response to storm, rainfall, snowmelt, etc ... ergo the flood season on the Mekong ..... however, this does not necessarily lead to flooding;*
- *flooding: the inundation of areas, which usually are not submerged.*

Related to the floods and flooding a wide range of others terms are relevant. While there are often different interpretations of the same term a draft glossary was prepared at the occasion of the 5th Annual Mekong Flood Forum. Based on new terms in the papers of this Forum the draft glossary has been updated. In addition a huge number of abbreviations and acronyms was used in the various papers. These have been explained in the overview of Abbreviations and Acronyms that is also published in the proceedings.

Objectives of AMMF-7

The immediate objective of AMFF-7 was identified as follows:

> *'Based on the outcome of the 7th Annual Mekong Flood Forum, the MRC-RFMMC, MRC Member Countries, international organisations (IO) and civil society organisations (CSO) will be able to improve their services, and strengthen their capability and collaboration mechanisms for improving flood risk management practices in the Lower Mekong River Basin (LMB) in order to better address the aspects of human security due to floods, development and environment'.*

More specifically AMFF-7 was set to discuss the following aspects:

- to review the progress each country has made towards a holistic and balanced flood management plan and to share lessons learned of the previous year floods by the concerned agencies;
- to present the development progress of the new system on flood forecasting for the mainstream of the Mekong River as it is being tested by MRC-RFMMC;
- to review and assess the development of flood forecasting and early warning systems by the MRC Member Countries and their interaction with the MRC-RFMMC as well as to discuss the development of new needs of the MRC Member Countries;
- to present and share with the MRC Member Countries and other interested stakeholders the progress of developments with respect to the other Components of the FMMP;
- to exchange experience, best practices and ideas with the international community, academic institutions, IOs and CSOs on institutional development and strengthen and

technical capability requirements in order to have effective and efficient flood risk management approaches and strategies implemented in the Mekong River Basin;

- to come up with effective working arrangements to enhance the process of improving flood risk management between the MRC Member Countries and the MRC-RFMMC, as well as to strengthen the cooperation and information exchange among the international community, IOs and CSOs.

The Forum would have to be very result-oriented to ensure that it benefits the MRC-RFMMC and MRC Member Countries and improves services of flood risk management, especially the provision of flood information and early warning systems to the vulnerable communities in the LMB. The goal was that the countries will use the Annual Mekong Flood Forums as a platform to review and improve their own flood policies, plans and implementations.

Envisaged outcome of AMMF-7

The main expected outcome of the Forum was formulated as follows:

Based on the outcome of the 7th Annual Mekong Flood Forum, the MRC-RFMMC, MRC Member Countries will be able to improve their integrated approaches to flood management. This implies improved database systems and tools for dissemination of the flood forecasting and early warning products, application of flood risk assessment and management, the development of guidelines for preparation of flood risk management plans and for evaluation of the impacts of flood risk management measures, identification of potential trans-boundary issues for negotiation, mediation and conflict prevention, as well as the development of a regional flash flood early warning system.

INAUGURAL SESSION

In the opening addresses the following items were mentioned that may be of relevance for the proceedings. These are:

- *Jeremy Bird, Chief Executive Officer Mekong River Commission:*
  - an evaluation mission of three weeks ago has stated that FMMP is well on its way to achieve its goals;
  - MRC-RFMMC plays important role in the MRC programme;
  - in Lao PDR there was an extreme flood, among others, resulting in an expected damage of US$ 135 million. It was a test for the MRC flood forecasting system. MRC was criticized. However, the forecast was good, but dissemination of messages could be improved;
  - a new agreement has been signed with China to submit data,
- *Siripong Hungspreag, Director General of the Department of Water Resources, Ministry of Natural Resources and Environment and Secretary General of Thai National Mekong Committee:*
  - the Forum is very important for the societies of the MRC Member Countries;
  - there is a strong need and there are good possibilities to improve data collection and dissemination of messages;
  - there are for example governance issues and trans-boundary issues. Therefore cooperation on range of issues is of importance;
  - it is also important to have good flash flood early warning systems;
  - we have to adopt an integrated approach in our practices covering the whole basin;
  - expressed the full commitment of the riparian countries with the work of MRC;

- *Martien Beek, Royal Netherlands Embassy, Ha Noi, Viet Nam:*
  - stressed the importance of broader donor involvement;
  - underlined that the annual forum is an important mechanism;
  - also referred to the external review mission of the FMMP. They showed great respect for the work that was done. However, the following issues of their observations are of importance as well: the funding mechanism could be improved and there could be a better dissemination of the products;
  - the weak link between flood management and mitigation and poverty alleviation needs to be improved;
  - the Netherlands Embassy is satisfied with the results of FMMP so far, but likes to see the comments of MRC Member States. If they also show their satisfaction and commitment a formulation mission could be organised as a first step in a clear follow-up process;
- *Ms. Sezin Tokar, U.S. Agency for International Development (USAID):*
  - showed interesting data on floods and losses, especially in Asia;
  - she informed the meeting that USAID has a strong focus in its work with respect to flood management and mitigation;
  - data and models alone are not enough. Prepared communities will really safe lives and losses;
  - she gave a brief review of the Asian Flood Network (AFN) programme;
  - she presented the flash flood guidance system;
  - the MRC model can be an example model for the world with respect to its integrated approach;
- *Timo Menniken, Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)* referred to the importance of the change from data collection and forecasting, towards integration, which is highly appreciated by GTZ;
- *Hatda Pich AN, Operations Manager, Regional Flood Management and Mitigation Centre (MRC-RFMMC) g*ave a summary of 6th Forum and reviewed the follow-up on recommendations of the previous six Forums;
- *Nicolaas Bakker, Chief Technical Adviser, Flood Management and Mitigation Programme (FMMP)* presented the objectives and expected outcome of AMFF-7.

The inaugural session was concluded with a video on the Flash Flood Guidance System that is being developed for the Mekong River Basin.

COUNTRY REPORTS AND PRESENTATIONS OF DIALOGUE PARTNERS

During the Forum the four MRC Member Countries presented their country flood reports for 2008. In addition there were presentations by the Dialogue Partners China and Myanmar. The country flood reports contain a good overview on the situation with respect to flood and flooding in 2008, as well as how the countries are organising their integrated flood risk management approaches, what progress has been made, both technically and institutionally and how they interact with the MRC-RFMMC. In addition the reports contain an impressive list of recommendations. Based on these lists, the presentations, discussions and the report by the rapporteur several key points have been derived that are listed underneath:

- *general:*
  - in 2008 there was one tropical storm Kammuri. The soil was saturated before the storm came, so most of the rainfall was directly discharged;
  - in the flood prone areas of Cambodia there is the highest population density,

because of the benefits of floods;

- in Viet Nam a Disaster Management Centre has been inaugurated;
- China has expressed its high appreciation for the work of the MRC and its willingness to fully cooperate with respect to flood management and mitigation;
- there was a general feeling that better community participation will have to be promoted. Awareness on meteorological/hydrological information to users and disaster prevention to flood risk communities need to be improved;
- unplanned urban development and spontaneous settlements escalate the flood damages and losses. Therefore it was stated that in urban development plans the implication for flooding would have to be considered and that spontaneous settlement needs to be controlled;

- *2008 flood events:*
  - 2008 brought average floods in the mainstream of Mekong River with exception of the upstream part where was severe flooding occurred in Laos PDR and North-east Thailand. A separate report on the Vientiane Capital flooding has been prepared by the MRC-RFMMC. The report was disseminated on the Forum participants. Otherwise flood levels were similar to 1996. The flood was not so much caused by flow coming from the most upstream of the mainstream of the Mekong River, but more from floods in the tributaries in the region;
  - the damage caused by the flooding in Vientiane Capital can be considered as a natural phenomenon which is inevitable. However, some lessons need to pay more attention to better flood management and mitigation. They are as follows:
    - the flooding in Vientiane was severe and exceeded the historical highest record of 1966, which initiated the improvement of the flood forecasting and warning system;
    - at Vientiane large-scale urban flooding was avoided principally due to the sandbagging of the river bank adjacent to the central business district, but large areas of suburbs and peri-urban the area were flooded to depths locally exceeding 1.5 m;
    - the flooding has demonstrated the workable approach for large-scale flood management, with strong government commitment and public participation and ownership;
    - the timely flood forecasting and dissemination provided by the Department of Meteorology and Hydrology is helpful for making arrangements and preparing measures by each level of Government Line Agencies in Lao PDR;
    - improvements of data collection coverage are particularly needed over the north of Luangprabang in Lao PDR in favour of accurate flood forecasting along the Mekong River;
    - strong political commitment is very crucial for successful large-scale flood preparedness;
    - there is no standard format for assessing flood damages in Lao PDR, which could result in the misuse of the resources for flood management and mitigation;
    - the flood would have to be considered as a lesson learned in responding to flood risk management. A meeting dealing with such an extreme would have to be held during or after the event;
  - in Cambodia there was less damage than in previous years;
  - flash floods may be even more destructive than mainstream floods. In 2008 there were especially flash floods in Laos, North-west Thailand and North and Central Viet Nam;

- in the annual flood report special attention was paid this year to the benefits of floods. Also proportion to flood damage by sector was given. The material presented does not provide a detailed economic assessment. Rather the objective was to use widely available data on the value of key regional sectors such as fisheries and agriculture in particular and compare them with annual flood damage figures, which have been systematically reported over the years by the riparian states. For the first time perhaps the degree to which the benefits far outweigh the costs has been demonstrated, while the material and information presented hopefully provides a useful introduction to a detailed economic cost/benefit analysis of the annual floods;
- *optimal packages for flood management:*
- Viet Nam has officially approved as a policy the following approach to the Mekong Delta: fully protect shallow areas, protect middle areas up to August and don't protect deep flooding areas. Together with the related measures this may be considered as an effective package of flood management;
- establishment of inundation maps is considered to be of major importance;
- flood management packages would have to be part of a framework of an integrated water resources management strategy for sustainable development. Initial comments on this subject could be made as follows:
  - flood risk management is a national responsibility, and each country may have different problems and priorities;
  - the purpose to develop optimal packages for flood management is to reduce the vulnerability of communities in the LMB to the negative impacts of floods;
  - key activities of proposed optimal packages for flood management will be:
    - to identify and prioritize flood issues in each country in the LMB through the development of regional and national road-maps for improved flood risk management;
    - to develop prioritizing programs of structural and non-structural flood risk management interventions in each county;
  - flood phenomena can be recognised easily but the nature of flood of the Mekong River needs to be carefully analysed in the context of physical conditions and the hydrological cycle;

- *recent developments in flood forecasting and early warning:*
  - the major constraint to forecasting accuracy over lead times in excess of two to three days is the emerging conclusion that the storm rainfalls indicated by satellite images are probably too low and that the network available for ground truthing needs to be improved in key areas of the basin;
  - the Department of Water Resources of Thailand has established the Water Operation Centre (Mekhala Centre) as the centre for monitoring, data accumulation and data processing regarding water resources, management of GIS and meteorological and hydrological data in the water crisis areas. The Mekhala Centre allows the officials involved to be aware and understand the water situation in advance in order to be prepared for giving any suggestions, solving problems, coordinating with agencies concerned to mitigate disasters caused by water crisis. It is also assists in efficient management and control damages from disasters. In 2008, Mekhala Centre has improved its efficiency of monitoring the water situation by installation of closed circuit television (CCTV) systems;
  - in order to achieve better flood forecasting and early warning at medium-term the following aspects need to be considered:
    - flood management and mitigation need to be well placed in modern planning and operation;

    + there is a need to build capacity in flood management and mitigation at all levels from data collection, processing to model development and operation. Funds for these activities need to be allocated;
    + tasks of all institutions and people concerned need to be clarified and coordination among them need to be promoted in order to avoid duplication of tasks and to encourage the sharing of data and information;
    + awareness on basic flood risk reduction and mitigation measures and knowledge to use hydro-meteorological information have to be provided to communities in flood risk areas so that they can somehow help themselves to some extent to reduce flood risk;
    + quantity, quality and timeliness of data need to be improved;
    + little is known on flash flood behaviour due to lack of data and information on the concerned river basins. Therefore, building knowledge on flash floods and finding a mechanism, methodology and facilities for flash flood forecasting and preparedness must be encouraged. More hydrological stations need to be installed. The experiences as obtained in Thailand may serve as a good and effective example;
  * in Viet Nam 72 hours rainfall forecast products, produced by the Fifth Generation Mesoscale Model (MM5) and High Resolution Model (HRM) etc., are now used as input data for the flood forecast models. New software is being applied such as Marine software developed by French experts and Vespa software developed by Belgian Consultants, etc. The French software is being applied for simulation of flood flow on the river system affected by tide at Hue province, while the Vespa software is used for the Central provinces. In addition, Mike 11 is applied for flood forecasting now. A plan to improve the flood forecasting services for the National meteorological network was approved. 400 new meteorological stations will be installed to increase to 2,000 stations in total, of which the automatic stations shall be 50% of the total network;
  * MRC would have to publish the forecasting news on rainfall, floods, especially early flood forecasting in early April every year so that the riparian line agencies will follow to prepare plans responding to urgent hydrological circumstance;
  * MRC daily forecasting news would have to be broadcasted before 10:00 hour, in order to be referred by the riparian agencies;
  * additional water level and rainfall data at 19:00 hour would have to be provided daily;
  * information on new technology on forecasting and warning needs to be frequently exchanged between MRC-RFMMC and the riparian line agencies;
  * training courses for riparian forecasters need to be conducted by MRC-RFMMC every two years;
  * an overview of the flood extremes in the in the LMB would have to be made;
  * seasonal forecast for agriculture would be useful;
- *effective approaches towards trans-boundary flood management:*
  * the Mekong River Basin covers parts of six countries, which implies the importance of coherent approaches in river management. This will especially be of importance during extreme conditions of floods and droughts;
  * the lessons and experiences with effective approaches towards trans-boundary flood management in Viet Nam have been applied as follows:
    + a ‘win-win’ approach is considered as a key tool in addressing trans-boundary flood issues with the neighbour counties;
    + the importance of open discussion in the spirit of mutual respect and cooperation dealing with trans-boundary flood issues;

    - + promote and strengthen bilateral cooperation from National to local levels in development of social and technical infrastructure in border areas;
    - + information and data sharing and exchanging concerning water resources management in the LMB as a whole and the infrastructural development projects along the boundary areas in particular;
    - + international cooperation and capacity building on trans-boundary issues;
  - * Cambodia promotes joint working groups and joint activities;
- *successful flood risk management approaches:*
  - * community based flood risk management would have to be strengthened. Community self reliance for flood management and mitigation has proven to be effective. Disaster management committees would have to focus on building capacity of the local communities in flood preparedness and emergency responses;
  - * it was reported that in the villages of Thailand where a flash flood warning system had been installed, there have been no casualties since then. A similar programme is going-on in Viet Nam;
  - * a standard format for assessing flood damages and losses need to be developed both for assessing direct and indirect damage in favour of improvement of flood management and mitigation;
  - * Cambodia has stressed the importance of good interaction between MRC Member Countries and MRC-RFMMC:
    - + In Phnom Penh MRC-RFMMC is located in the same compound of the DHRW who is responsible for forecasting in the country. This provides a good opportunity to exchange regularly knowledge and information;
    - + MRC-RFMMC needs to help strengthening capability of national forecasting institutions, on collection, processing to development of forecasting models;
    - + MRC-RFMMC would have to allocate funds for longer term data collection and provide technical support;
    - + MRC-RFMMC would have to help to install more hydrological stations to extend the coverage areas, so that they can cover also main tributaries;
    - + MRC-RFMMC needs to continue to help taking care of some other manual hydrological and meteorological systems as they will continue to be served as a back up;
    - + the FMMP needs to consider orienting its activities to benefit the local level by providing a supportive role in building the capacity of local authorities and communities in flood management and mitigation;
    - + the MRC flood forecasting and dissemination needs to focus on establishing the link with the national flood forecasting agency, so that the MRCS as the knowledge based river basin organization can provide its products to benefit the flood forecasting at the national level;
  - * in Viet Nam the following lessons have been experienced, improved, actions taken as well as adopted:
    - + a flood is not necessary a disaster, unless and until it affects people. The annual moderate flood is a natural phenomenon that is essential to food security and biodiversity;
    - + extreme mainstream flood events can be destructive and cause enormous damage on human and properties in the affected areas where people could not receive advance forecasting and warning of approaching water;
    - + flood flow plays a role as the natural resources (fresh water, fishery, natural fertilizer, etc.) to be widely acknowledged in the Mekong Delta;
    - + annual flood preparedness planning responding to flood emergency supports the affected people to reduce flood damages;

+ maintain close cooperation with the FMMP;
+ adopt a National Strategy for Natural Disaster Prevention, Response and Mitigation (was approved by the Government in November 2007);
+ improve peoples' awareness on the world climate changes and how to live with floods;
+ at present there is no coordination and relation between the MRC Member Country centres for flood forecasting and warning at the time of occurrence of flood events, or other natural disasters. MRC-RFMMC would have to arrange meetings and workshops for sharing and exchanging knowledge and experiences among the MRC Member Country agencies concerned;
+ a networking of the forecasting agencies dealing with not only flood forecasting but also respond to climate change would have to be established;
+ flood preparedness programmes involving the local communities and the Governmental centres can be useful to manage and mitigate flood risk and hazard. A community communication centre together with capacity building to the community would have to be made.

- *other items:*
  * reconstruction and relief measures need to be improved, financial assistance would have to be made to affected communities so that their daily life can be sustained, the technical and financial assistance needs to be effectively and efficiently mobilized as soon as possible afterwards, and a financial reserve needs to be established for flood emergency response;
  * in order to identify an effective set of flood management and mitigation measures, a good process for assessment flood damage will be relevant. Such a process is also necessary because comprehensive assessment of damage gives important data that will reflect the economic loss of the country. This will result in significant supporting information for setting up of both structural and non-structural measures for flood prevention and mitigation;
  * a good digital elevation model (DEM) for the floodplain and delta of the Mekong River remains to be of importance in support of flood forecasting and flood management;
  * isolated intervention will not assure continuation of activities initiated by projects;

LESSONS LEARNED FROM 2008 FLOODING AND NATIONAL AND MRC-RFMMC EXPERIENCES WITH INTEGRATED FLOOD RISK MANAGEMENT

During the Forum the approach and progress of each of the components of the FMMP were presented and discussed. The major points are summarised underneath.

Component 1: Structural measures and flood proofing

The first version of the new MRC Mekong Flood Forecasting System based on the Unified River Basin Simulator (URBS) Model and the Delft-FEWS platform has been established at the MRC-RFMMC. The new system was operated in 'test mode' during the 2008 flood season in conjunction with the existing Streamflow Simulation and Reservoir Regulation (SSARR) based system. The performance of the first test has been evaluated and compared to the existing system. The results show satisfying improvement of forecasts made by the URBS model at stations between Luang Prabang and Mukdahan, however, further improvements are required at some locations, especially in the area downstream of Pakse. After the 2008 flood season a second version of the system, coupled with the ISIS hydrodynamic model has been developed and the initial analysis indicates that on average there are significantly fewer errors than with

the original version. An investigation at Vientiane during the August 2008 flood showed that the water levels were accurately predicted with the improved system. The new flood forecasting system is currently capable of producing a medium-term forecast (up to 10 days). However, there is a need for further development and continuous improvement in order to obtain more accurate forecasts.

Component 2: Short and medium-term flood forecasting at the Regional Flood Management and Mitigation Centre

Component 2: Short and medium-term flood forecasting at the Regional Flood Management and Mitigation Centre has two objectives:

- *to reduce the vulnerability of people living in the LMB to the negative impacts of floods*. The first objective requires the preparation of concrete measures at all steps that are crucial for a socio-economic and environmentally sound flood risk management. Integrated Flood Risk Management (IFRM) is defined as applying the most attractive mix of all possible measures, hard and soft, for the reduction of flood damage risk. There are five steps: the first step in the process is the proper assessment of flood damage risk. Secondly, structural flood risks management measures. The third step involves the evaluation of the effects and impacts of the different types of measures and developing a strategy for flood risk management - for different types of flooding. In the fourth step, IFRM plans are to be developed on the basis of the four previous steps. These will include a 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;
- *to establish sustainable capacity in the MRC, Mekong River Commission Secretariat (MRCS), National Mekong Committees (NMC) and national line agencies.*
  The second objective will be met through a series of consultations and training sessions to the MRC, National Mekong Committees and national line agencies. Capacity building has also being applied through the implementation of selected demonstration projects. The implementation of the selected demonstration projects will apply IFRM planning exercises in a limited number of focal areas. From these exercises 'best practice' guidelines (BPG) for the preparation of flood risk management plans and for the evaluation of impacts of flood risk management measures will be developed.

Implementation of the Component is divided into three phases: The inception phase, Stage 1 and Stage 2.

Component 3: Enhancing cooperation between Mekong River Commission (MRC) Member Countries in addressing trans-boundary flood and related issues

The objective of Component 3: Enhancing cooperation between Mekong River Commission (MRC) Member Countries in addressing trans-boundary flood and related issues is to strengthen cooperation and capacity of the NMCs and line agencies in addressing and resolving differences and disputes in trans-boundary flood issues.

Under this component numbers of key documents were produced and outputs have been achieved. Among others, the three keys working papers and the design and implementation of the Capacity Building Programme (CBP) – Phase I are the most important outputs and achievements of the component to date. The key working documents are Trans-boundary Flood Issues Identification, The Legal Aspects of the Mandate of the 1995 Mekong Agreement for Enhancing Cooperation in Addressing Trans-boundary Floods and Related Issues (LA-MA95), and An Explanatory Notes - Manual to the LA-MA95.

The capacity building programme aims at to provide tailor–made trainings to the MRC, NMCs and line agencies in addressing trans-boundary floods and related issues, which is also

the ultimate goal of the Component.

Implementation of the component started in mid 2007 and it will be completed by the end of 2010. The Capacity Building Programme Implementation Plan - Phase 1 (CBP Phase 1) was finalised in December 2008. The implementation of CBP Phase 1 has started in March 2009 and being completed in November 2009. Implementation of Phase 2 of the Capacity Building Programme schedules for 2010.

Component 4: Flood emergency management strengthening. People-centred approach in integrated flood risk management

Component 4: Flood emergency management strengthening. People-centred approach in integrated flood risk management deals with strengthening the capacity of disaster management authorities at all levels, raising public awareness and trans-boundary province-to-province cooperation on emergency assistance,. With its non-structural measures this component forms an important part of IFRM, which is being applied for the first time in the LMB.

Component 4 focuses on enhancing the ‘competence of civil authorities at various levels, emergency managers and communities in flood preparedness and mitigation‘, which will ultimately help facilitate the objective that ‘Emergency management systems in the riparian countries more effectively deal with Mekong floods.’

The project has been providing assistance and technical support to disaster management (DM) authorities, particularly at the sub-national levels (provincial, district and commune) and in filling the gaps and needs of the existing system. The process started with Institutional Role Analysis and Improvement Identification that identified the gaps and needs.

Local DM authorities have taken the lead in the development and implementation of Flood Preparedness Programs (FPP) in which clear roles and responsibilities are defined for each line department of the Provincial and District Disaster Management Offices. Various innovative approaches to flood risk reduction were carried out in support to the FPP, including promoting local, national and regional knowledge sharing and trans-boundary province to province cooperation in flood emergency assistance, as well as ensuring the sustainability the FPP activities by integrating them into the local development planning process. Linkage of Component 4’s activities with other FMMP Components is also highlighted.

Component 4 activities deal with flood preparedness and emergency management of local authorities and communities at the forefront of flood disasters. This people-centred approach is low-cost, effective, and relevant to local conditions in the LMB. Ownership is gradually evolving and sustainability is being secured step-by step. It is recommended that once the model is well tested it would have to be replicated across the LMB, well beyond the border of the project target areas.

Component 5: Flood information based land management (FIBLM)

Component 5: Flood information based land management (FIBLM) has commenced its Phase 2 by August 1, 2008 and will run until December 31, 2010. Phase 1 (2004-2008) focused on the development of an approach to generate flood probability information for floodplains of the LMB, particularly flood probability maps in three pilot districts in Cambodia. Phase 2 focuses on the adaptation of the developed technical tools (software) by the respective line agencies of all four riparian countries (Cambodia, Laos, Thailand, Vietnam) for an improved FIBLM.

Given the different conditions in each of the four MRC Member Countries in terms of capacities and data available, the project supports each country to develop its own strategy and approach in flood probability based land management. The project initiates national discussions, facilitates the development of a national strategy, trains authorities (line agencies) and relevant land management related organizations in all four countries and supports the implementation of flood probability based land management in seven pilot districts (two in Cambodia, Laos and Vietnam and one in Thailand) along the Mekong and in the Mekong floodplains.

Current land management practices are an important factor contributing to a situation where the regular floods of the Mekong cause substantial damage to agriculture and infrastructure. More effective decision making in these fields, as well as disaster management, requires the provision of more relevant and accurate flood related information.

Improvements in land management by considering flood probability information do not only provide direct positive impacts through the reduction of damage to agriculture and infrastructure, but also indirect benefits through the avoidance of damage to the most vulnerable parts of the population living and working in the floodplains.

Component 5 produces flood probability maps in a scale of 1 : 10,000 or larger. Therefore the project helps to supply the decision making authorities (particularly provincial and district offices of line agencies) in the four participating countries with an urgently required planning tool of the right scale, which will help to avoid or at least minimize flood risks and damages along the Mekong River.

So far Flood Probability Maps have been only produced in the three pilot districts in Cambodia and no experiences exist concerning the use of these maps in land management and land use planning. It is premature to expect the mapping carried out so far to be actively used by planning agencies, since the Cambodian pilot areas are not sufficiently extensive (approximately 15 - 50 km^2). However, the current Training of Trainers (TOT) training programme, which addresses the data processing and the data using line agencies in all four countries, includes components designed to show how the maps used singly or in combination can be analyzed in a GIS application to answer complex planning questions relating to Land Management, Agriculture, Irrigation, Disaster Preparedness and Rural Infrastructure Development.

RESULTS OF THE PLENARY AND PARALLEL SESSIONS

The content and summarised results of the plenary and the parallel sessions on the four topics are as shown underneath. Based on the presentations and discussions more detailed recommendations were presented on each topic. These will be used by the MRC-RFMMC during the further development of the new approach.

General items

There were five plenary presentations. On three of the topics there was a paper selected out of the submitted papers. For Topic III no paper was submitted, while the topic is considered as very important in light of integrated river basin development a separate paper was prepared on *Development of trans-boundary cooperation in the Rhine River Basin*. A special presentation on *Importance of integrated flood risk management packages. Experiences from practices in Bangladesh* was given by Dr. M.A. Quassem, Former Director General, Water Resource Planning Organization, Ministry of Water Resources, Dhaka, Bangladesh.

Plenary session 1. Lessons learned from 2008 flooding and national and MRC-RFMMC experiences with integrated flood risk management

In addition to the issues, conclusions and recommendations as summarised before the following relevant points were mentioned:

- lack of tools for flood victims evacuation such as boats, rescue teams no means of access to flooded areas;
- the standard format for assessing flood damage and losses need to be developed both for assessing direct and indirect damages in favour of better flood management and mitigation, resources allocation in particular;
- the characteristic situation of Thailand can be summarised as follows: average of annual

rainfall 1,581 mm, average runoff 213,800 MCM (million cubic metres) and flow to Mekong River 65,000 MCM;

- water resources situation in 2008 - Climate Data rainfall 1,643 mm, N-E Thailand 1,638 mm, Isohyets of N-E Thailand and Graph of water level. Impact of 2008 flooding - 65 provinces affected with a loss of US$ 72 million which was higher than 2007 US$ 23 million, around 95 people dead. Responses to flood events in Thailand - put in place preventive measures (develop data, install early warning system), in 2008 warning 64 times to 168 villages, to ensure proper water resources management, draft of Water Act.
- Recommendation from Thailand. While some problems of water resource concern many sectors the process of resolving flood disasters is performed by many agencies as follows from their authority and it is limited due to many legal issues, which implies that there is no leading role of water resource law. As a result the resolving operation becomes less effective. Therefore the water act needs to be supported more seriously. To increase flood management, there must be an agency that takes direct responsibility to plan and coordinate with the related organizations at community, basin and national level.
- main causes of flooding in Mekong Delta are rainfall, river flooding, local rainfall and river basin deforestation;
- the Chinese representative acknowledged the importance of the Lancang - Mekong River (politics, economy and historical and cultural). He expressed appreciation for being invited to the forum as an excellent platform for sharing experience in flood management especially on flood forecasting and warning;
- an indicative distribution of average annual regional flood costs of US$ 76 million over the MRC Member Countries was shown, as well as the 2000 and 2008 Mekong floods – proportional and total damage. The relative costs and benefits of the annual Mekong floods were shown;
- maximum discharges at Luang Prabang and Vientiane/Nong Khai occurred on the 14 and 15 of August and were in the order of magnitude of 23,000 m^3/s or 50% above the annual average. The associated water levels were comparable to those of 1966, when both city centres were flooded.

Plenary session 2. Towards integrated flood risk management in the Mekong River Basin

In addition to the issues, conclusions and recommendations as summarised before the following relevant points were mentioned:

- the forecasts on the mainstream of Mekong River are now more user-friendly, reliable and robust. The new flood forecasting system will be ready for the 2009 flood season;
- more highly trained and experienced forecasters are needed;
- key output of the completed Roads and floods project are three sets of Best Practice Guidelines for the Integrated Planning, Environmental Assessment and Technical Design of Roads in the Mekong Floodplains of Cambodia and Viet Nam;
- key outputs of the Structural Measures and Flood Proofing project will be: sets of best practice guidelines for IFRM, implementation of demonstration projects, preparation of a list of priority investment projects and capacity building in IFRM practices;
- with respect to trans-boundary flood and related issues three working papers have been completed on respectively:
  - trans-boundary flood issues identification report;
  - legal aspects of the Mandate of the 1995 Mekong Agreement for Enhancing Cooperation in Addressing trans-boundary Floods and Related Issues;
  - an explanatory note that could be useful for MRC programmes and national members in addressing trans-boundary water issues;
- creation is on-going of reliable Flood Probability Maps for subsequent use in Land Management by the relevant authorities and organisations.

Plenary session 4. Summary of day 1, plenary paper presentation, discussions

There were four papers presented in the session as well as a report on day 1 of the Forum. In addition to the issues, conclusions and recommendations as summarised before the following relevant points were mentioned:

- *first report.* Flood hazard mapping in Nan River, Thailand:
  - the study area is located in Nan River Basin in the upper reach of Nan River. It covers the area of Nan municipality and Phupiang Municipality in Nan province. Topographically, It is the plain area surrounded by mountains;
  - methodology consists of three phases and uses HEC-RAS and HEC-GeoRAS to provide flood hazard mapping for 10yr, 20yr, and 50yr flood events;
  - flood hazard maps corresponding to 10 yr, 20 yr and 50 yr return period flood events were prepared. These flood hazard maps will be utilized in flood warning system of this province;
- *second report.* Statistical ensemble flood forecasting for the Mekong River in five steps:
  - *fist step:* Determination of rainfall – runoff relation with the SSARR model;
  - *second step.* Statistical analysis of discharges;
  - *third step:* correlating discharge differences between two stations with rainfall and regression with different rainfall averages;
  - *fourth step.* Using approaches from step 3 to generate system model for the upstream system;
  - *fifth step.* Including hydrological approaches to lake and channel hydraulics;
  - conclusions: the objective of a forecasting model is:
    - to make a crisp forecast, as an expected value. To produce an error band for the range of possible deviations from the crisp value. To minimize the error band by entering as much conceptual information based on the physics into the model as is significant. An objective benchmark must be established by means of which forecast quality can be judged;
    - further improvement must include rainfall information:
      - correlation of runoff increase between stations with daily rainfall;
      - correlation of runoff increase between stations with 5 day averages of days before forecast;
      - further concepts would have to include time delay between rainfall and runoff (unit hydrograph).
- *third report.* Development of trans-boundary cooperation in the Rhine River Basin:
  - over the centuries many cases of flooding, oldest record of a flooding is from 1233;
  - especially in the Netherlands impacts of floods have increased due to subsidence, population growth and increase in value of buildings and infrastructure;
  - in 1990s attention to integrated water management. In study ‘integrated environment management’. In this approach developments in land use, water management, flood protection and environment will be better integrated;
  - impacts of climate change are in the order of magnitude of 10 – 30% per century, while impacts of change in land use are in the order of 100 – 1,000% per century;
  - impact of 1993 and 1995 floods: *International Commission for Preventing Pollution of the Rhine: development of strategy paper for flood protection* (December 1995);
  - in January 1998: *Flood Action Plan (FAP);*
  - European Water Framework Directive (accepted at 23 October 2000);
  - European Flood Directive of 23 October 2007 on the assessment and management of flood risks;

- the European countries have to make Flood Risk Management Plans at river basin level by 22 December 2015;
- Concluding remarks:
  - history has shown that again and again new measures have to be taken in answer to new developments. There is no reason to suppose that in this will come to an end;
  - anticipating future developments - rather than only reacting to them – will be the challenge;
  - for the Rhine Basin Countries it will be of increasing importance to continue and expand their cooperation with respect to developments in land use, water management, flood protection and protection of the environment;

- *fourth report.* Hydrological risk zone mapping in Dong Thap Province for developing agricultural insurance:
  - the paper described 4 steps of the approach to natural hazard risk and the development of agricultural insurance in Vietnam;
  - conclusions and recommendations:
    - hydraulic model is well calibrated;
    - long-time series data are required for statistical analysis;
    - reliable data set from MRCs and National Agencies to generate flood maps;
    - the instant water level at Tan Chau station could be used for flood management decision;
    - the study is important to identify impediments to developing sustainable agricultural insurance in Viet Nam, propose policy options, provide feasible models for informal agricultural risk mitigation and formal agricultural insurance for pilot testing and identify major risks that farmers face;
    - findings will be used to aid in the design of appropriate insurance products;
    - the product of the project is education to determine if effective risk transfer markets for catastrophic natural disaster risk can be started in Viet Nam;
    - would have these type of risk transfer products help change some other government social policy and provide a linkage mechanism from the bank for indemnity based insurance and risk mitigation payments as well.

Results of the parallel sessions

Underneath the issues, conclusions and recommendations of the parallel sessions will be summarised as far as these points have not been shown above.

Topic I. Optimal packages for flood management

Under Topic I three papers were presented. The summarised relevant points of the topic were:

- floods occur in the Yang River Basin (area = 4,145 km^2) in Thailand are caused by monsoon rains and tropical cyclones every 2 - 3 years. The most severe floods occurred in 1978, 1980, 1995, 2000, and 2001. Therefore flood prevention and mitigation is needed. An integrated hydrologic and hydraulic modelling approach can evaluate the effect of flood mitigation measures on flooding and damages. This was simulated with the models Soil and Water Assessment Tool (SWAT) and SOBEK 1D/2D within the Delft FEWS format to produce flood and flood risk maps. Two measures for flood mitigation were analysed: natural flood storage to delay discharge quantity (peak) and green river to decrease discharge (inundated area). The results provide information and understanding for identifying more desirable and effective flood management options by which flood management will improve and serves as base for comprehensive flood management strategies;

- charting the strategy of the International Centre for Water Hazard and Risk Management (ICHARM) for IFRM in the LMB covered the identification and assessment of risk from flood and other consequences for the future development in the target area. The two components of the proposed technical assistance (TA) prepared by the Asian Development Bank (ADB) and ICHARM are in-country project support and program quality support through regional cooperation. In-country project support will provide TA to the countries of the LMB on: (i) flood management investment projects, strategies and programs, applications of flood hazard mapping; (ii) demonstration projects to improve flood forecasting and warning; (iii) action research on innovative community-managed flood preparedness and disaster risk management practices; (iv) identification of 'no-regret' investments in flood management to accommodate climate change impacts; (v) capacity development activities; (vi) diagnostic assessments of executing and implementing organizations.

  Program Quality Support through regional cooperation in the region will be provided for the following: (i) workshops and exchange visits; (ii) incorporating climate change adaptation effects into flood risk management; (iii) training to develop the capacity of river basin organizations in flood risk management and to incorporate flood risk management in cities, through existing city networks such as CityNet; (iv) policy development and institutional training for ICHARM's Masters Course on Disaster Management; (v) organizing a pool of regional experts to improve flood management and emergency response services; (vi) developing a regional index for in-country water-related disaster preparedness; (vii) a comparative study of institutional arrangements for flood risk management in the region.

  The ICHARM's strategy for Technical Assistance towards integrated flood management in the LMB is charted in four main themes: (i) in-depth hydrological analysis; (ii) integrated flood analysis system (IFAS); (iii) inundation modelling; (iv) flood vulnerability and risk mapping.

  With the intended result output from ICHARM ongoing research for tool development for generating near real-time satellite rainfall information and heavy rainfall area identification, the proposed approach is expected to deliver a more pragmatic IFRM system for the LMB.
- risk based flood management for adapting to climate change presented recent changes in climate, for example: daily rainfall over 200 mm is significantly increasing and hourly rainfall over 100 mm is increasing. This was followed by a review of impacts on water related disasters, like more frequent high tides and coastal erosions and more frequent floods. Projections were given of future climate change, like rainfall after 100 years is projected to increase 10 to 30%, the increasing rate in the northern area is expected to be larger. The increasing rainfall intensity will make the flood safety level significantly lower than at present. Basic concept for tackling in increasing risks consist of mitigation measures and adaptation measures (facility-dike, dam, regional development-land use regulation, building restriction, crisis management-flood hazard map, real-time information, monitoring-river information, planning). The challenge of a new flood management program would have to be based on risk assessment by implementing a risk assessment, taking into consideration the increasing future climate change, and carrying out analysis of floods of various magnitudes that may occur at different precipitations. When structural measures are not enough to eliminate the hazards, we may concentrate non-structural measures;
- during the discussion the following points were raised:
  - an enabling environment has to be created in terms of institutional arrangements and legal support;
  - IFM should follow a Road Map. It should have a multi sector approach. Optimal flood management should balance the environmental needs, flood protection needs,

interest of all livelihood groups related to water and mitigation of adverse effects. It would have to start with basin/regional approach and be country specific be on the national development agenda;

* intensive capacity building to enhance the knowledge base making use of locally available knowledge and experience;
* easy accessibility and sharing of data and information is necessary for IFM.

Topic II. Recent developments in flood forecasting and early warning

For Topic II seven papers were submitted. Some recommendations were:

- an overview was presented of numerical model applications for simulation of the hydraulic regime of the Mekong River flow, especially in floodplains as the Mekong Delta. The limitations of 1D models in describing such flow situations were clearly indicated. To overcome of the limitations of 1D models, approaches in the combined 1D and 2D numerical modelling of flood wave propagation were introduced, in particular the ways in which the process descriptions are best integrated. The presentation also dealt with the data requirements for such models, demonstrating the possibilities and limitations of current state-of-the-art in data collection;
- recent observations and findings related to operational applicability of the methods for improving hydro meteorological forecasts were summarized. In addition, hydro meteorological observation system issues related to spatial configuration and overall performance of the network were presented. Manuals for surface measurements have traditionally formed the basis for hydro meteorological observation networks. However, the limited availability of real-time precipitation data for the Mekong River left bank (eastern) sub-catchments of Lao PDR has reduced the accuracy of flood forecasting. Longer lead times and improved input accuracy for flood forecasting can be reached by increasing observations of atmospheric water i.e. measuring water before it precipitates on a river basin. Satellite and aircraft observations, a very low frequency (VLF) long-range lightning detection network could be used to monitor convective activity and estimate rainfall associated with tropical systems over data-sparse sea areas. The numerical weather prediction (NWP) models such as the Fifth Generation Mesoscale Model (MM5) from weather radar forecasts can be used as input for medium term hydrological forecast models, while weather radar derived quantitative precipitation estimates (QPE) can be combined with surface observations for improved forecast input.
- new equipment for survey purposes were introduced as the ‘Next Generation RiverSurveyor’ that has been used in the South-western US, as well as throughout the world. The following items were summarized: (i) initially an oceanographic application; (ii) reliable standard for discharge measurements; (iii) world water issues (demand and pricing models); (iv) multi-frequency acoustics.
- the status of MRC Hydro-meteorological network for river monitoring was presented. The progress of implementation of the AHNIP and Mekong HYCOS has been reported. With the new Mekong HYCOS, all key tributaries can be monitored thus enhancing a better near real-time river monitoring and flood forecasting for the mainstream and tributary basins of the LMB. The future equipment and data flow of AHNIP will be the same as Mekong HYCOS. The integration will increase ease and convenience for operation and maintenance of the system. Under IKMP work plan 2009, the AHNIP equipment will be upgraded. Planned to be completed by 2010.

Topic III. Effective approaches towards trans-boundary flood management

For Topic III no papers were submitted. Based on the discussion that was held the following was formulated:

- learn from best practices of sharing benefits and reduction of damage among member countries. Approach these issues in a broader context;
- enhance and strengthen cooperation in different sectors;
- increase increments over long term periods;
- mobilize commitment of stakeholders would have to be preferred above imposing of laws and regulations.

Topic IV. Successful flood risk management approaches

Seven papers were presented under this topic. This resulted in the following recommendations in addition to those as already shown above:

- communication of technical information and products in simple form are required for various audiences;
- structural measures can not be avoided. However, non structural measures for flood management and mitigation would have to be emphasized;
- multi purpose water management structures from flood management to hydropower generation are of importance;
- flood risk management would have to consider a basin-wide approach rather than local areas;
- flash floods are common in the region , the accuracy of forecasts needs to be considered and there is a need for flash flood risk identification;
- awareness of flood risk management needs to be considered in the national development planning cycle;
- the importance of locally appropriate and sustainable, and culturally acceptable measures for flood risk management within a basin-wide approach was stressed;
- efforts would have to focus on flood risk management rather than on flood control;
- MRC plays a major role in supporting inter agency coordination and data and information exchange by sharing experiences regarding flood risk management;
- There is a need for a methodology for comprehensive flood damage assessment (direct and indirect);
- There is a strong need for participation of civil society, communities and all stakeholders at all stages of flood risk management activities.

FOLLOW-UP

Follow-up actions at three levels were formulated, being follow-up actions directly after the Forum, recommendations for the theme of the 7th Annual Mekong Flood Forum (AMFF-7) and on the more comprehensive follow-up.

Follow-up directly after the Forum

The follow-up actions directly after the Forum were of a practical nature and have resulted in the proceedings. These concerned:

- all authors and rapporteurs have received their edited paper/report back with the request to check the editorial changes and complete the paper/report;
- papers have been published in the proceedings on CD-ROM. MRC Member Countries, Dialogue Partners and other partners will receive the CD-ROM through the MRCS. A hard copy of the proceedings will also be made for limited distribution. It can also be ordered from the MRCS. The PDF files of the papers will also be available on the MRC web site. The CD-ROM can be ordered through the MRC website as well.

Next Mekong Flood Forum

As main theme for the 8th Annual Mekong Flood Forum provisionally was proposed:

Integrated approaches to flood risk management and mitigation in Mekong River Basin

It is expected that this main theme will be the basis for the formulation of the sub-themes and the programme for (AMFF-8).

Having in mind the rotation that is followed with the venue of the Forum, the 8th Forum will most probably be held in Vientiane, LAO PDR.

More comprehensive follow-up

Fore the more comprehensive follow-up of AMFF-7 several considerations and recommendations were given. These are especially:

- continue with annual flood forums, based on actual topics of joint interest of the MRC Member Countries and Dialogue Partners. The two days format, as well as the modified format for the programme that was introduced in this Forum seems to be appropriate;
- in the coming period up to the end of 2010 the work for the present phase of the FMMP will be completed along the lines as presented, with input from Forum results for improvement;
- also in the coming period discussions will take place on the follow up of FMMP from 2011 onwards. It is expected that initial ideas can be presented during the 8th Forum;
- during the coming flood season the new system for flood forecasting will be fully implemented in practice;
- it will be of importance that the flood forecasters of MRC-RFMMC and the National Line Agencies of the MRC Member Countries will come to a closer cooperation, therefore a may be useful to organise a special session were they present their approaches and practices. May be this can be associated with a joint workshop;
- quite some developments towards integrated approaches to flood risk management and mitigation are on-going both in the MRC-RFMMC, as well as in the countries. For example the developments with respect to flash flood forecasting, warning and management. It will be of importance that especially papers by the MRC Member Countries on these developments will be prepared for and presented during the 8th Forum;
- take care in the next Forum for a better time management of the presentations.

CONCLUDING REMARKS

This summary of proceedings will be concluded with some final remarks:

- there were good presentations by the MRC Member Countries and Dialogue Partners, making clear their situation with respect to floods in 2008 and how they are improving their institutions and integrated flood risk management approaches;
- in addition there were several interesting papers from the region that were based on new developments and approaches. They have provided useful additional information;
- there was a number of interesting papers on flood risk mapping;
- the papers based on international experiences and developments showed that on a global scale there are also impressive developments on-going that are of relevance for the region and that also put the developments within the region in a global perspective;
- a lot of hard and good work has been done by the rapporteurs in preparing their reports on the plenary and parallel sessions at a very short notice;
- although we are all concerned about the possible impacts of climate change on sea level

rise, increase in river discharges and increase in extreme rainfall, there is such a pressure on the lowland, flood prone areas that the number of people living in these areas keeps to be increasing as well as the value of property. There are no indications that this tendency will change. Due to this it is expected that globally by 2050 80% of the World population will live in the flood prone areas, the majority of them in urban areas. It will be a major effort of the concerned governments to take, in close consultation with the stakeholders, care for the required measures in the field of flood management and flood protection. For the Mekong River Basin the Annual Mekong Flood Forums create undoubtedly a mechanism to promote and support such developments.

At the end of the Forum the participants adopted the Forum Statement. This Statement has been posted on the MRC web site and is included in the proceedings.

Prof. Bart Schultz, PhD, MSc
Forum facilitator
Phnom Penh, Cambodia
30 July 2009

7th Annual Mekong Flood Forum (AMFF-7)

FORUM STATEMENT

Preamble

About 120 participants - including those from the Mekong River Commission (MRC) Member Countries of Cambodia, Lao PDR, Thailand and Viet Nam and their National Mekong Committees and line agencies, Dialogue Partners: China and Myanmar, regional and international scientists and experts, and representatives of international and national civil society organizations - attended the 7th Annual Mekong Flood Forum, 13 and 14 May 2009, Bangkok, Thailand. The Forum was organised by the MRC Regional Flood Management and Mitigation Centre (MRC-RFMMC) in cooperation with the Thai National Mekong Committee. The theme was *'Integrated flood risk management in the Mekong River Basin'*. The participants were involved in two days of interesting presentations, discussions and exchanges of information on the theme and topics of the Forum. Based on this the following statements were produced and supported by the participants at the concluding session of the Forum.

I. The theme *'Integrated flood risk management in the Mekong River Basin'* is very relevant in the present day situation of the MRC Member Countries and Dialogue Partners. It is understood that only integrated and coordinated approaches can result in effective and sustainable flood risk management and mitigation.

II. Under the main theme there were presentations of the MRC Member Countries and the Dialogue Partners. The 2008 flooding in parts of Lao PDR and North Thailand, which was a natural event resulting from the tropical storm Kammuri, has brought about US$ 135 million of damage. It was also a test for the practical application of the new Mekong flood forecasting systems. In general the forecasts have been quite accurate - within 0.10 m for up to two day forecasts - however, especially the dissemination of the forecasts needs to be improved, in order to get the messages well understood at the right place in the right time. Flash floods have caused substantial damage in the region as well. In order to contribute to reduction of their impacts the implementation of the flash flood guidance system as it is now under development is urgently required. The MRC member countries are grateful to China for the provision of daily hydrological data during the flood season, which enhances MRCs capacity to provide more accurate flood forecasts.

III. In addition there were presentations on the five Components of the Flood Management and Mitigation Programme (FMMP) and on four Topics: (i) optimal packages for flood management; (ii) recent developments in flood forecasting and early warning; (ii) effective approaches towards trans-boundary flood management; (iv) successful flood risk management approaches. The papers give a good overview of the on-going activities in the Mekong River Basin and of achievements and plans with respect to integrated approaches to flood management.

IV. The participants expressed their strong wish to continue with their efforts to improve structural measures, flood proofing and the preparedness for floods by improved flood forecasting and early warning, as well as to increase their cooperation based on the overarching objective to reduce flood risk and flood damage in the Mekong River Basin.

V. Land use zoning related to flood risk management may be a very effective contribution to the reduction of flood risk and mitigation. The approach for the Mekong Delta in Viet Nam, where the focus will be on full protection of shallow areas, partly control of the main flooded area up to early August; no protection for the deep flooded areas and related land use development may serve as an interesting example.

VI. Due to population growth, urbanisation and industrial development, and the possible impacts of climate change, the risk and damage of flooding in the Mekong River Basin may rapidly increase. This makes especially the poor population more vulnerable for flooding. Based on the various objectives of the Forums, like presentation of the progress made by the MRC Member Countries and the MRC-RFMMC, the interactions with new developments in the region and at global scale and last but not least the networking function there was a common understanding that it would be important to continue with the Forum on an annual basis, if and when required with gradual modifications to the programme, based on new developments and needs. As theme is provisionally proposed:

Integrated approaches to flood risk management and mitigation in Mekong River Basin

VII. The present phase of the Flood Management and Mitigation Programme (FMMP) will be completed by the end of 2010. Recently there has been a Review Mission with representatives of the MRC member countries and the Mekong River Commission

Secretariat. Based on the report the Netherlands Embassy has expressed its satisfaction with the progress made so far. However, they would like to discuss the report, conclusions and recommendations during the next FMMP Steering Committee meeting. This in order to provide stronger focus and awareness on the most useful products. Thereafter a formulation process is envisaged of a follow-up phase in which the member countries will be thoroughly involved, as well as the MRCS/FMMP, the Netherlands Embassy and other development partners. This phase would have to be aimed at securing the sustainability of the core functions of the MRC-RFMMC by the end of the next Strategic Plan (2011-2015).

VIII. The participants like to thank the donors, the Netherlands, USA, Germany and the Asian Development Bank for their support of this 7th Annual Mekong Flood Forum, the MRC Regional Flood Management and Mitigation Centre for organising AMFF-7 and the Thai National Mekong Committee for hosting this important event. The participants support continuation of the Annual Mekong Flood Forums.

Bangkok, Thailand

Thursday 14 May 2009

ADB INTERVENTION

MR. IAN MAKIN

Senior Water Resources Management Specialist, Asian Development Bank (ADB), Manilla, Philippines

Excellencies, Ladies and Gentlemen,

Thank you for the invitation to give some comments and thoughts on Flood Management and Mitigation in the Mekong Basin in the closing session of the 7th Annual Flood Forum.

The breadth of topics covered in the papers and discussions of the past two days illustrates just how crucial floods are to the lives and livelihoods of the people in the basin. We heard about high tech measurement systems, modelling systems, different strategies to protect people from 'bad' floods and the need to 'live with the good floods'. A new theme that I heard for the first time in these forums is the explicit need to focus efforts to recognize the disproportionate impact of floods on the poor and disadvantaged.

As the MRC Flood Program nears the end of the first phase, the value of the efforts to establish regional cooperation to improve the flood forecasts and warnings has been recognized and the Regional Flood Management and Mitigation Centre (MRC-RFMMC) of the Mekong River Commission (MRC) is reaching the stage of maturity where the data and forecasts it produces are more highly valued by the MRC Member Countries.

At the Asian Development Bank (ADB) we are pleased to be one of the development partners supporting the work of the Flood Management and Mitigation Programme (FMMP), specifically contributing finance to the Component 2 Structural Measures and Flood Proofing. We are also working with MRC and the MRC Member Countries to design investments to assist in both structural and non-structural interventions to reduce the negative impacts of floods in the Greater Mekong Sub-region (GMS). We expect those investments to be implemented in 2011. A new cooperation between the International Centre for Water Hazard and Risk Management (ICHARM) and FMMP will improve the flood hazard mapping of the basin.

However, while we can see many signs of improving capacity for increasing accurate and timely flood forecasts, there remain a number of issues which are a cause for concern.

- the ever present concern about the availability of data that is accurate, well distributed and timely. Each country must continue to make investments to ensure the maintenance of the basic data networks and the associated processing and analysis systems. This is critical for sound decision making both in the short-term and long-term;
- with regard to the FMMP - it would seem that it is essential that the MRC reconsider the policies for staffing the program and the MRC-RFMMC - with a view to establishing the critical core of skilled professionals that will be required if reliable forecasts are to be produced over the long-term.

However I do believe a second phase of the FMMP should be considered as MRC develops its next strategic plan - the forecasts are improving; but tools and techniques are improving and MRC needs to continue to access these tools, modify them for the Mekong and then apply them.

In closing let us not forget that floods will be, forever, a fact of life in the Mekong River Basin. With climate change, increasing population and economic development, the potential for negative impacts from such events will continue to grow. The FMMP, the national disaster response organizations, and forums such as this will continue to grow in importance. My colleagues at ADB, the World Bank and other development partners will continue to seek opportunities to assist the work to minimize the negative and maximize the positive impacts on the region and its people.

CLOSING ADDRESS

MR. TE NAVUTH

Director of Technical Support Division of the Mekong River Commission Secretariat (MRCS), Vientiane, Lao PDR

Excellencies and Dialogue Partners;
Representatives of Development Partners and International Organisations;
Distinguished Delegates;
Ladies and Gentlemen

On behalf of the Mekong River Commission Secretariat (MRCS), I firstly have to apologise that our Chief Executive Officer of the MRCS, Mr. Jeremy Bird is unable to join us at the end of this Forum. He is engaged in a launching of navigation aids in Cambodia.

However, I am confident I speak for him when I say that we are all delighted that the 7th Annual Mekong Flood Forum has been such a success.

I would like to take this opportunity to once again thank our forum sponsors the governments of the Netherlands, Germany, the United States and the Asian Development Bank for their kind assistance.

I also thank all the delegates; presenters and speakers from our member countries of Cambodia, Lao PDR, Thailand and Vietnam and our Dialogue Partners, China and Myanmar and all those participants and delegate both from the region and from elsewhere who gave up their time to be with us for this forum.

Excellencies;
Ladies and Gentlemen

This 7th Annual Mekong Flood Forum has provided a window onto the work of the MRC Flood Management and Mitigation Programme (FMMP). We have had two days of interesting presentations and discussions on various subjects and main topics such as national and regional flood reports, optimal package for flood management, recent development in flood forecasting

and early warning and successful integrated flood risk management approaches including recommendations. These have given us opportunities to share appropriate technologies, tools and flood risk management experiences that will ultimately help build capacity and raise awareness of central, provincial and local peoples and authorities in mitigating negative impact caused by flooding, while enhancing people's abilities to capitalise and maximise the benefits of floods.

What we have learned at this forum will guide and shape us in our future work and enable us to further improve our work on integrated flood risk management in the Mekong River Basin. It is accepted that only integrated and coordinated approaches can result in effective and sustainable flood risk management and mitigation.

Finally this 7th Annual Mekong Flood Forum has provided the MRC and FMMP with opportunity to bring everyone up to speed on how its programme is progressing after four years of operation and what should be done in the remaining period of the 1st Phase of FMMP. I think we can feel assured that all is on target and that the programme will prove to be of immense assistance to those people of the basin who are living with floods. Moreover, the FMMP review mission jointly conducted recently by The Netherlands and Denmark has expressed satisfaction on the progress and preliminary recommended immediate actions for FMMP on areas to be more focused on from now until end of current phase and the preparation requirements for 2nd phase. The findings and review recommendations would be further brought up for discussion and consideration at next FMMP regional steering committee meeting and the coming Joint Committee meeting.

I would like to express my gratitude and sincere thanks to the Member States and Dialogue Partners for their cooperation. I also thank to the Netherlands, Germany, Denmark, Japan, the United States, The Asian Development Bank and the European Commission for their continuing support for the FMMP.

My thanks also go to staff of the MRC Regional Flood Management and Mitigation Centre (MRC-RFMMC) for their hardworking in preparing of this Forum and to the Department Water Resources and Thai National Mekong Committee for their valuable assistance and logistical support to allow this Forum held here successfully.

To conclude my closing address, I would like to declare the 7th Annual Mekong Flood Forum closed by wishing you all safe journeys back home and for those who have a chance to stay a little longer I hope you can take the opportunity to visit some of the wonderful sites in Bangkok.

Thank you

Poster

STREAMFLOW SIMULATION USING REMOTELY SENSED RAINFALL DATA: BRAHMAPUTRA RIVER

GULEID ARTAN[1], SHAHRIAR PERVEZ[2], MANDIRA SHRESTHA[3], SEZIN TOKAR[4], SAUD AMER[5], AND MICHAEL CRANE[5]

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[2]Stinger Ghaffarian Technologies (SGT), contractor to the U.S. Geological Survey (USGS) Earth Resources Observation and Science (EROS) Center.
[3]Integrated Water and Hazard Management, International Centre for Integrated Mountain Development (ICIMOD)
[4]U.S. Agency for International Development Office of Foreign Disaster Assistance (USAID/OFDA)
[5]U.S. Geological Survey

ABSTRACT

During the summer monsoon months of June - September, the Brahmaputra River experiences severe floods every year, causing death and destruction of property along its course through Bangladesh. A flood forecasting and monitoring system will help lessen losses associated with the floods. A major challenge to operational flood forecasting systems is the scarcity of hydrometeorological data and the lack data exchange across international borders. In this study, we show the utility of a flood forecasting system that is based on remotely sensed precipitation estimates. The model was calibrated using observed river discharges from 2002 to 2003 and validated using observed data from 2004 to 2005 at the same stream gage station. The validation results show that the use of satellite-derived precipitation estimates enables the identification of major flood events in terms of both their timing and magnitude. Overall, the simulated discharge explained 80% of the variability in the observed discharge. When an autoregressive error correction model was added, agreement between simulated and observed flows improved moderately. The Nash-Sutcliffe efficiency coefficient (NSCE) increased from 0.8 to 0.96, 0.90, and 0.84 for the first, second, and third days of forecast. We conclude that the use of satellite-driven precipitation estimates and the Geospatial Stream Flow Model (GeoSFM) can aid decision makers in the monitoring, forecasting, and early warning of floods in the Brahmaputra River Basin.

INTRODUCTION

Floods are natural and recurrent phenomena that inundate about 30% of Bangladesh each year; severe floods inundate about two-thirds of that area. Bangladesh lies at the delta of the Ganges-Brahmaputra-Magna (GBM) River system (Figure 1), and over 90% of the river flow originates outside the borders of Bangladesh. Even a small increase in water height above river bank-full level can cause extensive inundation due to the country's flat terrain. The difference in peak water levels between the 2-year and 20-year floods is about 2 meters and only 1 meter between the 20-year and 100-year floods for most locations along the GBM in Bangladesh. Despite hundreds of millions of dollars invested in flood control infrastructure, the loss of life and total amount of economic damage from floods has steadily increased during the last few decades. In recent years, the frequency and severity of the floods in Bangladesh has increased (Ahmad and

Ahmed, 2003). The country has experienced 18 catastrophic floods during the last 50 years. In order to reduce its vulnerability to severe and devastating floods, Bangladesh plans to advance flood preparedness and other mitigation measures.

During the monsoon season, the Dhaka-based Flood Forecasting and Warning Centre (FFWC) for Bangladesh issues flood warnings with a 3-hour lead time at locations near the border of India, and with 30-hour lead time for locations in the center of the country. FFWC forecasts are based mainly on in-country observations of river stage and rainfall data. There is limited real-time hydrometeorological data exchange with countries, which limits the lead time of forecasts. Flood forecast systems that rely solely on in-country observed river stage and rainfall data lack the ability to simulate the response of the entire GBM river system. Therefore, a basin-wide hydrologic model is needed to increase the lead time of the FFWC flood forecasts.

The U.S. Agency for International Development, Office of Foreign Disaster Assistance (USAID/OFDA) launched the Asia Flood Network (AFN) to reduce vulnerability to flooding in Asia in 2001. AFN aims to strengthen the capacity of regional and national hydrometeorological institutions in climate, weather, and hydrological forecasting, directly involving at-risk communities to reduce vulnerability while encouraging data and information exchange in trans-boundary river basins. USAID/OFDA implements AFN in collaboration with the National Oceanic and Atmospheric Administration (NOAA), U.S. Geological Survey (USGS), Hydrologic Research Centre (HRC), and regional partners in Asia. For South Asia, the AFN partner organization is the International Centre for Integrated Mountain Development (ICIMOD), with representatives from Afghanistan, Bangladesh, Bhutan, Burma, the People's Republic of China, India, Nepal, and Pakistan.

In this study, we present results of a streamflow forecasting system for the Brahmaputra River at the Bahadurabad stream gage station. This work, done as part of the AFN project activities, was a collaborative effort that involved USAID/OFDA, NOAA, USGS, and ICMOD. The flood forecasting system presented is based on the USGS Geospatial Stream Flow Model (GeoSFM), a large-area distributed hydrologic model that uses satellite-based rainfall estimates and precipitation forecasts.

BRAHMAPUTRA BASIN

The Brahmaputra River is one of the largest rivers in the world. It ranks fifth in terms of discharge (Thorne et al., 1993). The basin is shared by China (Tibet), Bhutan, India, and Bangladesh and drains an area of 520,000 km^2, of which only 8% is in Bangladesh (Figure 1). The middle section of the river drains some areas that have the highest measured rainfall amounts recorded anywhere in the world. Land cover in the basin is characterized primarily by grassland in the upper parts in Tibet, forest in the middle section, and irrigated land in the lower section.

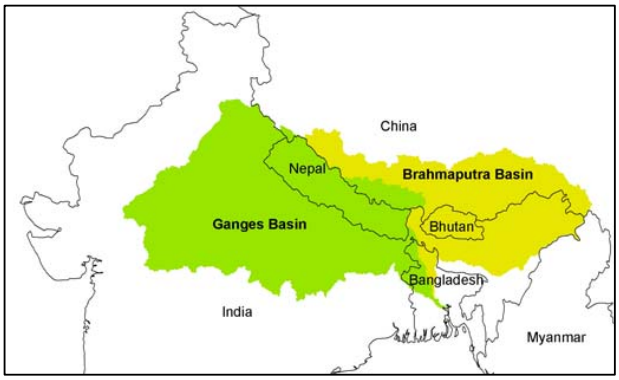

Figure 1. Areal extents of the Ganges (green) and Brahmaputra (yellow) Basins

MODEL AND DATA

For this study, we used the GeoSFM (Artan et al., 2007a), a physically based distributed hydrologic model that uses sub-basins as its basic unit for modelling (Asante et al., 2007a). GeoSFM simulates the dynamics of runoff processes by using satellite remotely sensed imagery with other widely available global datasets. The model is parsimonious - parameter and variable input data requirements are few. Most of the model parameters have physical meaning determined from digital databases. Parameterization is accomplished through the use of three datasets to characterize the Earth's surface: topography, land cover, and soils.

Topographic data provide the spatial framework of the modelling system, and for this project we used the USGS HydroSHEDS dataset. The HydroSHEDS digital elevation model (DEM) has a resolution of 3 arc-seconds and is derived from the digital elevation data of the Shuttle Radar Topography Mission (SRTM). For land cover, we used the USGS land cover/land use LC/U datasets. The USGS LC/U was made from a 12-month series of 1-km global vegetation index imagery for the classification of land cover types (Loveland and Belward, 1997). Soil data (soil water holding capacity, saturated soil hydraulic conductivity, hydrologically active soil layer depth, and soil texture) were extracted from the Digital Soil Map of the World (Food and Agriculture Organisation (FAO), 1997).

The model was forced with fields of precipitation and evapotranspiration (ET) data. Both precipitation and ET were acquired from remotely sensed or weather forecast model output. For precipitation data, we used the NOAA Climate Prediction Centre (CPC) satellite-based rainfall estimates (RFE) product (Xie and Arkin, 1997). The RFE is made by combining remotely sensed rainfall estimates from three satellite sources with WMO GTS station data. The GTS data are used to remove bias from the satellite-based component of the rainfall estimates. NOAA/CPC RFE products have been used successfully in the past for flood forecasting (Artan et al., 2007b; Asante et al., 2007b). The RFE has 0.1-degree resolution. For precipitation forecasts, we used data from the NOAA Global Forecast System (GFS) weather forecast model output. GFS data have a spatial resolution of 35 km and a temporal resolution of 3 hours.

The ET represents atmospheric demand for water from the Earth's surface and is a function of solar radiation, air temperature, wind, humidity, and atmospheric pressure. The ET used here is a global product produced daily by the USGS and calculated according to the Penman-Monteith equation (Verdin and Klaver, 2002). The ET model uses USGS-developed GIS routines that ingest grids of input variables produced by NOAA's Global Data Assimilation System (GDAS) on a 1-degree grid. The ET fields are downscaled to a 0.1-degree resolution. In the forecast mode, we limited ourselves to forecasts of 24 hours, 48 hours, and 72 hours.

RESULTS

A GeoSFM modelling window was created for an area of the Brahamaputra River Basin above the Bahadurabad gaging station. The model was forced using RFE rainfall data and calibrated with observed data collected at Bahadurabad station. Observed streamflow data from 02/2002 to 02/2005 were available and the first 2 years were used to calibrate the model, whereas data for the last year were used to validate the simulated flows. Figures 2a and 2b show the hydrograph and scatterplots for the observed and simulated flows. A good calibration was achieved in terms of both timing and magnitude of the peak flows. In addition, a NSCE of 0.8 was attained for the calibration and validation based on the 3-year period of record. The scatterplot of observed and simulated flows, while not lying on 1:1 line, showed a remarkable agreement with no noticeable outliers. A slight underestimation with a bias of ~ –5% of the total flow was observed.

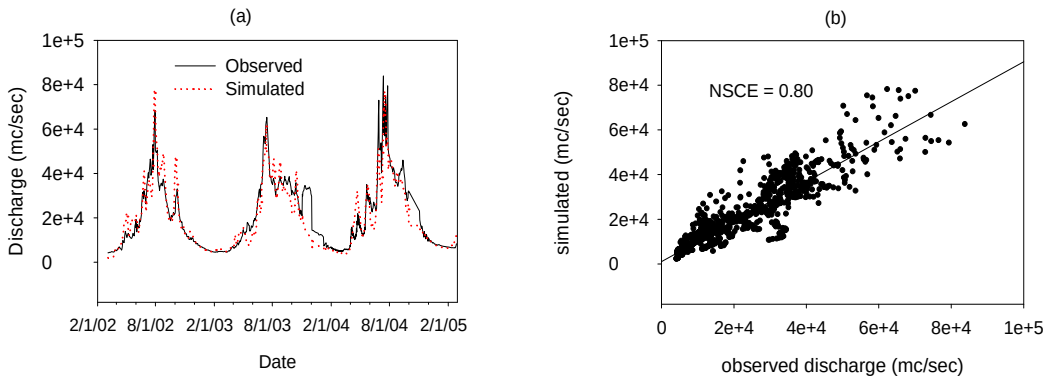

Figure 2. Comparison of simulated and observed flows at Bahadurabad gaging station for the entire period of record using (a) a hydrograph and (b) a scatterplot.

Although the agreement between simulated and observed hydrographs was deemed to be good, to improve the forecast further, an autoregressive error correction model was used. Despite their simplicity, Refsgaard (1997) has shown that autoregressive error models are effective in eliminating systematic errors in the hydrologic model output. Given that the FFWC receives the Bahadurabad gage station data in near-real time, an autoregressive error correction model could be implemented if the system we are proposing here is used for forecasting the flows of the Brahmaputra River. We tested the effectiveness of the error correction model for three forecast time horizons. Figure 3 depicts the forecast horizons. During forecast periods, the GFS rainfall fields were used instead of the RFE as input to the GeoSFM.

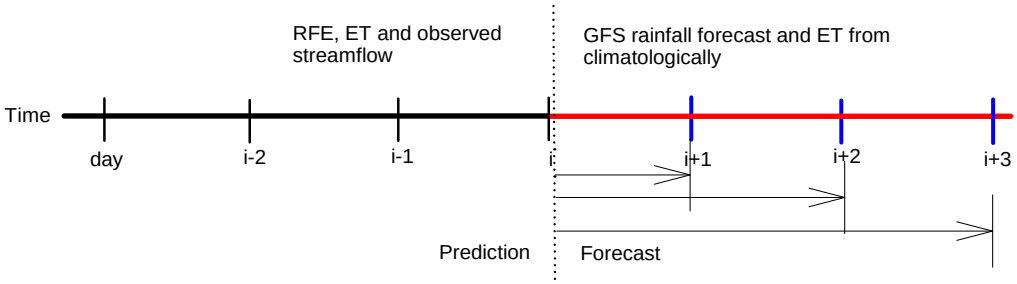

Figure 3. Schematic of the three forecast time horizons where model predictive skills were tested

The error correction model was effective in reducing errors in the forecasted flows. Goodness-of-fit, measured with NSCE, increased from 0.8 to 0.96 for the 1-day forecast, over 0.90 for the 2-day forecast, and over 0.84 for the 3-day forecast (Figures 4a-f). Results demonstrated that the use of satellite-derived precipitation allows forecasting of major flood events in terms of both their timing and magnitude. Figure 5 shows forecasted and observed cumulative flows for the entire simulation period. The error correction model reduces considerably the flow underestimation that was observed in simulated flows; the underestimation went from as high as 5% to less than 1% of the total observed flow.

We conclude that GeoSFM (or a similar model) driven with satellite-based precipitation and precipitation forecast can help decision makers improve monitoring, forecasting, and early warning of floods in the Brahmaputra River Basin or in analogous large trans-boundary basins where there are limited hydrometeorological observation networks and data exchange in real time.

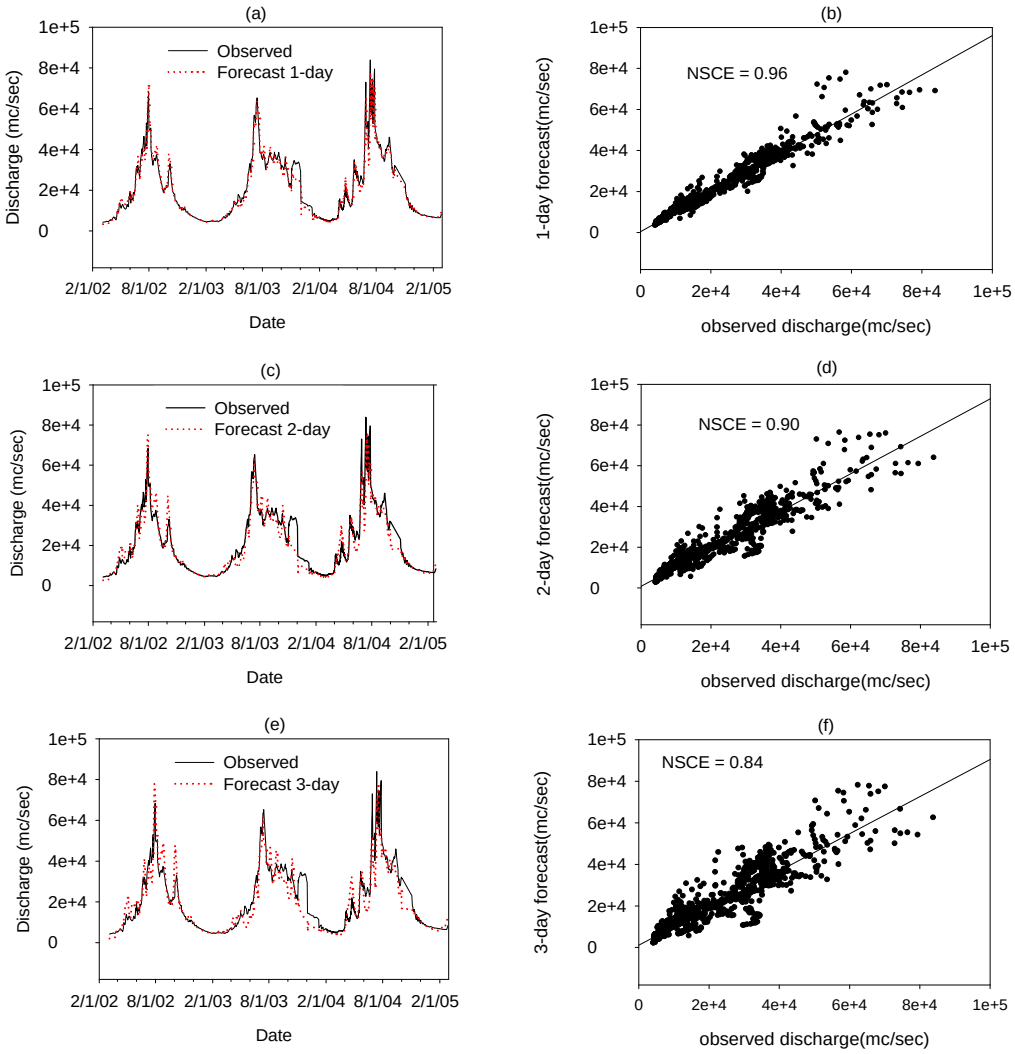

Figure 4. Comparison of simulated and observed streamflow for the Brahmaputra River at Bahadurabad gaging station. Simulated flows were done in a forecast mode.

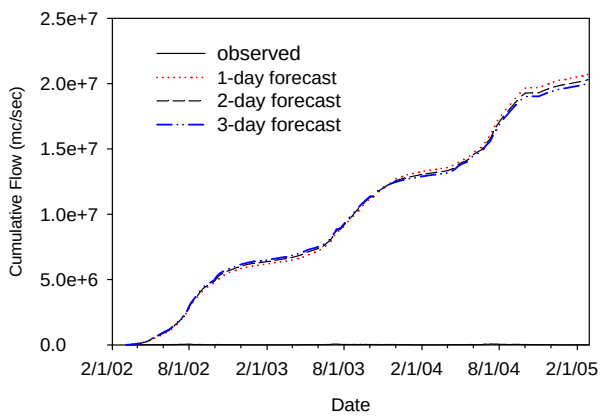

Figure 5. Comparisons of cumulative forecasted and observed streamflow at Bahadurabad.

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ANNEXES

ANNEX I. Abbreviations and acronyms

ACF/AAG	Action Contra La Faim/Action Against Hunger
ADB	Asian Development Bank
ADP	Area Development Plan
ADPC	Asian Disaster Preparedness Centre
AFD	Armed Forces Division
AFF	Annual Flood Forum
AFN	Asia Flood Network, USAID/OFDA flood mitigation initiative in Asia
AHNIP	Appropriate Hydrological Network Improvement Project
AIDRECEP	Committee for Coordination and Reception of Foreign Aid
AIS	Advanced Information Service, Thailand
AIT	Asia Institute of Technology
AMFF	Annual Mekong Flood Forum
AMFF-1	1st Annual Mekong Flood Forum, Flood Preparedness
AMFF-2	2nd Annual Mekong Flood Forum, Information Flow, Networking and Partnership, 28 - 29 October 2003, Phnom Penh, Cambodia
AMFF-3	3rd Annual Mekong Flood Forum, Flood Management and Mitigation in the Mekong Basin, 7 - 8 April 2005, Vientiane, Lao PDR
AMFF-4	4th Annual Mekong Flood Forum, Improving Flood Forecasting and Warning Systems for Flood Management and Mitigation in the Lower Mekong Basin, 18-19 May 2006, Siem Reap, Cambodia
AMFF-5	5th Annual Mekong Flood Forum, Improving Inputs Towards Medium-term Flood Forecasting and Warning in the Mekong Basin, 17 - 18 May 2007, Ho Chi Minh City, Viet Nam
AMFF-6	6th Annual Mekong Flood Forum, Integrated approaches and applicable models towards flood forecasting and early warning in the Mekong River Basin
AMSU	Advanced Microwave Sounding Unit
APFM	Associated Programme on Flood Management
API	antecedent precipitation index
ARIMA	autoregressive integrated moving average
ARMA	autoregressive moving average
ARTS	ASRC Research and Technology Solutions
ARW	Advanced Weather Research Forecasting
AUSAID	Australian Agency for International Development
AWS	Automatic Weather Station
BCM	billion cubic metres
BDP	Basin Development Plan
BMD	Bangladesh Meteorological Department
BMZ	German Federal Ministry for Economic Cooperation and Development
BOH	Bureau of Hydrology
BPG	best practices guidelines
BT	Bottom track
BWDB	Bangladesh Water Development Board
CAFFG	Central America Flash Flood Guidance
CBDRM	Community-Based Disaster Risk Management
CBDRR	Community Based Disaster Risk Reduction
CBFRM	Community Based Flood (or general disaster) Risk Management
CBO	Community Based Organization
CBP	Capacity Building Programme
CBPD	Community-based Disaster Preparedness Program
CCDM	Commune Committee on Disaster Management
CCFSC	Central Committee for Flood and Storm Control
CCNR	Central Commission for Navigation on the Rhine
CCTV	closed circuit television
CDMP	Community Disaster Mitigation Project

CDP	Cambodian Defenders Project
CDP	Commune Development Plan
CEGIS	Centre for Environmental and Geographic Information System
CEO	Chief Executive Officer
CFAB	Climate Forecast Application in Bangladesh
CFAN	Climate Forecast Application Network
CFIS	Community Based Flood Information System
CG	cloud-to-ground
CHR	Commission for the Hydrology of the Rhine
CIFOR	Centre for International Forestry Research
CIP	Commune Investment Plan
CLUP	Commune Land Use Planning
CNMC	Cambodia National Mekong Committee
CONOPS	Concept of Operation
CRC	Cambodian Red Cross
CRED	Centre for Research on the Epidemiology of Disasters
CRHMC	Central Region Hydrometeorological Centre
CSA	Canadian Space Agency
CSO	Civil Society Organisation
CSPT	Committee on Sport and Physical Training
CTA	Chief Technical Advisor
CWRC	Yangtze (Changjiang) Water Resources Commission
CWS	Church World Service
DACA	Damage and Casualties Assessment
DAE	Department of Agriculture Extension
DANA	Damage and Needs Assessment
DANIDA	Danish International Development Agency
DCDM	District Committee for Disaster Management
DDMFCSP	Department of Dike Management, Flood Control, and Storm Preparedness
DEM	Digital Elevation Map
DEM	Digital Elevation Model
DFID	Department for International Development
DGPS	Differential Global Positioning Satellites
DHRW	Department of Hydrology and River Works
DIPECHO	Disaster Preparedness European Commission Humanitarian Aid Office
DLL	Dynamic Link Library
DM	Disaster Management
DMB	Disaster Management Bureau
DMH	Department of Meteorology and Hydrology
DMO	Disaster Management Organisation
DMP	Disaster Management Plan
DMR	Department of Mineral Resources
DOE	Department of Environment
DOLA	Department of Local Administration
DOM	Department of Meteorology
DONRE	Department of Natural Resources and Environment
DOR	Department of Roads
DORW	Department of River Works
DRFDA	Day River Flood Diversion Area
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
DSF	Decision Support Framework
DTM	Digital Terrain Model
DUFLOW	Simplified 1D hydraulic flow model
DWIR	Directorate of Water Resources and Improvement of River Systems
DWR	Department of Water Resources

EAP	Emergency Action Plan
ECHO	European Commission Humanitarian Aid Department
ECMWF	European Centre for Medium-range Weather Forecasts
EFS	Empirical Forecasting Schemes
EGAT	Electricity Generating Authority of Thailand
EIA	Environmental Impact Assessment
ENSO	El Nĩno – Southern Oscillation
EP	Environment Programme
EROS	Earth Resources Observation and Science
EW	Early Warning
EWFD	European Water Framework Directive
EWS	Early Warning System
FAO	Food and Agriculture Organisation of the United Nations
FSC	Flood and Storm Control
FEMS	Flood Emergency Management Strengthening
FEWS	Flood Early Warning System
FEWS NET	Famine Early Warning Systems Network
FF	Flood Forecasting
FFG	Flash Flood Guidance
FFGS	Flash Flood Guidance System
FFS	Flood Forecasting System
FFT	Flash Flood Threat
FFWC	Flood Forecasting and Warning Centre
FIBLM	Flood Information Based Land Management
FMM	Flood Management and Mitigation
FMMP	Flood Management and Mitigation Programme
FMMP-C1	Flood Management and Mitigation Programme, Component 1: Short and medium-term flood forecasting at the MRC Regional Flood Management and Mitigation Centre
FMMP-C2	Flood Management and Mitigation Programme, Component 2: aims at the development of guidelines for the preparation of flood risk management plans and for the evaluation of the impacts of flood risk management measures
FMMP-C3	Flood Management and Mitigation Programme, Component 3: to identify potential transboundary issues for negotiation, mediation and conflict prevention; and develop mediation and conflict management capacity
FMMP-C4	Flood Management and Mitigation Programme, Component 4: Flood emergency management strengthening, based on a people-centred approach in integrated flood risk management
FMMP-C5	Flood Management and Mitigation Programme, Component 5. Flood information based land management
FMMSIP	Flood Management and Mitigation Strategy Implementation Plan
FPP	Flood Preparedness Plan
FPP	Flood Preparedness Program
FRMP	Flood Risk Management Plan
FRA	Flood Risk Assessment
FRI	Flood Risk Index
FSC	flood and storm control
FTP	File Transfer Protocol
FVI	Flood Vulnerability Index
GATECH	Georgia Institute of Technology
GBM	Ganges, Brahmaputra and Meghna
GCM	General Circulation Model
GCOS	Global Climate Observing System
GDAS	Global Data Assimilation System
GDP	Gross Domestic Product
GeoSFM	USGS Geospatial Streamflow Model
GFS	Global Forecast System

GIS	Geographic Information System
GISTDA	Geo-informatics and Space Technology Development Agency
GMS	Greater Mekong Sub-region
GMS	geostationary meteorological satellite
GMT	Greenwich Mean Time
GNP	Gross National Product
GNSS	Global Navigation Satellite System
GOB	Government of Bangladesh
GOS	Global Observing System
GOV	Government of Viet Nam
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile communications
GSMaP	Global Satellite Mapping of Precipitation
GT	ground truth
GTS	Global telecommunication system
GWP	Global Water Partnership
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
HANET	Humanitarian Accountability Network
HEA	Humanitarian & Emergency Affairs
HEC	Hydrologic Engineering Centre
HEC-RAS	Hydrologic Engineering Centres River Analysis System
HECgeoRAS	Hydrologic Engineering Center's Geo River Analysis System
HFA	Hyogo Framework of Action
HIS-SSM	'Hoogwater Informatie Systeem - Schade- en Slachtoffermodule'. Damage and Casualties tool in the Netherlands
HMDC	Hydrometeorological Data Centre
HOWISS	Hochwasser-Informations und Schutz-System (German)
HPC	High performance computing
HRC	Hydrologic Research Centre
HRM	High Resolution Model
HVCA	Hazard, Vulnerability and Capacity Assessment
HYCOS	Hydrological Cycle Observing System
HYMOS	Hydrological Modelling System
ICHARM	International Centre for Water Hazard and Risk Management
ICBP	Integrated Capacity Building Programme
ICID	International Commission on Irrigation and Drainage
ICIMOD	International Centre for Integrated Mountain Development
ICPR	International Commission for preventing Pollution of the Rhine later renamed in International Commission for the Protection of the Rhine
ICPDR	International Commission for the Protection of the Danube River
IDP	internally displaced people
IDS	International Development Statistics
IEE	Initial Environmental Examination
IFAS	Integrated Flood Analysis System
IFM	Integrated Flood Management
IFRC	International Federation of Red Cross
IFRM	Integrated Flood Risk Management
IID	Imperial Irrigation District
IKMP	Information and Knowledge Management Programme
IMDMCC	Inter-Ministerial Disaster Management Co-ordination Committee
INGO	International Non-Governmental Organization
IO	International Organisation
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter-Tropical Convergence Zone
ITC	International Institute for Geo-Information Science and Earth Observation

IWG	Institute of Water Resources and River Basin Management
IWM	Institute of Water Modelling
IWRE	Institute of Water Resources and Environment
JAXA	Japan Aerospace Exploration Agency
JC	Joint Committee
JICA	Japanese International Cooperation Agency
JMA	Japan Meteorological Agency
JTWC	Joint Typhoon Warning Centre
LA	Line Agency
LA-MA95	Legal Aspects of the Mandate of the 1995 Mekong Agreement for Enhancing Cooperation in Addressing Trans-boundary Floods and Related Issues
LIDAR	Light Detection and Ranging
LIS	Lightning Imaging Sensor
LLDN	Vaisala's Long Range Lightning Detection Network
LM	Land Management
LMB	Lower Mekong River Basin
LMB-FMS	Lower Mekong Basin Flood Mapping Service
LNMC	Lao PDR National Mekong Committee
LNMCS	Lao National Mekong Committee Secretariat
LRIAD	Land Resources Inventory for Agricultural Development
LUP	Land Use Planning
LWF	Lutheran World Federation
LXQ	Long Xuyen Quadrangle
M&E	Monitoring and Evaluation
MAF	Ministry of Agriculture and Forestry
MAFF	Ministry of Agriculture Forestry and Fisheries
MARD	Ministry of Agriculture and Rural Development
MCM	million cubic metres
MDG	Millennium Development Goal
MDV	Mekong Delta in Vietnam
MHI	Mean Hazard Index
M-HYCOS	Mekong Hydrological Cycle Observing System
MLMUPC	Ministry of Land Management Urban Planning and Construction
MM5	Fifth Generation Mesoscale Model
MOF	Ministry of Finance
MOFA	Ministry of Foreign Affairs
MOH	Ministry of Health
MOI	Ministry of Interior
MONRE	Ministry of Natural Resources and Environment
MOP	Ministry of Planning
MOU	Memoranda of Understanding
MOWRAM	Ministry of Water Resources and Meteorology
MPI	Ministry of Planning and Investment
MRB	Mekong River Basin
MRBV	Mekong River Basin of Vietnam
MRC	Mekong River Commission
MRC-IS	MRC Information System Portal
MRC-RFMMC	Mekong River Commission - Regional Flood Management and Mitigation Centre
MRCS	Mekong River Commission Secretariat
MRD	Mekong River Delta
MRD	Ministry of Rural Development
MR-FFS	Mekong River Flood Forecasting System
MSL	Mean Sea Level
MTD	Multilingual Technical Dictionary of the International Commission on Irrigation and Drainage (ICID).

MTPWWM	Ministry of Transport, Public Works and Water Management
MWR	Ministry of Water Resources
NAM	Nedbør-Afstrømnings-Mode
NASA	National Aeronautics and Space Administration
NCDM	National Committee for Disaster Management
NCEP	National Centre for Environmental Protection
NCHMF	National Centre for Hydrometeorological Forecasting
NCSAR	National Committee for Search and Rescue
NDMC	National Disaster Management Committee
NDMO	National Disaster Management Office
NDMP	National Disaster Management Plan
NDVI	normalized difference vegetation index
NESDIS	National Environmental Satellite, Data, and Information Service
NFFS	National Flood Forecasting System
NFU	National Flood Unit
NGO	Non Government Organisation
NHMFC	National Hydro-Meteorological Forecasting Centre
NLDN	Vaisala National Lightning Detection Network
NMC	National Mekong Committee
NMHS	National Meteorological and Hydrologic Service
NOAA	National Oceanic and Atmospheric Administration
NREM	Natural Resources and Environmental Management
NSCE	Nash-Sutcliffe Efficiency Coefficient
NWP	Numerical Weather Prediction
NWRD	National Water Resources Database
NWS	National Weather Service
ODA	Overseas Development Assistance
OECD	Organisation for Economic Co-operation and Development
OEI	Overview Effects Infrastructure
O&M	Operation and Maintenance
OFDA	Office of U.S. Foreign Disaster Assistance
OIC	Office of Information and Culture
OOG	Office of the Government
PAFO	Provincial Agriculture and Forestry Office
PCDM	Provincial Committee for Disaster Management
PCFSC	Provincial Committee for Flood and Storm Control
PCM	Power and Communications Module
PDIES	Procedures for Data and Information Exchange and Sharing
PDR-SEA	Partnerships for Disaster Reduction – Southeast Asia
PDWRAM	Provincial Department of Water Resources and Meteorology
PFSC	Provincial Flood and Storm Control
PHMFC	Provincial Hydrometeorological Forecasting Centre
PLUP	Participatory Land Use Planning
PHMO	Provincial Hydro Meteorological Office
PMHO	Provincial Meteorology and Hydrology Office
POD	Probability of prediction
POE	Probability of Exceedance
POR	Plain of Reeds
ProDIP	Project Development and Implementation Plan
PSDD	Programme to Support Democratic Development through Decentralization and Deconcentration
PUB	prediction in ungauged basin
PWRI	Public Works Research Institute
QPE	Quantitative Precipitation Estimates

RANET	Radio and Internet
RAP	Rhine Action Plan
RBO	River Basin Organisation
RCM	Regional Circulation Model
RCV	Red Cross Volunteers
RFE	merged satellite- and ground-based rainfall estimation
RID	Royal Irrigation Department
RMI	Regional Mean Index
RMSE	root mean square error
RORB	runoff and streamflow routing program
RRD	Red River Delta
RTH	regional telecommunication hub
RTK	Real Time Kinematic
RTS	Regional training specialists
SA	sub-area
SAP	Strategic Action Program
SCaMPR	Self-Calibrating Multivariate Precipitation Retrieval
SCLS	synthesised constrained linear system
SCS	South China Sea
SEA	Strategic Environmental Assessment
SFSP	School Flood Safety Program
SGT	Stinger Ghaffarian Technologies
SILIC	CONCERN Supportive Initiatives Livelihood Improvement Programme
SIWRP	Sub-Institute for Water Resources Planning
SMAR	Soil Moisture Accounting and Routing
SNAP	Strategic National Action Plan
SPI	Standardized Precipitation Index
SPWG	Scientific Partnership Working Group
SRE	Satellite Rainfall Estimate
SRHMC	Southern Region Hydrometeorological Centre, Viet Nam
SRTM	Shuttle Radar Topography Mission
SSARR	Streamflow Simulation and Reservoir Regulation
SSM/I	Special Sensor Microwave/Imager
STS	Severe Tropical Storm
SWOT	Strengths, Weaknesses, Opportunities, and Threats
SWOT	Surface Water Ocean Topography
TA	Technical Assistance
TBFI	Trans-Boundary Flood Issues
TBFII	Trans-Boundary Flood Issues Identification
TBI	Trans-Boundary Issues
TBIDD	Trans-Boundary Flood Issues, Differences and Disputes
TD	Tropical Depression
TDA	Trans-boundary Diagnostic Analysis
TIN	Triangulated Irregular Network
TMD	Thai Meteorological Department
TMPA	Tropical Rainfall Measuring Mission (TRMM) Multi-satellite Precipitation Analysis
TOR	Terms of Reference
TOT	Training of trainers
TRMM	Tropical Rainfall Measuring Mission
TS	Tropical Storm
TSD	Technical Support Division
TSU	Technical Support Unit
UDMC	Union Disaster Management Committee
UMB	Upper Mekong River Basin

UNDMT	United Nations Disaster Management Team
UNDP	United Nations Development Programme
UN ISDR	United Nations International Strategy for Disaster Reduction
URBS	actually not an acronym, but sometimes rendered as 'Unified Run-off Basin Simulation'
USAID	U.S. Agency for International Development
USGS	U.S. Geological Survey
UTC	Universal Time Coordinate
VB	Vertical Beam
VDRP	Village Disaster Reduction Plans
VIC	Village Implementation Vommittee
VLF	Very Low Frequency
VNMC	Vietnam National Mekong Committee
VNRC	Vietnam Red Cross
WAD	Waterways Administration Division
WAN	wide area network
WCRR	World Conference on Risk Reduction
WFP	World Food Programme
WHH	Women headed household
WHM	Watershed hydrological models
WHO	World Health Organization
WHYCOS	World Hydrological Cycle Observing System
WIGOS	WMOs Integrated Global Observing System
WIS	WMO Information System
WMO	World Meteorological Organization
WREA	Water Resources and Environment Administration
WRF	Weather Research Forecast
WUP	Water Utilization Programme
1D	One Dimensional
2D	Two Dimensional

ANNEX II. Glossary

Anabranch	A channel that depart from the main channel, and sometimes running parallel to it for several kilometres before rejoining it.
Annual-flood peak series	The tabulation or graph in order of decreasing magnitude of the maximum peak floods of each year.
Average annual flood	The mean of the annual floods over a number of years. The smallest of the annual floods during the period of record is called the 'minimum annual flood'.
Catastrophic flood	A flood due to meteorological conditions of exceptional rarity, and due either to catastrophical rainfall spread over a period considerably longer than the time of concentration for the area, or to violent rain of the cloud burst type.
Controlled flooding	Unlike in free flooding, water is diverted to levelled lands and in a sequential manner in such a way as to deliver everywhere the desired dose: it includes flooding from ditches, border irrigation and corrugation irrigation.
Cyclone	Atmospheric system of low barometric pressure (depression) accompanied by strong winds that rotate counter-clockwise in the northern hemisphere and clockwise in the southern hemisphere. Called 'cyclone' in the Indian ocean and southern Pacific, it is called 'hurricane' in the western Atlantic and eastern Pacific and 'typhoon' in the western Pacific.
Depression	an area of lowered air pressure that generally brings moist weather, sometimes promoting hurricanes and tornadoes
Design flood	1 - The maximum flood that any structure can safely pass. 2 - The flood adopted to control the design of a structure. 3 - The flood against which a given area is to be protected.
Design flood hydrograph	The hydrograph of flow adopted to represent limiting volumes and concentration of runoff for use in determining design capacities of spillways for dams, etc., or other hydraulic studies.
Early warning	Information at the shortest notice that a flood may come, including on the expected magnitude of the flood
Extreme flood	The highest flood observed during a given period.
Flash flood	A flood of short duration and abrupt rise with a relatively high peak rate of flow, usually resulting from a high intensity of rainfall over a small area.
Flash flood guidance	Amount of rainfall for a given duration over a small basin needed to create minor flooding (bankfull) conditions at the outlet of the basin.
Flash flood threat	Rainfall of a given duration in excess of the corresponding flash flood guidance value. The *flash flood threat* then becomes an indication of areas where flooding is imminent or occurring and where immediate action is or will be shortly needed.
Flood	Natural abundance of water in response to storm rainfall, snowmelt, etc., ergo the flood season on the Mekong.....however, this does not necessarily lead to flooding.
Flood absorption	Reduction in flood discharge resulting from accommodation of flowing water in a reservoir, channel, valley or lake.
Flood damage	The destruction or impairment, partial or complete, of the value of goods or services, or of health, resulting from the action of flood waters and the silt and debris they carry. They are commonly divided into tangible - where monetary values can be assigned - and intangible - where direct monetary values cannot be assigned. Intangible damages include ecosystem loss and ill health, and attempts are being made to quantify in some way intangible damages. Flood losses can be direct - caused by the flood itself- or indirect, and caused by events triggered by the flood. Lost industrial production is an indirect loss. Flood losses are determined by flood depth, velocity, duration, timing (by season or time a day, for example), and sediment load.

Flood disaster	Disaster caused by an extreme flood, especially after the failure of dikes or dams.
Flood estimation	Approximate calculation or assessment of the probable height, frequency or magnitude of a flood.
Flood frequency	Over a period of years, the average number of times a flood of a given magnitude is likely to occur.
Flooding	The inundation of areas, which usually are not submerged.
Flood management	The organisation of responses to flood problems.
Flood control benefits	The value of the flood protection as estimated in terms of damage eliminated or other advantageous effects of the proposed works. 2 - The return from investment in flood alleviation schemes, either tangible or intangible. 3 - 'Direct benefits' based on reduction in flood damage to land and other property in terms of cost of restoration to preflood condition or reduction in its value and reduced damages to crops in terms of market value adjusted by replanting possibilities and production costs not incurred; and 'indirect benefits' based on higher grade use of land formerly flooded in terms of increased earnings, and reduced interruption of business, industry and commerce, traffic, communications and other activities both within and outside the area subject to flooding in terms of net loss of income or added operating costs and cost of evacuation, reoccupation, temporary quarters, emergency flood protection work, and relief and care of flood victims.
Flooded area	*Area covered by water when streamflow exceeds the carrying capacity of a channel or as a consequence of damming a river downstream. 2 - Area flooded due to (i) storm surges and/or subsequent dike breaches, (ii) impeded drainage of rain water.*
Flood forecasting	Prediction of the characteristics of an imminent future flood (timing, depth, discharge, etc.) given current information. The prediction of flood events on the basis of analysis of essential meteorologic data, such as storm trends, antecedent precipitation, air moisture, temperature trends, wind etc. Analysis of such information in relation to known stream response behaviour and basin characteristics can provide the basis for issue of flood warnings. The rapidity of data accumulation and analysis, and of dissemination of resulting warnings, is vital to the effectiveness of flood forecasting. 2 - The science of forecasting the stage, discharge, time of occurrence, and duration of a flood, especially of peak discharge at a specified point on a stream, resulting from precipitation and/or snowmelt and based on the existing meteorological and hydrologic conditions. The goal of flood forecasting is to obtain real-time precipitation and stream flow data through a microwave, radio, or satellite communications network, insert the data into rainfall-runoff and stream flow routing programs, and forecast flood flow rates and water levels for periods of from a few hours to a few days ahead, depending on the size of the watershed.
Flood irrigation	A method of irrigation in which water is swiftly taken towards one or more storage basins where it collects before infiltrating into the soil. In the case of more permeable and less deep soils, several waterings are required during the cultivation season. 2 - Colloquially, surface irrigation, especially those methods where the soil surface is indundated.
Floodplain	The portion of the landscape inundated by a flood. The extent of the floodplain is often defined by a particular frequency flood : the 100-year floodplain is the area inundated by a flood with an average return period between events of 100 years, or an annual probability of occurrence of 0.01 (illustrated). 2 - The flood prone areas adjacent to a river channel over which flood waters habitually and temporarily spill when river flows exceed the bank-full capacity of the river channel. In flatter areas, the floodplain serves as a substantial reservoir, storing excess run-off and attenuating the flood peak. Additionally, floodplains can also provide substantial discharge capacity, depending on ground slopes and shapes, and upon the depth of inundation. The formal designation of the floodplain can be a difficult task,

	involving the definition of appropriate flood volumes, levels, and return period. Generally a 100-year return period flood level is accepted as defining the limit of a floodplain.
Flood prone area	Area that may be subject to flooding, either periodically, or when flood protection measures fail.
Flood preparedness	Timely taking of measures to eliminate, reduce, or mitigate the possible damaging effects of floods.
Flood protection	The protection from flood damage afforded by a given programme of flood control.
Flood risk	A measure of the seriousness of the flood hazard : 1 - The chance of experiencing a flood. Risk is usually expressed in terms of the return period of peak discharges, but velocities, sediment loads and depths are sometimes also used in identifying risk zones. An assessment of risk may also be based on the life and property exposed. 2 - The probability of an event multiplied by its consequences (such as event damages). This is equal to the expected value of damage, and is a concept used in risk analysis.
Flood risk map	1 - A map that depicts the extent of former floods or the anticipated extent of any particular magnitude of flood. 2 - The identification and representation of flood risk areas on a map. 3 - Topographic maps of river floodplain areas that identify the estimated water levels associated with a series of floods typically of 10, 20, 50 and 100-year return period.
Flood stage	The elevation of the water surface fixed by local usage above which the stream is considered to be in flood.
Flood storage	The part of the active storage used exclusively for flood control. 'Flood storage' should not be confused with 'flood surcharge'.
Flood vulnerability	the susceptibility of a person or group to the adverse impacts of flooding.
Flood wave	A rise in stream flow to a crest consequent of runoff, generated by precipitation, and its subsequent recession constitutes a flood wave.A flood wave may also be regarded as a temporary unbalance in river regime resulting from the application of more water to the land in the form of precipitation or by the melting of snow that can be absorbed by the land itself. The regime during the resulting unsteady flow is determined, largely , by complex local transfers of energy and of volume.
Maximum computed flood	The largest momentary discharge believed possible from a consideration of meteorological condition and snow cover on the watershed. It pre-supposes simultaneous occurrence of all possible natural contingencies favourable to high floods.
Maximum flood	The highest of the recorded floods, at a section of a stream, during a specified period; the period may be a week, a month, a year or even the entire period of record.
Maximum probable flood	Flood which would be produced by the maximum probable precipitation and which is computed using a rainfall-runoff relationship (like unit hydrograph).
Minimum annual flood	The smallest of the annual floods during the period of record.
Monthly flood	The maximum flow occurring in a stream during a calendar month.
Nonstructural measures	The measures that alter the exposure of life and property to flooding (floodplain land use planning, flood forecasting and warning, flood-proofing, assistance).
N-Year flood	A flood which has a probability of being equalled or exceeded once every N-years or has one chance in N of occurring in any one year.
Resilience	The ability of a community and its infrastructure to recover from the adverse impacts of natural disasters; it is a measure of both the time and extent of the recovery.
River flood	A relatively high flow or stage in a river, markedly higher than the usual. A mass of water, rising, swelling and overflowing land.

Spillway design flood	1 - The flood that has been decided to be carried past the dam, without failure of that structure during a stipulated time period after a thorough study of the hydrology of the drainage area. 2 - The flood used in the design of a dam for sizing the spillway and for determining the flood storage or the flood subcharge during a determined time period.
Structural measures	The measures that alters the physical characteristics of the floods (reservoir operation, upstream catchment management, channel modifications, levees, operation of hydraulics works).
Tidal flood interval	Time between transit of moon over meridian of a place and the time of the following strength of flood.
Tropical cyclone	Cyclone originating in the tropics
Tropical storm	A cyclonic storm having winds ranging from approximately 48 to 121 kilometres per hour
Tsunami	Flood in coastal areas or in low lying lands, caused by sea waves after a submarine earthquake or a volcanic eruption.
Typhoon	Any violent tropical cyclone originating in the W Pacific, esp. in the South China Sea
Unsaturated zone	The zone between the land surface and the regional groundwater table. It includes the capillary fringe and may also include localized perched groundwater
Vulnerability	The characteristics of a person or group and their situation that influence their capacity to cope with, resist and recover from the impact of a natural hazard

ANNEX III. Characteristic data on the Mekong River Basin

WATER RESOURCES SITUATION

The Lower Mekong River Basin (LMB) covers the Cambodian, Lao, Thai and Vietnamese parts of the Mekong River Basin (MRB). It has a population of some 62 million people and an area of 606,000 km^2. The entire MRB includes parts of Myanmar and of the Yunnan Province of China, and has an area of 795,000 km^2. The MRB covers 86% of the area of Cambodia; 97% of the area of Lao PDR; 36% of the area of Thailand; and 20% of the area of Viet Nam (Figure 1).

The water resources of the LMB are described in some detail in the Mekong River Commission State of the Basin Report of the Mekong River Commission (MRC) (2003). In strategic terms, important characteristics of Mekong water resources include:

- *abundance.* Annual runoff averages around 475 billion m^3/year. Per capita resources currently stand at over 8,500 m^3/person/year - compared with 2,200 for the Nile; 1,400 for the Rhine; 2,265 for the Yangtze and 1,700-4,000 for the Ganges;
- *low level of exploitation for extractive uses.* Average annual withdrawals are estimated at around 60 billion m^3, or 12% of total annual flows; the total volume of regulated storage in the basin (including the Upper Basin) for hydropower and irrigation is less than 20,000 million m^3 (less than 5% of annual flows); and it is estimated that only 5% of hydropower potential has been developed;
- *high dependence on in-stream uses (particularly by the poor).* The Mekong fishery is the largest inland fishery in the world, estimated to be worth at least US$ 2 billion annually, and providing the major protein source for many people in the basin. Inland navigation is an important mode of transport for many areas where road access is limited;
- *extreme seasonality.* In most parts of the Basin, flows in the driest three months constitute less than 10% of total annual flows while flows in the wettest three months make up over 50% of total annual flows Mekong River Commissions Decision Support Framework (MRC-DSF);
- *importance of the flood pulse for the ecology of the floodplain and the Mekong fishery.* During the wet season, between 1 and 4 million hectares of floodplain are submerged, including the Tonle Sap Great Lake;
- *dry season water shortages.* Dry season shortages occur as a result of the rainfall seasonality, concentration of extractions in the driest period and drought events during the onset of the wet season;
- *water quality.* Water quality in the mainstream is generally good, and is rarely a constraint to water use. The exception is saline intrusion, acid sulphate drainage and pollution in intensively used areas of the Mekong Delta;
- *groundwater.* Groundwater resources are very widely used as a source for domestic and industrial supply. Use for irrigation is limited, but expanding. Groundwater systems in the floodplain are closely coupled to the river;
- *Upper Basin.* Flows (from China and Myanmar) constitute around 18% of total Mekong flows. The proportion is higher in the dry season, when snowmelt contributes a significant component of flow.

Figure III.1. Mekong River Basin (MRB)

WATER UTILISATION IN THE LOWER MEKONG RIVER BASIN (LMB)

Agriculture and irrigation

Agriculture is the cornerstone of the economy in the Lower Mekong River Basin. 22% of the area is cultivated with rice being the major crop (typically harvesting one crop per year, except in the Delta, where 2 or 3 crops can be grown). More than 80% of the rural labour force is employed in the agricultural sector. Throughout the basin, however, most rural households have highly diversified and multiple sources of income and combine farming with a range of non-agricultural activities. Within the basin, income from wages and salaries currently accounts for up to 25-30% of household income. Government policies that target larger scale commercialised agriculture as well as the growth of rural industries will further influence the economic activities of the rural population.

The total water-managed cultivation areas (irrigated areas) are around 390,000 ha (Cambodia); 155,000 ha (Lao PDR); 540,000 ha (Thailand); 40,000 ha (Vietnamese Highlands); and 1,000,000 ha (Vietnamese Delta). In both Cambodia and Lao PDR, there is a large potential for development of irrigation infrastructure within existing water-managed areas. In the same two countries, there is a potential for expanding the irrigated area by around 600,000 ha in each country. In Northeast Thailand, the tributaries are fully exploited, and in the Delta, the flow is fully utilised for irrigation and to curb salinity intrusion.

Fisheries

The present fisheries yield of the Basin is 1.5-2 million tonnes per year. Some 15% comes from aquaculture and the rest from freshwater capture. Fish is an important part of the staple diet supplying most of the protein, over 80% in Cambodia, for instance. Today, the capture stock is utilised close to its capacity. The aquaculture production is escalating rapidly in Cambodia and in the Delta. The capture fishery is exposed to habitat degradation, and barriers to migration, while aquaculture production is exposed to a deteriorating water quality, partly due to polluted irrigation tailwater.

Wetlands and other habitats

The wetland areas of the Basin, such as Tonle Sap, Plain of Reeds, and others, are important ecological habitats. Tonle Sap is among the World's most productive freshwater fisheries areas. Also the floodplains serve as fish breeding grounds. Tonle Sap functions as a large natural storage reservoir that reduces the maximum flow and increases the minimum flow downstream of the confluence at Phnom Penh.

For a multitude of reasons, the forests, wetlands, coastal ecosystems and other natural habitats are in a state of continuous degradation. On the other hand, there is attractive potential for development of controlled, sustainable forestry.

Hydropower

There is great hydropower potential in the Lower Mekong River Basin. The MRC has estimated it to around 30,000 MW depending on the feasibility criteria applied. Of this, 13,000 MW are on the mainstream; 13,000 MW on Lao tributaries; 2,200 MW on Cambodian tributaries; and 2,000 MW on Vietnamese tributaries. To date, 11 schemes have been completed in the LMB, totalling some 1,600 MW, or 5% of the potential. All of these are tributary projects. The largest ones are located in Viet Nam (Ialy, 720 MW) and Lao PDR (Theun Hinboun, 210 MW, Nam Ngum, 150 MW, and Houay Ho, 150 MW).

In Yunnan, two hydropower projects were completed on the mainstream: Manwan (1,500 MW) and Da-Chao-Shan (1,350 MW). Additional large mainstream projects have been initiated (Xiaowan) or planned (Jinghong and Nuozhadu), with storage capacity of 15 billion m^3.

Navigation
Waterway transport has traditionally been the principal means of travel for much of the population, both locally and for international trade. Around a third of the population in rural areas of Cambodia and Lao PDR live further than 10 km from a road that can be used year round. Waterborne transport represents 85% of all means of transportation in the Mekong Delta of Viet Nam.

The use of the river for transportation depends not only on the physical potential of the waterways but also on the demand for trade. In 2002, trade estimated at US$ 4.7 billion was distributed by inland waterway transport (US$ 88 million between Thailand and China; US$ 350 million between Lao PDR and Thailand; US$ 235 million in Cambodia; and US$ 4 billion in the Mekong Delta).

Floods
Severe floods occur regularly, in recent years for example in 1996, 2000, and 2001. The consequences have been extensive, in terms of human casualties, production loss, and damage to infrastructure and private property. Flood management and mitigation is an important issue with a strong regional emphasis.

Tourism
Tourism is a major foreign currency earner in Thailand, although today it is most dominant outside of the Mekong Basin. In Cambodia, Lao PDR and Viet Nam, the sector has an attractive potential for development, which can be pursued in a basin-wide collaboration.

SOCIO-ECONOMIC CONDITIONS

The last two decades have witnessed rapid economic development in the lower basin countries. At the same time, however, the quality of life of the poorest people has barely improved at all.

Most of the rural population, that is more than 80% of the total population in all basin areas, continues to live in great poverty. The socio-economic indicators in Cambodia and Lao PDR remain low, and in Thailand and Viet Nam, the indicators within the basin area are substantially lower than in the areas outside of the basin. Significant investments are urgently needed in the agriculture sector and in rural development in general, as well as in education and basic health.

Education levels are generally low. The average school attendance is less than five years. There is a shortage of schools and higher education facilities, particularly in rural areas. Poverty can impede children from going to school, not to speak of higher education. In this way, huge human resources are critically under-utilised and do not reach their potential. Currently, 75-80% of the basin’s population lives in rural areas. Population growth remains high throughout the basin despite declining fertility rates and improved health conditions and life expectancy. Projections for 2000-2020 show annual total population increases ranging from 1% in Thailand to 1.4% in Viet Nam, 2.3% in Cambodia and 2.6% in Lao PDR. Moreover, the growth rate of the urban population is 2-2.5 times higher than national rates, due to migration towards secondary as well as major urban centres. If these conditions persist, the proportion of people living in urban areas in 2025 will be in the range of 25-30%.

ANNEX IV. Forum programme 7th Annual Mekong Flood Forum (AMFF-7)

	WEDNESDAY, 13 MAY 2009
08:00-08:30	Registration
08:30-12:30	*MORNING SESSION*
08:30-09:30	***Inaugural Session*** Master of Ceremony: *Nicolaas Bakker*, Chief Technical Advisor, Flood Management and Mitigation Programme (FMMP-CTA)
	Welcome address by *Jeremy Bird*, Chief Executive Officer, Mekong River Commission Secretariat (MRCS-CEO)
	Opening address by *Siripong Hungspreug*, Director General of the Department of Water Resources, Ministry of Natural Resources and Environment and Secretary General of Thai National Mekong Committee
	Statement by *Martien Beek*, Royal Netherlands Embassy, Ha Noi, Viet Nam
	Statement by *Ms. Sezin Tokar*, U.S. Agency for International Development (USAID)
	Statement by *Timo Menniken*, Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)
	Summary AMFF-6 and follow-up on recommendations *Hatda Pich AN, MRC RFMMC*
	Objectives and expected outcome of the 7th Annual Mekong Flood Forum (AMFF-7) *Nicolaas Bakker*
	Video presentation on the MRC Flash Flood Guidance System (FFGS)
09:30-10:00	Coffee Break, Posters and Exhibition
10:00-12:30	***Session 1: Lessons Learned from 2008 Flooding and National and MRC-RFMMC Experiences with Integrated Flood Risk Management*** Chairperson: *Siripong Hungspreug*, Head of the Thai Delegation Rapporteur: *Hak Socheat*, Coordinator of CNMC-FMMP
	Cambodia country flood report for 2008 *Sok Bun Heng*
	Lao PDR country flood report for 2008 *Virana Sonnasinh*
	Thailand country flood report for 2008 *Supapap Patsinghasanee and Srisunee Wuthiwongyothin*
	Viet Nam country flood report for 2008 *Trinh Hoang Ngan*
	Dialogue Partner report – China *Zhong Yong and Li Bo*
	Floods of Mekong River Basin (2008) in Myanmar territory *U Hla Myint Thein and U Sein Tun*
	2008 annual Mekong flood report *Peter Adamson and Ms. Janejira Tospornsampan*
	Panel discussion facilitated by *Hatda Pich AN*
12:30-13:30	Lunch
13:30-17:00	*AFTERNOON SESSION*
13:30-15:00	***Session 2: Towards Integrated Flood Risk Management in the Mekong River Basin*** Chairperson: *Pich Dun*, Head of the Cambodian Delegation Rapporteur: *Nguyen Anh Duc*, Coordinator of VNMC-FMMP
	Presentation of FMMP Component 2: Structural measures and flood proofing *Ms. Pham Thi Van Lan and Nicolaas Bakker*
	Presentation of FMMP Component 1: Short and medium-term flood forecasting at the MRC Regional Flood Management and Mitigation Centre *Ms. Janejira Tospornsampan, Terry Malone, Bob Pengel, Phung Katry and Hatda Pich AN*

	Presentation of FMMP Component 3: Enhancing cooperation between Mekong River Commission (MRC) and MRC Member Countries in addressing trans-boundary flood and related issues *Ms. Pham Thi Van Lan and Nicolaas Bakker*
	Presentation of FMMP Component 4: Flood emergency management strengthening. People-centred approach in integrated flood risk management *Thanongdeth Insisiengmay*
	Presentation of FMMP Component 5: Flood information based land management (FIBLM) *Martin Falk*e
	Questions, discussion facilitated by Nicolaas Bakker
15:00-15:30	Coffee Break, Posters and Exhibition
15.30-17.00	***Session 3: Parallel Paper Presentations from the Mekong Region on the four Topics Followed by Parallel Group Discussions***
	Topic I: Optimal packages for flood management Chairperson: *Le Duc Trung*, Head of the Vietnamese Delegation Facilitator: *M.A. Quassem* Rapporteur: *Sok Bun Heng*
	I.1 Integrated hydrologic, hydraulic, and damage analysis for selection of optimal flood management measures *Kittiwet Kuntiyawichai, Bart Schultz, Stefan Uhlenbrook and F.X. Suryadi* I.2 Charting ICHARM's strategy for integrated flood risk management in the Lower Mekong River Basin *A. Chavoshian, K. Miyake, T. Sugiura, P.T. Hai, and L. Rajapakse* I.3 Risk-based flood management for adapting to climate change *Toshio Okazumi and Eiji Ootsuki*
	Topic II: Recent developments in flood forecasting and early warning Chairperson: *Pich Dun*, Head of the Cambodian Delegation Facilitator: *Erich Plate* Rapporteur: *Trinh Hoang Ngan*
	II.1 Flash floods, hydro-meteorological forecasting and warning systems in Viet Nam *Bui Duc Long* II.2 Recent developments in flood forecasting and early warning *Yin Savuth* II.3 Help-desk for integrated flood management: supporting river basins in implementing an integrated approach *Wolfgang Grabs, Masahiko Murase, Joachim Saalmueller, Avinash Tyagi and Daisuke Yamashita* Extra presentation: The WISDOM Project – Structure and First Results *Erich Plate*
	Topic IV: Successful flood risk management approaches Chairperson: *Nirat Phuriphunpinyo* Facilitator: *Ms. Sezin Tokar* Rapporteur: *Virana Sonnasinh*
	IV.1 An overview of community based disaster risk reduction initiatives in Cambodia *Khun Sokha* IV.2 Assessment on integrated flood management strategies in the Lower Dong Nai -Sai Gon River Basin, Viet Nam *Nguyen Anh Duc; Klaas-Jan Douben; Tang Duc Thang and Vu Minh Thien* IV.3 Best practice guidelines for flood risk assessment in the Lower Mekong River Basin *Gert Sluimer, Henk Ogink, Ferdinand Diermanse, Frank Keukelaar, Bas Jonkman, Tran Kim Thanh and Tes Sopharith*
18:30-20:30	Forum Dinner

THURSDAY, 14 MAY 2009	
08:30-12:30	*MORNING SESSION*
08:30-10:30	***Session 4: Summary of Day 1, Plenary Paper Presentations, Discussions*** Chairperson: *Chanthachit Amphaychith*, Head of Lao PDR Delegation Rapporteur: *Burachat Buasuwan*
	Summary of Day 1 of AMFF-7 by Nicolaas Bakker
	4-1 Flood hazard mapping in Nan River, Thailand *Somchit Amnatsan, J.S.M. Fowze, Arnob Bormudai, Manzul K. Hazarika and Lal Samarakoon*
	4-2 Statistical ensemble flood forecasting for the Mekong River *Muhammad K. Shahzad, Falk Lindenmaier, Jürgen Ihringer, Erich J. Plate and Franz Nestmann*
	4-3 Development of trans-boundary cooperation in the Rhine River Basin *Bart Schultz*
	4-4 Hydrological risk zone mapping in Dong Thap Province for developing agricultural insurance *Dang Thanh Lam*
	Plenary Discussion – Facilitated by Hatda Pich AN
10:30-11:00	Coffee Break, Posters and Exhibition
11:00-12:30	***Session 5: Parallel Paper Presentations by International Specialists Followed by Parallel Group Discussions***
	Topic II: Recent developments in flood forecasting and early warning Chairperson: *Pich Dun*, Head of the Cambodian Delegation Facilitator: *Erich Plate* Rapporteur: *Trinh Hoang Ngan*
	II.1 The way forward in hydrodynamic flood modelling in the Mekong River Basin *Adri Verwey* II.2 Real-time hydrometeorological observation networks - development possibilities for the early warnings system of the Mekong River Basin *P.J. Airaksinen, J. Ikonen, N.W.S. Demetriades and H. Pohjola* II.3 Enhanced discharge measurements in irrigation canals using multi-frequency acoustics *Mike Cook, Victor Montano, John Sloat and Mark Tepper* II.4 The status of real-time hydro-met data monitoring and its application in river/flood monitoring and forecasting *Sompong Boonprasert*
	Topic IV: Successful flood risk management approaches Chairperson: *Suwit Thanopanuwat* Facilitator: *Ms. Sezin Tokar* Rapporteur: *Virana Sonnasinh*
	IV.1 An integrated approach to flood risk mapping for flood detention areas - a case study of Day River flood diversion basin in the Red River Delta, Vietnam *Nguyen Mai Dangand Muk and Singh Babel* IV.2 Flood damage assessment integrating geospatial technologies. A case study in Hue, Vietnam *Dinh Ngoc Dat, J.S.M. Fowze, Nguyen Duong Anh, Manzul K. Hazarika and Lal Samarakoon* IV.3 Development of a 1D hydraulic model for flood inundation mapping along the anabranched Mekong River, Siphandone, Lao PDR, as affected by recent land use changes *T.P.D. Van and P.A. Carling* IV.4 Flood risk approach and use of the DACA instrument in the Lower Mekong River Basin *Jakolien Leenders, Astrid Janssen and Jurjen Wagemaker*
12:30-13:30	Lunch

13:30-17:00	*AFTERNOON SESSION*
13:30-14:30	***Session 6: Parallel Group Discussions, Formulation of Recommendations on the Topics***
	Topic I: Optimal packages for flood management Chairperson: *Dao Trong Tu* Facilitator: *M.A. Quassem* Rapporteur: *Sok Bun Heng*
	Topic II: Recent developments in flood forecasting and early warning Chairperson: *Pich Dun*, Head of the Cambodian Delegation Facilitator: *Erich Plate* Rapporteur: *Trinh Hoang Ngan*
	Topic III: Effective approaches towards trans-boundary flood management Chairperson: *Chanthachit Amphaychith*, Head of Lao PDR Delegation Facilitator: *Bart Schultz* Rapporteur: *Phonepaseuth Phouliphanh*
	Topic IV: Successful flood risk management approaches Chairperson: *Suwit Thanopanuwat* Facilitator: *Ms. Sezin Tokar* Rapporteur: *Virana Sonnasinh*
14:30-15:00	Coffee Break, Posters and Exhibition
15:00-17:00	***Session 7: Concluding Session*** Co-Chairpersons: *Te Navuth*, Director of Technical Support Division *Nicolaas Bakker*, FMMP-CTA
	Presentations by the rapporteurs of the plenary sessions 1, 2 and 4 and of the parallel sessions (3, 5 and 6) on the 4 Topics
	Importance of integrated flood risk management packages. Experiences from practices in Bangladesh *M.A. Quassem*
	Video: When the Mekong rises
	Summary of proceedings and recommendations for follow-up *Bart Schultz*
	Remarks by Representatives of Participants
	Presentation of the Forum Statement by *Hatda Pich AN*
	Intervention by *Ian Makin*, Asian Development Bank (ADB)
	Closing address by *Jeremy Bird*, MRCS-CEO

ANNEX V. List of participants

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