Mekong River Commission

Proceedings of the 8th Annual Mekong Flood Forum
Vientiane, Lao PDR, 26 - 27 May 2010

Flood Risk Management and Mitigation in the Mekong River Basin

Mekong River Commission

Regional Flood Management and Mitigation Centre

8th Annual Mekong Flood Forum

Flood Risk Management and Mitigation in the Mekong River Basin

Proceedings

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Office of the Secretariat in Phnom Penh
576 National Road #2, Chak Angre Krom
P.O. Box 623, Phnom Penh, Cambodia
Telephone: (855-23) 425 353, Facsimile: (855-23) 425 363
E-mail: mrcs@mrcmekong.org
Website: www.mrcmekong.org

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Preface

On behalf of the Mekong River Commission (MRC), I am pleased to present to you the Proceedings of the 8th Annual Mekong Flood Forum that was held on 26 and 27 May 2010 in Vientiane, Lao PDR. This year the theme of the Forum was '*Flood risk management and mitigation in the Mekong River Basin*'.

Discussions focused on the database systems and tools used for dissemination of flood forecasting and early warning products; guidelines for the preparation of flood risk management plans and for evaluation of the impacts of flood risk management and mitigation measures; potential trans-boundary issues for negotiation, mediation and conflict prevention; and on the MRC's new regional flash flood early warning system.

Country reports, MRCs Flood Management and Mitigation Programme (FMMP) papers and presentations from other participants were presented within the framework of the Forum theme, which was defined under five topics:

- Community focused approach to flood risk management and mitigation;
- Flood forecasting and flash flood guidance;
- Structural measures and flood proofing;
- Trans-boundary cooperation for managing floods and related issues;
- Land use and climate change impacts on flood management.

The 8th Annual Mekong Flood Forum also provided the opportunity to discuss the Annual Mekong Flood Report for 2009 produced by the MRC Regional Flood Management and Mitigation Centre (MRC-RFMMC). This report examined the impact of floods from the perspectives of the MRC Member Countries, Cambodia, Lao PDR, Thailand and Viet Nam. A major typhoon, tropical storm Ketsana, occurred in late September 2009 principally affecting southern Lao PDR, eastern Cambodia and parts of the Delta in Viet Nam and causing hundreds of deaths and about US$ 900 million in damage. The experiences of flash flooding from Typhoon Ketsana as well as the limitations of existing warning systems were presented. The major theme of the 2009 Annual Flood Report concerns climate change and its implications for future floods and flooding in the Mekong River Basin.

This years' Forum was held as Phase I of the Flood Management and Mitigation Programme (FMMP) draws to a close and steps are being taken to formulate the follow on Phase expected to be operational by January 2011. Various papers outlined an overview of what has been achieved so far and what may be important directions for Phase II. It is widely agreed that flood forecasting and support to warning services are core functions of MRC and it is expected that based on the outcomes of this Forum, the MRC-RFMMC will be able to more closely define its services and strengthen its capability and cooperation mechanisms for flood risk management and mitigation. The Annual Flood Forums also provide MRC Member Countries with an opportunity to review and further improve their own flood policies, strategies, plans and projects, based on experiences of the past and sharing of information with others from outside the region. The future of the Annual Flood Forums, including their frequency and format, are also being considered as part of the formulation of the second phase and I invite your comments on the direction they should take.

I would like to take this opportunity to thank the country report authors from Cambodia, Lao PDR, Thailand and Viet Nam, as well as from our Dialogue Partners, China and Myanmar, and all other presenters for their invaluable reports and papers. I also extend our gratitude to the governments of Denmark, France, Germany, Japan, the Netherlands and the United States of

America, as well to as the Asian Development Bank and the European Union for their support to MRCs Flood Management and Mitigation Programme over the past years.

I trust that participants and other interested individuals will find much useful information in these Proceedings and that this will benefit day-to-day practice and contribute to the improvement of our work in flood risk management and mitigation in the Mekong River Basin.

Jeremy Bird
Chief Executive Officer
Mekong River Commission Secretariat
1 June 2010

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WELCOME ADDRESS

MR. JEREMY BIRD

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

Mr. Phonechaleun Nonthaxay
Director General, Department of Water Resources
Water Resources and Environment Administration (WREA)
Alternate MRC Joint Committee Member for Lao PDR

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

It is my great pleasure to welcome you all here today to participate in the 8^{th} Annual Mekong Flood Forum. On behalf of the MRC Secretariat, I would like to extend my special thanks to Mr Phonechaleun Nonthaxay for finding time in his schedule to open this important event.

Providing long-term or seasonal flood forecasting has become more relevant than ever. The Mekong Basin like many other regions in tropical regions is highly variable, and people of the Basin have learned to cope and adapt to this situation. However, as populations rise and economic development progresses, the nature of these coping mechanisms also needs to change. On the one hand, the value of assets at risk has increased rapidly and on the other, the advent of modern communications technology provides new opportunities for flood management. We will hear about some of these challenges and opportunities over the next couple of days.

Peak flood flows in the Mekong are incredibly variable from year to year, for example, ranging from just over 30,000 cubic meters per second, recorded in 1992, to just under 80,000, recorded 14 years earlier in 1978 - a factor of over two.

But we are now facing new developments that will modify the natural hydrology of the river system. These include potentially flood-reducing changes resulting from the construction of dams throughout the basin - in China and in the tributaries of the Lower Mekong Basin. Individually they may not have much impact, but collectively they can potentially have a significant influence on redistributing water from the wet season to the dry season. This is the subject being addressed by various scenario assessments undertaken by our Basin Development Plan Programme.

More indirect human-induced changes are being brought about by global warming and the consequences for increased rainfall and temperatures, leading to a trend in the other direction - increased flood peaks. In addition, there is an increased frequency and intensity of extreme events - both flood and drought.

Both these changes, which are already challenging planners in the basin, lead us to ask a very fundamental question. *To what extent can we still use the data of the past to predict the floods of the future*?

It is a question which challenges the very science of hydrology as we have known it for past decades. It requires a different approach to the way in which we examine our forecasting

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systems and the confidence we can provide to affected communities that we can get the answer right. It is not simply business as usual, and as with many other flood-prone basins around the world, we need to learn and adapt to this new reality.

Since joining the MRC just over two years ago, I have been a witness to one regional mainstream flood in northern Laos and Thailand that saw water levels higher than they have been in more than 40 years; seen the incredibly destructive power of flash floods in tributary rivers caused by typhoon activity and resulting in deaths measured in the hundreds and extensive damage to property - in 2009, Ketsana alone caused loss of US$ 900 million of which the greatest proportion occurred in Viet Nam; and just a few months ago, experienced a regional drought situation with the lowest river levels in the mainstream and tributaries for over 40 years - it affected the food security of millions of people living in the Mekong River Basin and the waterway transport of the region.

Maybe these extreme events are just part of the natural variability of the Basin. Or maybe they are the first signs of climate change. We don't know if climactic events like the 2008 flooding, Typhoon Ketsana in 2009 and regional drought early this year will continue to be considered unusual by future generations. But, what we can be sure of is that this reflects the strong need to plan, mitigate and more accurately forecast flood events. The consequences we saw of Typhoon Ketsana and other similar events demonstrate how important just a few hours of warning can be to save lives.

Even if it is too early to tell whether climate change effects are already a reality, there is one important conclusion - that flood forecasting and warning has become a core function of the MRC for the foreseeable future and more than just a programme activity.

Distinguished Participants,
Ladies and Gentlemen

Today we will hear more about the events of the 2009 flood and how it affected the countries of the region. We will also hear about the various components of MRCs Flood Management and Mitigation Programme including what the Regional Flood Management and Mitigation Centre in Phnom Penh has been working on in the past few years. This includes strengthening its links with the meteorological and water resource agencies in the MRC Member Countries to monitor river and weather conditions and forecast the likelihood of flooding.

Daily updates on water levels of the mainstream Mekong are provided on the MRC website, and more detailed information is routinely sent to the concerned government agencies, academic institutions, and international, regional and non-governmental organisations 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.

Beyond that there a wide range of measures related to flood warning and preparedness and pilot activities and capacity development initiatives.

The first phase of the Flood Management and Mitigation Programme will complete by the end of this year, and the next phase is under formulation. This Forum will provide an excellent opportunity to look back on FMMPs performance, to learn from the past six years of experiences on flood forecasts, warnings, emergencies responses as well as its support for further strengthening the operations of government agencies in riparian governments.

The six year implementation period has provided a firm foundation for the provision of regional

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flood management and mitigation services and products. The next few years require us to continue to develop systems to face the challenges I have already mentioned and to even more closely integrate the information provided into national systems.

However, it is obvious that the long term ability of MRC to help its Member Countries cope with the increasing demands and challenges of countering flood risks as well as achieving the question of the financial sustainability of the Regional Flood Management and Mitigation Centre has to be answered.

As the economies of the region grow, countries of the region will increasingly be required to finance the regional forecasting activities. Innovative financing mechanisms will be need to be explored as well as more conventional contributions from government budgets. The First MRC Summit has committed to MRC becoming fully financially sustainable by 2030. Some would like to see this happen earlier.

It is clear that this will require additional external support to the transition period, but again this will not be business as usual and careful consideration is required in the next phase of FMMP development to chart out a roadmap for this financial 'coming of age'. At the same time, we will need to prioritise our activities and determine what is best done by a regional organisation like MRC and what further capacity should be built within the countries themselves.

We are fortunate in this respect to have had a broad range of support from Development Partners **-** from the governments of Denmark, France, Germany, Japan, the Netherlands, and the United States and other international organisations, namely, the Asian Development Bank and the European Commission. Some have already expressed initial interest to continuing this support and we look forward to working with them during the formulation process of the next phase.

As an example of this support, MRC has been able to expand its flood early warning system from five flood prone areas in Cambodia in 2004, when the Programme started, to the 11 most flooded provinces in the four MRC Member Countries.

As part of a regional effort to improve accuracy of forecasts of localised floods, villagers in those provinces were equipped with cell phones, flood information markers and billboards and trained to use them to monitor, measure and report water levels to national flood forecasting agencies. The villagers will be able to publicise flood information on the billboards or inform their villages of any imminent floods because they can now get flood warnings from the national agencies two days in advance.

The villagers' involvement will complement the MRCs greater effort to develop a flash flood guidance system that disseminates localised flooding with greater accuracy with over 30 hydro-meteorological stations established on tributaries. This automatic real-time information on rainfall and water levels is transmitted to the MRC for analysis and, when the system is fully tested and online this year, will result in quicker up to the minute information about the risk of imminent small-scale flash floods throughout the Mekong River Basin.

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

Distinguished Delegates;
Ladies and Gentlemen

Also over the past six years, there has been a remarkable increase in the cooperation and learning with our Dialogue Partners, China and Myanmar. With the provision of daily

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hydrological data from the two hydro-meteorological stations upstream on the Lancang River during the flood season, we have enhanced our capacity to provide more accurate flood forecasts. This agreement extended from the one we had in 2002 amply indicates China's willingness to engage with Lower Basin countries and cooperate not only in forecasting work, but also in MRCs independent analysis of the flow regime in the upper part of the basin. At the First MRC Summit China reaffirmed its commitment to regional cooperation and to addressing the challenges facing the basin. In two week's time, we will follow up on this cooperation by the first official MRC visit to the hydropower dams upstream on the Lancang River and a meeting in Beijing with concerned ministries.

Already in the field of flood management we have seen significant advances in cooperation with a study visit to the Chianjiang Water Resources Commission last year and a special training course on flood and disaster risk management organised by Chinese experts next month.

Distinguished Delegates;
Ladies and Gentlemen

It is in the spirit of improving our performance that we are here today. But we are not here just to look only at the Mekong or the FMMP. We have a wealth of experience from around the world gathered here and I would like to thank you for your contributions and I personally look forward to the learning and sharing of ideas. I welcome you all to this meeting.

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 active cooperation with us. I also thank the governments of Denmark, France, Germany, Japan, the Netherlands and the United States, and the Asian Development Bank and the European Commission for their continuing support for the MRCs Flood Management and Mitigation Programme.

Distinguished Delegates, Ladies and Gentlemen,

Although not wishing to shortcut this next two days of fruitful interaction, I do look forward to seeing the Forum Statement and its recommendations. They will help to set us on the right path for the next phase of our wok in this important sector and support our MRC Member Countries to better manage floods in the Basin, both their positive and negative effects, in an integrated manner. Ultimately that will provide a more secure and better future for the vulnerable people in the basin.

Let me wish you all fruitful interactions and an enjoyable time with us at the 8th Annual Mekong Flood Forum.

Thank you.

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OPENING ADDRESS

H.E. MS. KHEMPHENG PHOLSENA

Minister to the Prime Minister's Office, Head of Water Resources and Environment Administration, Chairperson of the Lao National Mekong Committee, and Member of the MRC Council for Lao PDR, Vientiane, Lao PDR

Excellencies;
Distinguished Delegates of the MRC Member Countries and Dialogue Partners;
Development Partner Representatives, and International Organisation Representatives;
Ladies and Gentlemen,

It is my great pleasure to be here today as we begin the 8th Annual Mekong Flood Forum on the theme that is so important and very relevant for our societies *'Flood risk management and mitigation 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 Lao National Mekong Committee - marks another significant achievement in the operations of this important institution.

Over the years we have had the benefit of increased experience with flood management and mitigation in the Mekong River Bain. The presentations and discussions during previous Forums have substantially contributed to this. The presentations and discussions during this Forum, I am sure, will contribute greatly to the improvement of our understanding and our practices.

Under the umbrella of the main theme - flood risk management and mitigation - I would like to encourage you to focus your discussions on the following five main issues:

- *A community focused approach to flood risk management and mitigation.* The experiences with the flood of 2008 that hit our capital Vientiane and other parts of northern Lao PDR and Thailand has underlined the importance of such an approach;
- *Flood forecasting and flash flood guidance.* We have considerable experience with flood forecasting and early warning, but we are only in the early phase of flash flood guidance. Earlier experiences show that by making more information available, a significant number of potential casualties can be prevented and damage can be significantly reduced. We have to further elaborate and improve on this flash flood guidance;
- *Structural measures and flood proofing.* The main objective here is to reduce the vulnerability of people living in the basin to the negative impacts of floods. This requires preparation of strong measures that are crucial for a socio-economic and environmentally sound flood risk management and mitigation response. This should result in the most effective mix of structural and non-structural measures to reduce flood damage risk;
- *Trans-boundary cooperation for managing floods and related issues.* With so much development being undertaken or planned in the Mekong River Basin, *trans-boundary cooperation* will be of utmost importance in facilitating activities so that all riparian countries will optimally benefit from these developments. This will present great challenges and be a major responsibility for our governments. In this context the Mekong River Commission can play a crucial role in supporting and assisting our decision making processes;

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- *Land use and climate change impacts on flood management.* The conditions in the Mekong River Basin are continuously changing. Notably this is due to the rapid pace of development in our societies. As improvements occur in the standard of living, urbanisation, industrialisation and changes in agricultural practices, and to a certain extent by climate change, we have to understand and document these processes to better equip ourselves to respond with appropriate measures for flood management and mitigation.

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

This Forum offers an excellent opportunity to present and discuss the Annual Mekong Flood Report for 2009 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. The theme of the 2009 Annual Flood Report concerns climate change and its implications for floods and flooding in the Mekong River Basin. These potential climate induced impacts are also considered in the context of other changes resulting from reservoir storages on the mainstream and larger tributaries, which will lead to changes in the hydrology of the flood season.

I trust that the presentations and discussions of the next two days will act as a mechanism to review and improve our practices by elaborating on the principles of flood risk management in our flood management and mitigation policies, plans and projects. Most of us are aware that we are approaching the end of Phase I of the Flood Management and Mitigation Programme and are in the process of formulating the components of Phase II. I sincerely believe that the presentations and discussions resulting from this two-day Forum will significantly and meaningfully contribute to the MRC Regional Flood Management and Mitigation Centre and in defining the focus of Phase II. In doing so, we also need to recognise the needs for capacity development to ensure that the systems that we introduce now are sustainable in the future.

The rapid population growth in the region, urbanisation, intensification of agriculture, changes in land use, impacts of climate change and the complexity of the river system require a holistic approach towards flood risk management and mitigation covering the whole basin from upstream to downstream. This is in the interest of everyone who lives in the Mekong River Basin. I am pleased therefore to recognise that our partnership with upstream countries is strengthening in this sector and has included study tours and training in China.

Let us contribute to 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 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 issues of joint interest in the Mekong River Basin.

In addition I would like to thank the governments of the Denmark, France, Germany, Japan, Netherlands, and the United States, other Development Partners and Observers namely, the Asian Development Bank and the European Commission for their continuing support to the MRC Flood Management and Mitigation Programme. Please be assured that the MRC Member

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Countries are fully committed to this important work which ultimately benefits those communities at risk from flooding.

In concluding, I declare the 8th Annual Mekong Flood Forum open and anticipate that every participant will have the opportunity to make a productive contribution to its success. I wish you all a pleasant stay here in Vientiane.

Thank you.

STATEMENT

MARTIEN BEEK

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

Your Excellency Ms. Khempheng Pholsena, Minister to the Prime Minister's Office and head of the Water Resources and Administration;

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

On behalf of the Embassy of the Kingdom of the Netherlands, it is an honour to welcome you to the 8th Annual Mekong Flood Forum. It is an important 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.

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.

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.

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.

We look back to a very important year for the Flood Management and Mitigation Programme (FMMP). One of the challenges was, on how to follow up on the existing programme that would formally be ending by the end of 2010. Last year, at the 7th Annual Mekong Flood Forum, I reported on the outcomes of the evaluation mission regarding the implementation of FMMP. Today I will not elaborate on these outcomes but the success and the importance of continuation of the FMM support to the MRC Member Countries was a clear statement. Flood management and Mitigation are within the core functions of MRC and should be supported at all times.

But let's not be misleaded. We have been lucky during the last years that the floods in the Mekong River Basin where not severe or extreme events. Unfortunately, natural disasters like floods come always unpredicted and always as a cumulative sum of unfortunate events. The current developments in the basin call for constant preparedness for such events.

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There are many examples all over the world that have demonstrated severe events resulting mostly from extreme rainfall events, human intervention on dams, dyke construction, land use and infrastructure development. There is damage in the sense of causalities, but also in economic loss by agriculture and infrastructure, as well as personal loss of property.

It is clear that regional dialogue and cooperation between the MRC Member Countries is principal to find the right answers and preparedness to these events. The FMMP programme has been successful and let me mention that the Government of the Netherlands is satisfied with the progress made so far. Still, there remain many challenges in improving the models, in improved information gathering and sharing of data between the MRC Member Countries and MRC Dialogue Partners.

Interventions like construction of dams will also impact the patterns of floods and discharges. Especially in the downstream part of the Mekong River Basin there are quite some concerns regarding the impacts on water quantity, sediment loads, flood and drought patterns. It is clear that more research is needed to get a more thorough understanding of the impacts, but also in the way of dialogue, cooperation, measuring, and regional information sharing. In my opinion the Regional Flood Management and Mitigation Centre should be at the core of this initiative.

The Netherlands Embassy has proposed the MRCS to continue the Flood Management and Mitigation Programme activities with another year extension to the end of 2011 with an additional budget to better anticipate on developing these tasks and consolidate the functions of the Regional Flood Management and Mitigation Centre.

In fact the programme should reflect the needs of the MRC Member Countries. I envisage involving the MRC Member Countries, the MRCS, FMMP, like-minded donors, into a formulation process. It should aim at securing the sustainability of the core functions of the MRC-RFMMC by the end of the next strategic plan (2011-2015).

In financial terms, I strongly believe, that the responsibility is with the MRC Member Countries to be the principle supporters of the Regional Flood Management and Mitigation Centre. Furthermore, I would also like to invite the other international donors to share ideas how MRC-RFMMC can cooperate with the other ongoing programs. Cooperation and exchange of information will lead to even better opportunities to develop new products on flood management systems and mitigation techniques.

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

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OPENING REMARKS

MS. A. SEZIN TOKAR

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

Excellencies
Distinguished Guests
Friends
Ladies and Gentlemen: Good Morning

On behalf of the U.S. Agency for International Development, Office of U.S. Foreign Disaster Assistance, it is my pleasure and honour to welcome you to the 8th Annual Mekong Flood Forum (AMFF).

For those of you who I did not have a chance to meet yet, my name is Sezin Tokar. I am the hydrometeorological hazard advisor for OFDA.

The Office of U.S. Foreign Disaster Assistance, or OFDA, is the lead U.S. agency responsible for providing humanitarian assistance when lives are threatened by natural hazards or technical and human-caused catastrophes. In addition to disaster response, OFDA also supports disaster risk reduction activities to reduce the impact of recurrent natural disasters which lead to OFDA and Mekong River Commission (MRC) partnership since 2001.

Being in this podium brings pleasant memories. Five years ago, I welcomed the participants in my first participation to the Annual Mekong Flood Forum in the lovely city of Vientiane in 2005. It was so inspiring to see the motivation and energy for the basin-wide cooperation and participating in the discussions that I have not missed one single AMFF since then. As I remember, MRC was celebrating the 10th anniversary of the '1995 Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin,' which was signed by four riparian countries. The agreement marked a significant step in addressing river management and flood risk reduction on a basin-wide sustainable development. Congratulations on your 15th anniversary!

Floods, as you all well know, do not recognize national boundaries and early warning, and management and mitigation of floods can only be accomplished with a strong basin-wide cooperation. Therefore, AMFF and the Regional Flood Management and Mitigation Centre (MRC-RFMMC) are vital in reducing loss of lives and livelihoods due to floods. In addition, Mekong cooperation sets an example to other river basins around the world that trans-boundary cooperation on floods is possible.

In the 3rd AMFF, we were still mourning for tremendous loss of lives and significant social and economic impacts of an Indian Ocean tsunami, which affected some of the MRC Member Countries. Tragic experience of the Indian Ocean tsunami once again reminded us that disaster risk reduction also requires an integrated approach, which links various components of early warning systems from monitoring of natural hazards to actions at community level that allow feedback from users, stakeholders and populations at risk. In other words, it requires an end-to-end approach to flood early warning and mitigation. The weakest link in this end-to-end system is usually the dissemination of warnings and information to communities and limited capacity of

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population at risk to make use of these products to take appropriate actions. OFDA and MRC, in partnership with non-governmental organizations (NGO), supported a community-based flood management demonstration project in Cambodia to help strengthen this weak link that was also presented in the 3rd AMFF. The project was concluded a few years ago, which illustrated the importance of linking technology and information to communities to reduce vulnerability to floods. It is my pleasure to report that similar projects are being implemented by MRC in partnership with NGOs and donors in the region.

As we observed by the experiences of 2000-2001 Mekong floods and Indian Ocean tsunami, the most vulnerable populations, such as people living below poverty levels and marginal lands, are disproportionately affected by natural disasters. These experiences once again proved that disaster response and recovery can set back poverty reduction and sustainable development many years, and in some cases erode communities coping capacity completely with no chance of recovery. Therefore, flood early warning, preparedness, and mitigation are critical components of sustainable development and poverty reduction.

In 2005, we discussed the construction and establishment of the MRC-RFMMC. Today, the Forum is organized and flood forecasts are continuously issued by the MRC-RFMMC in Phnom Penh, Cambodia. OFDA and other U.S. Government (USG) agencies have been providing support to MRC on satellite precipitation estimation and forecasts in support of MRC flood forecasting efforts since 2001. We have initiated the use of remote sensing data to estimate precipitation. Precipitation is the main input to river and flood forecasting model, especially in areas where hydrometeorological networks are limited and transmission of data in real-time does not exist. In the 3rd AMFF, we also emphasized the importance of building capacity of MRC, national line agencies, communities, and partners. OFDA and MRC, in partnership with USG technical agencies, supported various training workshops to strengthen the capacity on rainfall estimation and forecasts, flash flood guidance, and dissemination of information to population at risk.

In the 3rd AMFF, we also discussed how flash floods are major threats to lives and livelihoods in the region in addition to river flooding. Flash flood vulnerability has been raised by many MRC Member Countries since the first forum. Today, I am glad to announce that the Lower Mekong Flash Flood Guidance System will be operational in the Lower Mekong Countries this rainy season. OFDA, National Oceanic and Atmospheric Administration *(NOAA),* World Meteorological Organization (WMO), and the Hydrologic Research Centre (HRC) have been collaborating on reducing the impact of flash floods in the region and around the world. We plan to continue our technical support through our implementing partners NOAA and HRC to support MRC and MRC Member Countries' efforts in fine tuning the operational use of the flash flood guidance system and continue to strengthen the capacity in the region so loss of lives due to flash floods is reduced in the basin this year.

In conclusion, there has been significant progress since my first participation in the Mekong Annual Forum. I congratulate MRC, especially the MRC-RFMMC staff, for their dedication and efforts to minimize the loss of lives due to floods. However, you are facing new challenges and difficult decisions. As Mr. Bird stated, one of the significant challenges of our life time is the climate change. Frequency and intensity of extreme meteorological events may be changing both temporally and spatially. We have limited knowledge on how climate change will affect precipitation, temperature patterns, and other meteorological and climatic characteristics in the basin and how these will affect the flow regime of the Great Mekong River. We need to improve our knowledge of potential impacts on hydrometeorology of the basin to adapt to our changing climate. There is a tremendous pressure for infrastructure development and increased demand for water in the basin for various purposes such as hydropower, navigation and irrigation, which may have significant impact on the ecosystem and environment. The Mekong

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is one of the river basins in the world that is naturally preserved. Finding the right balance between fulfilling the increasing demand for water and economic development and protecting the ecosystem and environment in the basin is a great challenge for the MRC and the MRC Member Countries. The activities to develop flood models, flash flood guidance system, and capacity building efforts will aid MRC and MRC Member Countries to understand the behaviour of the Great Mekong and analyze potential impacts of various pressures in the basin to be prepared for and adapt to these challenges while still preserving the Great Mekong.

I want to thank our gracious host Lao National Mekong Commission and the MRC for organizing and holding the 8th AMFF. I would like to extend my appreciation to MRC and MRC-RFMMC staff to continue organizing annual forums to strengthen trans-boundary cooperation to reduce vulnerability to floods. I would like to thank my partners from my home country U.S., USG agencies, U.S. Geological Survey, NOAA, and HRC and our partner WMO to make resilience to floods a priority. Last but not least, thank you to all of you: National Mekong Committees, National Meteorological and Hydrological Service and Disaster Management agencies, NGO partners, and communities for your participation, motivation and efforts to work to reduce vulnerability to flash floods, floods and other hydrometeorological disasters. We look forward to our collaboration with MRC in reducing vulnerability to floods in the region. I wish you a successful forum.

Thank you!

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OPENING STATEMENT

MS. PETRA SHILL

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

Her Excellency Ms. Khempheng Polsena, Minister to the Prime Minister's Office, Head of the Water Resources and Environment Administration, Chairperson of the Lao National Mekong Committee, and Member of the MRC Council for Lao PDR,

Jeremy Bird, Chief Executive Officer of MRCS,
Delegates from the Lower Mekong Basin countries,
Development Partners,

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 8th Annual Mekong Flood Forum.

It is encouraging to see such a large number of participants from such a variety of countries and regions and backgrounds. In previous years, the Annual Mekong Flood Forum (AMFF) has reliably provided the expert community from the Mekong region and beyond with an opportunity of networking, sharing and exchanging of state of the art knowledge and information. This exchange is becoming even more important, as the hydrological regime appears to be undergoing significant and unprecedentedly rapid changes.

It is here in Vientiane, in fact only 100 m away from this conference room, that indications of these changes could be eye-witnessed lately. Within the 18 months from August 2008 to February 2010, Vientiane has experienced the highest and the lowest water levels of at least the past five decades. Other parts of the Mekong basin have been affected strongly, too. While it continues to be debated what the causes for this massive fluctuation are - with dams, climate change and statistical extravaganza high on the list - this forum goes a step further and discusses the strategies to manage the risks deriving from these extreme events and the underlying potential uncertainty in ever-evolving hydrological patterns.

By a common definition, risk concerns the deviation of one or more results of one or more future events from their expected value. And while, technically speaking, risk incorporates both positive and negative results, it is commonly used to describe a state of uncertainty where some of the possibilities involve a loss, catastrophe, or other undesirable outcome.

In any river basin, uncertainties of the water level constitute risks for water users and people living along river banks. In a complex hydrological setting as that of the Mekong river basin with its unique seasonal pulse and the high dependency of the population on water and related resources the potential losses arising from these 'deviations from expected values', from these risks, are enormous. It is therefore that flood management always also is risk management and it is therefore that we commend the choice of this year's theme of the AMFF: 'Flood Risk Management and Mitigation'.

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As the end of this first phase of the MRCs Flood Management and Mitigation Programme is drawing close, there is an opportunity of including and addressing new risks, or old risks taking on a new quality. Regardless whether the recent events are caused by hydropower development, climate change, land-use changes or any combination of these events, few experts would contend that we are facing rapid changes and increasing uncertainties. A potential Flood Management and Mitigation Programme, phase 2 (FMMP-2) needs to tackle these issues through developing models and tools for the interfaces of flood management and hydropower development, flood management and climate change adaptation and so on. The German development cooperation is therefore delighted to see so many experts gathered to discuss these issues and help to shape the future of flood risk management and mitigation in the Lower Mekong basin.

Excellencies and distinguished delegates

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 information on the progress of the components of the Flood Management and Mitigation Programme (FMMP), as well as to design future activities in this field.

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 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 risk management at the level of affected communities from which viable lessons for the future of flood risk management can be derived. A recent summary of the ongoing impact monitoring showed that in target districts of awareness raising on disaster management, farmers practical knowledge on immediate emergency management in the event of floods has been significantly increased over recent years to a point where on average more than 90% of the necessary measures are known to farmers and households.

This is sort of risk management 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 Lao National Mekong Committee (LNMC), as well as the other National Mekong Committees and of course the dedicated individuals from the FMMP. I wish organizers and participants a fruitful and successful 8th Annual Mekong Flood Forum.

Thank you very much for your participation.

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ADB STATEMENT

MR. IAN MAKIN

Senior Water Resources Management Specialist Asian Development Bank (ADB), Manila, Phillippines

Mr Phonechaleun, Mr Bird, Colleagues,

Thank you for the opportunity to participate in the opening session of the 8th Annual Mekong Flood Forum. It is a great pleasure to join colleagues and friends for two days of discussion and learning about what is new in the field of flood management and mitigation and how new tools, techniques and approaches can be applied in the Mekong basin.

At the close of the 7th Flood Forum on Bangkok in 2009, it was noted that the value of the Flood Management and Mitigation Programme (FMMP) efforts to establish improved regional flood forecasts and warnings has been recognized. We concluded that the Regional Flood Management and Mitigation Centre of the Mekong River Commission (MRC-RFMMC) was reaching a stage of maturity where the data and forecasts it produces are more highly valued by the MRC Member Countries. We will hear in this Forum that the new forecasting model is expected to enter operational use in the 2010 flood season.

The 8th Flood Forum is the last that will take place under the Flood Management and Mitigation Program Phase I. It is an appropriate time for the members of the MRC to consider the progress that has been made in gathering together knowledge to manage and mitigate the impacts of the flood events that occur in the Mekong. It is also the time to look forward to determine how the communities in the basin can be best assisted to maximize the benefits provided by the floods and minimize the risks and hazards associated with the more extreme events.

The Asian Development Bank (ADB) has agreed to provide funds to assist MRC mobilize a formulation mission to design FMMP Phase II. An important outcome from that work will be the delineation of the core functions of the MRC-RFMMC, largely financed by the member countries, and the research and development tasks to be implemented by the FMMP Phase II, co-financed with the development partners. We look forward to proposals for innovative financing mechanisms to sustain the operations of the MRC-RFMMC, including secondment of member country staff to the centre; allocation of official development assistance to finance MRC-RFMMC support to national flood management and mitigation efforts; and possible mobilization of private sector finance for improved flood warnings.

ADB is working with MRC and the member countries to design investments to assist in the both structural and non-structural interventions to reduce the negative impacts of floods in the Greater Mekong Sub-region (GMS). The team working on the regional flood and drought management road map will make a presentation during the Forum. Over the next few months the tools developed by the FMMP Phase I will be used to identify and evaluate potential projects for investment projects to be implemented in 2011.

I look forward to two days of interesting papers and presentations. With climate change, increasing population and economic development, the potential for negative impacts from flood and drought events will continue to grow. The MRC FMMP, the national disaster response organizations, and forums such as this will continue to grow in importance.

Thank you

PAPERS OF THE INAUGURAL SESSION

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Paper 0-1

SUMMARY OF THE 7TH ANNUAL MEKONG FLOOD FORUM (AMFF-7)

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) convened the 7th Annual Mekong Flood Forum (AMFF-7) in Bangkok, Thailand on 13-14 May 2009, with the theme of *Integrated flood risk management in the Mekong River Basin*. About 120 participants coming from the 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 video show on the MRC Flash Flood Forecasting System and six 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 Optimal packages for flood management;
- II Recent developments in flood forecasting and early warning;
- III Effective approaches towards trans-boundary flood management; and
- IV Successful flood risk management approaches.

Based on the presentations and discussions more detailed recommendations were documented on 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 2008 and how they are improving their institutions and integrated flood risk management approaches. In addition there were several papers from the region that were based on new developments and approaches. There were a number of papers on flood risk mapping where good progress has been made and a number of papers based on international experiences and on-going developments that are of relevance for the region and that also put the developments within the region into a global perspective. At the end of the forum the participants adopted the Forum Statement. Through the Forum Statement the participants recognised that 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. The Statement has also included the theme for the 8th Annual Mekong Flood Forum (AMFF-8) 'Flood risk management in the Mekong River Basin', which was the basis for the formulation of the topics and the forum programme.

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. The two-day format, as well as the modified format for the programme that was introduced in this Forum seems to be appropriate; however, the tropics need to be well defined in light of the progress made within the MRC Member Countries and the FMMP with the aim for more involvement of the Civil Society Organisations (CSO);
- works for phase I of the FMMP will progress along the line as presented, with input from Forum results for further development and improvement with the anticipation of having the final outputs to be presented during the AMFF-8 before its completion in late 2010;
- during the 2009 flood season the new system for flood forecasting will be tested in operating mode. Based on the system performance evaluation decisions will be taken on introduction of the new system for flood forecasting in the MRC-RFMMC in close consultation with and acceptance of the MRC 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 flash flood watches and flash flood warning for the tributaries of the Mekong River. Towards this end the MRC-RFMMC has to closely work with the MRC Member Counties in order to ensure the proper development, capacity building and testing of the Mekong Flash Flood Guidance System (MRCFFGS), which is expected to take place in the 2010 flood season;
- 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 AMFF-8;
- 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 it may be useful to organise a special session where they present their approaches and practices;
- in the coming period discussions will take place on the follow-up of the FMMP from 2011 onwards. It is expected that initial ideas can be presented during the AMFF-8;
- ensure that in the next Forum there is better time management of the presentations.

INTRODUCTION

Flood risk 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 the impact 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 continuing to improve their flood risk management and mitigation by adopting an integrated flood risk management approach in which the capability of river flood forecasting and tributary flash flood guidance have been further enhanced. For the MRC Member Countries this also concerns early warning systems.

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 common 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 attended the Forum, as has become a common practice.

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 (IO), civil society organisations (CSO), institutions and companies, attended. There were 34 presentations in the plenary and parallel sessions, two Video shows on the MRC Flash Flood Forecasting System (MRCFFGS) and Flood Emergency Management Strengthening (FEMS) in the Lower Mekong River Basin (LMB) and six booths at the exhibition.

ENVISAGED OUTCOME

Based on the outcome of AMFF-7 the MRC-RFMMC and MRC Member Countries will be able to improve their integrated approaches to flood management. This implies improved database systems and tools for dissemination of flood forecasting and early warning products, application of flood risk assessment and management, 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, and the development of a regional flash flood early warning system.

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. 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.

OBJECTIVES

The objectives of the AMMF-7 could be summarised as follows:

- understand the progress each country has made with flood management and share lessons learned on previous year flood;
- share with MRC Member Countries and other interested stakeholders progress on the Components of the Flood Management and Mitigation Programme (FMMP);
- present progress of the new system on flood forecasting for the mainstream of Mekong River;
- review flood forecasting and early warning systems by MRC Member Countries and their interaction with MRC-RFMMC;
- exchange experience with the international community to have effective flood risk management approaches/strategies in MRB;
- enhance effective working arrangements to improve flood risk management of MRC member countries and MRC-RFMMC

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RESULTS OF THE AMFF-7

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 were 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 reports by the rapporteurs, several key points have been derived that are listed underneath:

- *2008 flood events:*
  - ∗ 2008 brought average floods in the mainstream of Mekong River with the exception of the upstream part where severe flooding occurred in Lao PDR and North-east Thailand. A separate report on the Vientiane Capital flooding was prepared by the MRC-RFMMC. The report was disseminated among the Forum participants. Otherwise, flood levels were similar to 1996. The flood was not so much caused by the 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 an inevitable natural phenomenon. However, some lessons need more attention to achieve better flood management and mitigation. They are as follows:
    - (1) 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;
    - (2) timely flood forecasting and dissemination as provided by the Department of Meteorology and Hydrology was helpful for making arrangements and preparing measures by each level of Government Line Agencies,
    - (3) strong political commitment is crucial for successful large-scale flood preparedness. Large-scale urban flooding was avoided principally due to the sandbagging of the river bank adjacent to the central business district, but large parts of suburbs and peri-urban areas were flooded to depths locally exceeding 1.5 m. The flooding has demonstrated a workable approach for large-scale flood management, with strong government commitment, public participation and ownership,
    - (4) improvements of data collection coverage are particularly needed over the north of Luang Prabang in Lao PDR in favour of accurate flood forecasting along the Mekong River. There is no standard format for assessing flood damages in Lao PDR, which could result in the misallocation of the resources for flood management and mitigation;
  - ∗ flash floods may be even more destructive than mainstream floods. In 2008 there were especially flash floods in Lao PDR, 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. The proportion to flood damage by sector was also 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.

During the Forum the approach and progress of each of the Components of the FMMP was presented and discussed. The major points are summarised underneath.

Component 1: Short and medium-term flood forecasting at the Regional Flood Management and Mitigation Centre

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 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 water levels were accurately predicted with the improved system. The new system is currently capable of producing medium-term forecasts (up to 10 days). However, there is a need for further development and continuous improvement in order to obtain more accurate forecasts.

Component 2: Structural measures and flood proofing

The structural measures and flood proofing Component has two main objectives:

- *to reduce the vulnerability of people living in the LMB to the negative impacts of floods*. This objective requires the preparation of concrete measures at the 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, 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 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.

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Component 3: Enhancing cooperation between Mekong River Commission (MRC) Member Countries in addressing trans-boundary flood and related issues

The objective of this Component is to strengthen cooperation and capacity of the NMCs and line agencies in addressing and resolving trans-boundary flood issues.

Under this Component numbers of key documents were 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, Legal Aspects of the Mandate of the 1995 Mekong Agreement for Enhancing Cooperation in Addressing Trans-boundary Floods and Related Issues (LA-MA95), and Explanatory Notes - Manual to the LA-MA95. The capacity building programme aims at to provide tailor–made training 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 started in March 2009 and completed in November 2009. Implementation of Phase 2 of the Capacity Building Programme is scheduled for 2010.

Component 4: Flood emergency management strengthening. People-centred approach in integrated flood risk management

This Component 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 ‘Emergency management systems in the riparian countries to more effectively deal with Mekong floods.’ The project provides assistance and technical support to disaster management (DM) authorities, particularly at the sub-national levels (provincial, district and commune) and in filling 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 sustainability of the FPP activities by integrating them into local development planning.

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.

Component 5: Flood information based land management (FIBLM)

This Component 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 risk 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 MRC Member Countries for an improved Flood information based land management (FIBLM).

Given the different conditions in each of the MRC Member Countries in terms of capacities and data available, the project supports each country to develop its own strategy and approach in FIBLM. 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, Lao PDR and Viet Nam and one in Thailand) along the Mekong River and in the Mekong floodplains.

Current land management practices are an important factor contributing to a situation where the regular floods of the Mekong River 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 risk maps at 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, which will help to avoid or at least minimize flood risks and damage along the Mekong River. So far flood risk maps have only been 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 data processing and data using line agencies in the four countries, includes components designed to show how the maps used singly or in combination can be analyzed in a Geographic Information System (GIS) application to answer complex planning questions related 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 further development of the new approach.

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.

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The key issues and outcomes of plenary session 1. *Lessons learned from 2008 flooding and national and MRC-RFMMC experiences with integrated flood risk management* and plenary session 2. *Towards integrated flood risk management in the Mekong River Basin* are summarised below.

Lessons Learned from 2008 Flooding and National and MRC-RFMMC experiences with Integrated Flood Risk Management

- special attention has been paid to quantify benefits and damages in relation to floods. There has been discussion on the results that were presented. We could understand from the authors that they have clarified their way of computation. In light of this the results are quite interesting and relevant for application, not only in relation to flood management, but also in relation to integrated river basin management;
- impact of the tropical storm Kammuri has been analysed and a separate report has been published.

Towards Integrated Flood Risk Management in the Mekong River Basin

- progress of the 5 Components of the FMMP programme was presented by staff and consultants of the RFMMC;
- forecasting of the flood due to the Kammuri tropical storm was a test of the new flood forecasting system;
- messages have to be in the right time at the right place. This requires careful preparation and coordination;
- Component 1 has to a large extent been implemented in practice. The other Components are not yet developed. Intermediate results are available, final results may be expected by the next Forum.

Plenary and parallel paper presentations and discussion

General:

- there were four papers presented, one on each topic;
- interesting application of flood simulation in Nan River Basin. Although simulations were made very carefully differences with observations up to 0.70 m were reported. This is valuable practical information for the MRC-RFMMC;
- there was an interesting overview of approaches to make flood forecasts, from very simple to very advanced. A new method is being developed, based on statistical analysis;
- development of the cooperation in the Rhine River Basin was presented;
- a new field was covered in the paper on insurance options for agriculture damage in relation to flooding.

Topic I: Optimal packages for flood management:

- a comparison of alternative flood mitigation measures based on an integrated hydrologic and hydraulic modelling approach to evaluate the effects of flood mitigation and management;
- ICHARM method for identification and assessment of risks from floods and other consequences for future development of flood prone areas;
- risk based flood management, taking into account possible impacts of climate change;
- the importance of a multi-sectoral and country specific approach.

Topic II: Recent developments in flood forecasting and early warning:

- papers give a good overview of the state-of the art and new developments with respect to data collection, modelling and preparation of forecasts in the region, as well as internationally;
- various points with respect to institutional and communication aspects were presented and discussed;
- an effective Digital Elevation Model (DEM) to enable the simulation of flooding in at least the key areas is needed.

Topic III: Effective approaches towards trans-boundary flood management:

- there were no papers submitted under this topic;
- a discussion was held on the relevant items, especially trans-boundary issues.

Topic IV: Successful flood risk management approaches:

- there was a range of papers on successful flood risk management approaches;
- non-structural measures for flood management and mitigation would have to receive more attention;
- stakeholder participation in the formulation of flood management measures is important as well as the dissemination of relevant messages to communities during flood events;
- special presentation by Dr. Quassem on *Experiences from practices in Bangladesh with integrated flood risk management practices.*

General remarks

- National Flood Reports have improved over the years and provide a better match with the role of MRCS/FMMP;
- flood risk assessment, mapping and flood risk management are commonly understood and presently accepted approaches and methodologies for MRC Member Countries. This offers good possibilities for enhancing cooperation in trans-boundary flood risk management and mitigation in LMB;
- cooperation in flood forecasting and sharing of data and information has made significant progress;
- there is much more awareness of 'lessons learned' and 'good practices' to design adequate measures to reduce flood risks in LMB;
- the possibilities of modern technologies (national scale) seem to better complement some limitations of traditional technologies (local scale) in LMB.

FOLLOW-UP

Three types of follow-up actions were formulated: follow-up directly after the Forum, recommendations for the 8h Annual Mekong Flood Forum (AMFF-8), and more comprehensive follow-up actions.

The main theme for the 8th Annual Mekong Flood Forum was provisionally proposed as:

'Flood risk management and mitigation in Mekong River Basin'

This provisional main theme, the status of the FMMP programme and actual topics of joint interest to the MRC Member Countries and Dialogue Partners have been the basis for the formulation of the provisional topics and the tentative programme for (AMFF-8). Keeping in mind the rotation of the venue for the next Forum, the 8th Forum will be held in Vientiane, Lao PDR.

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The more comprehensive follow-up actions discussed were:

- continue with annual flood forums, based on actual topics of joint interest of the MRC Member Countries and Dialogue Partners. The two-day format, as well as the modified format for the programme that was introduced in this Forum seem to be appropriate. However, the topics need to be well defined in light of the progress made within the MRC Member Countries and the FMMP with the aim for more involvement of the CSOs;
- work for phase I of the FMMP will progress along the line as presented, with input from Forum results for further development and improvement with the anticipation of having the final outputs to be presented during the AMFF-8 before its completion in late 2010;
- during the 2009 flood season the new system for flood forecasting will be tested in operational mode. Based on the system performance evaluation decisions will be taken on introduction of the new system for flood forecasting in the MRC-RFMMC in close consultation with and acceptance of the MRC 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 flash flood watches and flash flood warning for the tributaries of the Mekong River. Towards this end the MRC-RFMMC has to closely work with the MRC Member Counties in order to ensure the proper development, capacity building and testing of the MRCFFGS, which is expected to take place in 2010 flood season;
- developments towards integrated approaches to flood risk management and mitigation are on-going both in the MRC-RFMMC, as well as in the MRC Member Countries. For example, in flash flood forecasting, warning and management. It will be important that papers by the MRC Member Countries on these issues will be prepared for and presented during the AMFF-8;
- it will be important that the flood forecasters of MRC-RFMMC and the National Line Agencies of the MRC Member Countries cooperate more closely. It may be useful to organise a special session where they can present their approaches and practices;
- in the coming period discussions will take place on the follow-up of the FMMP from 2011 onwards. It is expected that initial ideas can be presented during the AMFF-8;
- the next Forums need better time management of presentation.

FORUM CONCLUDING SESSION

The concluding session started with presentations of the summary of the proceedings of the Seventh Annual Mekong Flood Forum by the forum facilitator. At the end of the Forum the participants adopted the Forum Statement through which 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. The participants also recognised that 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 populations more vulnerable to floods. 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.

Finally, the concluding session ended with a note of thanks to the organising staff of the MRC-RFMMC and the Thai National Mekong Committee (TNMC) by the Chief Technical Advisor of the Flood Management and Mitigation Programme (FMMP-CTA) and the concluding speech of the Assistant CEO of the MRCS.

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Paper 0-2

OBJECTIVES AND EXPECTED OUTCOMES OF THE 8^{H} ANNUAL MEKONG FLOOD FORUM (AMFF-8)

LAM HUNG SON[1] AND NICOLAAS BAKKER[2]

[1] *Programme Coordinator, Flood Management and Mitigation Programme (FMMP), Mekong River Commission (MRC), Phnom Penh, Cambodia*
[2] *Chief Technical Advisor, Flood Management and Mitigation Programme (FMMP), Mekong River Commission (MRC), Phnom Penh, Cambodia*

ABSTRACT

Under the MRC umbrella, the Regional Flood Management and Mitigation Centre (MRC-RFMMC) has been established in 2005 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 a timely and effective dissemination; and providing accurate, well documented and consistent tools for basin-wide flood risks 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 DPR, 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 Mekong River Commission (MRC) has successfully organized seven Annual Mekong Flood Forums with the following themes ‘Flood Preparedness’, ‘Information Flow, Networking and Partnership’, ‘Flood Management and Mitigation in the Mekong Basin’ and ‘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’, ‘Integrated approaches and applicable systems for medium-term flood forecasting and early warning in the Mekong River Basin’, ‘Integrated Flood Risk Management in the Mekong River Basin’ respectively.

As an annual event of the MRC-RFMC, the 8th Annual Mekong Flood Forum was held on 26 – 27 May 2010 under the theme ‘Flood Risk Management and Mitigation 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 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 and mitigation 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, infrastructure development 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.

More specifically, the 8th Annual Mekong Flood Forum is set to discuss the following aspects:

- lessons learned based on the 2009 floods by the concerned line agencies of the MRC Member Countries;
- achievements, progress and future outlook with respect to the five components of the Flood Management and Mitigation Programme (FMMP), being: *1. Establishing a Regional Flood Management and Mitigation Centre; 2. Structural measures and flood proofing 3. Enhancing cooperation in addressing trans-boundary flood and related issues 4. Flood emergency management strengthening. 5. Land management*;
- current status of and future outlook on flood risk management and mitigation approaches and measures;
- experiences with the Flood Forecasting System (FFS) of the Mekong River Commission Secretariat (MRCS) and systems for flood forecasting and early warning in use and under development by the National Centres. To keep the MRC Member Countries, their concerned line agencies and CSOs informed about the progress with respect to the MRC-RFMMC flood forecasting database system, as well as the exchange of data and data sharing among the MRC Member Countries and the MRC-RFMMC, which is essential for operational medium-term flood forecasting for the mainstream of the Mekong River, based on basin wide rainfall and water level data availability;
- experiences and best practices with CSOs, International Organisations (IO), academic institutions, consultants, manufacturers on the various elements of flood risk management and mitigation. To strengthen cooperation and information exchange among the international community, IOs and CSOs;
- information on the requirements that the different types of land use and various types of measures pose to flood risk management and mitigation in the conditions of the Mekong River Basin;
- information on to what extent integrated flood risk management results in information that enables institutions or individuals to take the best possible measures to reduce damage and number of casualties;
- how lessons learnt from the flood season 2008 and subsequent Action Plan was implemented in 2009.

The Forum will be very result oriented to assure that it really benefits the MRC-RFMMC and MRC member countries for their improved services of flood risk management and mitigation and especially the provision of flood information and early warning systems to the vulnerable communities in the Lower Mekong River Basin (LMB). The goal is that the countries will use the Annual Mekong Flood Forum as a platform to review and improve their own flood policies, plans and implementations.

INTRODUCTION

Alarmed by the devastating floods of the year 2000, the Council of the Mekong River Commission (MRC) through its Secretariat (MRCS) formulated a Strategy on Flood

Management and Mitigation, which was the basis for much stronger 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) was established.

After an extensive consultation process was made through national meetings, discussions and donor appraisal; when funding was secured, all stakeholders were ready to take FMMP from its inception phase into full scale operation in 2006.

Presently, the MRC-Regional Flood Management and Mitigation Centre (MRC-RFMMC), which is located in Phnom Penh, 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 a timely and effective dissemination; and providing accurate, well documented and consistent tools for basin wide flood risks assessment and trans-boundary impact assessment.

The MRC has taken the lead in organizing the Annual Mekong Flood Forum, which is an annual event. In May 2010, the MRC-RFMMC organized the 8th Annual Mekong Flood Forum around the theme '*Flood Risk Management and Mitigation in the Mekong River Basin'*. The themes of previous years have included:

- *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,*
- *Integrated Approaches and Applicable Systems for Medium-term Flood Forecasting and Early Warning in the Mekong River Basin,*
- *Integrated Flood Risk Management in the Mekong River Basin,* respectively.

MAIN EXPECTED OUTCOME

Based on the outcome of the 8th Annual Mekong Flood Forum, the MRC-RFMMC, MRC Member Countries will be able to improve their integrated approach to flood management and mitigation. This implies improved data and information exchange, improved systems and tools for dissemination of flood forecasting, flash flood guidance and early warning products, improved application of a flood risk assessment and management, the development of guidelines for preparation of flood risk reduction plans and for evaluation of the impacts of flood risk reduction and management measures, strengthened identification of potential trans-boundary issues for negotiation, mediation and conflict prevention.

OBJECTIVES

The *Development objective* of this programme is to prevent, minimise or mitigate taken from the FMM Strategy '*People's suffering and economic losses due to floods 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.

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The *Immediate objective* of this programme, which describes how the target group will use the outcome of the programme to achieve the development objective, has been identified as:

'Based on the outcome of the 8th Annual Mekong Flood Forum, the MRC-RFMMC, MRC member countries, CSOs and IOs will be able to improve their services, and strengthen their capability and collaboration mechanisms for improving flood risk management and mitigation practices in the LMB in order to better address the aspects of human security due to floods, development and environment'.

More specifically, the 8th Annual Mekong Flood Forum is set to discuss the following aspects:

- lessons learned based on the 2009 floods by the concerned line agencies of the MRC Member Countries;
- achievements, progress and future outlook with respect to the five components of the Flood Management and Mitigation Programme (FMMP), being: *1. Establishing a Regional Flood Management and Mitigation Centre; 2. Structural measures and flood proofing 3. Enhancing cooperation in addressing trans-boundary flood and related issues 4. Flood emergency management strengthening. 5. Land management*;
- current status of and future outlook for flood risk management and mitigation approaches and measures;
- experiences with the Mekong River Flood Forecasting System and systems for flood forecasting and early warning in use and under development by the National Centres. To keep the MRC Member Countries, their concerned line agencies and CSOs informed about the progress with respect to the MRC-RFMMC flood forecasting database system, as well as the exchange of data and data sharing among the MRC Member Countries and the MRC-RFMMC, which is essential for operational medium-term flood forecasting for the mainstream of the Mekong River, based on basin wide rainfall and water level data availability;
- experiences and best practices with CSOs, International Organisations (IO), academic institutions, consultants, manufacturers on the various elements of flood risk management and mitigation. To strengthen cooperation and information exchange among the international community, IOs and CSOs;
- information on the requirements that the different types of land-use and various types of measures pose to flood risk management and mitigation in the conditions of the Mekong River Basin;
- information as to what extent integrated flood risk management results in information that enables institutions or individuals to take the best possible measures to reduce damage and number of casualties;
- how lessons learnt from the flood season 2008 and subsequent Action Plan were implemented in 2009.

The Forum will be very result oriented to ensure that it really benefits the MRC-RFMMC and MRC Member Countries for their improved flood risk management and mitigation services; 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 Forum as a platform to review and improve their own flood policies, plans and implementations.

FORUM TOPICS

Under the proposed theme the 8th Annual Mekong Flood Forum will be structured and organized with the following topics.

Topic I: Community focused approach to flood risk management and mitigation

Flood preparedness and emergency management of local authorities and communities is at the forefront of flood disaster management. This non-structural community approach forms an important part of flood risk management and mitigation, which is only recently being applied in the LMB. Programmes of enhancing the competence of civil authorities at various levels, emergency managers and communities in flood preparedness and mitigation will ultimately help facilitate emergency management systems in the riparian countries to more effectively deal with Mekong floods. Therefore assistance and technical support to disaster management authorities, particularly at sub-national levels (province, district and commune) may help to fill the gaps and needs of existing systems. Local disaster management authorities may take the lead in the development and implementation of flood preparedness programs in which clear roles and responsibilities are defined for each line department of provincial, district and commune disaster management offices. Various innovative approaches to flood risk reduction can be carried out in support to flood preparedness programmes, including promoting local, national and regional knowledge sharing, trans-boundary province-to-province cooperation in flood emergency assistance, and in ensuring sustainability of flood preparedness programme activities by integrating them into the local development planning process. People-centred approaches are generally low-cost, effective, and relevant to local conditions in a flood prone area. Ownership may gradually evolve and sustainability can be secured step-by step. Under this topic papers were invited that present approaches and experiences of a community focused approach to flood risk management and mitigation.

Topic II: Flood forecasting and flash flood guidance

The meteorology, the weather forecast and the conditions in the river basin create the basis for producing flood forecasts and early warnings. 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 river flow modelling and finally the issuing of forecasts. In case of the Mekong River Basin most of the data is collected by 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 and timely provision of the data. The 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. Analysis and evaluation of extreme flood situations (such as in August 2008) generated a range of measures to strengthen the provision and dissemination of data and information as well as the coordination between MRC-RFMMC and the National Centres. In addition to floods in the mainstream, flash floods usually occur in the tributaries, especially in sloping and urbanised areas. The preparation of forecasts for flash flood requires quite different ways of data/information collection and forecasting mechanisms. With respect to these two aspects a wide range of new developments need to be employed such as weather models, satellite technology, remote sensing techniques, global positioning systems, geographic information systems, automation in data collection, transmission, storage and retrieval, and actual issuing of the forecasts and warnings. The applicability of new developments for the conditions of the Mekong River and its tributaries will be an important aspect of this topic. Papers on new developments and successful experiences were invited under this topic.

Topic III: Structural measures and flood proofing

The main objective of structural measures and flood proofing in the LMB is to reduce the vulnerability of people living in the LMB to the negative impacts of floods. This requires the preparation of concrete measures at all steps that are crucial for a socio-economic and environmentally sound flood risk management by applying the most attractive mix of possible measures, hard and soft, for the reduction of flood damage risk. This generally requires 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. Under this topic papers were invited that present methods of and experiences with structural methods of flood proofing.

Topic IV: Trans-boundary cooperation for managing floods and related issues

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, became under such conditions measures taken in one country may easily have a negative impact downstream. Under certain conditions measures in a downstream country may even have impacts in an upstream country. In several river basins experience has been, or is being obtained with approaches to regional cooperation. In light of the on-going developments in the Mekong River Basin 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. Papers on experiences with effective approaches towards trans-boundary flood management were welcome under this topic.

Topic V: Land use and climate change impacts on flood management

Rapid population growth, a significant increase in agriculture, urbanisation and industrialisation may be observed in most of the lowland, flood-prone areas. In addition there may be impacts of land subsidence and climate change. Although the changes due to these processes may be of different speed and magnitude, they all result in an increase in vulnerability for extreme weather conditions and the requirement for an increase in measures to be taken with respect to flood management. Therefore countries would have to develop a strategy and approach with respect to flood probability based land management. Current land management practices may be an important factor contributing to a situation where already regular floods may cause substantial damage to agriculture, buildings and infrastructure. More effective decision making in these fields, as well as disaster management, requires on the one hand the provision of more relevant and accurate flood related information and on the other hand how conditions with respect to flood vulnerability may change in the short and longer term future under the influence of the impacts of the changes as mentioned above. 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. Under this topic papers were invited that present cases where experience has been obtained with the impacts of land use and climate change on flood management.

PAPERS

SESSION 1

LESSONS LEARNED FROM 2009 FLOODING AND NATIONAL AND MRC-RFMMC EXPERIENCES WITH FLOOD RISK MANAGEMENT AND MITIGATION

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Paper 1-1

CAMBODIA COUNTRY FLOOD REPORT FOR 2009

SOK BUN HENG

National Flood Expert, National Flood Unit, Cambodia National Mekong Committee, Phnom, Cambodia

ABSTRACT

A large part of the floodplain of Mekong River, one of the international rivers in Asia, is located in Cambodia. Annual recurrent floods of the Mekong River bring Cambodia fertile silt into the floodplain for agriculture production, feeding the food chain for fisheries, providing water supply for people living along the river side, providing navigation routes and necessary environmental functions, but extreme floods usually caused severe damage and suffering, especially to people living in low lying areas.

Mekong floods in 2009 were considered as normal floods, they brought more benefits rather than destruction. They caused little damage compared to previous years. The observed water level at all mainstream stations along the Mekong, Bassac and Tonle Sap rivers in Cambodia were lower than the alarm level.

Beside extreme floods of Mekong River, which can cause severe damage, flash floods caused by heavy rainfall resulted in other bad events during recent years. This year Cambodia was affected two times by flash floods. During the first half of September 2009 some part of Cambodia was covered by low pressure that produced heavy rainfall and caused damage to about 6,700 ha of rice, 30 houses, killed 13 people, and damage to others and to infrastructure. During the last week of September 2009 the Typhoon Ketsana hit Cambodia and caused flash floods to a large part of Cambodia and damaged about 60,000 ha of rice, 2,000 houses, affected 80,000 families, killed 43 people and damaged some other infrastructure.

Government together with its partners and civil society organisations (CSO) has been working very hard to provide all kind of flood management and mitigation services to the affected people. Moreover, recognizing the effect of climate change on the flood situation, Cambodia is working locally and with the international community to address climate change issues.

The report intends to present an overview of flood and drought characteristics of the country, reports on the lessons learned from the 2009 floods and provides recommendations for better management of floods so that their negative effects can be minimized and at the same time positive effects can be maximised.

INTRODUCTION

In general, Cambodia can be affected by two main types of floods: Mekong floods which are caused by cumulative rainfall in the upper river basins throughout the rainy season and most severe floods that are the results of tropical storms and depressions affected by typhoons. The Mekong flood is slowly but steady rising, especially near the peak and last for several days. Flash floods, caused by heavy rainfall from tributaries are swift and have flash flood characteristics. They last only for a few days, but often cause severe damage to crops and

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infrastructure, especially for tributaries around the Tonle Sap Great Lake and eastern tributaries of the Mekong.

The Mekong floods provide important benefits for socio-economic development of the country as they carry and distribute fertile silt into the floodplain feeding an important food chain for fisheries and fertility for agricultural production, provide water supply for people living along the river side, navigation route and environmental cleaning function. However, extreme Mekong floods have caused severe damage and suffering to millions of people living in the low lying areas, they damaged communication infrastructure such as roads and bridges, and caused long periods of live disruption. Population density in the area along Mekong River and around Tonle Sap Great Lake as well as in other floodplains, although these areas can be flooded every year, is higher than in highland areas. People living along the Mekong River have adapted themselves to the rhythm of the Mekong flood. Their live styles are also organized according to the rhythm and magnitude of the floods.

In addition to Mekong flood or flash flood caused by heavy rainfall, drought is another risk for crop production for rainfed cropping due to little rainfall.

Some forms of flood forecasting services have been established at national level with support and cooperation of the Regional Flood Management and Mitigation Centre (MRC-RFMMC), and initiatives on flood warning and flood preparedness have started and bring flood information to and from the provincial, district, commune and village level in most vulnerable provinces of the country. However, there is little focus on analysis of cost and benefits of floods and lack of proper records of actual damage by floods. Therefore, more efforts are needed in order to build the capacity for people to rely on themselves to reduce the risks of floods.

The report intends to present an overview of flood and drought characteristics of the country, it reports on the lessons learned from 2009 floods and provides recommendations for better management of floods so that their negative effects can be minimized and at the same time maximize the positive effects.

OVERVIEW OF THE 2009 FLOODS AND FLOODING

Mekong floods

In Cambodia, Mekong floods in 2009 can be considered as normal floods, with more benefits and less damage compared to floods in other years. Damage by Mekong floods was very small. Compared with floods in previous years, as shown in Figures 1, 2 and 3, with the wettest years in 2000 and 2001 and the driest year in 1998, floods in 2009 can be considered as mild floods with observed water levels at all mainstream stations along the Mekong, Bassac and Tonle Sap rivers in Cambodia - except at the Bassac-Koh Khel where the peak was 0.13 m higher than the alarm level - lower than the alarm level (Table 1). Flood peak value at Mekong-Stung Treng station occurred on October 5 with peak value of 10.56 m+MSL (Mean Sea Level) while the flood peak at this station in 2008 occurred on August 9 with a peak value of 9.90 m+MSL.

However, during the last week of September, Cambodia got affected by the Typhoon Ketsana that caused flash floods in some places and water level at some stations rised very fast. In only 1 day the water level did rise about 2.69 m at Lumphat-Sre Pork, 4.48 m at Se San-Veunsai, and 3.54 m at Sekong-Siempang stations as shown in the Figures 1, 2 and 3.

According to the above figures, the flood in 2009 was below the Warning/Alarm level: with -0.14 m at Stung Treng, -0.56 m at Kratie, -0.04 m at Kompong Cham,-0.58 m at Chaktomuk, -0.28 m at Neak Loung, +0.13 m at Koh Khel and -0.44 m at Prek Kdam. The maximum water

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levels this year were higher than in 2008. Only at Bassac-Koh Khel the level was higher than the Alarm level with 0.13 m. With reference to long-term observations, the 2009 flood is somehow similar to the long-term annual average flood.

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

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

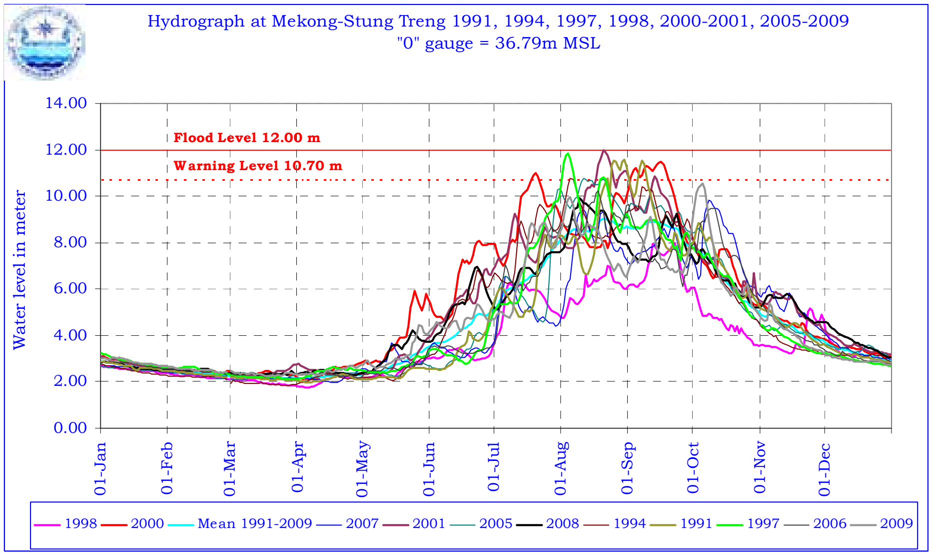


Figure 1. Hydrograph at Mekong-Stung Treng in 1991, 1994, 1997-1998, 2000-2001, 2005-2009

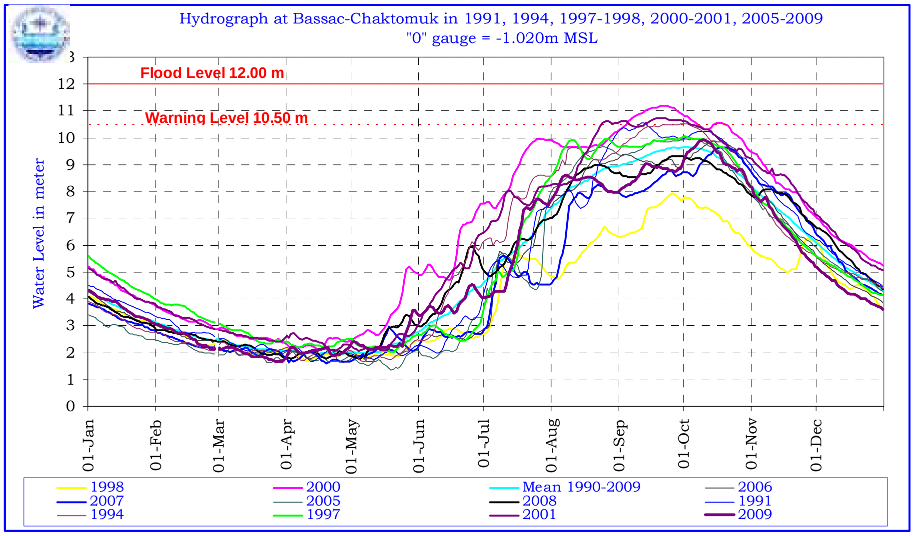


Figure 2. Hydrograph at Bassac-Chaktomuk in 1991, 1994, 1997-1998, 2000-2001, 2005-2009

Table 1. Annual maximum water levels in m+MSL at Mekong, Bassac and Tonle Sap rivers, 1991-2009

Maximum Water Level along Mekong, Bassac and Tonle Sap rivers in 1991-2009														
Station Name	Stung Treng		Kratie		Kampong Cham		Chak Tomuk		Neak Loung		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-3Sep	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	29Sep	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
2009	10.56	05 Oct	21.44	6 Oct	15.16	07 Oct	9.92	9 Oct	7.22	10 Oct	7.53	10 Oct	9.06	11 Oct

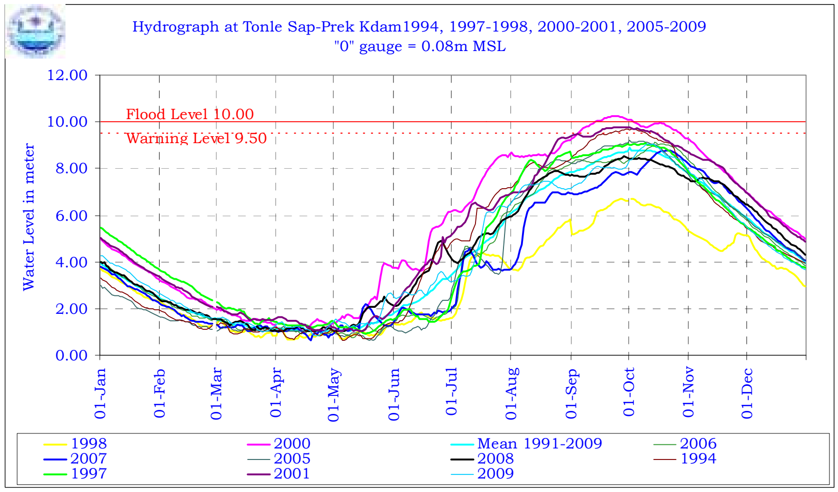
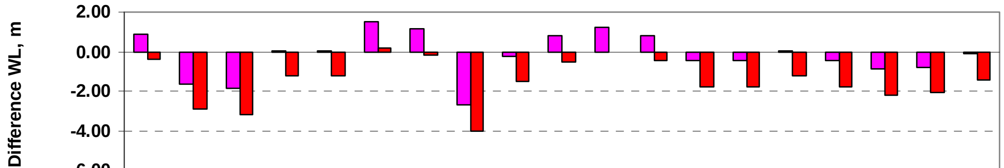


Figure 3. Hydrograph at Tonle Sap Great Lake -Prek Kdam in 1991, 1994, 1998, 2000, 2001, 2005, 2009



	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
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	-0.14
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	-1.44

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

The Tonle Sap Great Lake

The Tonle Sap 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. The Lake is the biggest water lake in Southeast Asia with its volume and flooded areas fluctuating on an annual basis. Normally the lake water level reaches its peak during the period of heavy rainfall in the Tonle Sap Great Lake sub-basins. The Tonle Sap 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. Water level in the Lake fluctuates between wet and dry season by about 7 to 8 m. The lake water level in 2009 reached its peak during 15-19 October with a water level of 8.59 m+MSL. Figure 5 shows the hydrographs of water level in the Tonle Sap Great Lake in 2009 compared with the previous years 1999, 2000, 2001, 2002, 20054, 2006, 2007, and 2008.

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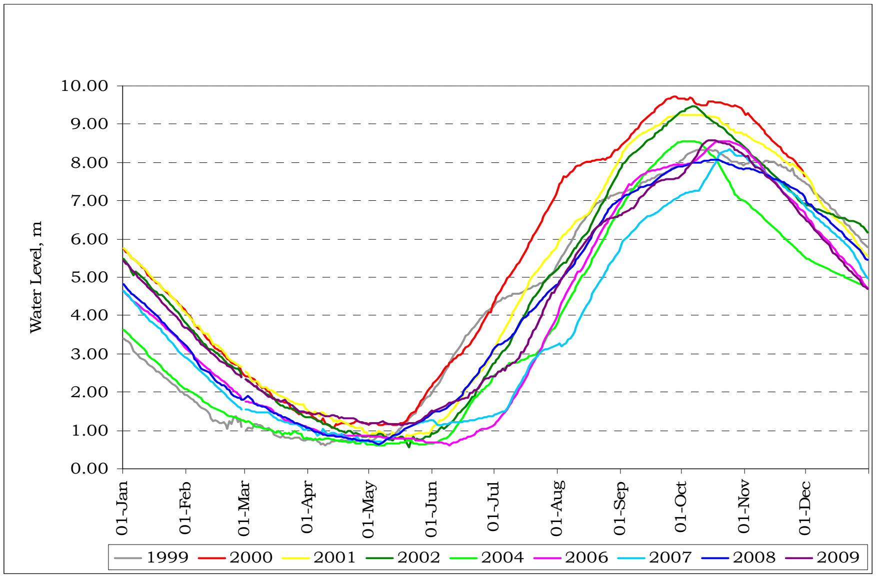

Figure 5. Hydrograph at Tonle Sap Great Lake -Kg Loung in 1999, 2000, 2002, 2004, 2006, 2007, 2008 and 2009.

Flash Floods in 2009

In 2009 Cambodia got affected by two main flash floods. The first flood occurred during early September. The second flash flood occurred during the last week of September due to influence of Typhoon Ketsana and caused flash floods in some places. The most affected provinces during Typhoon Ketsana were Preah Vihear, Kampong Thom, Bantay Meanchey, Odormeanchey, Ratanakiri, Modulkiri, Stung Treng, Kraties Kampong Cham, Siem Reap, and Battambang. These flash floods caused severe damage to crops, houses and infrastructure and killed also people (Table 2).

Table2. Damages by flash floods in 2009

Description	First flash flood (early Sept.)	Second flash flood (Ketsana) (late Sept.)	Total damage in 2009
Households affected	15,729	83,542	99,271
House damage	30 houses	1,222 houses	1,252 houses
People affected		342,522	342,522
People killed	13	43	56
Roads affected		479 km	479 km
Schools and pagoda		1,169	1,169
Dykes and canals	7	102 sites	109 sites
Bridges	50 m		50 m
Animals		341	341
Rice and other crops (drought)		52,414 ha	52,414 ha
Rice and other crops (flood)	6,729 ha	54,542 ha	61,271 ha

Source: National Committee for Disaster Management

Picture 1. Flash flood in Kampong Thom on 1 October 2009

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 better preparedness will help to reduce considerably damages 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;
- capacity of the responsible organisation is very limited, usually activities stop after completion of a project supported by external funding;
- flash floods are even more destructive as it are rare events and the country still lacks human and financial resources, capacity. The methodology for flash flood forecasting is still new for responsible institutions;
- lack of continuity and technical expertise to assess cause-and-effect relationships

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) 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 them to communities. Under the Flood Management and Mitigation Programme (FMMP) of MRC Training of Trainers (TOT) on the flash flood guidance system was provided to relevant institutions. DHRW is working together with other concerned agencies on how to proceed with the system.

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 MRC-RFMMC in forecasting and dissemination of flood information. The DHRW's forecasting time is only three days.

There are about 40 stations serving for hydrological data collection in the country. At the moment, only 7 stations are operational due to the lack of operation and maintenance funds. Those 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. For flood forecasting data on rainfall and water levels of the 7 hydrological stations are transmitted real time to DHRW of the Ministry of Water Resources and Meteorology (MOWRAM) in Phnom Penh before 7:00 hour by telephone. Usually data are collected and transmitted twice a day at 7:00 hour and 19:00 hour. 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, approved and then send to mass media, line agencies concerned and the end-users by fax, around 9:00 hour everyday to about 60 users.

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

Under Component 5 of the FMMP, DHRW installed additional 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 Development, Office of Foreign Disaster Assistance (OFDA) with the aims to resume the activities implemented under a previous project. Cell phones were provided to communities for exchange of flood information between DHRW and communities.

Recently forecasting by DHRW was limited to only major mainstream stations along 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. The current data collection system is not sustainable and limited to the mainstream stations only, which is mainly supported by the MRC program. Only some stations can keep proper records with limited funds of the Provincial Department of Water Resources and Meteorology (PDWRAM).

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 forecast done by DOM is mainly based on information obtained from Internet and the forecast is limited to simple description of weather and temperature conditions.

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.

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 develops preventive measures to protect or reduce the effect of the disasters. NCDM used to work closely with 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 over the role of the CRC in terms of warning and dissemination of flood information. Under Component 4 of FMMP, the project to support the implementation of Flood Preparedness Program of MRC-RFMMC, the Provincial and District Committees for Disaster Management (PCDM and DCDM) of the provinces along the Mekong River 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.

Assessment of flood damage is usually aggregated at provincial level with data and information provided from communes and villages. The provincial areas are generally too large leading to data and information on the actual damages which are not really reliable. The PCDM then sends their annual report to NCDM, which will be later on compiled as national disaster report. There is no proper method to assess the actual damages due to floods. The assessment of losses concerns mainly the most direct economic loss and excludes the recovery cost, cost for replacing damaged means of production and infrastructure and other indirect cost.

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 CSOs 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, 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) of the Ministry of water Resources and Meteorology (MOWRAM) 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 plans to provide forecast and early warning services to the target villages in two districts with technical and financial assistances from Component 5 of the FMMP, but most likely, there will be no possibility to so do for other areas.

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

However, due to the lack of capacity and financial support, the forecasts 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 Tonle Sap 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 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 would have to 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 preparedness programmes and provide them with appropriate training to help them with better understanding of flood related issues.

ACTIVITIES AND ISSUES WITH RESPECT TO THE THEME AND TOPICS OF THE 8TH FORUM

Theme: Flood risk management in the Mekong River Basin

Topic I. Community focused approach to flood risk management and mitigation

To cope with great losses of infrastructure, property and live 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 (DHRW) and Department of Meteorology (DOM). Two other main institutions dealing with dissemination of flood forecasts and early warning and flood preparedness and response are the National Committee for Disaster Management and the Cambodia Red Cross.

At the moment, the NCDM coordinates 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 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 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. The goal of the CBDP program is ‘to reduce the impact of disasters on the most vulnerable people affected by disasters in Cambodia’.

The CRC’s 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 field 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.

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. The Disaster Reduction Plans (DRP) will also be integrated into the CBDP activities across the country.

Topic II. Flood forecasting and flash flood guidance

The Department of Hydrology and River Work (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 uses also weather forecasts from the Department of Meteorology to adjust its flood forecasting. The DHRW also exchanges data and information between countries in the Lower Mekong River Basin though MRCS by using e-mail and internet system. DHRW receives MRC’s flood forecasting products by e-mail and also sents back to MRC-RFMMC its Flood Forecasting Bulletin by fax.

The Department of Meteorology (DOM) is responsible for meteorological data collection and weather forecasting. Although weather forecasting is limited, based on information obtained from Internet and the forecasts are limited to simple description of weather and temperature conditions, they also can serve as complementary information for flood forecasting.

DHRW and DOM recently received training on the flash flood guidance system organized by FMMP. They are now working on how to operate the system.

Topic III. Structural measures and flood proofing

Efforts have been made through policies, strategies, plans and projects to cope with the negative effects of floods, 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 which was approved by the Council of Ministers on 16 January 2004 and ratified by the National Assembly in June 2007. Two key policy statements regarding flood proffing are:

- Phnom Penh and other localities with a high concentration of people and or economic assets will be fully protected against flooding;
- all public facilities will be constructed above the estimated 50-years flood level in the particular locality, and will be provided for unimpeded drainage.

Following the policy statement, there are many activities being implemented with respect to flood management and protection.

However, only the capital city of Phnom Penh has proper flood protection structures, almost all towns have no proper structural works to protect them from flooding, although there some forms of structural measures for flood protection in place (floodwalls), especially in towns along Mekong River and some towns around the Tonle Sap Great Lake. 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 water issues.

Under Component 2 of FMMP knowledge of structural measure has been build for some technical staff of the institutions concerned. Some projects also have been formulated.

Topic IV. Trans-boundary cooperation for managing floods and related issues

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. Cambodia has already been working with its neighbour country to find optimum ways for flood management in order 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 states including exchange visits of Heads of Government, joint commissions and committees, local authorities meetings, and applications of disaster risk reduction (DRR) mechanisms. 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 V. Land use and climate change impacts on flood management

Data and information on land use is one of the essential parts for better flood forecasting and early warning. Detailed studies for flood management and mitigation require good quality topographic data. In Cambodia agriculture is the predominant land use. To secure production from planting of recession rice and others crop after the flood season in the Tonle Sap Great Lake areas and in the floodplain seasonal forecast of the expected flood is more relevant while water level flood forecast is more useful for areas that potentially may suffer from flooding. In Cambodia, due to the lack of financial and human resources, very little data and information on land use and topographic data exist, only in some areas. Under Component 5 MRC-RFMMC flood probability maps for three districts in three provinces along the Mekong were produced.

The Ministry of Land Management, Urban Planning and Construction is responsible for commune land use planning, land title and master planning, but there is little consideration on flood mapping and/or flood risk management. To achieve better flood forecasting and early warning there is a need to conduct topographic survey, prepare land use maps and collect relevant hydrological data. Moreover, coordination and cooperation between the institution responsible for land use planning and the institution responsible for flood forecasting and early warning need to be strengthened.

Based on the past five year data, rice production loss in Cambodia was mainly due to the occurrence of flood (more than 70%), followed by drought (about 20%) and others such as pest and diseases (10%). Based on field observations, flooding mostly occurred due to the increase in water levels of the Mekong River and Tonle Sap Great Lake. These two water bodies are linked to each other. The Mekong River starts from the Tibet Plateau. The increase of water level in the Mekong River s closely related with the rainfall throughout the Mekong River Basin. This might explain why the flood occurrence was not always related with Cambodian rainfall. Some studies indicate that under changing climate intensity and frequency of flood events might increase.

According to a study by the Ministry of Environment on the vulnerability and adaptation assessment to climate change in Cambodia, Koh Kong Province, which covers over 64% of the coastal zone (11,160 km2), is the most vulnerable to the impact of sea level rise. The study indicated that if the sea level rises by 1 m, about 0.4% (4,444 ha) of the area would be under water.

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

- 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 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 of the Ministry of Water Resources and 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 operation 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 at flood risk 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. 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.

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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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Paper 1-2

LAO PDR COUNTRY FLOOD REPORT FOR 2009

VIRANA SONNASINH

National Flood Expert, National Flood Unit, Lao National Mekong Committee Secretariat
Water Resources and Environment Administration, Vientiane, Lao PDR

ABSTRACT

Flooding in Lao PDR during 2009 can be observed from the North to the South due to the seasonal variation, Unlike flooding in 2008, where the major flooding was highlighted by the extreme overflow from the Mekong River into the urban area of the Vientiane Capital and major cities along the Mekong River, the flooding in 2009 was dominated by flash floods in the major tributaries of the Mekong River, particularly the flash flood in the Southern part of Lao PDR induced by the Typhoon Ketsana, which caused heavy rainfall, recorded between 53 – 201 mm. The Typhoon Ketsana has resulted in significant losses of life and limb in Savanakhet, Saravane, Champasack, Xekong, and Attapeu provinces. More than 180,000 persons were directly affected and 28 storm-related deaths were reported. The direct damage was estimated more than US$ 58 million.

The damage caused by Typhoon Ketsana was considered as national catastrophe and the national relief campaign was launched. The disaster management committees at national, provincial and district levels functioned and the national fiscal plan was revised to support the emergency response. However, the national effort was considered insufficient and international relief support was called in.

INTRODUCTION

Lao PDR covers an area of 236.800 km2, 97% of which falls within the lower sub-basins of the Mekong River which traverses the country from North to South. With the population of 6 million, Lao PDR's population density is the lowest in South East Asia. Lao PDR is predominantly mountainous, 70% of its land surface is being dominated by hills, plateaus and mountains ranging from 200 to almost 3,000 m+MSL (Mean Sea Level) (Mekong River Commission Secretariat (MRCS), 2004).

The climate characteristics of Lao PDR are tropical monsoon with alternating wet and dry seasons. The dry season (northeast monsoon) occurs from mid October to mid May when 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) occurs 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 are often experienced from the end of June to the beginning of July (Souvany, 2007).

In 2009 a number of extreme weather events were observed throughout the country, from Luangnamtha and Luangprabang provinces in the North to Sekong and Attapeu provinces in the South (Figure 1). Although the series of extreme weather events in 2009 may look similar to

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what happened in 2008 in terms of their distribution. The incident of severe flooding was the flash flooding in the southern part of Lao PDR caused by Typhoon Ketsana, unlike the 2008 severe flooding from mainstream Mekong River. Therefore, the Mekong water levels in 2009 in major stations were under the danger levels. This report has reviewed the major flood events with significant damage to life and limb that occurred during 2009 by looking at the hydrological and meteorological conditions, as well as to the flood management and mitigation measures being executed in 2009. The results from the field visits to Savanakhet, Saravanh, Champasack, Sekong, and Attapeu provinces during 19 - 24 January 2010 are also incorporated in this report.

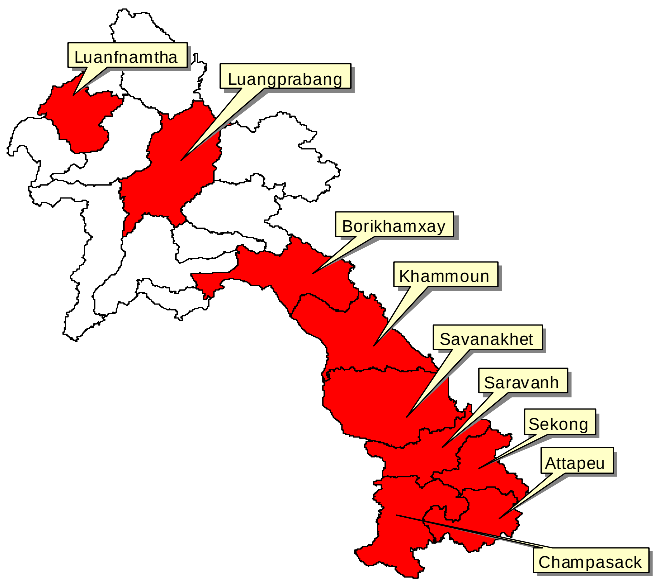


Figure 1. Provinces affected by extreme weather events in 2009

HYDRO - METEOROLOGICAL CONDITION

During 2009 localised flash flooding in Luang Namtha, Bolikhamxay, Khammuane provinces in July and mid - August, 2009 were in response to orographically induced monsoonal and tropical depressions which produced 81 mm and 179 mm per day on 5 and 6 July 2009, while the southern provinces were hit by Typhoon Ketsana with the 53 - 201 mm rainfall, measured in the southern stations on 29 and 30 September 2009.

Flash Flooding along low lying areas of Namtha River and Nam Ou River

In 2009 the onset of the southwest monsoon took place earlier than normal (normal is mid May). At the beginning of the rainy season heavy rain was frequently observed in Northern and Central areas. During 4 to 6 July a strong southwest monsoon covered northern to central Lao PDR, which produced moderate to heavy rain between 50 and 179 mm/day.

A large amount of precipitation reached the ground. At 7:00 hour on 6 July 2009 the water level rose very fast and caused flooding along low laying areas of Nam Tha, Nam Ngen, Nam Thoung and Nam Hoy tributaries and flowed into rice fields and some areas such as: Khone, Donkhoune and Louang villages. At 13:00 hour the road between Donkhoune and Tha Oh villages was inundated over about 70 m in length with flood depth 0.20 - 0.40 m. This flooding took less than one day (from 7:00 hour to midnight of 6 July 2009) and on 7 July 2009 at 7:00 hour. See Figure 2 for the water level at hydrometric station Muang Ngoy (Num Ou River) rose to 10.12 m+MSL. The following flood affected for a few hours low laying areas at some villages of Muang Ngoy District in Luangprabang Province.

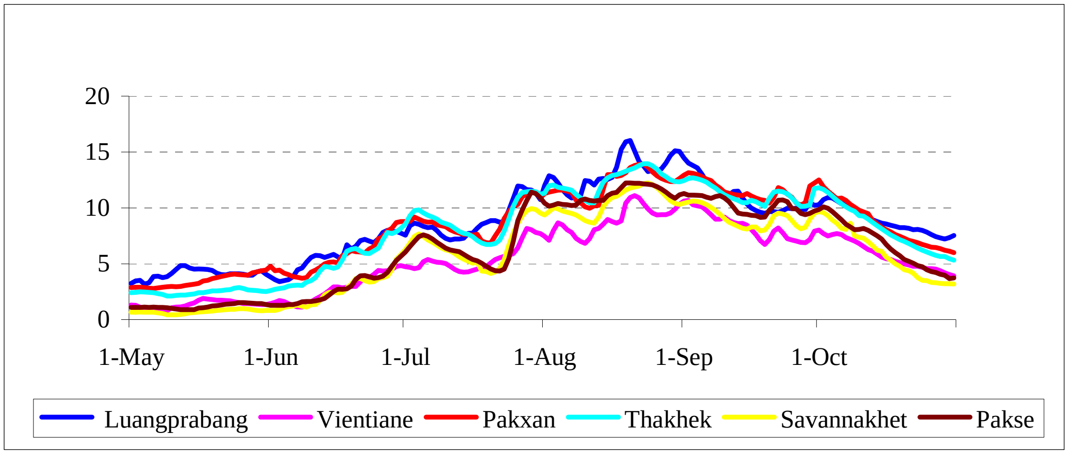


Figure 2. Hydrograph of the Mekong River at different sites in 2009

Flooding in low-lying areas along the Nam Sane River, affected by Monsoon heavy rainfall during 29 - 30 July 2009

During the end of July there was a moderate southwest monsoon over central Lao PDR, particularly at Paksane station, the rainfall intensity was observed from moderate to heavy in two consecutively days with a daily rainfall recorded between 41 - 73 mm on 29 - 30 July, 2009. As a result, water overflow occurred from Nam Sane River into low laying areas of Thaback Village (Bolikhane District) and Thabo and Ohtay villages (Paksane District). The road was flooded over 6 – 7 km in length with flood depth 0.50 – 0.60 m between Phokham and Hatpho villages (Bolikhane District) on 29 – 30 July, 2009.

Flooding in low-lying areas along the Sebangfai River, affected by Tropical Storm Koni (0907) on 09 – 16 August 2009

Tropical storm Koni (0907) landfalls onto central of Viet Nam, it downgraded into a Tropical Depression and passed over the central area of Lao PDR at 15:30 hour (8:30 UTC) on 9 September 2009. This Tropical Depression produced heavy rainfall over Khammuane Province; with total daily rainfall recorded of 140 mm at Hydrometric station Mahaxay (Sebangfai) and 228 mm at Meteorological station Thakhek on 8 and 9 August, 2009.

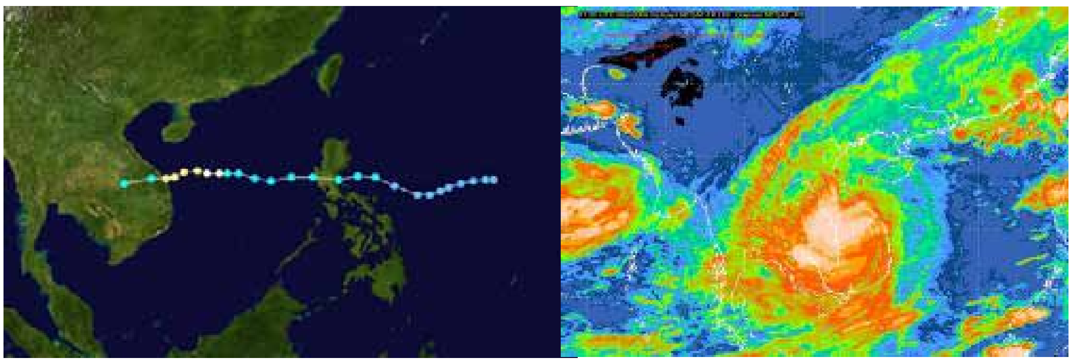
Rainfall distribution and maximum Mekong water level in Lao PDR during the wet season 2009

The monthly rainfall departures in the wet season 2009 at main stations of Mekong River in Lao PDR were observed as moderate and heavy over northern and central areas of Lao PDR at the beginning of the rainy season. As a result during the first few days of July, 2009 the increase in water levels of Mekong River upstream was extremely rapid with first peak that marked the highest water levels attained for the year (Figure 2). The second peak was observed in mid August at the central and southern hydrometric gauge of Mekong River and the tributaries that were affected by a Tropical Depression passing through the central areas. However, the water levels were below flood the warning level.

In comparison with 2008, the flood peak condition has been much very high alarm stage, particularly at northern to central provinces due to heavy rainfall took place earliest at upper areas and during mid - wet season continuously observed widespread heavy rains over upstream part of Mekong River as well as in northern and central areas of Lao PDR that affected.

Flash flooding caused by Tropical Storm Ketsana (1609) during 29 – 30 Sept. 2009

On 29 September, 2009 Typhoon Ketsana made landfall to Central Viet Nam. Thereafter it downgraded to a Tropical Storm and passed through Thateng District (Xekong Province) at 6:30 hour (11: 30 UTC) with movement speed of 30 km/h (15 knots) It then moved towards Thailand (Figures 3 and 4).



Figures 3 and 4. MTSAT–1R Infrared channel at 0:30 hour (5:30 UTC) of Typhoon Ketsana (i) and colour Enhanced image at 6:30 hour (11:30 UTC) (ii) of Severe Tropical Storm Ketsana (1609) on 29 September, 2009

Nam Xekong has a length 320 km (data source from MRC 2005), and flows through Xekong Province and joined Nam Xekhaman at Attapeu Prefecture. Flash flood at Xekong River in 2009 was caused by Typhoon Ketsana (1609). At 29 September 2009 heavy rain of 53 – 201 mm was recorded in almost all southern provinces (Table 1).On utilization of rainfall estimation from different regional Weather Forecast Centres indicated that the rain rate over the upstream part of Xekong and Xekhaman river basins was more than 200 mm in 12 hours.

Table.1. Daily rainfall (in mm) recorded at 29 September, 2009 at meteorological stations during passage of the Severe Tropical Storm Ketsana (1609)

Station/date	Thakek	akhet	Seno	Saravane	Attapeu		g	
29 September, 2009	1.4	12.8	12.1	201	53.4	172	183	90.4

During the passage of the Severe Tropical Storm Ketsana on 29 September 2009, the flash flood affected several villages in Saravane, Savanakhet, Champasack, Xekong and Attapeu provinces.

IMPACTS OF FLOODING IN 2009

Flood magnitudes from the 1st week of July to the 3rd week of August 2009 seem moderate and usual as occurred during the past years. Flooding has been reported in 9 of the 17 provinces in Lao PDR in Luangnamtha and Luangprabang provinces in the northern part, in Birikhamxay, Khammoun and Savanakhet provinces in the middle part and in Saravane, Champasack,

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Xekong and Attapeu provinces in the southern part the damage was significant in the rural areas where more than 2000 hectare of rice field and farm land were inundated.

The most severe flood damages were the impact from Typhoon Ketsana, which made landfall in Lao PDR from 29 – 30 September 2009, According to the Government of Lao PDR report on Typhoon Ketsana, the Ketsana disaster struck the five southern provinces of Attapeu, Saravan, Xekong, Savannakhet, and Champasak at the upperstream of the Xekong River, four of them were severely affected, the rainfall was estimated at over 500 mm in 24 hours, 3,178 houses were affected (1,194 houses were completely damaged), 52,547 households were affected (10,670 households were displaced), 28 people died, 1 was missing and 94 injured. Almost 32,000 hectares of rice and other crop fields were damaged, followed by 91 schools, 10 hospitals, 144 irrigation schemes and 47 road sites. The direct economic loss in the four provinces was US$ 58 million.

FLOOD MANAGEMENT AND MITIGATION MEASURES

Institutional arrangements

The Government of Lao PDR regards flood as one of the major disasters and considers disaster management as an important issue that urgently needs to be properly managed. Therefore, the National Disaster Management Committee (NDMC) was established, the NDMC is an inter-ministerial committee that has the responsibility for developing policies and coordinating Disaster Risk Management (DRM) activities in the country. The NDMC was established in August 1999 through a prime ministerial Decree No. 158/PM.

In the NDMC there is currently representation by several important sectors such as health, education, public works, transport, etc. Its mandate and structure is being reviewed by the government and a proposal is under consideration for expanding the membership of the NDMC to include additional important sectors such as energy and mining, planning and investment, water resources and environment, science and technology and agencies such as the Lao PDR Women Union, and the Lao PDR Youth Union.

Disaster risk management is integrated into the Lao PDR's Sixth National Socio Economic Development Plan (NESDP) (2006-2010) and the National Growth & Poverty Eradication Strategy (NGPES). The DRM issues are further articulated in the draft NESDP (2011 – 2015) which provides the supportive basis for mainstreaming DRM into the national agenda.

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, 119 staff gauge stations, 49 discharge measurement stations and a C-Band Doppler radar[1] at DMH Headquarter and s MTSAT – 1R satellite receiving station (Souvany, 2006). The data from the stations are collected by the Provincial Meteorology and Hydrology Office (PMHO) with the assistance from the local people who live close to the stations, the data are later reported to the DMH in Vientiane Capital.

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

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Flood forecasting

The hydrological division of the DMH receives real time data (rainfall and water level observed at 7:00 hour (00:00 UTC) from seven major stations at the mainstream (Pakbeng, Luangprabang, Vientiane, Paksane, Thakek, Savanakhet, Pakse) and main tributaries of Mekong River by high frequency / single slide band (HF/SSB) and telephone. Supplementary information on real time data (rainfall and water level) 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 form of a mathematical model between DMH and the Mekong River Commission Secretariat (MRCS) has been done by e-mail, and the DMH has received 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 2009 at the mainstream of the Mekong River in Lao PDR still use the method of stage correlation regression, between upstream and downstream water levels, with a related 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 observes on 7:00 hour (local time) at hydrological station Vientiane Km4
HLB = water level observes on 7:00 hour (local time) at hydrological station Luangprabang

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

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 (see http://dmhlao.etllao.com/) which can provide the weather and flood forecast information, has been established in 2007.

The flood forecasting, warning and dissemination are made by DMH through the Office of the Water Resources and Environment Administration (WREA), the Prime Minister’s Office and to provincial governor offices and later to concerned line agencies. However, the standard operation procedure for warning and dissemination is not yet standardized and officially adopted.

The WREA is initiating a comprehensive program on early warning system, which will consider the issuing of early warnings in an integrative manner.

Flood preparedness, relief, and rehabilitation

Flood management and mitigation are important issues that need to receive attention. The degree of damage can vary from location to location. After floods, in most case, the national disaster management committee, in coordination with the concerned line agencies at central and local level is responsible for planning and implementation of flood preparedness, relief, and rehabilitation by mobilizing all available means for flood preparedness and relief. The disaster management committee will be set up at different levels (provincial, district, and village). Their tasks include flood warning and preparation, relief assistance, damage assessment, and rehabilitation.

In the worst flooding case, the ad hoc committee can be set up at the national level and adopted in the national agenda in order to gain political commitment and mobilize strong support, e.g. the impact from Typhoon Ketsana during 29 - 30 September, 2009 was regarded as National Catastrophe. The Government called for disaster management committees at all levels (National, Provincial, and District) The assessment for damages was made and emergency response was launched, the national budget of 111 billion kip was allocated.

Structural counter measures

In the long term, permanent flood protection dikes and bank protection structures are 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 is planned and will be implemented in the urban development projects, mainly, the Vientiane Urban Development Project, the Secondary Towns Development Project (Luangprabang, Khammouan, Savanakhet, and Champasack). In the short term for emergency response, sand bag - flood protection dike construction and drainage channel dredging will be applied.

LESSONS LEARNT

The flooding in 2009 can be considered as natural phenomenon which is inevitable, however, some lessons need to receive more attention for better flood management and mitigation. These are the following:

- 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;
- population attitude towards flooding is vital for the effective implementation of flood preparedness plan;
- improvements of data coverage is important for comprehensive flood forecasting and warning dissemination;
- strong political commitment is very crucial for successful large-scale flood preparedness;
- no standard format for assessing flood damages results in misuse of resources;
- DRM mainstreaming into the national planning cycle is crucial for its successful implementation;
- an internal and external coordination mechanism is important for resources mobilization;
- institutional strengthening for DRR is urgently needed;
- comprehensive review and sector wide program approach are required for DRM in favour of effective implementation (standard operation procedures, hazard mapping, clear mandate of DMCs at all levels);
- community resilience is important.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

During 2009, a number of extreme weather phenomena could be observed. Unlike flooding in 2008 where the major flooding was highlighted by the extreme overflow from the Mekong River into the urban area of the Vientiane Capital and major cities along the Mekong River, the flooding in 2009 was dominated by flash floods in the major tributaries of the Mekong River, particularly, the flash flood in the Southern part of Lao PDR, induced by the Typhoon Ketsana which causes heavy rainfalls recorded between 53 – 201 mm, the Typhoon Ketsana has resulted in the significant losses of life and limb in Savanakhet, Saravane, Champasack, Xekong, and Attapeu provinces, 28 storm-related deaths were reported, more than 52,547 households were directly affected and the direct economic losses were US$ 58 million.

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

The flooding caused by Typhoon Ketsana in September 2009 has demonstrated the pro-active management approach for large scale flooding, the Disaster Management Committees were called at all levels (National, Provincial, and District), the coordination among different sectors had shown the collaborative emergency response, apart from the internal coordination, the international appeal was made to ensure that the responsive measures were fully supported and mobilized.

Recommendations

The above issues result in the following recommendations:

- a standard format for assessing flood damages and losses needs to be developed for assessing direct and indirect damages in support of better flood management and mitigation, and of resources allocation in particular;
- community based flood risk management needs to be strengthened. Community self reliance for flood management and mitigation has proved to be effective. The disaster management committee would have to 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;
- a national capacity building program for DRM needs to be established in support of comprehensive flood risk management;
- national flood hazard mapping needs to be developed to facilitate the implementation of flood preparedness plans;
- a financing mechanism for DRM would have to be developed;
- affordability for flood forecasting needs to be considered, appropriate technology and trans-boundary cooperation on data and information exchange is useful;
- the MRC Flood Management and Mitigation Programme would have to 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 would have 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.

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Paper 1-3

THAILAND COUNTRY FLOOD REPORT FOR 2009

PIYA KUNASOL

Thailand National Mekong River Commission, Department of Water Resources, Bangkok, Thailand




ABSTRACT

As the theme of the Mekong Annual Flood Forum (AMFF-8) is relevant with the *'Flood risk management and mitigation in the Mekong River Basin'*. The core study focuses on measures and strategies developed for addressing flood occurrence and the action plans which are properly implemented for each inundation case during the monsoon period.

In 2009 flood hazards in Thailand mostly were the results from Typhoon Ketsana, a major flood problem. It initially developed in South China Sea as low pressure area and upgraded to tropical storm on 26 September 2009. It tracked westward passing over the island of Luzon in the Philippines. Whilst moving towards to the West, it led to a severe tropical storm during 27 September. Typhoon Ketsana tracked towards Thailand on 30 September as tropical depression. There were widespread heavy rainfall and flash floods in mostly 40 provinces, especially in the North-eastern part and partially in the Northern and Central part of Thailand. This flood circumstance affected directly to 2,897,554 people. It was also reported that there were more than 577,000 families suffering and that two people died (Lampang and Yasothon). The depression partially damaged 4,638 houses as well as 3,320 km2 (2,077,392 Rai) of Agricultural land.

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To response to the flood hazard the Royal Thai Government set Policy Statements of the Council of Ministers against flood disaster by implementing of the Flood Management Master Plan, which can be categorized in three phases, comprising the preparation of flood awareness, management in emergency situations and also management after a disaster.

GENERAL SITUATION

Thailand is mainly influenced by two types of monsoon comprising the Southwest Monsoon and the Northeast Monsoon, which cause changes in the climatic seasons in Thailand. The Southwest Monsoon passes through Thailand during mid May to October and carries mass humid air from the Indian Ocean to Thailand causing widespread rainfall. The Northeast Monsoon starts from mid October and lasts until February. The mass dry cool air from Mongolia and China passes through Thailand in the upper Northern and North-eastern regions, but will cause heavy rainfall in the South while the monsoon will carry moisture from the Gulf of Thailand. The storm tracks over Thailand are show in Figure 1.

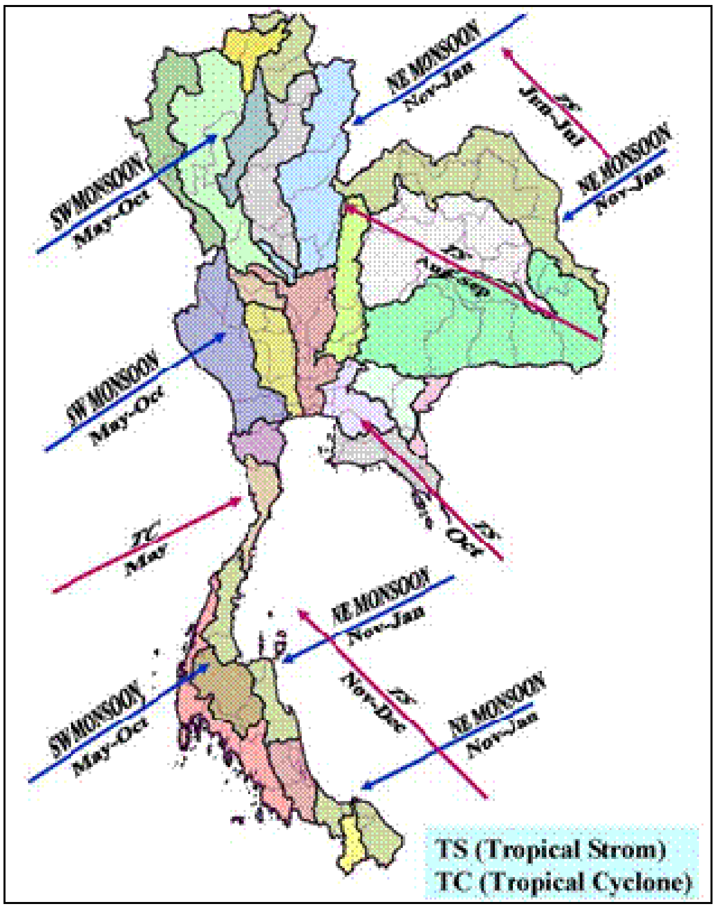

Figure 1. Storm tracks over Thailand

According to the monthly rainfall during 1978 - 2009 in Thailand, the average annual rainfall in Thailand is 1,573 mm and varies from 800 - 4,400 mm.

The average runoff in Thailand is 213,303 MCM (million cubic metres), divided into 9,401 MCM (4.4%) flow to Salawin River, 65,057 MCM (30.5%) flow to Mekong River, 22,397 MCM (10.5%)

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flow to the Andaman Sea, and 116,448 MCM (54.6%) 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 2009

Related data have been gathered, hydrologically evaluated and analyzed for the studies. All of the relevant data from many agencies, such as: Thai Meteorological Department (TMD), Department of Water Resources (DWR) and Royal Irrigation Department (RID) consisting of topography, climate, rainfall and water levels are summarized in the following session.

Topograhy

Among the Mekong, Chi and Mun river basins, Chi and Mun rivers were undertaken as major streams for studying and analyzing hydraulic behaviour with respect to the change of water level characteristics.

Chi River originates in the Petchaboon Mountains, then runs eastward through Chaiyaphum, Khon Kaen and Mahasarakham provinces and turns southward in Roi Et, running through Yasothon and joins with the Mun River at Kanthararom District in Srisaket Province.

Chi River Basin, total area 49,130 km2, is surrounded by mountain ranges along the eastern, northern and western sides, with elevation in the range of 300 to 1,300 m+MSL (Mean Sea Level). The land between these mountain ranges is mostly plateau and some is hilly and mountainous area on the South, with elevation of 110 to 200 m+MSL.

Mun River originates in the Khao Yai National Park of the Sankambeng range, near Nakorn Ratchasima in the North-eastern part of Thailand. It flows from the East through the Khorat Plateau in the southern part of North-eastern regions (Buriram, Surin and Sisaket provinces) for 750 km until it joins the Mekong River at Khong Chiam District in Ubon Ratchathani Province.

Mun River Basin has a total area of 71,060 km2. The basin is mainly highland with some hilly area on the East and has Phanom Dong Rak Mountain as the southern border. The area is gradually sloping to the East with an elevation of 110 to 170 m+MSL.

Figure 2 shows the longitudinal profile of Chi River. From this figure it can be derived that the elevation varies from 200 to 110 m+MSL and there are six hydraulic structures, weirs of the Khong-Chi-Mun Project, along the river.

Climate

According to the aggregated series of hydological data from the TMD and other line agencies, such as DWR and RID, the main variables of climate considered in this study focus on rainfall, humidity, cloudiness and evaporation.

With the mean annual values of climate data it is found that Thailand has 27.0 oC of temperature, 76.4% of humidity, 1,622 mm of evaporation, 6.1 Octa of cloudiness and 2.4 knots of wind. For the North-eastern part of Thailand (Mekong, Chi and Mun river basins) it is 26.3 oC of temperature, 72.9% of humidity, 1,625 mm of evaporation, 5.56 Octa of cloudiness and 2.33 knots of wind respectively.

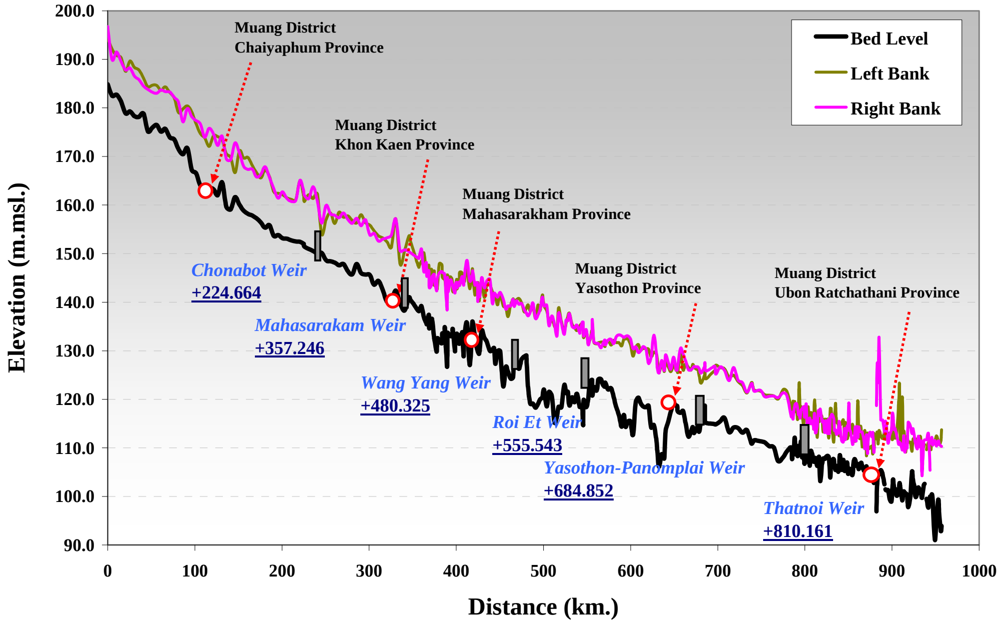


Figure 2. Longitudinal profile of Chi River

Rainfall

Isohyets of Thailand and of the North-eastern part of Thailand in 2009 are illustrated in Figure 3. The location of rainfall stations in the North-eastern region is shown in Figure 4.

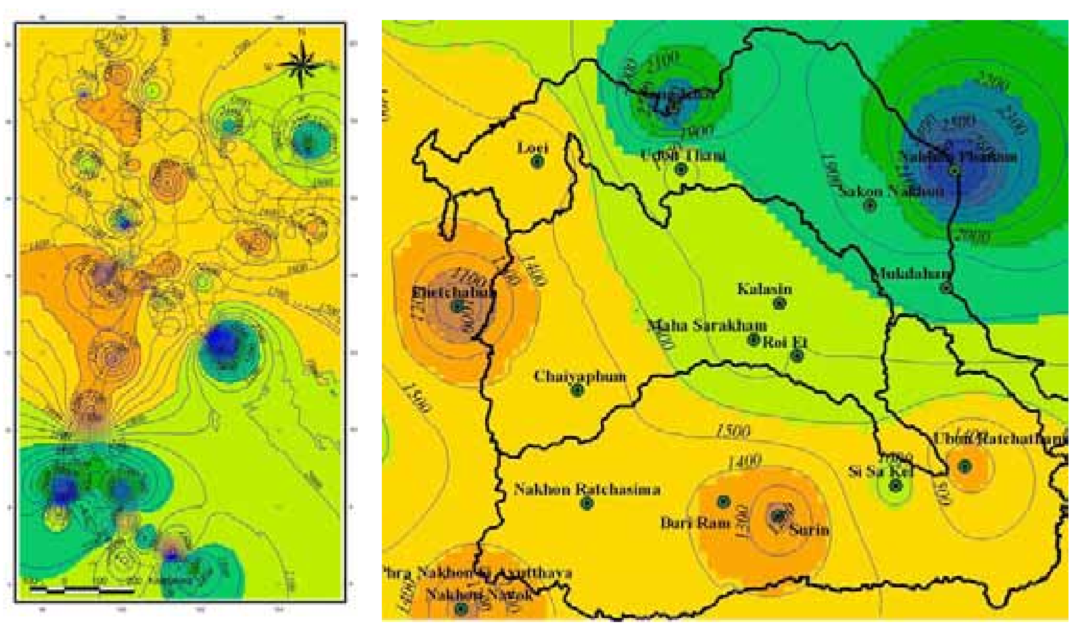


Figure 3. Isohyets of Thailand and the North-eastern part of Thailand in 2009

Within the North-eastern part of Thailand, the daily rainfall and cumulative rainfall of two representative stations from RID can be plotted as shown in Figure 5.

From Figure 5, the cumulative rainfall in 2009 of the E.20A station, located in Chi River Basin, was

1,253 mm. This was 41 mm more than the average cumulative rainfall of the past 30 years and 257 mm more than the cumulative rainfall in 2008 (the cumulative rainfall in 2008 was 995 mm), but 422 mm less than the cumulative rainfall in 2002 (the cumulative rainfall in 2002 was 1,675 mm). In the M.7 station, located in Mun River Basin, the cumulative rainfall in 2009 was 1,881 mm. This was 527 mm more than the average cumulative rainfall in 2008 (the cumulative rainfall in 2008 was 1,354 mm) and 212 mm more than the cumulative rainfall in 2002 (the cumulative rainfall in 2002 was 1,669 mm), but 13 mm less than the cumulative rainfall of the 30 years period (the cumulative rainfall of 30 years period was 1,894 mm).

The distribution of monthly rainfall of six existing stations of DWR and RID that are located throughout Mekong, Chi and Mun River Basins can be illustrated as shown in Figure 6.

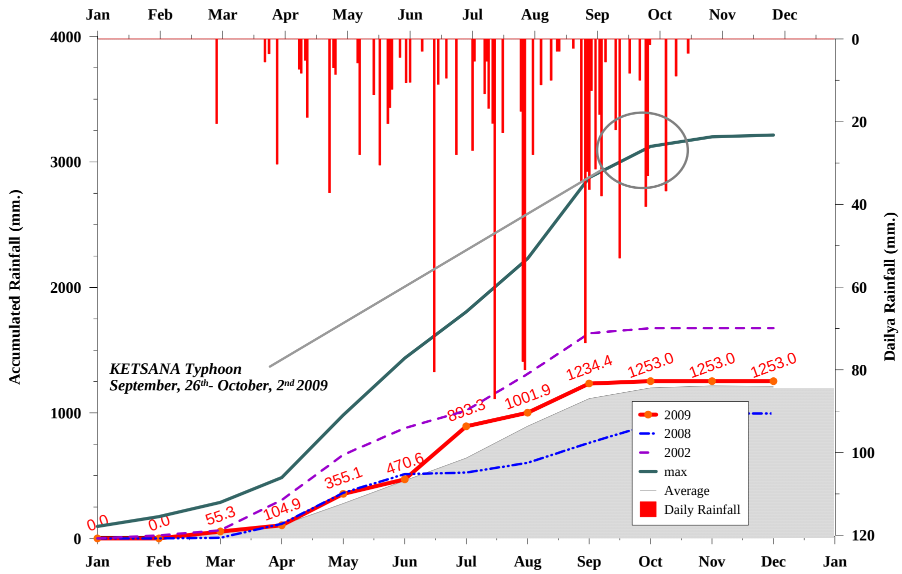
The monthly rainfall in 2009 was highest in July except for Mukdahan where maximum monthly rainfall occurred in May. In Ubon Ratchathani was found that the monthly rainfall in September (398 mm) was higher than the average monthly rainfall (284 mm), which was caused by the influence from Typhoon Ketsana.

Figure 4. Location of rainfall stations in the North-eastern region of Thailand

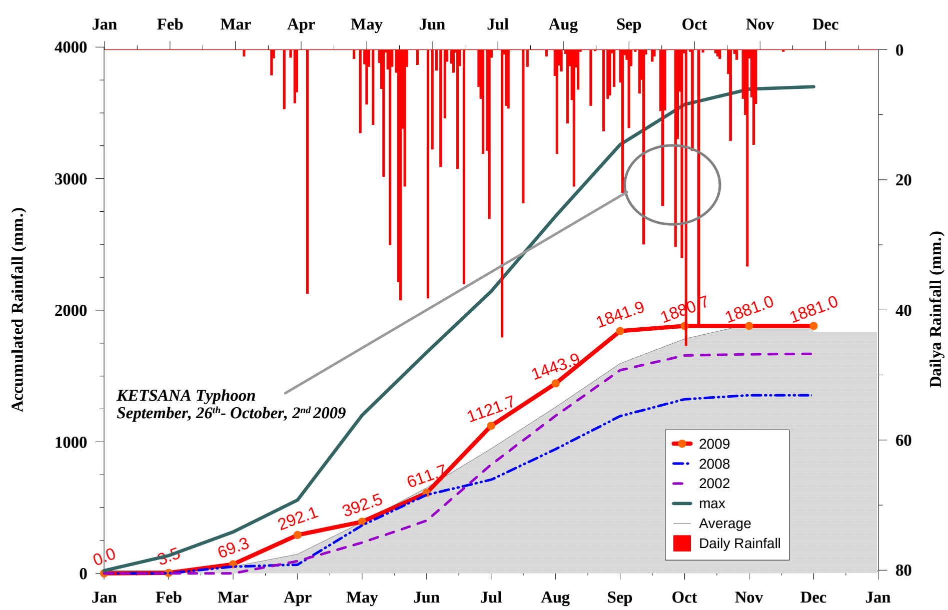
Water Level in the North-eastern part of Thailand

In 2009, water levels in the Mekong, Chi and Mun river basins on the key index stations were E.20A at Mahachanachai (Chi River) ,M.7 at Muang Ubon Ratchathani (Mun River), Chiang Khan and Mukdahan respectively. The water level stations which will be used to evaluate the flood situation as shown in Figure 7 and the relationship between observed daily water levels in 2009 compared with the bank level data in 2008, averaged data and also the maximum data can be plotted as shown in Figure 8. The maximum annual water level against return period can be plotted as shown in Figure 9.

From Figure 8, the water situation shows that the water level in 2009, in Chi River starts to reach overbank in the middle of July to November, Mun River starts to reach overbank in the middle of September to October. The maximum water level in 2009 in Chi River was 121.53 m+MSL , which was lower than the maximum in 2002 and 2008 even though it was influenced by Typhoon Ketsana, as well as the maximum water level in 2009 in Mun River was 112.77 m+MSL , which was lower than the maximum water level in 2002.

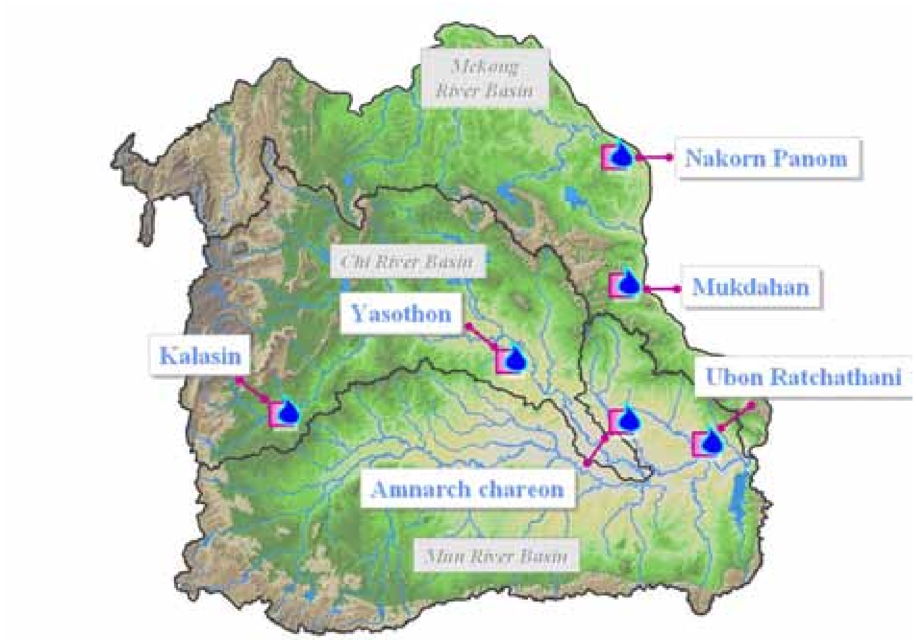


Chi River (E.20A station)



Mun River (M.7 station)

Figure 5. Observed daily rainfall and cumulative rainfall in 2009 compared with data in 2008, averaged data, and the maximum data



Location of six selected rainfall stations in Mekong, Chi and Mun river basins

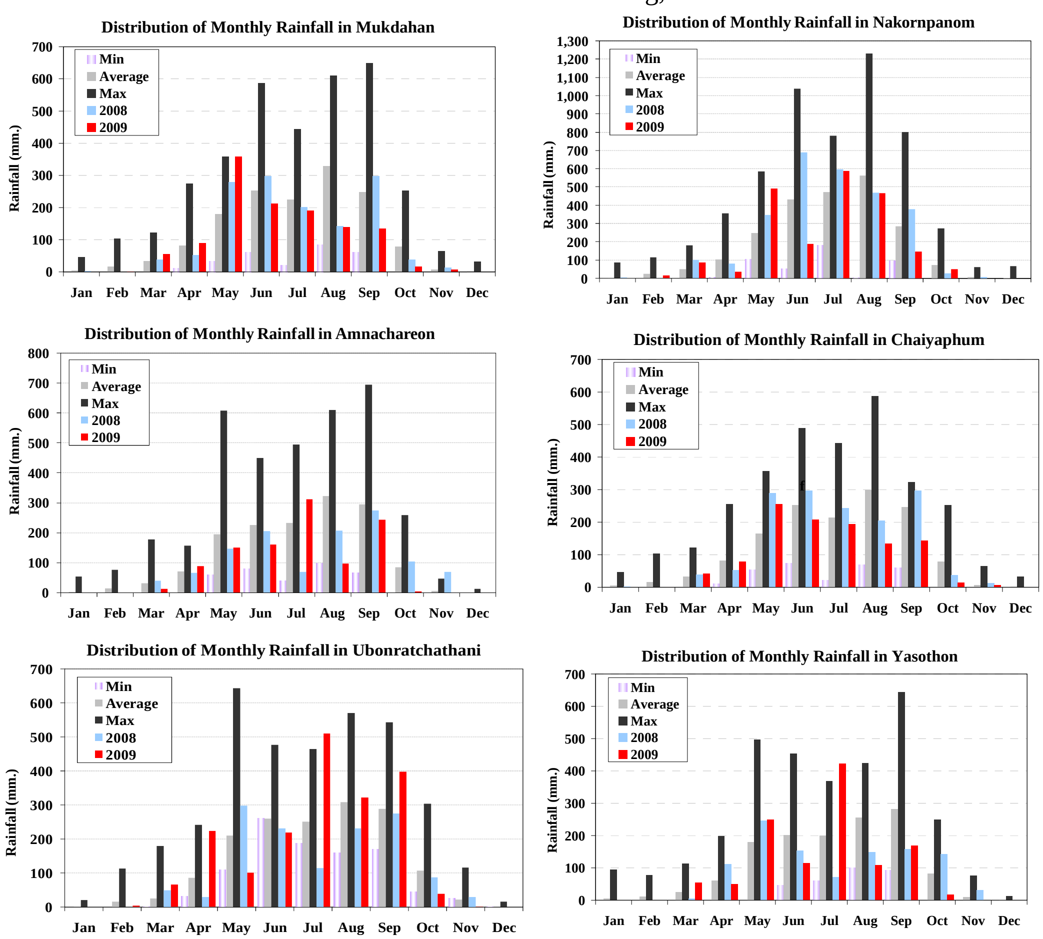


Figure 6. Distribution of monthly rainfall

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Figure 7. Location of water level stations

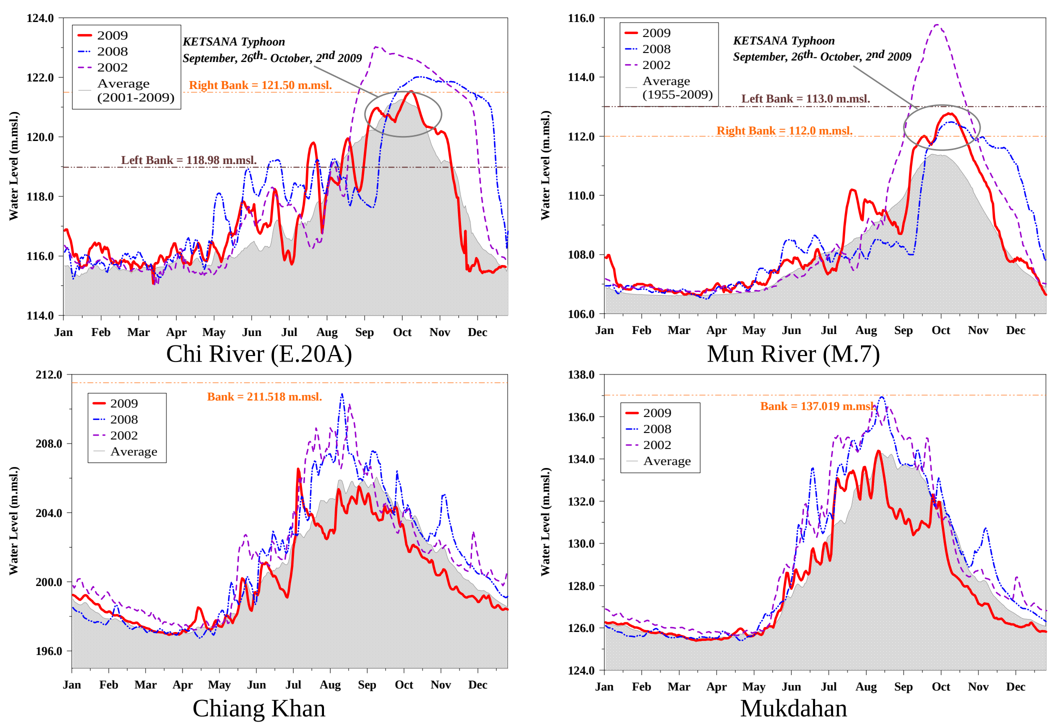

Figure 8. Observed daily water levels in 2009 compared with the bank level, data in 2008, averaged data, and the maximum data

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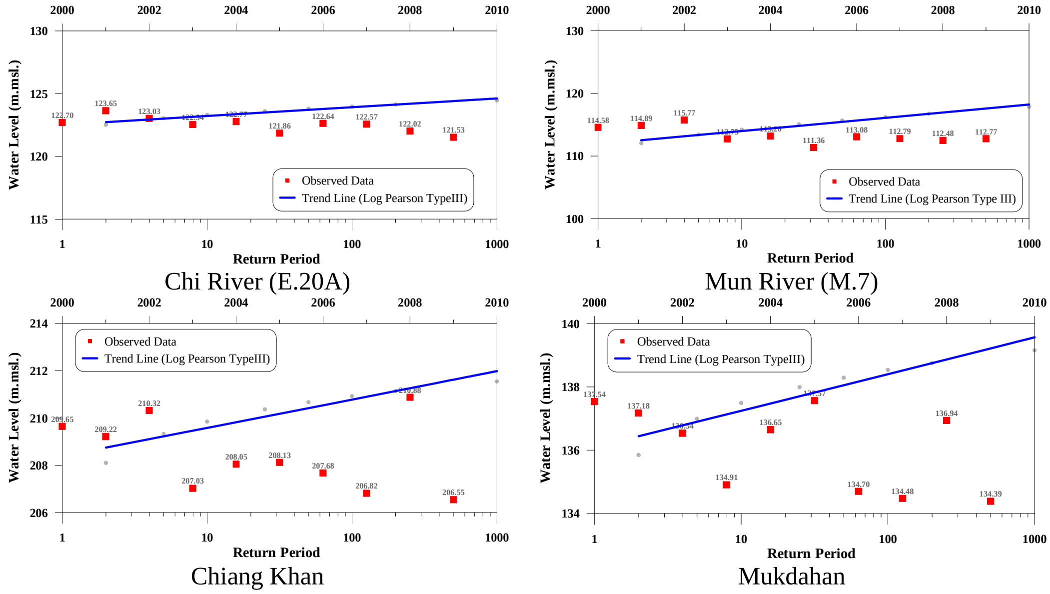

Figure 9. Relationship between maximum water level corresponding return period and observed data

From Figure 9 the maximum water level in 2009 in Chi River was 206.55 m+MSL, which was lower than at the 2-year return period, as well as the maximum water level in Mun River was 112.77 m+MSL, which was slightly lower than at the 2-year return period. In Mekong River, both water level stations obviously showed that the maximum water level in 2009 was massively lower than the water level in 2008, especially in Chiang Khan, which was equivalent to the around 250-year return period. Meanwhile the maximum water level in 2009 was less than at the 2-year return period.

SIGNIFICANT FLOOD EVENTS 2009

So far, floods destroy many lives and properties and tend to become worst in the future because Thailand is located in the monsoon area. The problems have been prevented and resolved by constructing hydraulic structures, increase in efficiency of draining the water from the floodplain and implementing early warning and telemetering systems, which were established to monitor, forecast and also disseminate flood circumstances to communities and relevance line agencies.

Over the past 30 years, Thailand has faced the flood problem up to 10 times in almost every province, and there was 6 times more violence in 1975, 1983, 1995, 2002, 2005 and 2006. The flood occurrences in 2009 were briefly as follows: the historical data of rainfall and water level in the past 30 years in the main rivers in Thailand are shown in Figure 9.

Significant flood events in May to July

From May to July, Thailand was influenced by a tropical storm that occurred by low pressure move towards the Northeast through the North of Thailand and with a Southwest Monsoon move towards the Andaman Sea and the Gulf of Thailand. This caused heavy rainfall in many areas and caused flooding and flash floods. There were 10 provinces, 24 districts and 69 sub-districts affected, especially in the northern, eastern and southern part of Thailand. The example of flood occurrences in May to July is illustrated in Figure 10.

Significant flood events in August

As there was heavy rainfall from 1 - 10 August in the northern and north-eastern part of Thailand, it caused flooding in Nakhon Phanom, Chiang Rai and Mukdahan provinces. Especially in Nakhon Phanom. It was heavy rainfall of about 160 mm on 1 August that caused a high flooding level, up to 0.50 m in Nakhon Phanom Municipality. This circumstance resulted in the most serious flood occurrence in the past 10 years.

In Chiang Rai Province it was heavy rainfall of about 85 mm on 9 August that caused flash flood in the mountainous areas, such as Mae Jun district, and damages of properties and agricultural areas and resulted in a flood depth of 0.2 - 0.4 m.

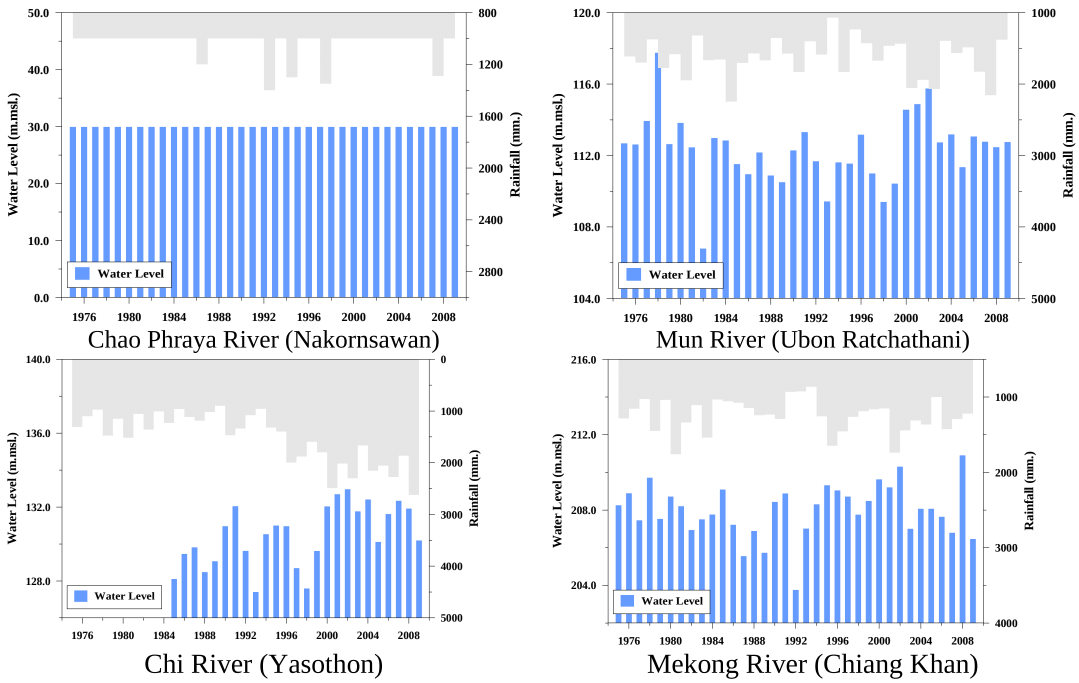

Figure 9. Historical data of rainfall and water level data in Thailand

Flash flood occurrence in Vang Chin District, Phrae Province on 18 June

Flash flood occurrence in Krang District, Rayong Province 22 - 23 July

Flood occurrence in 7 districts in Satun Province 13 - 15 July, which affected 25,483 people

Figure 10. Flood occurrences in May to July 2009

The calamity of flooding bought suffering in 3 provinces, 48 districts, 298 sub districts and 2,310 villages. The daily rainfall distribution and the maximum daily rainfall are shown in Figure 11 and the example of flood occurrences is illustrated in Figure 12.

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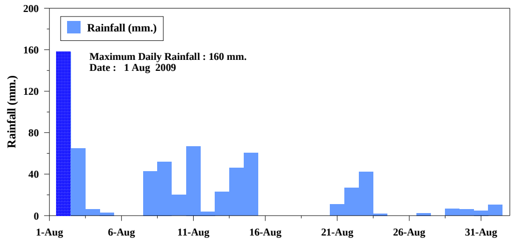
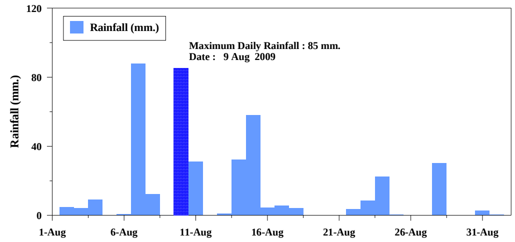
Significant flood events in September

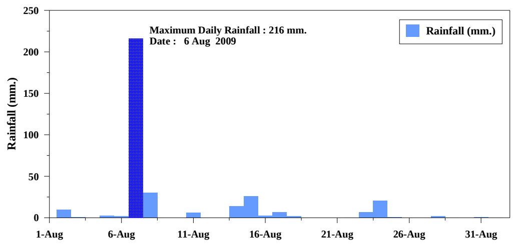
The significant flood events in September due to the influence of Typhoon Ketsana occurred during 30 September – 4 October. This event caused heavy rainfall in the lower part of the North and throughout the North-eastern regions. The formation of Typhoon Ketsana is described in the following section and is shown by the weather chart and satellite image. Also the path of Ketsana is illustrated in Figure 13.



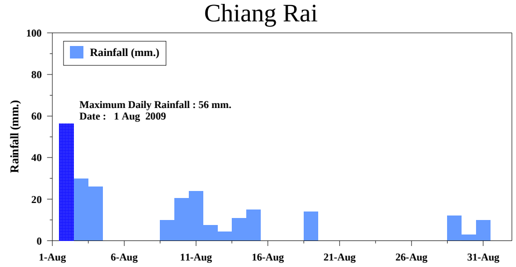
Nakhon Phanom



Chiang Rai

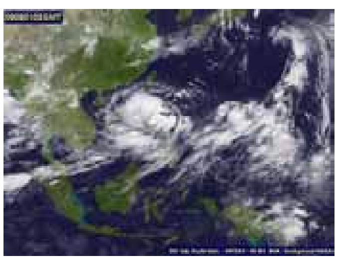


Chiang Rai (Chiang Saen District)

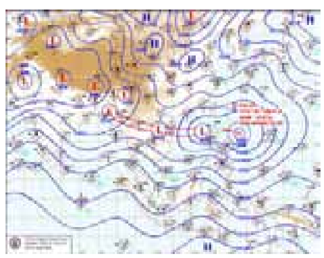


Mukdahan

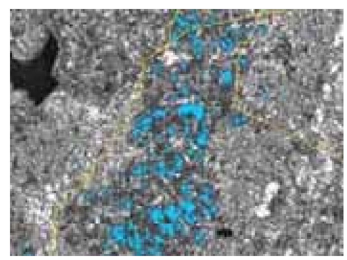
Figure 11. Monthly rainfall distribution in August 2009



Satellite image illustrated storm characteristic cover the Northern and North-eastern part on 1 August



Satellite image on 9 August



Inundation map (RADARSAT) in Nakhon Phanom Province

Heavy rainfall in Nakhon Phanom Municipality on 1 August that cause flood level reach up to 0.50 m.

Flood situation in Nakhon Phanom Municipality on 10 August

Sri Don Muang Chiang Saen district Chiang Rai Province on 6 - 9 August

Figure 12. Flood occurrences in August

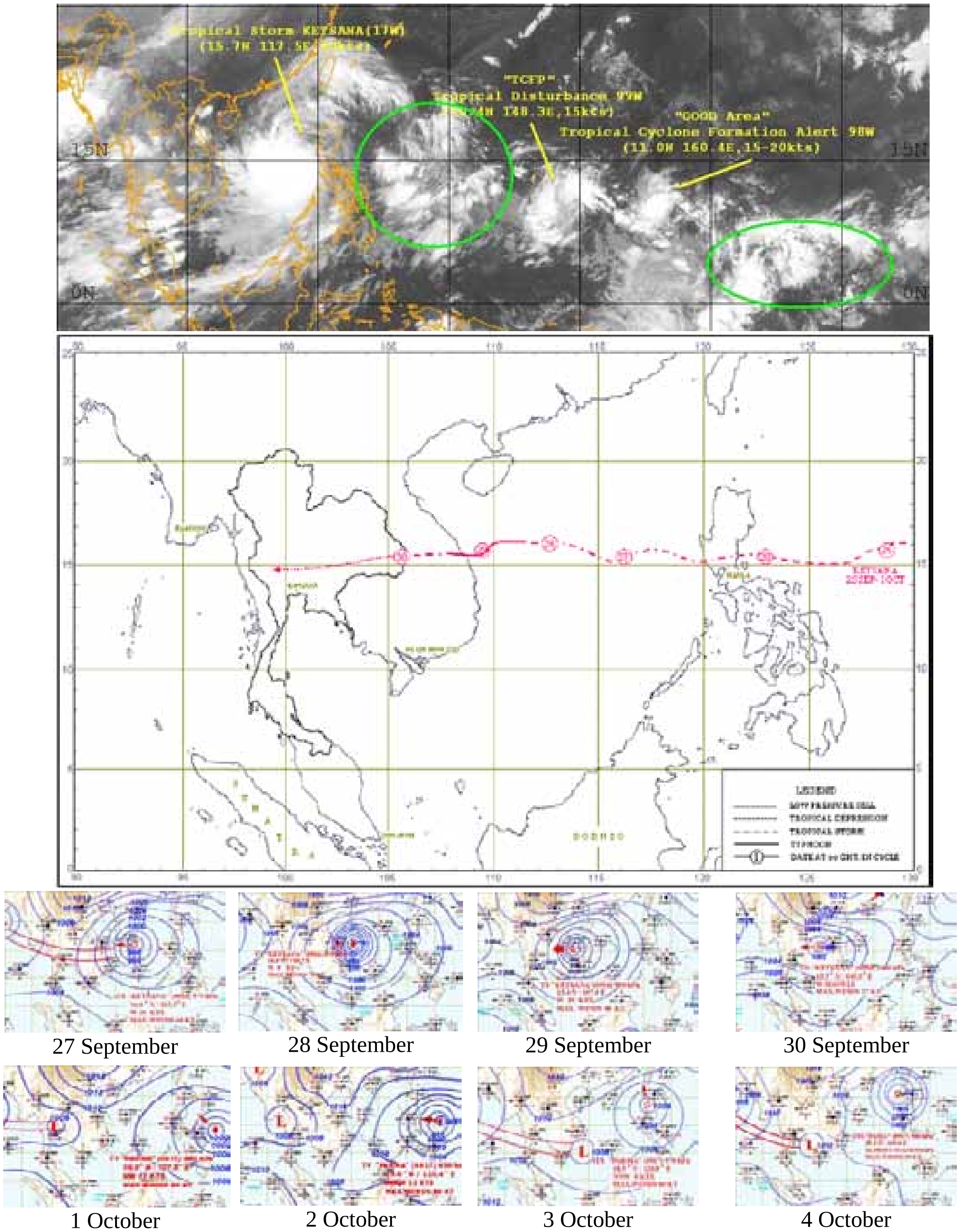


Figure 13. The formation of Typhoon Ketsana

As shown in Figure 13 the Typhoon Ketsana caused a major flood problem in Thailand. It initially formed in the South China Sea as low pressure area and tracked westward within the Pacific Ocean and upgraded to tropical storm on 26 September at the latitude 15.6 N and Longitude 123 E. It tracked westward passing over the island of Luzon in the Philippines. It moved to the South China Sea, the system dramatically deepened and expanded while moving towards the West, which led to a severe tropical storm during 27 September. It gradually developed further and was upgraded to Typhoon Ketsana, intensified quickly during that day

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under favourable conditions reaching peak wind speeds later that day of 165 km/h (105 mph) and 140 km/h (85 mph).

Nevertheless, Typhoon Ketsana rapidly weakened into a severe tropical storm. However, many agencies in Thailand for instance TMD, DWR, and DDPM continued to monitor Typhoon Ketsana as a severe tropical storm until later that day when it downgraded to a tropical storm before downgrading to a tropical depression.

Typhoon Ketsana tracked toward to Thailand on 30 September as a tropical depression. As the weakening typhoon moved through Thailand, there were widespread heavy rainfall and flash floods in mostly 40 provinces, especially in the North-eastern part and partially in the Northern and Central part of Thailand.

This flood circumstance affected directly 2,897,554 people. These also reported that there were more than 577,000 families suffering and it caused the death of two people (Lampang and Yasothon). The depression partially damages 4,638 houses as well as 3,320 km2 (2,077,392 Rai) of agricultural land. The estimated cost for this flood circumstance were around 711 million Baht. The daily rainfall distribution and the maximum daily rainfall are shown in Figure 14 and the example of flood occurrences are illustrated in Figure 15.

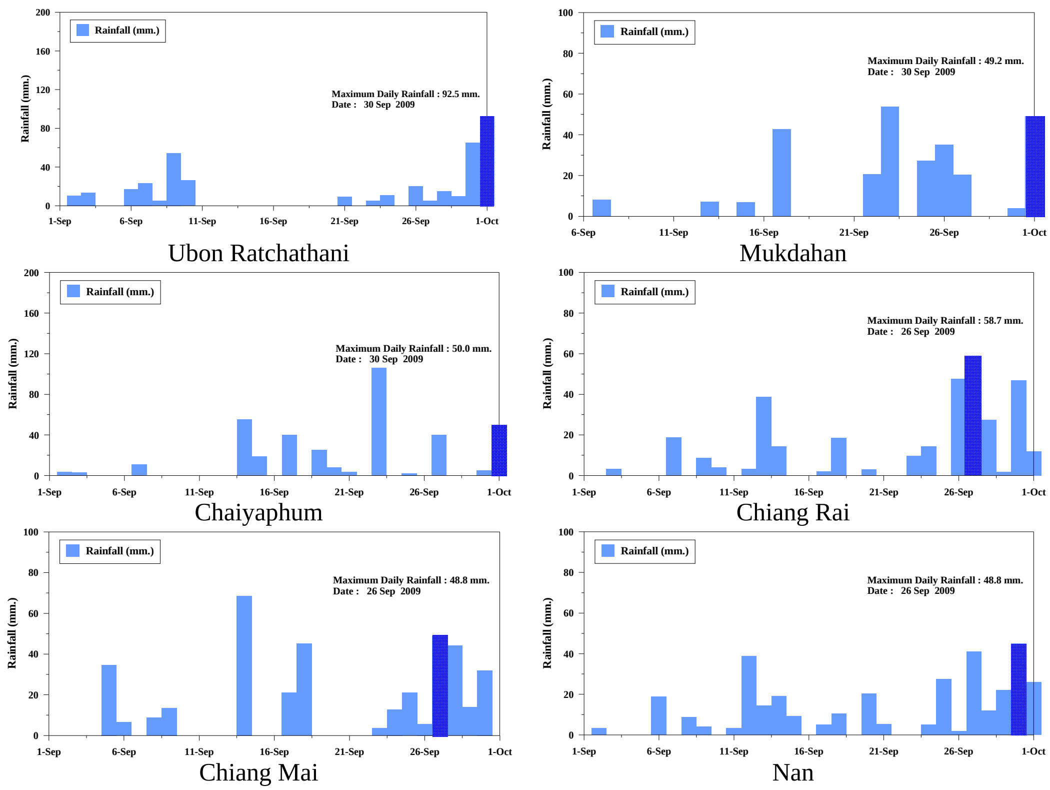


Figure 14. Monthly rainfall distribution in September 2009

Significant flood events in October

The causes of the flood between 6 and 12 October were heavy rainfall in the Central part of Thailand and the high discharge in the upstream part of the river from the Northern part with the result that the water level in Chaopraya and tributary river reached over the bank. It caused inundation in Chainat, Nakornsawan, Angthong, Ayuthaya and Bangkok provinces. The rainfall distribution in October, the water level in Chaopraya River and the example of flood occurrence in October is shown in Figures 16, 17 and 18 respectively.

Significant flood events in November

The flood situation during November to December came from the tropical storm name 'Minere' 2-5 November 2009. It caused heavy rainfall prolonged over the South of Thailand as shown in the weather chart and satellite image in Figure 18. It caused flood in 61 districts 11 provinces comprising Surat Thani, Nakhon Sithamarat, Chumpon, Trung, Pattalung, Songkla, Satun, Narathiwat, Yala, and Pattani provinces.

In Songkla Province, there was 275 mm of heavy rainfall on 5 - 6 November, which caused flooding problems in 8 districts. Especially in Hat Yai, flood level height up to 0.50 m. In Pattani Province, there was 180 mm of heavy rainfall on 21 November, which caused a flood level up to 1 m. in some districts. The rainfall distribution in November is shown in Figure 19. The formation of Minere and the example of flood occurrences in November is illustrated in Figures 20 and 21 respectively.

Thailand's flood situation data of each month in 2009 and satellite image given from Geo-informatics and Space Technology Development Agency (GISTDA) flood occurred in the areas in the Northern and North-eastern part of Thailand. Figure 22 shows an example of the inundation map from GISTDA.

THE 2009 BASIC AID TO THE PEOPLE FROM FLOOD ENCOUNTERS

From the occurrences of flood in 2009, 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. Aid came not only from the government sector; there were also many private sectors helping with donation to those people who were the victims of disasters from floods. The basic aids are summarized in Table 1 and in the picture in Figure 23.

Flood occurrences in Chaiyaphum Province

Flood occurrences in Buriram Province

Flood occurrences in Buriram Province

Flood occurrences in Srisaket Province

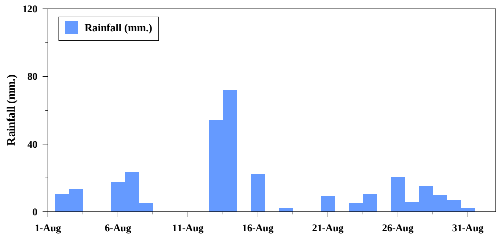
Interview suffering people in Varinchamrab District

Flood hazardous in Ubon Ratchathani Province

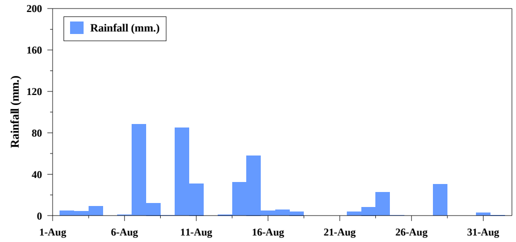
Interview suffering people along Mun River

Flood occurrences in Chiang Rai Province

Figure 15. Flood occurrences in September 2009

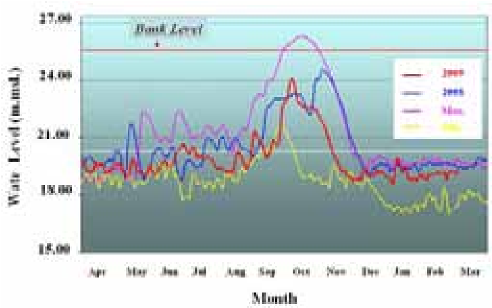


Bangkok

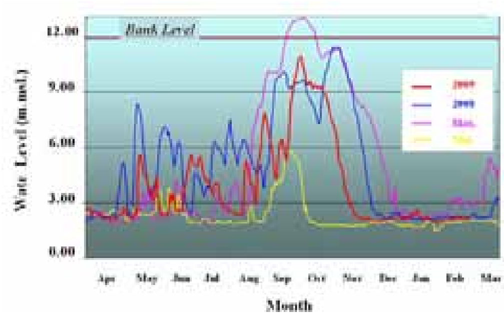


Nakornsawan

Figure 16. Monthly rainfall distribution in October 2009

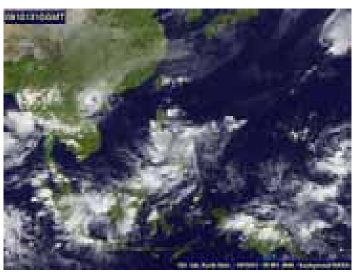


Nakornsawan (Muang Nakornsawan District)

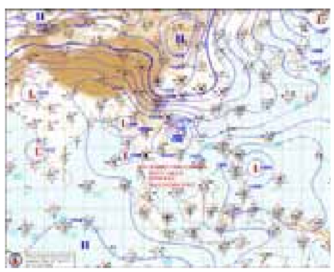


Nakornsawan (Sunpaya District)

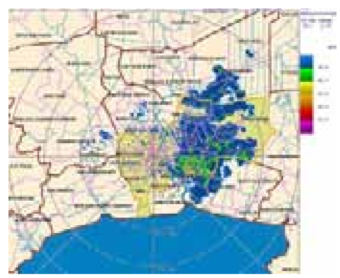
Figure 17. The trend of water level in Chaopraya River



Satellite image illustrated storm characteristic cover the Central Part on 13 October



Satellite Image on 13 October



Distribution of daily rainfall in Bangkok collected by BMA

Heavy rainfall in Bangkok, cumulative rainfall 13 and 14 October, result flood level in Bangkok reach 0.50 m. and which are the most serious situations in the past 25 years

Flood occurrence in Shingburi Province that affected 900 households, 31 villages, 8 sub-districts and 2 districts 5 - 9 October

Flood occurrence in 10 districts in Lopburi Province which damaged an irrigation area of around 90 km^2 (56,000 Rai) 5 -8 October

Figure 18. Flood occurrences on October 2009

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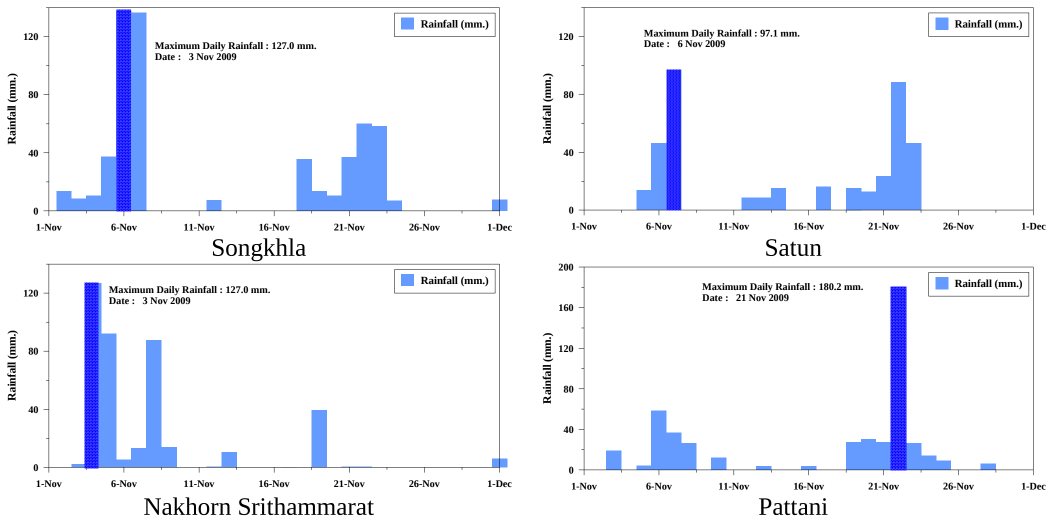


Figure 19. Monthly rainfall distribution on November

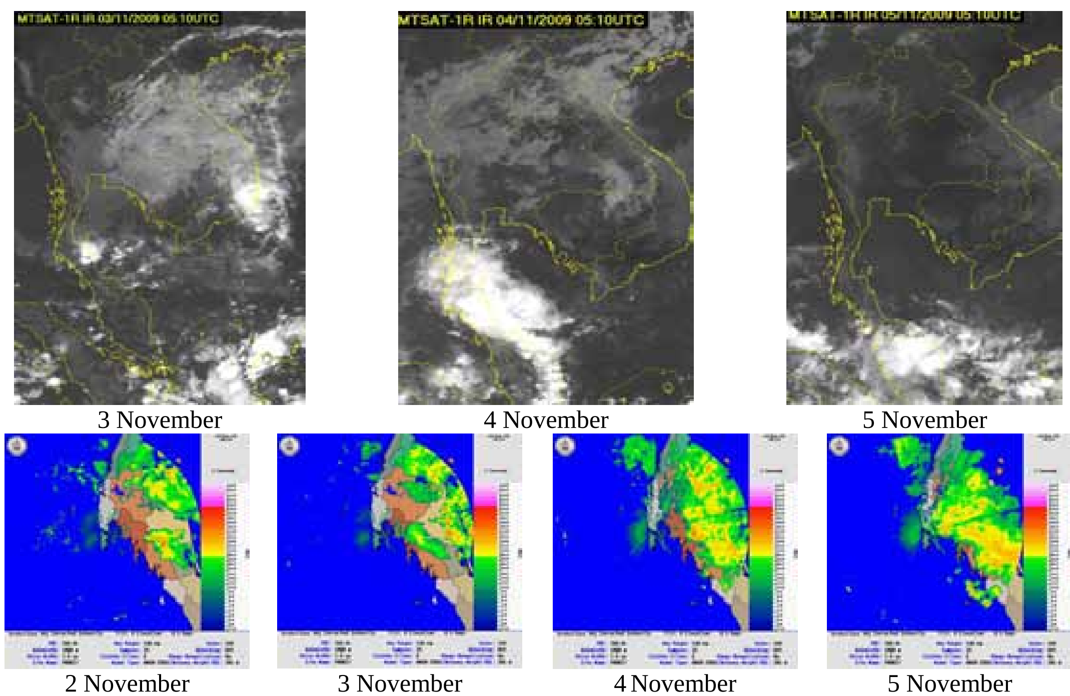
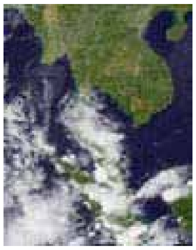
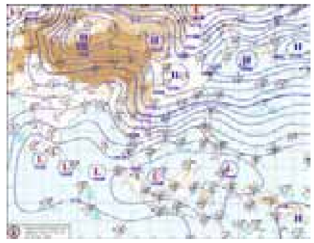
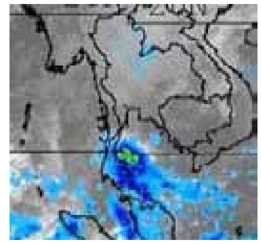


Figure 20. The formation and detail of Minere


Satellite image illustrating storm characteristic cover the Central Part on 4 November


Satellite Image on 4 November


Daily rainfall in southern part of Thailand on 4 November


Flood occurrence in 8 districts in Songkla Province which affected 4,652 households 4 – 7 November


Flood situation in 5 districts in Satun Province which resulted in more than 1,000 suffering households on 7 November


Flood situation in 9 districts in Pattani Province due to heavy rainfall, up to 180 mm, on 21 November

Figure 21. Flood occurrences in November 2009

Table 1. The 2009 basic aid to the people affected by flooding

Type	Month								
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Pump	136	N/A	N/A	N/A	N/A	N/A	N/A	N/A	136
Preserve bag	N/A	11,777	650	14,800	57,347	1012	N/A	N/A	N/A
Boat	N/A	20	N/A	N/A	N/A	28	N/A	N/A	N/A
Medicament	N/A	N/A	N/A	N/A	4860	N/A	N/A	N/A	N/A
Truck	N/A	N/A	N/A	N/A	N/A	4	N/A	N/A	N/A

Source: Department of Disaster Prevention and Mitigation.

As example of aid in August at Nakhon Phanom Province, the Local Administration Network supplied 13,950 bags for living and 3 boats, Rajaprajanugroh Foundation under Royal Patronage supplied 500 bags for living, Public Health supplied 7,000 medicaments and Royal Irrigation Department installed 3 pumps to discharge flood water from the municipal area. The other related institutes had inspected and gives basic aid to those people.

IMPACTS OF FLOODING IN 2009

In 2009 the calamity of flood brought suffering to 8,891,257 people of 2,144,771 households in 63 provinces. This disaster affected 8,891,257 people and 32 people died. Other assets were destroyed such as 36,717 houses in communities about 40,176 fish ponds, 55,222 livestock and poultries and an agriculture area about 5,664 km2 (3,540,117 rai).

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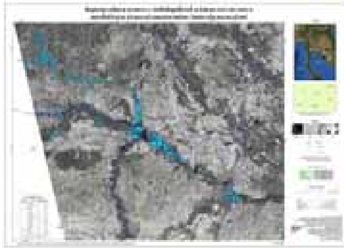
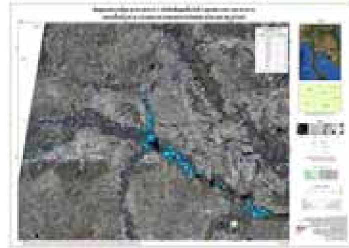


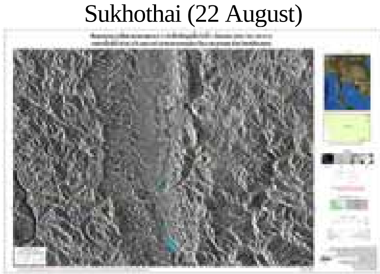
Srisaket (26 September)



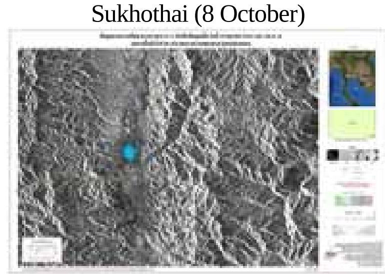
Srisaket (2 October)

Sukhothai (22 August)

Sukhothai (8 October)



Mae Hong Son (1 September)



Mae Hong Son (19 October)

Figure 22. Inundation map from Geo-informatics and Space Technology Development Agency (GISTDA)

Moreover the flood situation had effect to many infrastructures which were 19,272 roads, 1,447 bridges, 651 drainage systems and 136 official buildings, schools and temples. In 2009 the cost of damage was 2,988 million Baht (US$ 94 million). Flood damage assessment in 2009 is shown in Table 2 and Comparison of impact from disasters in (2003 - 2009) is shown in Table 3.

From the 2009 flood damage data, which were compared with the previous 6 years (2004-2008) it was found that the flood damage assessment in 2009 was higher than in 2008. For example, the cost of damage in 2009 was about 18% higher than in 2008 about 416 million Baht (US$ 13 million) and in 2009 63 provinces less than in 2008 were affected. This was caused by Typhoon Ketsana in late September to October and heavy rainfall in the Southern part of Thailand in November. In Figure 24 comparison is shown in number of provinces, people and infrastructure affected and cost of damage.

RESPONSES TO FLOOD EVENTS IN THAILAND

The Policy Statement of the Council of Ministers was delivered by Prime Minister, H.E. Mr. Abhisit Vejjajiva on 5 August, on the Policy to combat flood disasters by implementation of the flood management plan and flood risk management. Basically, measures implemented to resolve and mitigate with flood circumstances can be categorized into 3 phases: before, during and after a flood circumstance.

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Table 2. Flood damage assessment in 2009

Description		May	June	July	August	September	October	November	December	Total
Area	Provinces	4	18	9	37	50	40	10	-	63
	Districts	4	47	24	187	349	251	105	-	-
	Villages	50	1,022	339	6,098	13,244	12,122	3,842	-	36,717
Human	People	17,073	249,686	54,495	1,016,062	3,643,337	2,897,554	1,013,050	-	8,891,257
	Casualties				9	9	1	13	-	32
Assets	House	5,081	78,244	13,760	289,736	790,422	701,288	266,240	-	2,144,771
	Fish ponds	-	113	9	2,333	23,470	5,097	9,154	-	40,176
	Live stock	-	-	-	6,675	8,739	16,018	23,790	-	55,222
	Agriculture field (rai)	-	29,319	600	274,561	910,622	2,077,392	247,623	-	3,540,117
Infrastructure	Roads	2	637	128	3,440	7,864	3,795	-	-	19,272
	Bridges	3	155	9	297	524	172	287	-	1,447
	Hydraulic structures	20	76	11	20	-	-	43	-	170
	Institute buildings	2	2	2	2	-	-	128	-	136
	Drains	1	81	-	39	-	-	530	-	651
Cost million Baht		-	111	-	238	1,171	711	757	-	2,989

Source: Department of Disaster Prevention and Mitigation.

Table 3. Comparison of impact from disaster in 2004 – 2009

Descriptions		2009		2008	2007	2006	2005	2004
		Total year	Ketsana					
Areas	Provinces	N/A	40	65	46	47	63	59
	Districts	N/A	251	584	486	482	541	337
	Villages	N/A	12,122	22,874	20,499	20625	10326	9,964
Human	People	N/A	2,897,554	4,494,187	3,640,978	5,198,814	2,874,673	2,324,441
	Households	N/A	N/A	1,197,253	940,663	1,430,085	763,847	619,797
	Casualties	N/A	N/A	97	62	340	88	31
Assets	House	N/A	4,638	18,258	7,369	49,611	6,040	5,947
	Fish ponds	N/A	5,097	42,424	34,767	125,683	13,664	12,884
	Live stock	N/A	16,018	504,737	38,079	142,211	696,123	71,889
	Agriculture field (rai)	N/A	2,077,392	3,023,477	2,645,982	5,605,559	1,701,450	3,298,733
Infrastructures	Roads	N/A	3,795	12,133	8,330	10,391	5,697	4,173
	Bridges	N/A	172	573	309	671	667	173
	Hydraulic structures	N/A	N/A	595	591	778	22,527	716
	Institute buildings	N/A	N/A	197	271	1,425	2,123	827
	Drains	N/A	N/A	561	163	1,085	1,482	594
Cost Mill Baht		N/A	711	2,528	1,697	7,077	5,982	850

Source: Department of Disaster Prevention and Mitigation.

Proceeding of the first measure is relevant with learning as well as the training and public relations, also, provided to communities and stakeholders to reach the methodology and to raise awareness of flood hazard.

Rajaprajanugroh Foundation

Thai Red Cross Society

Source: Rajaprajanugroh Foundation, the Thai Red Cross Society

Figure 23. The 2009 basic aid to the people affected by flooding

The measures applied during flood circumstances emphasize on the action plan raised to save or alleviate the suffering people. It comprises closely coordinated and urgently established special centre/focal centre to carry out the collaboration to prepare the fundamental conveyance system and provide the casualties with facilitation provisions.

The last measure served after the flood circumstance has the main purpose to analyze and evaluate flood hazard circumstances and plan the scope of optimal measures for coping and addressing the problem in the next situation. Furthermore, survey of damages, rehabilitation of casualties, assessment of the flood hazard and the evaluation of the implementation plan are the main activities in this phase. The strategy of the Master Plan concerning the prevention and mitigation of flood hazards as described above can be deduced as shown in Figure 25.

Regarding Figure 25, main responsibilities and activities of DWR in addressing flood issues concern telemetering and flood forecasting as described below.

Flood forecasting

The Department of Water Resources has been implementing monitoring, forecasting and early warning systems, which have been completed in Chi and Mun river basins and will be implemented in Mekong River (North-eastern) Basin in 2011. The main purposes of establishment flood forecasting system are to step outside in advance together with the national economy and to improve community's 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.

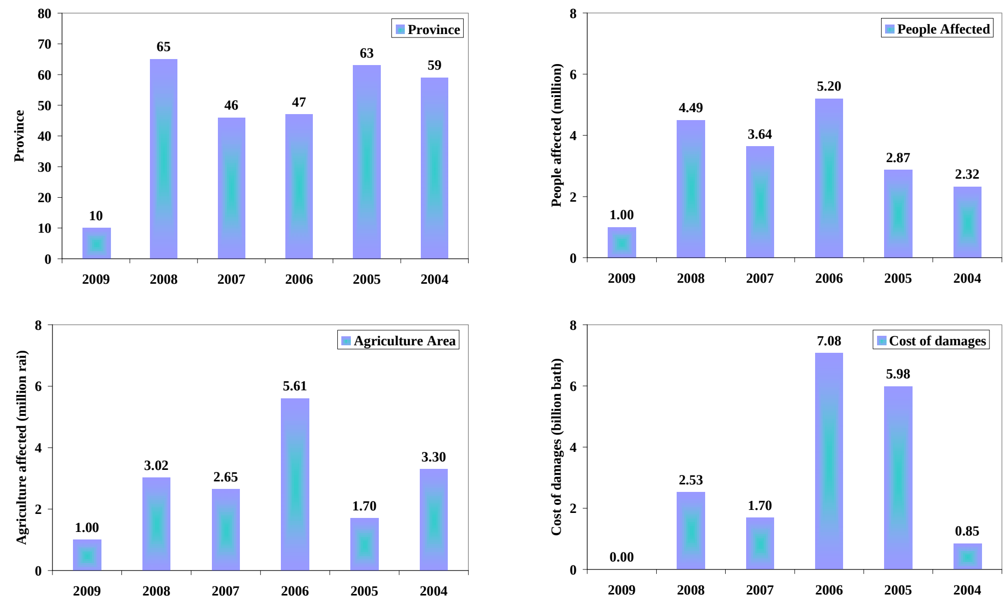

Figure 24. Number of provinces, people, infrastructure affected and cost of damages

All flood forecasting systems in Mekong, Chi and Mun river basins, use the InfoWorks and FloodWorks program, product from HR Wallingford Ltd., which have been configured for the individual study area. About the detail and the concept of the telemetry system and also the results from forecasting systems can be deduced as follows.

FloodWorks model concept

FloodWorks offers powerful and comprehensive facilities that integrate sophisticated hydrological and hydrodynamic modelling with real-time decision support and control. FloodWorks is a modular system based on a client/server, multi-user, multi-model architecture. The core of the Forecasting Module is based on the River Flow Forecasting System (RFFS).

The software combines data assembly, validation and management, advanced hydrological and hydrodynamic simulation engines, geographical analysis and a relational database within a single environment. It is designed to be linked to real-time hydrological and meteorological time-series data sources to provide detailed and accurate real-time modelling in an operational environment. It allows managers and engineers to carry out fast, accurate simulation of the key elements of the future behaviour of the system to support mobilisation of emergency responses and provision of public warnings. Key features of FloodWorks include as follows:

- generic design;
- real-time central operation;
- fast and robust simulation;
- flexibility in choice of model set;
- multiple model network configurations;

- client/server multi-user access to data, models and results;
- web based access to published results and reports;
- windows User Interface with geographical views over map backgrounds;
- version control and audit trail of configuration data;
- integration with desktop GIS;
- integration with the InfoWorks RS river basin modelling system.

Figure 25. The flow chart concerning the strategy of the Master Plan

The following outline provides a brief description of the principal modules involved in the operation of FloodWorks, as shown in Figure 26.

Whenever a new forecast is initiated, the data-gathering module collects the latest data from the available data sources (telemetry, radar, etc.). This module matches up the data points from the telemetry and other systems to the model input data series and carries out data validation and conversion of data formats.

In automatic operation, or if the operator has no changes to make, these data pass directly to the forecasting module. This module feeds the data through a network of hydrological and hydrodynamic models to generate forecasts of water levels, flows, structure operations and other

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quantities over the selected forecast period.

The forecasted time-series from the forecasting module are processed by the analysis module, which summarizes and interprets the forecast time-series in relation to the warning levels defined for the various forecast points. The summary tables produced by this module contain geo-referenced data for subsequent map-based display.

The complete set of input data, forecast time-series and forecast summary tables for each run of the forecasting module are stored in the forecast database.

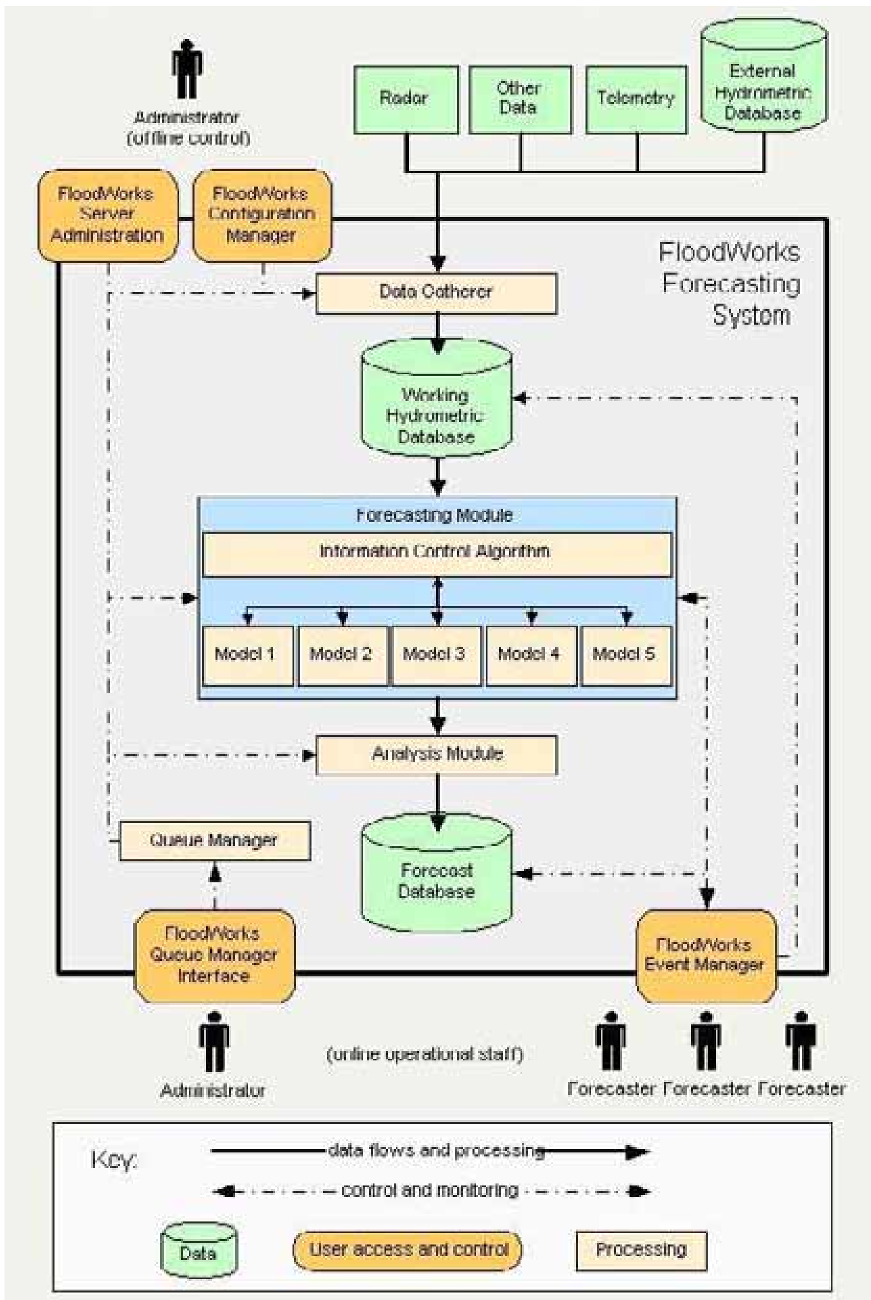

Figure 26. Component of FloodWorks System

Through the event management user interface, operators can initiate additional runs, display the data from any of the runs in the form of maps, tables, graphs or reports, and construct fax or email bulletins based on the forecasts.

Flood Works run automatically at regular intervals. Expert operators will also be able to carry out 'special' runs in which they can select initial conditions for a run, initiate runs based on previous forecasts, produce forecasts only for selected parts of the network, choose between alternative meteorological forecasts, and edit any of the observed or forecast data to be used in the run. For instance, an expert operator might carry out a sequence of runs that differ only in the operation of selected control structures, in order to decide on the alternative that gives the lowest risk of flooding. When the operator is satisfied with the results, the forecast can be issued as an 'official' forecast.

InfoWorks model concept

One of the models to calculate forecast of flow is InfoWorks. InfoWorks is used to model open channel and overbank flows in any network of channels. Any sensible looped or branched network can be modelled using InfoWorks, which incorporates a wide range of hydraulic network objects including a variety of conduit types, hydraulic structures, and so on.

Info Works computes flow depths and discharges using a method based on the equations for shallow water waves in open channels - the Saint-Venant equations.

Info Works can be used to solve systems under both steady and unsteady flow conditions. For unsteady solutions InfoWorks uses the governing hydraulic equations for each network object. These equations are inevitably a combination of empirical and theoretical equations many of which are non-linear. The non-linear equations are first linearised and the solution to the linear version of the problem is then found via matrix inversion. An iterative procedure is used to account for the non-linearities.

The Preissmann four-point implicit finite difference scheme is employed for the channel equations and the matrix is inverted using a powerful sparse matrix solver. Figure 27 describes the main step for running a simulation in InfoWorks.

Flood forecasting results

Results can be viewed in several ways, the most common of which are:

- graphical view;
- run summaries (brief or detailed);
- flood mapping;
- results comparisons;
- tabular view;
- web results.

Figure 28 shows flood map from forecasting systems compared with observed data from GISTDA.

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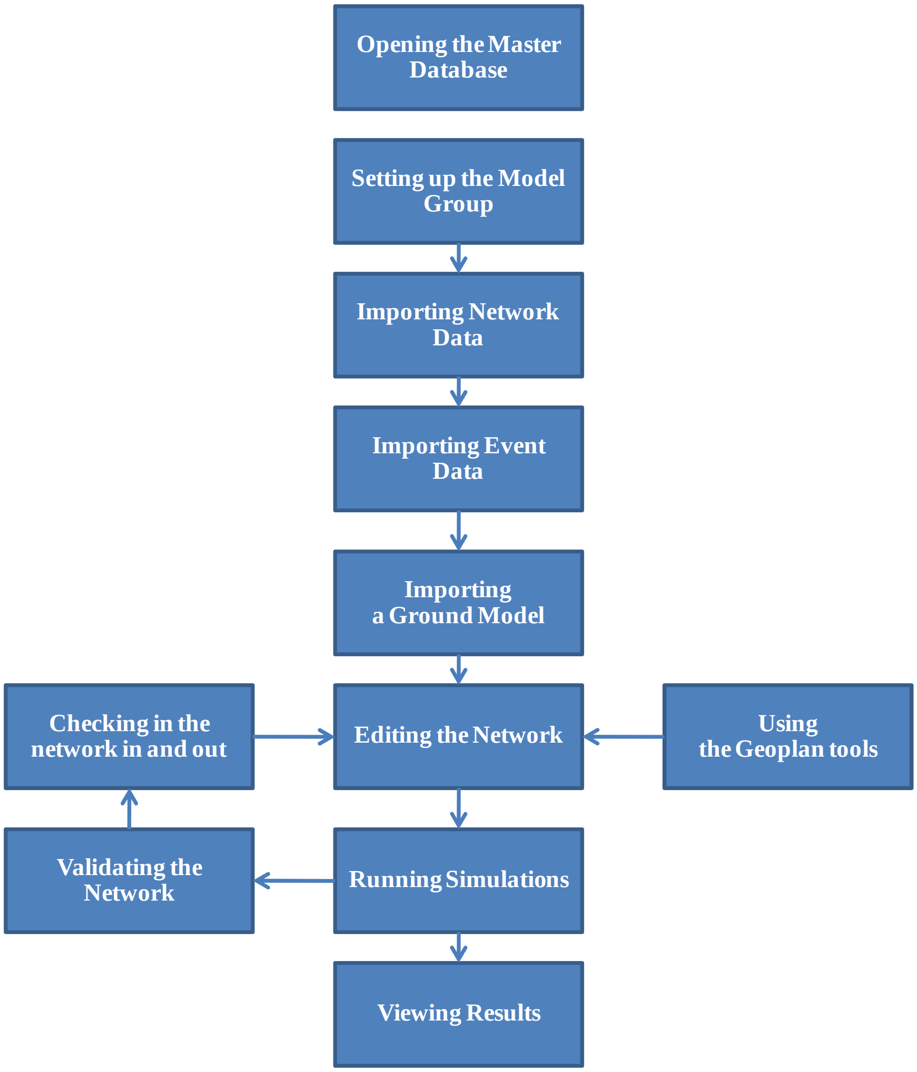

Figure 27. Steps for running a simulation in InfoWorks

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 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 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):

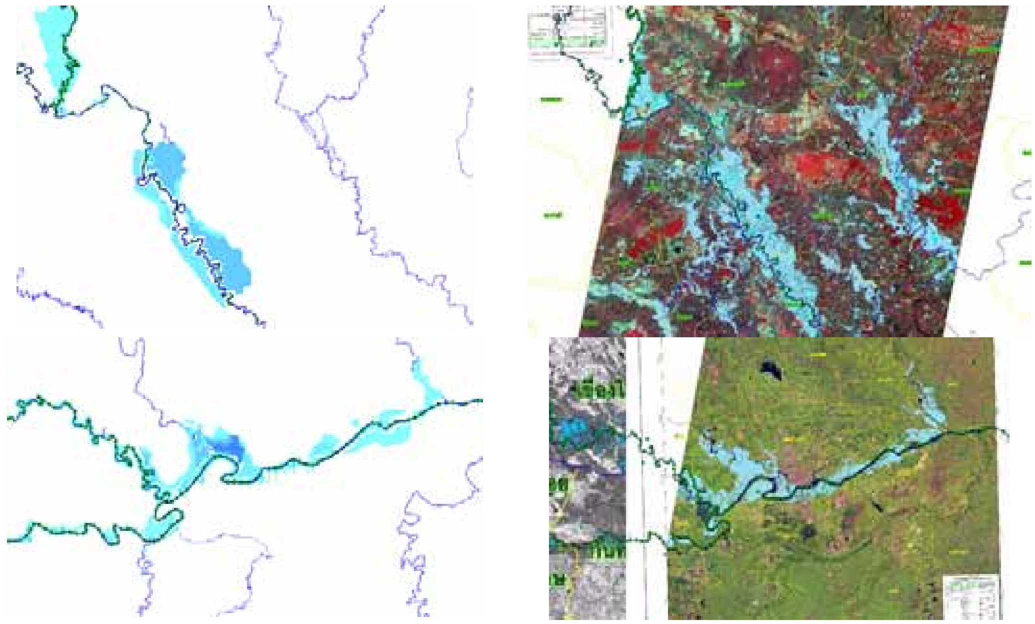

Figure 28. The results of flood forecasting systems

- 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 demand of people;
- to set guidelines and directives 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 report their implementation in terms of water quantity and quality;
- to consider and solve any urgent problem or impediments;
- to prioritize water allocation and regulate the use of water from various sources to the requirements for consumption, hydropower generation, industry, agriculture, and other; and also to report to the Cabinet;
- to propose to the Cabinet any introduction or revision of rule, regulation or laws relating to construction or development, control, prevention, and conservation of water resources and water quality.

River Basin Committee

A River Basin Committee comprises members selected from government officials, state enterprise representatives, representatives of local organizations and water uses organizations, stakeholders who work or live in the concerned river basin, and qualified persons who have knowledge and experience relating 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 obstacles to development, utilization, conservation, and any other necessary implementation relating to water resources management as well as any pertinent action of the concerned agencies in river basin;

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- to formulate water resources management plans and coordinate the formulation of such plans by relevant agencies in the river basin;
- to prioritize water allocation and specify water requirement as well as equitable and efficient water allocation measures;
- to monitor and evaluate performance of the agencies relevant to water resources in the river basin;
- to compile statistics, data, comments, and recommendations regarding water resources management, development and conservation, as well as solution to water shortage, flood, and water quality problems;
- to conciliate conflicts and solve problems;
- 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 Resource 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 issue, which are:

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

LESSONS LEARNT

The excessive water quantity in the rainy season cannot be controlled including lack of well management could result with suffering to lives, properties and economies. The flooding problem is extreme because of it’s continuous occurrence and it seems to increase every year. This problem mentioned reflects some lessons as follows:

- lack of action plan in managing, developing, protecting, and rehabilitation of water resource by involving communities;
- lack of evaluation of the water resources management plan following the policy, Master Plan, action plan, and measurement are determined in basin and national level;
- lack of integration of database systems and data network information systematically;
- lack of promotion, support, technique and law in water resources management to local organizations.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The trend of cumulative rainfall, water level analysis and also the flood situation obviously prove that flood occurrence in 2009 was not more severe than in 2008. In 2009 Thailand’s flood situation almost only resulted from tropical storms that occur by low pressure movement towards the North-east through the North of Thailand, as in 2008. This effect caused by rainfall in many areas and prolonged heavy rain in some areas. Therefore, floods happen such as flooding in low lying areas and flash floods in mountainous areas.

For example, from 29 September to 26 October, it has been Tropical Storm Mekkhala and from 2 to 5 November, it has been Tropical Storm Minere. The calamity of flood brought suffering in 36 provinces to 1,783,245 people of 437,723 households. Due to these disasters 1 person died, assets were destroyed, such as about 16 houses in communities and 2,187 km2 (1,366,659 rai) agricultural land. The damage was US$ 33.4 million, especially in September about US$ 21.6 million was damaged, 39.2 %of total cost of damage in the year 2009.

During the flood events, there was aid from many institutes such as 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

While problems of water resources concern many sectors the process of resolving flood disasters is performed by many agencies as by their authority and there are many legal issues without a leading role of the water resource law. Due to this the resolving operations become less unified. So that the Water Act need to be followed more seriously.

To increase flood management, needs to be an agency that takes direct responsibility to plan and coordinate with the related organizations from the communities, 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, i.e. water operation centre, development of surveillance, monitoring, forecasting and early warning systems to support the decisions support system, etc.

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Appendix I. Cause of Flood Occurrences in North-eastern Regions

Chiyaphum Province: The main reasons for the flood problems in this province resulted from the volume of the flood peak in the Chi River and its tributaries: Huai Pratao and Lumkajuan, and from tributaries located in the upper part of Chi River Basin. The flood extent covered the riparian area along the main river and tributaries, especially the confluence between Chi and Huai Pratao.

High precipitation and the deficiency of the drainage system also caused the water level reach over the bank/levee especially in urban and economical area, Muang Chaiyaphum District. Moreover, the intrusion of the accommodation in Chi River, Jaturat District, affected the proficiency to release the flood volume. Thus, the reasons of the flood problems in this area can be deduced as follows:

- combined flood from flow at upper area and water level at the confluence between Chi and tributaries;
- unavailable storage or detention pond for retarding the flood peak especially in the upstream of the upper river basin;
- the obstacles in Chi River from accommodation intrusion as well as in the tributaries in this reach is too narrow and became a labyrinth which caused inefficiency to release the flood peak;
- the low topography of Muang Chaiyaphum District, and the deficiency of the drainage system.

Due to the reasons above, participating line agencies in Chaiyaphum established the measures to address with these flood circumstances. There are normally many agencies that have the responsibility for serving and resolving with flood problems, such as DWR, RID and DDPM, which are appointed as the focal point to carry out measures during flood occurrences.

Buriram Province: The main reason for the flood problem in this province was the volume of the flood peak from the tributary Lum Plaimas which occurs every year. The consequent cause of this comes from the main road, 226 road, which is an obstacle for the overland flow from Lum Plaimas Basin.

Furthermore, the flooded area at Lum Plaimas, Satuk District has occasionally affected flood occurrence due to water level spill over the levee, especially on the left bank of Mun River.

Monitoring measures to address the flood issue are related to water level and rainfall data, especially in the upper part of the basin, as well as monitoring of the water level in the reservoir located in the upper part of the river basin. DDPM is the main agency to resolve this flood problem. They established the focal point centre to coordinate with other agencies to cope with and alleviate flood problems.

Srisaket Province: The main reasons for the flood problem in this province is the volume of the flood peaks from the tributaries Huai Sam Ran and Huai Tab Tun, which occur in every year, and the most important factor is heavy precipitation in the mountainous area Panom Dong Ruk. The storage can not retard the peak flow and the flood is released to low lying area downstream.

Among the measures by responsible agencies are to prepare and to monitor hydrological data, water levels and precipitation in the upper part of this basin and monitor the water level in the reservoir located in the upper part of this area.

As DDPM is assigned to be the main organization to address flood problems, they establish the focal point centre to coordinate with other agencies to cope with and alleviate flood problems.

Ubon Ratchathani Province: The main reasons for the flood problems in this province are the volume of flood peaks in the Chi and Mun rivers and their tributaries, as well as the water level of Mekong River, which is the major cause of flood problems in this area.

The flood extent covers the riparian area, especially in Varin Chamrab District, which is located on the right bank of Mun River. In this place normally flooding occurs every year, because of the low lying area. However, the communities are familiar with it and know how to address this issue. Most of them have moved their assets before the flood occurrence. The summary reasons of flood issues in this area are:

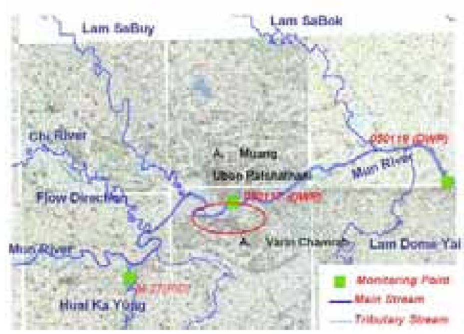
- combined flood due to flow at the upper part of the area and the water level at the confluence between Mun and Mekong rivers;
- the obstacle in Mun River due to accommodation intrusion, especially in Varin Chamrab District.
- the low topography of Varin Chamrab District and the deficiency of the drainage system.

Measures addressing with the flood issue are mainly related to dissemination of in formation on the flood situation (monitor of the water level and/or telemetering station of DWR and RID). Normally, this can be announced around 6 hours before the flood peak reaches to this risk area.

Chiyaphum

Buriram

Srisaket



Ubon Ratchathani

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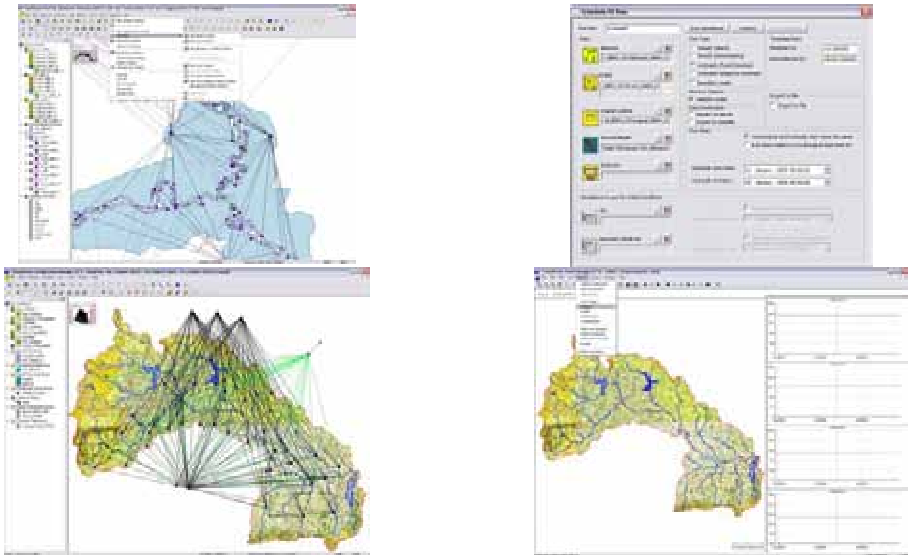
Appendix II. Graphic user interface of FloodWorks and InfoWorks Program



Graphic user interface of FloodWorks and InfoWorks

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Paper 1-4

VIET NAM COUNTRY FLOOD REPORT FOR 2009

DAO TRONG TU[1] AND BUI DUC LONG[2]

[1]National Flood Expert, National Flood Unit, Viet Nam National Mekong Committee, Hanoi, Viet Nam
[2]National Centre for Hydro-Meteorological Forecasting, Ministry of Natural Resources and Environment, Hanoi, Viet Nam

ABSTRACT

During 2009 the meteorological conditions in Viet Nam were very complicated, with several extreme food events in the central part and the highlands. There were three low pressures and 11 tropical storms approaching the East Sea, of which six tropical storms and one tropical depression exerted their direct impacts on Viet Nam's territory. There were a series of tropical storms (TS) that landed in Viet Nam, namely Soudelor (TS No. 4), Mujigae (TS No. 7), Ketsana (TS No. 9), Parma (TS No. 10) and Mirinae (TS No. 11). During 2009, due to the effects of some tropical storms, nine serious floods occurred in main rivers, of which two were historical flood events in rivers in the Central Region and Central Highlands and in the South.

The content of the Country Report of Viet Nam will reflect four topics of the 8th Annual Mekong Flood Forum (AMFF-8), namely Community focused approach to flood risk management and mitigation, Flood forecasting and flash flood guidance, Structural measures and flood proofing and Trans-boundary cooperation for managing floods and related issues. The report also presents lessons learned from the 2009 flood events in Viet Nam.

In this Country Report an overview and analysis is given of 2009 floods and flooding in Viet Nam, especially in the territories in the Mekong River Basin, as well as an update of the status of the flood forecasting and warning organizations.

OVERVIEW OF THE 2009 FLOODS AND FLOODING IN VIETNAM

During 2009 the meteorological conditions in Viet Nam were very complicated with several extreme food events in the central part and the highlands. There were three low pressures and 11 tropical storms approaching the East Sea, of which six tropical storms and one tropical depression exerted their direct impacts on Viet Nam's territory.

Highlights meteorological assessment

During 2009 the meteorological conditions in Viet Nam were extreme with five tropical storms (TS). There were a series of tropical storms that landed in Viet Nam, namely Soudelor (TS No. 4), Mujigae (TS No. 7), Ketsana (TS No. 9), Parma (TS No. 10) and Mirinae (TS No. 11). Besides that, a tropical depression that developed in the South China Sea on 3 September 2009 did not make landfall in Viet Nam but its circulation, incorporating a strong South-west Monsoon, caused heavy rainfall in the central part of Viet Nam. Total rainfall for 6 days was 500 – 700 mm in general, especially more than 1,000 mm in Thua Thien Hue (1,022 mm) and in Da Nang (1,239 mm).

TS No 4 (Soudelor) was upgraded from a tropical depression over the South China Sea. It entered the Gulf of Tonkin at 11 July on 6:00 UTC with a maximum wind speed of force 8, gust 9, 10 and made landfall on Quang Ninh and Hai Phong provinces. This was not a strong tropical storm with maximum wind speed recorded at Bach Long Vi station of 11 m/s, gust 13 m/s; Co To 15 m/s, gust 22 m/s; Mong Cai (Quang Ninh) 12m/s, gust 16m/s: Bai Chay (Quang Ninh) 13 m/s, gust 17 m/s. Minimum pressure of 994 mb was recorded at 12 July on 10:00 UTC at Hon Dau station. Soudelor caused heavy rain in the North of Viet Nam. In total in 2 days (12 and 13 July) it was 100 mm in general. Some stations got more, such as: Moc Chau (Son La) 211 mm, Nam Dinh 166 mm, Hoi Xuan (Thanh Hoa) 175 mm (Figure1).

Figure 1. Tropical Storm Soudelor in July 2009

TS No 7 (Mujigae) was upgraded from tropical depression over the South China Sea at 9 September on 21:00 UTC, with maximum wind speed of force 8, gust 9 - 10, moving West-north-west at 25 km/h. After entering the Gulf of Tonkin, Mujigae slowed down at 10 km/h, then made landfall on Nam Dinh and Thanh Hoa provinces on 12 September in the morning. Maximum wind speed recorded at Bach Long Vi station was 20 m/s, gust 27 m/s; Co To 18 m/s, gust 24 m/s; Hon Dau 13 m/s, gust 21 m/s; Van Ly (Nam Dinh) 18 m/s, gust 21 m/s. On 11 September at 8:30 UTC a minimum pressure was recorded of 995 mb at Bach Long Vi station. Mujigae did not cause really heavy rain for the North of Viet Nam, total in 3 days (11 - 13 September) was 30 - 80 mm in general. Some provinces got more such as: Hoa Binh 180 mm, Nam Dinh 159 mm, Ninh Binh 231 mm and Thanh Hoa 263 mm (Figure 2).

TS No 9 (Ketsana) was upgraded from tropical depression over the East Philippine Sea at 26 September on 0:00 UTC with maximum wind speed of force 8, gusts 9 - 10, moving Westward at 25 km/h and intensified rapidly. After entering the South China Sea Tropical Storm Ketsana continued to move West-ward at 20 – 25 km/h, when Tropical Storm Ketsana approached Hoang Sa archipelago, it reached maximum intensity of 13 Beaufort, gusts 14 - 15 Beaufort. After crossing the Hoang Sa Archipelago, Tropical Storm Ketsana continued its west-ward direction and slightly changed its direction before making landfall on Quang Nam and Quang Ngai provinces on 29 September afternoon. Maximum wind speed recorded at Ly Son station was 32 m/s, gusts 43 m/s; Con Co 17 m/s, gusts 24 m/s; Da Nang 22 m/s, gusts 30 m/s; Tam Ky (Quang Nam) 16 m/s, gusts 29 m/s; Quang Ngai 16 m/s, gusts 22 m/s. At 29 September on 5:30 UTC a minimum pressure of 965 mb was recorded at Ly Son station. Tropical Storm Ketsana caused really heavy rain for Central Viet Nam (including the provinces from Quang Binh to

Quang Ngai, Gia Lai and KonTum). The total rainfall in 3 days (28 - 30 September) was 120 - 270 mm in Quang Binh; 200 - 400 mm in Gia Lai, Kon Tum, and Quang Tri to Quang Ngai; 400 - 600 mm for the provinces from Thua Thien Hue to Quang Ngai. Some provinces got more rainfall such as: Nam Dong (Thua Thien Hue) 884 mm and Tra Bong (Quang Nam) 914 mm. Tropical Storm Ketsana also caused historic flood in some rivers in Central Viet Nam (Figure 3).

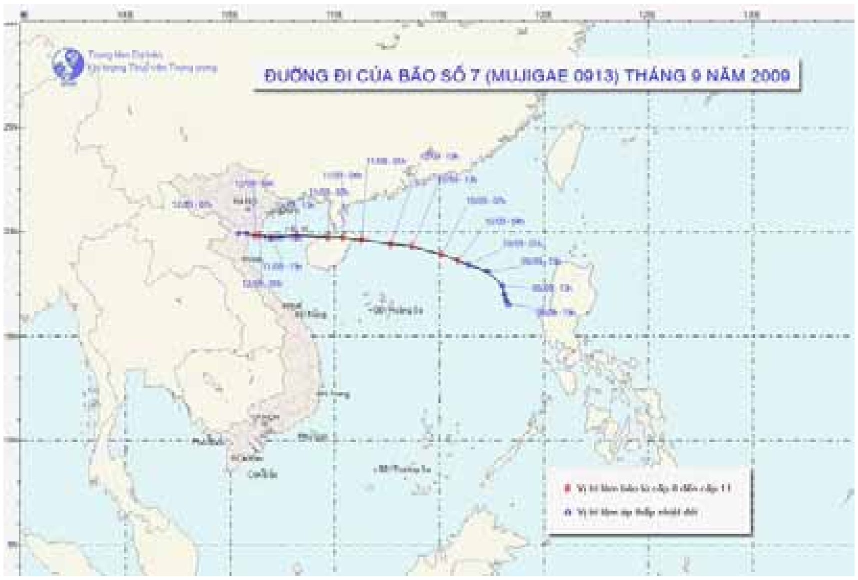

Figure 2. Tropical Storm Mujigae in September 2009

Figure 3. Tropical Storm Ketsana in September 2009

TS No 10 (Parma – 0917) was upgraded from tropical depression over the North West Pacific. At 12 October on 12:00 UTC, after entering the South China Sea on 4 October in the morning, Parma moved North-north-west, then West-north-west. At 5 November on 0:00 UTC Parma was at 20.1 N – 119.3 E with maximum intensity of 10 Beaufort. Since then, because of interaction with Typhoon Melor Parma was almost stationary moving East-south-east and then South-east, going out of the South China Sea. After crossing 122.0 E longitude, Parma came back, crossed Luzon once more and entered the South China Sea on 9 October in the morning. Before entering the Gulf of Tonkin, slightly intensifying and then dissipating over the coastal area of Thai Binh and Nam Dinh provinces, Parma moved West ward and North-west ward with unstable speed. This was one of the most complicated typhoon tracks in 2009 over the South China Sea. Although Parma did not make landfall with tropical cyclone or tropical depression intensity it caused damaging wind over the Gulf of Tonkin, maximum wind speed of 42 m/s, gusts 53 m/s for Bach Long Vi station and 18 m/s, gusts 30 m/s for Co To station. For the coastal area Parma also brought 18 m/s, gusts 24 m/s for Cua Ong station and 12 m/s, gusts 16 m/s for Mong Cai station. In Bach Long Vi station a minimum pressure of 989 mb was recorded at 13 October on 8:15 UTC. Parma caused heavy rain in Quang Ninh and Hai Phong provinces. Total rainfall in 3 days (13 - 15 October) was 100 - 150 mm. Some stations got more such as: Mong Cai (Quang Ninh) 181 mm, Bach Long Vi 193 mm, Co To 317 mm, Thanh Hoa 179 mm (Figure 4).

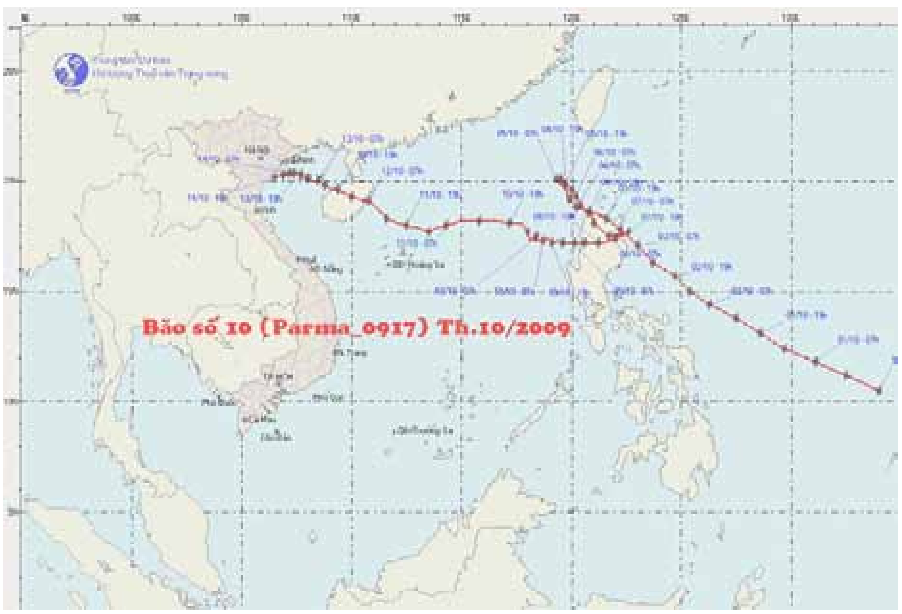

Figure 4. Tropical Storm Parma in October 2009

TS No 11 (Mirinae – 0921) was formed over the North-west Pacific. At 31 October Mirinae crossed Luzon island and entered the South China Sea. This was the 10th tropical storm over the South China Sea in 2009. Tropical Storm Mirinae moved mostly steady to the West at 20 - 25 km/h and reached a maximum intensity of 11 Beaufort. When Tropical Storm Mirinae was 250 km away from the Binh Dinh and Khanh Hoa coastline, it turned to South-west before making landfall in Phu Yen and Khanh Hoa provinces on 2 November. Maximum wind speed recorded at Ly Son station was 20 m/s, gusts 25 m/s; Tuy Hoa 19 m/s, gusts 33 m/s; Quy Nhon 17 m/s, gusts 28 m/s; Nha Trang 12 m/s, gusts 22 m/s. At Tuy Hoa station a minimum pressure of 990 mb was recorded at 2 October on 07.30 UTC. Tropical Storm Mirinae caused heavy rain in the South of Viet Nam (including the provinces from Quang Ngai to Khanh Hoa, Gia Lai). Total rainfall in 2 days (2 and 3 November) was 200 - 300 mm. Some provinces got more rainfall such as: A Luoi (Thua Thien Hue) 377 mm, Tra My (Quang Nam) 391 mm, Van Canh (Binh Dinh) 666 mm, Quy Nhon (Binh Dinh) 368 mm and Van Ninh (Khanh Hoa) 355 mm (Figure 5).

Hydrological assessment

In the North

During the flood season of 2009 in some river basins in the North of Viet Nam there were heavy rain and historic floods. In the middle of May (11-18), due to the effect of the western edge of a high pressure area in combination with activity of south-eastern wind heavy rains over 90 - 200 mm were recorded in areas in the North of Viet Nam. Rainfall in some places was higher such as Hoang Xu Phi: 411 mm, Viet Lam: 375 mm, Nam Giang: 358 mm, Lai Chau: 317 mm and Vang Po: 315 mm. The Tieu Man flood (early flood) occurred in most of the rivers with a rise in water level from 2 to 4 m. The flood peak was higher and earlier compared to the yearly average. The level in Thao River at Yen Bai station was 29.13 m+MSL with a flood peak of 3.62 m; in Da River at Ta Bu station the level was 110.23 m+MSL with a flood peak of 4.75 m; in Lo River at Tuyen Quang station the level was 21.82 m+MSL with a flood peak of 5.40 m; and downstream of Hong River at Hanoi station the level was 5.6 m+MSL with a flood peak of 3.92 m.

Figure 5. Tropical Storm Mirinae in October-November 2009

Early July, due to the effect of a trough in combination with wind convergence, heavy rains over 100 - 200 mm were recorded in areas of the North Viet Nam. Rainfall in some places was higher than 300 mm such as Muong Te: 443 mm; Ban Chieng: 442 mm; Ha Giang: 364 mm; Bac Quang: 534 mm. Heavy rain, mainly concentrated on 4 - 5 July, with very high daily rainfall, in some places, such as Muong Te: 208 mm, Ha Giang: 220 mm and Bac Quang: 230 mm. The big floods occurred in most of the rivers in the North of Viet Nam. In some rivers the peak of the flood exceeded alarm level 2. The water level in Thao River at Yen Bai station was 30.16 m+MSL, with a flood peak of 3.71 m; in Da River at Ta Bu station the water level was 116.75 m+MSL with a flood peaK of 6.67 m and in the downstream part of the Hong River at Hanoi station the water level was 8.79 m+MSL with a flood peak of 5.73 m. The maximum inflow to Hoa Binh Reservoir was 11,600 m3/s. Historical flood especially occurred at Ta Gia on Nam Mu River and in Tuyen Quang Reservoir on Gam River. The maximum inflow to Tuyen Quang Reservoir was 7,900 m3/s, which is highest observed discharge.

Table 1. Flood peak on some rivers in Central and Highlands provinces

No	Province	River	Station	Flood peak		Compared to warning level 3 (m)
				Date and time	Water level (m+MSL)	
1	Quang Binh	Gianh	Đồng Tâm	1 October 2:00 hour	14.29	lower 1.71 m
2	-	-	Mai Hóa	1 October 5:00 hour	6.67	exceeding 0.67 m
3	-	K.Giang	Lệ Thuỷ	30 September 21 hour	3.05	exceeding 0.35 m
4	Quang Tri	Quảng Trị	Thạch Hãn	30 September 7:00 hour	7.08	exceeding 1.68 m, lower than historical flood 1999: 0,21 m
5	Thua thien Hue	Bồ	Phú Ôc	30 September 9:00 hour	4.26	lower 0.24 m
6	-	Hương	Kim Long	29 September 20 hour	4.57	exceeding 1.57 m
7	Quang Nam	Vu Gia	Aí Nghĩa	30 September 3 hour	10.77	exceeding 2.97 m, exceeding historical flood 1964: 0.67 m
8	-	Thu Bồn -	Giao Thủy	30 September 4 hour	9.75	exceeding 1.15 m
9	-	-	Câu Lâu	30 September 7 hour	5.29	exceeding 1.59 m, lower than historical flood 1964: 0.19 m
10	-		Hội An	30 September 10 hour	3.20	exceeding 1.50 m, lower than historical flood 1964: 0.20 m
11	Da Nang	Hàn	Cẩm Lệ	30 September 12 hour	3.16	exceeding 1.46 m
12	Quang Ngai	Trà Khúc	Trà Khúc	30 September 1 hour	8.12	exceeding 2.42 m, lower than historical flood 1999: 0.24 m
13	-	Trà Bồng	Châu Ổ	29 September 20 hour	6.35	exceeding 2.25 m, exceeding historical flood 1964: 0.67 m
14	-	Sông Vệ	Sông Vệ	29 September 22 hour	5.37	exceeding 1.27 m
15	Kon Tum	Đakbla	KonPLong	29 September 20 hour	597.20	exceeding 3.2 0m, exceeding historical flood 1996: 0.93 m
16	Kon Tum	-	Kon Tum	29 September 23 hour	524.15	exceeding 2.15 m, exceeding historical flood 1996: 1.13 m
17	Dak Lak	PôKô	Đắc Mốt	29 September 23 hour	591.03	exceeding 7,03 m, exceeding historical flood 2006: 4.39 m
18	-	Sêrêpôk	Bản Đôn	30 September 4 hour	174.00	exceeding 0.50 m

In the Centre

During the flood season of 2009, in rivers in Central Viet Nam and in the Highlands three large floods and two medium and small floods occurred. From 2 - 11 September, due to the effect of TD No. 8 two flood events occurred on rivers from Quang Binh to Binh Dinh and Tay Nguyen area. From 2 - 5 September, heavy rains, over 200-500 mm, were recorded in provinces from Quang Binh to Binh Dinh and in the Tay Nguyen area. The rain in some places was extremely heavy such as in Phong Binh: 649 mm, Nam Dong: 547 mm, Da Namg: 651 mm and Tam Ky: 562 mm. Heavy rain mainly concentrated on 4 September with very large daily rainfall in some places such as Phong Binh: 428 mm, Phu Oc: 340 mm, Nam Dong: 356 mm, Da Nang: 391 mm.

Medium and small floods occurred in Quang Tri to Quang Nam provinces with flood peaks from 2.5 to 4.0 m. Flood peaks in most of the rivers in the area were at the alarm levels 1 and 2, except the flood peak at Kim Long on Huong River, which exceeded alarm level 3 by 0.06 m (Figure 6).

Figure 6. The points with flood peaks higher than the Alert Grade 3 in 2009

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From 6 to 9 September, heavy rains, over 100-350 mm, were recorded in provinces from Thua Thien Hue to Binh Dinh and in Tay Nguyen area. Rainfall in some places was higher than 400 mm such as in Tien Phuoc: 480 mm, Tra My: 455 mm, Cau Lau: 404 mm, Tam Ky: 588 mm, Ly Son: 593 mm, Chau Doc: 408 mm and Tra Khuc: 349 mm. Maximum daily rainfall in some places was higher than 200 mm such as in Tra My: 226 mm, Tien Phuoc: 247 mm, Cau Lau: 224 mm and Tam Ky TV: 283 mm. The heavy rain caused floods in rivers from Thua Thien Hue to Quang Ngai provinces and in Tay Nguyen area with flood peaks from 1.5 to 3.5 m at the alarm level 2, with exception of the flood peaks at Ban Don on Serepok River and Daknong on Dak Nong River that exceeded alarm level 3 by 0.06 m and 0.69 m respectively.

From 28 to 30 September 2009, due to t Tropical Storm Ketsana, heavy rains, over 300-600 mm, were recorded in the provinces from Quang Binh to Quang Ngai, Gia Lai and Kon Tum in Viet Nam (Figure 7). The rain in some places was very heavy and higher than 600 mm, like in Nam Dong: 884 mm and Tra Bong: 914 mm. Heavy rainfall mainly concentrated on 29 September with daily rainfall from 200 - 450 mm. In some places the maximum daily rainfall was very large such as in Nam Dong: 596 mm, Tra Bong: 748 mm, Tra Khuc: 518 mm and Minh Long 521 mm.

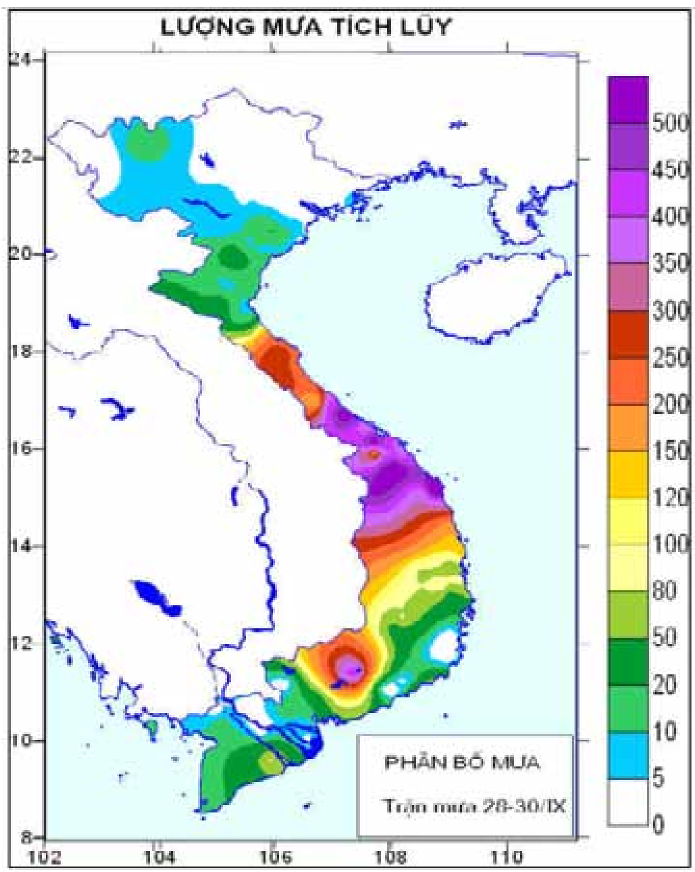

Figure 7. Accumulated rainfall from 28 to 30 September

The big floods occurred in the rivers from Quang Binh to Phu Yen and in Highland areas. Historical floods and extreme floods occurred in rivers from Quang Tri to Quang Ngai and Kon Tum provinces. The flood peak was from 11.0 to 16.5 m in the upstream part and from 3.8 m to 6.3 m in the downstream part of the rivers in Quang Tri and Quang Ngai provinces. In the Northern Highlands, the flood peak was from 6.0 to 8.0 m. The flood peaks exceeded alarm level 3 with 1.0 to 4.0 m in the rivers from Quang Tri to Quang Ngai provinces and got over the historical value in Vu Gia, Tra Bong, Dakbla, Po Ko rivers. The heavy rainfall and extreme floods led to very serious large and deep inundations, about 1.0 - 4.5 m during 3 - 7 days in these provinces. Flood peaks on some rivers in Central and Highland provinces are shown in Table 1 and the map of the points with flood peaks higher than the Alert Grade 3 in 2009 is presented in Figure 6.

From 2 to 3 November, due to the effect of Tropical Storm Mirinae in combination with cold air surge, heavy rains, over 100 - 300 mm, were recorded in Quang Tri to Ninh Thuan provinces in the Central and Highlands parts of Viet Nam (Figure 8). Rainfall of 400 - 500 mm was recorded in some places, for instance in Son Giang (Quang Ngai Province): 428 mm. Especially, the rainfall of 842 mm with maximum rainfall intensity per 6 hours of 294 mm was recorded at Vam Camh in Binh Dinh Province. The heavy rainfall and concentration in one short period led to a very serious flood and inundation in the provinces from Quang Tri to Ninh Thuan and in the Highlands area. Historical floods and extreme floods occurred from Quang Ngai to Khanh Hoa and in Gia Lai provinces. Peak floods in rivers from Thua Thien - Hue to Quang Nam, Kon Tum và Dak Lak exceeded the alarm level 2, in the rivers from Quang Ngai to Ninh Thuan and Gia Lai provinces they exceeded alarm level 2 by 1 to 4 m. Especially, historical floods occurred in some rivers such as Ky Lo (Phu Yen Province), Cai Nha Trang (Khanh Hoa Province) and Ba (Gia Lai Province) as shown in Table 2.

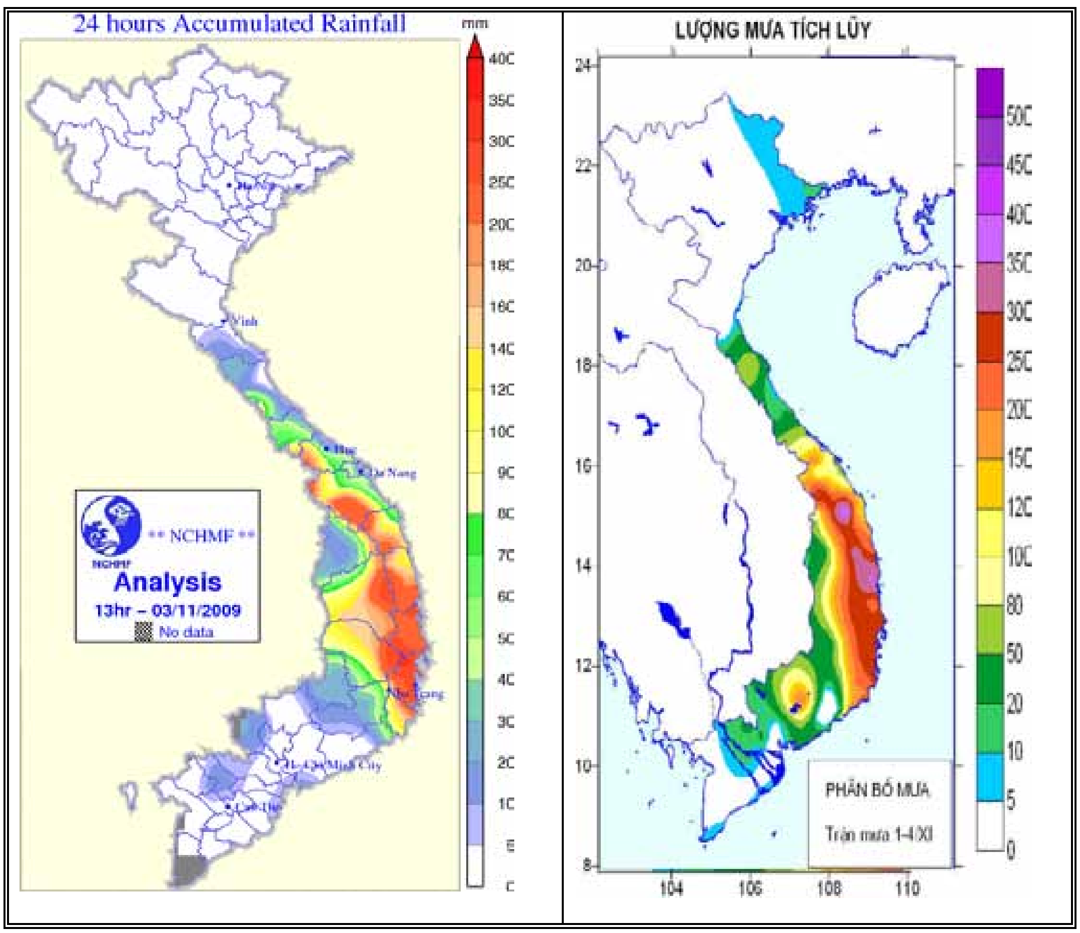

Figure 8. aximum 24 hours accumulated rainfall from 2 November 13:00 hour to 3 November 13:00 hour and accumulated rainfall from 1 to 4 November in the Mekong Delta in Viet Nam (Cuu Long Delta)

Table 2. Flood peak on some rivers in Central and highland provinces

No	Province	River	Station	Flood peak		Difference to the alarm grade 3 (m)
				Date and time	Water level (m+MSL)	
1	Quảng Ngãi	Trà Khúc	Trà Khúc	3 November 8:00 hour	6.91	exceeding 1.21
2		Sông Vệ	Sông Vệ	3 November 8:00 hour	5.38	exceeding 1.28
3	Bình Định	Kôn	Thạnh Hoà	3 November 14:00 hour	9.03	exceeding 1.53
4		Kỳ Lộ	Hà Bằng	3 November 4:00 hour	13.47	exceeding historical flood (1988: 12.47m) 1.0
5	Gia Lai	Ayun	PMơ Rê	3 November 8:00 hour	677.19	exceeding 2.19
6		Ba	An Khê	3 November 9:00 hour	406.98	exceeding 0.48
7		Ba	Ayunpa	3 November 15:00 hour	158.63	exceeding historical flood (1988: 157.97m) 3.13
8	Phú Yên	Ba	Củng Sơn	4 November 4:00 hour	37.65	exceeding 4.15
9		Đà Rằng	Phú Lâm	4 November 4:00 hour	4.65	exceeding 1.45
10	Khánh Hoà	Dinh	Ninh Hoà	3 November 16:00 hour	6.34	exceeding 1.34
11		Cái Nha Trang	Đồng Trăng	3 November 21:00 hour	13.42	exceeding historical flood (2003. 13.34 m) 3.42

Table 3. Characteristics of floods in months of 2009

Station	Flood foot		Flood peak		Difference	$T_{lên}$	Flood Intensity			In comparison with alarm level (AL)
	Time	H	Time	H	ΔH		I_{max}	Time	I_{ITb}	
		(cm)		(cm)	(cm)	(day)	(cm/day)		(cm/day)	
Upstream part of Cuu Long delta										
Tân Châu	3 July	126	25 July	276	150	22	18	13 July	8	< Alarm Level 1
	31 July	253	21 August	323	70	22	5	18 August	14	= Al1
	30 August	290	20 September	351	61	22	6	7 September	10	< Al 2:0.1m
	29 December	329	11 October	412	83	13	10	1 October	8	<Al3:0.08m
Châu Đốc	4 July	114	25 July	224	110	21	13	13 July	8	< Al 1
	31 July	194	23 July	276	82	24	10	18 August	8	> Al 1: 0.16m
	30 August	244	21 September	302	58	23	6	17 September	10	= Al 2
	29 September	277	14 October	352	75	16	9	4 October	8	>Al 3:0.02m

Table 4. Peak flood in Mekong River Basin in 2009

TT	Station	Alarm level (m+MSL)	Flood level (m+MSL)	Date of occurrence	Hmax (m+MSL)	Note
1	Chiang Saen	11.50	11.80	26 August	7.19	< Alarm level
2	Luang Prabang	17.50	18.00	7 July	13.84	< Alarm level
3	Chiang Khan	17.32	17.40	8 July	12.36	< Alarm level
4	Vientiane	11.50	12.50	9 July	9.23	< Alarm level
5	Nong Khai	11.40	12.20	9 July	10.10	< Alarm level
6	Paksane	13.50	14.50	18 July	11.72	< Alarm level
7	Nakhon Phanom	12.60	12.70	14 August	10.01	< Alarm level
8	Thakhek	13.00	14.00	14 August	11.10	< Alarm level
9	Mukdahan	12.50	12.60	15 August	10.17	< Alarm level
10	Savanakhet	12.00	13.00	14 August	8.99	< Alarm level
11	Khong Chiam	16.00	16.20	15 August	11.95	< Alarm level
12	Pakse	11.00	12.00	15 August	9.22	< Alarm level
13	Stung Treng	10.70	12.00	5 October	10.56	< Alarm level
14	Kratie	22.00	23.00	6 October	21.44	< Alarm level
15	Kampong Cham	15.20	16.20	7 October	15.16	< Alarm level
16	Phnom Penh Port	10.50	12.00	10 October	9.93	< Alarm level
17	Phnom Penh Bassac	9.50	11.00	10 October	9.03	< Alarm level
18	Koh Khel	7.40	7.90	9 October	7.53	< Alarm level
19	Neak Luong	7.50	8.00	10 October	7.23	< Alarm level
20	Prek Dam	9.50	10.00	10 October	9.06	< Alarm level
21	Tan Chau	3.00	4.20	11 October	4.12	< Alarm level
22	Chau Doc	2.50	3.50	13 October	3.52	> Flooded level

The 2009 flood in the Mekong Delta (in Viet Nam) was at average. The maximum water level in Mekong River at Tan Chau was 4.12 m+MSL, approximately warning grade No. 3. At Chau Doc in Bassac River it was 3.52 m+MSL, a bit lower than the warning grade No. 3.

The Flood season in 2009 in the Mekong River started a bit (from 15 - 30 days) earlier in comparison with the annual average event. The upstream area of the basin flood water level started rising early May and reached to the peak in early July, 1-1.5 months earlier than average and the water level was lower than the annual average. At the upstream part of Mekong Delta in Viet Nam the flood came nearly one month later than average and ended 10 days later in comparison with the average. Especially, the 2009 flood peaks at the main stations along the Mekong River were lower than those of 2008, but higher than in the lower part.

The mean daily water levels, flood hydrographs, and total monthly rainfall at some stations in Mekong and Bassac rivers are presented in the Tables 3, 4, 5 and 6 and in Figures 9, 10, 11, 12 (sources: National Centre for Hydro-meteorological Forecasting (NCHMF)).

Generally the 2009 flood in the Mekong River and the upstream part of the Cuu Long Delta was at the low average. The peak of the flood in the Mekong River at Tan Chau reached 4.12 m+MSL (11 October) and was 0.08 m lower than warning grade No. 3 and at Chau Doc in the Bassac River 3.52 m+MSL (14 October), which was equal to warning grade No. 3.

In the whole Mekong River Basin 6 heavy and medium rainfall periods occurred, lasting from 3 to 30 days of which one heavy rain in late September occurred due to the influence of Typhoon Ketsana (Typhoon No. 9) that caused big floods in the middle and lower parts of Mekong River Basin and historical floods in the northern part of the Central Highlands of Viet Nam. The heavy short periods of rain usually concentrated in the months of July, August and September.

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In summary, it has been observed that the 2009 flood in the Mekong River Basin conformed with the regular rule. However, the flow in the river was impacted by the operation of upstream reservoir systems in China and other storages in the tributaries. In order to improve the accuracy of and be able to provide longer term flood forecasts, it is proposed:

- strengthening the cooperation with MRC in exchange of meteo-hydrological data, information and also the regulation mechanisms of reservoirs in the Mekong River Basin (on main stream and tributaries);
- supplement electronic gauge stations along Mekong River, especially upstream;
- investment in the research and technologies to improve the longer term forecasts.

SOCIO-ECONOMIC DAMAGE BY 2009 FLOODS AND OTHER DISASTERS IN VIET NAM

Floods in 2009 caused death and injure for more than 100 people, damaged thousand houses, public infrastructure and agricultural production. The summary of damages caused by the 2009 flood in Viet Nam is presented in Table 7 and Figure 13.

Table 5: Mean daily water level for year 2009 at Chau Doc station (unit: cm+MSL)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	138	95	70	76	71	81	87	188	239	282	287	159
2	136	83	72	84	69	78	84	193	239	289	283	160
3	132	75	74	79	64	74	84	200	241	295	280	163
4	121	77	72	73	60	75	87	206	242	303	278	164
5	115	82	72	63	64	81	91	214	243	310	275	161
6	115	88	71	67	65	82	92	220	243	317	272	156
7	117	93	67	72	65	79	93	225	246	325	269	151
8	120	92	61	72	67	78	97	226	251	331	265	144
9	126	92	67	75	65	78	100	227	254	338	259	135
10	128	94	73	75	63	76	98	229	256	343	251	131
11	130	96	73	75	62	76	99	230	260	347	243	125
12	130	94	69	69	63	74	103	233	263	348	237	125
13	133	85	65	65	65	71	107	234	267	348	231	125
14	134	75	65	60	66	67	115	235	271	348	227	124
15	129	66	72	53	64	66	124	237	274	347	224	123
16	122	57	74	45	61	66	130	238	278	346	221	122
17	113	57	70	39	53	64	137	242	281	344	218	129
18	104	61	64	27	47	69	152	247	285	341	218	130
19	95	65	60	13	45	74	166	252	290	339	216	131
20	91	61	51	4	45	83	175	255	291	335	212	132
21	86	65	37	13	48	91	182	259	292	330	207	127
22	82	68	27	26	49	98	187	261	291	325	202	122
23	88	63	25	33	53	104	192	261	289	320	193	114
24	96	66	32	37	61	110	199	259	287	315	183	103
25	107	66	35	43	70	113	202	257	285	312	173	99
26	105	66	42	50	80	111	202	254	282	311	164	96
27	100	68	48	56	89	105	200	251	280	309	158	99
28	105	67	51	60	96	98	196	247	276	306	158	100
29	103		56	65	98	91	190	243	274	301	159	106
30	98		62	68	91	87	184	240	276	296	160	107
31	94		70		81		184	239		291		111
Mean	113	76	60	55	66	83	140	236	268	322	224	128

Max	181	151	126	134	142	153	224	276	301	352	295	164
Date	14	11	4	1	28	24-25	25	23	23-24	14-16	1	4
Min	24	-10	-50	-66	-19	15	39	173	228	272	130	46
Date	22	20	22	20	18	15	4	1	1	1	30	31

FLOOD MANAGEMENT AND MITIGATION PROGRESS IN VIETNAM (UPDATED PROFILE)

Organizations of flood management and mitigation in Viet Nam.

Central Steering Committee for Flood and Storm Control (CSCFSC)

The Central Steering Committee for Flood and Storm Control (CSCFSC) is 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. Figure 14 shows the updated organization chart of CSCFSC, provincial and district levels.

Table 6. Mean daily water level for year 2009 at Tan Chau station (unit: cm+MSL)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	155	108	75	79	74	93	106	251	288	340	320	179
2	153	98	78	84	71	91	104	256	289	348	315	179
3	148	88	79	79	66	89	104	265	291	355	310	181
4	138	87	77	72	63	89	108	274	293	365	308	182
5	133	92	74	63	69	96	113	283	294	372	304	179
6	132	96	73	67	69	96	114	291	295	379	302	175
7	134	100	69	74	68	94	116	297	298	389	301	169
8	135	101	64	74	68	93	119	298	304	396	297	161
9	140	101	72	75	66	93	122	298	309	403	289	153
10	143	103	78	75	65	90	120	298	314	407	279	148
11	145	103	79	75	64	89	124	298	320	409	271	142
12	146	100	74	71	65	89	134	299	325	408	264	142
13	148	92	70	67	65	89	142	301	329	406	259	142
14	147	85	69	62	66	87	154	302	332	402	255	140
15	142	74	78	53	64	86	166	303	333	398	251	138
16	135	65	79	46	63	82	177	305	334	395	247	138
17	127	62	73	41	58	79	192	308	337	390	243	143
18	118	67	66	31	52	85	215	310	340	386	243	145
19	110	71	62	17	51	93	231	313	343	381	240	146
20	104	68	55	8	51	103	238	314	344	376	235	145
21	98	73	42	15	54	110	241	315	343	371	229	139
22	95	75	32	26	56	117	243	314	343	366	222	135
23	101	69	29	35	59	125	250	311	340	360	213	129
24	109	71	33	40	68	134	259	307	338	355	204	119
25	118	73	38	45	77	138	263	305	334	353	195	114
26	115	73	44	51	88	135	263	301	332	352	185	110
27	111	75	50	57	99	127	260	297	330	350	179	112
28	115	73	54	61	106	117	254	293	328	347	179	113
29	116		57	68	109	110	248	289	327	340	180	120
30	114		62	72	103	106	244	287	331	333	181	118
31	110		72		94		246	287		326		121
Mean	127	84	63	56	71	101	183	296	322	373	250	144

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Max	178	152	123	128	143	166	276	323	351	411	326	208
Date	1	11	3(3)	1	29	24-25	26	21-22	20	11	1	4
Min	48	9	-33	-51	-4	42	70	240	280	322	155	68
Date	22	20	23	20	18	10(3)	4	1	1	31	30	30

The chairman of provincial, district and commune people's committee issues the decision to establish the Provincial, District and Commune Committee for Flood and Storm control. The members of the committee include: the chairman of people's committee as the chairman, Chief of water sector as the vice chairman and the members are the chief or vice chief of sectors related to the flood and storm control work of local nature. The office of the committee is located in the water sector office. The expenditure for the operation of the committee is provided by the provincial budget, in the budget provided for the water sector.

Committees for flood and storm control at local levels have the responsibility to assist the provincial people's committee at this level to develop and directly implement the flood and storm control measures in the concerned area, to protect the dikes and the economic and residential areas, to overcome the aftermaths of floods and storms, as well as to prepare planning for flood and storm preparedness and prevention.

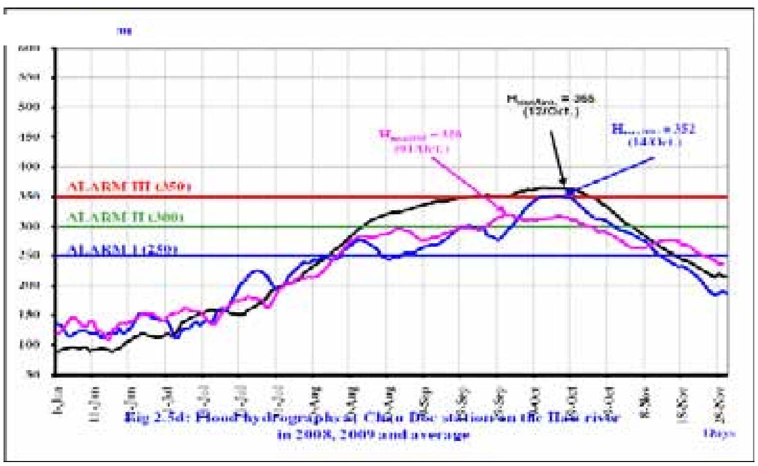

Figure 9. Flood hydographs at Chau Doc station in the Hau River in 2008, 2009 and average

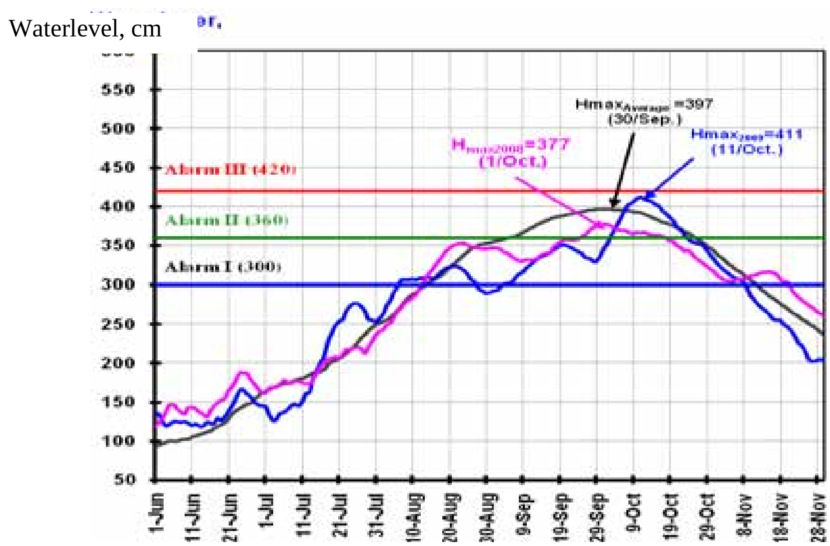

Figure 10. Flood hydographs at Tan Chau station in the Hau River in 2008, 2009 and average

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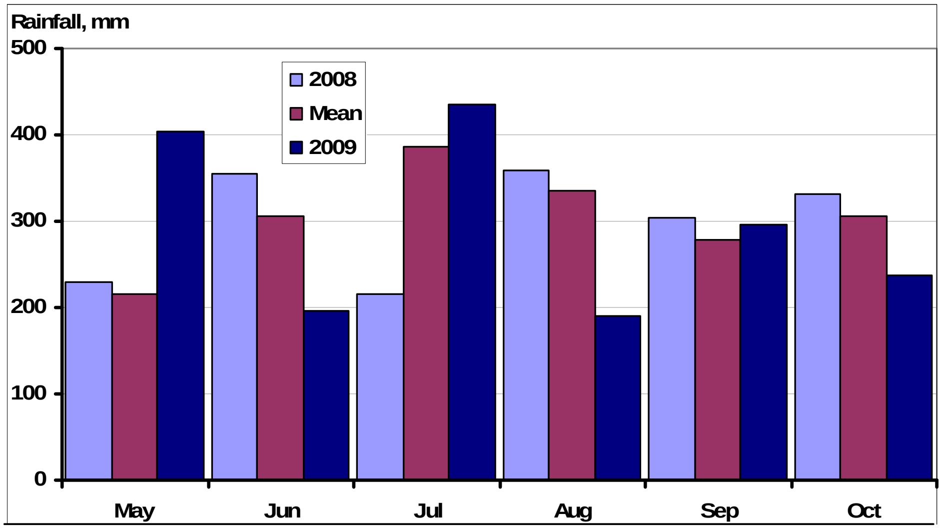

Figure 11. Total monthly rainfall in the flood season in 2008, 2009 and mean rainfall at the Rach Gia station

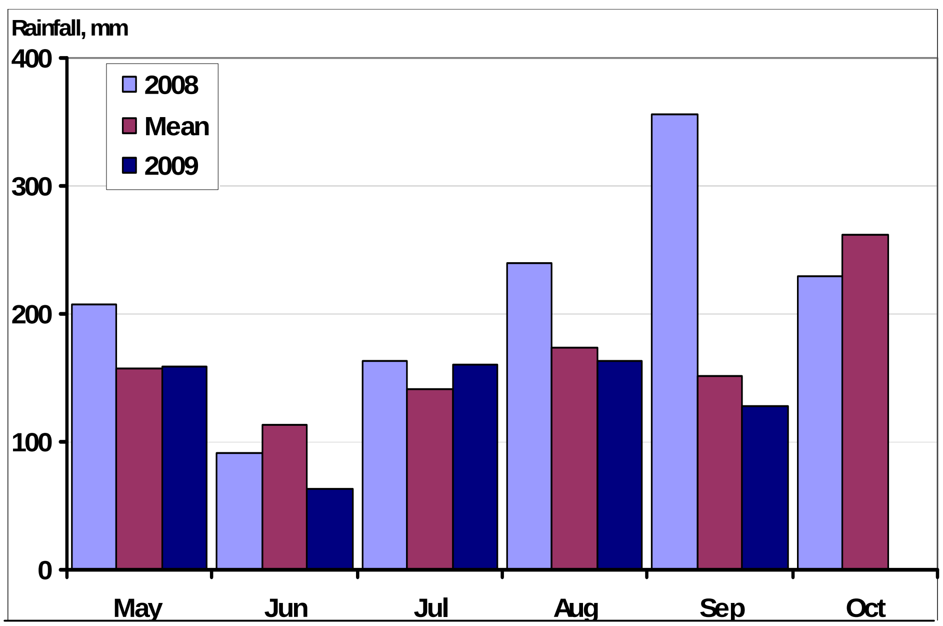

Figure 12. Total monthly rainfall inthe flood season in 2008, 2009 and mean rainfall at the Chau Doc station.

The Standing Office for flood and storm control at the provincial level operates in close collaboration with the Central Committee for Flood and Storm Control, the National Committee for Research and Rescue, the Southern Centre for Hydro-meteorological Services, in order to monitor the hydro-meteorological situations, and prepare timely information on the flooding and raining situation, directives from the Central and provincial people committees towards respective departments, provincial authorities and agencies in districts, towns and the people.

The Standing Office of Flood and Storm Control allocates the specific duties to its members in their locations, frequently conducts the monitoring supervision and solves difficulties.

Table 7. Summary report on damage caused by disaster in Viet Nam in 2009 (Source: CSCFSC)

Category	Item damaged	Unit	Floods	Tropical storms	Others	Total
People	Killed	No	79	308	48	435
	Injured	No	29	1,310	51	1,390
	Missing	No	15	9	9	33
Housing	Houses collapsed, drifted	No	223	12,618	513	13,354
	Houses submerged and damaged	No	33,586	374,315	3,963	411,864
School	School collapsed	Room	0	1,364	0	1,364
	School submerged and damaged	Room	35	7,453	55	7,543
Hospital, clinics	Clinics collapsed	No	0	0	0	0
	Clinics submerged and damaged	No	1	13,306	1	13,308
Agriculture	Rice fields submerged	ha	131,973	77,048	28,777	237,798
	Farms submerged, damaged	ha	40,189	123,213	10,259	173,661
	Food damaged by water	ton	920.7	52,583	8	53,511
Water Resources	Land washed away	m^3	589,887	2,426,327	16,988	3,033,202
	Stone drifted	m^3	450	392,055	0	392,505
	Dykes slumped	m	11,570	52,380	0	63,950
	Small hydraulic structures collapsed	Unit	97	332	16	445
	Small hydraulic structures damaged	Unit	527	1,438	392	2,357
Transportation	Land drifted	m^3	1,128,810	9,019,245	173,138	10,321,193
	Rock drifted	m^3	100	84,444	0	84,544
	Bridge, sewer collapsed	Unit	13	8	13	34
	Bridge, sewer damaged	Unit	330	890	1	1,221
	Roads damaged	Km	25.4	38,102	4	38,131
Aquatic product	Shrimp, fish poll broken	Ha	4,203	5,098	123	9,424
	Ships sunk, lost	Unit	39	638	6	683
	Ships sunk, damaged	Unit	4	237	2	243
Communication	Telephone poles collapsed	Unit	0	3,101	0	3,101
	Telephone wire broken	m	0	483,600	340	483,940
Energy	High voltage electric towers broken	Unit	0	0	1	1
	Electric distribution poles broken	Unit	108	5,519	57	5,684
	Electric wire broken	m	0	607,226	800	608,026
	Total damage	Bil VND	1,690.3	21,901	154	23,745

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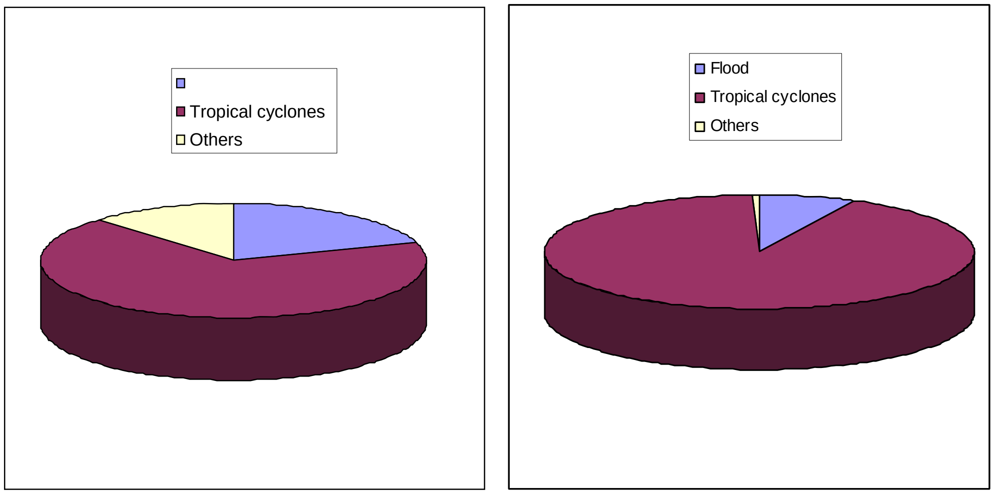

Figure 13. Human loss and socio-economic impacts by flood and other disasters in Viet Nam during 2009 (sources: CSCFSC)

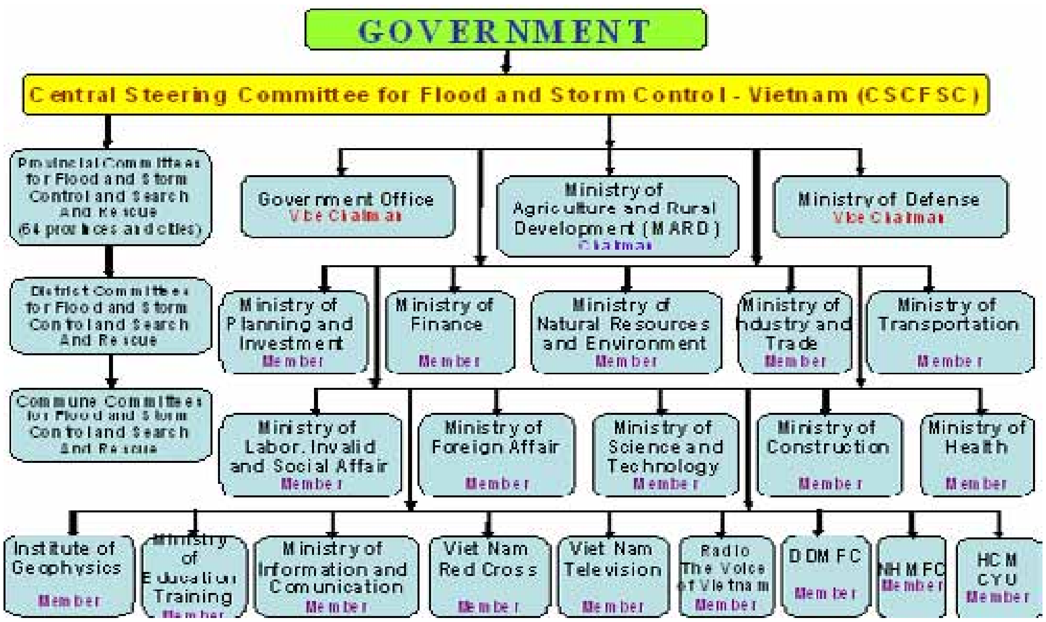

Figure 14. Indicative organization chart for responding to disastrous floods and storms

National Committee for Search and Rescue (NCSAR)

NCSAR is responsible for coordinating, controlling, implementing the national warning system and equipment for providing the technical assistance/expertise to search and rescue the victims caused by natural disasters (Figure 15). This agency was formed based on a Strategy and Action Plan for Mitigating Water Disaster in Viet Nam prepared by the International Consultants and Former Ministry of the Water Resources since the 1990s of the 20th Century. It's tasks and responsibilities were upgraded and improved since 2002 covering activities not only water disasters but also other sectors, including space and marine areas.

After a long time for preparation, the National Strategy for Natural Disaster Prevention, Response and Mitigation until 2020 was approved by the Government, dated 19 November,

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2007 that will promote and make advantage of a foundation supporting the National Flood Management and Mitigation Programme (FMMP) as well as a Regional FMMP. A natural disaster classification map in Viet Nam is also attached in the National Strategy for Natural Disaster Prevention, Response and Mitigation until 2020. In addition, the Dike Law was approved by the Parliament in November 2006.

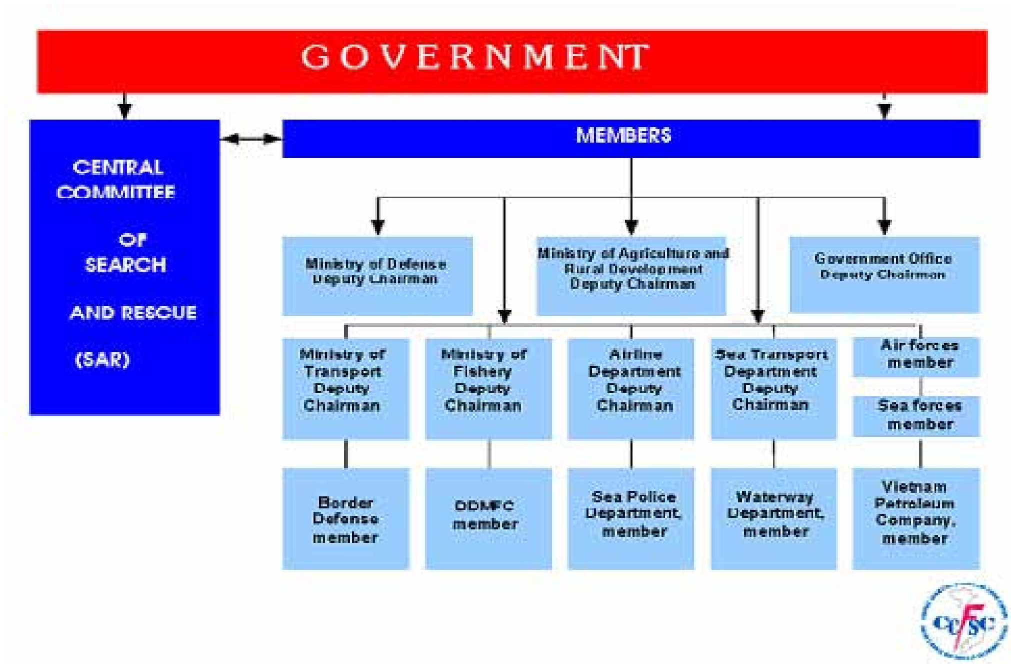

Figure 15. Organization of National Committee for Search and Rescue in Viet Nam

Flood warning activities shall be carried out when the weather pattern brings heavy rainfall in the Lower Mekong Basin, resulting from the Southwest monsoon or typhoons from the East Sea, is detected and then adjusted based on the rainfall distribution.

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

The Statute on Flood and Typhoon Mitigation was promulgated (8 March, 1993), establishing the responsibilities and powers of the Department for Dyke Management, Flood Control and Storm Preparedness (DDMFCSP) and for the Provincial and District Agriculture and Rural Development Services, as well as defining the control of development in flood prone land areas. This statute also empowers authority's officers to take the necessary steps to prepare for floods and typhoons, and to participate in emergency repairs and protective works.

The DDMFCSP approves the Disaster Management Plans. Typhoons and floods are relatively rare in the South of Viet Nam and the emergency information system is not developed as in the Northern and Central Parts of Viet Nam. However, when a disaster occurs, it can inflict massive damage. Recent examples of the big floods in the Mekong Delta (2000, 2001 and 2002) as well as the typhoons (Durian in 2006 and Noname 2007) caused serious losses of people and properties.

During the pre-disaster period, DDMFCSC regularly receives information updates from the Hydrometeor Logical Services. It keeps the Ministry of Agriculture and Rural Development

(MARD), Office of the Government (OOG), Ministerial Committee for Flood and Storm Control (MCFSC), the Provincial Committee for Flood and Storm Control (PCFSC) and also the mass media, i.e. TV, radio and newspapers informed.

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 damages. 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.

It is a fact that sometimes the local and provincial governments send their request for international assistance directly to Non Governmental Organisations (NGO), United Nations (UN) agencies or embassies in Hanoi and in Ho Chi Minh City. MOFA should be consulted before any action is taken with regard to such requests.

Hydro-meteorological forecasting agencies

The hydro-meteorological forecasting system includes three levels as follows:

- Central level is performed by the National Centre for Hydro-meteorological Forecasting;
- Regional level is implemented by 9 Regional Hydro-meteorological Centres;
- Provincial level is executed by 54 Provincial Hydro-meteorological Centres.

National Centre for Hydro-meteorological Forecasting (NCHMF)

At present, the National Centre for Hydro-meteorological Forecasting (NCHMF), under the leading of the Ministry of Natural Resources and Environment (MONRE), is an agency performing both forecasting and warning at the national level. Besides, other agencies are concerned with warning activities, including the Central Steering Committee for Flood and Storm Control (CSCFSC), National Committee for Search and Rescue (NCSAR) and the Department for Dyke Management and Flood Control and Storm Preparedness (DDMFCSP) that are responsible for providing indicative/instructed warnings for implementation. More details regarding duties and responsibilities of major agencies are presented hereafter.

Two projects are under implementation, of which the local funded project mainly concentrates on building capacity while the World Bank funded project is to improve and upgrade facilities of the forecasting network.

The National Centre for Hydro-meteorological Forecasting (NCHMF) is responsible to collect and exchange domestic and international hydro meteorological information. The domestic hydromet telecommunication system is used by radio, telephone, computerized wide area network (WAN) and MetTV to ensure received data from hydro meteorological observation network to NCHMF and transmit forecast information from NCHMF to the Regional Hydro-meteorological Centres (RHMC) and the provincial Hydro-meteorological Forecasting Centres (PHMFC). There are three kinds of forecasting as below:

- short-term predictions (1 - 5 days);
- medium-term predictions (6 - 15 days);

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- long-term predictions (months to seasonal).

(i) *Short-term forecasts.* The forecasting results are issued based on analyzing 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 implemented in the main river systems. The flood forecasts are issued by application of the models: Stream-flow Simulation and Reservoir Regulation (SSARR), Nedbor-Afstromings-Mode (NAM), regression and hydraulic models. The Hydro-meteorological forecasts are broadcasted via national and local radio, television networks and published in the various daily newspapers;

(ii) *Medium-term predictions.* Daily rainfall and flow data are needed. The forecasting methods are applied including the Rainfall-Runoff TANK model and regression method;

(iii) *Long-term predictions (month to season).* Series of flow data, meteorological data and monthly seawater temperature at the El-Nino regions: A, B, C and D, ENSO, etc. Forecasting methods are applied in historical flow process analysis, regression and an objective statistical identification method.

For the mainstream of the Mekong River the NCHMF is responsible for forecasting at two main stations namely Tan Chau and Chau Doc in the SA-10V. The forecasting results are posted on the website/internet and delivered to the concerned agencies.

Southern Region Hydro-meteorological Centre (SRHMC)

Located in Ho Chi Minh City, the Southern Region Hydro-meteorological Centre (SRHMC) is responsible for the management of activities regarding hydro-meteorology in the South of Viet Nam, including the Mekong Delta in Viet Nam. The tasks and responsibilities are:

- to collect hydro-meteorological data from international and national network stations from the NCHMF and the field station network. Data is processed to prepare forecasts and to transmit hydro-meteorological forecasting information towards provincial stations;
- to manage the hydro-meteorological network in the South of Viet Nam, including 19 provinces and cities;
- to manage, measure and survey hydro-meteorological 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 on severe weather and hydrological phenomena as well as tropical storms, floods, flash floods, drought, salinity intrusion, serious thunderstorms and heavy rain, etc. to satisfy the requirements of socio-economic activities and prevent damage due to natural disasters;
- to research and conduct meteorology, hydrology, oceanography, and environment services.

Central Region Hydro-meteorological Centre (CRHMC)

Located in Gia Rai province, the Central Region Hydro meteorological Centre (CRHMC) is responsible for management of activities regarding hydro-meteorology in the Central provinces of Viet Nam, including the Central Highlands (SA-7V). The tasks and responsibilities are the same as of SRHMC.

Provincial Centres for Hydro-meteorological Forecasting (PCHMF)

The functions and responsibilities of the Provincial Centres for Hydro-meteorological Forecasting (PCHMF) are to collect data from regional and provincial stations within their area. Collected data are processed and forecasted internally within the region. In addition, every province has the local network operated with funds from the Provincial people committee; most of the stations of the local network are located in the irrigation canals. Based on the forecast results issued by the Regional Centres the PCHMFs also forecasts the hydro-meteorological factors in their local networks.

Process of dissemination of flood forecasting and warning products

There are two warning systems: (i) the information warning system and (ii) the indicative warning system. The first system is mainly responsible for conducting weather and flood forecasts representing for the hydro meteorological forecasting network of MONRE while the second system is responsible for conducting guidance and instructions for implementation of the warnings from the natural disaster mitigation and management offices representing for the Prime Minister (CSCFSC) and MARD (DDMFCSP). These two systems (Figure 16) are in close coordination and collaboration for the same purpose of reducing damages and deaths caused by storms and flood hazards.

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 warning is based on the alarm water levels system that is divided into three stages:

- *water rising warning stage* that will be issued in case of the highest flood water level forecasted is lower than level III, such as less than 4.2 m+MSL at Tan Chau station on Mekong River;
- *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 on Mekong River;
- *urgent flood warning stage* that will be issued in case the flood water level can reach 4.2 m+MSL and then continuously rises up at Tan Chau station on Mekong River.

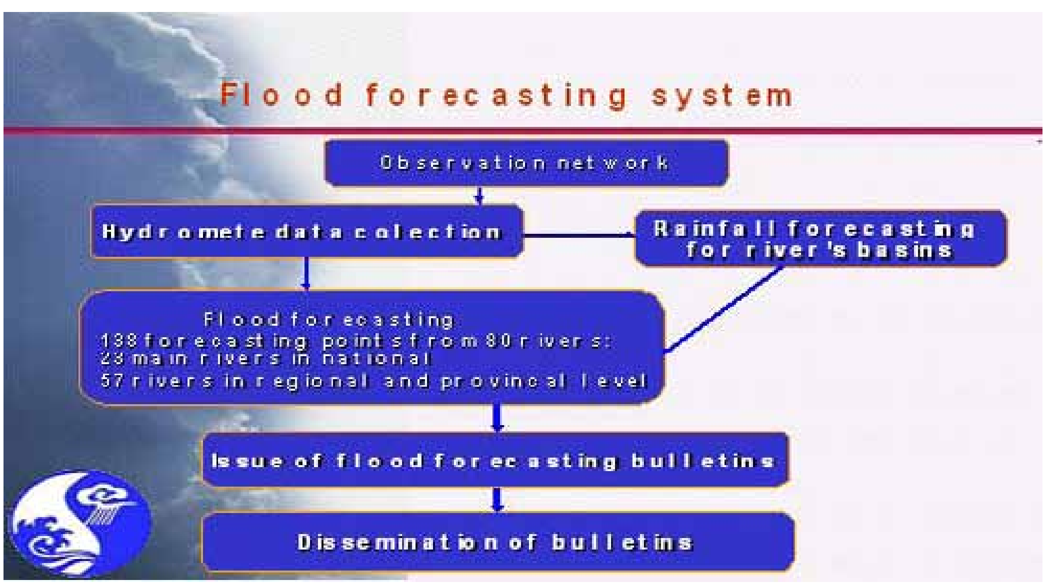

Figure 16. Scheme of the flood forecasting system in Viet Nam

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There are two steps of flood warning (normal and urgent warning) being applied in Viet Nam, of which the normal step will be started at the beginning of the rainy season. The hydro-meteorological forecasting bulletins are delivered to the users as below:

- CSCFSC, MARD and MRC;
- mass-media;
- television, broadcasting network during daily program.

The urgent step starts in case the water level exceeds alarm level III, especially when it is over 4.5 m+MSL at Tan Chau station. The flood forecasting bulletins are delivered to the following agencies:

- CSCFSC, MARD and MRC;
- mass-media, daily newspapers;
- television, broadcasting network informing with many programs per day frequency.

CSCFSC will inform and deliver the warning massages to the offices concerned in the framework of the warning organization for disastrous floods and storms. At the same time CSCFSC will instruct the local network for implementation of the indicative plan as flood emergency response during the urgent step.

IMPROVEMENT OF DISASTER AND FLOOD MANAGEMENT AND MITIGATION IN VIET NAM

The progress of improvement and strengthening disasters and flood management and mitigation in Viet Nam in 2009

In 2009 many activities have been undertaken in Viet Nam at all levels from the central to community levels in order to improve the management and mitigation of natural disasters and especially the flood disasters. These activities are carried out by the country and also in cooperation and supported by many regional and international organizations and donors, one of them is MRC. Some records of these activities are listed bellow.

Reduced loss of life from typhoon-related disasters. Establishment of the flash flood warning system with 8 automatic rainfall gauges in Lao Cai Province, flood warning system with 2 automatic rainfall gauges in Kon Tum Province and the flood warning system with 10 automatic rainfall gauges in Thua Thien Hue Province on the frame of MAHASRI's near-real-time rainfall data in Central Viet Nam.

Minimized typhoon-related social and economic impacts. In October, the Asian Disaster Preparedness Centre in cooperation with the Ministry of Education and Training and Tien Giang Province organized a workshop on 'Provincial partnership for implementing and maintaining the School Flood Safety Program in Flood areas in Tien Giang. The Mekong River Commission Secretariat (MRCS), Viet Nam National Mekong Committee, Department of Dyke Management – Flood and Storm Control, provincial line agencies, teachers and students of project provinces and neighbouring provinces, such as Ben Tre, An Giang and Dong Thap have participated in the meeting.

The School Flood Safety Program (SFSP) in Mekong Delta, which is implemented by the Asian Disaster Preparedness Centre (ADPC) through the Mekong River Commission with funding support from the German Government Development Agency (GTZ) and European Commission Humanitarian Aid department (ECHO), launched an innovative public awareness program

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involving Primary and Secondary School teachers and the students to reduce the impact of the annual flooding in Mekong Delta.

Improved typhoon-related disaster risk management in various sectors. In 2009 the Government's Decree on the responsibilities and duties of the CCFSC and the committees at lower levels was amended. The Program on Community Based Disaster Reduction Management until 2020 was approved by the Prime Minister in July. A conference on the national storm and flood prevention and response, search and rescue was expedited online, chaired by the Deputy Prime Minister of Viet Nam, Hoang Trung Hai. A workshop on dyke management and maintenance, and flood and storm control operations for the Northern, Central and Highland provinces with dykes was organized in April in Da Nang, Central Region. In March the National Disaster Mitigation Partnership (NDMP) and Disaster Management Centre (DMC) jointly organized and facilitated a workshop on Planning for the Future of Natural Disaster Mitigation Partnership and the Disaster Management Model. In May the Standing Office of the Central Committee for Flood and Storm Control (Standing Office of CCFSC) and CARE facilitated a workshop on Initiating the Process for Development of Legislation on Disaster Management in Viet Nam under the Disaster Preparedness European Commission Humanitarian Aid Office (DIPECHO) funded JANI project. In June Standing Office of CCFSC organised and conducted a consultation workshop in the South of Viet Nam. The purpose of the workshop was to get provincial feedback on Government plans to revise the decree outlining the functions, duties and organizational structures of the CCFSC. The workshop was broadened to include consultation with representatives from lower levels of Government, the academic community and civil society.

In June CCFSC held a major workshop on International Disaster Management Models. The workshop, focusing on all disaster management, decentralized disaster management and institutional systems for disaster management, was considered extremely successful with a large amount of interest and involvement, particularly from Government participants. A learning workshop and training for flood and storm control planning capacity building was conducted for 4 days, 9 – 12 June in Ben Tre Province. It was co-organized by the Ben Tre Committee for Flood and Storm Control, Mekong River Commission and the Asia Disaster Prevention Centre. This workshop is one of the activities under the 6th action plan of DIPECHO funded by the European Humanitarian Committee.

Strengthened resilience of communities to typhoon-related disasters. Special arrangement was made with the national television channels to improve weather programs. Forecasted parameters and fields are automatically sent to the TV by a reserved server. In the case of extreme weather such as a tropical cyclone, additional briefings are provided to the TV weather interpreters so that the weather situation can be better explained to the public. As a result, the weather forecasts as well as tropical cyclone warnings have become more popular and understandable to the people; A link has been established from NCHMF to the office of Emergency Rescue for a quick dissemination of meteorological information (satellite images, observations, weather bulletins and TC warnings).

Improvement of observation network. A new receiving station of FY satellite has been installed since November 2007 for getting geostationary satellite images, which provide additional information from satellite observations to forecasters. The DVORAK technique is adopted to estimate the intensity of tropical cyclones in operational forecasting.

Improvement of numerical weather prediction. The High Resolution Model (HRM) is operationally running 4 times per day with the increased horizontal resolution of 14 x 14 km with different initial and boundary conditions interpolated, not only from the DWD global model GME, but also from the Japanese Global System for Mobile communications (GSM) model; The ETA model has been put into operational running twice per day for the Vietnamese

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region; The storm surge model adopted from the Japanese version has been used semi-operationally when a typhoon was predicted to affect our region. The input data are taken from either the forecast fields from Japanese GSM model, or HRM outputs of the predicted tracks. Additionally, the wave model (WAM) has been studied for running on the parallel computer. The short-range ensemble forecast system (SREFS) with 20 members from 5 global models (GEM, Global Forecast System (GFS), GME, GSM and NOGAPS) for 4 regional models (BOLAM, ETA, HRM, WRF-NMM) was developed and under testing for operational application. The GEMPAK/N-AWIPS) package from UNIDATA/UCAR has been installed, studied and undergone the adaptation to be used with the data feed from local sources at NCHMF. An interactive software for assisting tropical cyclone forecasting (TCAid) has been used operationally by forecasters in producing TC subjective guidance. This software was developed in 2007 as a new version of TCInfo using Microsoft SQL Server 2000 database. Inheriting all the advantages of ‘TCInfo’ and applying the advanced IT technology, TCAid has many other convenient functions to meet forecaster’s requirements in operational work and it has been used for the 2009 typhoon season; HMSTyph software was developed for displaying TYPH observations at hourly intervals during the TS approaching coastal areas of Viet Nam.

Improvements of software in data processing and analysis. There is continued development of the software for the preservation of the hydro-meteorological database, for hydrological data collection, processing and timely transmitting hydrological information and forecasts to end-users. The MARINE and FIRR models will be employed to forecast flow in upstream area of Da, Thao and Lo rivers. The Reservoir Flood Routing model is used for reservoir’s regulation in Da River and to create input for the hydraulic model TL2 in the lower stream of the Red River. The TANK Model is being applied for flood forecasting with lead time of 120 hour and a time step of 6 hour since the flood season of 2005. The MIKE-11 model for flow forecasting with lead time 48 hour is applied in the lower Red River. The HydroGIS model is being developed for flood forecasting with lead time of 5 days in the Lower Mekong River; The distributed hydrologic model WETSPA and hydraulic model Hydrologic Engineering Centres River Analysis System (HEC-RAS) for flood forecasting with lead time 24 – 36 hours are being developed for Vu Gia – Thu Bon river systems.

Development and application of the forecasting system on meteorological factors using statistical methods on the HRM model included:

- study and application of the ETA model and products of the global model GFS on operational weather forecasting;
- development of software to display surface-meteorological data on AERO;
- development of a Hydro-meteorological database system to serve operational forecasting and research in NCHMF;
- development of a method of estimating quantitative rainfall base on geostationary satellite images MTSAT;
- development of a short-term weather ensemble forecasting system in Viet Nam;
- experiments with and application of satellite data FY-2 on hydro-meteorological operational forecasting;
- application of NAWIPS software to analyse and display weather maps on the computer;
- study of data assimilation on Water Research Forecast (WRF) model to serve weather and typhoon forecasting;
- study using weather radar DWSR 2500C at Nha Be station to serve warning and observing rainfall;
- investigating, surveying, zoning and warning for the possibility of occurring of flash flood in mountainous area of Viet Nam;
- application of climate information and climate prediction to serve social-economic industries and disaster preparedness in Viet Nam;

- sea level scenarios and possibility of minimizing natural disaster-related hazards;
- impacts of climate change on water resources and adaptation methods;
- flash flood mapping project with the purposes: drawing up of flash flood maps and establishing flash flood warning systems in the North of Viet Nam (first phase 2006-2008 in Ha Giang Province with more than 70 automatic rainfall stations);
- establish the alarm system of water levels in Viet Nam;
- development and application of the American NWSRFS Model for Flood and inundation forecasting and warning in the Hong - Thai Binh River System**;**
- development of flood prediction and inundation warning technology in Ve - Tra Khuc river system, the technological experiment and transfer;
- development of 5-day flow prediction technology to large reservoirs in Da and Lo river systems.

Building capacity. The staff, especially young professional staff, from line agencies of the Viet Nam National Mekong Committee (VNMC) related to the management and mitigation of flood disasters at all levels were nominated to be trained in different related courses such as: training course on 'Mekong River Commission's Flash Flood Guidance (MRCFFG) System' that was held by VNMC and MRC-RFMMC in Hanoi, Viet Nam from 16-18 December 2009; a training course on 'Advanced Analysis of COMS Data' was held in Koica, Korea from 3-24 September 2009; training course on 'Building sustainability and resilience in high risk areas of the typhoon committee: assessment and action' in Cebu, Philippines from 14-18 September 2009; training workshop on 'Application and verification of global flood warning system (GFAS)' in Tshukuba (Japan) from 3-7 August 2009; the 4th International Coordination Group (ICG) meeting of the GEOSS Asian Water Cycle Initiative (AWCI) held at the Kyoto Research Park, Kyoto, Japan, 6-7 February, 2009; the 5th meeting of the GEOSS Asian water Cycle Initiative (AWCI) international Coordination Group (ICG) held on the University of Tokyo campus in Tokyo, Japan on 15-17 December 2009, with a satellite data training course and workshop on 17-18 December at the same venue; Vietnamese-Japanese workshop on 'the Hue Water along community' held on the University of Tokyo campus in Tokyo, Japan on 11-12 January 2010.

Regional cooperation assessment: Existing Contract for Network Improvement of Data Transfer from the National Centre for Hydro-meteorological Forecasting of Viet Nam (NCHMF) to the Regional Flood Management and Mitigation Centre was signed between The Mekong River Commission Secretariat (MRCS) and NCHMF, the objective of this contract is to upgrade and improve the network coverage of the rainfall stations of the NCHMF and to secure proper delivery to the MRCS timely, accurate and reliable real-time water level and rainfall data, which will be used for operational flood forecasting. Existing agreements were continued between Mekong committee and NCHMF for exchanging the hydrological data from China, Thailand, Laos and Cambodia and for the flood forecasting and warning agency and disaster management agency of Viet Nam. Cooperation between HMS Viet Nam and DHI for using Mike-11 model to flood forecasting is conducted.

THE ASSESSMENT OF IMPACTS OF CLIMATE CHANGE ON FLOODS IN THE MEKONG BASIN IN VIETNAM

Climate change - new challenge in Viet Nam

Viet Nam is one of the most vulnerable countries in the world with respect to climate change. According to the World Bank's 2008 Global Monitoring Report, Viet Nam ranks eighth in the ten most vulnerable countries in East Asia to weather extremes. A staggering 70% of the country's population lives in areas subject to water-related natural disasters. Although Viet Nam has centuries of experience with natural disasters and mitigating their effects, climate change presents a new threat that could lead to disasters of a different magnitude and frequency. As some recent studies show climate change impacts to Viet Nam are serious. The climate change challenges the cause of hunger eradication and poverty reduction, millennium development goals, and country's sustainable development. Most vulnerable sectors and regions to climate change are water resources, agriculture and food security, public health, deltas and coastal areas.[2]

Also, according to the World Bank Viet Nam is the most seriously impacted by sea level rise (Susmita Dasgupta et al., 2007). Up to 16% of its area would be impacted by 5 m sea level rise. Most of this impact would be in the Mekong and Red River deltas. Most of Viet Nam's land area southwest of Ho Chi Minh City would be severely impacted. Large percentages of Viet Nam's population and economic activity are located in these two river deltas. 10.8% of Viet Nam's population would be impacted by a 1 m sea level rise. This is the largest percentage of impacted population among all 84 countries. Viet Nam's impacted population would reach 35% with 5 m sea level rise. The impacts of sea level rise on Viet Nam's GDP and urban extent closely follow the impact on its population. With a coastline of 3,260 km length and two of the large deltas in the world, Viet Nam bears the worst damages by climate change (Susmita Dasgupta et al., 2007).

It is found that in Viet Nam changes of climate factors and sea level have the following noticeable features:

- over the past 50 years, annual average temperature has increased about 0.5 to 0.7 ^{o}C;
- typhoon trajectories moved southward and the typhoon season shifted to later months of the year and there were more typhoons with high insensitive;
- the number of drizzle days decreased significantly;
- frequency of cold fronts in the North decreased significantly in the past three decades, from 288 events in the period of 1971 -1980, 287 events in 1981 - 1990, to 249 events in 1991 - 2000. Number of extreme cold spells decreased, however, in some years it prolonged with historical insensitive, e.g. in 2008;
- the number of hot wave was more in the period of 1991 - 2000, especially in the Centre and the South;
- the rainfall increased in the rainy season (September to November) causing more frequently severe floods in the Centre and South of Viet Nam. However, it decreased in the dry season (July to August) causing drought every year in most regions of the country. Off-season extreme rainfall events occur more frequently, More profound are events in November in Ha Noi and its surroundings in 1984, 1996, 2008;
- ENSO has stronger effects on weather and climate in Viet Nam. Climate change and sea level rise scenarios for Viet Nam are being developed. The global climate model (MRI-AGCM) from the Meteorological Research Institute and Japan Department of Meteorology, PRECIS model of the Hadley Centre, United Kingdom, and the statistical downscaling method are applied. The low emission scenario (B1), medium emission scenario (B2), and high emission scenario (A2) are considered in the study[1].

There is evidence that over the last forty years there has been an increase in the number of disaster events. This is just one of the changes monitored by climate scientists in Viet Nam. Wide regional variations in rainfall have been recorded, but the annual volume has remained largely stable. However, the localized intensity and unpredictability of the rainfall has increased, causing severe floods. There have been more droughts in the South in recent years, which have tended to last longer. Typhoons have reduced in number in the last four decades, but they have become more intense and are tracking southwards. El Niño/La Niña weather events have

[2] Oxfam Viet Nam, 2008

become more intense in the last 50 years, causing more typhoons, floods and droughts. Just in the last twelve months, there have been unusual weather patterns including storms, floods, and droughts affecting tens of thousands of people across the country. In the central provinces, local people pointed to the heavier rainfall in the main flooding season. A sustained cold spell in early 2008 lasted for an unprecedented 38 days, beating the previous record of 31 days set in 1989. Temperatures dropped to below 10 ^{o}C, and reached -2 ^{o}C in two localities, a rarity in Viet Nam. The cold weather killed more than 60,000 cattle, destroyed at least 100,000 ha of rice, and caused economic losses of US$ 30 million. Vietnamese climate scientists blamed much of the recent unusual weather on the La Niña phenomenon. La Niña is the opposite meteorologically of the better known El Niño, and usually is associated with a drop in sea surface temperatures in the eastern and central Pacific Ocean by 1.5 - 2.0 ^{o}C below the average. The latest La Niña period, which started in the third quarter of 2007 and was due to last until July 2008, was particularly intense and was linked to weather extremes as far apart as Australia, China and Chile. Climate scientists in Viet Nam interviewed for this report say El Niño and La Niña weather events will become more intense as a result of global warming.

Many scientists agree, but others point out that different computer climate models come up with different results: some models have suggested that an increase in Green House Gas (GHG) in the atmosphere will increase the frequency and intensity of El Niño/La Niña. However, other models predict little or no change in how they occur. There is much less doubt that global warming is very likely to bring an increased risk of disasters to Viet Nam. There will be an increase in the intensity and/or frequency of extreme weather events such as typhoons, flooding and drought, whilst other changes will be more gradual like sea level rise, salt-water intrusion and warmer temperatures. All could have a very damaging effect on poor men and women. There are different predictions but there is broad consensus that, if there is no major international effort to reduce global greenhouse gas emissions, then the average temperature is expected to increase by between 1 to 2 ^{o}C (over pre-industrial levels) by 2050, and by 2 to 3 degrees by 2100. Rainfall patterns will vary from region to region, but rainfall and droughts are likely to increase both in intensity and in area of impact. Rainfall is likely to be less predictable. Typhoons are expected to increase in intensity and be subject to more unpredictability. They may also continue the trend of also affect the South of the country. Storm surge heights are expected to increase on the coasts.

Assessment of impacts of climate change to the Mekong Delta in Viet Nam

Forecasts on the flow in the Mekong River show that in the rainy season the flow will increase with up to 41% in the upper river basin and 19% in the Mekong Delta of Viet Nam (Cuu Long Delta). However, in the dry season, the flow will reduce up to 24% in the upstream area and 29% in the Mekong Delta of Viet Nam. These impacts of climate change will make the extreme events in flood and dry seasons more severe. It is expected that there will be about 8.4 million people in Viet Nam facing water shortage in 2050 (ADB forecast).

With the scenario of sea level rise with 1 m about 1.5 - 2 million will be inundated in the Mekong Delta of Viet Nam (half of the delta). During the big flood years, more than 90% of the Mekong Delta in Viet Nam will be flooded with 4 to 4.5 m and in the dry season 70% delta area will be impacted by salt-water intrusion with concentration of 4 g/1. Figures 17-20 show the tendency of changes of flows entering the Mekong Delta in Viet Nam (source: SRHMC).

Tables 8 - 11 and Figures 21 – 32 show relevant data on the water levels in the Mekong Delta.

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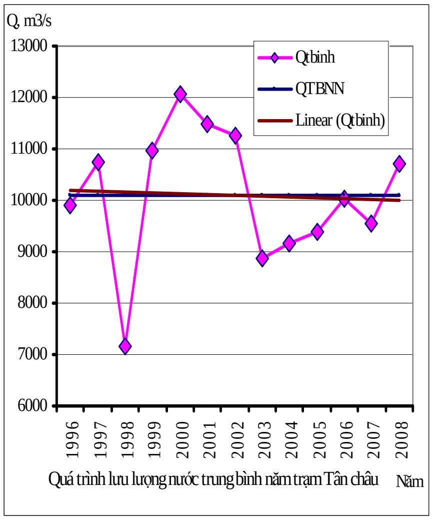

Figure 17. Hydrograph of annual mean flow at Tan Chau

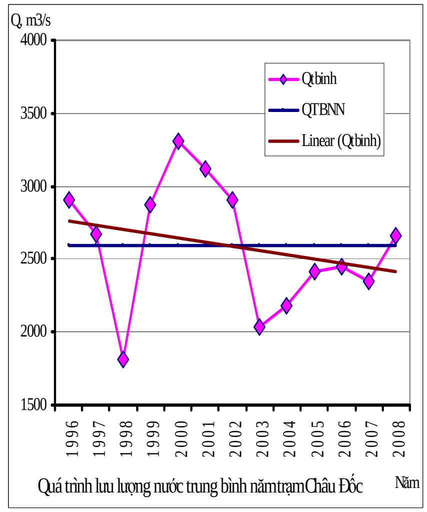

Figure 18. Hydrograph of annual mean flow at Chau Doc

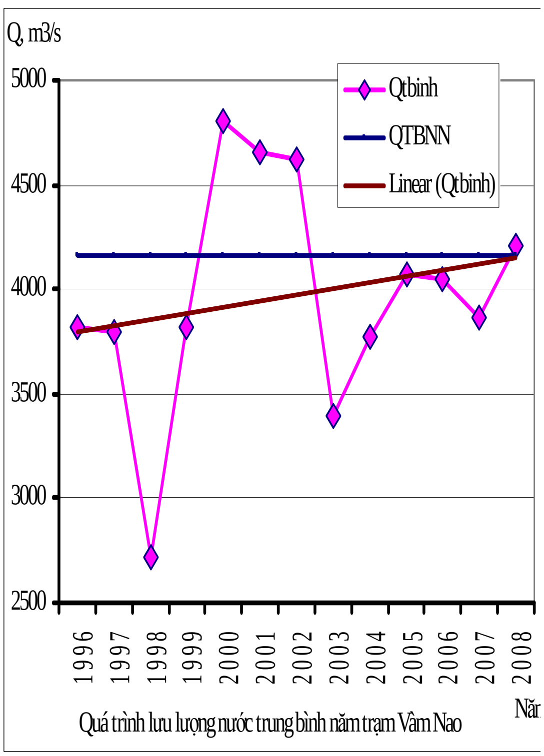

Figure 19. Hydrograph of annual mean flow at Vam Nao

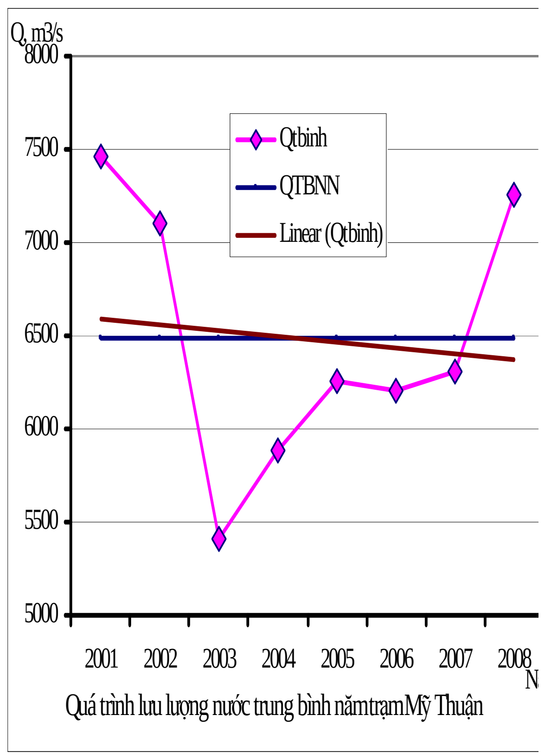

Figure 20. Hydrograph of annual mean flow at My Thuan

Table 8. Annual month average water level in cm+MSL (1980 - 2009)

TT	Trạm	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Năm
1	Tân Châu	118	81	59	46	50	97	185	300	374	378	285	184	180
2	Châu Đốc	105	74	55	42	43	77	144	239	325	343	262	165	156
3	Long Xuyên	75	54	39	27	24	41	79	123	166	187	156	108	90
4	Mỹ Thuận	54	40	28	18	10	13	33	53	78	96	92	72	49
5	Cần Thơ	42	28	18	8	2	5	24	44	66	85	79	60	38
6	Bến Trại	19	10	2	-5	-15	-25	-24	-22	-8	17	28	26	0
7	Trà Vinh	23	13	5	-3	-13	-22	-19	-12	4	28	36	31	6

ACTIVITIES AND ISSUES WITH RESPECT TO THE TOPICS OF THE 8th FORUM

Topic I. Community focused approach to flood risk management and mitigation

Situated in the tropical monsoon zone close to the typhoon centre of the western pacific, Viet Nam is one of the most disaster prone countries in the Mekong region. Currently 70% of the 73 million people in Viet Nam live in disaster-prone areas, with the majority of the people in the Central region. Losing crops and homes in floods and storms keeps many rural Vietnamese trapped in a cycle of poverty. This has been intensified in the recent years with major floods occurring more frequently.

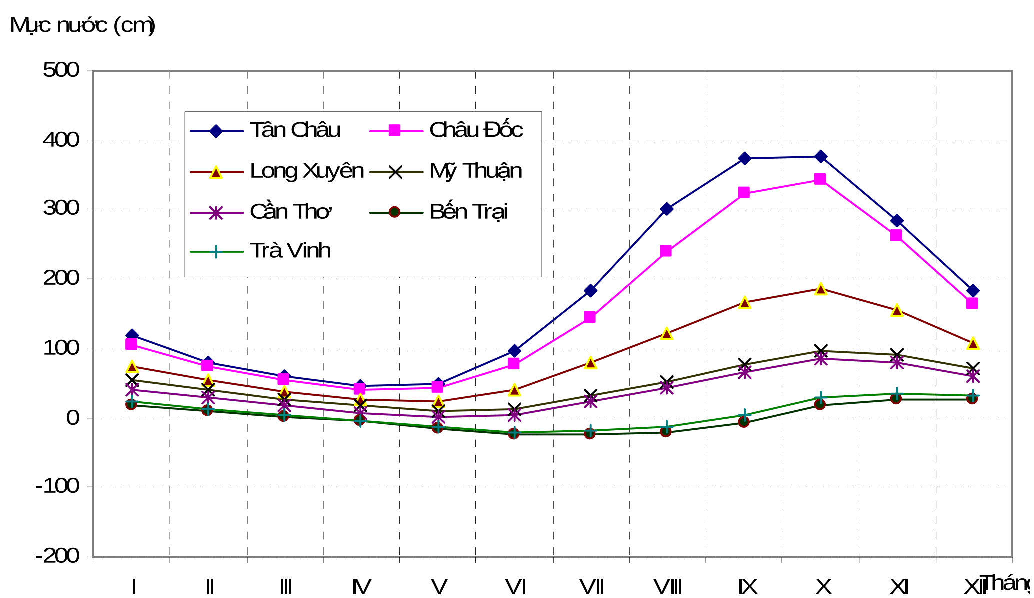

Figure 21. Hydrograph of annual mean water level at Mekong delta of Viet Nam

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Table 9. Characteristics of maximum monthly water level at main stations in Mekong delta of Viet Nam (1980 - 2009)

Station	Characteristics	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Năm
Tân Châu	Mean maximum	168	133	119	105	115	171	258	358	403	407	341	239	415
	Absolute maximum	204	173	140	117	168	300	421	465	506	487	413	321	506
Châu Đốc	Mean maximum	157	130	118	105	110	144	201	297	358	368	305	220	372
	Absolute maximum	183	164	135	121	147	222	378	434	490	469	406	307	490
Long Xuyên	Mean maximum	145	129	117	105	106	122	152	184	211	221	200	167	222
	Lớn nhất tuyệt đối	166	150	140	129	141	159	200	215	263	261	234	198	263
Mỹ Thuận	Mean maximum	136	124	117	106	101	105	119	140	158	168	160	146	170
	Lớn nhất tuyệt đối	176	163	159	154	150	148	149	176	180	192	192	180	192
Cần Thơ	Mean maximum	142	134	127	119	113	115	130	152	169	178	169	153	180
	Lớn nhất tuyệt đối	179	151	151	134	135	139	157	180	193	203	199	179	203
Bến Trại	Mean maximum	152	145	140	126	115	106	110	124	145	165	163	157	170
	Lớn nhất tuyệt đối	183	172	173	142	139	126	134	146	169	188	190	183	190
Trà Vinh	Mean maximum	149	144	134	124	112	104	110	121	141	156	156	151	162
	Lớn nhất tuyệt đối	166	163	172	137	136	123	150	137	164	174	180	175	180

Table 10. Monthly-average minimum water level in main stations in the Mekong Delta in Viet Nam (1980- 2009)

Trạm	Đặc trưng	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Năm
Tân Châu	Nhỏ nhất trung bình	52	9	-22	-32	-28	13	99	226	339	333	219	112	-37
	Nhỏ nhất tuyệt đối	9	-28	-48	-52	-56	-41	-52	91	176	204	146	19	-56
Châu Đốc	Nhỏ nhất trung bình	37	-4	-36	-46	-43	-9	69	171	287	304	200	95	-50
	Nhỏ nhất tuyệt đối	-1	-35	-54	-65	-69	-69	-13	58	148	192	123	45	-69
Long Xuyên	Nhỏ nhất trung bình	-20	-53	-75	-82	-82	-64	-14	47	113	146	92	21	-86
	Nhỏ nhất tuyệt đối	-63	-83	-95	-98	-107	-101	-72	-13	28	59	37	-15	-107
Mỹ Thuận	Nhỏ nhất trung bình	-68	-94	-109	-118	-123	-116	-77	-61	-24	14	-2	-41	-127
	Nhỏ nhất tuyệt đối	-108	-127	-139	-170	-160	-147	-138	-101	-65	-40	-50	-79	-170
Cần thơ	Nhỏ nhất trung bình	-89	-112	-125	-128	-134	-130	-107	-76	-36	-3	-21	-65	-138
	Nhỏ nhất tuyệt đối	-110	-142	-146	-143	-161	-153	-138	-124	-72	-44	-62	-86	-161
Bến Trại	Lớn nhất trung bình	-200	-188	-174	-190	-215	-229	-224	-225	-201	-171	-186	-198	-235
	Lớn nhất tuyệt đối	-235	-222	-208	-214	-240	-251	-258	-250	-235	-212	-230	-236	-258
Trà Vinh	Nhỏ nhất trung bình	-171	-178	-167	-179	-198	-213	-211	-197	-170	-137	-141	-161	-216
	Nhỏ nhất tuyệt đối	-202	-199	-201	-202	-217	-240	-232	-215	-200	-173	-180	-186	-240

Table 11. Comparison between 10-year water level features in main stations in the Mekong Delta in Viet Nam

Trạm	Hmax (cm)			Havegare (cm)			Hmin (cm)		
	1980-1989	1990-1999	2000-2009	1980-1989	1990-1999	2000-2009	1980-1989	1990-1999	2000-2009
Tân châu	404	406	436	176	177	187	-41	-36	-35
Châu Đốc	357	370	392	149	157	165	-59	-45	-44
Mỹ Thuận	152	162	183	55	48	47	-123	-122	-132
Cần thơ	160	169	194	39	33	43	-147	-140	-130
Long Xuyên	210	218	243	85	88	97	-94	-83	-82
Trà Vinh	155	162	170	3	5	11	-226	-212	-210
Bến Trại	161	172	176	-4	-1	5	-245	-232	-231

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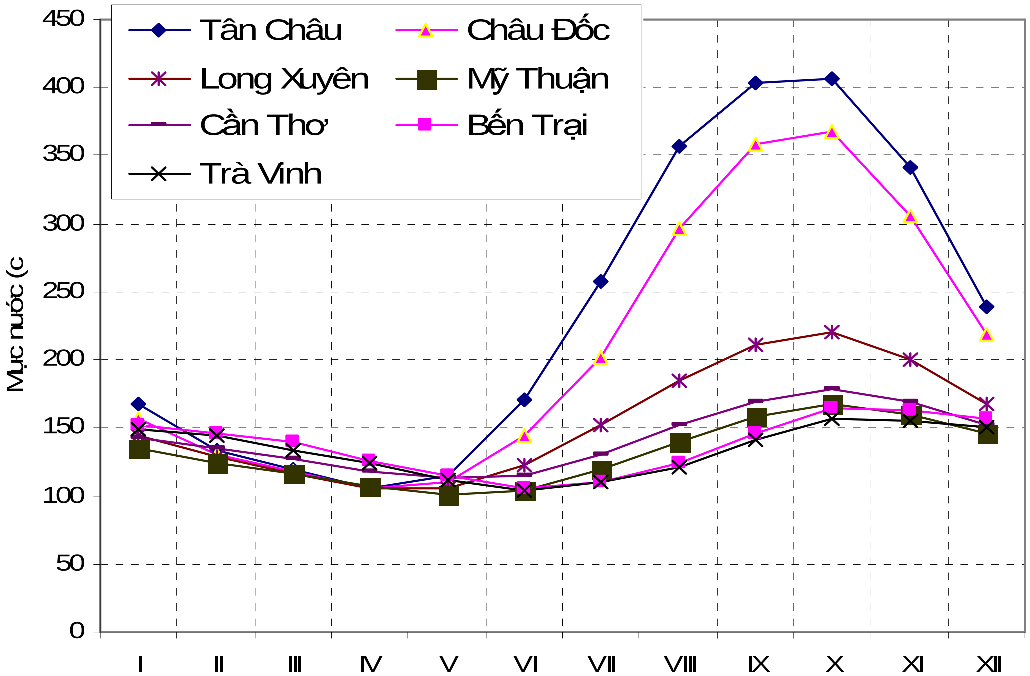

Figure 22. Hydrograph of Month average maximum water level

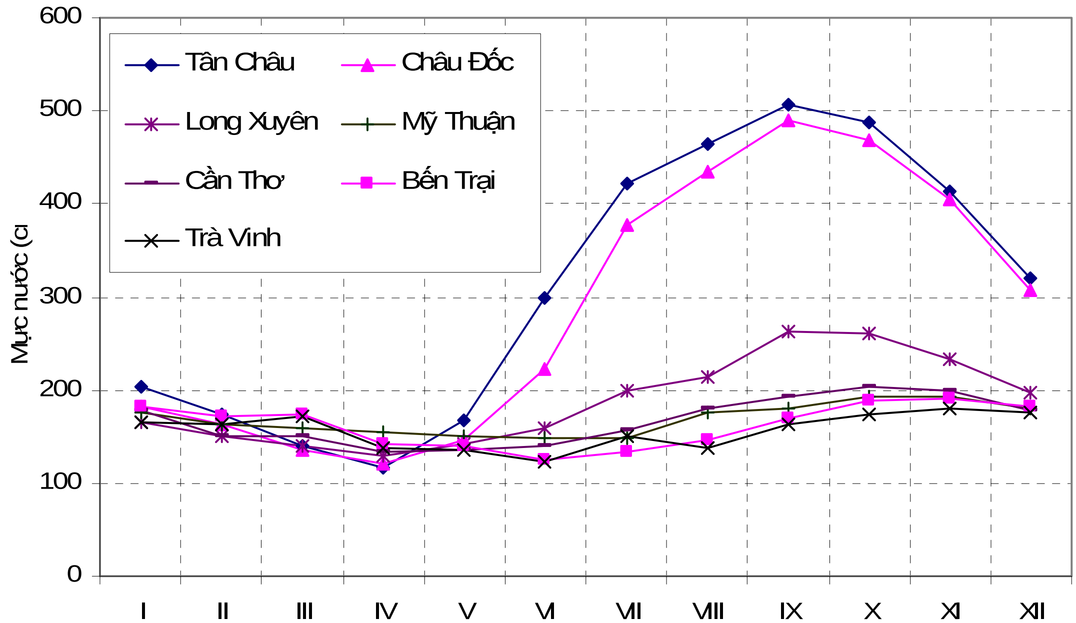

Figure 23. Hydrograph of month absolute maximum water level

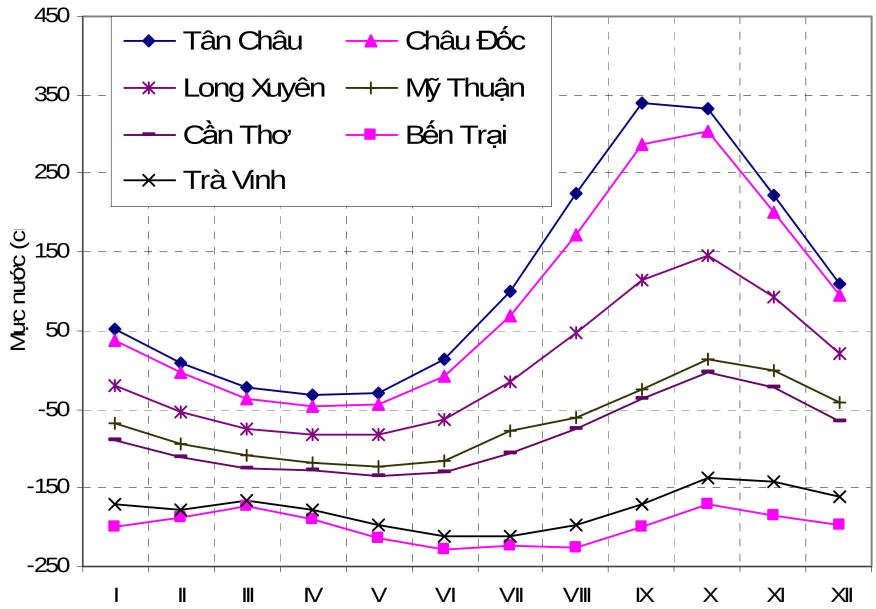

Figure 24. Hydrograph of month average minimum water level

Based on the geographical and climatologically features and the disaster conditions of all types of the country, the Government of Viet Nam made decisive policy for each zone as follows:

- *for the Northern Part of Viet Nam.* It is to strengthen the dyke system, flood retardation and diversion structures to improve the flood resistance coefficient of constructions, and to protect essential population and economic areas against flooding;
- *for the Central Part of Viet Nam.* Central Viet Nam is narrow and topographically complicated, frequently affected by storms, and rapid rainwater concentration resulted in flooding. The decisive policy is to supplement active measures for flood prevention and mitigation, as well as for familiarizing with floods;
- *for the Mekong River Delta.* The decisive policy is to prepare measures for living with floods, to minimize damage caused by floods as well as to make use of the advantages of floods for sustainable development;
- a community based focus is considered as one of the most important measures for flood mitigation and management in Viet Nam in general and in Mekong Delta in particular. '4 local readiness's' principles are applied in the strategy for flood management;
- within the framework of FMMP many activities to help in improving community awareness in flood mitigation and management have been implemented successfully.

Topic II. Flood forecasting and flash flood guidance

Because of particularities on appearing suddenly, normally appearing in the night, short-activating, tremendously devastating capacity, it is very difficult to forecast and warn for flash floods. However, flash flood forecasting and warning have been implemented in the National Centre for Hydro-meteorological Forecasting, following two processes.

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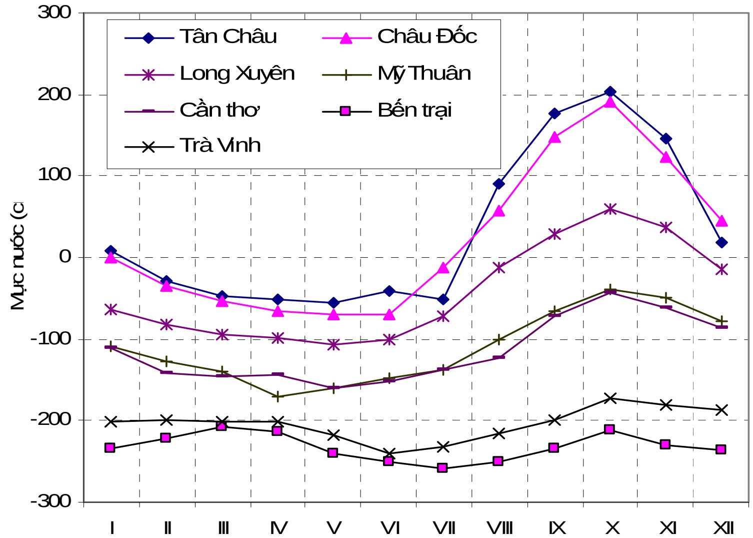

Figure 25. Hydrograph of month absolute minimum water level

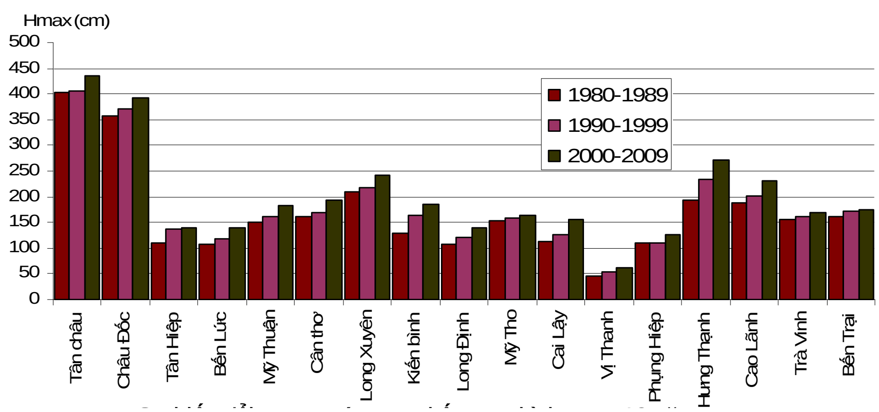

Figure 26. 10-year maximum *water level features in main stations in the Mekong Delta*

A. General forecasting and warning

Flash flood forecasting and warning have been implemented daily for high risk areas in Viet Nam following three steps:

- general warning for the possibility of flash floods based on monitoring, forecasting the development of weather pattern causing heavy rainfall and combined with natural and hydrological conditions in the river basin.
- warning for possibility of flash flood for the narrow basins based on predicted rainfall;
- warning for flash flood based on heavy rainfall and analyzing the map of measured rainfall (this map is synthesized from rainfall measured on station network and rainfall calculated from satellite images and weather radar).

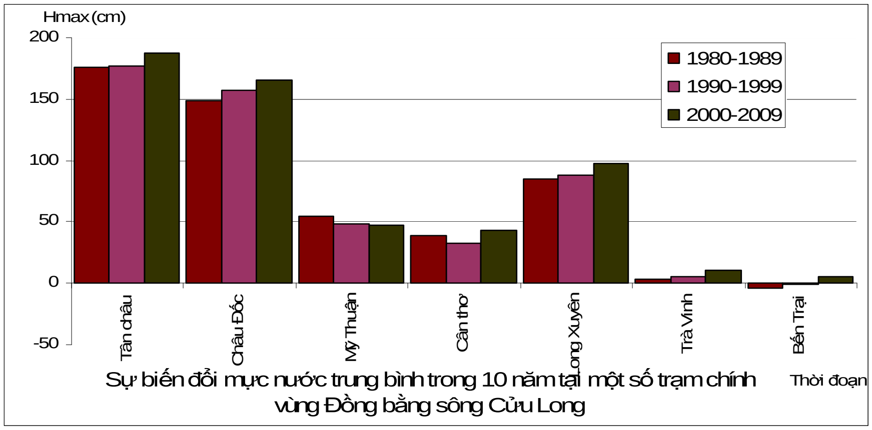

Figure 27. 10-year average *water level features in main stations in the Mekong Delta*

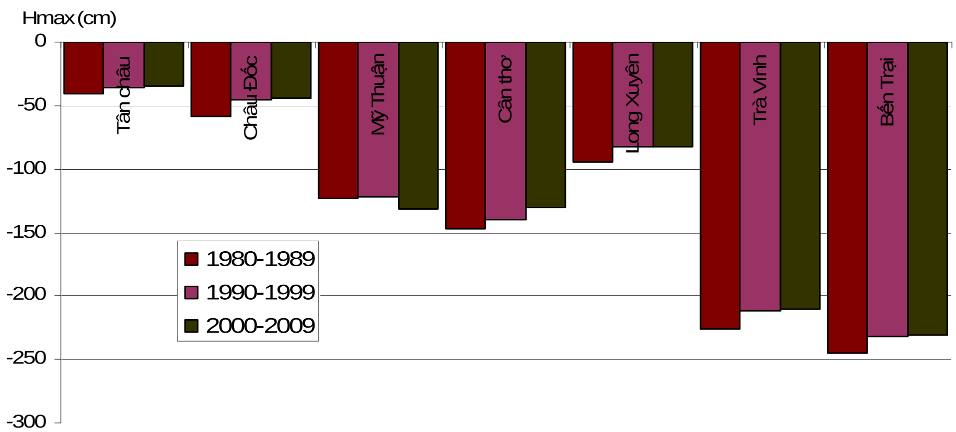

Figure 28. 10-year minimum *water level features in main stations in the Mekong Delta*

B. Automatic warning

In 2000, Viet Nam has established the first flash flood forecasting and warning system in Nam La - Nam Pan. This system has been maintained and developed up to now.

Flash flood forecasting and warning 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 in the North-western area. It is changed to a regime of receiving and transmitting one time per hour. Simultaneously, warning bulletins about possibility of flash flood in 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 the raingauge stations at which the rainfall intensity is larger than 10 mm per minute and in the hydrological stations at which the flood amplitude is larger than 2 m. Simultaneously, flash flood calculating and forecasting software using the Tank model work automatically and give forecasting results one time per 10 minutes at positions of Son La, Ban Ai and Hat Lot.

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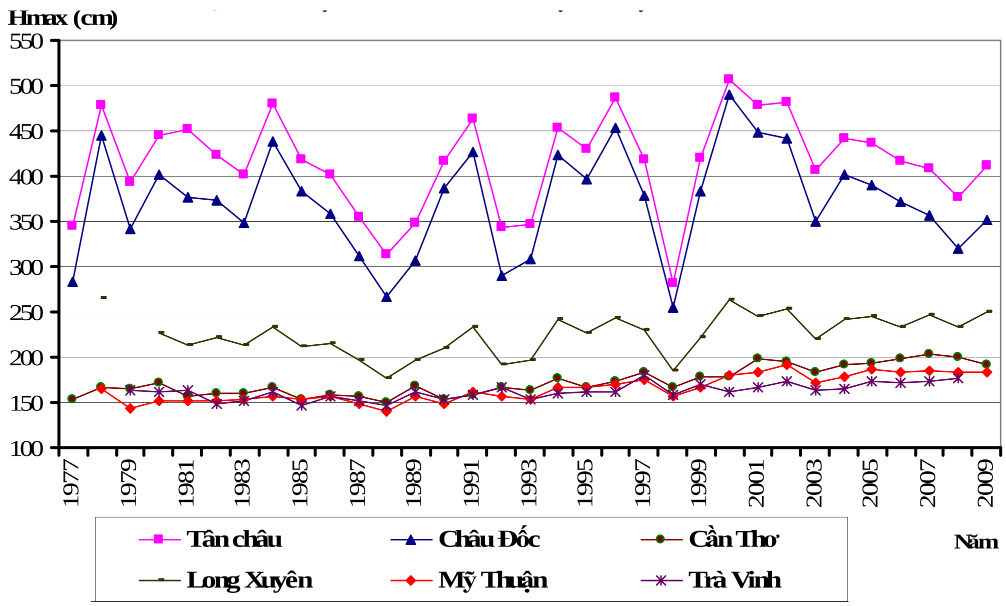

Figure 29. Yearly maximum water level in some main stations in the Mekong Delta in Viet Nam

Step 3. Analyzing results, issuing flash flood forecasting bulletins and sending them to 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 preventive 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 preventive methods.

The results of system operation

The system has worked very well and has been maintained frequently. However, from 2000 up to now, no flash floods have occurred in Nam La - Nam Pan River Basin. In big flood events occurring in August 2, 2001 and August 10, 2002, the system has been set up in alarm position but still in the second step at which was warned for the possibility of a flash flood. Rainfall intensity and flood amplitude norms have been met in all stations yet.

Methods used in hydro-meteorological forecasting. The short-range meteorological forecast uses methods of Synop and Synop combined with numerical meteorological forecasting products of the world. Applying of numerical rainfall forecasting methods such as the HRM model and ETA model has started Viet Nam. Rainfall- runoff models, conceptual models,

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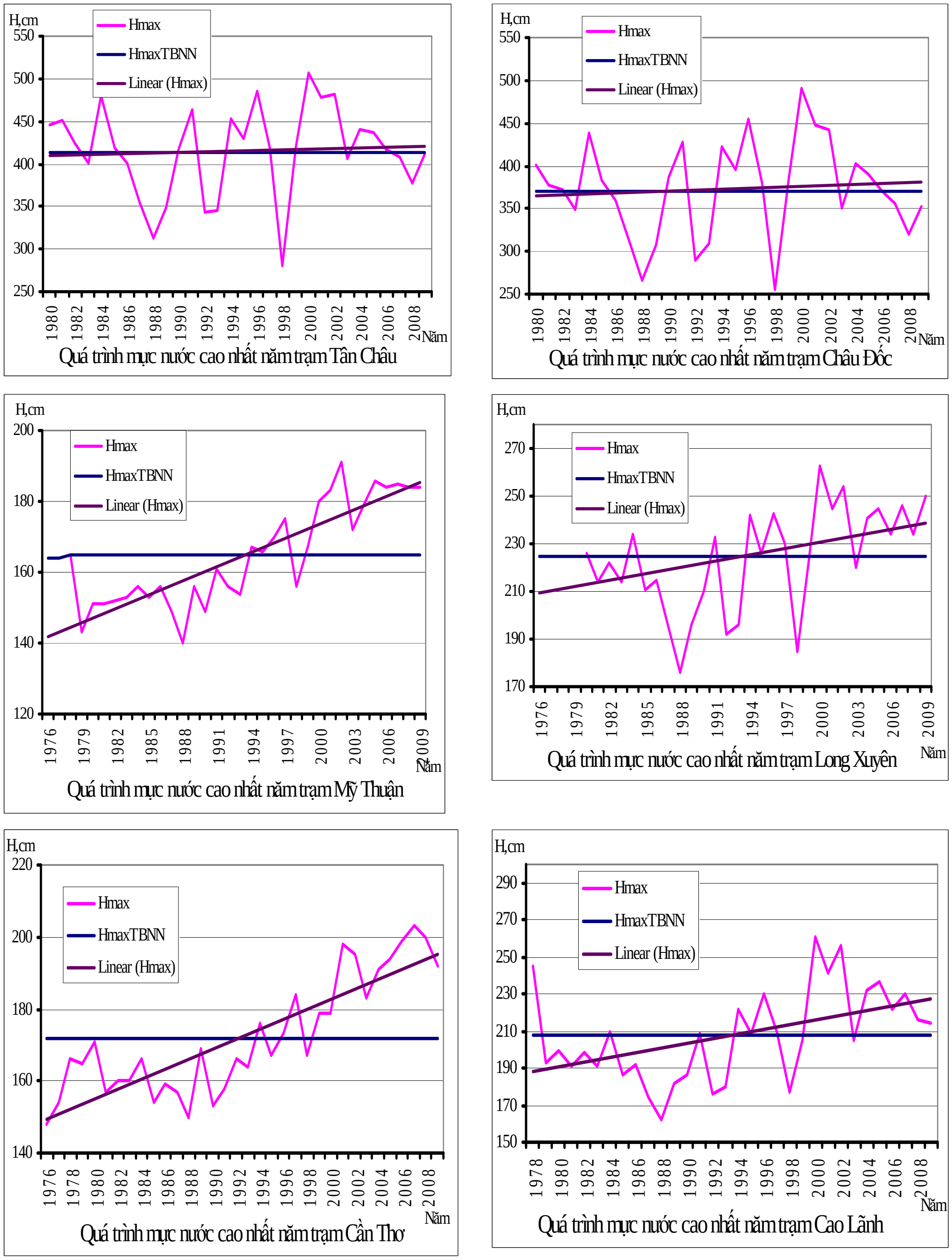

Figure 30. Yearly-average maximum water level in some main stations in the Mekong Delta in Viet Nam in comparison with the multi-yearly-average maximum water level and the linear regression.

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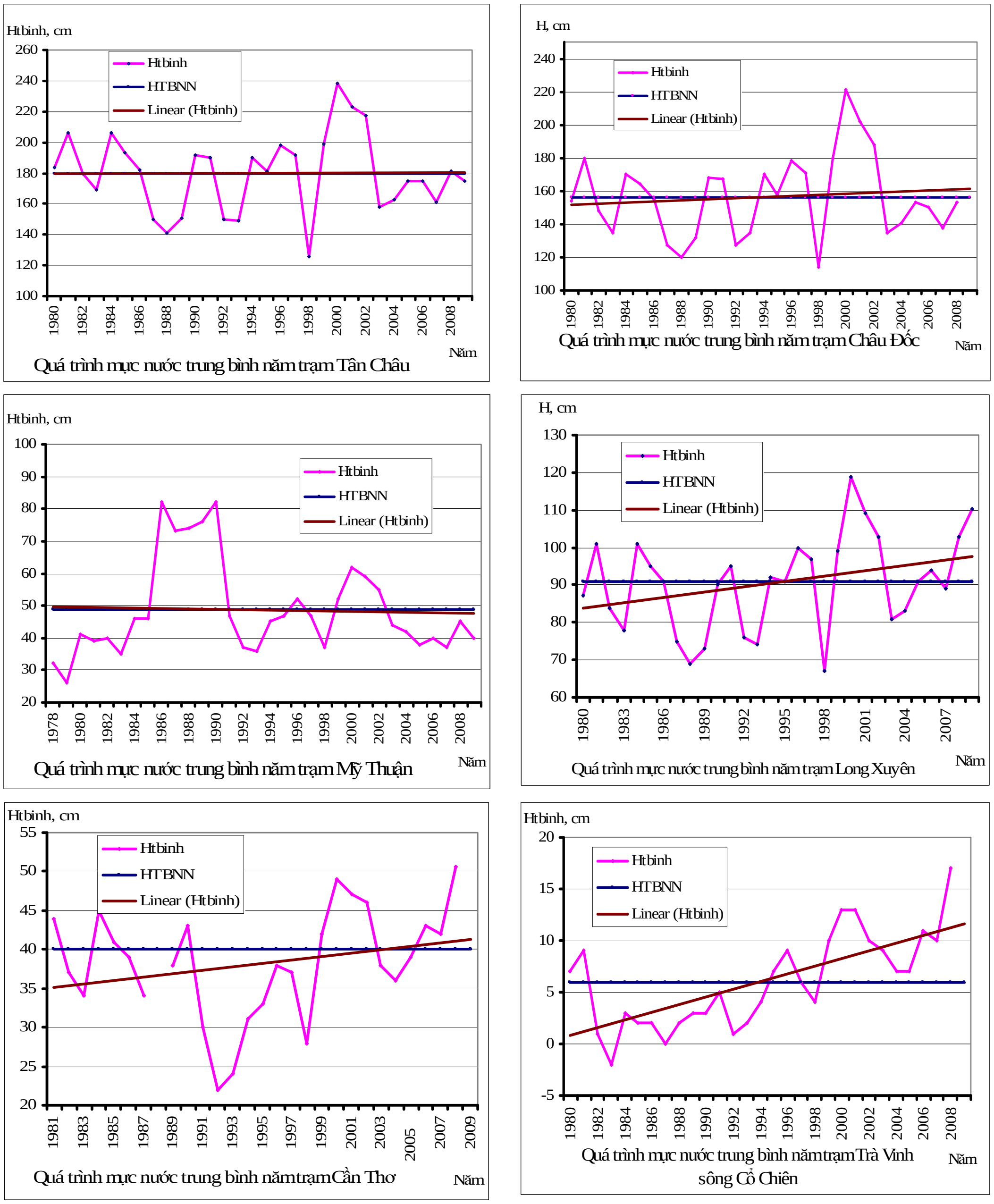

Figure 31. Yearly-average mean water level in some main stations in the Mekong Delta in Viet Nam in comparison with the multi-yearly-average mean water level and the linear regression.

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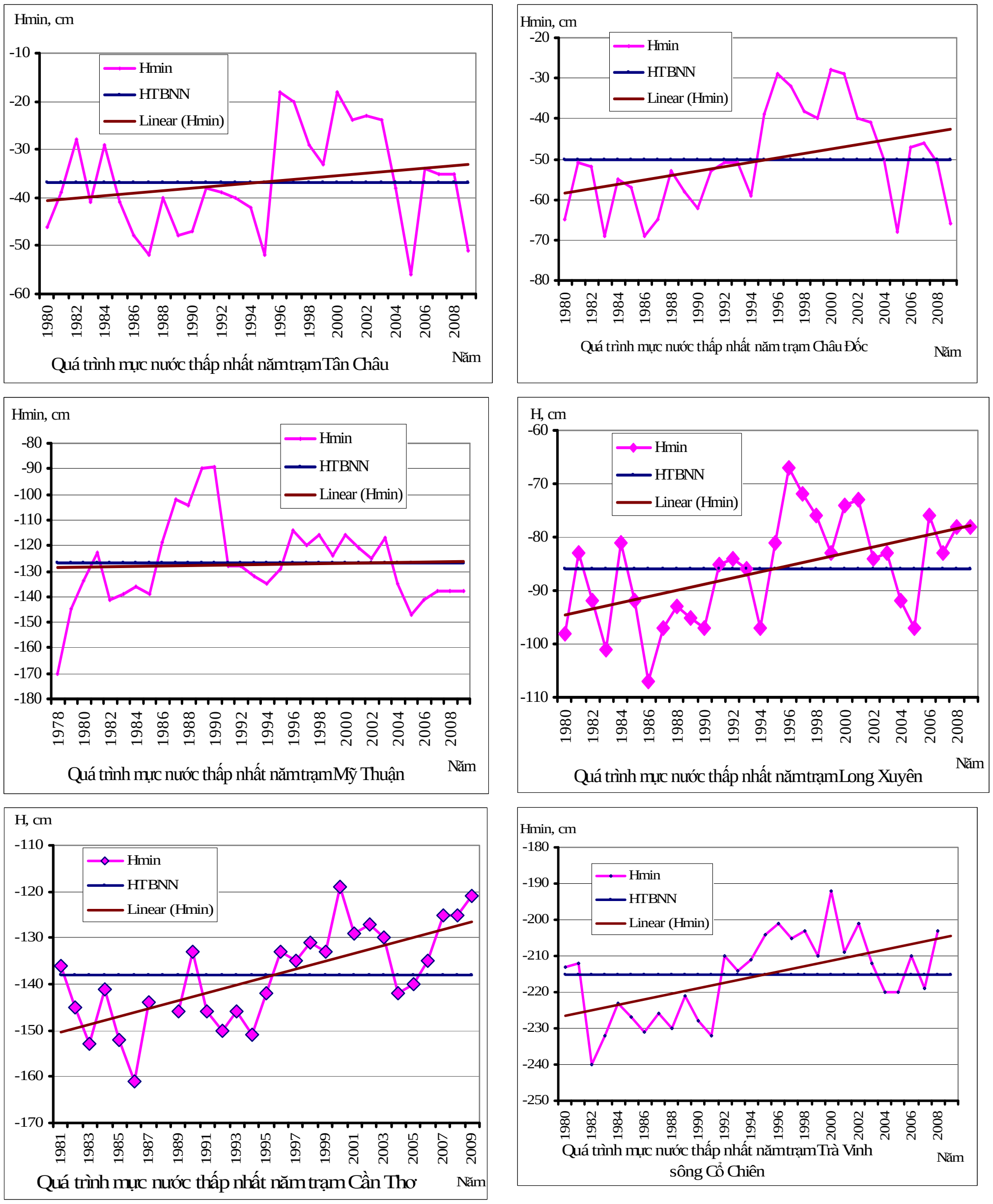

Figure 32. Yearly-average minimum water level in some main stations in the Mekong Delta in Viet Nam in comparison with the multi-yearly-average minimum water level and the linear regression.

correlative methods and regression methods have been used mainly in short-range hydrological forecasting. In recent years, SSARR, TANK and NAM models have been used for calculating and forecasting floods in small and medium size rivers. Hydrological and hydraulic models have also been used to forecast flood and inundation in downstream areas of big rivers, such as: Hong River, Mekong River and some of the big rivers in the Centre. Statistical methods, such as: time series analysis methods, multi-regression methods and similar methods have been used mainly in medium-range and long-range hydro-meteorological forecasts. Besides, reference is made to forecasting products at international forecasting centres such as in USA, Japan, Australia, Western Europe, etc.

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Forecasting techniques have been automated for all phases from receiving, encoding, processing data to update data for the model, calculating and issuing bulletins. The short-range hydro-meteorological forecasts have an accuracy of 75% to 85%; the medium-range hydro-meteorological forecast an accuracy of 70% and the long-range hydro-meteorological forecast an accuracy of 65-70%. (Thi, Nguyen Viet).

Topic III. Structural measures and flood proofing

The Government of Viet Nam has issued the National Strategy on Protection and Mitigation Flood and Inundation to 2020 with main policies related to structures and proofing to management and mitigation of water related disasters as follows:

- State budget for the building and reinforcement of dykes and other works to prevent and fight flood and drought and other serious effects caused by water,
- reserve Sate budget to be spent on the overcoming of the consequences of flood, drought and other serious effects of water;
- fund for preventing and fighting against flood and storms of locality contributed by the population according to the prescriptions of the Government;
- aid from organizations and individuals in the country, from foreign governments, foreign organizations and individuals and international organizations.

National policy responding to water related disasters, including structural and non-structural as follows:

- dyke systems. The regions are protected against flooding by one of the world's major river dyke (levee) and sea dyke (coastal protection) systems that has been built and added onto for over a thousand years. 5000 km of river dyke and 3000 km of sea dyke;
- Water Strategy Towards the Year of 2020 identified. Upgrading, modernizing and completion of flood monitoring, warning and forecast systems, developing warning systems for flash floods and mud and rock slides, with priority for mountainous areas in the North and Central regions;
- defining flood and inundated areas in all river basins, focusing on areas with the highest frequency and occurrence of natural disasters;
- establishment and implementation of plans for the prevention, control and mitigation of adverse impacts caused by water for major basins and central coastal rivers, while a harmonious combination of structural and non structural measures are to be applied to ensure safely to human life and limitation of losses to the minimal extent possible.

In recent years, numerous other flood protection measures have been applied effectively such as flood forecasting and warning, flood resistance of infrastructure, water laws and regulations for the mitigation of flood disasters, and public awareness training and education.

Topic IV. Trans-boundary cooperation for managing floods and related issues

Viet Nam is fully aware of the changes of the river due to natural and human impacts, Viet Nam's Mekong Delta, where millions of people are living, is suffering heavily from flood, droughts and salt penetration. Viet Nam pays attention to the Mekong cooperation and pledges to join hands with regional countries to realize the Mekong Agreement; preserve the Mekong River which would connect different cultures and represent regional solidarity, friendship, cooperation, prosperity and integration.

Within the framework of the FMMP, Viet Nam actively participated in all activities to promote and improve cooperation among Mekong countries relation to trans-boundary issues, especially in Component 3 of FMMP.

Various key cooperative frameworks and modalities have appeared in relation to the development of the Mekong River Basin. Some of the important arrangements, such as *GMS (Greater Mekong Sub-region)* cooperation advocated by ADB (Asian Development Bank) where the first meeting was held in 1992. Regular members are: Viet Nam, Lao PDR, Cambodia, Thailand, Myanmar and China (Yunnan). *MRC (Mekong River Commission),* established in April 1995, as the successor of the Mekong Committee (established in September 1956), consisting of four downstream countries (Viet Nam, Lao PDR, Cambodia and Thailand) has expanded from its original tasks during the Mekong Committee period of primarily water resources related development including environmental, capacity building and socio-economic considerations in its programmes. *AMBDC (ASEAN Mekong Basin Development Cooperation)* initiated by ASEAN with Malaysia's proposal. The first ministerial meeting was held in Kuala Lumpur in June 1996 with participation of 10 Southeast Asian countries and China.

The large number of initiatives discussed above shows the extent and expansion of development related activities in the basin. Except for Mekong River Commission, none of the other initiatives takes water resources explicitly as agenda item which underscores the sensitive nature of water sharing issues. If there is a basin wide consensus on the state of water and its behaviour, it would be easier to bring water as a key issue for the above discussion forums. The role of water sciences and water professionals in the region would be the facilitation of such a process (source: Srikantha Herath).

Topic V. Land use and climate change impacts on flood management

Viet Nam is one of five most vulnerable countries impacted by climate change. Mekong Delta is expected to be one of the most impacted areas by climate change. In some scenarios, if sea water raises 1 m, 10% of Mekong Delta will be flooded.

Changing land use and land management practices in Mekong River Basin as in Mekong Delta of Viet Nam can also alter the hydrological system. Land use change has a direct effect on hydrologic processes through its link with the evapotranspiration regime on the one hand and the sometimes extreme change in surface runoff on the other hand. Hence, land use also plays a main role in assessing groundwater resources. Precipitation is the primary source of groundwater and varies both temporally and spatially. For most hydrological applications, it is appropriate to assume that precipitation is independent of vegetation type, and evapotranspiration and surface runoff are closely linked with land cover characteristics. A large number of land use impact studies on water resources have been carried out for river basins with a focus on water scarcity, flood, erosion, and water management (Source: Priyantha Ranjan).

Government of Viet Nam has set up a National Target programme to respond to climate change (2008) and climate change, sea level rise scenarios for Viet Nam (June 2009). Under this framework, all sectors are in a process of preparation of their sectors' action plans for adaptation and mitigation to climate change.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The weather conditions in Viet Nam in 2009. The weather conditions in Viet Nam in 2009were complicated, disasters including floods caused big loss of life and properties of people and public. In Mekong Delta in Viet Nam, the flood was not as big as it was 2007 and 2008.

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However, it has been observed that the flood peaks were more pointed and flood duration was shorter than usual. In the Central Highlands, the weather has clearly changed with more frequent typhoons and floods. The flash floods have very high risk potentially for the people in the Central Highlands. It has been observed that the factor of global climate change has its negative influence to the floods and disasters in Mekong River Basin and in Viet Nam in particular;

Impacts of climate changes. In the rainy season in the Mekong River Basin, the flow will increase up to 41% in the upper river basin and 19% in the Mekong Delta of Viet Nam (Cuu Long Delta). However, in the dry season, the flow will be reduced up to 24% in the upstream area and 29% in the Mekong Delta of Viet Nam. These impacts of climate change will make the extreme events in flood and dry seasons more severe. It is expected that about 8.4 million people in Viet Nam will face water shortage in 2050 (ADB forecast). With the scenario of sea level rise to 1 m, about 1.5 - 2 million ha will be inundated in the Mekong Delta of Viet Nam (half of the delta). During the big flood years, more than 90% of the Mekong Delta in Viet Nam will be flooded with a depth of 4 to 4.5 m and in the dry season 70% of the delta area will be impacted by salt-water intrusion with a concentration of 4 g/1.

Recommendations

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 countries line agencies will prepare action plans responding to the hydrological circumstances;
- MRC daily forecasting news should be broadcasted before 10:00 hourr, in order that it can be referred to by the riparian countries;
- additional water level and rainfall data at 19:00 hr daily should be provided;
- 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.

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Paper 1-5

CHARACTERISTICS OF 2009 FLOODS AND THE FLOOD CONTROL AND DISASTER MITIGATION IN CHINA

Ms. CHU MINGHUA

Office of State Flood Control and Drought Relief Headquarters, Beijing, China

ABSTRACT

Flood disasters occur frequently in China. Owing to the vast territory in the east of the Eurasia and the complex topography and climate and most in monsoon climate zone, rainfall distribution in China is uneven in spatial and temporal scales and varies greatly annually and monthly. Rainfall in most areas of China concentrates in the flood season between June and September, accounting for 60-80% of the total in a year. The large floods occurred more than 50 times since 1949.

Chinese government pays high attention to flood control and disaster mitigation. A large amount of manpower and materials have been input to strengthen engineering construction, set up flood detention areas, and dredge up and regulate rivers. Flood control systems in seven large rivers have been built preliminarily. In respect of non-structural measures, institutional systems with corregidor responsibility have been established. Flood control offices were set up in seven river basin authorities, and flood control headquarters were set up in all the provinces, municipalities and counties as well. Flood reporting websites were established, and communication networks for flood control and flood forecasting and warning systems were also set up in important areas.

In 2009, large floods occurred in more than 210 rivers in China. The main characteristics are as follows: quite high rainfall frequency and heavy rainstorms in partial areas; quite high floods frequency and higher scale of runoff; quite more landing typhoons and heavy regional impact; more hidden dangers in dams and big difficulties for flood control; more flash flood disasters and high proportion of casualty.

The objectives for flood control and disaster mitigation set up at the beginning of 2009 have been completed entirely. It realized the flood safety of the main rivers and lakes, and the safe reservoirs operation during flood season, and the effective response to typhoon disasters. The death toll caused by floods was decreased by 80% than that of the normal years and the benefit of flood control and disaster mitigation in 2009 is obvious.

GENERAL SITUATION OF FLOOD CONTROL IN CHINA

China is situated in the eastern Eurasia, and has a vast territory and complicated topography and climate. Most of China belongs to the monsoon climate zone with the precipitation highly varying in time and space, particularly in the year and from year to year. In most parts of the country, the annual precipitation mainly occurs in the flood season from June to September, with the four months accounting for 60-80% of the annual total precipitation. More than 50 heavy floods have occurred in China since 1949 and two thirds of the national territory is threatened by flood and waterlogging disasters.

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FLOOD EMERGENCY MANAGEMENT INSTITUTION AND MECHANISMS IN CHINA

The Chinese government attaches great importance to flood control. The Flood Control Law, PRC provides that the State Council establishes the state flood control headquarters responsible for leading and organizing the flood control and flood fighting work nationwide, with its office instituted in the department of water administration under the State Council; and local people's governments at or above the county level with tasks of flood control and flood fighting establish flood control headquarters composed of the heads of relevant governmental departments, local garrisons and the people's armed forces departments, to lead the flood control and flood fighting work under the leadership of the flood control headquarters at the next higher level and the people's government at the same level.

In order to control flood and waterlogging disasters, since 1950, the Chinese government has invested a lot of resources in the construction of flood control works, building up more than 86,000 dams, 286,900 km of dikes, 98 major flood retention zones, training river courses, and practically completing flood control engineering systems for the seven major rivers, thus having greatly strengthened the capacity against flood and waterlogging disasters in China. As for non-structural measures, a governmental head responsibility system for flood control and flood fighting has been established. At the central level there is the state flood control and drought relief headquarters; at the level of the major river basins, there are flood control headquarters in charge of flood control and flood fighting in respective river basins; and all the local people's governments with tasks of flood control and drought relief at or above the county level each have a headquarters in charge of flood control and drought relief work under the leadership of the flood control and drought relief headquarters at the next upper level and the government of same level. Flood reporting networks have been established, and special telecommunication networks for flood prevention and flood forecasting and warning systems have been established for important areas, which have played an important role in flood control and drought relief work.

FLOOD AND WATERLOGGING DISASTERS IN CHINA, 2009

In 2009 heavy floods occurred to more than 210 rivers in China. The Taihu Lake witnessed the highest water stage since 1999; a flood exceeding the warning stage occurred to the Main Xijiang River; the heaviest flood since 2004 happened to the upper Yangtze River; and extraordinary floods hitting historical record occurred to 12 medium and small rivers. Severe flash flood, mudflow and landslide disasters happened to some areas in Southwest and South China, and nine typhoons landed in the coastal areas of China in succession. According to statistics, totally 29 provincial level jurisdictions suffered flood or waterlogging disasters to a varying extent in 2009, which affected 8.7 million ha of farmland, ruined 3.8 million ha of crops, affected 110 million people, including 538 deaths and 110 missing persons, destroyed 556,000 houses, and caused a direct economic loss of 84.596 billion Yuan (RMB).

The floods in 2009 had the following characteristics:

- multiple precipitation processes and intensive local rain storms. During the flood season of 2009 totally occurred more than 30 precipitation processes with a wide scope and a high intensity;
- a large number of high-magnitude floods. Floods exceeding the warning stage occurred to more than 210 rivers, including the biggest one since 2004 on the upper main Yangtze River, the biggest one since 1999 in the Taihu Lake, and a 20-year flood on the Liujiang River in Guangxi;

- a large number of typhoons affecting a large scope. Totally 22 tropical cyclones were formed in the southwestern Pacific and the South China Sea, four less than normal in number, but of which nine landed in the coastal areas of China, two more than normal in number;
- a lot of hiding troubles with the dams, hence more difficulties in flood prevention. With a large number of dams damaged by earthquake in Sichuan, Gansu, Shaanxi, etc, in 2008, and having not been fully consolidated, more than 160 dams were damaged by earthquake in Yunnan last year, making the dams either newly built or under consolidation amounting to 6166, of which more than 4100 witnessed a danger during the flood season of 2009;
- a large number of flash floods to bring about a large number of casualties. The last year saw occurrence of 116 big flash floods totally causing 430 deaths.

ACHIEVEMENTS OF FLOOD CONTROL AND DISASTER MITIGATION EFFORTS IN CHINA, 2009

In 2009, the flood control work in China succeeded in achieving all the targets set at the beginning of the year:

- the safety of important rivers and lakes against flood was guaranteed, no breach occurred to any of important dikes and no important cities and protected targets were inundated;
- the safety of dams was ensured and no dam breach occurred in the flood season in the whole country;
- the impacts of typhoons were effectively mitigated with the deaths per typhoon reduced significantly;
- the deaths caused by flooding in the whole country were decreased to 538 persons, or by 80%, as compared with normal, which is the least since 1949;
- the flood control and disaster mitigation work produced significant achievements, with the inundated farmland reduced by 2.7 million ha, the number of flooded cities reduced by 214, and the benefit of disaster mitigation amounting to 62.7 billion Yuan (RMB).

Paper 1-6

RIVER TRAINING ACTIVITIES IN THE UNION OF MYANMAR ONE OF THE STRUCTURAL MEASURES FOR FLOOD PROTECTION

U SEIN TUN AND U TINT LWIN

Directorate of Water Resources and Improvement of River Systems, Ministry of Transport, NayPyiTaw, Myanmar

ABSTRACT

In 1988, a Master Plan for river training courses for Ayeyarwady River and Lower Chindwin river was formulated under the United Nations Development Programme (UNDP) funded project of umbrella III Programme. Different types of river training structures were investigated for the Master Plan. For engineering reasons, river training structures such as rock groynes, wooden pile groynes, steel cable groynes and protective mattresses with vegetation were considered as suitable for the Master Plan. The Directorate of Water Resources and Improvement of River Systems tried these performances to ensure their functioning in accordance with the broad objectives of the Master Plan. Apart from the navigation purpose, proper inland river channel improvement, which assists both direct and indirect functions, was considered as to fulfil infrastructure requirement for prevention of extreme events, i.e, floods and droughts. Among the structural measures, river training is one of the effective tools for flood protection.

RIVERS OF MYANMAR

Myanmar belongs to the Asian monsoon region. Two-third of the country lies in the tropical and one-third in the temperate zone. Thus, Myanmar rivers are primarily under the influence of monsoon winds. Myanmar, which covers a total area of 677,000 km^2 is well endowed with natural river resources; of which the Ayeyarwady, the Chindwin, the Sittaung, the Thanlwin, the Mekong and numerous small rivers.

90 to 95 percent of the rainfall is concentrated in the period of May to October, especially in the months of July, August and September. The extreme rainfall between seasons lead to marked difference in the reaction in the drainage areas. As a result, Myanmar rivers rise as from May/June and generally peak in July/August. The water level starts to fall again by September and October.

Rivers are being faced with deterioration by artificial activities and natural processes. Braided channels, insufficient water depth in low water season, dangerous flood/serious erosion in wet season and large sediment transport are the symptoms of deterioration. Some are visible symptoms and some are hydrological features.

RIVER TRAINING WORKS

Since 1972, Directorate of Water Resources and Improvement of River Systems (DWIR) is involved in river training works in major navigable rivers. To improve the rivers in terms of

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Least Available Depth, DWIR uses the types of structures which are inexpensive in cost, workable in local conditions with local material and labour, and satisfactory in effectiveness (Figure 1).

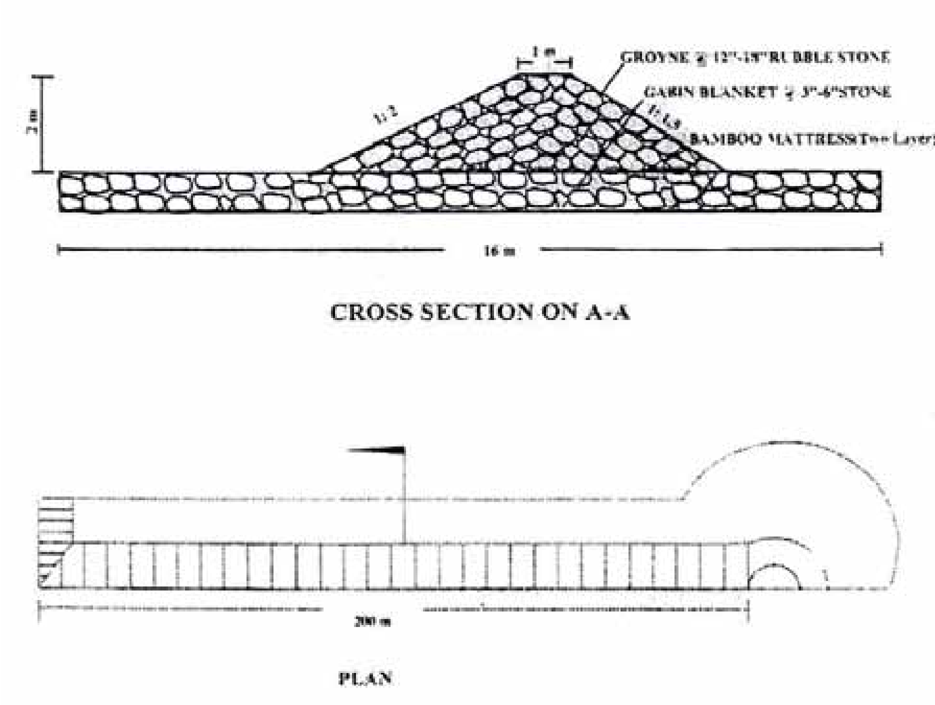

Figure 1. Typical design of rock groyne

In 1988, a Master Plan of river training works for Ayeyarwady river and lower Chindwin river was formulated under the U.N.D.P funded project of umbrella III programme. Different types of river training structures are investigated for Master Plan. For engineering reasons, those structures considered as suitable for the Master Plan are listed below:

- rock groynes;
- wooden pile groynes;
- steel cable groynes:
- protective mattresses with vegetation.

Existing river training works are undertaken on an ad-hoc basic in response to short term or local needs (Figure 2). DWIR tries these performances to ensure in accordance with the broad objectives of the Master Plan. But only few parts of the Master Plan for the development of the Ayeyarwady and Lower Chindwin rivers has been implemented.

EXTREME EVENTS MITIGATION

Mitigation of natural disasters is an important part of effective water resources management. Proper river channel improvement is one of the structural measures for extreme events. River training provides for drainage channels to drain the flood water efficiently. Similarly these provisions can mitigate the impacts of severe drought. Practically, inland river channel improvement for navigation is usual to conduct in accordance with the nature of the river pattern. However flood and drought management related river training activities are being undertaken against the nature of the river.

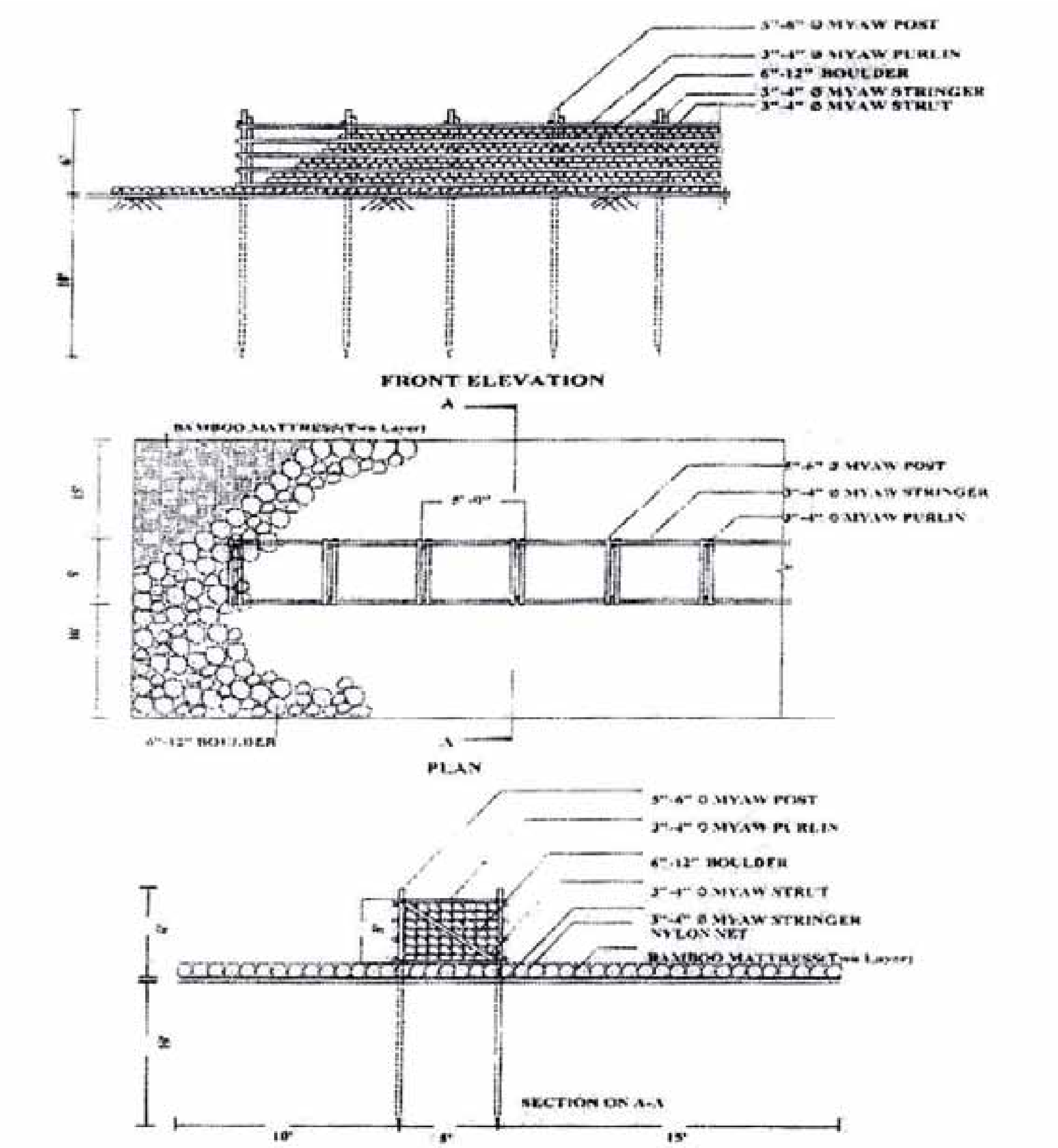

Figure 2. Typical design of rock-filled groyne

SOME RECENT RIVER TRAINING ACTIVITIES FOR FLOOD PROTECTION

U Yu River

Like Chindwin is the largest tributary of the Ayeyarwady River, U Yu River is the most important tributary of the Chindwin River. 267 km longs U Yu river is the one of the main suppliers of silt and snags into Chindwin River.

The U Yu river Basin is rich with gold and jade. Since years ago, gold and jade are being exploited in this region. These economy related artificial activities are the main cause which deteriorates the U Yu River. Snags in the lower reach of the river are dangerous for navigation and create sand bars, which lead to the river channel blocking and flooding.

Among the records of flooding, the 2008 flooding in the river basin, particularly Seik Mu village tract area, revealed some casualties. In the dry season of 2009, local authorities and jade exploring companies jointly conducted the flood protection tasks in this area, i.e., river channel cleaning, channel widening, earth dike construction and temporary bridges removing. DWIR undertook the river training works including snags removal activities especially at the lower reach of the U Yu River.

Mekong River

2008 was a significant year for the Mekong River flooding. During 72 hours, the river water level rose up 1.5 meter jumped over the bank of Wang Pong Port area. Not only flooding but also land slide and river bank erosion were caused by flood accompanied by heavy rain.

In 2009/2010, bank protection and river training works are being undertaken by DWIR. Results and achievement will be reviewed in the coming wet season.

CONCLUSION

This paper likes to highlight that Inland River Channel Improvement (IRCI) is one of the infrastructure requirements for flood prevention and drought elimination apart from the navigation purpose.

Existing river channel improvement works are undertaken especially for navigation purposes. But it is limited. The approach we practice in river training work is Bed Regulation Method which is inexpensive in cost, workable in local condition with local materials and labours.

Construction of dams, reservoirs and irrigation facilities are said to be major preventive measure of flood protection. Apart from these activities, proper IRCI which assists both direct and indirect measures, should be considered as to fulfil an infrastructure requirement for prevention of extreme events, specially with respect to flood protection.

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Paper 1-7

2009 ANNUAL MEKONG FLOOD REPORT

PHUNG KATRY[1], NGYUEN TIEN KIEN[2] AND PETER ADAMSON[3]

[1]*Hydrologist, Regional Flood Management and Mitigation Centre, Phnom Penh*
[2]*Operational Meteorologist/Flood Forecaster, Regional Flood Management and Mitigation Centre, Phnom Penh*
[3]*Consultant to the Mekong River Commission, Vientiane, Lao PRD*

ABSTRACT

The theme of the 2009 Annual Flood Report concerns climate change and its implications for flooding in the Mekong River Basin. These potential climate induced impacts on flooding are considered in the context of potential changes that may occur due to large reservoir storages on the mainstream and larger changes to tributaries. Findings and implications of the major regional climate change studies are reviewed, summarized and compared. The question is also asked as to whether the impacts of climate change are already evident and analyses of the long-term discharge and rainfall data are presented. The statistical complexity of uncovering systematic hydrological and climate change is addressed as are the wider long-term implications of any such change.

The format of the 2009 Annual Flood Report is consistent with those of 2006, 2007 and 2008 and comprises three major sections:

- the theme, climate change, is presented in the first section;
- a hydro-meteorological assessment of the 2009 flood season comprises the second section;
- the four riparian 2009 National Flood Reports complete the Report.

Regionally the 2009 flood on the mainstream was very much below average both in terms of peak and volume. The South-west Monsoon also ended early with the effect that the flood season ended up to six weeks earlier than normal. This has had major implications for flows since October, which by February 2010 had declined to a severe drought condition, particularly in the northern parts of the basin. The only major typhoon of the 2009 season was Tropical Storm Ketsana which occurred in September in the southern parts of the basin, principally affecting eastern Cambodia and parts of the delta in Viet Nam. Otherwise water levels were about average in early 2010, but declined towards drought conditions later in the flood season as very low upstream flows took hold.

AN OVERVIEW OF THE 2009 ANNUAL FLOOD REPORT

Introduction and scope

In line with previous years, the 2009 Flood Report combines an annual theme with a review and analysis of flood conditions over the year. The theme for 2009 focuses on the potential impacts of climate change on the flood regime of the Mekong River. Much attention has been directed at

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the wider regional consequences of global warming and relevant research results are summarised. The question of whether there is any evidence to date of the anticipated impacts is also addressed through statistical analyses of the relevant long-term hydrological and meteorological time series. The case is made that the regime of the Mekong River is on the verge of significant impacts becoming evident as a consequence of regional hydropower development. In particular impact on the mainstream and in comparative terms the more subtle hydrological changes brought about by climate modification may be extremely difficult to detect at any statistically meaningful level.

The magnitude and pattern of the 2009 Mekong flood links well with this annual theme. In the northern parts of the basin the annual flood peak and volume were much below average, which combined with an atypical early end to the flood season meant that water levels and discharges were extremely low from late December onwards. By February 2010 they were amongst the lowest observed since records began, leading to claims that the conditions were a manifestation of the consequences of global warming.

Although the regional focus has been very much upon the drought conditions that followed the weak 2009 monsoon season, the Lower Mekong River Basin (LMB) was not spared from the devastating impacts of typhoons and severe tropical storms during the year. Between 29 September and 5 October Typhoon Ketsana, which developed in the Western Pacific into one of the most severe tropical storms of recent years, made landfall over the South of Viet Nam and tracked westwards into Cambodia. Over 200 lives were lost and total damage and losses are currently estimated to exceed US$ 900 million. In line with the previous annual reports flood incidence and severity at the national level are summarised based on the more detailed data contained in the country reports.

CLIMATE CHANGE AND THE MEKONG FLOOD REGIME

According to the Intergovernmental Panel on Climate Change (IPCC) (2007), average global temperature has increased by 0.74 0C during the 100 year period between 1906 and 2005. While this may not be considered a significant increase, it is the reason behind it that is crucial. Previous changes in the world’s climate have been precipitated by variations either in the angle of the earth’s rotation or in its distance from the sun as the orbital dynamics of the solar system change. The rise in temperature is widely regarded as having been caused by human production of greenhouse gases, which effectively act as an atmospheric insulator, thus warming the planet.

The only way to project these changes into the future and estimate the possible consequences is through global climate models. At the macro level, modelling what is one of the most complex and chaotic global mechanisms is extremely difficult, not least with regard to the effect of the so called ‘feedback loops’, which may be positive, thus reinforcing warming, or negative, thus countering it. It is not surprising therefore that the projected increases in global temperature to the end of the 21st Century range from 1.1 to 6.4 0C (Intergovernmental Panel on Climate Change (IPCC), 2007).

Such warming would modify atmospheric dynamics globally and in Asia systems, such as the tropical Indo-Pacific circulation, which determines the climate of the Mekong River Basin, would be affected. The consensus is that the strength of the South-west Monsoon would increase as would inter annual variability (see Anderson et al, 2002, for example), thus increasing the incidence and severity of flood and drought conditions.

Table 1 presents a broad summary of the conclusions drawn by major regional climate change impact studies. There is broad agreement on the direction of the changes to rainfall and the subsequent hydrological consequences. There is less agreement however with regard to the magnitude of the changes. A common finding is an increase in the incidence of severe tropical weather systems such as typhoons; the inevitable consequence of a rise in tropical sea surface temperature. It could be argued that this change, more than any other, has the greatest consequence to the Mekong flood regime. Another significant aspect could be the potential impact of any systematic change to the start and end dates of the South-west Monsoon and therefore to the start and end of the Mekong flood season.

These dates have a characteristic narrow range with a typical standard deviation of only two weeks. However, when they are early or late the consequences can be severe. The early onset of the flood season in 2000 resulted in extreme seasonal volumes of floodwater and prolonged inundation, which caused the worst damage and losses witnessed for decades in Cambodia and Viet Nam. In 2004 the monsoon ended two months early causing drought and huge crop losses in North-east Thailand and throughout Lao PDR. The current regional drought conditions are largely the result of the monsoon season finishing early in 2009 (see below).

The only explicit attempt to specifically estimate the impacts of global warming on the Mekong flood regime have been undertaken by a Commonwealth Science and Innovation Research Organization (CSIRO) study (2007). Focusing on the projected situation at Kratie. By 2030 it is speculated that flood conditions currently defined as extreme (Mekong River Commission (MRC), 2007), that is; with a mean annual recurrence interval beyond 1:20 years, will be exceeded with an annual probability of 75% under the median of the future projections. In other words the present 1:20 year threshold conditions will be surpassed in four out of five years which would have severe consequences for the depth and duration of inundation within the Cambodian floodplain and across the delta in Viet Nam. Intuitively, this appears to be an extreme and implausible assessment. The associated projected and baseline mean monthly hydrology at Kratie is shown in Figure 1.

In the case of the Mekong Delta, the threats posed by climate change are severe. Sea level rise could be anywhere between 0.30 and 1.00 m by 2100, although the latter is the more likely figure. If it does reach 1 m, 90% of the Delta would be inundated annually at the peak of the flood season, compared to 35% to 50% at present, depending on flood magnitude.

Even by 2030, the sea level rise could expose around 45% of the delta’s land area to extreme salinisation and crop damage through flooding. Any climate change driven falls in dry season flows would add to the salinity problem, though the consequences of upstream hydropower development are almost certain to result in a net increase in the dry season discharge. Declining crop productivity would particularly affect the spring rice crop, which is expected to fall by 8% by 2070. If sea level rise of 1 m would happen, *Viet Nam* would lose about 12% of its land area and 23% of the national population would be affected. (all figures quoted here are drawn from United Nations Development Programme (UNDP) (2007) and IPCC (2007).

Table 1. Selected climate change impacts reported for the Mekong Region

Source	Temperature	Rainfall	Hydrology
Intergovernmental Panel on Climate Change (IPCC) (2007)	Significant local variation in warming, which will be greater in the interior and less towards the coast	Increased monsoonal precipitation, particularly on Tibetan plateau. Increase in the regional incidence of cyclones	Increase in the frequency of extreme flood events
Chinvanno (2003)	Locally variable increases of 1 to 3 °C between January and May, followed by a cooler late wet season in August and September.	Wet season will begin and end later in the year	Decrease in mean annual flood volumes but increased variability
Aerts et al. (2006)	1 °C mean temperature increase	6 – 7% increase in annual rainfall	Increase in mean annual discharge
Assessment of the impacts and adaptations to climate change (AIACC) (2006)		Increases throughout the region, locally up to 25%. Greatest increases over Lao PDR with increased storm rainfall intensity	Increased magnitude and possibly frequency of flooding
International Water Management Institute (IWMI) (2006)	Increase by + 1 ^{0}C in the period 2010-2039	Average rainfall will decrease by -20mm in 2010-2039	More drought and water shortage in dry season in lower Mekong sub-basins. Increased floods
Hoanh et al. (2004)	Mean annual temperature in the whole MRB will increase from 24 ^{0}C in 1961-90 to 25 ^{0}C during 2010-2039 depending upon the climate change scenario modelled.	During 2010-2039, the change in mean precipitation in different sub-basins varies from about -6% to +6% depending upon the climate change scenario modelled.	Tropical cyclone frequency and related floods may increase
South East Asia Regional Committee. System Analysis, Research and Training (SEA START) (2006)	Depends on atmospheric CO_2 concentrations	Increases of 20 to 30% throughout the region	
IPCC Working Group 2 (2001)	Warming most rapid and significant over the Tibetan plateau, with glaciers projected to shrink from 500,000 km^2 in 1995 to 100,000 in 2030	Increase in winter precipitation over the Tibetan Plateau and summer rainfall elsewhere along with higher intensities and annual variability.	A 1 m increase in mean sea level 15,000 to 20,000 km^2 of the Mekong Delta will be flooded
Commonwealth Science and Innovation Research Organization (CSIRO) (2006)	Regional temperatures projected to increase, the amount ranging from 0.5 to 2 ^{0}C	Increased summer monsoon rainfall. Increased drought risk during El Nino events	Increased tropical cyclone induced floods
Asian Disaster Preparedness Centre (ADPC) (2005)	Increase of 0.5 to 2.5 ^{0}C by 2070	South-west Monsoon rainfall increased by up to 5%	Due to higher sea levels and backwater effects up to 14 million people will be exposed to frequent flooding in the Mekong Delta

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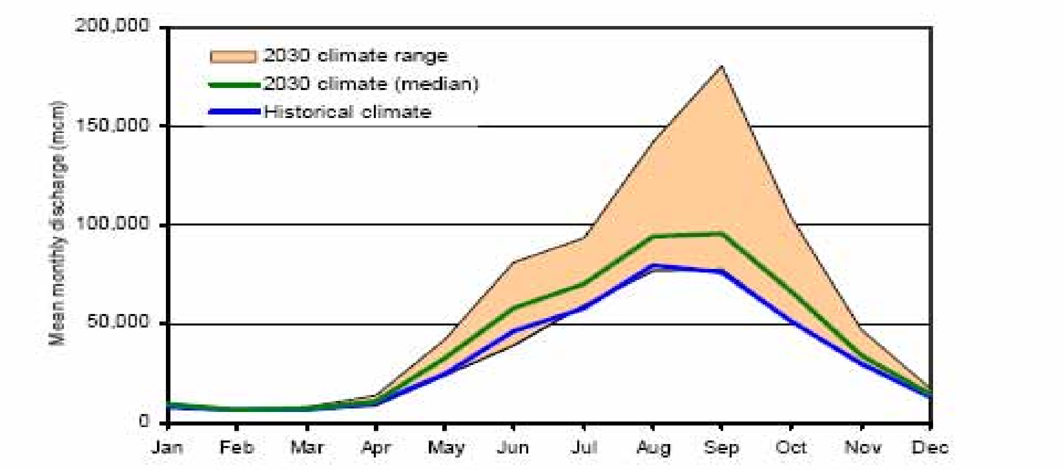

Figure 1. Kratie. Baseline (1951 – 2000) and projected climate change impacts upon mean monthly discharge (Source. CSIRO. 2007)

IS THERE ANY EVIDENCE TO DATE OF THE IMPACTS OF CLIMATE CHANGE ON THE FLOOD REGIME OF THE MEKONG?

Figure 2 shows the deviations above and below the mean annual flood peaks and volumes at Vientiane and Kratie over the last 80 to (almost) 100 years. Points to consider include:

- there is no evidence at all of any systematic trend in the direction proposed by most of the climate change impact studies;
- on the contrary, post 1980 peaks and volumes have been considerably below average in most years, with the key exceptions of 2008 at Vientiane and 2000 to 2002 at Kratie;
- the evidence strongly suggests that drier and wetter conditions cluster across a number of years and that there is therefore a quasi **-** periodic pattern to the time series. This feature, combined with the high overall variance of the data from year to year makes detecting climate change impacts much more difficult;
- results presented in the Annual Flood Report 2009 indicate that there has been no increase in the regional incidence of severe tropical storms and typhoons over recent years.

The plethora of uncertainties inherent in climate change projections clearly makes future risk assessment difficult. That global warming will to some degree affect the meteorological, hydrological and socio-economic fabric of the Mekong region is virtually certain. The incentives to plan accordingly are incontestable. However, to claim that the evidence of climate change is already regionally manifest, that the floods and droughts of recent years are the result of global warming is statistically indefensible in the light of the structure and pattern of the historical data.

THE 2009 FLOOD SEASON

Flood conditions in the Lower Mekong River Basin during the 2009 monsoon season were significantly below average, both in terms of peak discharge and with regard to the seasonal volume of runoff. The early end to the South-west Monsoon determined that the flood season ended early with the onset of the flood recession setting in as early as September at Chiang

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Saen. The recession was also very rapid when compared to the average historical rate, such that by mid October flows were generally less than the long-term mean annual discharge, which is adopted as the criterion to define the onset of the low flow season.
This early onset of the low flow season combined with flow volumes that were well below average during the flood season itself, meant that:

- natural catchment storage towards the end of the flood season, particularly in terms of groundwater levels and soil storage, was low;
- these reserves were drawn upon early and given that even under normal conditions natural subsurface water storage in the Lower Mekong River Basin is not well developed, this reservoir soon became depleted; and as a consequence, tributary and therefore mainstream flows and water levels became critically low by late December. By January 2010 a severe regional drought had developed.

Tropical storm activity during 2009 was confined to two major events. Tropical Storm Ketsana made landfall over Central Viet Nam during the last week of September causing high winds and three-day accumlated rainfalls as much as 600 mm over large areas. In the Central Highlands and upper Se San and Sre Pok tributary basins localised rainfall of over 1,000 mm was recorded. In these large tributaries water levels rose rapidly and by as much as 6 m in 5 days (Figure 3).

During the first week of December Tropical Storm Mirinae moved across southern Viet Nam and caused heavy rainfall of more than 200 mm over two days. However, the impact of Mirinae was less widespread than that associated with Ketsana and largely confined to the delta. The 2009 flood season saw the first significant impact of the mainstream dams in China on the flood hydrograph within the Lower Mekong River Basin. Notification was given to the MRC that the filling of Xiaowan would commence in July 2009 and end in December 2009. The effects of this during July are clearly evident in the hydrographs at Chiang Saen, Luang Prabang and Vientiane / Nong Khai (Figure 4). The flood discharge hydrographs (below) merely serve to confirm the fact that conditions during the course of the 2009 flood season were considerably below average, particularly in the northern regions of the Lower Mekong River Basin.

The historical perspective of these lower-than-normal conditions is indicated in Figure 5:

- the 1992 flood season was clearly the most extreme recorded before or since, with a peak and volume far below any of those observed in the last 50 to 100 years, particularly in the northern parts of the Lower Mekong River Basin;
- in these northern regions 2009 saw one of the lowest water levels ever recorded, particularly in terms of the overall volume of seasonal floodwater. At Vientiane the flood volume was the fourth lowest in almost 100 years;
- further downstream at Pakse and Kratie conditions were not as low. However, they were still well within the lowest quartile recorded over the last 80 years.

Water levels on the Cambodian floodplain and in the delta were average throughout the year (Figure 6). Maximum water levels occurred in October, a week to two weeks later than usual. After the peaks the levels at Tan Chau and Chau Doc decreased rather more rapidly than normal in response to the conditions that prevailed upstream.

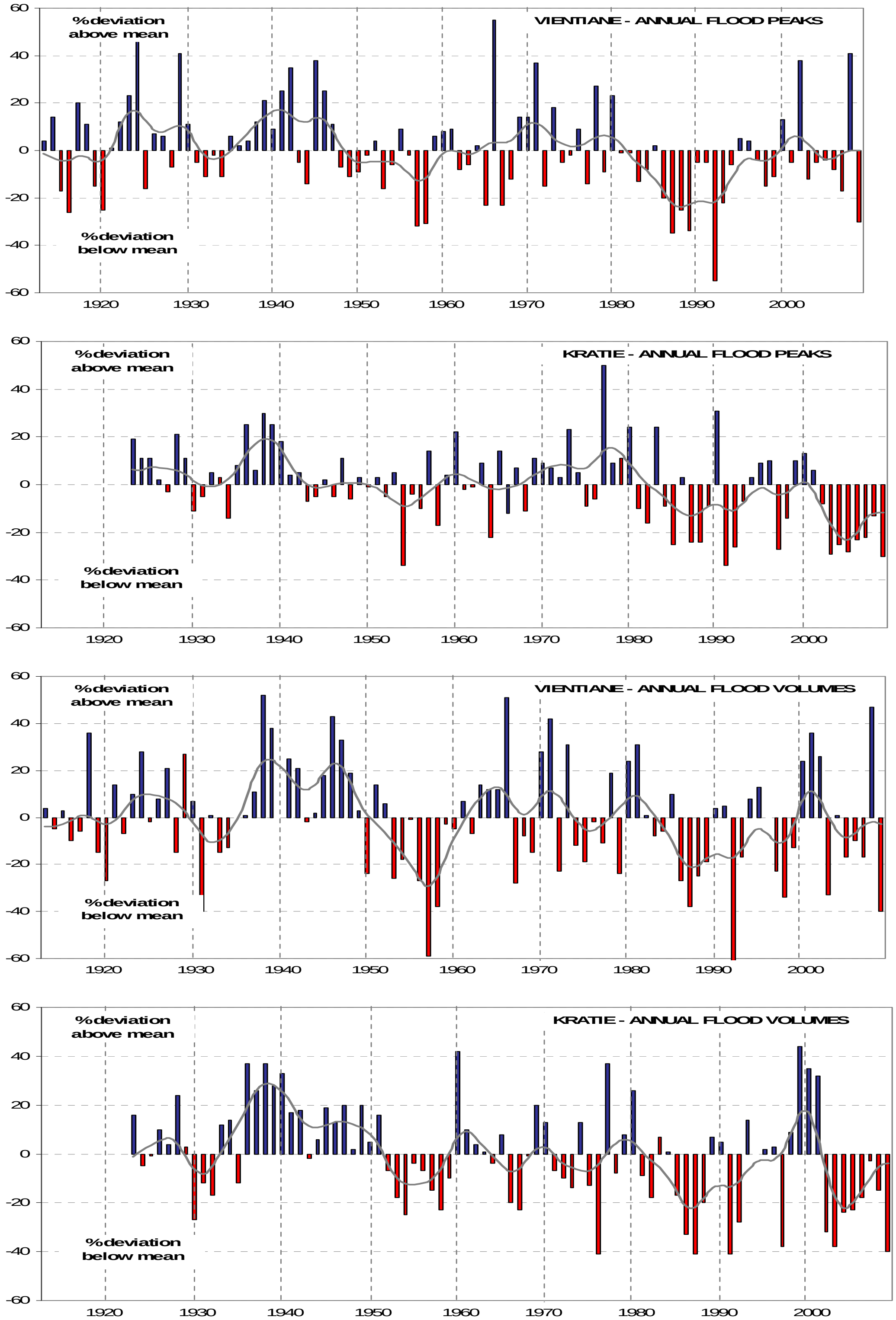

Figure 2. Percentage deviations of annual flood peak and volume above and below their historical mean values at Vientiane (1913 – 2009) and at Kratie (1924 – 2009). The smooth function is a reflected Gaussian filter with a wavelength of 11 years.

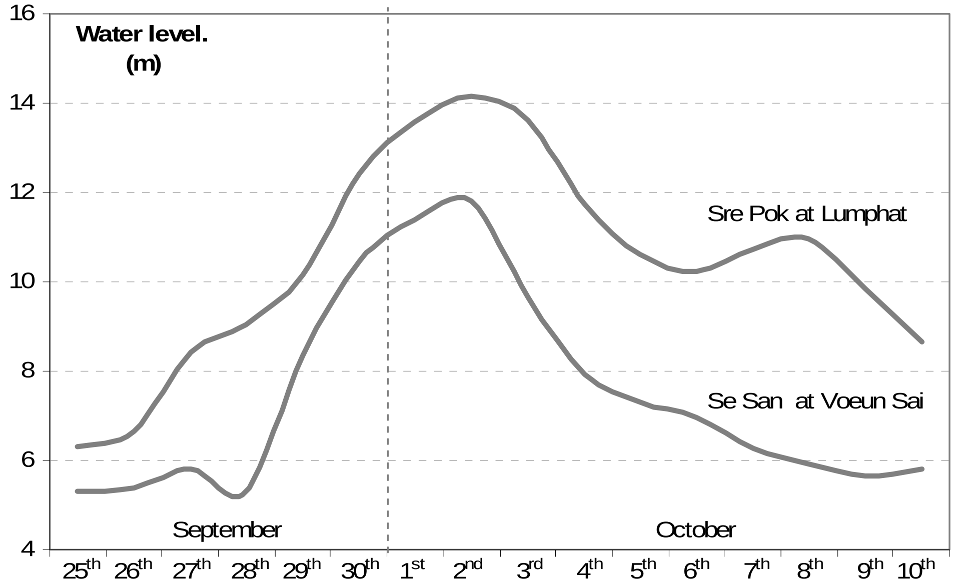

Figure 3. The water level response in the Se San and Sre Pok to tropical storm Ketsana at the end of September.

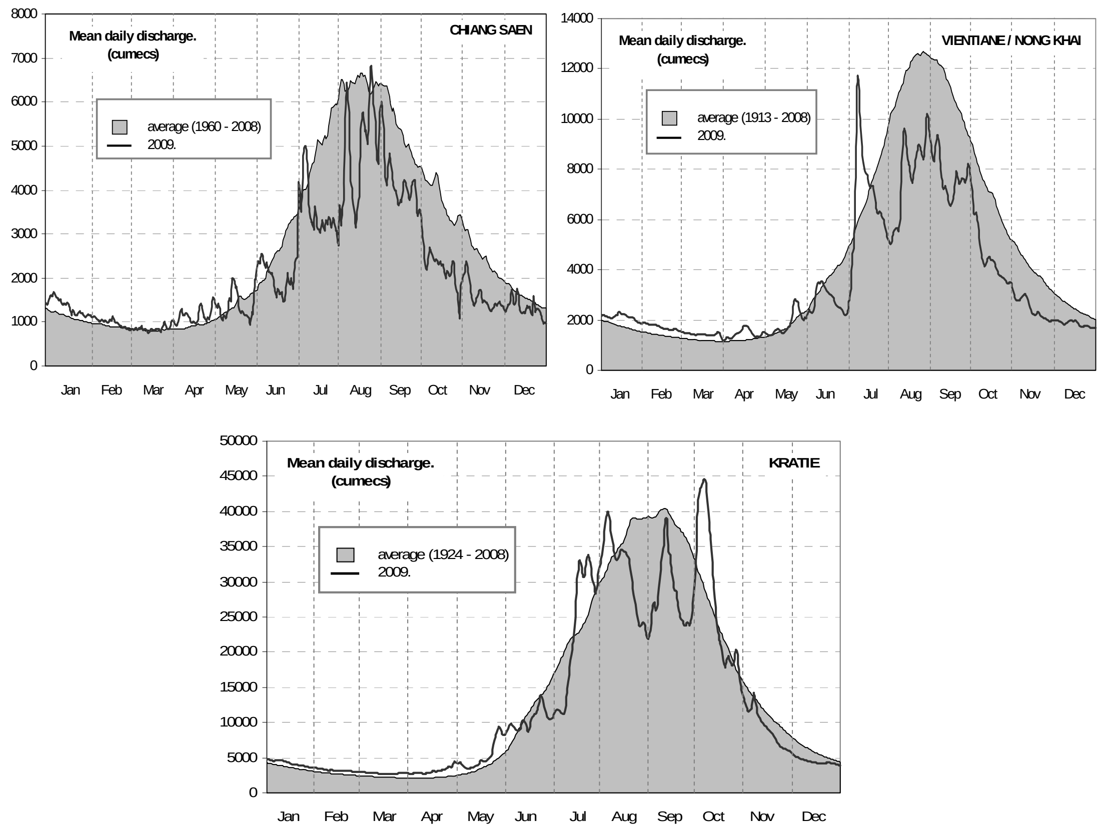

Figure 4. Chiang Saen, Vientiane and Kratie: the 2009 daily discharge hydrograph on the Mekong mainstream compared to the long-term average.

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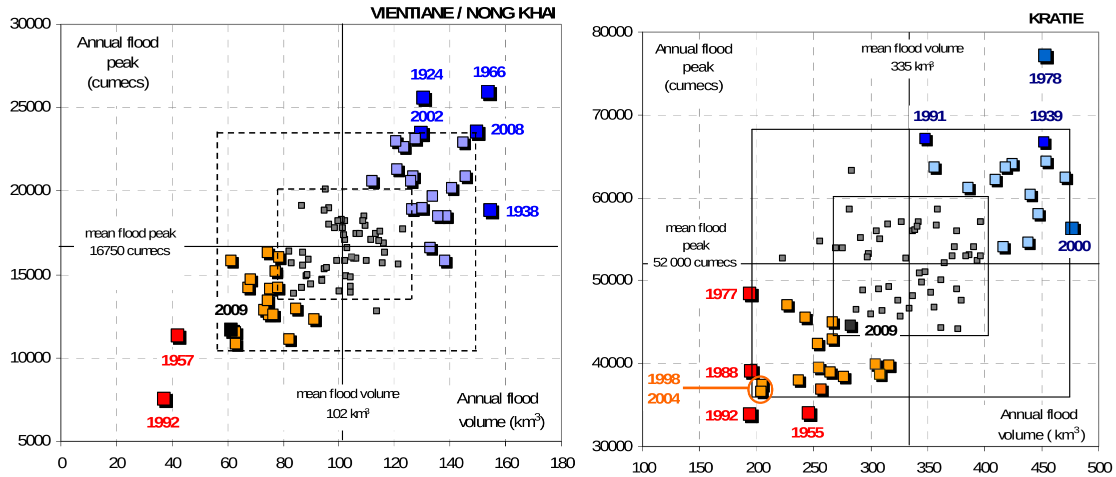

Figure 5. Scattered plots of the joint distribution of the annual maximum flood discharge (m3/s) and the volume of the annual flood hydrograph (km3) at selected sites on the Mekong mainstream. The 'boxes' indicate one (1δ) and two (2δ) standard deviations for each variable above and below their respective 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.

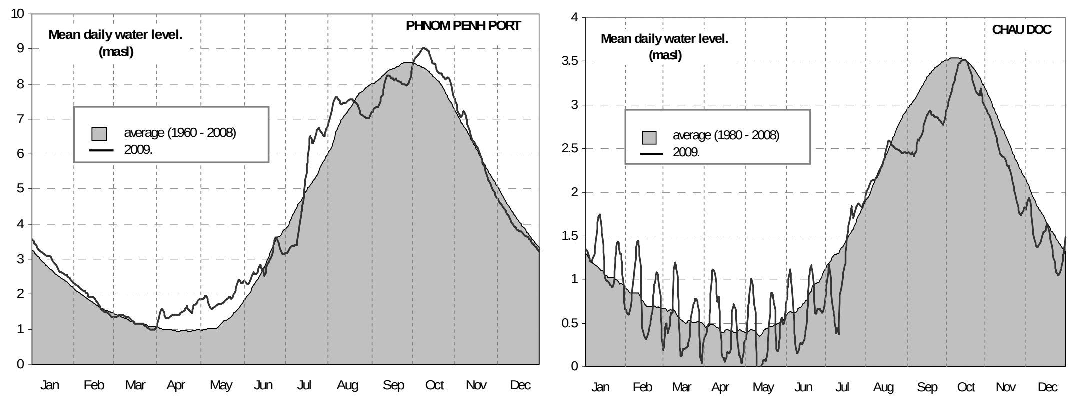

Figure 6. Mean daily water levels in Cambodia and the Mekong Delta for 2009 compared to their long-term daily average

FLOOD LOSSES AND DAMAGE

Events during 2009 demonstrated the pivotal role that typhoons and severe tropical storms play in generating regional flood loss and damage. The passage of Typhoon Ketsana across southern Viet Nam and northern Cambodia resulted in levels of loss and damage not seen in decades in a flood season that was otherwise well below average due to a weak South-west Monsoon. Ketsana made landfall over Central Viet Nam during the last week of September causing high winds and 3-day accumlated rainfalls as high as 600 mm and 1000 mm in some parts of the Central Highlands and upper Se San and Sre Pok tributary basins. Flash flooding occurred in these areas and in nothern Cambodia and southern Lao PDR. Total damage arising from Ketsana amounted to US$ 900 million of which the greatest proportion occurred in Viet Nam. Damage and loss costs in Cambodia were US$ 132 million.

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Ketsana also affected southern Lao PDR, with over 200 mm of rainfall observed at Saravane on 29 September. Flash flooding resulted in what is one of the poorest areas of the country and damge and losses amounted to US $58 million. By the time it crossed into Thailand Ketsana had been downgraded to a tropical storm with maximum daily rainfalls still in excess of 60 mm and locally up to 100 mm. Total damge is estimated to be US$ 22 million, confined largely to the Mun and Chi river basins.

During the first week of December tropical storm Mirinae moved across southern Viet Nam and caused heavy rainfall of over 200 mm over two days, though the impacts were less widespread than those associated with Ketsana and largely confined to the delta.

CONCLUSIONS AND RECOMMENDATIONS

The 2009 flood season provided an example of how the flood situation within the Lower Mekong River Basin in a given year can be geographically quite varied. In the North, flood volumes were low and the duration of the season cut short by the early withdrawal of the South-west Monsoon leading to severe drought. Further towards the South, conditions were average.

The year also illustrated how the incursion of a single typhoon such as Ketsana can; within a week generate extreme levels of loss and damage in a season that was otherwise well below average in terms of flood peaks, volumes and potential loss.

Recommendations drawn from the four National Reports are varied, though there are a number of common themes. There is a general recognition of the value of flood hazard mapping and regionally this needs to be expanded beyond pilot areas in order to implement effective national flood preparedness and mitigation planning, the identification of the most at risk sub-areas and the development of land-use planning (Mekong River Commission (MRC), 2009). The identification of areas vulnerable to flash flooding is a generally acknowledged issue that needs to be addressed more fully.

There are also calls for the MRC and the Flood Management and Mitigation Programme (FMMP) to continue to strengthen links with the national flood forecasting agencies so that the MRC Secretariat, as the regional knowledge hub river basin organisation, can provide its products and services in benefiting flood forecasting at the national level.

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SESSION 2

ACHIEVEMENTS AND PERSPECTIVES OF THE FLOOD MANAGEMENT AND MITIGATION PROGRAMME (FMMP)

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Paper 2-1

FLOOD PREPAREDNESS AND EMERGENCY MANAGEMENT: PEOPLE-CENTRED APPROACH IN INTEGRATED FLOOD RISK MANAGEMENT

ASLAM PERWAIZ

Program Manager, Asian Disaster Preparedness Centre (ADPC)
MRC Flood Management and Mitigation Programme (FMMP) Component 4: Flood Emergency Management Strengthening, Phnom Penh, Cambodia

ABSTRACT

Flood preparedness and flood emergency management strengthening remain core elements of the Flood Management and Mitigation Program (FMMP) of the Mekong River Commission (MRC), as these directly address the needs of flood vulnerable communities, and also indicate/guide the strengthening and operations of government agencies in the MRC Member Countries (at different levels: national, provincial, district and communes) and of national and international Non Governmental Organisations (NGO). This is vital for enhancing communication, coordination and cooperation between these stakeholders, as well as the consistency of national disaster management and mitigation policy implementation.

Realising the goal of the MRC to 'more effective use of the Mekong's water and related resources to alleviate poverty while protecting the environment', all the components of the Flood Management and Mitigation Program (FMMP) focus on strengthening capacities of the riparian countries in flood forecasts, flood data dissemination, technical standards and training packages. This is a good example of how the MRC is adopting integrated water resources management at the basin level. Component 4 i.e., Flood Emergency Management Strengthening (FEMS) assists the MRC Member Countries in strengthening their local and national authorities as well as selected relevant non-governmental actors in flood preparedness and emergency management in the Lower Mekong River Basin.

The paper outlines the overall strategy with working experiences on how the increased capacity of the key officials of the provincial, district and commune Disaster Management (DM) committees has led to a better flood preparedness in the selected provinces in the four MRC Member Countries i.e., Cambodia, Lao PDR, Thailand and Viet Nam. The paper analyses the capacities of the selected provinces in the MRC Member Countries for developing and implementing flood preparedness programs (FPP), community early warning systems, flood damage ad needs assessment, and flood emergency response contributing the overall flood risk reduction initiative by the national governments. While the contributions from the German Government through the 'Deutsche Gesellschaft für Technische Zusammenarbeit' (GTZ) and European Commission through the European Commission Humanitarian Aid Department (ECHO) are widely recognised by the MRC Member Countries as time-bound 'pilot' initiatives, covering some of the vulnerable provinces and districts, and improving the competence in dealing with the Mekong Floods. It also provides assessment-based solutions on how partnerships at various levels work in implementation of some of the important aspects of flood risk management. Be it public awareness or capacity building on community based flood management, Component 4 of FMMP takes a longer term programmatic approach to ensure that the flood management and mitigation policy objectives are solidly embedded into the national disaster management strategies of the MRC Member Countries.

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FLOOD MANAGEMENT AND MITIGATION (FMM) IN LOWER MEKONG BASIN

The Lower Mekong River Basin (LMB) - Cambodia, Lao PDR, Thailand and Viet Nam - is home to approximately 60 million people. Floods along the Mekong River every year have the potential to directly endanger life, do millions of dollars worth of damage to property, destroy livelihoods and crops and put people at increased risk of poverty, malnutrition and disease. At the same time, they are an important and essential natural process, bringing water, nutrients and other benefits to floodplains, wetlands and ecosystems. Climate, and particularly the South-west Monsoon, is the immediate cause of the annual floods. Most basin inhabitants are poor rural farmer/fishers although they may be resource rich. One third of the population lives on less than a few dollars per day. Being poor makes them more vulnerable to floods and flooding because the cheapest places to live are those which are mostly threatened by floods. Flood damage in the Lower Mekong River Basin 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 end of 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 amount to a regional total 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. By far the larger overall damages occurred in 2000 and amounted to US $811 million, those of 2008 being much less at US$ 135 million3.

Knowing the causes and the impacts of the Mekong floods, an important issue remains to be solved which is 'how to get people ready for floods before they come' and 'how to help people cope with floods'. The current status of flood management and mitigation in the MRC Member Countries has improved considerably from 'response to floods when they occur' rather than to prevent major damage or to be prepared in the forehand. However, the preparedness level backed with institutional coordination is yet to be fully achieved. To deal with the Mekong floods more effectively there is a need to continued support to strengthen the capacity of local disaster management authorities in flood preparedness and disaster risk reduction activities.

The Flood Management and Mitigation Programme (FMMP) of the Mekong River Commission Secretariat (MRCS) is a rolling programme that commenced operation in January 2005 and is funded to the total value of around US$ 20 million. The FMMP provides technical and coordination services to the four countries in the Lower Mekong River Basin to prevent, minimize or mitigate the civil and socio-economic losses due to floods and flooding, while preserving the environmental benefits of floods. Forecasts, flood data, technical standards, capacity-building and training packages are key outputs of the programme. The programme has five components:

1. Establishment of a Regional Flood Management and Mitigation Centre;
2. Structural Measures and Flood Proofing;
3. Mediation of Trans-boundary Flood Issues;
4. Flood Emergency Management Strengthening;
5. Land Management.

Component 4 focuses on flood preparedness and strengthening flood emergency management in the four MRC Member Countries. The emphasis is on capacity building, knowledge sharing and

[3] Annual Flood Report 2008, Mekong River Commission Secretariat (MRCS)

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public awareness campaigns at the provincial, district and community levels. With the continued support from the Government of the Federal Republic of Germany (FRG) represented by the 'Deutsche Gesellschaft für Technische Zusammenarbeit' (GTZ) and the European Commission (EC) under the European Commission Humanitarian Aid department (ECHO), the major focus has been to enhance skills of key officials at provincial, district and commune disaster management committees to develop and implement the Flood Preparedness Program. The core objective of Component 4 has been to enhance technical capacities of relevant authorities and other stakeholders in all riparian countries (at the province, district and commune levels) in flood preparedness and emergency management, thus creating an enabling environment for a people centred approach towards integrated flood risk management. Component 4 with funding support from GTZ (2004-2010) and with different Disaster Preparedness European Commission Humanitarian Aid Office (DIPECHO) South-east Asia funding cycles of ECHO (2003-2010) has covered a total of 11 most flood provinces in the LMB with flood preparedness programs in 30 vulnerable districts. The overall coverage is presented in Table 1.

Table 1. Geographic coverage Component 4 - Flood Preparedness and Emergency Management Strengthening

MRC Member Country	Province	District
Cambodia	1 Prey Veng 2 Kandal 3 Kratie 4 Svay Rieng	• Peam Chor, Sithor Kandal, Peam Ro • Lovea Em, Leuk Dek, Kien Svay • Kratie, Sambour and Chhuloung • Svay Chrum
Lao PDR	5 Khammouane 6 Savanakhet	• Nong Bok, Xebangfai Hin Boun, Mahaxay, Nhommalath • Xaybouly
Thailand	7 Nakhon Phanom	• Nakhon Phanom • Tha Utehn districts
Viet Nam	8 An Giang 9 Dong Thap 10 Tien Giang 11 Ben Tre	• Chau Thanh, Tan Chau, An Phu • Thanh Binh,Tan Hong, Tam Nong • Chau Thanh, Cai Be and Cai Lay • Cho Lach

The core activities carried out under Component 4 since 2004 were to develop and implement innovative flood preparedness and emergency management programs at the sub-national level by addressing directly the needs of the flood vulnerable communities. This has increased communication, coordination and cooperation between these stakeholders, as well as the consistency of national disaster management and mitigation policy implementation of the MRC Member Countries. The overall activities are summarized in Table 2.

FLOOD PREPAREDNESS AND EMERGENCY MANAGEMENT ACTIVITIES IN THE LOWER MEKONG RIVER BASIN

Flood preparedness programs: strengthening the capacities of local authorities in flood risk reduction

MRC through its FMMP is providing assistance to the MRC Member Countries in adopting holistic flood management initiatives that address the interaction between beneficial aspects of floods and the risks posed by the annual flood events to the Basin communities through

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development and implementation of flood preparedness programs. The flood preparedness programs assign equal emphasis on both preparedness and emergency interventions of flood management. They also promote participatory approach in order to enhance the consensus and ownership among the provincial and district level stakeholders. Additionally, the flood preparedness programs help define clear roles and responsibilities of the member line agencies of local disaster management committees and detail out the budgetary requirements for implementing such tasks.

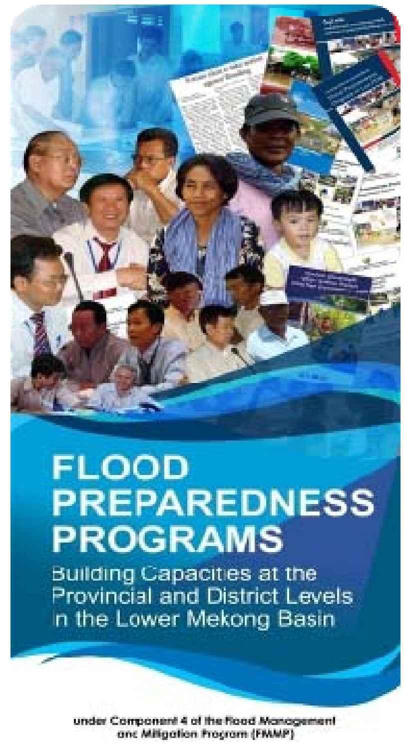
Table 2. Activities of Component 4. Flood Preparedness and Emergency Management Strengthening

	Core area of intervention	Key activities
1	Flood Preparedness Programs (FPP) Development	Annual and Multi-year Disaster Risk Reduction Plans at Province and District, Clear roles and responsibility for each line ministries, Multi-Hazard risk profile and identification of flood focused measures
2	FPP Implementation	Innovate partnership and cost-sharing implementation of flood risk reduction measures i.e., Emergency Kindergarten, Safe Area, Search and Rescue etc.
3	Capacity Building for Flood Risk Reduction	Enhanced capacity of provincial, district, commune level disaster management authorities on Planning for Flood Preparedness and Emergency Management, Community Based Flood Management, Search & Rescue, Swimming Lesson and Teachers Training
4	Flood Awareness and Education	Partnership and capacity building of concern line ministries such as Education and Training and Information and Culture on flood awareness activities i.e., Posters and Information Booklet, Cultural Shows, Flood Information Billboards etc
5	Flood Knowledge Sharing and Documentation	Regional and National Workshops/Forums, Safer Communities series Case Studies on innovative flood risk reduction practices
6	Integration of Flood Risk Reduction into local development planning process	Sectoral Plans and implementation of Flood Risk Reduction through commune development planning. National and Provincial consultation and development of Approach and Strategy paper on integration of flood risk reduction into development planning process.
7	Trans-boundary Cooperation	Province to Province cooperation meeting (Viet Nam - Cambodia and Thailand-Lao PDR), Joint-Planning for flood Information and resource sharing

The flood management and mitigation program has played a key role in facilitating the development and implementation of flood preparedness programs (FPP) through the most participatory process by the national, provincial and district disaster management committees to improve the coordination of member line departments with clearly defined roles and responsibilities and to reduce flood risks by implementing priority action areas identified in the FPPs.

The engagement of the Provincial and District Disaster Management (PCDM and DCDM) focal points in the FPP development process offered them exclusive opportunities to enhance their ability in other aspects of flood risk reduction beyond the emergency response phase and to utilize their knowledge obtained from the trainings. Subsequent to the successful development of FPPs, further capacity building activities were supported to be implemented by PCDM and DCDM, both as part of the FPP priority area implementation and also as a progressive movement towards building of local capacities.

The provincial and district level FPP process also facilitated in collecting and compiling information on existing resources in their vicinity such as location and number of health centres

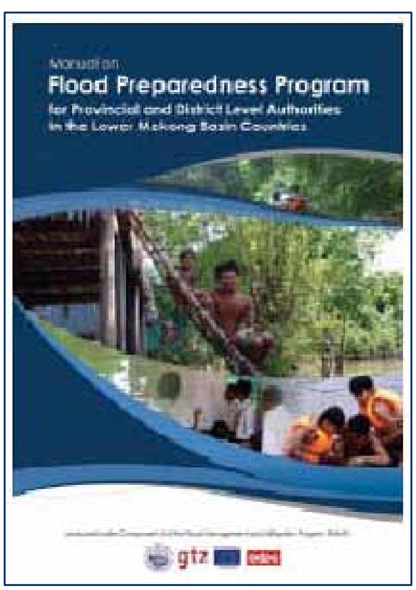


and safe areas and related facilities, existing number of boats and communication equipment, etc., in their provinces and districts. These resource inventories were used in the existing provincial and district maps with help from Regional Flood Management and Mitigation Centre (MRC-RFMMC) facilities situated at Phnom Penh, Cambodia. These maps incorporated information required for planning such as national, provincial and district road and railway networks, rivers and streams, district and commune boundaries, etc. PCDM and DCDM were provided with final products and the information was also kept at the MRC-RFMMC for further use by other interested users.

The provincial and district level disaster preparedness planning process by the DM committee members has helped in institutional capacity and building confidence in the local DM officials to deal with the Annual Mekong Flooding. The experiences of the provincial and district levels officials show that they were able to demonstrate their built capacities and coordinate better than before in recent disasters including the Ketsana Typhoon that stuck Cambodia, Lao PDR and Viet Nam. The FPP manual and the template on which they have prepared the plans have been useful for them to understand their roles and exercise their knowledge during such crisis.

Developing the local capacity base on flood risk reduction

A manual on Flood Preparedness Program Planning and Implementation for provincial and district level authorities in the Lower Mekong River Basin countries has been developed by each of the MRC Member Countries in local language. The manual serves as an effective guide for local disaster management authorities for planning and implementing appropriate measures at all stages from flood preparedness to flood mitigation to response to rehabilitation and recovery. The manual highlights essential elements, including detailing of roles and responsibilities of all stakeholders to ensure that preparedness and response activities are undertaken and assigned to avoid duplication or oversight of any activities and maintaining a resource inventory for rapid deployment of resources in case of emergency. It also underlines such cross cutting issues as livelihood planning, environmental conservation, flood plain management and mainstreaming of flood risk reduction into local development planning process. The manual stresses the importance of accountability within the process of disaster management and risk reduction and the need for the presence of a nodal agency in charge of overall supervision of implementation arrangements. Although the manual was intentionally developed to address flood preparedness in the Lower Mekong River Basin countries, it can easily be adapted to suit other country contexts and alternative hazard events.



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A pool of trained human resources in all the 30 target districts has been created during trainings and workshops at the national and sub-national while implementing the flood preparedness and emergency management project activities. These key officials play an important role as Trainers in further training and capacity building activities at the local levels

The Community Based Flood Management (CBFM) trainings to selected commune level disaster member officials aimed to improve the practical skills in flood management and to strengthen their capacities in flood preparedness planning and implementation, enabling them to manage and mitigate the negative impacts of floods. These training were carried out across the 11 target provinces in the four MRC Member Countries.

To meet the challenges of drowning during the flooding season, Search and Rescue trainings were provided in Viet Nam in collaboration with the the Viet Nam Red Cross and the the local Military Operation. These on the job training improved existing skilled human and material resources and also strengthened the Rescue Posts at strategic locations at the confluence of rivers/canals and along the waterways (i.e. at locations identified as dangerous during the flood season), usually manned by Red Cross Volunteers and Youth Union members.

In Cambodia, capacity building on generating reliable and timely data in the immediate aftermath of any disaster were carried out through Damage and Needs Assessment (DANA) to the district level official were carried out. The key focus was on the optimal usage of existing formats on damage and need assessment (DANA) developed by the national authorities and systematic reporting to the NCDM on immediate needs after disaster. Such capacities in the target provinces played crucial roles during the Typhoon Ketsana and the flooding in 2009.

The initial results of the result based monitoring shows that the component has created a receptive environment for the implementation of a range of dedicated flood risk reduction interventions at the province, district and commune level. It looks now on mainstreaming the Flood Risk Reduction (FRR) activities in line with the national Disaster Risk Reduction (DRR) strategies into local development planning processes.

Improving access to and dissemination of flood early warning

Under its Flood Management and Mitigation Program (FMMP), MRC is widening its reach to the community level through praiseworthy early warning initiatives while incessantly working to improve its forecasting system. Between 2003 and 2008, MRC, in collaboration with the Department of Hydrology and River Works (DHRW), supported the implementation of community based early warning initiatives in Cambodia, spreading over six provinces along the Mekong: Stung Treng, Kratie, Kampong Cham, Prey Veng, Kandal and Takeo. The initiatives were executed as part of FMMP priority activities4 by Action contra La Faime (ACF), Cambodia Red Cross, American Red Cross and Asian Disaster Preparedness Centre (ADPC) except for Takeo Province where OXFAM GB operated out of FMMP context but the basic modalities applied were more or less the same. Supported by U.S. Foreign Disaster Assistance (OFDA), European Commission Humanitarian Aid department (ECHO) and GTZ, the community based early warning activities provided crucial flood forecasting information to the

[4] The projects fell under the umbrella of FMMP in general and under Component 1 (Flood Referencing Project) and Component 4 in particular.

communities.

The involvement of Cambodia Red Cross (CRC) in these projects, though in varying degree as key project implementer in one project and as project partner in others, was instrumental since it has a far reaching network of provincial, district and village teams of volunteers that work closely with the disaster management structures at respective levels throughout Cambodia.

The Early Warning System (EWS) projects shared a common goal of 'Through improved warnings, vulnerable communities in Cambodia will reduce their risk to higher-than-normal floods' and the activities were implemented in three major phases: installation of flood reference tools, management enhancement and community empowerment as described below.

In addition to flood marks installed by the DHRW, community/home flood marks were also created for easy access where flood level markings were painted on school walls, along the ladders of pagoda, pillars of the houses of women headed households, stilts of the houses of village chiefs and deputy chiefs and on the pole of the flood early warning billboards. To facilitate the information flow, the provincial hydrology departments, Provincial, District and Commune disaster management offices were equipped with two way communication devices. In some villages where houses were widely spread out, loud speakers were set up.

The village chiefs and village volunteers were trained to efficiently perform their tasks as flood mark operators to read and record flood water levels in the log-sheets, to understand the flood information flow and how to care and maintain the flood marks.

To feed into the two way communication system, the local authorities cooperated with the hydro meteorological services to read and record the water levels from the flood marks and communicate with DHRW regularly. DHRW then fed the data into the forecasting model and the flood bulletins for the next 3 days were prepared and transmitted to the local authorities. Such a system helps build community owned 'flood Information Billboards'. These billboards provide updated information on water levels and forecast for next three days.

Promoting community awareness and strengthening community resilience

In efforts to reduce the flood risks, well designed public communication campaigns contributed enormously in educating the public and in conveying the intended message over a large geographical area to a vast and diversified audience. Raising the awareness of communities on hazards and risks they are exposed to and what they can do at the individual household level to mitigate or minimize those risks can transform them from passive to active participants of wider disaster risk reduction scenarios. Since 2004, Component 4 has effectively implemented awareness raising initiatives in various forms; IEC (Information, Education and Communication) materials development and distribution, organizing cultural shows and sector specific activities, like school flood safety programs. One of the key factors contributing to the wide acceptance of the public awareness campaign undertaken so far under Component 4 was the successful mobilization and collaboration of the key disaster management actors in the province. All major stakeholders from provincial government officials to community focal persons were involved in the process, encouraged more so by the fact that at both national and sub-national levels, the existing natural disaster management strategies of the Lower Mekong River Basin countries acknowledge the power of public awareness raising. In essence the awareness campaign was a product of a collaborative effort of local disaster management officials (i.e., the provincial, district and commune disaster management committees), provincial line departments (i.e., the departments for Education, Women's Affairs, Cultural, Information, etc.) and partner Non Governmental Organisations (NGO). Involvement of the provincial line departments from inception to implementation of the awareness campaigns

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produces a strong sense of buy-in.

The School Flood Safety Programs (SFSP) is one of the innovative activities being implemented successfully in all four MRC Member Countries with the objectives of supporting the school authority, particularly the Education Department, in implementing flood preparedness program in selected vulnerable schools and enhancing the vulnerable communities' capacity in dealing with floods via children as primary risk reduction communicators. The key role is played by the provincial Education Departments that are given an instrumental role in implementing SFSP activities under the guidance of provincial and district disaster management agencies. Provincial working groups are established comprising of representatives from other member line departments of provincial and district disaster management committees to facilitate coordinate and monitor the implementing activities.

The initiative to educate the community on flood risk reduction through traditional art forms in Cambodia succeeded in enhancing the understanding of roles and responsibilities of these line agencies as well as supporting the communities in their understanding of and ability to respond to and mitigate flood situations. The Royal University of Fine Arts was the key institution in developing the scripts, the provincial officials played the key role in the conceptualization and eventual conduct of the plays. IEC materials on flood risk management such as the flood booklet and 'Living with Flood' video were provided to the Royal University and the Department of Culture and Fine Arts for their preparatory works.

A similar initiative in changing the attitude of local communities on flood management using performance arts in Viet Nam has been quite successful utilising the capacities of the Office of Information and Culture (OCI) including the development of scripts, conducting performance rehearsals, charting the schedule and organizing the shows.

The availability of limited resources for public awareness has hampered the replication of awareness campaigns over a wide area beyond the project geographical coverage. In order to broaden the pool of resources, the idea of public-private partnership has been initiated in Lao PDR, Thailand and Viet Nam.

The advantages of the involvement of private agencies in public awareness raising are that they provide an extended networking beyond the disaster risk reduction sector and more efficient use of resources and funds. It is envisaged that the roles of private sector can range over sponsorships of awareness raising activities to adoption of flood memorials installed in strategic places.

Improving participation and addressing the needs of children and women in flood risk reduction

In the Mekong Delta where high water levels during the flood season can last up to two months in some areas, women have to bear more responsibilities during that time as even their daily house chores of family caring call for more concerted efforts, for instance securing food for the family might require travelling longer distances than usual and they have to be more alert to ensure the safety of the children. The burden is even heavier on women who do not have any male relatives to rely on, such as poor women-headed households.

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Children, on the other hand, rely on adults to cope with any stressful situation including disastrous events like natural hazards. In most cases, the resulting deaths of children can be attributed to either negligence of adults or lack of knowledge on the parts of both children and adults on how to react in a disaster situation. One way to establish a sense of control and to build confidence in children before a disaster is to raise their understandings on hazards and their impacts and provision of life-saving programs like free swimming lessons, which should be accompanied by knowledge enhancement of adults on how to take care of the children during severe floods.

Pioneered by agencies the like of Save the Children and World Vision, disaster risk reduction programmes that consider and incorporate perspectives of children and their needs during disasters have been in place in the MRC Member Countries. Though the extent of such programmes is, limited both government and non-government agencies alike are working towards creating a safer environment for children.

Even though still in the infancy stages, the national disaster management plans of the Lower Mekong River Basin countries concede the gains of child-focused disaster risk reduction. In Cambodia and Lao PDR the formal education sector has been involved in crafting a culture of preparedness by mainstreaming disaster risk reduction into school curriculums. In Viet Nam, the establishment of emergency kindergartens heighten the child safety and the parents of poor families to be able to devote more time for income generating activities. The swimming programs in the Mekong Delta provinces in collaboration with other stakeholders significantly reduce the child drowning. Kids between 6-14 years old, considered most vulnerable in the districts, were equipped with life jackets and provided with swimming lessons.

Under the FMMP, a specific flood risk reduction activity targeting the women-headed households was implemented in Kandal and Prey Veng provinces in Cambodia in partnership with the Ministry of Women's Affairs (MOWA). A common recommendation that emerged was to build the capacity of the commune women and children focal points in two major areas: enhanced knowledge on flood risk reduction, mainly the community based flood risk reduction and planning on how to disseminate the flood risk reduction information to the target groups of poor women-headed households. The goal was to enable the poor women-headed households to adopt proper and inexpensive flood mitigation measures in order to reduce the cost of recovery and stress thereby helping them to invest more time, money and efforts in income generation activities.

Province-to-Province trans-boundary cooperation in emergency management

Mekong River Commission (MRC) offers such mechanism with its officially recognized role to address differences and to facilitate bilateral agreements between the MRC Member Countries with respect to trans-boundary issues. For instance, on land-use or structural flood mitigation measures, MRC should serve the member countries, upon invitation, as a neutral facilitator. MRC holds the unique position to build confidence among the neighbouring countries through its ongoing programs such as Water Utilisation Programme, the Basin Development Plan and the Environmental Program and could also assist in coordinating floodplain management aspects of national programmes.

In strengthening trans-boundary collaboration, existing mechanisms were utilized in creating awareness between the neighbouring provinces between Cambodia and Viet Nam as well as Thailand and Lao PDR for exchange of flood information and cooperation on flood response. Between Kandal and Prey Veng provinces of Cambodia and An Giang and Dong Thap

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provinces of Viet Nam, prospect of promoting trans-boundary flood emergency assistance has been set in motion with bilateral meetings and initiation of a joint planning on flood preparedness and resource sharing. Building on this existing mechanism, the provincial disaster management authorities in conjunction with national counterparts worked on the inclusion of trans-boundary emergency assistance and flood preparedness into the regular meeting agenda.

A similar intervention of flood risk reduction cooperation between provinces of Lao PDR (Khamamoune) and Thailand (Nakhom Phanom) has also been initiated under Component 4 of the FMMP. A preliminary activity for the development of a detailed joint plan has been initiated in the form of a provincial meeting. It is anticipated that the upcoming meeting will also address to a considerable extent the strategy for integration of trans-boundary issues into development planning at the provincial level.

LESSON LEARNT AND NEXT STEPS

Flood preparedness and flood emergency management strengthening remain core elements of MRC's Flood Management and Mitigation Program (FMMP), as these address directly the needs of the flood vulnerable communities, and also indicate/guide the strengthening and operations of government agencies in the MRC Member Countries (at different levels: nation, provincial, district and communes) and of national and international NGOs. This is vital for enhancing communication, coordination and cooperation between these stakeholders, as well as the consistency of national disaster management and mitigation policy implementation.

The experiences clearly show that increased capacity of key officials of the provincial, district and commune Disaster Management (DM) committees has led to a better flood preparedness in the selected provinces in the MRC Member Countries, mainly Cambodia, Lao PDR and Viet Nam. Active involvement of national government and local authorities at provincial, district and commune levels in the formulation and implementation of the Flood Preparedness Programs (FPP) has been a major step to ensure consistency, ownership and sustainability, in addition to the activity of integrating Flood Risk Reduction (FRR) into local development plans. The flood preparedness and emergency management initiatives in the member states have helped target provinces to be better prepared for floods.

While the FMMP contributions are widely recognised by the MRC Member Countries as time-bound 'pilot' initiatives, covering some of the vulnerable provinces and districts, and improving the competence in dealing with the Mekong Floods, a longer term programmatic approach and up scaling to a wider geographical area is required to ensure that the flood management and mitigation policy objectives are solidly embedded into the national disaster management strategies of the MRC Member Countries.

The role and mandate of MRC, being an inter governmental regional organization, provide MRCS the unique position and niche, which allows connecting the FMMP with national, provincial and district disaster management agencies, as the MRCS works through its member countries to implement programs at the national, provincial and district levels. The MRCS has thereby created a receptive environment for the implementation of a range of dedicated interventions at the commune level. It looks now on mainstreaming the FRR activities in line with the national DRR strategies into local development planning processes. The flood management and mitigation tools developed by MRCS have a basin wide approach and can be applied to support local level interventions.

With the follow-up of the current FMMP phase, the formulation of FMMP phase II, MRCS seeks a long-term partnership with European Commission under its long-term as well as ECHO modality to continue focus on enhancing capacities on FRR. With the lesson learnt from the various components of FMMP and particularly from Component 4: 'Flood Preparedness and Emergency Management Strengthening', continuance of innovative flood focussed activities are crucial to reduce the risk of negative impact by floods on the livelihoods of the people living in the Lower Mekong River Basin.

Paper 2-2

THE MEKONG FLOOD FORECASTING AND FLASH FLOOD GUIDANCE SYSTEMS AT THE REGIONAL FLOOD MANAGEMENT AND MITIGATION CENTRE

JANEJIRA TOSPORNSAMPAN, PHUNG KATRY AND HATDA PICH AN

MRC Regional Flood Management and Mitigation Centre, Phnom Penh, Cambodia

ABSTRACT

The new MRC's Mekong Flood Forecasting System (FFS) based on the Unified River Basin Simulator (URBS) model, the ISIS model, a suite of Regression Models and the Delft Flood Early Warning System (FEWS) platform, has been established at the Regional Flood Management and Mitigation Centre (RFMMC) of the Mekong River Commission (MRC). The new system was tested during the 2008 and 2009 flood seasons in conjunction with the existing Streamflow Simulation and Reservoir Regulation (SSARR) based system.

The assessment for forecast accuracy taken for the forecasts in 2008 and 2009 reveals that the new MRC Mekong FFS offers an improvement in robustness and reliability over the SSARR based system. It increases the 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, flexible, reliable and robust because it is less dependent on missing data and provides a platform for the incorporation of new models.

It was agreed by the MRC Technical Task Group (TTG), established in August 2009 to verify the performance of the new MRC Mekong FFS, that the MRC-RFMMC can officially switch from the old system to the new system in 2010 leading to the official operation of the new system from 2010 onwards. Nevertheless a need for further development and continuous improvement in order to obtain more accurate and acceptable forecasts for both short-term and medium-term is still needed and emphasized by the MRC-RFMMC.

In late 2009 performance indicators for flood forecasting have been indentified and a set of reasonable benchmarks suitable for the Lower Mekong River Basin (LMB) has been established for the new flood forecasting system. This is to determine what the stakeholders, MRC Member Countries, the MRC and the MRC-RFMMC itself should expect from the new MRC Mekong FFS and how the present prototype system addresses these benchmarks. These performance indicators and benchmarks are presented in the paper as well.

Apart from the MRC Mekong FFS, the MRC Flash Flood Guidance System (MRCFFGS) is an adaptation of the Hydrologic Research Centre (HRC) Flash Flood Guidance System used in various regions of the world to empower forecasters to cope effectively with flash floods and their impacts. The primary purpose of the MRCFFGS is to provide real-time information guidance products pertaining to the imminence of potential small-scale flash flooding. Two computer servers, i.e., (1) the MRCFFG Computational Server (MRCFFGCS) and (2) the MRCFFG Dissemination Server (MRCFFGDS) were installed at the MRC-RFMMC in September 2009. These two servers divide the processing demand of Flash Flood Guidance (FFG) product processing and dissemination through segregated roles of server functions. The

MRCFFGCS is responsible for all of the real-time data acquisition, ingest and model processing, product export and uploading of products to the dissemination server. The MRCFFGDS disseminates the information by providing the user with remote real-time access to the MRCFFG products for online review and/or download to their local computer for further application in forecasting activities. These products, in conjunction with national insight into flash flood prone areas of their countries, will better prepare the countries to address the reduction of the loss of life and suffering from the devastation caused by flash floods through developing and issuing warnings to specific communities most at risk.

INTRODUCTION

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 Regional Flood Management and Mitigation Centre (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 implementation of the Unified River Basin Simulation model (URBS) as a trial model for flood forecasting was decided by the Regional Consultation Meeting on 1 December 2006, with the expectation to replace the existing Streamflow Synthesis and Reservoir Regulation (SSARR) model. A suite of URBS models have been developed since 2007 and in early 2008, the MRC-RFMMC decided to use the Deltares Flood Early Warning System (Delft-FEWS or in short FEWS) as the flood modelling platform. A connection was made between FEWS and URBS in March 2008 and 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. 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/Tonle Sap Great Lake system and the Mekong Delta together with some improvement of the URBS hydrologic models. The updated system was tested again over the 2009 flood season.

The Regional Consultation Meeting which took place on 13 March 2009 requested the MRC-RFMMC to keep MRC Member Countries well informed about the future progress of the new MRC Mekong FFS development. The need for capacity building for the use of the new Mekong FFS by national agencies responsible for flood forecasting and warning of the MRC Member Countries was also identified. The MRC Member Countries agreed with a number of issues concerning the future operations of and capacity building for the new MRC Mekong FFS in the 2009 flood season. As a result of this meeting, the establishment of the Technical Task Group (TTG) for verification of the new MRC Mekong FFS was established in August 2009 and completed in late 2009.

The USAID-Office of US Foreign Disaster Assistance (OFDA) has been cooperating with the Mekong River Commission on flood mitigation issues since 2001 to reduce the impact of floods in the region. They support a project to implement a flash flood guidance system for the Mekong region which is carried out by the MRC-RFMMC. The system is initiated and developed by US Hydrologic Research Centre (HRC). A central Mekong or MRC Flash Flood Guidance System (MRCFFG) was set up at the MRC-RFMMC in Phnom Penh, Cambodia in September 2009 making flash flood guidance information available for the responsible agencies in the MRC Member Countries using the internet. In this way the Mekong Flash Flood Guidance system will become one of the nodes of a future Global Flash Flood System and the people of the Mekong River Basin will be safer from the danger of flash floods. Systems similar to the MRCFFG have been and are being set up all around the world.

This paper describes the current steps towards a state-of-the-art on both river flood forecasting system and flash flood guidance system inside the MRC-RFMMC. General overview of the river flood forecasting tools and flash flood guidance system are briefly introduced. The post evaluation of the flood forecasting system performance, operational data for flood forecasting, as well as the performance indicators for flood forecasting and a set of reasonable benchmarks suitable for the Lower Mekong River Basin (LMB) are also discussed.

OPERATIONAL DATA FOR FLOOD FORECASTING IN THE MRC-RFMMC

The MRC-RFMMC has been continuous jointly working with the four riparian countries to improve and upgrade their hydro-meteorological networks with the aim of achieving a reliable and timely data transfer/exchange for flood forecasting. During each flood season, the MRC-RFMMC receives daily the hydro-meteorological data from the four riparian countries through a telemetry system and SMS (manual) data transferred through a software package called HydMet database management software. The HydMet is the primary database management system by which rainfall and water level observations are collected from the riparian countries and collated for use within the new flood forecasting system. This software is installed in the main national line agencies of the MRC Member Countries those are dealing with flood forecasting as well as at the MRC-RFMMC.

Since the beginning of the flood season 2009 the MRC-RFMMC, in cooperation with the national line agencies, has taken several actions to improve the rainfall and water level data collection and transfer from the observation stations, for example refreshment training on hydro-meteorological data sending by SMS. In parallel to the capacity building the MRC-RFMMC also provided the financial support to the national line agencies, such as providing mobile phones, credit cards, desktop computers to be installed with the HydMet.

During the 2009 flood season the MRC-RFMMC has received rainfall and water level data from 135 stations located within the LMB or close to the boundary of the LMB. Among these 135 stations, 49 stations are from Cambodia, 42 stations are from Lao PDR, 10 stations are from Thailand, and 34 stations are from Viet Nam. Apart from these 135 stations the MRC-RFMMC regularly receives rainfall and water level data from 2 stations in China during each flood season.

MRC RIVER FLOOD FORECASTING SYSTEM

The Regional Flood Management and Mitigation Centre (MRC-RFMMC) completed the first version of the new MRC Flood Forecasting System based on the Unified River Basin Simulator (URBS) Model and the 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 SSARR based system. In 2009 an additional connection among FEWS, URBS and ISIS was made and the system was operated again in ‘test mode’ over the 2009 flood season.

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 (Carroll, 2007), is a hydrologic modelling program that enables the simulation of river basin 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: 1) a rainfall runoff model, which converts the gross rainfall into net or excess rainfall; and 2) a runoff routing model, which takes the excess rainfall as input and converts it into flow.

The models have been developed since 2007 and by 2009 a set of 52 URBS models, covering over 740,000 km2 and represented by over 2,217 sub areas, was developed and calibrated. Forty nine of these models are runoff routing models which are linked together by three channel routing models from Chiang Saen to Kratie, the Tonle Sap Great River system and from Kratie to Tan Chau/Chau Doc.

ISIS hydrodynamic model

ISIS is a generic 1D model for 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 nonstaggered 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.

The ISIS model within the FEWS environment covers the Mekong River Basin from Stung Treng instead of Kratie as in the MRC-DSF to the South China Sea, including the Tonle Sap Great Lake and the floodplain, the Cambodian floodplains and the Vietnamese Mekong Delta. Tributary inflows supplied to the model are obtained from the URBS. The extent of downstream boundaries of the model is beyond the influence of the flood flow, namely to the sea boundaries at the mouths of the Mekong (and the West Sea).

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 hand 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 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).

MRCs 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 in 2008 was a standalone application run on a Windows platform and had excellent utilities to manage and display rainfall and observed and forecast water level and flow data. It also

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incorporated an ARMA error correction module which was applied to the key locations along the mainstream. After the 2008 flood season FEWS has been moved to a client-server system and has been operated for testing over the 2009 flood season. The advantages of the FEWS client-server system are that users in different offices are able to connect the system via the 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.

MRC FLASH FLOOD GUIDANCE SYSTEM

The MRC Flash Flood Guidance system (MRCFFG) has been developed by the U.S. Hydrologic Research Centre (HRC) through a program funded by the U.S. Agency for International Development (USAID) - Office of US Foreign Disaster Assistance (OFDA). The project is based on extensive consultation with all stakeholders and covers the development of the system, intensive training and capacity building of local staff, and implementation of the central system. The system has been completely set up and installed at the MRC-RFMMC in early September 2009.

The MRCFFG is designed to provide flash flood guidance information on a small basin scale across the four riparian countries. The primary purpose of the MRCFFG system is to provide real-time informational guidance products pertaining to the imminence of potential small-scale flash flooding. The system has been designed to address the reduction of the loss of life and suffering from the devastation caused by flash floods. The system provides the necessary products to support the development of warnings for flash floods from intense rainfall events through the use of satellite and gauge-based rainfall estimates.

Two computer servers, i.e., (1) the MRCFFG Computational Server (MRCFFGCS) and (2) the MRCFFG Dissemination Server (MRCFFGDS) divide the processing demand of FFG product processing and dissemination through segregated roles of server functions (Figure 1). The MRCFFGCS is responsible for all of the real-time data acquisition, ingest, and model processing, product export and upload of products to the dissemination server. The MRCFFGDS disseminates the information by providing the user with remote real-time access to the MRCFFG products for online review and/or download to their local computer for further application in forecasting activities.

The system has been designed to integrate real-time data from various hydro-meteorological sources and to evaluate a number of diagnostic indices that are pertinent to the occurrence and development of natural flash floods. A user-friendly dissemination interface provides quantitative real-time diagnostic information that may be used by the forecaster in conjunction with other local forecast information to produce reliable flash flood forecasts and warnings. It is noted in the outset that the flash flood guidance system is not a predictive system in itself, rather it is a diagnostic system for flash floods that the forecaster can use with forecasts or nowcasts of precipitation to produce forecasts and ultimately warnings for flash floods.

The system outputs are made available to users as diagnostic information to analyze weather-related events that can initiate flash floods and then to make a rapid evaluation of the potential for a flash flood at a location. The system aims to empower users with readily accessible observed data and products and other information to produce flash flood warnings over small flash flood prone basins. The system is designed to allow the use of the forecaster’s experience with local conditions, incorporate other data and information (e.g., Numerical Weather Prediction output) and any last minute local observations (e.g., non-traditional gauge data), to assess the threat of a local flash flood. Evaluations of the threat of flash flooding are done over hourly to six-hourly time scales for basins with a mean area of approximately 150-200 km2 in size. Satellite precipitation estimates are used together with available precipitation gauge data

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taken from Global Telecommunication System (GTS) to obtain bias-corrected estimates of current rainfall volume over the region. These precipitation data are also used to update soil moisture estimates, through a soil moisture model in the system. Important technical elements of the MRCFFG system then are the development and use of a bias-corrected satellite precipitation estimate field, in-situ synoptic observation gauge data and the use of hydrologic modelling. The system then provides information on rainfall and hydrologic response, the two important factors in determining the potential for a flash flood.

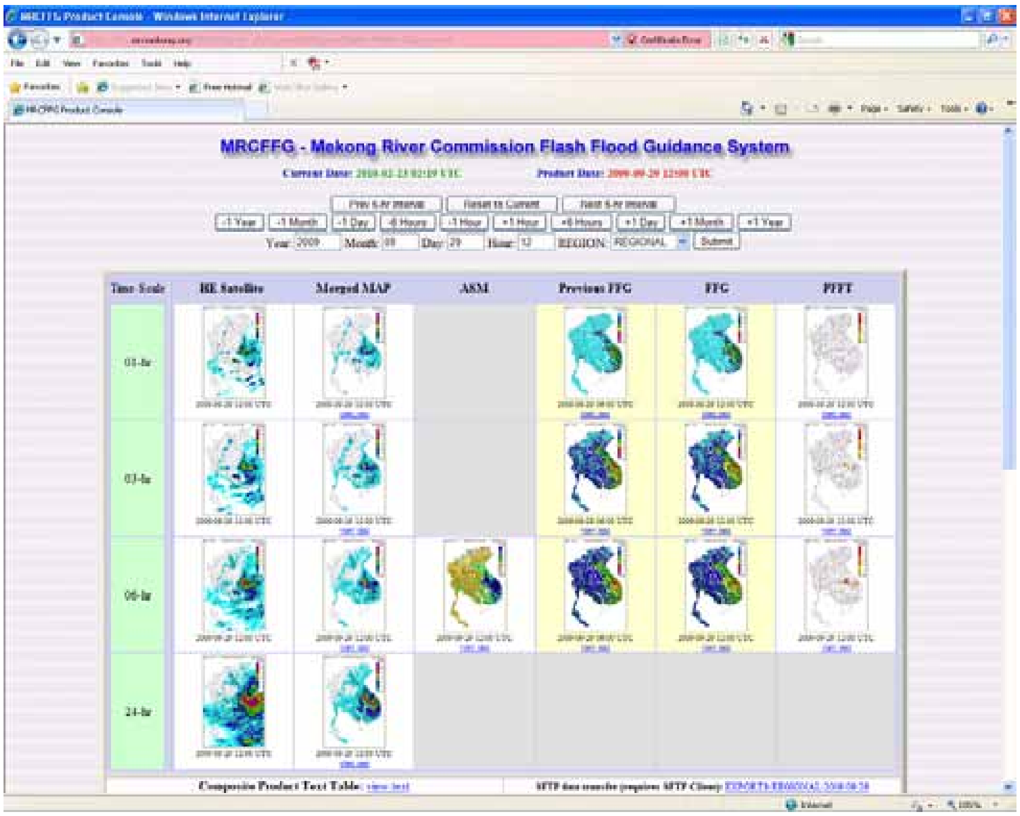

Figure 1. MRC Flash Flood Guidance (MRCFFG) dissemination server user interface

The MRCFFG system will produce two primary products which can be used in developing warnings or alerts for flash floods - flash flood guidance (FFG) and flash flood threat (FFT)5. These are defined as follows:

- *Flash Flood Guidance* is the amount of rainfall for a given duration over a small basin needed to create minor flooding (bankfull) conditions at the outlet of the basin. For flash flood occurrence, durations up to six hours are evaluated and the basin areas are of such a size to allow reasonably accurate precipitation estimates from remotely sensed data and in-situ data. Flash Flood Guidance then is an index that indicates how much rainfall is needed to cause minimal flooding in a basin;
- *Flash Flood Threat* is the amount of rainfall of a given duration in excess of the corresponding Flash Flood Guidance value. The flash flood threat when used with existing or forecast rainfall then is an index that provides an indication of areas where

5 The FFG and FFT guidance provided by the MRCFFG system is not applicable for urban, household or building basement or other flooding not associated with a stream.

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flooding is imminent or occurring and where immediate action is or will be shortly needed;

Products produced by the MRCFFG system which can be found MRCFFGDS include the following:

- *HE* - un-biased corrected rainfall for 1, 3, 6, and 24 hour accumulations (based on satellite rainfall estimates from a Japanese satellite:
- *MAP* - mean areal precipitation for each basin for 1, 3, 6, and 24 hour accumulations based on bias-corrected satellite rainfall estimates;
- *ASM* - A really averaged soil water content for each basin (fraction of saturation for the upper soil layer, nominally 20 cm);
- *FFG* - flash flood guidance for each basin for 1, 3, and 6 hours (also included is PREV FFG, the FFG value prior to the latest system update);
- *PFFT* - persistent flash flood threat for each basin for 1, 3, and 6 hours (Flash Flood Threat products are based on persistent rainfall estimates for the duration of interest);
- *FFT* - flash flood threat (likelihood) for each basin for 1, 3, and 6 hours (Flash Flood Threat products are based on observed rainfall estimates for the duration of interest)

The MRCFFG system also provides a table of current, available surface GTS synoptic data for all reporting stations. These data include: wind direction and speed, air temperature, relative humidity, atmospheric pressure, 6-12-24 hour rainfall accumulations.

PERFORMANCE INDICATORS

The consultation for Development of Performance Indicators (PI) for the new Mekong Flood Forecasting System has been undertaken by the MRC-RFMMC to ensure that clear benchmarks are established, which will determine what the stakeholders - MRC Member Countries, the MRC and the MRC-RFMMC itself - should expect from the new MRC Mekong FFS and the ability of the present prototype system to address the proposed PIs to meet these benchmarks. A mission of an international consultant for the development of Performance Indicators for the new Mekong Flood Forecasting System (FEWS-URBS-ISIS) was conducted in November 2009.

Benchmarks for performance indicators (PI) are a critical factor in the successful development and implementation of the new MRC Mekong FFS. Two sets of PIs recommended by the consultant for both FFS and FFGS are summarized below.

MRC Flood Forecast System

- *Mean Absolute Error* with benchmarks for the current system and those that can only be achieved with enhancements to the MRC FFS - scientific assessment of the forecast;
- *Categorical Flood Forecast metrics of Average Lead Time, Average Categorical Errors, False Alarm Ratio, and Probability of Detection,* where the benchmark values would be determined by the choice of flood forecast categories relevant to the Mekong River - impact assessment of the forecast:
    - *Average Lead Time.* The number of hours from the time of forecast issuance to the time of the forecast hit (i.e., when river conditions enter the category forecast. A lead time is only computed when, (1) the ordinates forecast and observation is in the same category, and (2) the previous ordinates observation was lower than the current category. This restricts lead time calculations to instances where the stage is rising, and crossing categories;
    - *Average Categorical Errors.* The amount the forecast would have to be changed to

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reach the observed category. Categorical error is only computed when you have a miss:

* *False Alarm Ratio (FAR).* The number of missed categorical flood forecasts divided by the total number of categorical flood forecasts issued;
* FAR = (False Alarms / (False Alarms + Hits)) {0.00 is best};
* *Probability of Detection (POD).* The number of categorical flood forecast hits divided by the total number of categorical flood forecasts observed:
* POD = (Hits / (Hits + Misses + No Forecast Misses)) {1.00 is best};

- *Customer Satisfaction Survey/Index.* The act of performing a Customer Satisfaction Survey and then responding to service priorities of customers focuses and helps prioritize investment decisions – effectiveness assessment of the forecast. An example of a Customer Satisfaction Survey is given in the Annex of the report of Smith (2009).

While Mean Absolute Error defines the scientific correctness of the river forecast, the categorical metrics define the impacts on people, infrastructure, business, and personal property. They are impact related metrics. Improving any one of them means that property damage and lives lost have been reduced because people have a better understanding of future river conditions that affect their lives and livelihood. The Customer Satisfaction Index tells an organization if they are effectively reaching their customers and delivering information in a timely manner that meets their needs.

Given the current state of precipitation and tributary inputs to the system, and the analysis of previous MRC consultants and MRC-RFMMC personnel, the evaluation of system performance represented by the Mean Absolute Error indicator, which varies by location and forecast lead time provides a reasonable measure of the current systems capabilities.

The error structure for Mean Absolute Errors was reported by Malone (2009). As noted therein, manual adjustment of these forecasts by trained forecasters improves the accuracy. Given the current state of precipitation and tributary inputs to the system and the analysis of previous MRC consultants and MRC-RFMMC personnel, the following is a reasonable expectation for current benchmarks for mean absolute errors at key Mekong River forecast locations.

If errors in precipitation estimates and forecasts can be reduced and forecasters are able to adjust model parameters during the course of the flood season these forecast location errors will reduce significantly, with the majority of impacts felt in the 3 - 7 day forecast range. The exact targets are difficult to assess because of the uncertainty in precipitation improvements and benchmarks should, in some sense, not only reflect the technical limitations of a current system but also the reasonable expectations of forecast system customers. Forecast service targets are always a compromise between what is possible and what is required. With the above as backdrop, a set of MRC FFS performance benchmarks for Mean Absolute Errors is proposed in Figures 2 and 3.

Additional PIs related to categorical forecasts of whether a location will or won’t be in a certain category of flood at a given time would enhance the ability of the MRC-RFMMC to track areas where research and investment could provide better flood forecasting service to the MRC Member Countries and customers. The MRC-RFMMC should consider adopting Average Lead Time, Average Categorical Errors, False Alarm Ratio, and Probability of Detection as categorical Performance Indicators for the new MRC Mekong FFS. Targets for these benchmarks should be established after experience collecting/analyzing them for a one or two year period of use during the flood season. Representative benchmarks from the well-established river forecast process, for instance, the U.S. National Weather Service (NWS) river forecast process can be used as potential ultimate targets.

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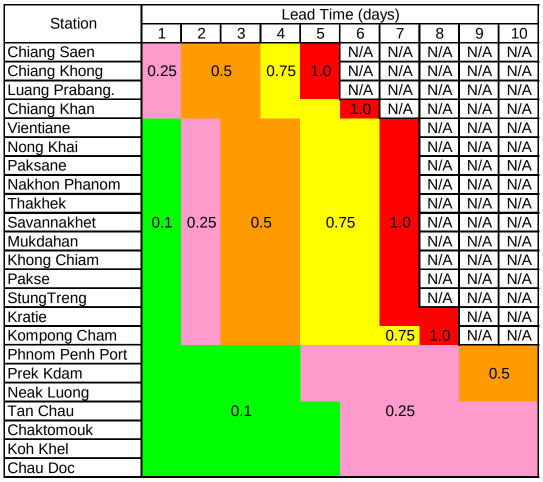

Figure 2. Proposed targets for the current MRC FFS - mean absolute errors - m (Malone's presentation at Regional Consultation Meeting on Mekong River FFS, 13 March 2009)

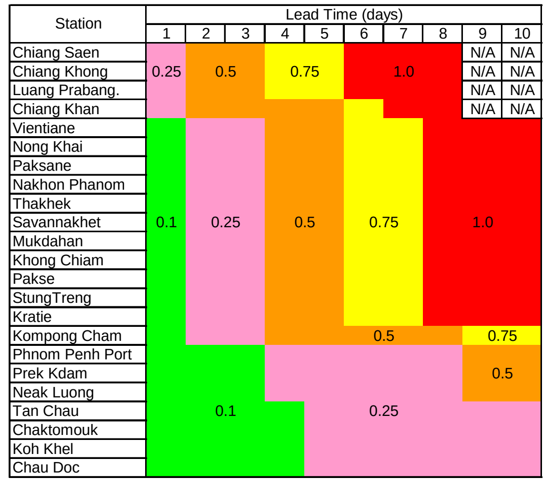

Figure 3. Proposed Performance Benchmarks for MRC FFS given improvements in precipitation inputs and ability to make real-time parameter adjustments - mean absolute errors – m

Taking into account customer and stakeholder expectations and satisfaction with MRC forecasts is recognized as an important metric of success for the MRC Flood Forecasting Program. A Performance Indicator related to the MRC Mekong FFS, in particular, and other aspects of the Flood Management and Mitigation Programme (FMMP), in general, would enhance transparency to customers and stakeholders of the benefits of investment in improvements to the FMMP and MRC Mekong FFS.

MRC Flash Flood Guidance

- the veracity of FFG cannot be measured directly and must be evaluated through an assessment of the complete Flash Flood Warning (FFW) programme;
- metrics to assess FFW are presented as Accuracy and Timeliness.

Specifying Performance Indicators for Flash Flood Guidance provides a unique challenge in that validation cannot be done directly on FFG. *It must be on the warnings that come out in the end*. These involve both the FFG and the forecast rainfall (external to the FFG system), with the latter carrying the bulk of uncertainty in most cases. The role of the forecaster in making real time modifications to FFG (as necessary) and in using a judgement to apply forecast rainfall in the small scale of the FFG basins is a critical and mandatory step. Validation therefore should be done on the final outcome after these human-machine based warnings. The foundation for further discussion of FFG/forecaster validation can be found in 'Modern Operational Flash Flood Warning Systems Based on Flash Flood Guidance Theory: Performance Evaluation' (Georgakakos, 2005).

EVALUATION OF 2008 AND 2009 FLOOD FORECASTING ACCURACIES

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 is emphasized during the actual flood season in three months of 2008 and 2009 from July to September for one to five day forecasts at ten mainstream stations from Chiang

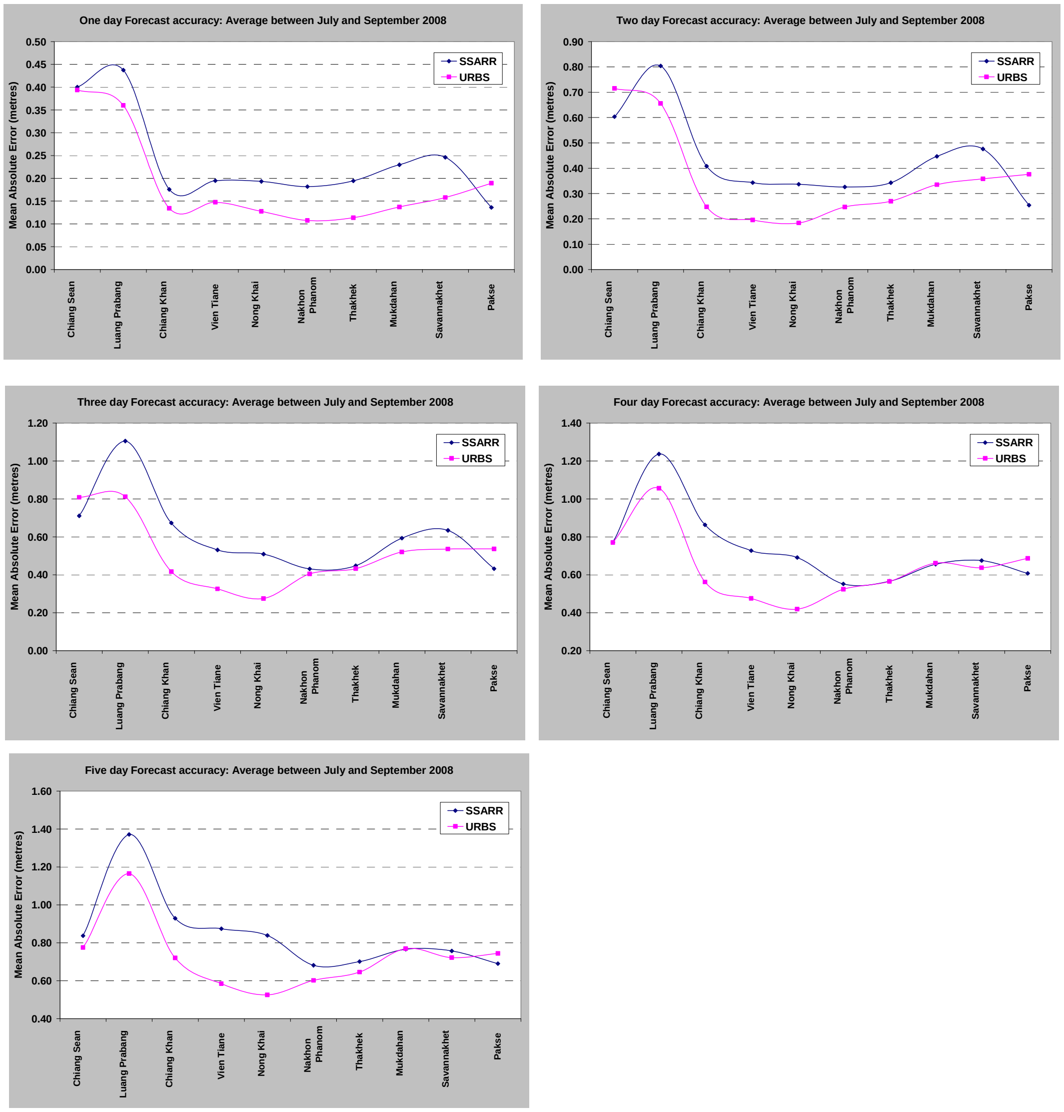

Figure 4. Forecast accuracy for 1-day to 5-day lead times between Chiang Saen and Pakse over 3 months from July – September 2008, comparison between SSARR and URBS

Saen to Pakse as shown in Figures 4 and 5. Forecasts at stations downstream from Stung Treng are not compared since they are derived using regression models in the current system as in the old 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 in 2008 for above-mentioned stations that 82% of forecasts made by URBS were more accurate than the forecasts made by SSARR. Improvements were found at most locations especially at Luang Prabang, Chiang Khan, Vientiane and Nong Khai, except at Chaing Saen and Pakse where the forecasts using SSARR are marginally better.

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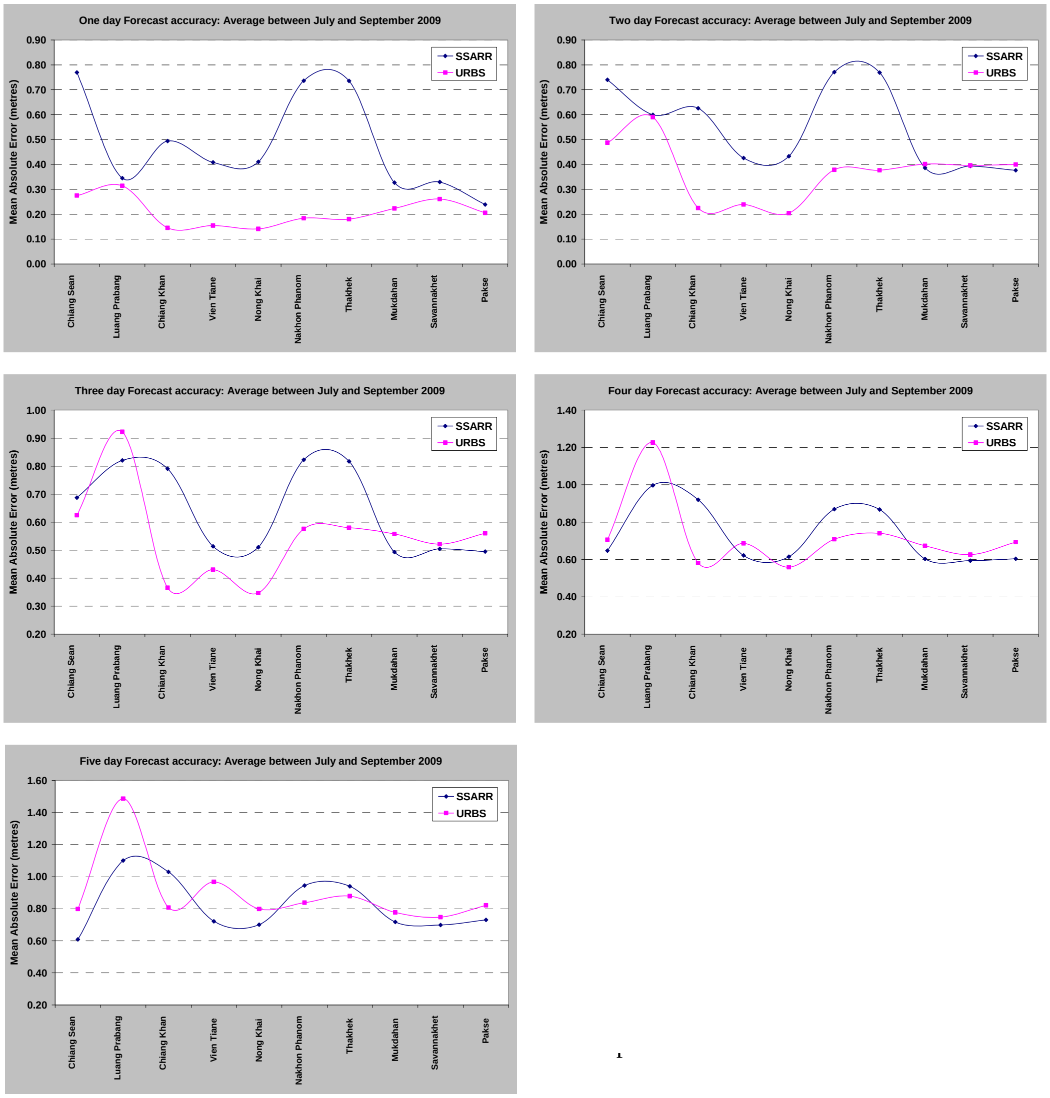
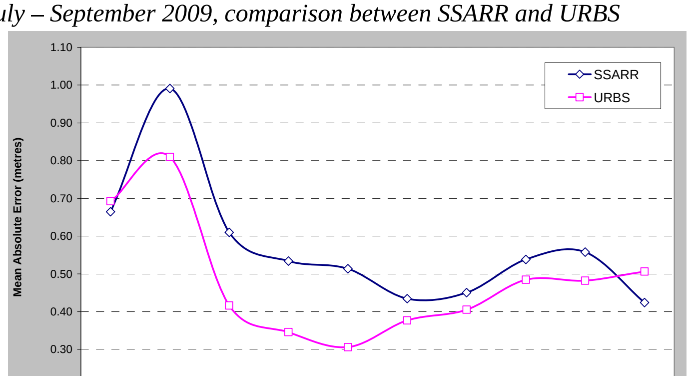


Figure 5. Forecast accuracy for 1-day to 5-day lead times between Chiang Saen and Pakse over 3 months from July – September 2009, comparison between SSARR and URBS



	CSA	LUA	CHK	VTE	NON	NAK	THA	MUK	SAV	PKS
SSARR	0.664	0.991	0.610	0.534	0.514	0.434	0.450	0.538	0.558	0.424
URBS	0.693	0.810	0.416	0.346	0.306	0.377	0.405	0.485	0.482	0.506

Figure 6. Average errors of 1-day to 5-day lead times between Chiang Saen and Pakse over 3 months from July-September 2008, comparison between SSARR And URBS

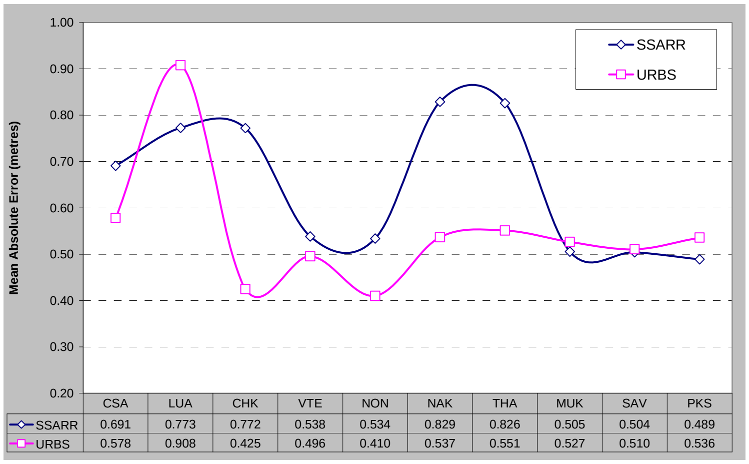


Figure 7. Average errors of 1-day to 5-day lead times between Chiang Saen and Pakse over 3 months from July-September 2009, comparison between SSARR And URBS

The assessment taken for the forecasts in 2009 reveals that 60% of the forecasts made by URBS were more accurate than the forecasts made by SSARR. Improvements were found at most locations especially at Chiang Saen, Chiang Khan, Nong Khai, Nakhon Phnom and Thakhet, except at Luang Prabang and Pakse where the forecasts using SSARR are better.

The overall spatial assessment for 2008 and 2009 as illustrated in Figures 6 and 7 indicates that URBS performs better than SSARR over the assessment period.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The new Mekong Flood Forecasting System offers an improvement in robustness and reliability over the SSARR based system. It increases the 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, flexible, reliable and robust because it is less dependent on missing data and provides a platform for the incorporation of new models. The assessments for forecast accuracies of SSARR and URBS indicate that in general URBS performed better than SSARR during the 2008 and 2009 flood seasons.

It was agreed by the MRC Technical Task Group that the MRC-RFMMC can switch from the old system to the new system in 2010, which leads to the official operation of the new system from 2010 onwards. However, there are facets of the models and modelling system which require refinement.

For the MRCFFG system, the MRC-RFMMC will maintain and operate the MRCFFG servers. Even though the FFGCS and FFGDS servers of the system are designed to be fully automated, there will always remain a critical need for ongoing observation and quality control of its processing tasks and data products. The MRC-RFMMC will be required to perform frequent observations of the MRCFFG system processing to ensure that the system’s automated features are working properly.

Recommendations

A number of recommendations are listed as follows:

1) improvement of hydro-met network over the LMB by increasing numbers of real-time rain gauges and hydro gauges, installing new real-time rain gauges and hydro gauges especially on the tributaries, increasing data frequency as well as the quality of data;
2) 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, system performance and forecast lead time;
3) the impact of dams on flood levels along the Mekong has yet to be fully determined and, to date, dams have not been explicitly included in any of the Mekong URBS models. Some account of the dams would have been taken into account implicitly in the determination of the model parameters. The MRC-RFMMC should undertake an investigation to identify storages which have a significant impact on flood levels. The characteristics of these dams should be included in the appropriate catchment model;
4) there is considerable variation in the mainstream ratings adopted by Information and Knowledge Management Programme (IKMP), the SSARR modelling system and those used in the Mekong FFS. It is highly desirable that the MRC further investigates and possess a single set of consistent ratings, which are used by all sections within the organization;
5) since the current system is capable in producing the medium term forecasts up to 10 days, the product can be made available to a designated national flood forecasting agency of each MRC Member Country for their internal uses. In the future, when the MRC-RFMMC is able to achieve the benchmarks with improved accuracy, it is recommended that the new flood bulletin format should be introduced with a 10 days lead time;
6) a second forecast cycle and product dissemination as appropriate during critical flood conditions should be initiated would provide valuable additional information for MRC Member Countries' and MRC customer life and property saving decisions;
7) it is recommended that the MRC-RFMMC continue providing capacity building and training to the MRC Member Countries for comprehensive understanding and leading to the implementation of a pilot project of new Mekong FFS in each respective country:
8) further evaluation for the system's performance of the medium to long term forecasts using historically similar rainfall patterns;
9) it is recommended that the MRC-RFMMC will establish a routine (bi-annual recommended - i.e., every two years) FMMP Customer Satisfaction Survey and corresponding Customer Satisfaction Index by which progress in FMMP service and MRC Mekong FFS enhancements can be tracked from a customer perspective.

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Paper 2-3

IMPROVED FLOOD RISK REDUCTION THROUGH IMPLEMENTATION OF STRUCTURAL MEASURES AND FLOOD PROOFING UNDER FMMP COMPONENT 2

NICOLAAS BAKKER, SLUIMER G.J., AND LAM HUNG SON

MRC Regional Flood Management and Mitigation Centre, Phnom Penh, Cambodia

ABSTRACT

Component 2 ‘Structural Measures and Flood Proofing’ has been identified after the 2000 Flood as one of the important interventions to help implementing the regional Flood Management and Mitigation (FMM) Strategy *‘people’s suffering and economic losses due to floods are prevented, minimized, or mitigated, while preserving the environmental benefits of floods’* of the Mekong River Commission (MRC). In MRCs FMM Strategy ‘structural measures’ were given ‘high priority’, concerning MRCs role in providing technical products and services and in relation to identifying potential trans-boundary impacts.

Component 2 has been focusing on the issue of flood damage risks and has provided an approach and methodology to practice integrated flood risk management (IFRM). This allows MRC Member Countries applying the concept of IFRM, which is an international concept, widely used to assess flood damages and risks, to evaluate the possibilities for investment in soft and hard measures, and thereby better manage and reduce the flood risks.

The main activities of Component 2 have been implemented through an international consultancy services contract, thereby applying the procurements procedures of the Asian Development Bank (ADB), which has been different to the approaches applied for the implementation of the other Flood Management and Mitigation Programme (FMMP) components. Some of the effects and lessons learnt will be shared in this paper.

The Final Report of Component 2 is scheduled to be approved by the MRC Member Countries and disseminated to the National Mekong Committees and dedicated line-agencies in May 2010. During earlier Mekong Flood Forums Component 2 referred to ‘work in progress’, while this 8th Annual Mekong Flood Forum is placed towards the end of the implementation period of the Flood Management and Mitigation Programme (2004-2010) and therefore provides an excellent opportunity to take note of the achievements and to share its products and services with other interested stakeholders.

As early as 2006 the FMMP developed a framework for the development of best practice IFRM guidelines for the Basin Development Plan. This initiative underlines the important role of flood risk assessment and management for future infrastructure developments and larger scale land use changes in the Lower Mekong River Basin.

The Mekong River Commission through the implementation of FMMP Component 2 has been developing basic documentation about flood characteristics in the Lower Mekong River basin, identification of flood proofing and flood protection measures; it has provided best practice guidelines for the application of flood risk management and it has provided training and capacity building. An important feature is the best practice guidelines on IFRM for Basin

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Development Planning. Considering the economic growth of the MRC Member Countries, including the possible effects of climate change, it is a vital capability of the Mekong River Commission to identify potential effects and to mitigate its negative national and/or trans-boundary impacts. Under Component 2 this flood risk assessment and management concept has been applied as a practical tool in Demonstration Projects and may serve the MRC Member Countries in support of sustainable development of the Mekong River Basin. As the Component 2 has provided options for future implementation of projects, some to the level of pre-feasibility, these can be considered by the MRC Member Countries in their relations with the development banks, like World Bank, Asian Development Bank and Japan Bank for International Cooperation, for further follow-up and eventual realization.

INTRODUCTION

Component 2 'Structural Measures and Flood Proofing' has been identified after the 2000 Flood as one of the important interventions to help implementing the regional Flood Management and Mitigation (FMM) Strategy 'people's suffering and economic losses due to floods are prevented, minimized, or mitigated, while preserving the environmental benefits of floods' of the Mekong River Commission (MRC). The focus of Component 2 is on the issue of flood damage risks and has provided an approach and methodology to practice integrated flood risk management (IFRM). This allows MRC Member Countries applying the concept of IFRM. IFRM is an international concept, widely used to assess flood damages and risks, to evaluate the possibilities for investment in soft and hard measures, and thereby more effectively manage and reduce the flood risks.

The main activities of Component 2 have been implemented through an international consultancy services contract, thereby applying the procurements procedures of the Asian Development Bank (ADB), which has been different to the approaches applied for the implementation of the other Flood Management and Mitigation Programme (FMMP) components. Some of the effects and lessons learnt will be shared in this paper.

The Final Report of Component 2 is scheduled to be approved by the MRC Member Countries and disseminated to the National Mekong Committees and dedicated line-agencies in May 2010. During earlier Mekong Flood Forums Component 2 referred to 'work in progress', while this 8th Annual Mekong Flood Forum is placed towards the end of the implementation period of the Flood Management and Mitigation Programme (2004-2010) and is therefore providing an excellent opportunity to take note of the achievements and to share its products and services with other interested stakeholders.

Flood Management and Mitigation (FMM) is part and parcel of Integrated Flood Risk Management (IWRM)-based Basin Strategy of the Mekong River Commission. The FMMP aligns with the IWRM-based Basin Strategy. The IWRM-based Basin Strategy is promoted by the Basin Development Programme. FMMP and in particular the design of Component 2 identified the important functional links with the Basin Development Plan. As early as 2006 the FMMP developed a framework for the development of best practice IFRM guidelines for the Basin Development Plan. This initiative created awareness and improved understanding among MRC Member Countries of the important role of flood risk assessment and management for future infrastructure developments and larger scale land use changes in the Lower Mekong River Basin.

The Mekong River Commission through the implementation of FMMP Component 2 has been developing basic documentation about flood characteristics in the Lower Mekong River Basin, identification of flood proofing and flood protection measures, it has provided best practice guidelines for the application of flood risk management and it has provided training and capacity building. An important feature is the best practice guidelines on IFRM for Basin Development Planning. Considering the economic growth of the MRC Member Countries, including the possible effects of climate change, it is a vital capability of the Mekong River Commission to identify potential effects and to mitigate its negative national and/or trans-boundary impacts. Under Component 2 this flood risk assessment and management concept has been applied as a practical tool in Demonstration Projects and may serve the MRC Member Countries in support of sustainable development of the Mekong River Basin. As the Component 2 has provided options for future implementation of projects, some to the level of pre-feasibility, these can be considered by the MRC Member Countries in their relations with the development banks, like World Bank, Asian Development Bank and Japan Bank for International Cooperation, for further follow-up and eventual realization.

DESIGN OF COMPONENT 2

After the devastating 2000 Flood the MRC Council endorsed the Flood Management and Mitigation Strategy in December 2001, thereby laying the ground for a much stronger future involvement of the MRC in regional flood management and mitigation. A Flood Management and Mitigation Strategy Implementation Plan was developed, which served as an early design of the Flood Management and Mitigation Programme, which would eventually be endorsed in November 2004.

In MRCs FMM Strategy ‘structural measures’ were given ‘high priority’, concerning MRCs role in providing technical products and services and in relation to identifying potential trans-boundary impacts, while capacity building and technology transfer were rated ‘medium priority’. Nonetheless, being aware of the fact that ultimately the dedicated line agencies of the MRC Member Countries would be the users of the IFRM products and services, a substantial training and capacity building element has been incorporated in the Component 2 design.

Although there has been a paradigm shift in the past from ‘structural flood control’ to ‘non structural flood management’, in the Lower Mekong River Basin, given the growth of the population and the development of infrastructure (housing, roads, canals and bridges) there is general awareness that many flood control and protection structures will be build. Component 2 has been designed to provide an understanding of soft and hard protection measures and its applications given the specific circumstances and requirements of the prevailing flood management and mitigation strategy.

The MRC, from the viewpoint of a regional river basin organization, envisaged providing the MRC Member Countries with an unbiased advice and guidance, on technical, as well as on policy and cooperation issues. Even though Component 2 has provided training and capacity building, in order to facilitate the dedicated line agencies of the MRC Member Countries reduce the flood risk and the flood damage further and broader, continuous capacity building is required at the level of these agencies at national, provincial and districts level.

OBJECTIVES

The overall development objective of the MRC FMM Strategy is stated as: ‘people’s suffering and economic losses due to floods are prevented, minimized, or mitigated, while preserving the environmental benefits of floods.’ Component 2 is seen as a vital step towards this goal, as a part of a long-term process, where MRC and the dedicated line agencies implement components of FMMP in a well-coordinated approach, so that Mekong floods, particularly the extreme floods, are well managed and mitigated.

This will assist MRC in accomplishing its mission: *'to promote and coordinate sustainable development and management of water and related resources for the countries' mutual benefit and the people's well-being by implementing strategic programmes and activities and providing scientific information and policy advice.'*

The immediate objectives of Component 2 are:

1 *'a reduced vulnerability of people living in the Mekong River Basin to the negative impacts of floods';*
2 *'management capacity established for development and refinement of the FMMP Implementation Plan'.*

As the FMMP is composed of five Components, the reference to the FMMP Implementation Plan targets the 'structural measures and flood proofing' elements of this plan.

IMPLEMENTATION

The design of Component 2 is characterized by a variety of activities to achieve the formulated outputs, packaged under the two immediate objectives. During early consultations on the Programme Implementation Plan in the first half of 2006 the MRC Member Countries and FMMP discussed the different options for mobilizing the capacities for implementation of the Component. There was general consensus among the Mekong River Commission Secretariat (MRCS) and the MRC Member Countries to develop Terms of Reference (TOR) for the procurement of Consultancy Services through international tendering. Drafting of the TOR started in the second half of 2006. However due to expectations on the one hand to focus on project development, while others emphasized the importance of capacity building, it took considerable time to reach consensus between MRCS and MRC Member Countries. The TOR version 13 was finally used for tendering.

Funding was provided by the ADB (US$ 1.0 million) and Royal Netherlands Embassy (RNE) (US$ 2.7 million) for Component 2. A reservation of US$ 2.9 million was made in the TOR. However the requirements for implementation from the donor perspective were different. The ADB had specified 'individual experts', while the RNE envisaged 'international tendering'. MRC, ADB and RNE agreed to go for international tendering of the Consultancy services, even though it took some time to sort this out. The ADB procurement procedures were applied; to reduce any potential delays FMMP in Phnom Penh worked closely together with MRCS in Vientiane with strict project management rules. It was a great achievement of the cooperating bodies, that all ADB compulsory steps for notification and approval within the overall procurement procedure, from expression of interest, short-listing, request for proposal, selection, to contracting, were completed within the nominal time of 252 days, as indicated by the ADB procurement manual.

A number of activities had been initiated in parallel to the implementation process of Component 2 consultancy services contract. As early as 2006 the FMMP developed a framework for development of best practice IFRM guidelines for the Basin Development Plan. This initiative created awareness and improved understanding among MRC Member Countries of the important role of flood risk assessment and management for future infrastructure developments and larger scale land use changes in the Lower Mekong River Basin.

Besides that, MRC and UNESCO-IHE had agreed to cooperate for the implementation of a challenging project, titled: '*The Integrated Planning and Design of Economically Sound and Environmentally Friendly Roads in the Mekong Floodplains in Cambodia and Viet Nam*'. This project (its abbreviation: *the Roads and Floods Project*) covered an element of the Component 2 TOR, which could be eliminated from the TOR used for the international tendering of

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consultancy services. The Project Plan was approved in February 2006; its final document was accepted by March 2009.

The original Component 2 planning (2004) schedule was based on the involvement of the national line agencies, individual national and international experts and consultants. Only part of the work would be contracted by a consulting company. Its implementation period was estimated in two years. In retrospect, given the complexity of Component 2, its vast number of challenging requirements, plus a growing linkage with other FMMP components, the original timeframe of two years is considered largely unrealistic. It would have been impossible to implement the Component 2 without substantial delays and difficulties in project management.

The actual implementation of Component 2 covered a period of 4.5 years, from September 2005 until February 2010. Twelve months, from September 2005 to September 2006, were required for the preparation and internal and external processing of the TOR for which 13 versions were required. A senior international flood management expert was contracted to support FMMP in drafting the TOR. The procurement procedure under ADB procurement rules covered a period of another twelve months, from August 2006 to August 2007, being the date of approval of the Expression of Interest up to the agreement on the selection of the International Consulting Company. The actual implementation of the Consultancy Services contract was scheduled to cover a period of 22 months, from 24 September 2007 to 24 July 2009.

Delays to the extent of 6.5 months in total have been encountered. Apart from a project interruption of two months for the selection of a new team leader for the Consultant company, calibration problems of the ISIS baseline model application, and instabilities in the ISIS model applications further delayed the final date roughly 4.5 months. However, the ISIS model applications have been adjusted and the model application has been substantially improved, thanks to the intensive support by MRCs Information and Knowledge Management Programme (IKMP) (Figure 1). The improved ISIS model application used under Consultancy Services Component 2 (baseline version) is: ISIS_LMB-2210 DAT-file, dated 3 November 2009.

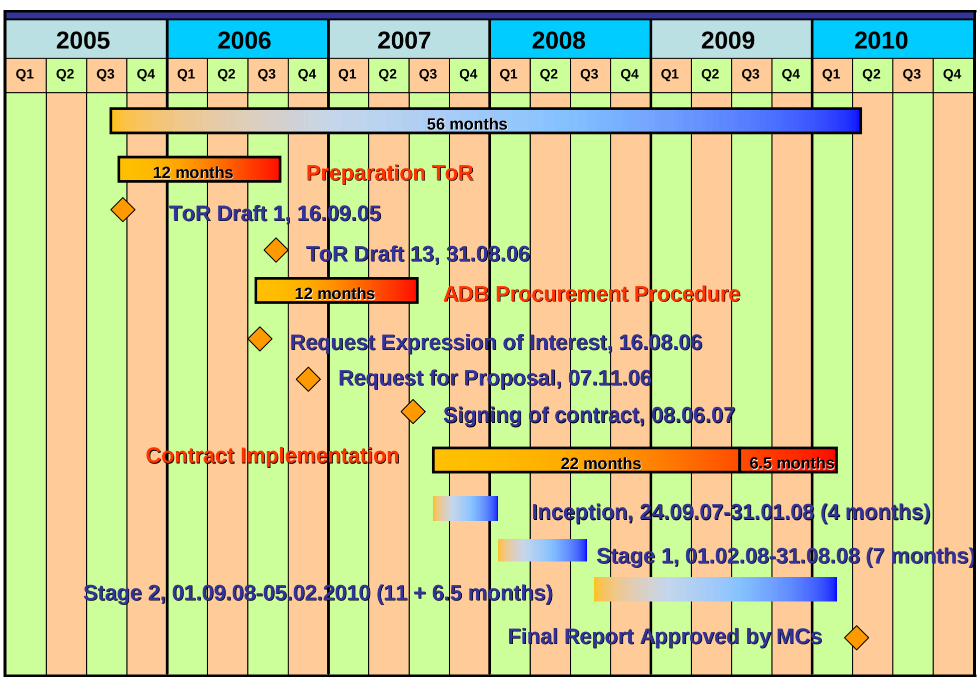

Figure 1. Implementation consultancy services contract Component 2

The improved model application may be considered a welcome by-product of the Component 2 Consultancy Services contract. The negative effect of the delays has been that some of the Demonstration Projects (Nam Mae Kok Demonstration Project and the Joint Cambodia-Viet Nam Border Zone Demonstration Project) could not be completed to the required level of sophistication. Mitigation measures could not be developed and supported by model applications and design calculations. At the request of the MRC Member Countries, these have been dealt with in a more descriptive manner.

The MRC hydrodynamic ISIS model was applied for the Kok River Basin, the Se Bang Fai Sub-basin and the Cambodian floodplain - Mekong Delta. Interestingly enough, the hydrodynamic model application assumption, which had been incorporated in the TOR for the Consultancy Services contract, stated that the Consultant 'should assess and experience the suitability of the MRC models, before proposing alternative models'. In retrospect, notwithstanding the mentioned delays, this wording led to a 'win-win' for FMMP and IKMP. In practice the Consultancy Services were initiated in September 2007 and completed in February 2010. Through the Consultancy Services, which were provided through 3 phases, a 4 months Inception Phase, a 7 months Stage 1 Implementation Phase and an 11 respectively 17.5 months Stage 2 Implementation Phase, a large array of products have been provided. The implementation costs did not exceed the contract amount.

It is generally concluded that the decision to contract consultancy services through international tendering has been a positive one. The perspective of providing an unbiased technical approach and methodology, allowing the MRC Member Countries to apply a uniform flood damage assessment and to propose flood risk reduction measures was concluded valid. The approach and methodology of IFRM could be consistently promoted through training and capacity building, particularly through the development of the Demonstration Projects.

Some activities conducted with Component 3 funding have been supporting Component 2. These refer to the contract with JBA Consulting in Wallingford, United Kingdom for the improvement of the ISIS model application in the Cambodian floodplain and the Mekong Delta. Reference is made to:

- '*Review and Proposals for Enhancement of Hydrodynamic Models*', July 2007, JBA Consulting, Wallingford, United Kingdom

Potential Model Improvements: In the short term it is apparent that improvements should firstly concentrate on the modelling within Cambodia, which is much less detailed than in Viet Nam (around 750 nodes out of 5100). Improvements can be made to improve the detail of the schematization and proving of the model against floodplain observations and observed flood extents from satellite information.

- '*Enhancement of Lower Mekong ISIS Hydrodynamic Model*', September 2008, JBA Consulting, Wallingford, United Kingdom

The flood paths through the Mekong right bank up to the Tonle Sap Great Lake have been completely re schematized and separate flow routes using extended river sections have been incorporated. Elsewhere within the Cambodian part of the model cells have been subdivided where desirable and minor model changes were made. At the border with Viet Nam the border canal and flood passageway have been updated for the Plain of Reeds and similarly in the Chau Doc area.

FLOOD RISK MANAGEMENT

Substantial data collection and data processing is required to develop the flood (damage) risk / probability functions for different damage categories. The basic method is explained as follows.

From the time series output of the ISIS hydraulic model, the probability of occurrence of different water levels can be analyzed. On the other hand the relation between flood level or flood depth and damage is known.

By combining the damage with the flood probability the damage probability curve can be estimated (Figure 2). An example is given in Figure 3, where for different flood probabilities of exceedance the (overall) flood damage in million US$ is presented for three districts in Cambodia. It is up to the specific requirements of each MRC Member Country for what damage categories the damage probability relations will be developed. Based on the district level data Component 2 has developed the flood (damage) risk functions for a number of districts for three damage categories (housing, infrastructure and relief, agriculture). An example of the absolute (expected) damage value in US$ per year is presented for three districts in Cambodia and three districts in Viet Nam. The size of the circle shows the magnitude of the risk, while the damage categories are specified within the circle.

Under Component 2 the flood damage risks have been developed for a number of districts in the Lower Mekong River Basin. Figure 4 shows for a number of districts in Cambodia and Viet Nam the levels of flood risk, regarding housing, infrastructure and relief and agriculture. This is extremely relevant information which helps identifying where the flood risk is highest and assessing where proof risk reduction options may have to be developed. Notwithstanding the inaccuracies in the modelling application, the results at district level are sufficiently indicative to identify where more specific studies in terms of soft and/or hard flood protection measures and for which and for sectors could be considered.

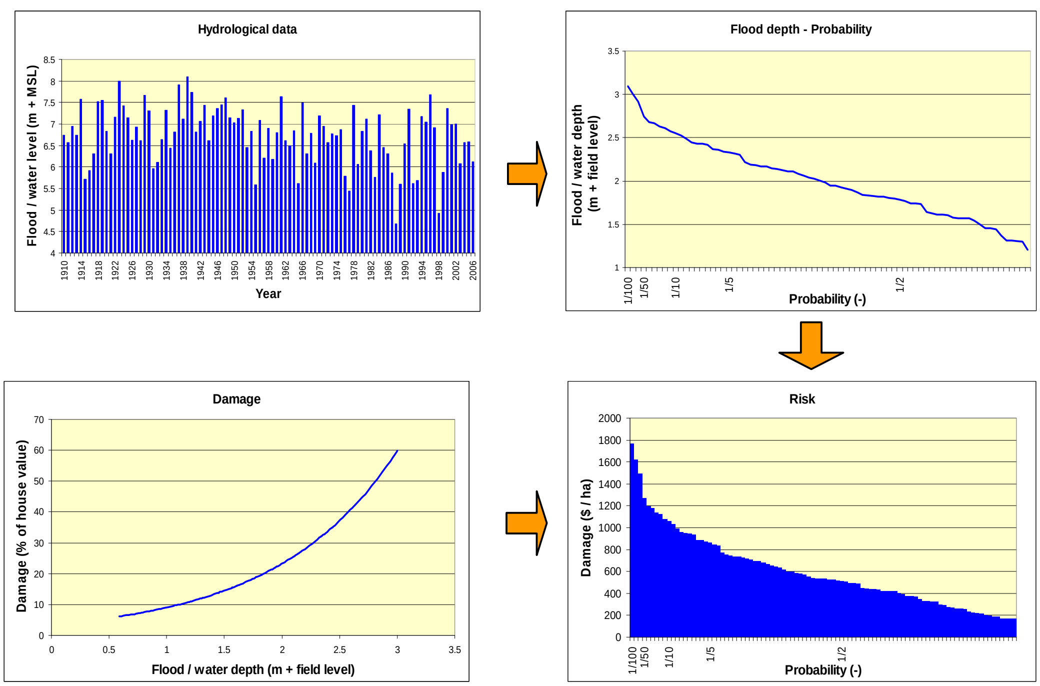

Figure 2. Approach for estimation of risk

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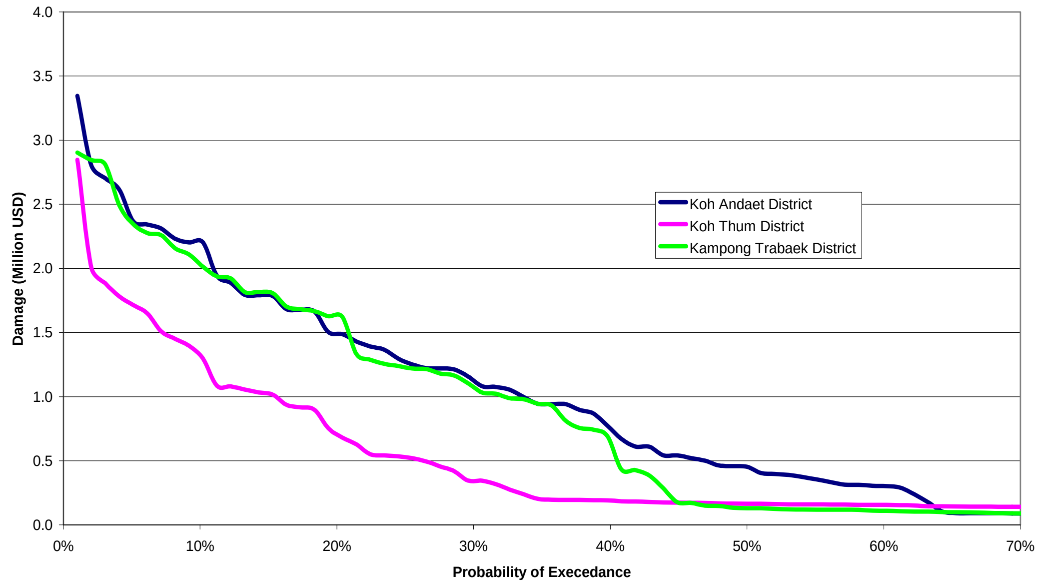

Figure 3. Example of Damage Probability relation for three districts in Cambodia

Based on the flood (damage) risk relationship the annual flood risk can be developed. This annual flood risk is a useful instrument to compare the annual flood risks among districts in the MRC Member Countries in flood prone areas. See Figure 5 for the flood risk per district, probability 4% for agriculture and Figure 6 for the flood risk per district probability 4% for housing and infrastructure.

The method for flood risk assessment is specified in the Guidelines for Flood Risk Assessment. The ISIS hydraulic model was used to simulate flood water levels in the entire Cambodian floodplain and the Mekong Delta. The output of water levels as representative locations for each district was used for flooding hazard analysis.

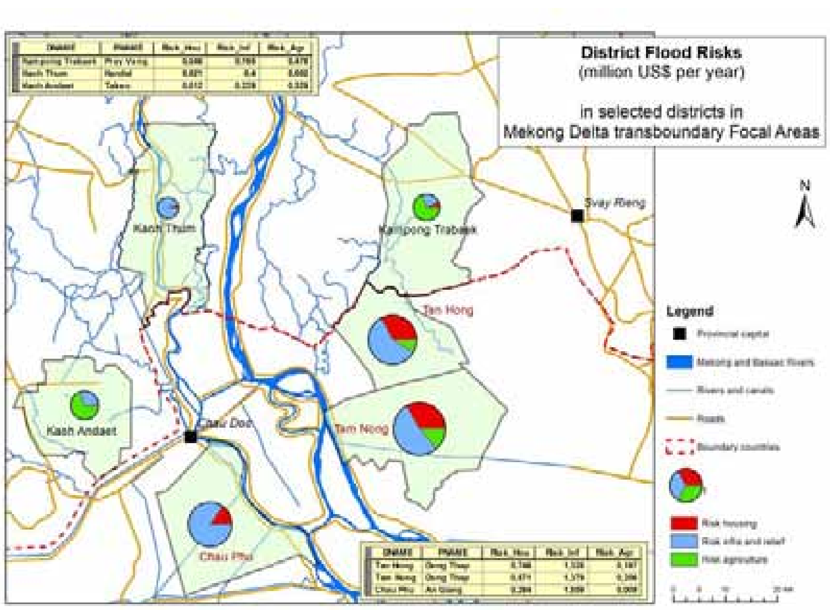

Figure 4. Example of District Flood Risks in US$ per year for 3 damage categories

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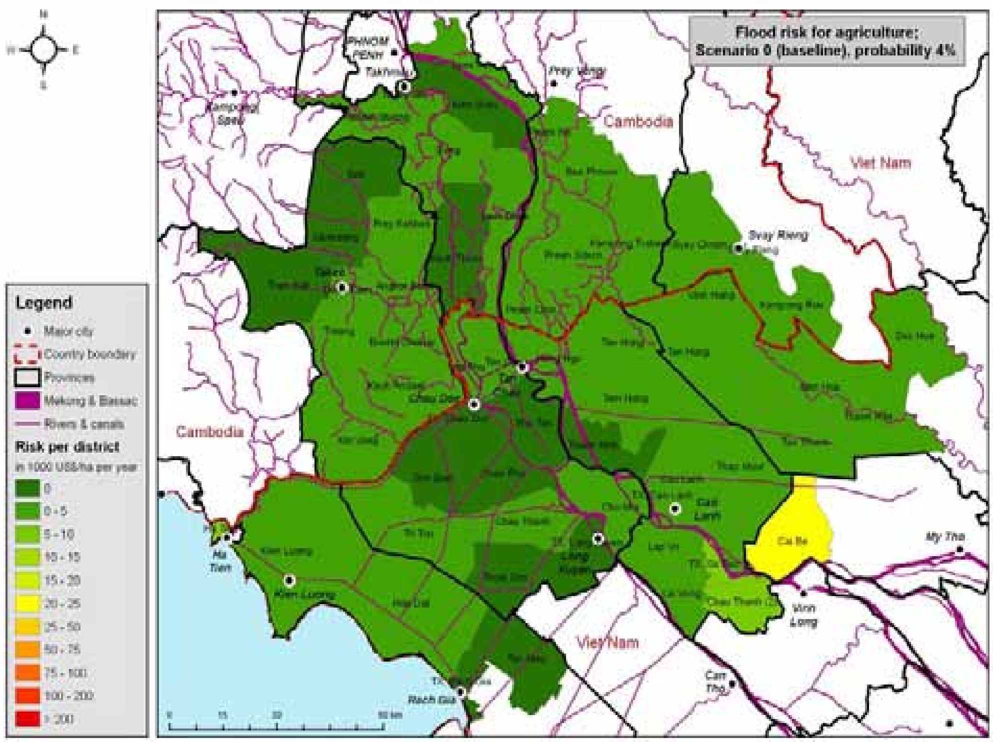

Figure 5. Flood Risk for Agriculture, Baseline, probability 1/25 yrs (4%)

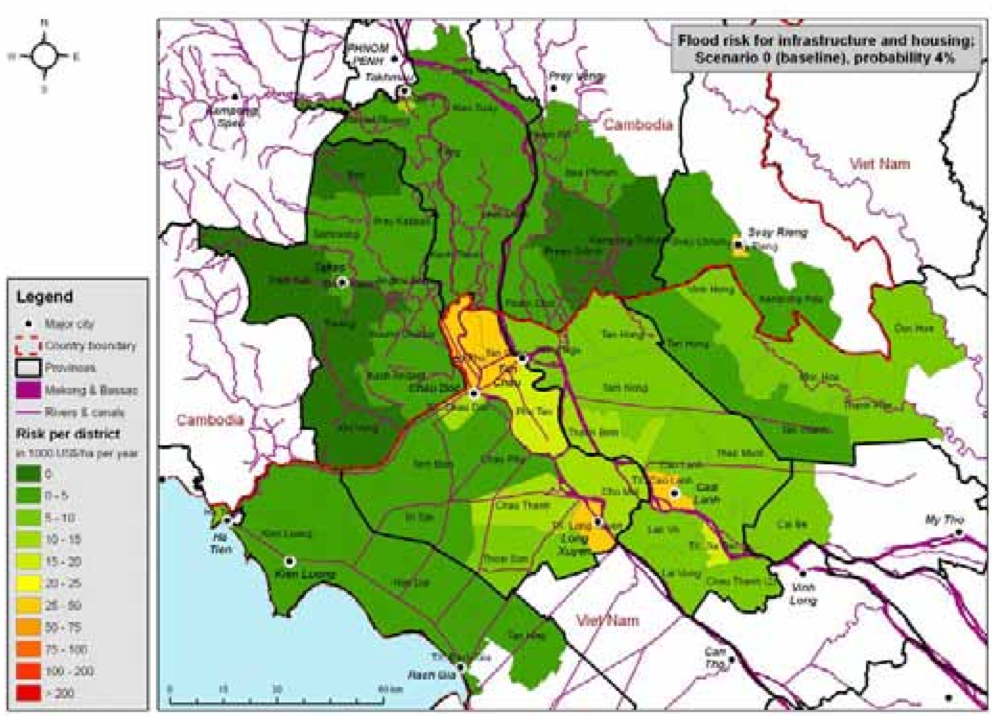

Figure 6. Flood Risk for Infrastructure and Housing, Baseline, probability 1/25 yrs (4%)

A more overall picture is provided for the border zone between Cambodia and Viet Nam. Direct flood damages were collected from provincial and/or district departments from annual reports. Indirect damages obtained from household and business surveys for selected districts in the focal area in Cambodia and Viet Nam for the baseline situation, as well as for possible future scenarios.

The results presented in Figure 7 serve as an example for a 2% flood damage probability. From this figure it can be deducted that the risk values on the Vietnamese side are much higher than in Cambodia, which is due to the much higher population density. Flood risks in 25 Cambodian districts are predominantly infrastructure and agriculture related, while in the 34 districts in Viet Nam these are related to primarily infrastructure and housing.

LIMITATIONS OF THE ISIS APPLICATION AND OPTIONS FOR IMPROVEMENT

The ISIS is the ‘accepted’ hydrodynamic tool of the MRC, which means that its use is endorsed by the MRC Member Countries. However, its application is mainly limited to planning purposes. There is among national experts of the MRC Member Countries and within the MRCS substantial doubt about the accuracy of the results of the ISIS model applications. The Component 2 Consultants have also stated that the ISIS model application is providing a reasonable representation of the hydrodynamics of the Cambodia floodplain and the Mekong Delta. However, the model has its limitations and it should not be used for design purposes. This statement is equally valid for carrying out detailed flood risk assessment at district or even sub-districts scales.
Furthermore it is evident that the 97 years of water level records are valid for a number of mainstream stations only and that therefore the ISIS calibration for the Mekong mainstream is reasonably reliable. For water levels in remote areas at greater distance from the Mekong mainstream the values may be questionable, even though trends in water levels even at greater distance from the mainstream may be valid.

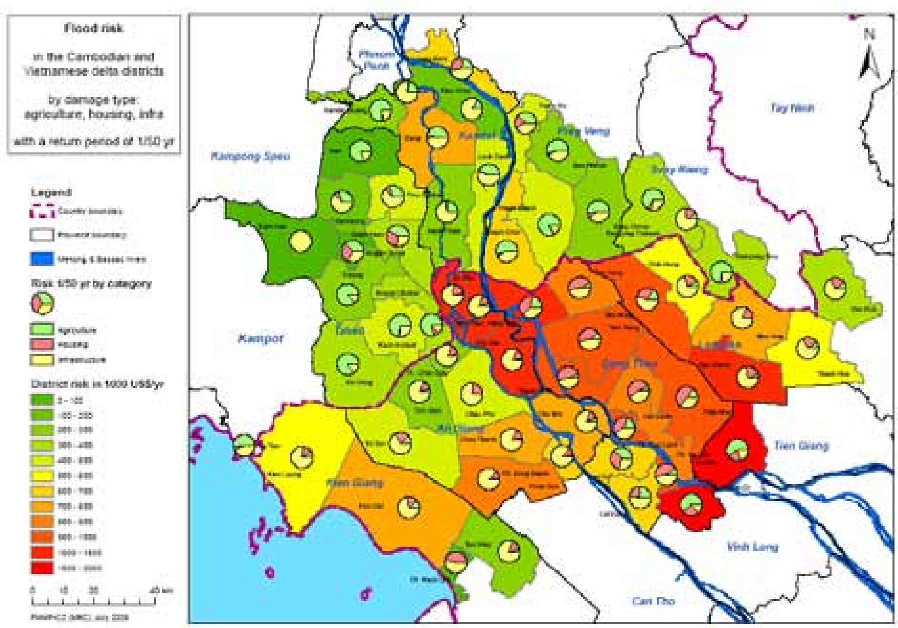

Figure 7. Flood Risk map in the Cambodia Floodplain and Mekong Delta districts for 1/50 years return period (2%)

Having stated these limitations of the present ISIS model applications and acknowledging the

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sensitivity of more accurate ISIS modelling applications, it seems the MRC has reached a point where it may consider if enhanced modelling capabilities remain a pivotal goal for the organization. The MRC Member Countries may wish to explicitly express the interest in improved hydrodynamic modelling for applications, like design of flood protection infrastructure, infrastructure planning, detailed flood risk assessment and floodplain wide flood forecasting (Figure 8) for a basin-wide flood depth map for 1/25 years.

Such an expression of interest would clarify the position of the MRC Member Countries and provide guidance in the developments of MRC programmes, while it may be considered a clear signal to funding agencies, especially the development banks, like World Bank, ADB and the Japan Bank for International Cooperation (JBIC), that cooperation is required with MRC in establishing a strong multi-sectoral tool for sustainable development of the Lower Mekong River Basin. Over the last 10-15 years systems (Delta scale laser-based Digital Elevation Model (DEM)/Digital Terrain Model (DTM) and combined 1D-2D hydrodynamic modelling) have been developed at commercially attractive rates, which bring this goal within the reach of the MRC.

Comparing the costs and benefits of the annual Mekong Flood (Annual Mekong Flood Report, 2008) there is an overwhelming argument and good reason to improve the modelling capabilities particularly in the Cambodian floodplain and the Mekong Delta for more effective flood risk management, given the estimated annual costs of flood damages. MRCS, the MRC Member Countries and development partners should consider options for improving the MRC modelling tools and capacities as a priority.

COMPONENT 2 PRODUCTS

FMMP has developed the Component 2 products by initiating a number of contracts with individual consultants, cooperation with UNESCO-IHE and an international Consultancy Services contract with Haskoning Nederland B.V. One Component 2 product, as explained earlier, was developed through the Roads and Floods Project and was later integrated in the product of the international Consultancy Services.

Roads and Floods Project

The final report (plus annexes) of the Roads and Floods Project was approved by Cambodia and Viet Nam in September 2009. The final reports include '*Best Practice Guidelines for the Integrated Planning and Design of Economically Sound and Environmentally Friendly Roads in the Mekong Floodplains of Cambodia and Viet Nam*'. These have been incorporated in the Final Report of the Component 2 Consultancy Services contract, Part III '*Best Practice Guidelines for Flood Risk Assessment, Planning and Impact Evaluation.*

The final *Roads and Floods Report* has been converted into a MRC Technical Paper and has been distributed to MRC Member Countries and other stakeholders.

The project identified four cases studies, two in the Cambodian floodplain and two in the Mekong Delta in Viet Nam. In-depth studies were carried out and their findings up-scaled. The cases illustrate that regarding the aspect of road planning and design in the Mekong floodplain, while reducing the socio-economic costs of flooding and preserving the benefits of floods, an integrated approach is required. The cases clearly show that:

- during the development process of roads in the Mekong floodplains, coordination between the road and transport sector, the water sector, the flood risk management/dike sector, the environment sector and the social sector is essential. Different sectors have a different

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perspective on floods and how to deal with them, and these perspectives should be balanced during floodplain development;

- the character of the floodplain system requires not only local (project) impacts to be considered, but also impacts and implications at a larger scale. The cases show that cumulative impacts of structural developments (including roads) occur. A solution at one location, might impact other locations. This requires coordination and integration at the (sub-)floodplain scale;
- it is essential that the financial sector and donors better work together, in order to link infra-structure investment budgets to operation and maintenance and damage repair budgets, and hence have the possibility to use limited financial resources more efficiently. The results of the case studies indicate that higher initial investments may lead to lower medium-term costs and ecological impacts. This requires an integrated financial assessment - integrated in terms of investment, operation and maintenance, and damage risk - at the early planning stages.

Consultancy Services Contract

The final report (plus annexes) is presently still in the review process. It is expected to be approved by the MRC Member Countries in May/June 2010. The final Report is structured as follows:

Title:
STRUCTURAL MEASURES & FLOOD PROOFING IN THE LOWER MEKONG BASIN

- Final Report
  - *Structural Measures & Flood Proofing in the Lower Mekong Basin*
- Hydrological and Flood Hazards in Lower Mekong Basin and Focal Areas
  - *Hydrological and Flood Hazards in the Lower Mekong Basin*
  - *Hydrological and Flood Hazards in the Focal Areas*
  - *Flood Damages, Benefits and Flood Risk in Focal Areas*
  - *Strategic Directions for Integrated Flood Risk Management in Focal Areas*
- Best Practice Guidelines for Flood Risk Assessment, Planning and Impact Evaluation
  - *Best Practice Guidelines for Flood Risk Assessment*
  - *Best Practice Guidelines for Integrated Flood Risk Management Planning and Impact Evaluation*
  - *Best Practice Guidelines for Structural Measures and Flood Proofing*
  - *Best Practice Guidelines for Integrated Flood Risk Management for Basin Development Planning*
  - *Best Practice Guidelines for the Integrated Planning and Design of Economically Sound and Environmentally Friendly Roads in the Mekong Floodplains of Cambodia and Viet Nam*
- Prioritization and Ranking of Possible Flood Risk Reduction Projects
  - *Project Development Implementation Plan, Prioritization and Ranking*
- Capacity Building and Training
  - *Capacity Building and Training*
- Sample Projects for Flood Hazard Assessment and Management in Lower Mekong Basin
  - *Flood Risk Assessment in the Nam Mae Kok basin, Thailand*
  - *Integrated Flood Risk Management Plan for the Lower Xe Bangfai area in Lao PDR*
  - *Integrated Flood Risk Management Plan for the West Bassac area in Cambodia*
  - *Flood Protection Criteria for the Mekong Delta, Viet Nam*
  - *Flood Risk Management in the Border Zone between Cambodia and Viet Nam*

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For the presentation of the individual products reference is made to the 8th Annual Mekong Flood Forum Paper by Mr. Gert Sluimer, Team Leader for the Component 2 Consultancy Services for Royal Haskoning Nederland B.V.

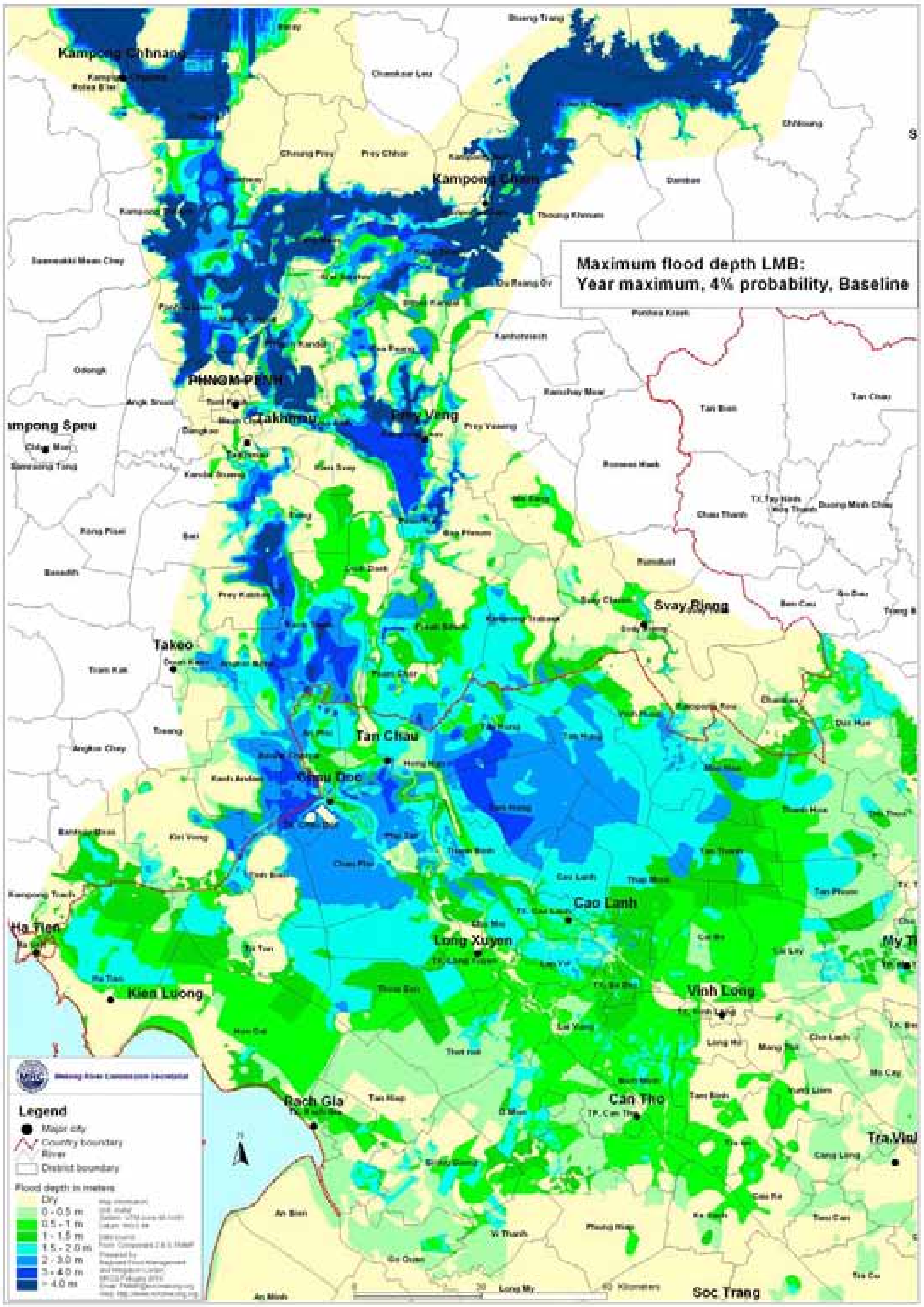

Figure 8. Flood depth map for 1/25 yrs (Baseline ISIS, 4%)

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Nonetheless some of the products are highlighted in this presentation, such as the flood depth maps for the baseline[6] situation (see Figure 8) and the flood risk maps, also for the baseline situation. See Figure 5 for 'agriculture', likewise maps have been developed for 'infrastructure' and 'housing' (Figure 6). The report presents as outcomes of the modelling results for probability of exceedance of ½, ¼, 1/10, 1/25 and 1/50 years.

LESSONS LEARNT

Finally some of the lessons learnt can be listed as follows:

- although the FMM strategies in the MRC Member Countries are in principle comparable, the capacities at national, provincial and district levels do substantially differ. In order to continue training and building capacity and promote the awareness and understanding of the concept of flood risk assessment, reduction and management follow-up of Component 2 under FMMP Phase 2 (2011-2015) is strongly recommended;
- in order to improve the awareness and understanding of the approach and methodology of flood risk assessment, reduction and management key elements of the guidelines should be translated into the riparian languages. Dissemination to dedicated line agencies/line departments in the MRC Member Countries, dealing with flood protection, through workshops under FMMP Phase 2 is recommended;
- although MRC Member Countries, FMMP and Funding Agencies opted for implementation of Component 2 through a single international consultancy services contract, the underlying financial management aspects were complicated in terms of payment schedule, EUR and US$ payments, and the relation of activities/achievements to the specific donor policy objectives incorporated in the funding agreement;
- regular calibration of the rating curves for the main cross sections of Mekong River and its tributaries remains important for the overall accuracy and consistency of the hydrologic and hydrodynamic modelling, and river monitoring and flood forecasting.

> Application of stage-discharge at Stung Treng and Kratie based on bottom tracking referenced Acoustic Doppler Current Profiler (ADCP)-measurements will lead to a discontinuity in the discharge series previously based on current meter measurements. A correction procedure based on the use of Differential Global Positioning Satellites (DGPS) should be introduced to improve the results. The current use of hand held Global Positioning System (GPS) also leads to discharge estimates of poor quality Conlan, 2008a). The measurement equipment should also be regularly re-calibrated (see also Conlan, 2008b). To eliminate uncertainty in the Mekong discharge measurement data it is also strongly recommended to carry out concurrent discharge measurements with both measuring techniques at Kratie (DGPS referenced ADCP and current meter measurements) for the full discharge range, with emphasis on higher flows. The results can be transferred to Stung Treng by referencing the flows to stages at the latter station of the previous day. In developing stage-discharge relations for Kratie, the effect of unsteady flow should first be eliminated by means of the Jones equation.
>
> It is further advised to re-evaluate the size of the floodplain flow at Pakse prior to 2002. The discharge series of Pakse from 1923 onwards should be recomputed. For this the water level series at Pakse, as available in the Technical Support Division – Hydrological Modelling System (TSD-HYMOS) database, should be extended with the period 1923-1959.

[6] The baseline is also called 'base case', used for the maps in the presentation, represents the existing conditions of land use and flood control levels in Cambodia and Viet Nam.

- the accuracy and consistency of the ISIS model application can be substantially improved by significantly enhancing the topographic/hydrographic information in the ISIS model schematization for the Cambodian floodplain and the Mekong Delta.

> Based on the analysis made in the framework of flood hazard assessment for the Mekong Delta it is strongly recommended to improve on the computational tools available at the MRC. The recalibration of the Mekong Delta hydraulic model is to be undertaken with priority including an extension of the computational network in the Focal Areas in Cambodia.

- the accuracy and consistency of the ISIS model application for the Nam Mae Kok Basin and the Se Bang Fai Sub-basin can be substantially improved by using a 1D2D configuration.

> The recommendations made for the Nam Mae Kok Basin regarding 1D2D modelling also apply for the Lower Se Bang Fai Sub-basin.

- one may reconsider the upper boundary for the hydrodynamic model application in the Cambodian floodplain and the Mekong Delta i.c. Kratie or Stung Treng.

> The GPS referenced ADPC measurements in Kratie are fully inconsistent with similar measurements at Stung Treng, as well as ADCP or current meter based ratings.
> The discharge ratings for Kratie gradually change in the course of time. The discharge ratings for Stung Treng and the stage relation curves can be used to develop and validate the ratings at Kratie.

- The use of the Component 2 products by the ADBs '*Flood and Drought Project*' is a great opportunity for the MRC Member Countries to select ProDIP projects (Project Development and Implementation Plan) for feasibility studies and later implementation.

FUTURE PERSPECTIVE

The implementation of Component 2 has presented an approach and methodology for flood risk assessment and management. As part of this methodology a set of practical tools was provided to line agencies allowing these to present systematically processed information and investment options to decision-makers in the field of flood management and flood mitigation. However, the hands-on application of the Flood Risk Assessment (FRA) principles under Component 2 was limited and should be continued under a second phase of FMMP. Core material should be translated in the riparian languages to be more accessible for engineers involved in preparation of flood protection works. Additional workshops for selected national and provincial staff are required for broader uptake of the Component 2 material for which the local language would be much more appropriate than English. Hands-on application of the FRA principles in a pilot project environment would be the most effective manner in understanding the approach and methodology to improve the process of decision-making for flood management in the MRC Member Countries. This 8th Annual Mekong Flood Forum may contribute to the awareness and understanding of the added-value of the use of flood risk assessment and management to reduce the loss of lives and damages to infrastructure by recurrent extreme floods in the Lower Mekong River Basin.

Finally it is recommended that under FMMP Phase 2 an (even closer) working relationship is continued with Basin Development Plan (BDP) and IKMP, and that actions will be identified for improving the data and information for modelling[7], modelling tools and modelling capabilities in MRCS and the MRC Member Countries, particularly the dedicated line-agencies, responsible for flood control and disaster management.

REFERENCES

Conlan Iwona (2008a), Cambodia, evaluation of discharge measurements in 2008. IKMP, MRC, September 2008

Conlan Iwona (2008b), Discharge and Sediment Monitoring Project 2009-2010, Draft project proposal. IKMP, MRC, December 2008

[7] Regarding the topographic/hydrographic information reference is also made to 'Future expectations' of AMFF-8 Paper on FMMP Component 3

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Paper 2-4

ENHANCED COOPERATION IN ADDRESSING TRANS-BOUNDARY FLOOD ISSUES BETWEEN MRC MEMBER COUNTRIES UNDER FMMP COMPONENT 3

NICOLAAS BAKKER AND LAM HUNG SON

MRC Regional Flood Management and Mitigation Centre, Phnom Penh, Cambodia

ABSTRACT

The original Component 3 document was titled '*Mediation in Trans-boundary Flood Issues*'. After initiating the component in 2006 it was found during regional consultation meetings in August and September 2006, that the Member Countries of the Mekong River Commission (MRC) re-confirmed their interest and support in Component 3, but that mediation was considered one of the many important dispute resolution strategies, that could be suitable for addressing differences related to trans-boundary flood issues, and that there was a need to equip the MRC with a variety of resolution tools. In additional the MRC Member Countries commented that some outputs in the original document are too ambitious and many not suitable.

The MRC Member Countries developed a holistic view on the revised design and implementation process of Component 3 with a focus on three goals/outputs: 1) information generation; 2) awareness raising, knowledge and skills building; 3) toolbox development, while under each of these outputs a number of activities had been designed to achieve the outputs. For the implementation of the Component the Flood Management and Mitigation Programme (FMMP) has applied a step-by-step approach, supported by individual national and international experts. For the implementation of the training and capacity building programme for the target groups mid-level professionals and high-ranking decision-makers and the exchange study visits to the Cambodian - Viet Nam border area of the Mekong River, Europe and China, FMMP has opted for selection of a dedicated international institute through international tendering.

At this moment, after four years of implementation, we can take stock; products which have been accomplished by FMMP can now be listed under the various activities to represent the status of progress. On the other hand it is a good moment to inform stakeholders regarding these Component 3 products, as many of these products are considered not only relevant for FMMP purposes, but may serve many other disciplines as well. The Component 3 products, which have been accomplished, are based on the past and present knowledge, information and findings. However, these are considered important for the strengthening of the cooperation on trans-boundary flood and other issues between the MRC Member Countries further in future.

The 8th Annual Mekong Flood Forum offers an excellent opportunity to share experiences on the implementation process, the way in which Component 3 is managed, the design of the Pilot Study under the Capacity Building Programme Phase 2, and finally a general assessment of the challenges hitherto and some of the expectations up to the end of 2010 and there after.

INTRODUCTION

The original Component 3 Document, which was endorsed in November 2004, was titled 'Mediation in Trans-boundary Flood Issues'. It would focus on the Mandate and Framework for addressing the trans-boundary flood issues under the Mekong Agreement 1995, on Regional Partnerships and the establishment of a Mediation and Coordination Section of the MRC Secretariat. The design incorporated an output of intra-, inter-, and external coordination, which would be taken out and positioned as a separate project under Component 1. After initiating the component in 2006 it was found during regional consultation meetings on a concept note and potential implementation arrangement in August and September 2006, that the MRC Member Countries re-confirmed their interest and support in Component 3, that mediation was considered one of the many important dispute resolution strategies that could be suitable for addressing differences related to trans-boundary flood issues, but that there was a need to equip the MRC with a variety of resolution tools. In addition, the MRC Member Countries commented that some outputs in the original document were too ambitious and many not suitable, while the heavy focus on dispute resolution has detracted from the primary objective of the 1995 Mekong Agreement to promote and enhance cooperation in developing and using water and related resources in the Mekong River Basin. The need for the establishment of a special Mediation and Coordination Section (MSC) as a 'permanent' section under International Cooperation and Coordination Section (ICCS) at this stage of developments was questioned by the MRC Member Countries. Besides such a MCS would not pertain to trans-boundary flood issues only, but would facilitate trans-boundary issues, differences and disputes in all sectors. It was seen as useful to clarify the role of the Mekong River Commission Secretariat (MRCS) to support the MRC Member Countries through the provision of 'good services' and thereby assist the Joint Committee in its dispute resolution role. MRC Member Countries recommended facilitating cooperation following a technical approach at the outset, while to address administrative issues in a later phase. The focus would be restricted to flood issues, arising from structural measures, as land use change impacts were considered too complicated. These approaches have been embedded in the revised Component 3 design and did create well-defined conditions for producing the three main outcomes/goals.

IMPLEMENTATION METHODOLOGY

The implementation of Component 3, given its character of dealing with national perspectives within the regional context, has been initiated through a series of arrangements, carried out by national experts for the compilation of national data and information. That groundwork was followed-up by international experts, which were well informed about the background, status and expectations of the Mekong River Commission and the Mekong Agreement 1995. Selective contracting of individual experts was instrumental for designing tailor made products. The only elements which were contracted through an international bidding process formed the Capacity Building Programme. The Capacity Building Programme was designed to be implemented in three consecutive phases. Phase 1 and 2 to be implemented under the Flood Management and Mitigation Programme (FMMP) 2004-2010. Phase 3 is expected to be implemented after 31 December 2010.

Phase 1 was considered a pilot phase. In 2009, under Phase 1, three workshops were conducted as well as three Exchange Study Visits, respectively to the Border Area of Viet Nam and Cambodia, to the Rhine River and the Meuse River commissions in Europe and the Yangtze Water Resources Commission in China. Phase 1 aimed at the target groups of high-level decision-makers and mid-level professionals of the four MRC Member Countries. In Phase 1 the cooperation has been structured with educational institutes/centres in the Mekong region for embedding and thereby creating possibilities for sustaining the capacity building and training

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capabilities. Training specialist of these centres participated during Phase 1.

Phase 2 will be an improved and upgraded 'repetition' of Phase 1 and limited to three Training Workshops (no Exchange Study Visits). Under Phase 2 the curriculum developed under Phase 1 will be adjusted based on a thorough analysis of the 'lessons leant' of Phase 1. Some lectures of the Capacity Building Programme will be presented by training specialists from the educational institutes/centres, thereby enabling the group of trainings specialists to disseminate the curriculum in future under Phase 3 (and thereafter).

Phase 3 will be using the curriculum in a national context in each of the MRC Member Countries. The training specialists from the national educational institutes/centres will be well positioned to provide training and capacity building at the national levels. Teaching materials will be translated into the riparian languages. The curriculum has been set-up in modules and can be combined to serve the needs of specific target groups. It is anticipated that Phase 3 will be implemented in the period 2011-2015 under FMMP Phase II.

REVISED DESIGN OF COMPONENT 3 OUTPUTS

The position of the MRC Member Countries about Component 3 design was to take a holistic view regarding the implementation process, providing focus to three goals/outputs: 1) information generation, 2) awareness raising, knowledge and skills building, and 3) toolbox development. Under each of these goals/outputs a number of activities had been designed to achieve the outputs. The Component 3 products, which have been accomplished by the FMMP will be listed under the various activities to represent the progress to date. Likewise it informs stakeholders regarding the products of Component 3, which are considered not only relevant for FMMP, but for many other disciplines as well. Details of the three outputs are presented in Figure 1.

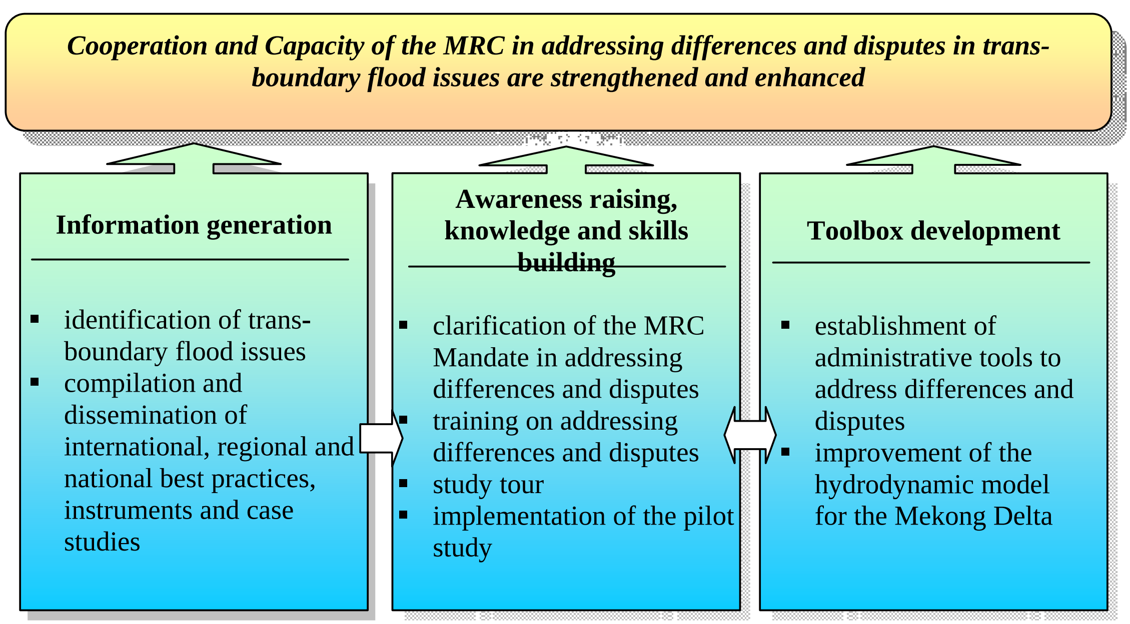

Figure 1. Details of the three outputs of Component 3

IMPLEMENTATION PLANNING

The revised Component 3 Document was endorsed on 13 November 2007 during the Fourteenth Meeting of the MRC Council in Siem Reap, Cambodia (Figure 2).

Activities had been initiated already after the decisive regional meeting on 19 October 2006 in Ho Chi Minh City, Viet Nam. However, these were limited to activities, which would not be impacted negatively by any later formal decision. From November 2007 onwards, after the Council's endorsement, all activities were guided by the revised design of Component 3. The activities under Component 3 were initiated mid 2006 and will be completed by the end of 2010. At the 8th Annual Mekong Flood Forum 2010 in Vientiane the overview of the achievements and products will be presented, as well as some early 'lessons learnt' of the implementation process.

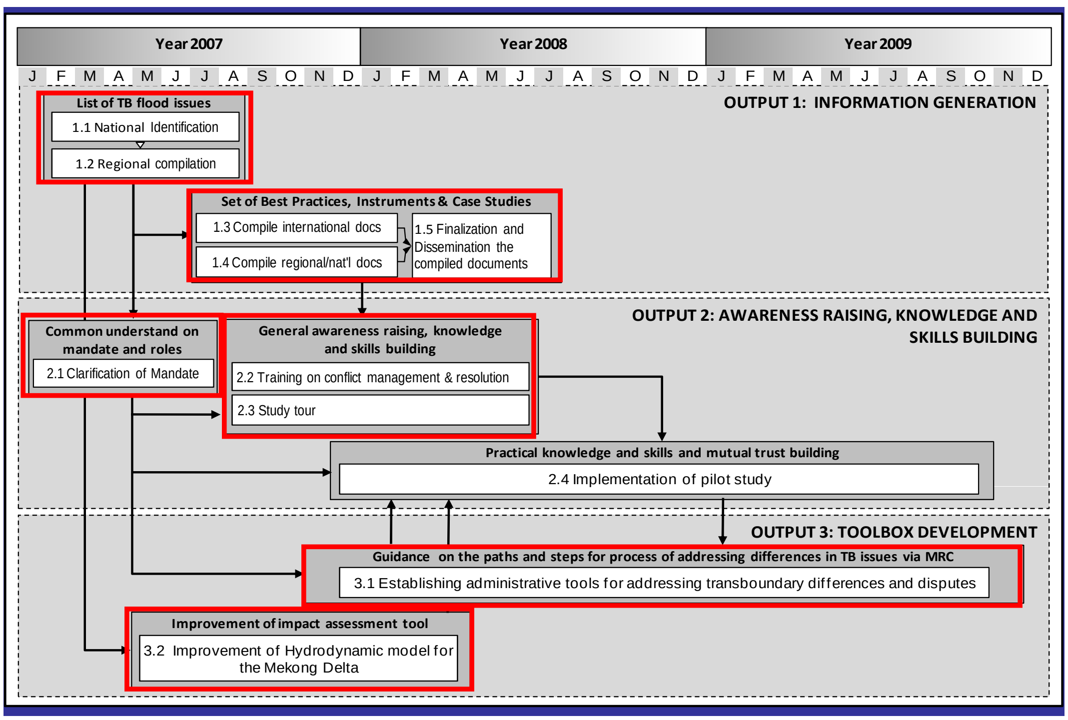

Figure 2. Progress implementation FMMP Component 3

IMPLEMENTATION PROCESS

Given its characteristic of addressing 'trans-boundary' issues, the programme has applied a strong participatory approach in its relation with the MRCS and the MRC Member Countries. The participation of MRC Member Countries during national and regional consultation included representatives of the National Mekong Committees, representatives of the Ministries/ Departments dealing with water resources and/or flood management, as well as representatives from the Ministry of Foreign Affairs. In some cases separate technical meetings were organized with representatives of the MRC Member Countries to review and assess documents prior to Regional Consultation Meetings. The technical meetings turned out to be very instrumental to reach consensus/agreement on the many technical issues, allowing the Regional Consultation Meetings to focus and agree on the policy issues. From the outset mid 2006 MRC Member

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Countries have demonstrated a keen interest in the design, the structuring and the development of the Component 3 products.

IMPLEMENTATION MANAGEMENT

During the implementation of Component 3 two dedicated component managers have been managing the implementation of the Component. The first manager was contracted from 24 April 2006 to 30 April 2008. The second Component Manager took over on 13 November 2008 until 13 October 2009. Component Manager, Programme Coordinator and Chief Technical Advisor have been working closely together during the implementation process given its complexity and sensitivity. Considering the pros and cons[8] of selecting a new Component Manager, it was concluded that the selection of a new Component Manager would not be efficient in terms of progress and process, while it would also not being cost effective. Therefore the Programme Coordinator and the Chief Technical Advisor have been directly responsible since mid October 2009 for the implementation of Component 3.

THE PRODUCTS

The goals/outputs, which have been indicated in Figure 2 have been gradually developed; all but one goals/outputs have been achieved. The remaining goal/output to be achieved relates to the implementation of the Capacity Building Programme, Phase 2. The completed products will be listed hereafter.

Information generation

National identification of the trans-boundary flood issues

National experts have compiled the national reports on '*Identification of TB Flood Issues at National Level*' during the period of April – June 2007, which were completed in August 2007. The national reports were routed to FMMP through the respective National Mekong Committees. The findings of the reports have been summarized and incorporated in the Annex 1 of the Working Paper '*Trans-boundary Flood Issue Identification*', January 2008.

> An interesting finding was that MRC Member Countries have developed a number of Bilateral Technical Cooperation Committees (for instance Lao PDR - Thailand and Cambodia - Viet Nam) as practical mechanisms to prevent and address trans-boundary flood issues.

Regional compilation of the trans-boundary flood issues

FMMP with support of an international consultant developed the regional perspective of trans-boundary flood issues, titled: '*TB Flood Issue Identification*'. This report was based on the national perspectives. The regional compilation was discussed during national and regional consultation meetings held in August/September 2007. The report was endorsed later by the MRC Member Countries in January 2008 as a Working Paper.

Key outcome was the identification of six groups of trans-boundary flood issues by the

[8] The reasoning was that FMMP could only offer a limited contract period to a suitable candidate, as the FMMP is finishing by the end of 2010. Apart from that the involvement of a new Component Manager would require a detailed briefing on the delicate subject of trans-boundary flood issues, while such a briefing in steps would consume a lot of time, while a new Component Manager would anyway need continued guidance.

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MRC Member Countries.

Group 1:	Issues related to floodplain developments within the Mekong Delta
Group 2:	Issues related to impacts of LMB upstream developments on the Mekong Delta
Group 3:	Issues related to impacts of upstream hydropower development in the Upper Mekong Basin on the LMB
Group 4:	Issues related to hydropower development and operation in the Se San, Srepok, and Se Kong river basins
Group 5:	Issues related to bank protection and port development; sand excavation; dam-operation communications in upper reaches of the Mekong mainstream
Group 6:	Issues related to increased floods on tributaries in northwest Cambodia

Compilation of international best practices, instruments and case studies relating to Inter-State differences and disputes over TB watercourses

Report of international best practices, instruments and case studies relating to inter-state differences and disputes over trans-boundary watercourses was developed during the period of 2008-2009 by FMMP through involvement of a senior international legal expert. Summaries of these reports were incorporated in Chapter 3 of the Explanatory Note- Supporting Document to the Working Paper '*Legal Aspects of the Mandate of the 1995 Mekong Agreement for Enhancing Cooperation in Addressing Trans-boundary Flood and Related Issues*' of December 2009.

> Appendices 1, 2 and 3 of the Explanatory Note consist of three volumes of annexes on International, National and Regional Best Practices, Instruments and Case Studies. The Explanatory Note and Appendices are available in hard and soft copies.

Compilation of National and Regional best practices and instruments to address Inter State differences and disputes over natural resource management

FMMP, supported by a senior international legal expert developed the compilation of national and regional best practices and instruments to address inter-state differences and disputes over natural resource management. The regional best practices are incorporated in Chapter 3 of the Explanatory Note-Supporting Document to the Working Paper '*Legal Aspects of the Mandate of the 1995 Mekong Agreement for Enhancing Cooperation in Addressing Trans-boundary Flood and Related Issues*' of December 2009.

> Appendix 3 presents the National reports. These National reports provide overviews of the legal frameworks, instruments and best practices to prevent and address trans-boundary flood issues and issues related to natural resource management.

Finalization and dissemination of the compiled best practices and instruments

The compilation of 'Best practices and instruments' was incorporated in the '*Explanatory Note'* - Supporting Document to the Working Paper: '*Legal Aspects of the Mandate of the 1995 Mekong Agreement for Enhancing Cooperation in Addressing Trans-boundary Flood and Related Issues*' of December 2009. Its annexes provide the details of the national, regional and international perspectives. The Working Paper and Annexes have been disseminated to MRC Member Countries and MRCS and MRC Programmes in hard and soft copies.

Awareness raising and knowledge and skills building

Clarification of the MRC Mandate in addressing differences and disputes

Already in early 2006 FMMP with support of an international legal expert drafted a concept of the Mandate of the 1995 Mekong Agreement. However, the approach under the original Component 3 document was not successful. After revision of the Component 3 document, the FMMP used the guidance of the MRC Member Countries to develop the structure and content of the MRC Mandate Working Paper. Four national consultation meetings in August 2007 and two Regional consultation meetings were conducted, applying a step-by-step development of the comprehensive Working Paper, titled: '*Legal Aspects of the Mandate of the 1995 Mekong Agreement for Enhancing Cooperation in Addressing Trans-boundary Flood and Related Issues*' of October 2007.

An Explanatory Note was developed at the request of the MRC Member Countries to facilitate better understanding of the Mandate Working Paper: '*Explanatory Note*', Supplement to the Working Paper on the Legal *Aspects of the mandate of the 1995 Mekong Agreement for Enhancing Cooperation in Addressing Trans-boundary Flood and Related Issues, Feb. 2010 (Working Paper).* This 'Explanatory Note' was developed in stages during 2008 and 2009.

After the approval of the 'Explanatory Note' MRC Member Countries requested to provide a so called 'Pocket Version', which would enhance the awareness and understanding of addressing the trans-boundary flood issues through a very practical, easily accessible booklet. The booklet will be shared with the MRC Member Countries in May 2010.

> The Mandate Working Paper states, that: '*it is recommended that the role and input of the MRCS be clarified and elaborated on to not only include facilitation of the process of identifying, addressing and resolving incidents of contentious issues, differences or disputes, but also to have a responsible role and function to keep records and issue timely reports (if more than annual reporting to the Joint Committee (JC)) of the nature and timeline of the incident, analyses of incidents, resolutions and terms, and monitor data and information to facilitate knowledge of the parties that the resolution agreed upon is working satisfactorily and sustainably for the concerned parties and the MRC in general. It is recommended to effectively carry out this function a position/post be created or expanded upon to serve as the focal point within the MRCS on identification by other MRCS staff, posts or programmes; informing the Office of the Chief Executive Officer (OCEO) of an MRCS anticipated or actual incident, facilitating the JC and concerned parties through coordination within proper units of the MRCS, and recording, reporting and monitoring of incidents and resolutions. An additional function of this post would be to prepare standardized format and forms for notification, acknowledgement, addressing and resolving incidents for use by the MRC, National Mekong Committees (NMC) and MRC Member Countries.'*

Training on addressing differences and disputes

Already in November 2006 FMMP and Environmental Cooperation Asia (ECO-ASIA), funded by U.S. Agency for International Development (USAID), established a relationship for the implementation of the Joint Programme of Cooperation: '*Trans-boundary Conflict Prevention and Management in the Mekong*' and a linkage with Component 3 of FMMP. The USAID programme was designed for all MRC Programmes and NMCs addressing '*Trans-boundary Waters Conflict Prevention and Management*' and would be implemented over a period of 24 months. Cooperation between ECO-ASIA and FMMP led to a joint implementation plan, whereby the ECO-ASIA would lay an important foundation for the later curriculum to be developed on trans-boundary flood issues. Ideas were developed on the structure of teaching

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modules, so these would become ‘interchangeable’ for compiling dedicated curriculums for specific target groups. A regional training, funded by ECO-ASIA with participation of FMMP was conducted in Bangkok 29-30 May, 2008. Unfortunately due to a re-shuffling of priorities, the ECO-ASIA cooperation programme with MRC was not continued.

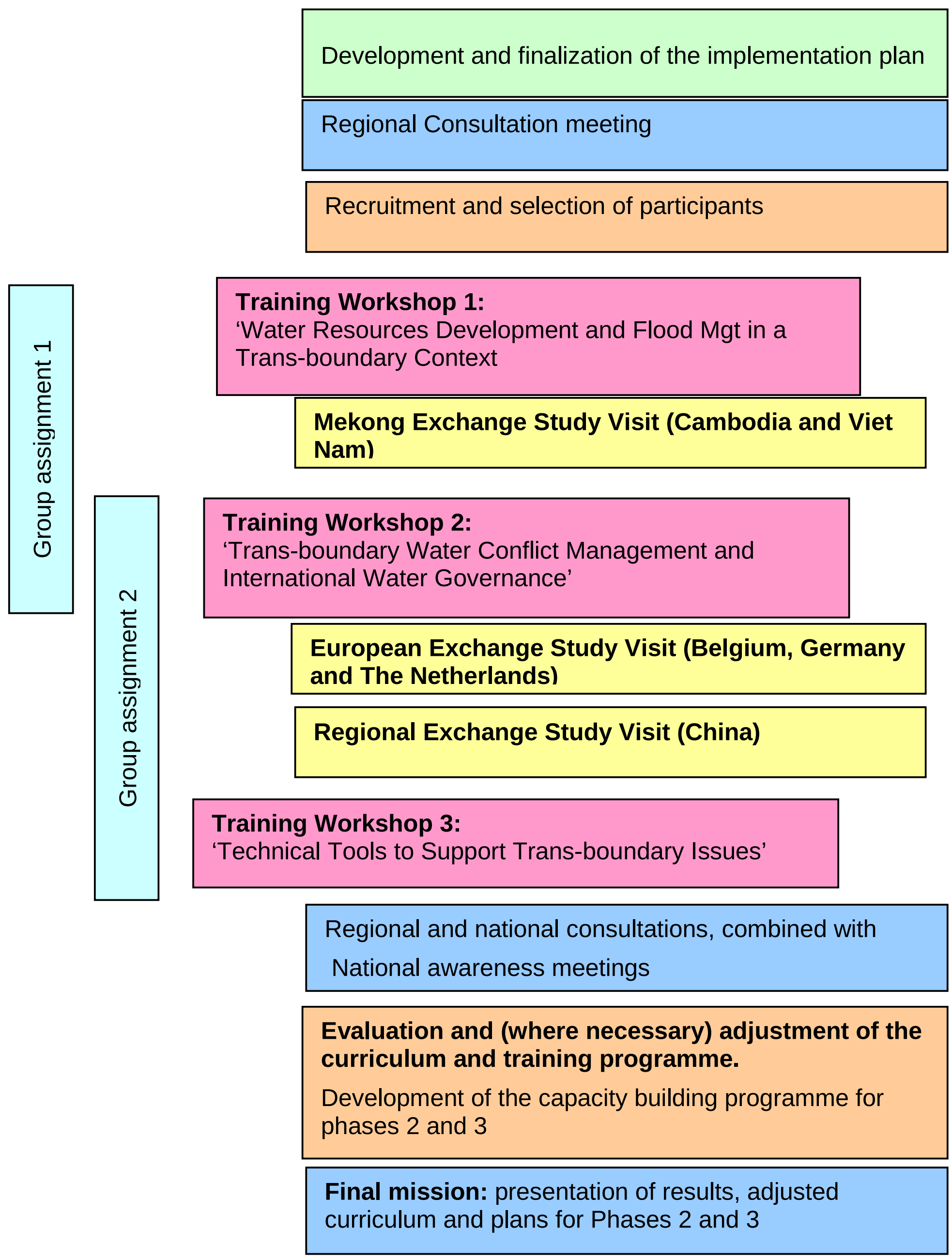

Figure 3. Structure of the Capacity Building Programme Phase 1

In December 2007 a technical brainstorm meeting with experts from the MRC Member Countries was conducted in Bangkok to inform the Capacity Building Programme, Phase 1, for

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Component 3. This meeting was instrumental in defining content and structure of the programme. It was also agreed to apply an international bidding procedure among interested specialist agencies/institutes. After subsequently launching the Expression of Interest (EOI) and the Request for Proposal (RFP) in the first quarter of 2008 a contract was arranged with UNESCO-IHE by the end of March 2008. Implementation was scheduled over a period of 9 months, between July 2008 and March 2009. The actual implementation was completed by November 2009, as a result of rescheduling of Exchange Study Visits and connected Training Workshops.

The UNESCO-IHE proposal, titled: '*Anticipating and Resolving Flood Issues, Differences and Disputes in the Lower Mekong Basin*' was implemented through three Training Workshops and three Exchange Study Visits.

- Training Workshop 1 '*Water Resources Development and Flood Management in a Trans-boundary Context*' was conducted in the Water Resources University, Ho Chi Minh City, Viet Nam, in the period 3-7 March 2009 (Lecture Notes, Presentations and Hand-outs Part 1 and 2 made available). The structure of the Capacity Building Programme Phase 1 is shown in Figure 3.

> Learning objective TW1:
> *Participants will develop a shared understanding of key Integrated Water Resources Management (IWRM) and Flood Management concepts, with a particular focus on the Mekong River Basin, and will be able to:*
> - *demonstrate a good understanding of key river basin management concepts including upstream-downstream interactions and asymmetries, benefit sharing, and the payment of environmental services;*
> - *demonstrate a good understanding of key flood management concepts, including mitigation of flood risks and damages, uncertainties and reducing flood vulnerability;*
> - *understand the need for trans-boundary cooperation and coordination in sustainable river management.*

- Training Workshop 2 '*Trans-boundary water conflict management and international water governance*', was conducted in the Mekong Institute, Khon Kaen, Thailand, 3 - 10 June 2009 (Lecture Notes, Presentation and Hand-outs; '*Enhanced Negotiation Skills and Dispute Resolution of International Water Resources*' made available)

> Learning objective TW2:
> *Participants will increase their ability to solve complex water problems by enhancing their negotiations and conflict resolution skills, and will be able to:*
> - *demonstrate a good understanding of key concepts and methods related to complex problem solving and conflict resolution to water;*
> - *understand legal and non-legal means to resolve and prevent water disputes;*
> - *improve their understanding of their national water management challenges from a river basin perspective;*
> - *improve their personal problem solving and negotiation capacity.*

- Training Workshop 3 '*Technical tools to address trans-boundary issues*', was conducted in the Lao-Japan Human Resource Cooperation Centre, National University of Laos, Vientiane, Lao PDR, in the period 16-20 November 2009 (Lecture Notes, Presentations and Hand-outs Part 1 and 2 made available).

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Learning objective TW3:
Participants will be able to:
- *describe the role of technical tools in the process of addressing, mitigating and resolving issues, differences and disputes;*
- *understand the main technical tools available at MRC and its member countries and what role they could play in the process of addressing, mitigating and resolving issues, differences and disputes;*
- *select and apply some appropriate technical tools that support the process of addressing, mitigating and resolving issues, differences and disputes in the LMB;*
- *reflect on the conditions needed for a successful application of these technical tools in the Lower Mekong River Basin context.*

A regional consultation meeting on the draft Detailed Implementation Plan of the Capacity Building Plan Phase 2, has been conducted on 29 March 2010. During that meeting consensus was reached on the Phase 2, particularly regarding the design and implementation of the Pilot Study. The Capacity Building Plan Phase 2 will be implemented by UNESCO-IHE and will basically cover the period June - December 2010. However an extension after 31 December 2010 may be required.

Exchange study visits

As part of the Capacity Building Programme Phase 1, Exchange Study Visits have been conducted. The Mekong Study Tour was implemented in the period 8-11 March 2009; exchanges took place with experts and visits were made to the Cambodia and Viet Nam border zone. The report on the Mekong ESV is available.

Main findings of the Mekong Exchange Study Visit:
- Cambodia and Viet Nam conduct regular bilateral meetings to agree on the flood managing; this is especially related to the opening of the rubber dams by Viet Nam in accordance with the agreement;
- Cambodia and Viet Nam are keen to maximize agriculture production and are therefore closely depending on each other, especially in the Cambodia-Viet Nam border zone;
- both in Viet Nam and Cambodia works are being carried out to improve irrigation, drainage and flood protection in agriculture areas.

The European Study Tour was conducted in the period 7-17 September 2009; exchanges took place with experts and visits were made among others to the International Commission for the Protection of the Rhine (ICPR) and the International Meuse Commission. A report on the Europe Exchange Study Visit is available.

Main findings of the European Exchange Study Visit:
- the mission was most interested in the organization of the Rhine Commission, as the Commission had few staffs; vacancies were open for all citizens of the Member Countries; most of the work was carried out by line agencies of the Member Countries.
- the European Flood Directive is an instrument that facilitates trans-boundary coordination and cooperation between Member Countries on flood risk reduction projects, as the ‘coordinated’ trans-boundary projects may be eligible for European Union (EU) subsidies;
- participants were impressed by the cross border navigation on the EU rivers without any direct customs / immigration involvement.

The Regional Study Tour was implemented in the period 12-17 October 2009; exchanges took place with experts and visits were made to the Yangtze Water Resources Commission, Wuhan, and the Provincial Water Resources Departments of Hubei and Hunan. The report on the China

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Exchange Study Visit is available.

Main findings of the China Exchange Study Visit:

- China considers flood control and flood management the top priority for the Yangtze River Basin. The Changjiang (Yangtze) Water Resource Commission (CWRC), Hubei and Hunan Water Resources Departments (WRD) have therefore the resources, including multiple technical tools (extensive data collection and suites of hydrologic- and hydrodynamic models) to anticipate, analyze, evaluate and respond to flood situations, and carry out flood damage assessment;
- the entire decision-making process at times of extreme flood situations in the Yangtze River Basin is linked for synchronized decision-making (Provincial DWRs, CWRC and the State Flood Control and Drought Relief Headquarter);
- although there are many commonalities in terms of approaches, methodologies, and flood characteristics (Tonle Sap Great Lake in Cambodia and Dongting Lake in Hunan province) the delegation observed that with the magnitude and complexity of floods in the Yangtze River Basin, the population and economic interest at risk, are significantly higher than in the Mekong River Basin.

Implementation of the Pilot Study

The Pilot Study will be implemented in the period May-December 2010 as part of the Capacity Building Programme, Phase 2.

Toolbox development

Establishing administrative tools for addressing trans-boundary differences and disputes

The administrative tools for application under the Mekong Agreement 1995 have been presented in the report: '*Legal Aspects of the Mandate of the 1995 Mekong Agreement for Enhancing Cooperation in Addressing Trans-boundary Flood and Related Issues*' of October 2007 (Working Paper).

Assessment of the needs and suitability of technical tools for facilitating the process of addressing trans-boundary flood issues, differences and disputes

Technical tools have been presented in the course material of Training Workshop 3. However, these tools were considered rather general, not specific enough for the application under the Mekong Agreement 1995. For that reason a document has been drafted called: '*A Framework for Addressing and resolving Trans-boundary Flood Issues: Synthesizing FMMP Outputs'* (draft) of March 2010. This document, which has been developed based on the findings of Training Workshop 3 in Lao PDR, has been drafted by FMMP with support of the senior international legal expert. So far this document has an internal FMMP status, and has not yet been shared with the MRC Member Countries.

Improvement of hydrodynamic model for the Lower Mekong River Basin

As part of this activity an international modelling consultant was requested to look into possible short, medium and long-term improvements of the ISIS model application for the Cambodian floodplain and the Mekong Delta. The findings are presented in the report: '*Review and Proposals for Enhancement of Hydrodynamic Models*', July 2007, JBA Consulting, Wallingford, United Kingdom.

Component 3, focusing on the possible short-term improvements, identified the need for topographic and hydrographic surveys in selected areas in the Cambodian floodplain. Through cooperation with the Department for Hydrology and River Works of the Ministry of Water Resources and Meteorology in Cambodia surveys were conducted. The results were incorporated in the ISIS model schematization for the Cambodia floodplain. The modification of the schematization led to calibration problems, causing substantial delays in the presentation of the final report. The findings were presented in the report: '*Enhancement of Lower Mekong ISIS Hydrodynamic Model*', September 2008, JBA Consulting, Wallingford, United Kingdom.

It was until the Component 2 Consultants used ISIS for model application for different frequencies of floods that the model problems were identified once more. The Consultants noted more than 200 locations with instabilities in the water levels, which was caused by wrong connections and nodes. The modelling problems were crucial for the Component 2 development of Demonstration Projects and were taken up with the full support of the MRCS. Information and Knowledge Management Programme (IKMP) provided support over a period of roughly three months to find the cause of the problems, to rectify and test the model schematization. Thanks to this support Component 2 could provide most of the contracted deliverables. The problems encountered under Component 2 led to substantial improvement of the ISIS model applications.

The latest version of the improved ISIS model application for the Cambodian floodplain and the Mekong Delta used under Consultancy Services Component 2 (baseline version) is: ISIS_LMB-2210 DAT-file, dated 03.11.2009.

Capacity building programme phase 2 and pilot study

The major challenge for Component 3 was the design and implementation of a Pilot Study. The pilot study has been presented in the design of the Capacity Building Programme Phase 2, which is scheduled for implementation in the period May - December 2010. Even though there have been different ideas about the concept of the Pilot Study, it has been accepted by the MRC Member Countries to effectively work out one pilot study. Given the complexity and financial implication of a pilot study, it was agreed during a Regional Consultation Meeting on the Detailed Implementation Plan for the Capacity Building Plan Phase 2, that one case would suffice testing of the administrative process and available technical tools. The present concept is defined as an imaginary case for floodplain conditions, comparable to those in the LMB. The physical flood related and socio-economic situation of the LMB has been incorporated to the extent possible in the imaginary case. A hydrodynamic model is available to simulate various flood frequencies and damage statistics. The cause of additional flood damages is due to 'structural measures', while options for mitigation of the additional flood damages are available with different effectiveness and at different costs levels. Participants will play different roles. The Mekong Agreement 1995 will be used for the administrative process and the MRCS tools and other tools have been made available. The Pilot Study needs to be solidly prepared; its success will depend on the build-in challenges, but also the commitment and the active involvement of participants. As such the Pilot Study will be unique in character. A report will be produced on the Pilot Study design soon. A report will be made after conducting the Pilot Study to describe the experiences during its implementation and an assessment of its usefulness for training and capacity building for MRC circumstances. The Pilot Study will include the application of administrative tools and technical tools, allowing adjustment and refinement. With the completion of the Pilot Study, the refinement of and reporting on the administrative tools and technical tools, the FMMP Component 3 will be completed.

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LESSONS LEARNT

Finally some lessons learnt of the implementation of Component 3:

a. from the beginning MRC Member Countries showed keen interest in the development of Component 3 through their national contributions and active involvement in screening processes of the preliminary products and documents;
b. the modification of the design of Component 3 has been very beneficial to the modality of cooperation between MRCS/FMMP and the MRC Member Countries;
c. the recommendation to initiate awareness raising and capacity and skills building, to clarify the administrative tools secondly and to enter into the application of technical tools for trans-boundary impact assessment through a pilot study seems indeed to foster and strengthen cooperation between MRC Member Countries;
d. the MRC Member Countries consider the documents produced by Component 3 on the Mandate of the 1995 Agreement extremely relevant for floods, but consider this information just as relevant for other MRC programmes;
e. for some MRC Member Countries it was difficult to maintain the group of selected participants unchanged during the entire capacity building programme, phase 1. Therefore not fully benefitting from the course material;
f. the Exchange Study Visits to Europe and China generated substantial added value for the individual participants, as well as for the MRC as a whole;
g. under FMMP Phase 2 is recommended to further explore the tools for trans-boundary flood impact assessment, and to develop MRC accepted tools.

FUTURE EXPECTATIONS

The implementation period of FMMP 2004-2010 has shown a steep learning curve in identifying the flexibilities and options in the Mekong Agreement 1995 for the purpose of enhancing the cooperation between the MRC Member Countries in fields relevant for the economic development and prosperity of the people living in the Lower Mekong River Basin and the Mekong River Basin at large.

The products, such as reports, training modules, and documented experiences, developed under Component 3 of the FMMP will serve the MRC Member Countries now and in future to cooperate, manage and mitigate trans-boundary flood impacts. MRC has entered into a phase of development, where substantial improvement of the modelling toolbox is required and technically possible. It is envisaged that over the next 4-5 years the level of detail of trans-boundary flood impact assessment can be significantly enhanced. This should not be considered as a threat. Creating more openness on technical alternatives, sharing of development scenarios like under Basin Development Plan (BDP) and FMMP will lead to more awareness, a better understanding and sustainable cooperation between the MRC Member Countries. Under a second phase of FMMP after 2010 FMMP in close cooperation with IKMP and the MRC Member Countries, may therefore improve the quality of trans-boundary flood impact assessment. This is not only required in the context of trans-boundary cooperation, but a need to identify the impacts of climate change and develop smart small-scale and large-scale adaptation options. The Capacity Building Programme Phase 3 may build further Phase 1 and Phase 2 and may sustain the national and regional training expertise and capabilities in addressing trans-boundary flood issues, difference and disputes.

Paper 2-5

FMMP COMPONENT 5 AND FLOOD INFORMATION BASED LAND MANAGEMENT (FIBLM)

MARTIN FALKE

GFA-Consulting Group
MRC Flood Management and Mitigation Programme, Land Management Component (FMMP-C5)
Regional Flood Management and Mitigation Centre (MRC-RFMMC), Phnom Penh, Cambodia

ABSTRACT

The Land Management Component of the Flood Management and Mitigation Programme (FMMP) commenced Phase 2 in August 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 flood plains of the Lower Mekong River Basin, particularly the production of flood probability maps (FPM in a scale of 1 : 10,000) 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, Lao PDR, Thailand, Viet Nam) for an improved 'Flood Information Based Land Management (FIBLM)'.

During 2009 country specific approaches on FIBLM - in line with national land use planning practices - were jointly finalized and the required infrastructure implemented by the respective national line agencies in seven pilot districts in the four member countries. A total number of 107 flood marks and 28 flood forecasting billboards were established in all of the pilot districts. Communities have been equipped and trained concerning the flood mark readings and data transmission to the respective hydro-data processing and flood forecasting agencies, required as data collection for the FMMP Component 5 (FMMP-C5) FPM-production-software and as part of a revived (Cambodia) or newly established (Lao PDR, Thailand, Viet Nam) Early Warning System (EWS) on district and commune level. All such activities received media coverage (press and radio) in the four Member Countries.

After the 2009-flooding season the subsequent data analysis and processing for the FPM-generation resulted in the following:

In Cambodia the trained staff of the Department of Hydrology and River Works (DHRW) upgraded the existing FPM and a strong project focus (by conduction of a National Working Group-Meeting and several trainings for Line Agency (LA) staff) was put on the distribution and use of the FPM in Land Management by the respective Line Agencies on national, provincial and district level. Concerning the future, sustainable use of the FMMP-C5-approach in a flood information based Land Management, additional success has been achieved by the fact that the Land Management Department of the Royal University of Agriculture (RUA) in Cambodia could be convinced to implement the FMMP-C5 TOT-Curriculum (including all existing, readily available and translated FMMP-C5 education materials) into their university teaching plan. University-students and -staff as well as Line Agencies (on National, Provincial- and District/ Commune - Level) have been trained by FMMP-C5 on the FPM-Use in Land Management (up to now 142 participants trained in total in Cambodia on FPM-production - and -use during Phase 2 of FMMP-C5). For these training purposes FMMP-C5 developed small

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pilot projects concerning the FPM-use in Land Management and Land Use Planning - in cooperation with Line Agencies (on National, Provincial and District/Commune Level) and the Land Management Department of the Royal University of Agriculture/Phnom Penh -, showing appropriate Land Use Zoning for Land Management and Agricultural Cultivation (including irrigation suggestions), vulnerable villages plus proposed safety areas and escape routes for Disaster Management in the communities as well as suitable infrastructure design and locations for the two FMMP-C5 pilot districts in Cambodia.

The project status concerning the FMMP-C5-approach in Lao PDR, Thailand and Viet Nam is the following:

The FMMP-C5-FPM-production (plus Training of Trainers (TOT) trainings based on this) is only possible for the FMMP-C5 pilot districts in Viet Nam, but not for the FMMP-C5 pilot districts in Lao PDR and Thailand (apart from the lack of flood mark data, caused by the absence of flooding in 2009, mainly because ongoing man made influences and constructions making the statistics of the river levels unstable in those areas). The alternative solution could be the establishment of Flood Event Maps for the pilot districts, but this would require an additional major project input (including hydraulic modelling and Digital Terrain Model (DTM) Extension), which cannot be covered within the remaining time frame of FMMP-C5-Phase 2. Consequently no flood information maps, meant to be used in Land Management, can be produced for Lao PDR and Thailand during the reminder of Phase 2 of FMMP-C5**.** Nevertheless, Line Agency-Staff (5 participants each) from Lao PDR, Thailand and Viet Nam participated in a study tour to Cambodia (February 2010) and received FPM-production-trainings (March 2010), for Thailand and Lao PDR based on the Cambodia experiences and examples.

INTRODUCTION

The Land Management Component of the Flood Management and Mitigation Programme (FMMP) 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 flood plains of the Lower Mekong River Basin, 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, Lao PDR, Thailand, Viet Nam) for an improved 'Flood Information Based Land Management (FIBLM)'.

Given the different conditions in each of the four member states in terms of capacity and the 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, Lao PDR and Viet Nam and one in Thailand) along the Mekong and in the Mekong flood plains.

Current land management practices are an important factor in 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 impact through the reduction of damage to agriculture and infrastructure,

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but also indirect benefits through the avoidance of damage to the most vulnerable parts of the population living and working in the flood plains.

FMMP Component 5 (FMMP-C5) produces flood probability maps in a scale on 1: 10,000 or larger. Therefore the project intends 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.

BACKGROUND/ REVIEW OF FMMP-C5 (PHASE 1)/ METHODOLOGY

Phase 1 of FMMP-C5 (2004-2008) focused on the development of an approach to generate flood probability information for flood plains of the Lower Mekong Basin, particularly flood probability maps (FPM in a scale of 1: 10,000) in three pilot districts in Cambodia (Figures 1 and 2) (Kaesler, 2006 and Plinston, 2007).

Figure 3 shows the steps - including a correlation model relating flood mark and river level - used by FMMP-C5 in generating the information displayed in its flood probability maps (Figure 4). 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 2003 to 2006;
- data from a topographic survey of features and overall ground levels in the flood plains specifically commissioned for this purpose in 2006. The whole technical FMMP-C5 approach is explained in detail in Falke (2009) and Plinston (2009 a/b).

Figure 1. Examples of village flood marks used to record water levels on the flood plains (Cambodia).

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 Phase 2 data are used for 5 new districts in Lao PDR (Hatxayfong and Sikhottabong), Thailand (Si Chiang Mai) and Viet Nam (Tam Nong and Chau Phu);
- *type of statistic.* The following statistics can be mapped:
- probability of flooding;
- start of flooding;
- maximum depth 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.

Figure 2. Example of a flood forecasting billboard and an equipped observer (Viet Nam).

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.

While for the data processing ArcGIS is required (Figure 3), the resulting output files can be displayed as maps in any GIS platform (e.g. ArcGIS, MapWindow GIS, Quantum GIS).

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PRESENT STATUS OF FMMP-C5 (PHASE 2), DATA COLLECTION AND ANALYSIS, RESULTS

During 2009 country specific approaches on FIBLM - in line with national land use planning practices - were jointly finalized and the required infrastructure implemented by the respective national line agencies in seven pilot districts in the four member countries.

Detailed topographic surveys were required and conducted in Lao PDR and Thailand, while sufficient topographic data (= DEM/DTM) were available in Viet Nam.

A total number of 107 flood marks (Figure 1) and 28 flood forecasting billboards (Figure 2) were established in all of the pilot districts. Communities have been equipped and trained concerning the flood mark readings and data transmission (via cell phones) to the respective hydro-data processing and flood forecasting agencies, required as data collection for the FMMP-C5-FPM-production-software and as part of a revived (Cambodia) or newly established (Lao PDR, Thailand, Viet Nam) Early Warning System (EWS) on district and commune level. All such activities received media coverage (press and radio) in the four member countries.

After the 2009-flooding season the subsequent data analysis and processing for the FPM-generation resulted in the following:

In Cambodia the trained staff of the Department of Hydrology and River Works (DHRW) upgraded the existing FPM and a strong project focus (by conduction of a National Working Group-Meeting and several trainings) was put on the distribution and use of the FPM in Land Management by the respective Line Agencies on national, provincial and district level. Concerning the future, sustainable use of the FMMP-C5-approach in a flood information based Land Management additional success has been achieved by the fact, that the Land Management Department of the Royal University of Agriculture (RUA) in Cambodia could be convinced to implement the FMMP-C5-TOT-Curriculum (including all existing, readily available and translated FMMP-C5-eduction materials) into their university teaching plan. University-students and -staff as well as Line Agencies (National, Provincial- and District/ Commune - Level) have been trained by FMMP-C5 on the FPM-Use in Land Management, so that up to now 152 participants have been trained in total in Cambodia on FPM-production - and -use during Phase 2 of FMMP-C5. For these training purposes small pilot projects concerning the FPM-use in Land Management and Land Use Planning have been developed by FMMP-C5 - in cooperation with Line Agencies and the Land Management Department of the Royal University of Agriculture.

The status concerning the FMMP-C5-approach in Lao PDR, Thailand and Viet Nam is the following:

The FMMP-C5-FPM-production (plus TOT- trainings based on this) is only possible for the FMMP-C5-pilot districts in Viet Nam (Plinston, 2010a/b), but not for the FMMP-C5-Pilot districts in Lao PDR and Thailand (Plinston, 2010b), apart from the lack of flood mark data, caused by the absence of flooding in 2009, mainly because:

- the continual change in flood protection works means that the statistical description of river hydrographs is not stable;
- the MapStat-procedure is not applicable where the floodwaters are not related to river levels throughout the flood season.

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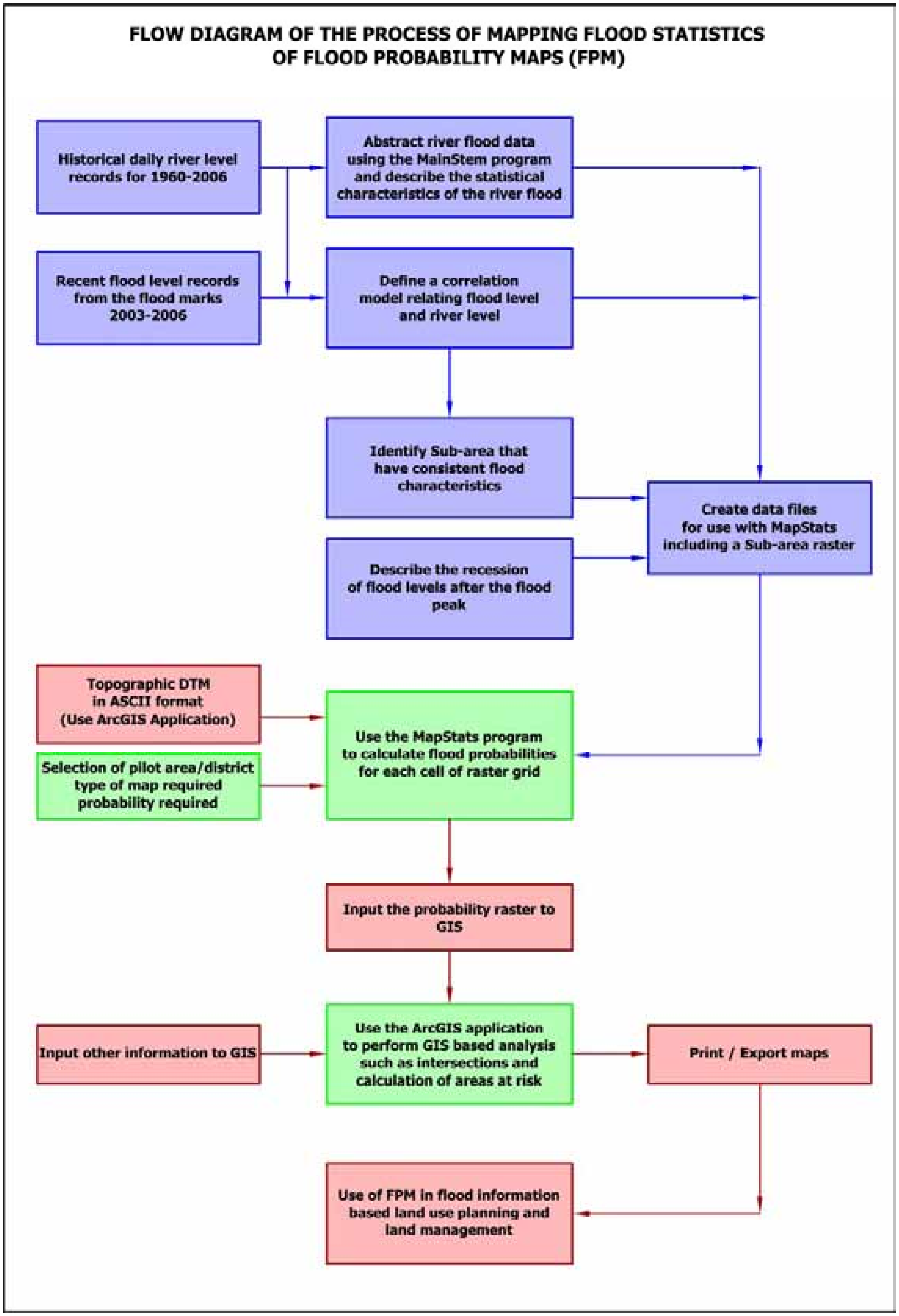

Figure 3. Outline of the approach used by Component 5 of FMMP to generate flood probability information and corresponding flood probability maps (FPM)

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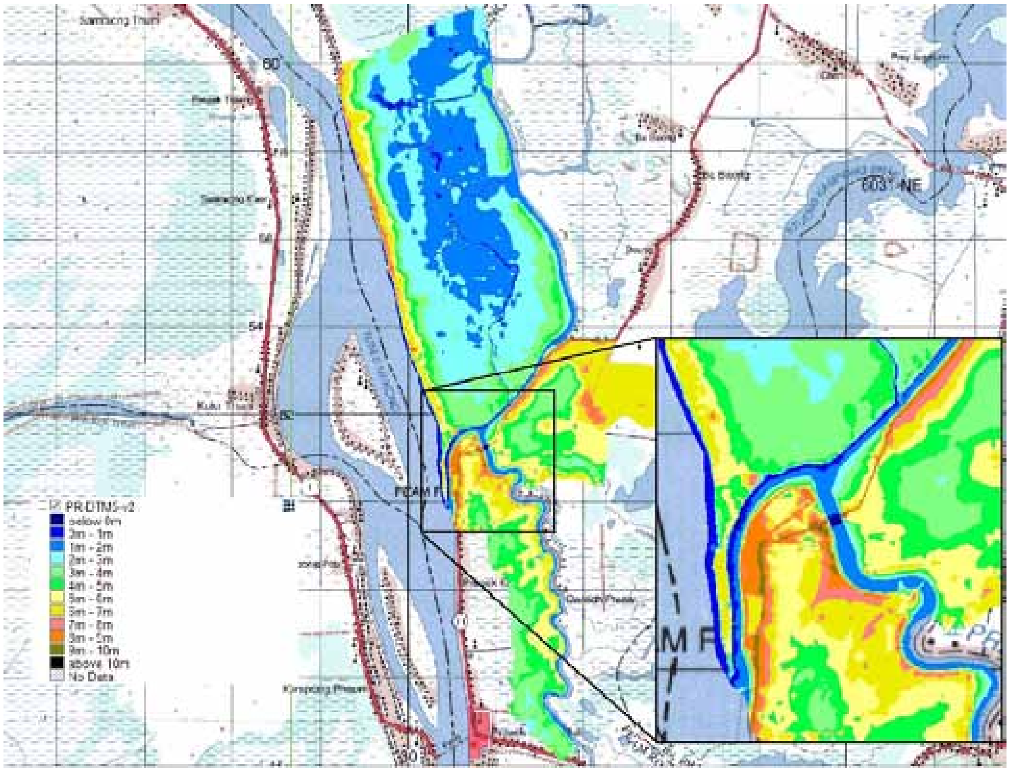

Figure 4. Example of a FPM based on a topographic raster file with a pixel size of 5 x 5 m (Peam Ro, Cambodia).

Due to that no flood information maps, meant to be used in Land Management, can be produced for Lao PDR and Thailand during the reminder of Phase 2 of FMMP-C5**.** Nevertheless, Line Agency-Staff (5 participants each) from Lao PDR, Thailand and Viet Nam participated in a study tour to Cambodia (February 2010) and received FPM-production- trainings (February/ March 2010), for Thailand and Lao PDR based on the successful Cambodia experiences and examples. For those FMMP-C5-TOT-Trainings (on GIS, Data processing and Data use) for Lao PDR, Thailand and Viet Nam three user manuals and one report (translated into the 4 riparian languages; Plinston, 2007; 2009a/b; 2010a) were updated and used as education material.

According to international standards of performance measurement, additional monitoring and evaluation (M&E)-activities are conducted by the 'Deutsche Gesellschaft für Technische Zusammenarbeit' (GTZ) and MRC and supported by FMMP-C5 as a contribution to overall quality management. The development and introduction of a results based monitoring system by GTZ-FMMP is linked to and in line with MRC activities of establishing its results-based M&E system. In October 2009 and March/ April 2010 monitoring was conducted for FMMP-C4 and FMMP-C5, which focused on the results as well as on the quality of both FMMP-components (GTZ-M&E-Reports December 2009 and May 2010).

USE OF FLOOD PROBABILITY MAPS (FPM) IN LAND MANAGEMENT/ RESULTS

A strong project focus was put on the distribution and use of the FPM in Land Management by the respective Line Agencies on national, provincial and district level in Cambodia.

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For training purposes small pilot projects concerning the FPM-use in Land Management and Land Use Planning have been developed by FMMP-C5 - in cooperation with Line Agencies (on National, Provincial and District/Commune level) and Land Management Department of the Royal University of Agriculture, showing appropriate Land Use Zoning for Land Management and Agricultural Cultivation (including irrigation suggestions), vulnerable villages plus proposed safety areas and escape routes for Disaster Management in the communities as well as suitable infrastructure design and locations for the two FMMP-C5 - pilot districts in Cambodia. These examples show the use of FPM in different Land Management Sectors as follows.

Flood conform policy formulation for flood plain management

As Figure 5 shows, the use of FPM (Probability of flooding, Maximum depth of flooding, Duration of flooding) in Flood Plain Management provides information concerning the identification of:

- Land Management Zoning with allowance and exclusion of certain activities (construction of commercial & residential buildings, agricultural plantation, fisheries, eco-tourism, road development, etc) and protection measures (e.g. for inundated forests, against soil excavation etc.);
- design characteristics for buildings (Minimum height, water proofing measures etc.);
- defining conditions for irrigation modernization/ rehabilitation and expansion.

Disaster management

As Figure 6 shows, the use of FPM (probability of flooding, maximum depth of flooding, duration of flooding) in Disaster Management Planning provides valuable information concerning the identification of:

- vulnerable villages;
- location of safety areas;
- location of escape routes;
- location of emergency food stores.

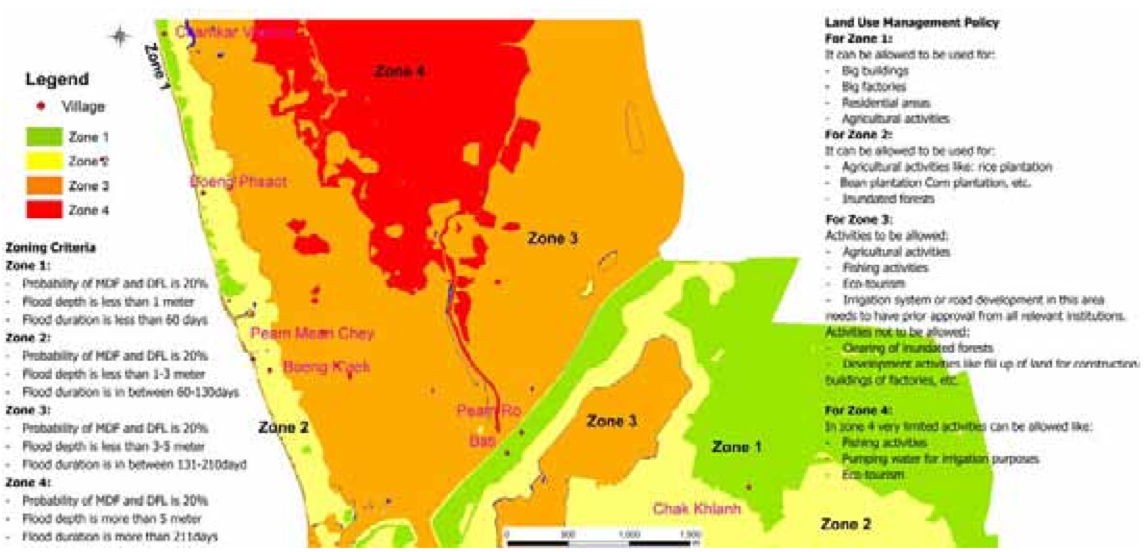

Figure 5. Land Management Zoning in a part of Paem Ro District/ Cambodia, using FPM-Information (mainly Maximum depth of flooding and Duration of flooding).

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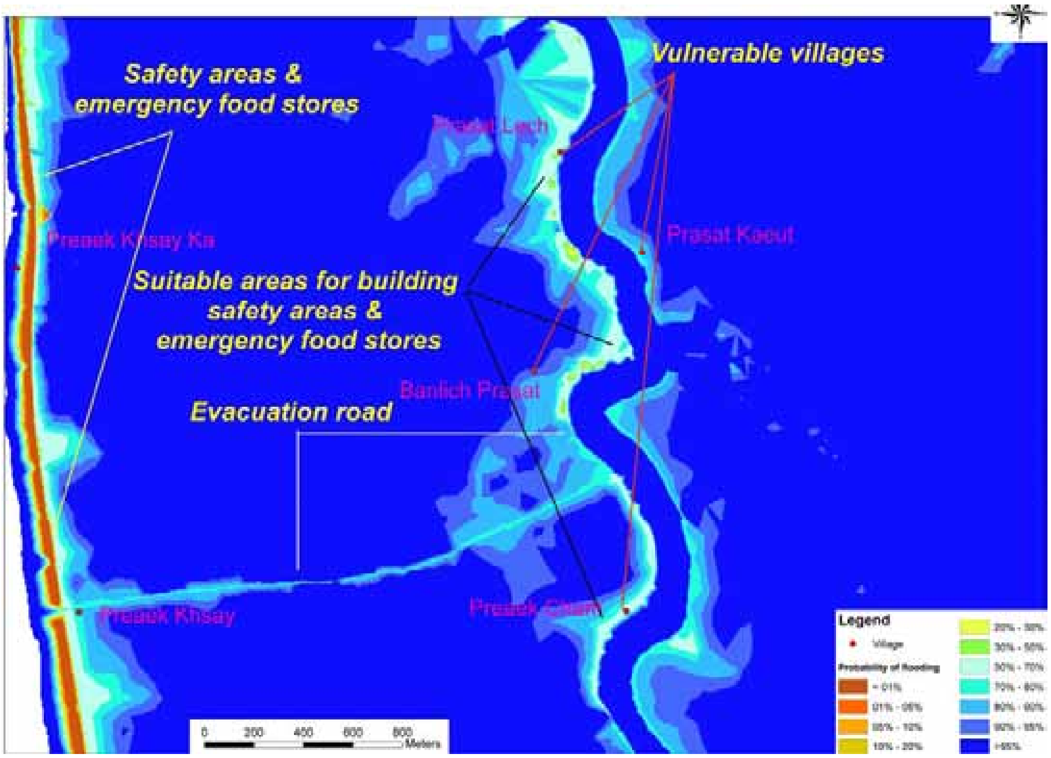

Figure 6. Disaster Management Planning with the FPM of Paem Ro District/ Cambodia, showing vulnerable villages plus proposed safety areas and escape routes.

Therefore the integration of FPM into Provincial and Communal Development and District Strategic Plans will result in an improved Flood Disaster Preparedness and Early Warning System with life saving effects for villages and communities and also allow a better quantification and assessment of anticipated flood impacts (= Risk Assessment).

Rural infrastructure planning and design

As Figure 7 shows, the use of FPM (Probability of flooding, Maximum depth of flooding) in Rural Infrastructure Planning allows a better flood adjusted planning and provides valuable information concerning the identification of appropriate design and location for roads, bridges, electricity networks and power lines, houses, schools, hospitals, safety areas, sanitation structures, waterways, water supply, etc. .

Irrigation planning

FPM (probability of flooding, maximum depth of flooding, duration of flooding, completion of draining) are crucial for the preparation of Irrigation Development Plans (District Master Plans) as well as for the categorisation and prioritization of irrigation schemes concerning their rehabilitation and potential modernization. Furthermore FPM can be used for the determination of the design of protection facilities of the schemes and a more appropriate system design (e.g. for more diversified cropping systems). Figure 8 shows an irrigation planning example from the FMMP-C5-Pilot District of Paem Ro/ Cambodia.

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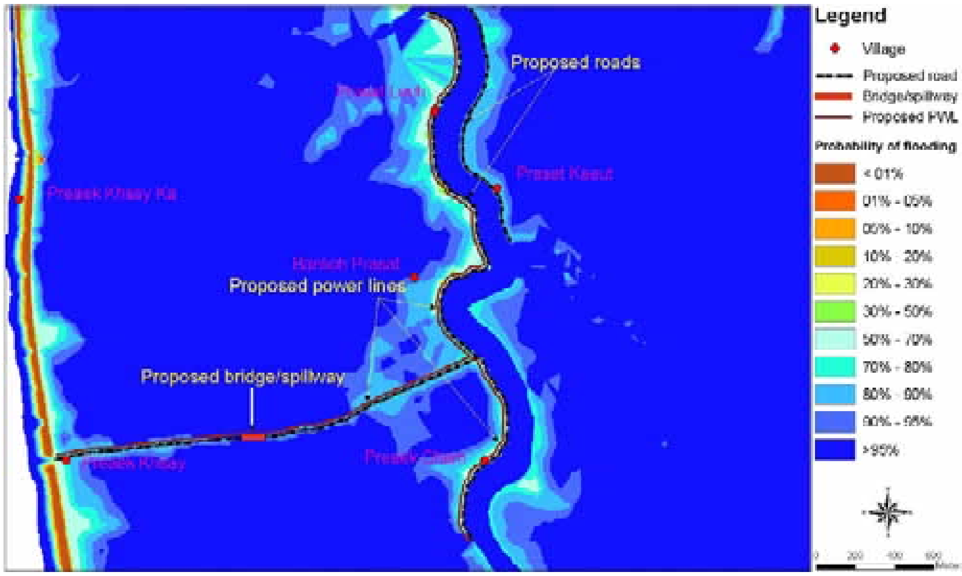

Figure 7. Infrastructure planning with FPM-information in a part of Paem Ro District/ Cambodia, showing a proposed alignment of a road and a power line in less flooded terrain.

Agricultural planning and programming

FPM (Probability of flooding, Duration of flooding, Completion of draining) facilitate the Elaboration of Communal-, District- and Agricultural Development Plans and are supportive to develop a more diversified cropping system.

As Figure 9 shows, the use of FPM in Agricultural Planning provides valuable information concerning the area-delineation (land use zoning) and schedules for the cultivation of different crops, in this case for different rice varieties, which can result in increase of yields.

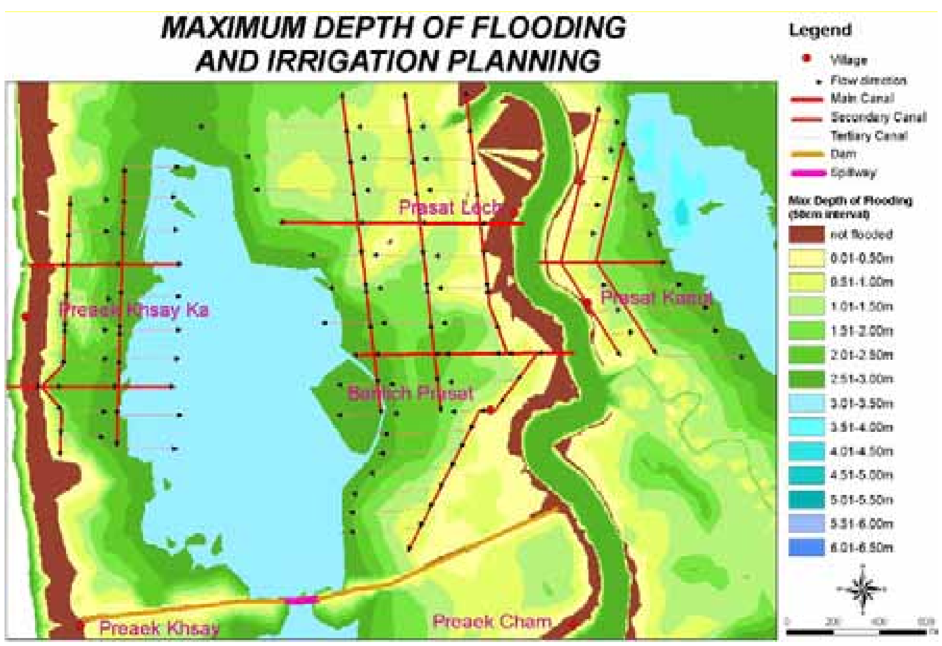

Figure 8. Irrigation planning using FPM-information in a part of Paem Ro District/ Cambodia.

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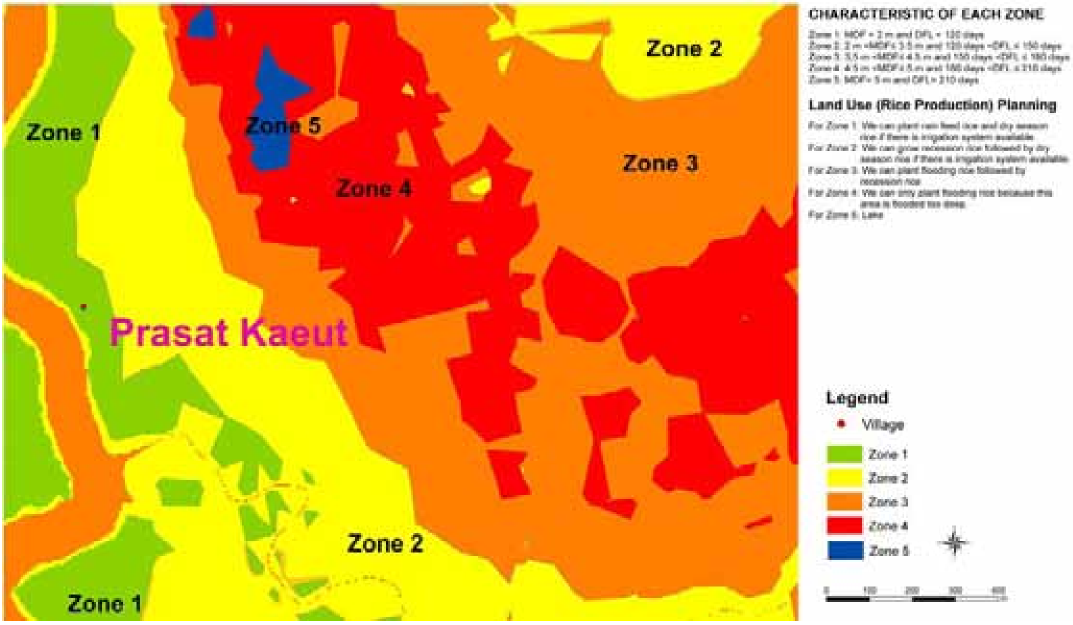

Figure 9. FPM-Map combined with Land Use Zoning for different rice varieties, Paem Ro District/ Cambodia.

CONCLUSIONS AND RECOMMENDATIONS

For Cambodia FMMP-C5 developed small pilot projects- as examples for training purposes- concerning the use of FPM in Land Management and Land Use Panning - in cooperation with Line Agencies (on National, Provincial and District/Commune Level) and the Land Management Department of the Royal University of Agriculture, showing appropriate Land Use Zoning for Land Management and Agricultural Cultivation (including irrigation suggestions), vulnerable villages plus proposed safety areas and escape routes for disaster management in the communities as well as suitable infrastructure design and locations for the two FMMP-C5- pilot districts in Cambodia.

Apart from several trainings for Line Agency (LA) staff concerning the practical use of the FPM in Land Management on national, provincial and district level FMMP-C 5 has been successful by the fact that the Land Management Department of the Royal University of Agriculture (RUA) in Cambodia could be convinced to implement the FMMP-C5 TOT-Curriculum (including all existing, readily available and translated FMMP-C5 education materials) into their university teaching plan. University-students and -staff as well as Line Agencies (on National, Provincial- and District/ Commune – Level) have been trained by FMMP-C5 on the FPM-Use in Land Management, so that up to now 152 participants have been trained in total in Cambodia on FPM-production - and -use during Phase 2 of FMMP-C5.

Particularly for Cambodia, extension of the FPM 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 FPM should remain a major function of the DHRW (Department of Hydrology and River Works)/ Phnom Penh, which should provide the Flood Probability Maps as a service to other, 'data and map using' Line Agencies along with technical expertise in their interpretation and use.

If a regular FPM-Production becomes possible in the other three Member Countries in the future, these should be the tasks of the DMH (Department of Meteorology and Hydrology/ under the Water Resources and Environment Administration (WREA)) in Lao PDR, the DWR (Department of Water Resources) in Thailand and the SRHMC (Southern Region Hydro-Meteorological Centre) in Viet Nam.

The Cambodian FMMP-C5-methodology - designed to deal with regular annual flooding of several months duration - can be applied in Vietnam to produce a similar range of maps of flood statistics. However, the influence of flood management measures, including accelerated drainage by pumping, needs to be identified so that maps of quasi-natural conditions can be produced (Plinston, 2010a/b).

An alternative approach is needed for the districts in Lao PDR and Thailand (Plinston, 2010b). The impact of flood protection works on the Mekong around Vientiane and Nong Khai (location of the pilot districts) means that the statistical description of river levels is not stable. Furthermore, the movement and drainage of floodwaters are not primarily dependent on river level after the short period of over-bank flooding has finished. Therefore, the correlation model used in Cambodia cannot be applied effectively and no FPM, meant to be used in Land Management, can be produced for Lao PDR and Thailand during the reminder of Phase 2 of FMMP-C5**.** An alternative solution would be to use a hydraulic model such as ISIS applied to each flood event and based on observed data. This model would estimate over-bank flooding from contemporary river levels and route the floodwaters through the district to define the variation in flood level and flood duration for all parts of the district. The area modelled would have to be expanded from the present pilot areas (e.g. extension of the DEM/DTM and number of flood marks, supported by high quality satellite based flood extent mapping). At present, there are insufficient data for model calibration, due to infrequent floods - there was no flooding in 2009 for example - and therefore statistical predictions cannot be derived from flood event maps for many years, if at all. Since FMMP-C5-Phase 2 has only a few months to go (until December 2010) and is therefore lacking the required time frame for the development and trial of a very complex new approach (which does not even guarantee a successful outcome concerning the establishment of flood information based maps to be efficiently used in Land Management), such a new approach, required for Lao PDR and Thailand, should be recommended and considered only for a 2nd Phase of FMMP.

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SESSION 3

PARALLEL PAPER PRESENTATIONS FROM THE MEKONG REGION ON THE FIVE TOPICS FOLLOWED BY PARALLEL GROUP DISCUSSIONS

Topic I

Community focused approach to flood risk management and mitigation

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Paper 3-1-1

WISDOM INFORMATION SYSTEM PROTOTYPE FOR THE MEKONG DELTA

FLORIAN MODER[1], CLAUDIA KÜNZER[2] AND VO KHAC TRI[3]

[1]*Ministry of Science and Technology, Southern Representative Office, Ho Chi Minh City, Viet Nam*
[2]*German Remote Sensing Data Centre, DFD, of the Aerospace Center, DLR, Germany*
[3]*Southern Institute of Water Resources Research, SIWRR, Ho Chi Minh City, Viet Nam*

ABSTRACT

The WISDOM Project (Water Related Information System for the Sustainable Development of the Mekong Delta in Viet Nam, www.wisdom.caf.dlr.de) is a bilateral project between the Federal Republic of Germany and the Socialist Republic of Viet Nam. It is built up of two thematic domains, each containing several work packages. The scientific domain focuses on multidisciplinary issues of water management within the Mekong Delta such as research on aspects of water quantity and hydrologic modelling, water quality, land use change, vulnerability, climate change related topics, socio-economic variables, and knowledge management amongst others. About 60 scientists of nine Vietnamese and ten German Institutions as well 15 project funded PhD Students, as well as three associated PhD students are currently involved in the still ongoing project and contributed first valuable results. The second domain resolves the issue of knowledge and data dissemination by designing and implementing a borderless customized web based information System application. All results of the interdisciplinary project are provided to relevant stakeholders through this semantic web application, providing a user friendly graphical interface enabling the retrieval of customizable maps for decision support and monitoring tasks. Next to map data the system enables the retrieval of statistical data on geo chemistry, sociology, legal documents from the water sector, as well as literature and publications; all linked to the corresponding geo location within the Mekong Delta. The whole System is currently being customized to the special requirements of Vietnamese institutions aiming at the implementation of a sustainable water management. The WISDOM System - which is currently in prototypical stage and will be further developed over the next year - therefore provides a neutral platform for exchange and dissemination of water management relevant data and knowledge. All activities within the project have been accompanied by capacity building measures at water management relevant key organizations on several institutional levels.

INTRODUCTION

The aim of the WISDOM project is the design, implementation and training of decision support technologies in the integrated water resources management (IWRM) domain. Large amounts of scientific data, originating from multiple scientific domains such as water quantity and hydrologic modelling research, water quality analyses, land use change investigation, vulnerability mapping, climate change related analyses, research on socio-economic variables, legal issues, and knowledge management amongst others have been generated, collected and archived by the WISDOM Project since 2007. Hence, those data have a wide verity of characteristics in terms of data amount, format, structure and spatial extent. To manage multidisciplinary data, harmonization and standardisation is necessary to enable participating institutions and users to access, administrate and disseminate the different types of data within the WISDOM framework. A common platform for participants from natural sciences, as well as social sciences was needed, which can handle different inputs independent from the location it originates from or the file type it is represented as. Here, the Internet as an overall linking medium with almost unrestricted application possibilities becomes an evident tool. The central component of the WISDOM project is therefore a web based data and knowledge management system, which acts as a platform for data exchange, data dissemination and data visualization, featuring several functions to link, locate, process and sort all kind of water management related data. All information can be accessed via a customised user friendly graphical interface applying web browsers. The paper addresses the WISDOM Information System prototype using OGC (Open Geospatial Consortium) compliant services, which was developed and runs currently as a prototype in Germany and Viet Nam. It is foreseen to develop this prototype (test application) further to a mature, full-grown Information and Decision Support System, which will then serve stakeholder from the water sector as well as the interested scientific community in their planning processes.

BACKGROUND

The Mekong-Delta covers an area of about 70,000 km² in South Viet Nam and underlies the influence of the tropical monsoon. The annual dry season lasts from November till April and the rainy season from May till October (Barth, 2002). The river regularly overflows its banks in the lower Mekong area, with beneficial effects, such as the accumulation of fertile sediment. However, extreme flood events occur more frequently causing extensive damage. On average once every 6 to 10 years river flood levels exceed the critical beneficial level (Plate, 2007). High population density, and farming as a major income source close to flooding endangered areas increase the economic and ecologic impacts of extreme river floods. Beside these extreme floods the Mekong Delta region encounters further challenges and problems, such as deteriorating water quality due to strong pesticide use in rice farming areas (Huan et al., 1999; Berg, 2001), unfilteres discharge of rural and industrial waste water, changing climatic conditions with predicted sea level rise, and thereupon resulting salinisation and acidification (Husson et al., 2000), species / habitats diminish, and regulatory measures (hydropower) is ongoing at the upper reaches of the Mekong. Several datasets on these issues are available from the project and the WISDOM partners. Collecting and analysing these data is important. However, the best project results and data set as well as conclusions drawn are not helpful, if the information does not reach the potentially affected regions, persons and institutions in charge at the right time. This is the key point where the WISDOM project tries to show a solution by developing and providing an online based Information System for water related issues of the Mekong Delta. Such an internet based system allows unlimited accessibility by everyone, who is connected to the internet; rather than a compilation of reports dusting in shelves and drawers, as it is often the case with research project results. At the current stage the Information System prototype needs to develop from a prototype to a fast, high-performance Information System, which runs stable, is being maintained, updated and contains a broad range of beneficial data. Furthermore, it is not only important that the data is accessible to the decision makers, but that the 'way' the data is being presented is realized in a approach that people can retrieve utmost benefit from it. Science must move away from 'discovery science' to 'solution science'. One of the most challenging questions to be addressed by the project in the future is: 'How do we ensure that the research results gathered during the WISDOM project will lead to actions and improvements in the relevant sectors, and furthermore, how do we ensure that the Information System is being used, maintained and updated in the future?'

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GENERAL DESCRIPTION

The current policy of the national Government of Viet Nam is to improve the cross-functional cooperation between local authorities and citizens by knowledge transfer, strengthening local capacities, and providing downstream services for decision taking processes for water- and land resources management. This requires an interdisciplinary linkage of natural science information, socio economic information and legal information, which originates from different institutions and agencies, distributed via a virtual Information System network. It should provide decision making institutions at all levels a simple to use, borderless and up to date access to graphical enriched information originating from all involved interdisciplinary institutions and scientific domains. In this way an improved regional cooperation in terms of information-, data- and knowledge exchange for a sustainable development of water- and land resources between different institutions in Viet Nam should be achieved.

The WISDOM Information System compiles several different components in one system. The are mainly three components: an extensive database holding different types of data, the so called middle ware processing environment, and the front end, which is basically the application seen by the user via the internet. The front end module handles the data input via a so called Data Entry Portal. It is furthermore responsible for the administration and integration from various sources, such as raw data, project results and several other products. All available data from different local authorities have been implemented in a first step. However before integrating them it was necessary to develop a common data standard to ensure data compatibility and quality. The front end is furthermore the visualization unit, which is used by the customer. The graphical user interface, GUI, allows the System User to perform different queries in different tool boxes; to visualize maps, to search for legal documents, to download data and so on. The database of the System has been structured based on spatial, thematic and temporal aspects of the data. A lot of data has been newly generated within the project – however, also central data bases on socio economy, agriculture and forest land use, water quality, infrastructure and water levels have been available in the Mekong Delta from different institutions with different geographic extends and locations. Those data have been collected and compiled during the last three years by Vietnamese and German partners of the WISDOM project. Together, all these data sets form the data basis on which the Information System builds upon.

Three case study sites, in which the majority of fieldwork is being undertaken, are currently well represented within the Information System prototype representing the main characteristics of Mekong Delta. These areas are: the Can Tho Province, the Tam Nong District, and Tra Cu District. Can Tho City with an estimated population of 1.200.000 as of 2008, is the biggest city in the Mekong Delta. Can Tho City is located on the south bank of Hau River, the bigger branch of the Mekong River and about 170 km south-west of Hồ Chí Minh City (Figure 1). Cities and their vicinities characteristics are relevant for the WISDOM research topics in terms of the increasing urbanization process, leading to distinct migration patterns within the Delta. Tam Nong District in Dong Thap Province is situated in the north-western part of the Mekong Delta also referred to as ‘Plain of Reeds’. It is characterized by regularly and deeply inundated areas in the rainy season, rice production as the major agricultural source of income, the presence of social minorities and associated poverty.

The WISDOM Information System prototype has been developed from the German side by the German Remote Sensing Data Centre (DFD) of the German Aerospace Centre (DLR) and the University of Wuerzburg, Germany in cooperation with the Geomatics Centre, GOC, of the Information Technology Park of Viet Nam National University (VNU) in Ho Chi Minh City, Viet Nam. All German and many Vietnamese project partners of the WISDOM project applied and entered their data into this prototype (compare Paper 3-5-2 / Project WISDOM: A progress report). The prototype is currently installed and runs for testing purposes at the SIWRR

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(Southern Institute for Water Resources Research) in Ho Chi Minh City, Viet Nam and at a DLR Server in Germany. However, these are currently only test versions to evaluate, which challenges exist for the consistent long term hosting and maintenance of such an Information System in Viet Nam. It is most likely that at projects end, which is foreseen for 2013 earliest, a well performing system will be hosted in the Mekong Delta, as well as in Ho Chi Minh City, and in Hanoi. Plans for Operational scenarios, maintenance, frequent update and long term funding therefore are under development by the WISDOM project coordination.

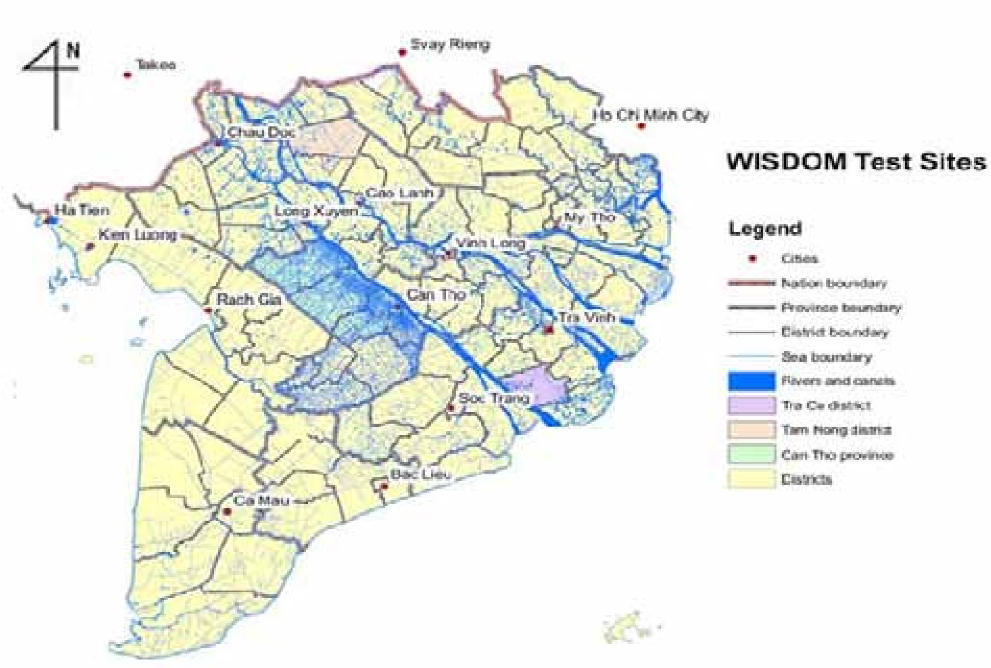

Figure 1. Fieldwork and ground truth areas of the WISDOM project in the Mekong Delta,Viet Nam

METHODOLOGY

Prior to the technical development of the WISDOM Information System prototype a detailed user requirement analyses was carried out in 2008. The user requirement analysis evaluated what kind of data should be hosted, processed and distributed by the system. This was necessary to define and to develop the underlying data standard and was discussed and finally developed with all involved data providers of the WISDOM project. It resulted in an ISO conform data standard for the WISDOM project, called WGEF (WISDOM Geodata Exchange Format). The WGEF is for all WISDOM partners mandatory to ensure data quality and a frictionless data exchange.

Requirements on technical aspects and the content of the WISDOM Information System were evaluated by questioning end users. Different interests and requirements resulting from different institutional as well different disciplinary background were compiled and finally poured in an overall technical system definition for the WISDOM Information System prototype. Several workshops and trainings were conducted by the German and the Vietnamese side on the WISDOM Information System and related technologies, such as training courses on GIS (Geographic Information Systems), remote sensing, database design, Information System architectural design, geodata management and others.

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Based on the IWRM (Integrated Water Resources Management) basic principles stakeholders on different levels were involved at all stages of the development in order to meet precisely the required specifications of the end users. Intermediate results were presented and discussed at all stages with users. 24 users at 14 institutions were involved into the technical development process of the WISDOM Information System. The prototype was built on the findings of the requirement analysis and in consultation with the users, resulting in a custom tailored system. However, here the challenge exists that different end users have their focus interest on different components of the system. While e.g. the Ministry of Natural Resources and Environment, MONRE, in Hanoi is especially interested in a wide range of national data to be fed into the System, so that it can also serve further catchments in the future, some players like the DONRES (District branches of the MONRE) in the Mekong Delta are interested in as precise as possible up to data for their specific province. While socio-economic institutions in the Delta might be especially interested in the legal document database or vector data on demographic parameters, natural science institutions might especially be interested on water level data or forecasting models on sea level rise impact. Furthermore, some customers and users are extremely computer literate, while other might need more training to use the data. Some users have well established fast linked internet access, while for others the transfer speeds are too low to use the System in an efficient manner.

From the software engineering point of view it was decided to approach the software development by applying vertical prototyping principles formulated by Kierulf et al. (1990). This means that the WISDOM Information System prototype came with reduced functionality, which the users can test and give feedback on. In this way the users can get a feeling of the potentials the system has and how it might look like, and also identify drawbacks and missing functionality. Based on the feedbacks adaptations, modifications and expansions on the WISDOM Information System prototype were and are currently being carried out in order to meet the users' needs. Furthermore it makes it easier to adapt the whole system on changing circumstances. Key components were designed and implemented already in an early stage of the WISDOM Project to provide key functionalities to the users. Additional components were added successively, which was possible due to the modular design. This design also ensures that future adaptations of certain components and extensions can be easily implemented. Some elements of agile software development (Balzert, 1996) were useful to support and enhance the prototyping process, e.g. working in self-organizing teams in order to use resources best possible and responding to changes over sticking to plans.

The best system does not fulfil its target, if there are no capacity building measures provided. Even the Information System does only require a minimum of technical expertise, it is necessary to explore the potential and show functionalities of the system within training workshops. Between 2007 and now the WISDOM project provided over 40 workshops in cooperation with the Vietnamese Partners on the WISDOM Information System and related issues.

RESULTS

A pre-condition for later use and applicability, which has been identified, is the need of low operational costs for the Information System. Here, open source software in combination with OGC data standard provides a solution, granting a system applicable free of charge. Recent technological developments showed that it is possible to create open architecture through the use of standard software components. Nowadays open source software in the field of Geoinformatics permit the development of SDI (Spatial Data Infrastructures) and internet applications even for comprehensive data sources and complex business processes (Dunfey et al., 2006).

Based on results of the requirements analyse and in close cooperation with the Vietnamese project partners the WISDOM Information System prototype was developed and implemented as a central tool for all involved institutions and end users of the WISDOM project. It provides several functionalities, such as data querying via a data catalogue system, browsing metadata (data describing the data concerning context, origin, date, projection etc.), data visualisation via a mapping client and campaign module (presenting field data, so called ‘field explorer’), getting organisational information via yellow pages, and last but not least general overview data and documents via the start portal (Figure 2). All kind of water relevant data and information from the Vietnamese partners and participating organisations are collected (still ongoing), pre-processed and indexed. After data harmonisation, data are stored in distributed database systems. For the data catalogue system metadata are automatically generated and stored in the ISO 19115 standard. In parallel hydraulic models are calculated for the Mekong Delta area calibrated with buoys measurements and remote sensing data. Beside water extent and quality, additional data products are generated based on remote sensing data, including land cover and land use information, surface sealing information, coastal zone information as well as general overview maps.

Figure 2. Screenshot of the WISDOM Information System Prototype – here the Sensor Toolbox - showing water level measurements at different locations in Tam Nong Province

The WISDOM Information System provides the following functionalities:

- *data preparation and integration***.** A Java application developed within the project supplies all necessary tools for data pre-processing and standardization. It tests for data consistency, analyses of different attributes (vector data, raster and Earth Observation (EO) based data) and its metadata, and registers data set and content into WISDOM data model realised in different databases;
- *data management and access***.** Several database management relational and XML based (Extensible Markup Language) systems hold all project relevant data using a sophisticated data model. The novel aspect of this model enables the transparent

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management of spatial and non-spatial data with a semantic enabled referencing. Data access is granted by several web services. Most of these services are OGC compliant allowing an easy exchange of used components. Additional interfaces cover these web services to map single resources to a meaningful URL;

- *operational data processing*. Within the project several processes are developed for data value adding (e.g. water surface extraction, land cover classification, etc.) These processes are controlled via OGC compliant Web Processing Service (WPS). Due to the fact that data access is managed by Web Coverage Service (WCS) for raster data and Web Feature Service (WFS) for vector data, processes can be easily connected to data. With this encapsulation every process can be controlled by the middleware for data processing. Thereby a process can be designed simple (data reprojection) or more complex (ready compiled PDF report);
- *web services*. All implemented web services can be addressed using WISDOM applications to get direct access to data, functionality or ready compiled information products. Beside WISDOM client, other OGC compliant software is able to connect to the data and processes. The main advantage is a possible integration into other software environments using these services. Independently from existing software structures end user can access WISDOM functionality and thus, integrate them into their business applications;
- *Tomcat web application*. The WISDOM application is a Java Web application using the SPRING application framework. This framework enables later integration of the WISDOM Information System into other existing enterprise applications sharing components and data. Business logic is separated from presentation and relating data according to the Model-View-Controller architecture pattern. For implementation purpose Java framework components were applied. Database access itself uses Data Access Object pattern (DAO) for the encapsulation of data access. An object relational mapping was implemented at Java side to connect data with the business logic. The object oriented design was fully applied to ensure later extensions and adaptations to new data, resp. additional functions. The web application itself is built using EXT-JS, a browser based JavaScript GUI (Graphical User Interface) framework and communicates with the Java web applications asynchronously (Asynchronous JavaScript and XML technology (AJAX)). All necessary functions are mapped directly to server-side web actions or web services. The resource mapping guarantees an easy integration of all developed components (data query and access, processing, visualisation and so on) into other applications using simple web requests. No additional software installations are necessary must be performed to integrate WISDOM into existing software infrastructures. In using web services all existing internet technologies (security, caching or distribution) can be integrated into WISDOM architecture. The web application provides several key functions to the end user:
    * *overview portal:* Users get an overview of new imported datasets and can access import documentation;
    * *data explorer:* Data can be queried using thematic, temporal and spatial arguments due to internal organization in a semantical way;
    * *map explorer:* Every dataset can be viewed in a map application. Datasets can be rearranged and combined to different purposes.
    * *yellow pages:* Organizational data and points of contact can be searched and accessed via our yellow page application. Administrative and legal documents are connected to the publishing organizations.
    * *campaign explorer:* In situ data is one key element for data understanding, evaluation and validation. User can access published data derived from field and measurement campaigns.

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CONCLUSIONS AND RECOMMENDATIONS

The sustainable middle to long term implementation of the WISDOM Project Information System is the overall goal of the project. The Information System architecture and software components itself are based on open source technologies and therefore free of charge. Operations costs are therefore cut to a minimum and are limited to hardware and personnel costs. The open source technology implicates interoperability with other systems, data standards, and grants the easy expendability of the System. Complementation of the System by further modules in accordance to future developments and demands is therefore easy. The open architecture keeps the system alive and ready for future demands. Additional thematic aspects, data formats and geographic regions can easily be implemented.

The focus on a user friendly approach, as well as keeping the limited Information Technology (IT) infrastructure especially in rural areas in mind, made it necessary to apply bandwidth saving technologies such as AJAX, Java Server Page (JSP) and Cascading Style Sheets (CSS). It enables the users, even in the rural areas, to access, analyse and disseminate water management related data via the web browser. The interaction with the system is easy due to an intuitive user interface and quick in respond.

As data sharing is a crucial issue within the institutional framework of administrative institutions in Viet Nam, the WISDOM Project Information System offers a solution to share data, without losing ownership and the control over the data. Data are expensive and owning data is synonymous with owning power. The Information System could serve as a neutral platform for all participating institutions to disseminate data and results. As a benefit, participating institutions get access to data from various sources, which can be viewed, analysed and combined online. However, downloading the source data can be suppressed if needed. The WISDOM Information System stands therefore as a value adding neutral platform for data dissemination for all involved institutions.

The WISDOM Project Information System, developed in the last two and a half years faces now the challenges of final maturing and operationalisation in case of a likely project extension. Findings of the first project phase will be implemented to improve the system. It is further the intention to integrate decision support components as a result of the emerging climate change issue and the demand of the users. The system will be permanently installed at WISDOM key institutions on the Vietnamese side, as soon as the beta phase of the WISDOM Information System is completed (foreseen for middle of 2011). The implementation comes along with intensive trainings on administrative as well on the user side. Partners in the provinces will be trained on the system. The low maintenance costs, intuitive user interface, value adding services and the emerging social, economic and environmental problems in the Delta make the WISDOM Information System an attractive and sustainable tool, not only for water management, but also for several other natural resources management purposes.

ACKNOWLEDGEMENTS

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Paper 3-1-2

MONITORING SPATIAL AND TEMPORAL DYNAMICS OF MAJOR FLOODS IN THE LOWER REACH OF SONGKHRAM RIVER, NORTHEASTERN THAILAND

THIHA, ROJCHAI SATRAWAHA, KOMGRIT WONGPAKAM, WEERACHAI SAIJUNTHA AND SUDARAT THANONKEO

Walai Rukhavej Botanical Research Institute, Mahasarakham University, Thailand

ABSTRACT

This study analyses the temporal and spatial dynamics of major floods in the lower reach of Songkhram River, one of three main tributaries of Mekong River and one of the most important areas for aquatic biological production in the Lower Mekong River Basin. Using RS/GIS tools, we first interpreted the time series Landsat imagery acquired at a two-year interval between 2000 and 2006 to identify the major floods that usually occur in September when the seasonal floods in the basin and backwater from the Mekong River reach their peaks. We then analysed its temporal dynamics using a GIS overlay between time series seasonal flood maps: 2000, 2002, 2004 and 2006. Analysis of temporal dynamics of major floods revealed that the extent of major floods were highly dynamic through 2006. Post-image classification revealed that the extent of major floods was accurately mapped, with quality ground truth data involved. Additionally, we estimated the areas that are located in lower elevations and land uses that are affected by major floods for the last few years using a 30-m space radar topographic mission (SRTM) digital elevation model and existing land use GIS data. Findings suggest that accurate mapping of seasonal floods and its temporal dynamics using space and time dependent data can be important for long-term flood monitoring and flood risk management. Output GIS maps and attribute data will serve as important spatial tools that can help conservation biologists to understand natural hydrologic regime in the Lower Mekong River Basin, one of the richest areas in biodiversity in the world, more and identify the areas where flood risk management activities should be implemented. Further research should focus on up-scaling monitoring efforts to the landscape level using integrated approaches of data collection and analysis and to assess the effectiveness of the existing flood monitoring frameworks.

INTRODUCTION

The Songkhram River is one of three important tributaries of the Mekong River in Northeastern Thailand. Flowing through Udon Thani, Sakon Nakhon, and Nong Khai provinces to join the Mekong river in Nakhon Phanom province in Northeast Thailand, the river supports significant proportion of aquatic and terrestrial ecosystems and biodiversity in the lower Mekong River Basin (Barbier et al., 1993 and Satrawaha et al., 2009). The river basin is one of the areas responsible for the majority of aquatic biological production in the Lower Mekong River Basin (Chutiratanaphan and Patanakanok, 2001). Recent reports from the Mekong River Commission reveal that in terms of fisheries, the Songkhram is the most productive river in the Thai part of the basin. A recent Thai Baan survey recorded 124 fish species including nine exotic species, with more than 50% of total 115 indigenous species migrating from the Mekong to spawn (Starr and Ingthamjitr, 2005).

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Seasonal floodplains that are mainly found in the lower reach of Songkhram river serve as large grazing grounds for domestic animals and breeding and spawning grounds for several Mekong fish species (Blake et al., 2006). Wetland ecosystems along its channel are closely intertwined and are dependent on the natural hydrological cycle, which is subject to dramatic seasonal changes of flood and recession (Barbier et al., 1993). This natural hydroecological factor is closely asscociated with the biodiversity of diverse habitats, several aquatic floral and fish species, and livelihoods of surrounding rural communities. During the last decades, basin's natural hydrologic regime has been modified due to rapidly growing commercial farming operations (drainage for agriculture) and populations, coal-making, over-exploitation of wetland resources, pollution, human settlements andconstruction of weirs. Consequently, the areas along the river channel have become increasingly vulnerable to water-induced natural disasters, and floods is one the main recurring natural hazards. In the long run, these water-induced natural disasters combined with habitat degradation and biodiversity loss may pose important threats to adjacent ecosystems and rural economy.

While protecting remaining wetland resources from futher depletion and developing policy initatives to mitigate communities' vulnerability to water-induced natural disasters are current conservation priorities, emergence of approaches for monitoring changes in river-based ecosystems is ungently needed. Monitoring seasonal major floods that usually occur in the late wet season (between August and September) along Mekong river and its tributaries is particularly important because this natural hydrological phenomenon is associated with habitat diversity of several Mekong fish species and the majority of aquatic biological production and safety of surrounding rural communities in the lower Mekong river Basin.

Wetland inventories and ecosystem monitoring efforts currently used in Thailand are, however, inadequate for this purpose, because they only classify habitat types, identify plant communities and animals that are found within those habitats, and document the present status of ecosystem components and economic values of selected wetland resources, and focus mainly on the use of traditional monitoring methods, such as ground survey. Therefore it is streesed that the lack of integrated wetland inventory and limited accessibility to available space and time-dependent data is major limitations to development of mitigation measures to reduce the impacts of environmetnal stressors (Finlayson and Spiers, 1999; Nagabhatla et al., 2007). In Thailand, awareness of Remote Sensing (RS) and Geographic Information System (GIS) technologies and their application in wetland management and flood monitoring is limited to a rather small community although the country has engaged in those technologies for few decade or so. Evidence from comtemporary research (Islam and Sado, 2000b and Zhou et al., 2000) have shwon that satellite remote sensing is the most effective approach to monitoring flooding extent, damages and flood frequency.

In order to provide baseline data and information highly relevant to monitoring changes in wetland ecosystems in general and flood monitoring and flood risk management in particular, we conducted this research with two main objectives. First, we assessed the extent of major flood that usually occur in the late wet season using the analysis of multi-spectral Landsat data combined with ground survey method. Second, we estimated the temporal dynamics of major floods responsible for water-induced natural disasters using simple GIS overlays. Additionally, we synthesized the effectiveness in terms of methodological advancement of existing flood monitoring frameworks.

MATERIALS AND METHODS

Study area

The Songkhram River Basin is located within 17^0 42'-17^0 54' N and 103^0 79'-103^0 46' E in North-eastern Thailand, and covers an area of 13,093 km^2 (Figure 1). In early 2009, we selected the lower reach of its basin, covering about 54.6% of the total catchment area, to fulfil the criteria of presence of agricultural land uses and human settlements located in low-lying areas which are vulnerable to water-induced natural disasters. The lower basin receives heavier annual rainfall than most other parts of Central, Northern and Northeast Thailand, with the annual average precipitation varying between 1,600 and 2,400 mm, causing the floodwater reaching far inland from the riverbanks (Mekong Wetlands Biodiversity Conservation and Sustainable Use Program, accessed February 2010). Covering about 150 km of the 420 long river channel, the lower reach has a low gradient of just 30-40 cm fall every kilometre. At the peak of floods, the area resembles a large shallow lake, with the water depth no deeper than 1-2 metre at most points. It is reported that the floods may extend up to 2,000 km^2 in a wet year, putting surrounding human settlements at high risk of water-induced disasters.

Remote sensing and GIS data

The remote sensing data used in this study included four Landsat seasonal image pairs (eight scenes) of the world resources satellite (WRS-2) Path127/Row048 acquired between 2000 and 2006 (Table 1). Of those, we purchased Landsat ETM+ gap-filled image from 2004 from the Tropical Rain Forest Information Centre (TRFIC). All other Landsat images were downloaded from the U.S. Geological Survey (USGS) Global Visualization Viewers (http://glovis.usgs.gov/) at no charge.

We analyzed the spatial and temporal dynamics of major floods at two years on average between 2002 and 2006. Monitoring such dynamics for consecutive years was not feasible due to the unavailability of wet season images primarily attributed to the regional cloud cover. The majority of wet season images we used in this study were recorded in September (Table 1), allowing us to capture the events of major floods along the lower reach of Songkhram River Basin. We also obtained other GIS data such as land use, village and town locations, administrative boundaries, road networks and topographic maps of 1:50,000 scale from the Land Development Department of Thailand for use in field data collection, image interpretation and ancillary GIS analyses.

Prior to image classification, all geo-referenced Landsat images were co-registered with the ortho-rectified image from 22 December 2000 for topographic errors. Co-registered image were then sub-setted into the lower reach of Songkhram River Basin. Required field data for image classification and post-classification were collected from two field trips, with the first trip occurring in September 2007 (wet season) and the second trip in February (dry season) 2008. GPS waypoints and tracks collected in the field were then entered into GIS for use in image classification. We also collected qualitative data such as land use history, presence of human activities, and surrounding land cover through asking local farmers whom we encountered in the field. Those data were used for verifying ground-referenced data, image classification and accuracy assessment of time series flood maps.

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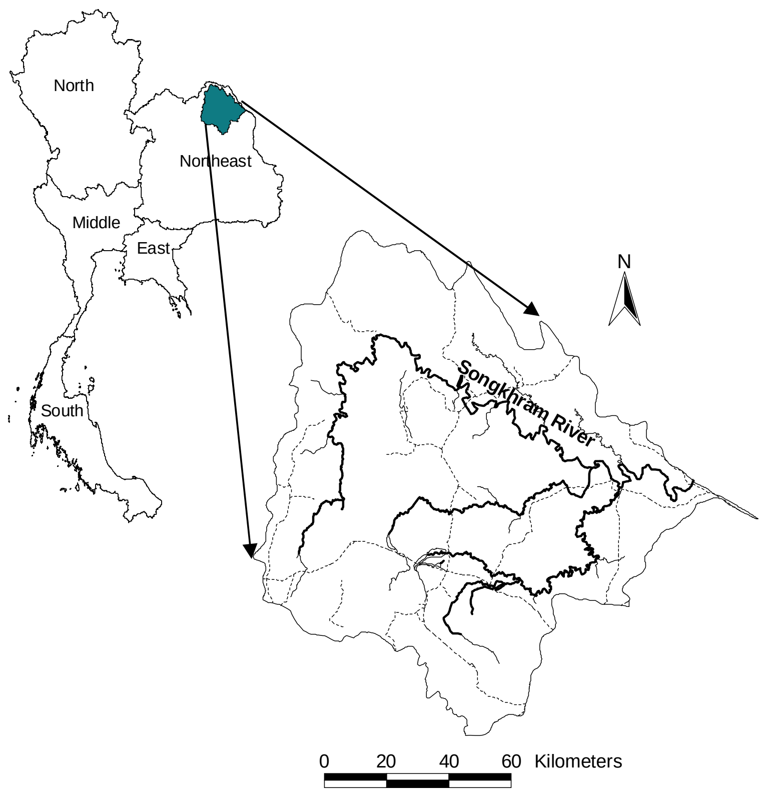

Figure 1. Map showing the location of Songkhram River Basin within Northeast Thailand

Table1. Remote sensing data, their acquisition dates, spatial resolution and source. * indicates images collected in scan-line corrector off (SLC-off) mode.

Satellite and sensor	Acquisition date	Ground resolution (m)	Source
Landsat7 ETM+	September 17, 2000	30	USGS
Landsat7 ETM+	December 22, 2000	30	USGS
Landsat7 ETM+	September 23, 2002	30	USGS
Landsat7 ETM+	November 10, 2002	30	USGS
Landsat7 ETM+	September 28, 2004*	30	TRFIC
Landsat7 ETM+	January 2, 2005*	30	USGS
Landsat5 TM	November 13, 2006	30	USGS
Landsat5 TM	December 15, 2006	30	USGS

Image classification

We first interpreted each Landsat image subset into ten (land cover) clusters using the unsupervised classification method that uses ISODATA clustering algorithm (Tou and Gonzelez, 1974) within Erdas Imagine® Image processing and GIS software. We then identified the classes associated with water body using ground reference data (GIS waypoints, tracks and field notes, etc.), and were finally recoded as 'water bodies'. The recoded time series images consisted of only two land cover classes: water body and other land covers. Additionally, we performed an accuracy assessment on the recoded images using a statistical approach to assess the classification accuracies. After accuracy assessment, we achieved overall

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accuracies more than 90% for water bodies.

Ancillary GIS analyses

Two ancillary GIS analyses were performed for identifying the extent of major floods and its temporal dynamics. We defined 'major floods' as the water bodies that extend from the dry season water bodies during the peak of seasonal floods. We first performed the matrix analysis on seasonal image pairs to produce the maps showing the extent of major floods for each time series. Subsequent to this, we performed GIS overlays between recoded image pairs from adjacent years (i.e., 2000 and 2002; 2002 and 2004, etc.) by producing maps showing the temporal dynamics in the extent of major floods and associated attribute data for each period. Additionally, we made use of recently available 30-m shuttle radar topographic mission (SRTM) digital elevation model (DEM) and existing land use GIS data from the early 2000s to identify the low-lying areas that are at high risk of being flooded during the peak of seasonal major floods and land uses that were being affected by the major flood events for the last few years. We performed all GIS analyses within ArcView® GIS software version 3.3.

RESULTS

As shown in Figure 2, the extent of seasonal major floods (coded in grey colour) in the lower reach of Songkhram River Basin was highly dynamic during the period between 2000 and 2006. When compared across time series, the highest extent was observed in the year 2000, suggesting that it coincided with a wet year with a high precipitation in the basin and a large backwater from the Mekong River. The extent of major floods gradually decreased over time that the extent in 2004 remained only 35,000 ha or about 55.8% of that in 2000. We excluded the statistics from 2006 from being compared with other time series when we analyzed the temporal dynamics of major floods, because the image acquired in November 2006, which was presumably representative of wet season in that year, did not capture the major flood events well. Despite this anomaly, the trend in the extent of major floods appeared to have been decreasing since the year 2000 (Table 2).

GIS overlays between time series flood maps showed that areas of major floods across four periods - 2000, 2002, 2004 and 2006 - were largely overlapped or nested. For example, the overlapped area of major floods between 2000 and 2002 flood maps was 79.3%, whereas the calculated nested area between 2000 and 2004 flood maps was 86.9%. We obtained similar statistics of nested areas for other image pairs, such as 2000 vs. 2006, 2002 vs. 2004 etc. This finding suggested that our image classification captured the recurrent nature of major floods well, supporting our claim that flood maps were accurately mapped.

We also found that the accumulated extent of major floods between 2000 and 2006 was 76,000 ha, constituting about 10.6% of the lower reach (Figure 3) or 5.8% of the total catchment area. Analysis of recently available digital topographic data (30-m SRTM DEM) showed that the total area of low-lying areas (i.e., topographic zones that covers the majority of the accumulated extent of major floods between 2000 and 2006) in the lower reach of the basin was 122,000 ha or about 9.3% of the total catchment area. Also those low-lying areas were confined within the elevation range between 130 and 150 m+MSL (Mean Sea Level) (Figure 4). Combined those findings with information from field survey suggest that those areas are at high risk of being affected by major floods during the wet season. The lowest elevation point along the Songkhram river is the Songkhram river mouth (confluence with Mekong river in Sakon Nakhon province), which was measured ~130 m+MSL.

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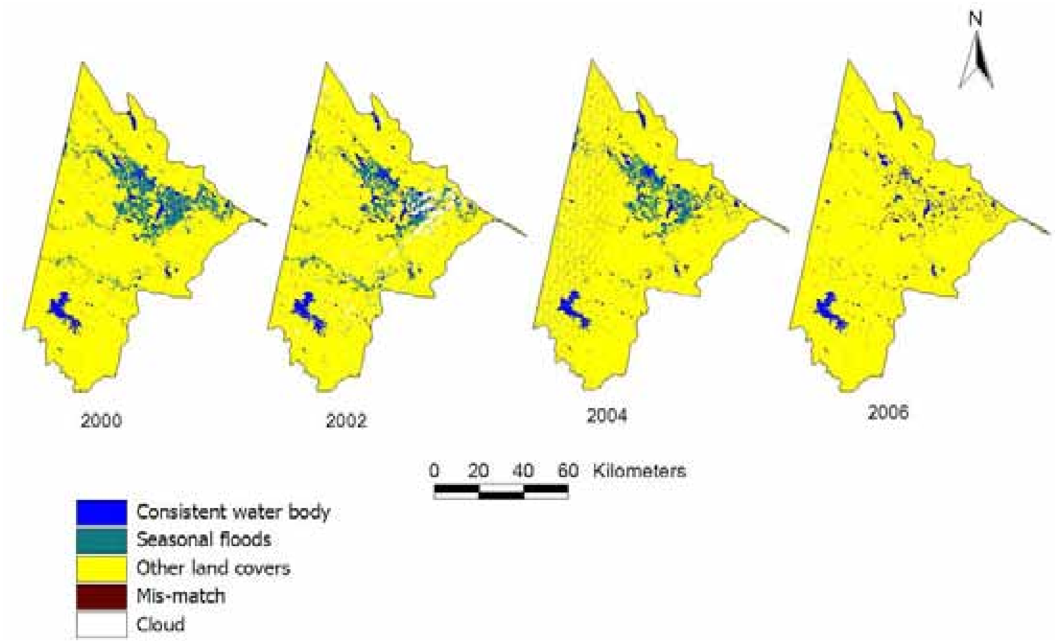

Figure 2. Classified time series images showing the extent of major floods in the lower reach of Songkhram River Basin

Table 2. Temporal dynamics in the extent of major floods in the lower reach of Songkhram River Basin

Land cover	2000		2002		2004		2006	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Consistent water body	25,300	3.5	30,100	4.2	23,500	3.3	30,400	4.2
Seasonal Flood	62,700	8.8	40,200	5.6	35,000	4.9	3,500	0.5
Other-water (miss-match)	4,900	0.7	4,000	0.6	11,900	1.7	1,900	0.3
Consistent other land cover	622,700	87.0	615,700	86.0	636,400	88.9	679,900	95.0
Cloud/missing pixel			25,600	3.6	8,800	1.2		
Total	*715,600*	*100*	*715,600*	*100*	*715,600*	*100*	*715,700*	*100*

Analysis on the extent of flood-affected land uses showed that an estimated area of 39,500 ha of agriculture and built-up land uses was inundated either once or repeatedly during the period between 2000 and 2006 (Figure 5). This accounted for about 5.5% of the lower reach (our study area) of river basin and 3% of the total catchment area. About 86.8% of total affected areas or about 34,300 ha was rice paddies, both irrigated and rainfed types. About 11% (4,300 ha) was being used for growing other agricultural crops, including cassava, corn, rubber, orchards and mixed field crops. About 2.2% (900 ha) were built-up, which is mainly constituted with urban land and villages.

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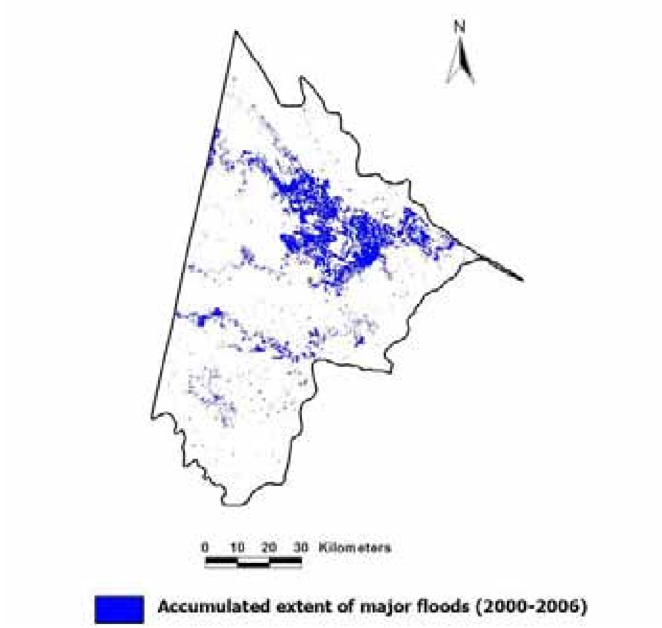

Figure 3 Map showing the accumulated extent of major floods (2000-2006) in the lower reach of Songkhram River Basin

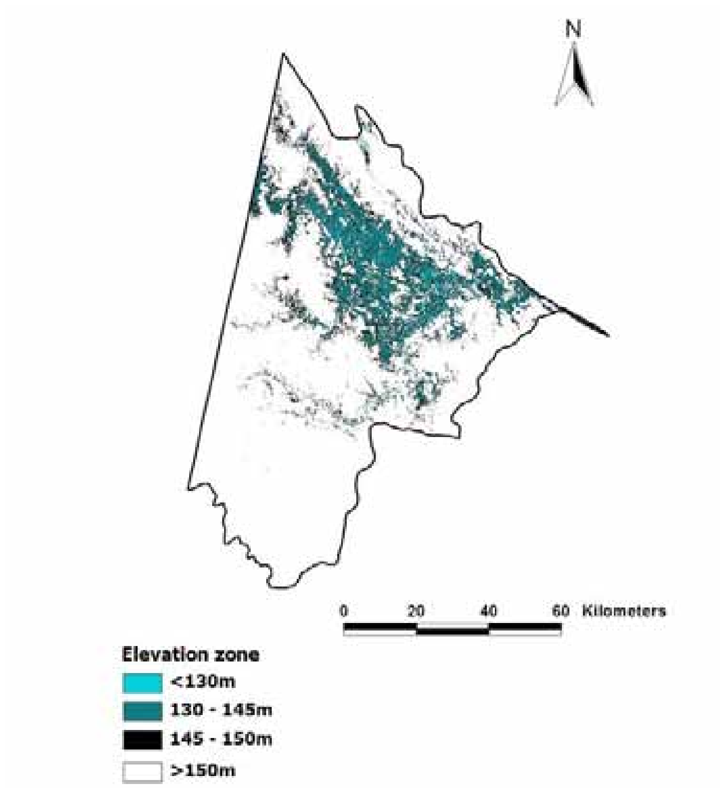

Figure 4. Map showing low-lying areas (coded in light grey, dark grey and black) in the lower reach of Songkhram River Basin

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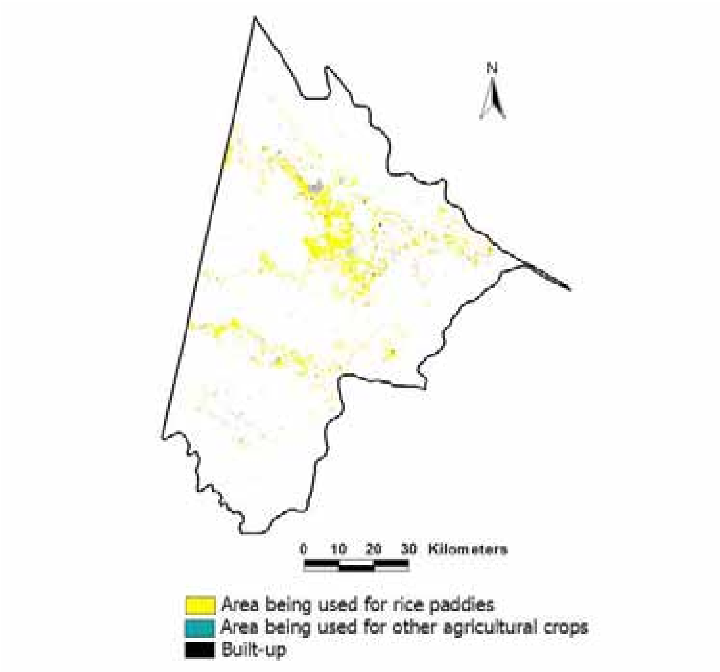

Figure 5. Map showing agricultural land uses and built-up affected by major floods in the lower Songkhram River Basin

DISCUSSION AND CONCLUSIONS

Our finding of dynamic nature of major flood events for the last few years in the lower reach of Songkhram River Basin is consistent with evidence from several contemporary research (such as Thai Baan research project). Accuracy assessment of time series flood maps through GIS overlays showed that the areas that are seasonally inundated were mapped accurately, indicating the success of using multi-spectral remote sensing data from satellite platforms in flood monitoring. This finding also suggests the possibility to
replicate our RS-GIS aided method in flood risk management and monitoring biodiversity of several wetland habitats and fish species. The gradual decrease in the extent of major floods shown in our image analysis was also reported by local residents and was consistent with other studies (see Mekong River Commission Secretariat Preliminary Report).

We believe that output GIS maps and attribute data will serve as important baseline spatial data to develop floods hazard maps at the national level (see Islam and Sado 2000a) and to assess the effectiveness of current biodiversity monitoring frameworks. In addition to provision of baseline spatial data for flood risk management, our research findings will help biologists and natural resources managers to make more informed decisions on where semi-permanent biodiversity monitoring stations should be set up. Evidence from recent land cover change research (for example, see Chutiratanaphan and Patanakanok 2001) showed that there are also significant changes in land cover along the Songkhram River in relation to several human activities (e.g., agricultural expansion) in recent years, although monitoring such dynamics went beyond the scope of this study. Our findings can serve as an important baseline spatial data associated with flood forecasting for long-term floods management in the lower Mekong River Basin.

In terms of future research directions, more accurate monitoring and mapping at a near real time

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using integrated data and information would be needed to identify the areas that are at high risk of being affected by water-induced disasters. Such monitoring efforts should also combine data from satellite platforms with inventory data collected in the field. As our study demonstrated, the success of monitoring seasonal flood events was highly dependent on availability of cloud-free wet season images from optical remote sensing platforms (e.g., Landsat, IKONOS). Increasing availability of radar remote sensing data (e.g., SAR) from RADARSAT and ERS could solve this issue as the radar remote sensing approach is capable of penetrating cloud cover and offering an opportunity for continuous observations of flood events. Such monitoring techniques have been employed in the region (for example, Zhou et al., 2000), but those have rarely taken into account the integration of ground truth information and other environmental variables, such as total discharge of the basin, depth of the floods and daily precipitation. Equally important is to analyze the level of resilience of affected communities in socio-economic terms and identify their coping strategies in the face of water-induced disasters. Because such variables and information are important inputs for flood forecasting models and flood hazard mapping in long-term flood risk management plans and can be derived only from field-based research, continuation of ongoing long-term monitoring works (e.g. Mekong River Commission's River Monitoring) would be critically important.

ACKNOWLEDGEMENTS

This research was partially supported by a research grant from Mahasarakham University, Thailand. We thank the local residents of Nong Khai, Sakon Nakhon and Nakhon Phanom provinces of Northeast Thailand for providing valuable information and sharing their insights toward water-induced disasters during our field work.

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Paper 3-1-3

FLOOD SITUATION IN MEKONG-CHI-MUN RIVER BASIN (3T AND 5T AREAS)

CHONGKOL PIMWAPEE

Programme Officer, Soi Wat Pa Sitawan, Thailand
Working group on 5T of MRC
Kong-Chi-Mun river basin people forum

Flood situation in the Kong-Chi-Mun river basin in the Northeast of Thailand did not create devastating impact everywhere in the region, except in the lowland, which was repeatedly flooded. The land is wavy, sloping to the East, and contains sandy loam soil that absorbes water well and enables rapid sublimation. This can explain how flood water was rapidly drained out. Therefore, most Northeastern farmers have the saying *'Having flood is better than no rain'* Another fact is that most of the agricultural area is on the highland and not irrigated. In other words, only 8,000 of 96,000 km^2 (5 out of 60 million rai) is irrigated. Floods caused problems to some small areas but brought higher agricultural production to the other. Furthermore the Northeast has harnessed the water management as a result of The First National Economic and Social Development Plan (1961). The plan brought about the construction of water projects, for example, Ubol Ratana Dam half a century ago, having the capacity to contain up to 2.4 million m^3 of water. Ubol Ratana Dam can generate electricity, supply water for the Lam Ta Khong Mam, Lam Pra Pheung Dam, Rasi Salai Dam, Hua Na Dam, Sirinthorn Dam, and Pak Mun Dam were constructed respectively around Mun River. Moreover Julaporn Dam, Lam Pao Dam, Huay Kum Dam, Fai Hin Thing Dam, and Yang Dam in several areas were built over Chi River Basin. In various rivers related to Mekong River, several dams were built; for example, Nam Mong Dam, Namoon Dam and Nam Phong Dam. These dams help to manage water and play a major role in reducing floods in the Northeast region effectively.

However, repetitive flooding still attacks some areas as listed below. Around Chi-Mun River there are:

- Amphur Muang Chaiyaphum, Amphur Kommalasai, Amphur Khongchai and Amphur Nongpan in Kalasin;
- Amphur Jdanghan, Amphur Chiangkwan, Amphur Thawatburi and Amphur Selephum in Roi-et;
- Amphur Muang in Yasothorn;
- Amphur Muang and Amphur Warinchamrab in Ubolratchathani.

Around Mekong River there is:

- Amphur Muang Sakon nakhon.

And along Mekong River some areas face severe flooding in some years when the water level in Mekong River is high:

- Amphur Thabor in Nongkai;
- Nakhon Panom;
- Mukdahan.

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A case study on the repetitive flood situation around the municipal area in Udornthani and its surrounding areas reveals that the problem was completely resolved with an integration and development strategy.

Strategies for flood management in Northeast Thailand

According to the Public Sector Reform in Thailand in 2002, Thailand refined its administrative structure and responsibilities of ministries and sectors. This resulted in the new way to the management system of the 25 main rivers in the country. The national structure was established to manage the use of rivers. The plan comprised the main river committee at country level and the sub-river committee at province level. Each level encourages the participation of stakeholders. In addition, each committee prepared a master plan for river management. The law, roles, responsibility, and authority of each sector were clearly defined. Also the technology, tools and budged were discussed in detail. However at this early stage a number of problems were found on various areas.

- sustainability and unity of flood solution;
- cross-functional and unclear responsible organization;
- construction of Upper-Chi Dam, Phong Kunpetch Dam, Yang Nadee Dam and Pha Khahao Dam (around Chi River) being protested by conservationists. Larger projects (e.g. Rasi Salai Dam, Fai Huana Dam and Pakmun, around Mun River) in the middle of dealing with unresolved compensation requests from affected farmers;
- Water law and Law Act not in effect yet;
- groups and organizations (especially local residents) lack knowledge in water management. Education in this issue is required;
- illegal use of conserved forest, national forest and water source forest;
- flood problems being resolved with short-term plans. In other words, the area was taken care of only when flooded;
- city development done without a long term / backup plan or a study on the outcomes.

As discussed above, policy makers and all stakeholders need to lend cooperation to come to a systematic and integrated strategy to deal with the problems:

1. to develop a firm, sustainable and responding to current world situation (e.g. global warming) policy. Indeed Kong-Chi-Mun River Basin policy has already illustrated several effective projects:
    - 'grow a forest' and 'grow a forest as to repay loan' (including forest in community, national park, conserved forest, and farm field forest). Farmers gather in groups and helping to grow trees;
    - 'build dams as to repay loan' - this project purposes to relieve floods, relieve drought and conserve water;
    - improve soil as to repay loan;

   The project above releases farmers from debts as well as improves their environment;

2. to precipitate the operation of the laws concerning with improving resources (soil, water, forest and personnel) as indicated in the Tenth National Economic and Social Development Plan. This will lead to sustainable economy and natural resources. Water Act and Irrigation Act are to be forced to take effect;
3. to precipitate the integration of all responsible organizations at all levels. Participation from local river management groups must be promoted;
4. to precipitate distribution of authority to local organizations and sectors so that communities can be part in their own river management;

5. to precipitate the completion of the construction of Phong Khunpetch Dam, Upper-Chi, Pha Khahao, etc. The finished project will help relieve the impacts of floods;
6. to precipitate the study of Pkchom Dam and Ban Kum Dam (to be Mekong River barriers) as to produce power and supply water to the Northeast. In addition, the Kong-Chi-Mun River Basin Master Plan, Wetland Project, growing forest to support water sources in eighty branch rivers of Mekong can all play a major role in dealing with water problems in the long term;
7. to precipitate the ways to prevent and reduce drought in both short and long term.
    - wetland and along-river basin land violation should be prevented by making clear landmarks to identify public rivers. This can be done with the cooperation of community and government sectors;
    - a systematic plan prior to the expansion of cities should be made. This includes the construction of industrial areas, bridges and roads. In addition, the impacts of the construction should be studied;
    - water sources should be improved to better store water for community supplement;
    - a warning system should be setup to effectively migrate the community in case of flooding and of land sliding;
    - role of local organizations to facilitate the rescue during flooding should be promoted;
    - communities should be provided with budget, equipment and resources for handling floods;
8. to offer a sincere and practical framework to cope with drought and flood (e.g. MRC, GMS, ACMEC and ASEAN) to the six countries in the basin of the Mekong River.

Topic II

Flood forecasting and flash flood guidance

Paper 3-2-1

FLASH FLOOD GUIDANCE SYSTEM (FFGS) EXPERIMENTAL APPLICATION ON WARNING FLASH FLOODS IN VIET NAM

BUI DUC LONG AND PHUNG TIEN DUNG

National Centre for Hydro-Meteorological Forecasting Ha Noi, Viet Nam

ABSTRACT

Viet Nam is located in the tropical monsoon of South East Asia, one of the vulnerable areas of natural disasters such as storms, floods, flash floods and landslides in the world. Floods and storms occur in Viet Nam every year and they are main results of extensive damage to people and property. Rains, flash floods, landslides appear frequently in the mountainous areas of the country. Based on statistics, there are around 10 flash floods per year. Vietnamese scientists have announced a number of researches for actual situations, the risk and the zoning of flash floods in Viet Nam.

Towards effective flash flood prevention, flash flood zoning in combination with warning of flash floods have to be established for each river basin and/or each specific region. Flash flood warning systems in a number of Viet Nam's provinces have already been established such as in Son La (Nam Na - Nam Pan rivers), Ha Tinh (Ngan Sau - Ngan Pho rivers), Yen Bai (Lao Cai), Kon Tum (Dakbla River). However, there are many areas on the Viet Nam territory facing the risk of flash floods occurrence where has not been built any warning system Therefore it is a very useful tool for a quick overview and assessment of the regions that have the risk of flash flood appearance caused by impacts of heavy rains, storms, tropical low pressure. In the flood season of 2009, the National Centre for Hydro-Meteorological Forecasting received and initially applied the Flash Flood Guidance System (FFGS) of the Mekong River Commission (MRC) for flash flood warning in Viet Nam. The main task of FFGS for Mekong River Basin is to provide real-time flash flood imminent risk information guidance on a small-scale for selected area.

GENERAL INTRODUCTION

In recent years, along with socioeconomic development on traffic, urban, industrial zone and residential area in mountainous provinces, extreme phenomena have occurred more and more due to global climate change which have influenced directly and clearly to weather and natural disaster in Viet Nam. Flash flood, hose flood, mud and stone flood and landslide have consecutively occurred in many mountainous regions. Flash flood and landslide often occur in small and narrow valleys, rivulet or sloping mountain side. Their destructions are very fierce, causing loss of life and properties, especially in ethnic community where the poverty is majority.

Flash floods have caused loss of life of whole family or community bringing about heart-rending for community. According to investigates and surveys from 1953 to 2009, at least 398 flash flood events have occurred in whole country. Tens of flash floods have occurred in mountainous area every year. Flash floods occurred more and more, especially, in 20 recent years (1990-2009), it has occurred 250 flash floods. Flash floods were occurred frequently in most of regions but mainly concentrated in mountainous area in the North as shown in figure 1.3. There were 7 flash floods in the period of 1970 - 1980, 8 flash floods in the period of 1981 -

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1990, 10.3 flash floods per year in the period of 1990 - 1999 (Figure 1). Especially, 147 flash floods occurred in mountainous provinces in ten years from 2000 to 2009 which directly affected the community, causing death and missing of 1,340 people; injuring of 846 people, thousand of houses collapsed and were damaged; nearly 200,000 ha of rice fields and farm were submerged; many transportations, bridges and sewers were damaged.

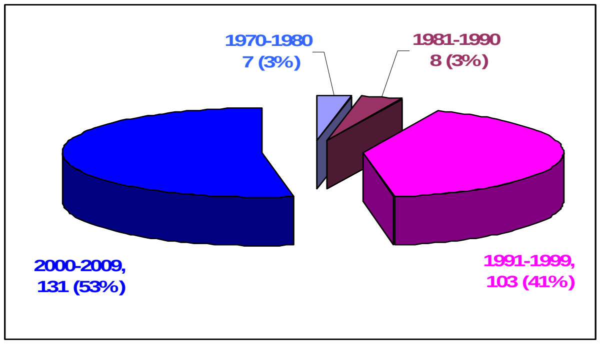

Figure 1. Occurrence frequency and number of flash floods from 1970 to 2009

Damages causing by flash flood in period of 2006 - 2008 were in general trend of higher than the previous periods i.e. 25 events in 2006, 18 events in 2007, 28 events in 2008 (Figures 2 and 3). Damages on human life, house, agriculture, transportation and property increased more and more, holding 77% damages in 10 year (Figures 4 and 5).

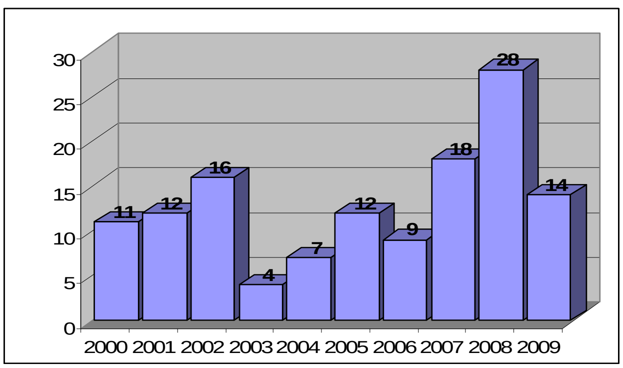

Figure 2. Number of flash floods occurring in a year (from 2000 – 2009)

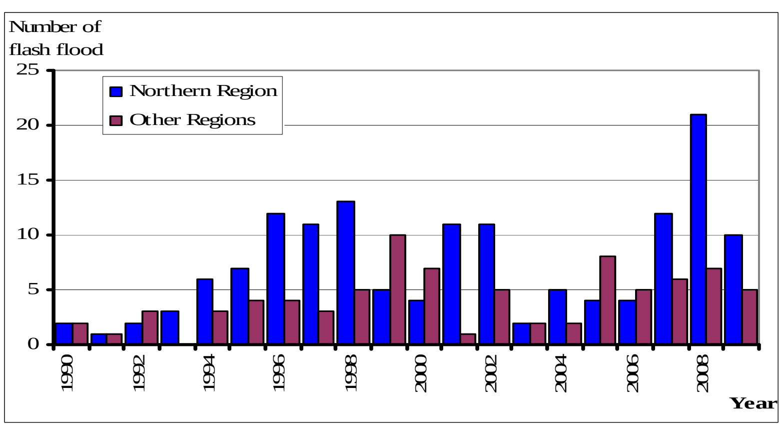

Figure 3. Distribution of flash floods in mountainous areas of the North and other areas

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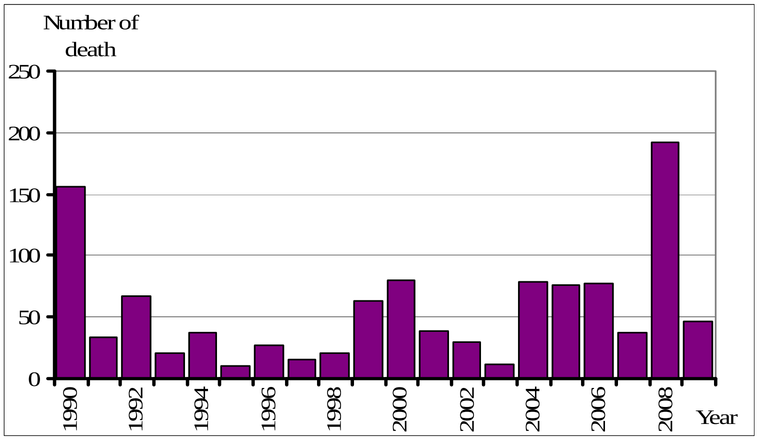

Figure 4. Number of death related due to flash floods in the period of 1990 – 2009

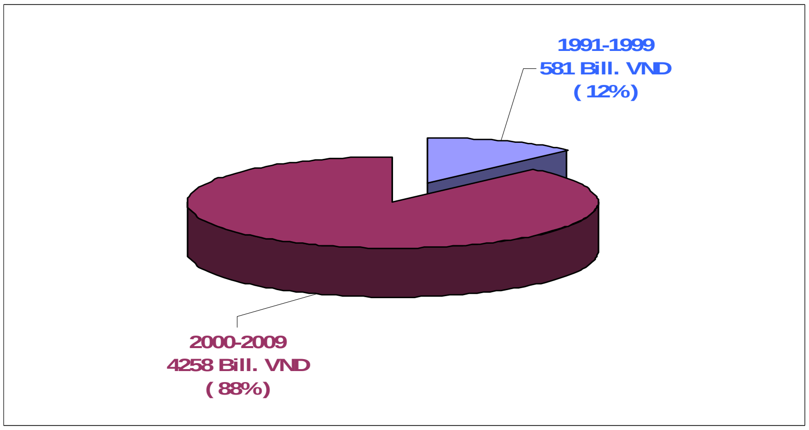

Figure 5. Damage caused by flash floods in the period of 1990-2009

Among flash flood events occurring in the recent decay, there were extreme 15 flash flood events causing considerable damages such as in Muong Lay and Lai Chau town in 1990 - 1991, 1994, 1996, 2000; in Son La town and Song Ma district in 1991; in Cao Bang, Ha Giang in 2004; in Yen Bai 2005; Ha Tinh 2002; in Nam Giai - Nghe An 2007; in Truong Son - Quang Binh in 1992; in Ham Tan- Binh Thuan 1999; in Dac Lac 1990, 2007; in early December and November 1999 in Central Viet Nam; in Lao Cai in 2008; in Bac Can in June 2009; and in Kon Tum in end of September 2009.

Statistical data show that Muong Lay town and Lai Chau town (Lai Chau Province) is one of typical cases where flash flood was occurred 6 times from 1990 to 1997 and two times in the year 1994 causing serious damages to there areas. Especially, two flash flood events occurring in 1990 and 1996 were rarely seen on its fierceness and damages causing for local community in the history.

SITUATIONS IN THE LAST FOUR YEARS (2006 - 2009)

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.

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In 2007, there were 17 flash floods. Although flash floods did not 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.

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, 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 of VND: 2,042 billion.

In 2009, there were 14 flash floods in 8 provinces in the North and Central highland of Viet Nam such as Nghe An (26 May), Lai Chau (6 and 21 July), Cao Bang, Ha Giang, Lao Cai (3 - 4 July), BacKan (3 - 4 and 10 July), Kon Tum (29 September), Binh Thuan (6 October), Phu Yen (2 November), they caused 47 people died and missing and total economic loss of VND 48 billion (Figures 6 and 7).

From 28 to 30 September 2009, due to the Tropical Storm Ketsana (Figure 8), the heavy rains, over 300 - 600 mm were recorded in provinces from Quang Binh to Quang Ngai, Gia Lai and Kon Tum in Viet Nam. The rain in some places was very heavy and higher than 600 mm such as Nam Dong: 884 mm, Tra Bong: 914 mm. Heavy rainfall mainly concentrated on 29 September with daily rainfall from 200 to 450 mm (Figure 9). In some places The maximum daily rainfall was very large such as Nam Dong: 596 mm; Tra Bong: 748 mm; Tra Khuc: 518 mm, Minh Long 521 mm.

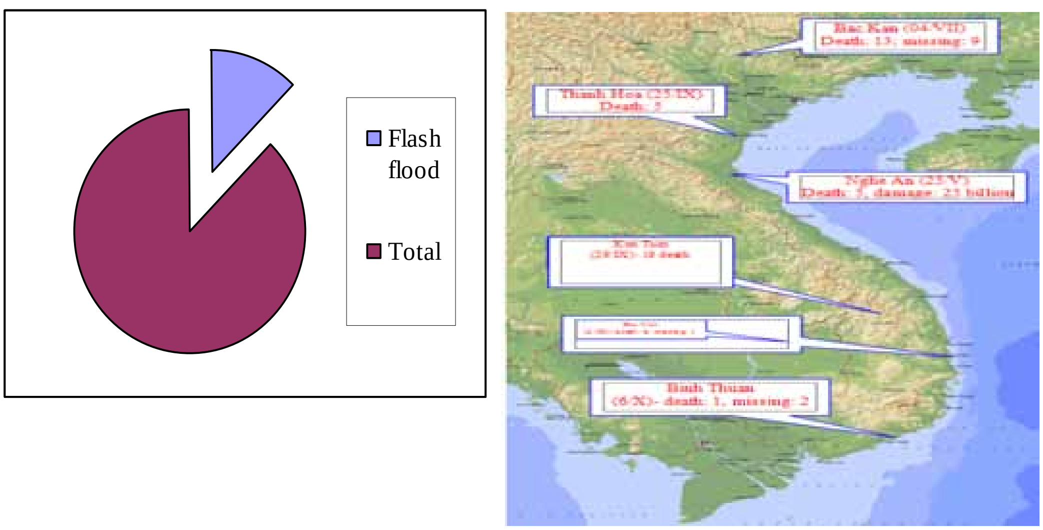

Figure 6. Number of death related to flash flood and some typical storms in 2009

The big flood and flash flood occurred in rivers from Quang Binh to Phu Yen and Highland areas. Historical flood and extreme floods occurred on rivers from Quang Tri to Quang Ngai and Kon Tum provinces. The flood amplitude was from 11.0 to 16.5 m in upstream and from 3.8 m to 6.3 m downstream of rivers in Quang Tri and Quang Ngai. On Sesan River, the flood amplitude was from 6.0 m to 8.0 m. The peak floods exceeded the alarm level 3 from 1.0 m to 4.0 m in rivers from Quang Tri to Quang Ngai and got over the historical value in Vu Gia, Tra Bong, Dakbla, Po Ko rivers. The heavy rainfall and extreme flood, flash flood led very serious large, deep inundation about 1.0 - 4.5 m during 3 - 7 days in these provinces.

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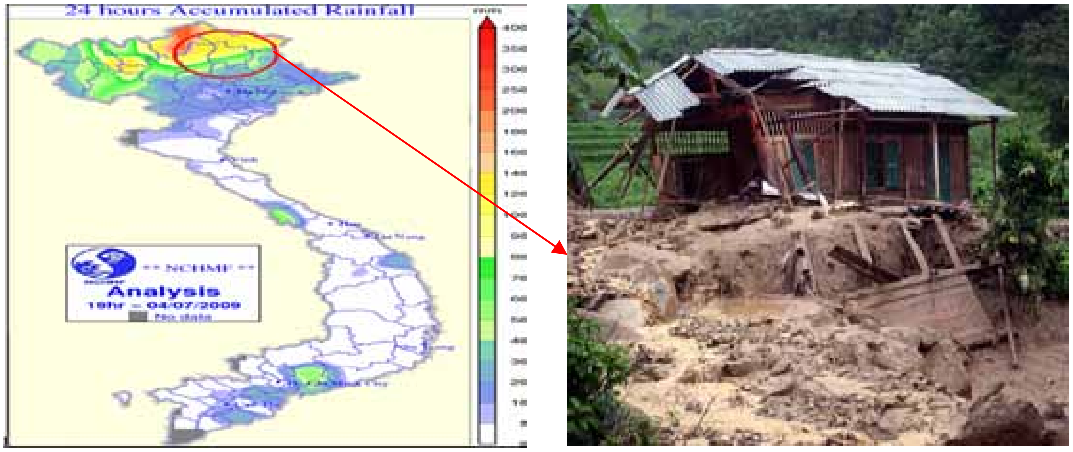

Figure 7. Ten people died and 16 houses were damaged at Khen Len - Bac Kan Province by flash flood on 4 July

Figure 8. Track of the Tropical Storm Ketsana

THE RECENT SITUATION OF FLASH FLOODS IN VIET NAM

The surveys carried out recently show that the number of flash floods per year, and in Viet Nam the trend is increasing year by year. Flash floods usually occur in water catchments of rivers and streams in the mountainous areas. The mountainous areas have the geographical features that are favorable 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 landslides can occur and obstruct the water flows. Those factors make favorable for rapid and huge water accumulation causing strong flood wave with huge potential energy. Strong flood wave with huge potential energy force the flood water to destroy the old stream flows and create the new stream 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.

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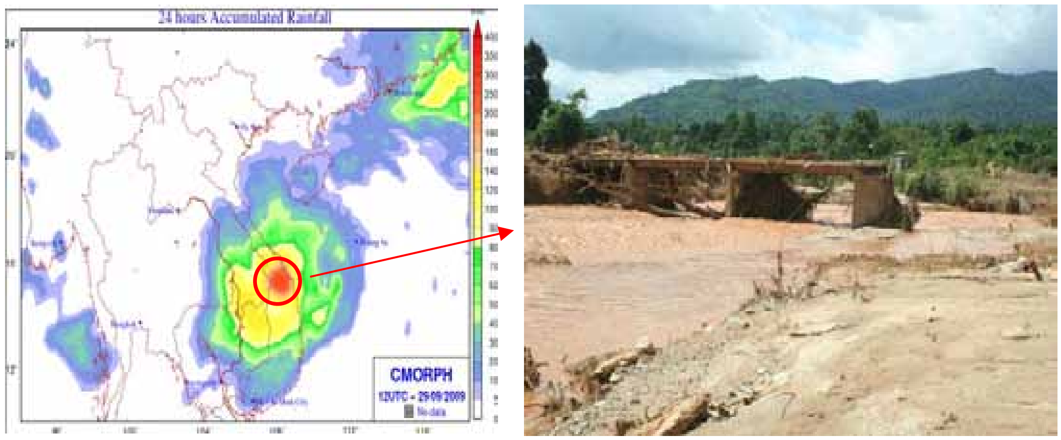

Figure 9. Landslide and flash flood after Storm Ketsana in Kon Tum in September 2009

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.

In mountainous areas of the Northern Viet Nam (Figure 10), 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).

FLASH FLOOD WARNING AND FORECASTING IN VIET NAM

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 five 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;
- to disseminate results to National and Provincial Flood and Storm Committee(s);
- to decide on the mitigation and prevention measures (National and Provincial Flood and Storm Committee(s)).

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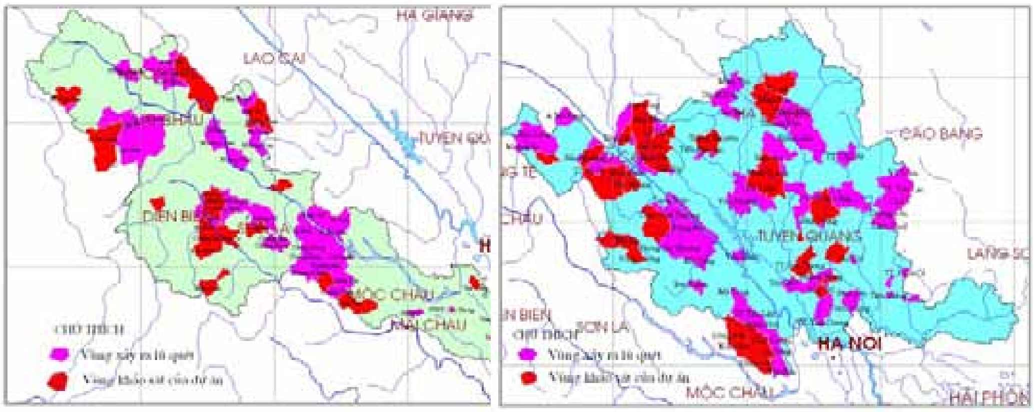

Figure 10. Map of flash floods partition in Northwest and Midland of Viet Nam

Automatic warning

Project 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. This system has been established in two basins Nam La and Nam Pan, Son La Province.

From 2006 to 2009, Institute of Meteorology, Hydrology and Environment of Viet Nam had flash flood project with two purposes:

- drawing up of flash flood map;
- establishing flash flood warning system at 37 river basins of 11 provinces.

The warning system has 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.

FLASH FLOOD GUIDANCE SYSTEM (FFGS) EXPERIMENTAL APPLICATION ON WARNING FLASH FLOODS IN VIET NAM

In the flood season of 2009, the National Centre for Hydro-Meteorological Forecasting received and initially applied the Flash Flood Guidance System (FFGS) of the Mekong River Commission (MRC) for flash flood warning in Viet Nam (Figures 11 and 12). The main task of FFGS for Mekong River Basin is to provide real-time flash flood imminent risk information guidance on a small-scale for selected area.

FFGS evaluated the possibility of flash flood occurrence in a certain basin from rainfall input data and parameters of the basin. The output of the system is a map indicating the dangerous locations that will have the possibility of flash flood occurrence. FFGS has been used in some areas of the world in order to help forecasters to cope with the impact of flash flood effectively. FFGS has been applied in Central America (CAFFG), Romania (ROFFG) and will be applied in South Africa (SAFFG).The system is designed for integrating real-time data from a variety of

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the meteorological and hydrological data to evaluate an estimated index of flash flood appearance and development. The system has a friendly interface, is easy to use, provide information in real time diagnostics, which can be used by forecasters associated with other local forecasting information to disseminate reliable flash flood warning. An operational system that monitors rainfall over the country and issues warnings for potential flash floods caused by extreme rainfall events of duration 1 to 6 hours. The flash flood warnings are issued on a small watershed basis so that the general public can make use of the information.

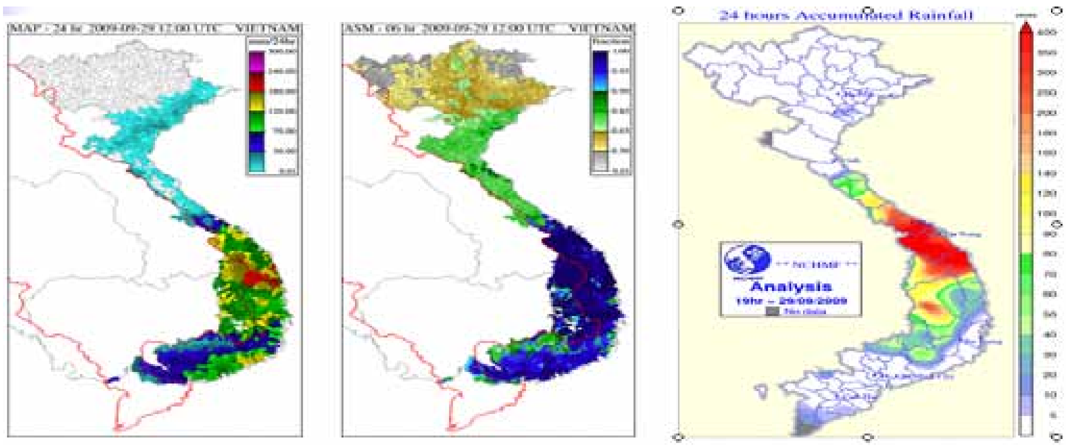

Figure 11. Rainfall accumulated 24 hours on 29 September in the Tropical Storm Ketsana

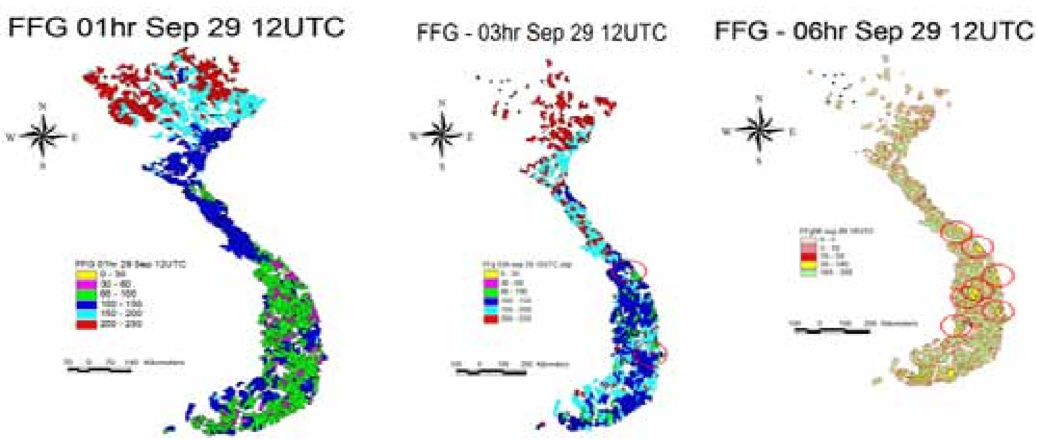

Figure 12. Application of the Mekong Flash Flood Guidance System (MRCFFGS) for the Tropical Storm Ketsana

In testing of FFGS application for the Tropical Storm Ketsana occurring from 28 September to 2 October, 2009, it can be seen that the system has the capability of detecting some areas where flash floods may appear such as Kon Tum, Da Nang, Quang Nam and Thua Thien Hue. In the actual situation, flash floods that occurred in Kon Tum resulted in losses of people and property. (Figures 13, 14 and 15).

In additional to the application of FFGS in Viet Nam, within the framework of the project, a FFGS training course was organized in December 2009 in the National Centre for Hydro-Meteorological Forecasting (NCHMF) in Ha Noi, there were 20 participants attending the course. Leader sof NCHMF appreciated FFGS and expected in the flood season 2010 to continue applying the FFGS for warning flash floods in Viet Nam.

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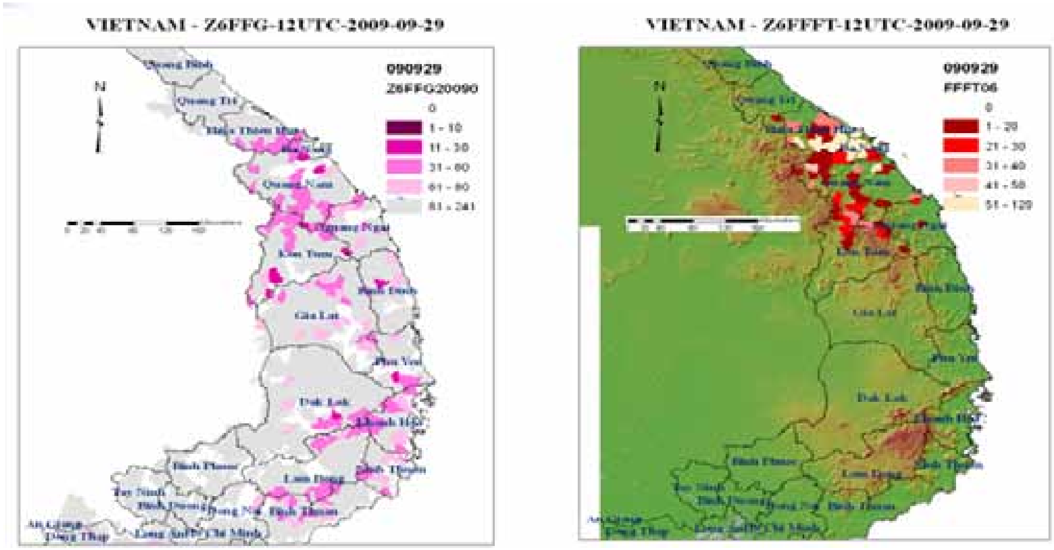

Figure 13. Product of MRCFFGS application for the Tropical Storm Ketsana in September 2009

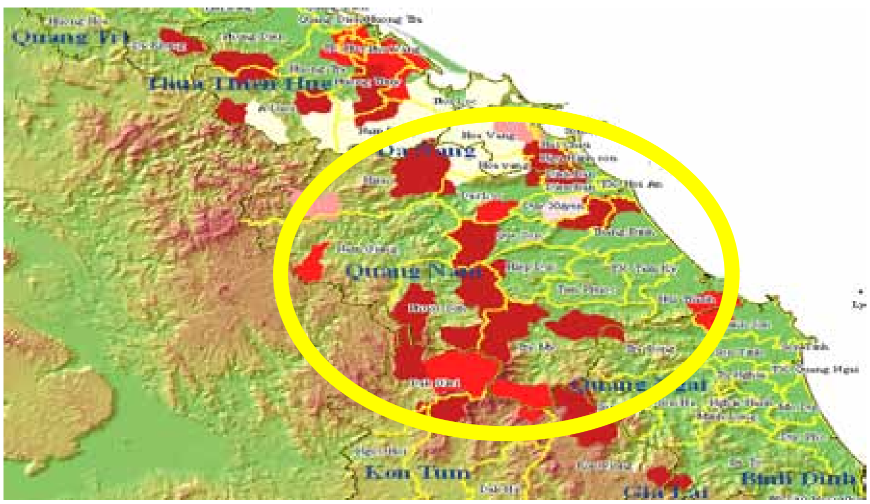

Figure 14. Flash flood occurred in Kon Tum Province

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations can be drawn:

- continuation of 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 and automatic rainfall gauges;
- improvement of Flash flood warning system (FFGS) and combine the FFGS outputs to river forecast bulletin cause model can detected some locations where flash floods may appear and need more information such as aadministration, roads, rivers etc. to the products;
- besides the application model FFGS, NCHMF plans proposed existing procedures;
- implementation of surveys and statistic analysis at residential areas, villages, households

in affected areas where are under the direct influence of flash flood and landslide, relocation of people out of flash flood areas;

- establishment of on-the-spot and local rescue teams 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 15. Regions where flash floods occurred in Kon Tum

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Paper 3-2-2

FLOOD FORECASTING IN CHI AND LOWER MUN RIVER BASIN BY THE DEPARTMENT OF WATER RESOURCES

SUPAPAP PATSINGHASANEE

Water Crisis Prevention Centre, Department of Water Resources, Bangkok, Thailand

ABSTRACT

For flood forecasting in Chi and Lower Mun River Basin the Department of Water Resources collects and analysis data by telemetry stations. The system is composed of 23 remote stations, 2 regional stations at Khon Kean and Ubon Ratchatani and 1 master station at the Department of Water Resources in Bangkok. The potential system shall cover the area of 16 provinces. The system is used for investigation of hydrological, hydraulic and water quality data. These data and information is used in the mathematic model for the theoretical analysis, simulation and assessment of the probably situation in order to minimize flooding, or other related flood hazards. The mathematic model used in the study consists of a rainfall-runoff model, a hydrodynamic model (Floodwork/Infowork) and an artificial neural network model (Qnet2000). The performance of the models was acceptable compared to observed data. Moreover, this project includes a study on flood management such as; analysis of travel times of floods and evaluation of flood warning criteria (warning criteria for flooding and warning criteria for flashfloods). The study on flood management is used to reduce damages to life and properties.

INTRODUCTION

Water-related problems have been the chronicle problem for long time, whether, water shortage in the dry season, flood in the rainy season and water pollution due to rapid development.

Flood occurs from the past up to the present causing damage to lives and properties and the trend is relatively high in the future due to the monsoon topography location. The problem could be prevented both by construction of hydraulic structures, increasing efficiency of drainage and installation flood warning systems. However, the socio economic development in Thailand led to an increasing number of population, changing of land pattern utilization, exploitation of natural resources, as a result, floods occur frequently and more seriously. Within 30 years, Thailand has been confronted with floods in almost every province for ten times. The six most severe floods occurred in 1975, 1983, 1995, 2002, 2005 and 2006 respectively.

OBJECTIVES

The objectives of flood forecasting in Chi and Lower Mun River Basins by the Department of Water Resources are as follows:

- to develop a network for the collection of meteorological and hydrological data;
- to develop water resources models and database software;
- to develop criteria that are being used for flood warning, flooding and flash flood guidance.

RESULT OF FLOOD FORECASTING IN CHI AND LOWER MUN RIVER BASIN

Project area

Chi and Mun river basins consist of 31 sub-basins, as shown in Figure 1, 21 sub-basins in Chi River Basin and 11 in Mun River Basin. The project area of this study includes the whole Chi River Basin plus the Lower Mun River Basin.

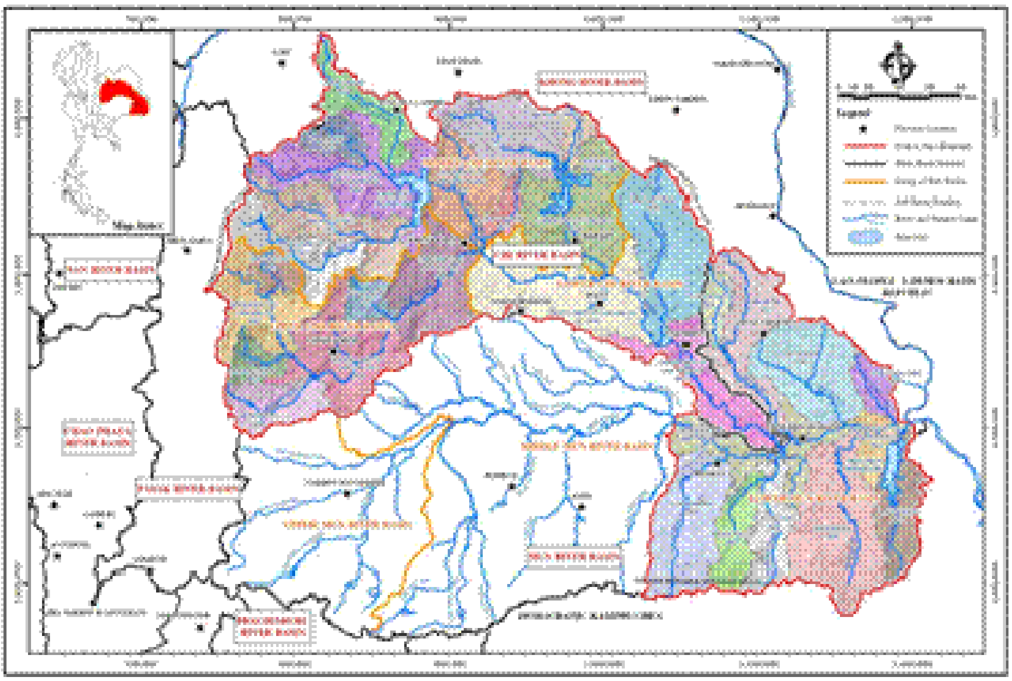

Figure 1. River Basins in the project area

The Chi River Basin has total area of 49,129 km^2, in 16 provinces i.e., Kalasin, Khon Kaen, Chaiyaphum, Nakhon Ratchasima, Phetchabun, Maha Sarakham, Mukdahan, Yasothon, Roi Et, Lop Buri, Loei, Si Sa Ket, Sakon Nakhon, Nong Bue Lumphu, Udon Thani and Ubon Ratchathani. The basin is surrounded by mountain ranges along the eastern, northern and western sides, with elevation in the range of 300 to 1,300 m+MSL (Mean Sea Level). Chi River and its main tributaries originate from Dong Phraya Yen Mountain at the east of the basin. The land between these mountain ranges is mostly plateau and some hilly area on the South, with an elevation of 120 to 200 m+MSL.

The Lower Mun River Basin has a total area of 25,995 km^2, covering 7 provinces i.e., Mukdahan, Yasothon, Roi Et, Si Sa Ket, Surin, Amnat Chareon and Ubon Ratchathani. The basin is mainly highland with some hilly area on the East and Phanom Doong Rak Mountain as southern border. The area is gently sloping to the East with an elevation of around 200 m+MSL.

Development of database and surveillance system of water disasters

Scope of system development

According to the scope of work, hardware and software developed in this project can be divided

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into three parts, i.e.:

- development of a telemetry system and a regional data centre: This task involves all hardware and construction works of remote stations, a sub master station at Khon Kaen, and a master station at Bangkok;
- development of mathematical models, which cover hydrodynamic, water resources and water quality;
- development of the SCADA system, Database system and data presentation/warning/ Decision Support System (DSS).

The configuration of the system as developed in the telemetry system is shown in Figure 2.

Overview of construction works

Installation works can be divided into three parts, as shown in Figure 3, i.e.:

- *regional data centre.* Regional data centre in this project comprises two stations, i.e., a master and a sub master station.
    - *master station*. The station is located at Mekhala Centre, Department of Water Resources, Bangkok. The system design of the master station has taken into account the upgrading plan of the Mekhala Centre Project;
    - *sub master station.* The sub master station is located at Hydrology Division, Khon Kean Province. The sub master station is equipped with a workstation computer and Internet ADSL for:
        - monitoring situation via presentation/warning/DSS system, which is developed as a web based application;
        - connection to the master station's database to allow the regional operator to perform more complicate query of the data;
    - *remote stations.* The number, location and components of each remote station, as well as its purpose or significance on water resources management is summarized in Table 1 and Figure 4.
- *mathematic models*. Summary on type and application of each model, as well as related customized software, developed in this project, can be summarized as shown in Table 2 and Figure 5;
- *SCADA database and presentation/warning/DSS System.* Summary on type and application of each model, as well as related customized software, developed in this project, can be summarized as shown in Table 2 and Figure 5. SCADA, database and presentation/warning/DSS system is designed to work together to control field stations, manage the data from/to field stations and models and act as an interface between operator and hardware/software. The whole system consists of:
    - SCADA system;
    - Database system and related data exchange programs;
    - Presentation/ Warning/ DSS system (Project website);
    - CCTV and image management system.

Interfaces of each system are shown in Figure 6. Regarding the project website, it can be accessed via a link in the main page of Department of Water Resources (DWR) website at www.dwr.go.th or at http://tele.dwr.go.th/chi.

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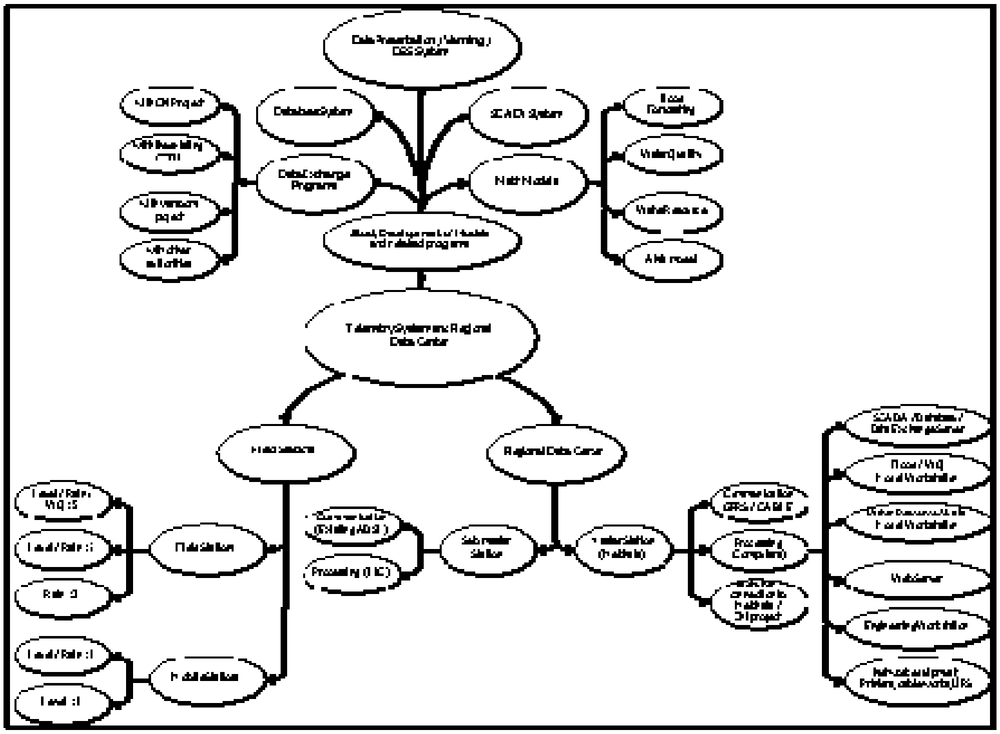


Figure 2 Configuration mind map of the telemetry system

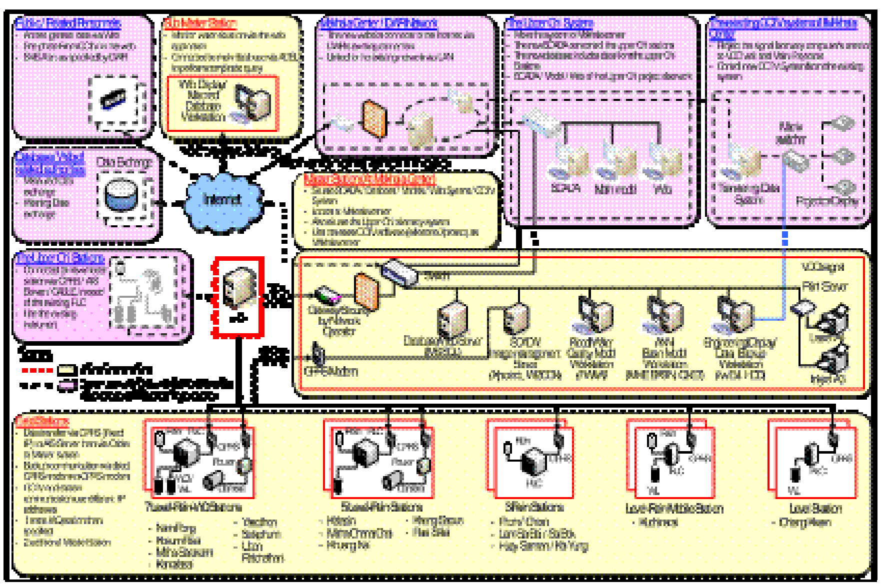


Figure 3. Configuration and process diagram of the telemetry system

Table 1. List of all telemetry stations in Chi and Lower Mun basins

Item	Name	Stream	UTM		Instrument			CCTV
			N	E	Level	Rain	Quality	
1	Nam Phong	Phong	1,842,628	267,798	1	1	1	1
2	Kosum Phisai	Chi	1,810,528	281,007	1	1	1	1
3	Maha Sarakham	Chi	1,795,538	332,315	1	1	1	1
4	Kamalasai	Pao	1,807,095	347,946	1	1	1	1
5	Kalasin	Pao	1,833,853	333,246	1	1	-	1
6	Selaphum	Chi	1,772,795	383,172	1	1	1	1
7	Yasothon	Chi	1,744,906	407,545	1	1	1	1
8	Maha Chana Chai	Chi	1,716,593	419,581	1	1	-	1
9	Ubon Ratchathani	Mun	1,683,074	484,677	1	1	1	1
10	Kaeng Sapue	Mun	1,685,741	525,618	1	1	-	1
11	Rasi Salai	Mun	1,696,183	409,064	1	1	-	1
12	Khueang Nai	Lam Sa Bai	1,714,039	456,531	1	1	-	1
13	Lam Sa Bai	-	1,758,109	459,622	-	1	-	-
14	Huay Samran	-	1,626,845	413,706	-	1	-	-
15	Phrom/Chern	-	1,848,373	803,356	-	1	-	-
16	Kuchinarai	Young	1,818,167	396,534	1	1	-	-
17	Chiang Khwan	Chi	1,792,848	365,064	1	-	-	-
18	Ban Laonokchum	Chi	1,813,811	914,728	1	1	1	
19	Wat Papacharat	Chi	1,783,282	881,869	1	-	-	
20	Wat Prachamongkol	-	1,775,897	853,840	-	1	-	
21	Ban Kaimueanpeao	Chi	1,736,143	822,555	1	-	-	
22	Wat Pathumchart	-	1,724,301	806,872	-	1	-	
23	Wat Noanchuak	-	1,741,223	803,223	1	-	-	

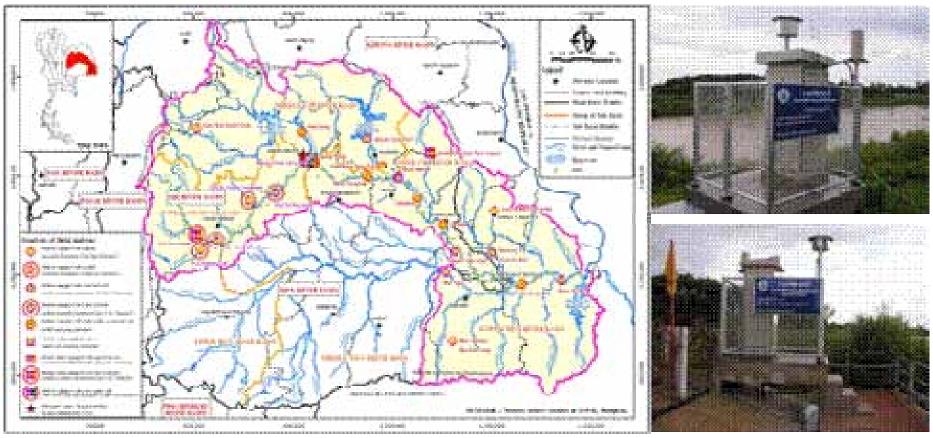
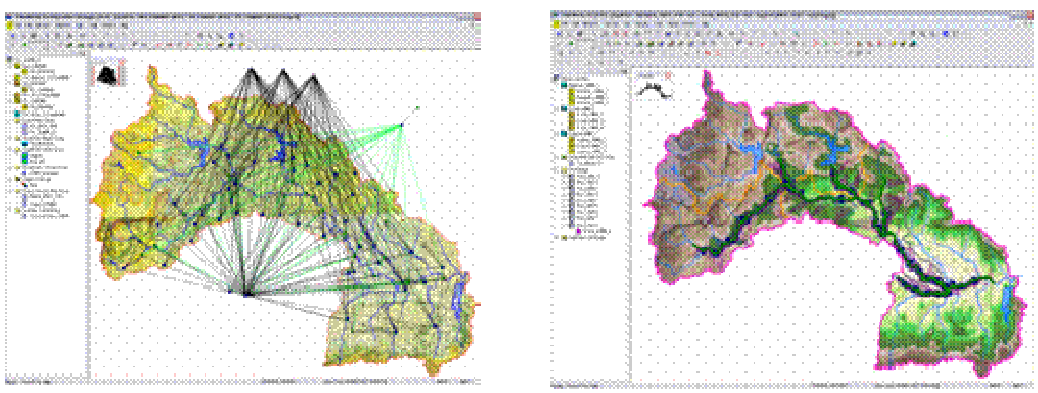


Figure 4. Station location map

Table 2. Summary on mathematical models and related customized software

Item	Model	Software	Application/capability
1	Hydrodynamics/ flood forecasting model	FloodWorks/ Infoworks	• automatically data input from database • automatically flood forecasting • graphical result presentation as flood map and graph, as well as table form. • use as manual tool to study related scenario for DSS • result sent to presentation/ Warning/ DSS system
2	Artificial Neural Network model	QNET2000	• predict the result from relations established from recorded data, such as rainfall vs. water level, using ANN equations. • result sent to presentation/ Warning/ DSS system
3	Data exchange/ aggregator	Customized application (VB, C++, ASP)	• aggregate related data into the project database • capable of web service data exchange to other organizations that DWR approves



Flood forecasting model

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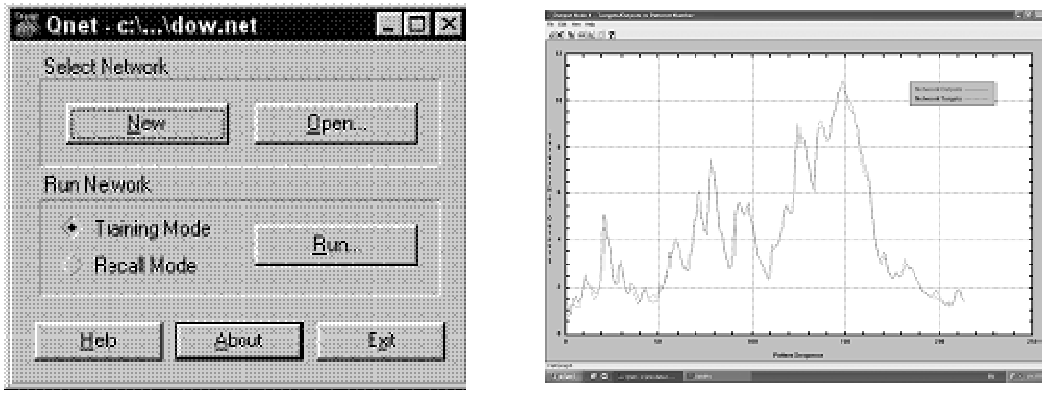

Figure 5 Interface of mathematical models

STUDY ON FLOOD MANAGEMENT AND WARNING CRITERIA

Study on flood management

Besides installation work, mathematical model and software development, the project also includes study work which is emphasized on flood management and evaluation of warning/operation criteria in order to be used in presentation/ warning/ DSS system. The study is based upon recorded measuring data, situation reports on flood and results from models.

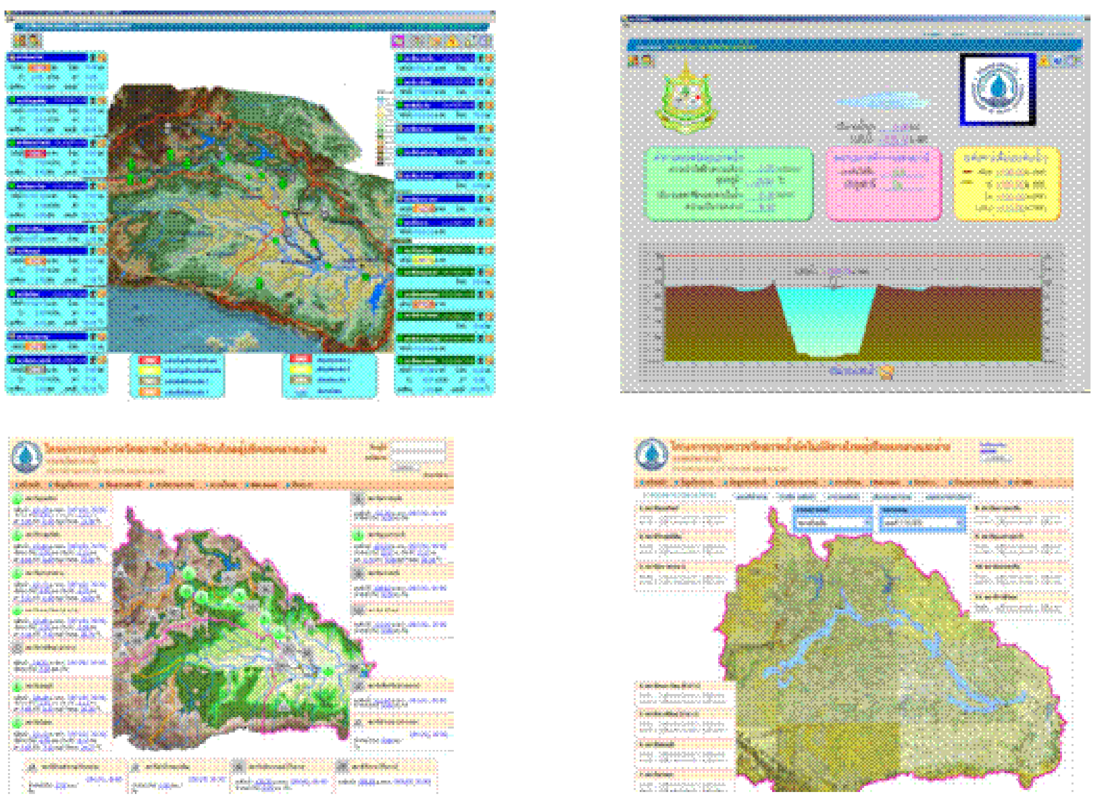

Figure 6. SCADA, database and presentation / warning / DSS system

Analysis of travel time of flood water

Aim of this study is to find the travel time of flood water in the rivers. The study is carried out by using the hydrodynamic model. The result is used to estimate the travel time of water between key points along the rivers when the real-time discharge is known from the telemetry data.

Analysis of the results of Chi and Mun rivers at high, average and low flood discharge are as shown in Table 3 .Three discharges used in the calculation are based on data in August 2006, the period that the basin experienced one of the serious floods.

Evaluation of flood warning criteria

There are two types of flood problems in project area i.e.:

- flooding along the rivers due to large quantities of water during the rainy season;
- flash flood due to high intensity of rainfall in mountainous area.

Table 3. Travelling time of flood discharge in Chi and Mun rivers

River	River reach		Distance	Discharge (m^3/s)			Travelling time (hr)		
	U/S	D/S	(km.)	Q max	Q mean	Q min	Q max	Q mean	Q min
Chi	Sta Wat Noanchuak	Mueang Chaiyaphum	106.4	623	289	77	40.0	49.5	54.5
		Mueang Khon Kaen	330.6	623	289	77	121.5	171.7	213.4
		Sta. Kosum Phisai	357.9	623	289	77	130.7	196.1	252.1
	Sta. Kosum Phisai	Mueang Maha Sarakham	77.1	667	379	76	32.2	59.2	86.1
		Sta. Maha Sarakham	104.5	667	379	76	43.4	78.4	112.9
	Sta. Maha Sarakham	Roi Et Weir	93.1	683	382	101	34.8	75.6	115.5
		Sta. Selaphum	134.3	683	382	101	48.0	95.9	142.4
	Sta. Selaphum	Mueang Yasothon	76.0	734	438	206	29.7	51.8	70.0
		Sta. Yasothon	80.6	734	438	206	31.7	54.3	73.1
	Sta. Yasothon	Yasothon Weir	7.6	756	522	353	3.5	4.0	4.8
		Sta. Maha Chana Chai	64.7	756	522	353	26.3	30.3	35.2
	Sta. Maha Chana Chai	That Noi Weir	68.2	787	486	385	24.9	29.1	32.9
		Chi Mun Junction	139.2	787	486	385	49.4	57.3	65.2
Mun	Sta. Rasi Salai	Chi Mun Junction	106.7	1,910	788	340	34.8	53.6	67.4
	Chi Mun Junction	Mueang Ubon Ratchathani	8.0	2,995	1,619	467	3.0	3.6	4.2
		Sta. Ubon Ratchathani	26.3	2995	1,619	467	8.9	12.2	15.3
	Sta. Ubon Ratchathani	Sta. Kaeng Sapue	49.4	3,344	1,860	1,025	16.0	25.4	32.3

Remark: Q max, Q mean and Q min are discharge in Chi and Mun rivers at maximum, mean and minimum value that are selected from the flood period between 1st August and 30th November, 2006, the high flood inundation year in Chi and Mun river basins.

Table 4. Flood warning water level at the remote stations

No.	Station	Water level (m+MSL)		Flooded area
		Hi	HiHi	
1.	Nam Phong	163.60+	163.90+	Nam Phong riverbanks at Nam Phong (Nam Phong and Wangchai)
2.	Kosum Phisai	147.20+	147.40+	Chi riverbanks at Kosum Phisai (Hua Kwang)
3.	Maha Sarakham	138.93+	139.23+	Chi riverbanks at Maha Sarakham
4.	Kamalasai	135.19+	135.49+	Lampao riverbanks at Kamalasai
5.	Kalasin	166.58+	166.88+	Lampao riverbanks at Kalasin (Huai Pho) and Kamalasai
6.	Selaphum	130.80+	131.00+	Chi riverbanks at Thung Khao Luang (Klang) and Yasothon
7.	Yasothon	126.61+	126.91+	Chi riverbanks at Yasothon, Maha Chana Chai (Fa Yad) and Phanom Phrai
8.	Maha Chana Chai	121.35+	121.65+	Chi riverbanks at Maha Chana Chai (Fa Yad)
9.	Ubon Ratchathani	110.53+	110.73+	Mun riverbanks at Ubon Ratchathani, Warin Chamrap (San Suk)
10.	Kaeng Sapue	110.09+	110.29+	Mun riverbanks at Phibun Mangsahan and Tan Sum
11.	Rasi Salai	118.70+	118.90+	Mun riverbanks at Rasi Salai (Muang Kong)
12.	Khueang Nai	126.60+	127.00+	Lam Sabai riverbanks at Khueang Nai
13.	Kuchinarai	138.60+	139.00+	Nam Yang riverbanks at Kuchinarai, Phon Thong
14.	Chiang Khwan	133.43+	133.63+	Chi riverbanks at Chiang Khwan (Thong Thani) and Thung Khao Luang (Klang)

Remarks : Hi = Early warning water level before flood inundation, HiHi = Water level of flood inundation

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Warning criteria for flooding

Warning criteria for flooding, evaluated from water level data and flood situation reports from 2006 to 2009 as well as resulting from the model are summarized in Table 4.

Warning criteria for flash floods

Warning criteria for flash floods, evaluated from rainfall data and flood situation data from 2006 to 2009 are shown in Table 5.

Table 5. Flood warning rainfall at the remote stations

No.	Station	Rainfall (mm)		Flooded area
		Hi	HiHi	
1.	Nam Phong	54	65	Area in Nam Phong (Nam Phong and Wangchai), Kranuan (Nhongko), Khao Suan Kwang and Ubolratana
2.	Kosum Phisai	65	78	Area in Kosum Phisai (Hua Kwang) and Chiang Yuen
3.	Maha Sarakham	49	54	Area in Mueang Maha Sarakham (Wangnang), Kae Dam, Kantharawichai (Kokphra, Nhongpan), Yang Talat (Yang Talat and Koksri)
4.	Kamalasai	54	65	Area in Kamalasai (Kamalasai and Huaipho), Mueang Kalasin and Yang Talat (Koksri)
5.	Kalasin	74	89	Area in Mueang Kalasin (Nhong So and Najarn)
6.	Selaphum	42	46	Area in Thung Khao Luang (Klang), Thawat Buri (Ban Niwet), Chiang Khwan (Thong Thani) and At Samat
7.	Yasothon	50	60	Area in Mueang Yasothon and Phanom Phrai
8.	Maha Chana Chai	53	64	Area in Maha Chana Chai (Fa Yad), Kham Khuean Kaeo, Kho Wang
9.	Ubon Ratchathani	51	61	Area in Mueang Ubon Ratchathani Warin Chamrap (San Suk)
10.	Kaeng Sapue	62	74	Area in Phibun Mangsahan and Tan Sum
11.	Rasi Salai	60	72	Area in Rasi Salai (Muang Kong), Bueng Bun
12.	Khueang Nai	52	62	Area in Muang Sam Sip, Khueang Nai and Huai Thap Than
13.	Lam Sa Bai	63	76	Area in Mueang Amnat Charoen (Nam Pleak) and Senangkhanikhom
14.	Huay Samran	63	76	Area in Khukhan (Hua Nhua) and Phrai Bueng
15.	Phrom/Chern	61	73	Area in Phu Pha Man, Chum Phae (Nonhan) and Khon San
16.	Kuchinarai	57	68	Area in Phon Thong, Nong Phok, and Kuchinarai (Bua Kaow and Kudwa)

Remarks : Hi = Early warning rainfall before flooding ; HiHi = Rainfall at flooding

LESSONS LEARNT

Technologies for flood forecasting and warning systems can significantly contribute to prevent or mitigate people’s suffering due to flooding. The direct immediate objective for such systems should be to provide people with fast, accurate, reliable, relevant and easy to understand forecasts and warning. Technologies for flood forecasting and warning system problems mentioned reflect some lesson as follows:

- variety of information where no grouping has been systematically arranged under the same stand, so it is quite difficult to access the database;
- lack of connection and linkage of complete and modest information;
- lack of skilful personnel;

- lack of information system and knowledge base centre for national water resources;
- problem of integrated participation in management of stakeholders in public, private sectors, local government and people.

CONCLUSIONS

Flood Forecasting in Chi and Lower Mun River Basin by the Department of Water Resources is based on collected data by telemetry stations and analysis. The system is composed of 23 remote stations, 2 regional stations at Khon Kean and Ubon Ratchatani and 1 master station at the Department of Water Resources in Bangkok. The potential of the system will cover the area of 16 provinces. The system is used for investigation of hydrological, hydraulic and water quality data. These data and information is used in the mathematic model for the theoretical analysis, simulation and assessment of the probable situation in order to minimize flooding and other related flood hazards. The mathematic model used in the study consists of a rainfall-runoff model, a hydrodynamic model (Floodwork/Infowork) and an artificial neural network model (Qnet2000). The performances of the models were acceptable with reliability compared with observed data. Moreover, this project includes studies on flood management such as; analysis of travel time of flood and evaluation of flood warning criteria (warning criteria for flooding and warning criteria for flash floods). The study on flood management is used for reduction of damages to life and properties.

When there is a massive amount of runoff that surpasses the conveyance of the river even though flood protection is fully implemented, the next best mitigation measure is early warning. In this study, flooded areas, when water levels reach those of the warning criteria, are identified. From these areas and real-time data from field stations, the operator will warn about the situation and, then, he can coordinate with local authorities within the flooded area to prepare mitigation measures and warn the people for the up-coming flood.

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Paper 3-2-3

RECENT DEVELOPMENT IN FLOOD FORECASTING AND EARLY WARNING

YIN SAVUTH

Department of Hydrology and River Works, Ministry of Water Resources and Meteorology, Phnom Penh, Cambodia

ABSTRACT

Flood forecasting

The Department of Hydrology and River Work (DHRW) is responsible for hydrological data collection and flood forecasting from July to October every year along the mainstream of Mekong River, Bassac River and Tonle Sap River in Cambodia for three days ahead by using the method of station correlation. The DHRW receives the near real time data before 7:00 hour by SMS since 2008 through HydMet Software and phone calls. Then DHRW exchanges the data and information with the countries in Mekong River Basin through the Mekong River Commission Secretariat (MRCS) by e-mail or HydMet software. A flood bulletin is 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 TV, radio, journalists, etc.

Early warning

DHRW provided flood forecasting and transferred flood information for three days ahead to 40 flood vulnerable villages in Cambodia around noon. This information to the 40 villages has been stopped since 2007 because there aren't any more reading water level data after the Office of U.S. Foreign Disaster Assistance (OFDA) project finished.

Under Component 5 of the Flood Management and Mitigation Programme (FMMP-C5) DHRW re-established the flood mark and flood information billboards in the Peam Ro and Leuk Dek districts and makes flood forecasting to the local communities of these two pilot districts. In cooperation with FMMP-C5 flood maps for these two districts have been made.

HYDROLOGICAL NETWORK IN CAMBODIA

The Department of Hydrology and River Works (DHRW) of the Ministry of Water Resources and Meteorology (MOWRAM) is responsible for flood forecasting and the hydrological monitoring network in Cambodia. There are water level stations, discharge stations and water quality stations. The equipment that we use for water level stations is staff gauge, slope gauge, automatic recorder (bubble sensor, float and radar sensor) such as Appropriate Hydrological Network Improvement Project (AHNIP) and Mekong Hydrological Cycle Observing System (M-HYCOS). The hydrological network in Cambodia is shown in Figure 1 and the water quality monitoring network is shown in Figure 2.

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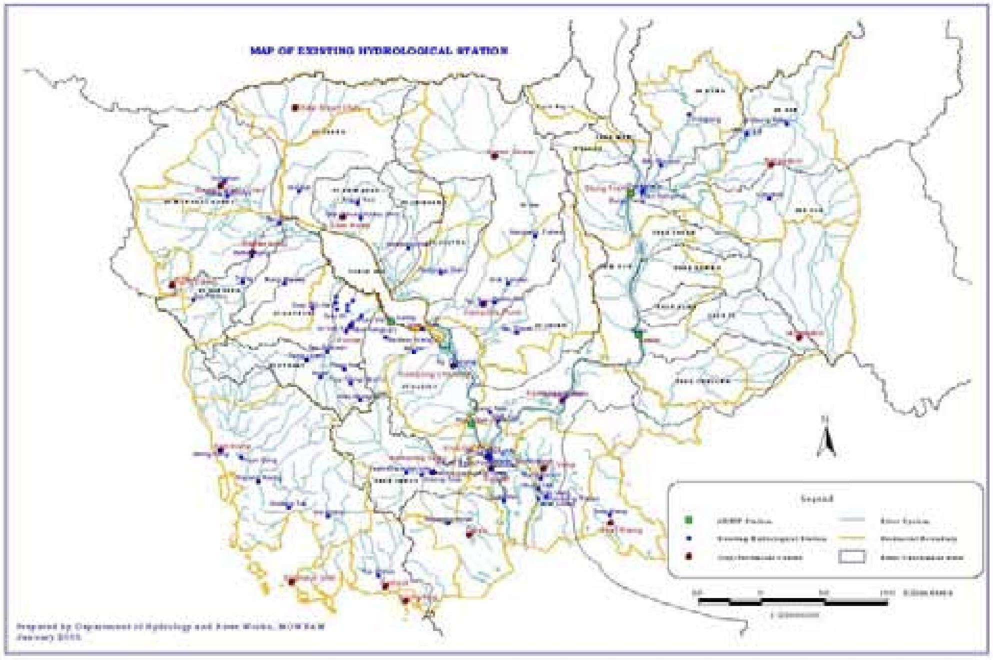

Figure 1. Map of existing hydrological stations

Figure 2. Map of water quality monitoring network

WATER LEVEL DATA TRANSFER

There are three types of water level data transfer to the Department of Hydrology and River Works as hourly, daily, weekly and 6 monthly data as shown in Figure 3:

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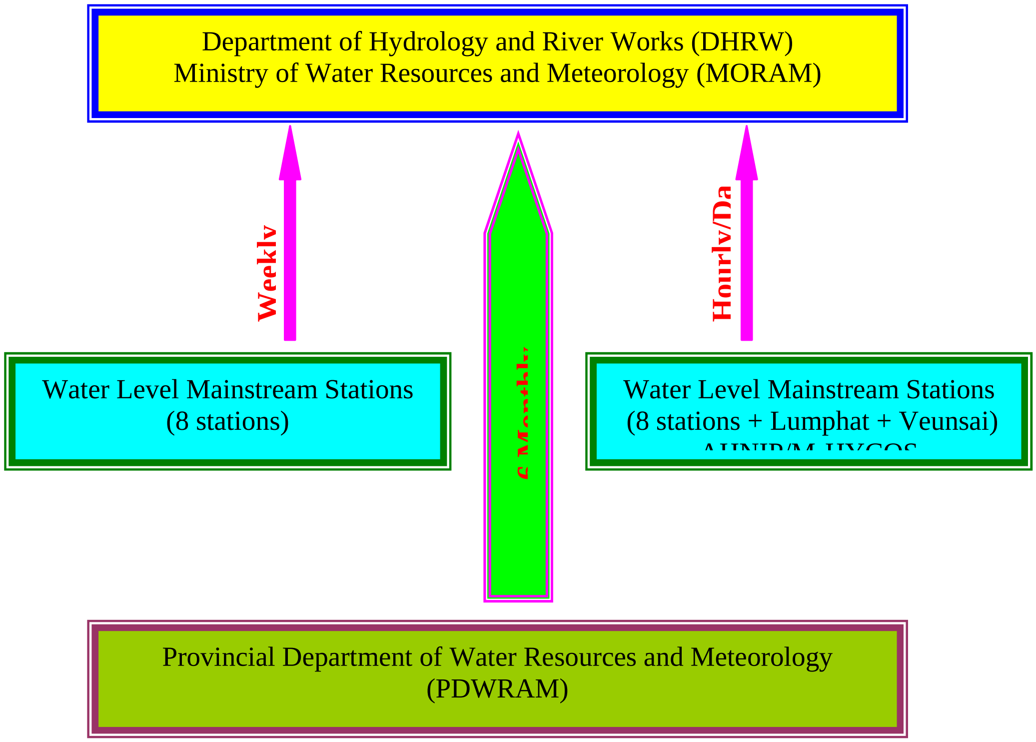

Figure 3. Three types of water level data transfer to Department of Hydrology and River Works

Hourly/Daily data transfer for flood forecasting

During the flood season from July to October, the DHRW makes the flood forecasting for 7 stations along the mainstream of Mekong, Bassac and Tonle Sap rivers. So, it needs the water level and rainfall data everyday of those 7 stations: Mekong-Stung Treng, Mekong-Kratie, Mekong-Kompong Cham, Mekong-Neak Loung, Bassac-Chaktomuk, Bassac-Koh Khel and Tonle Sap-Prek Kdam and additional data of three stations: Tonle Sap-Phnom Penh Port, Se San-Veunsai, Sre Pork-Lumphat.

The data are transferred to DHRW everyday before 7:00 am by SMS through HydMet or telephone call to observers of the field stations. But the real time data of hydro-meteorology was sent to DHRW by GSM or General Packet Radio Service (GPRS) and shared with the Mekong River Commission Secretariat (MRCS), Flood Management and Mitigation Programme (FMMP) and Mekong River Commission (MRC) Member Countries.

Weekly data transfer for river monitoring

During the dry season from November to June, DHRW does river monitoring by receiving data every Monday from the 8 water level stations along the mainstream of Mekong, Bassac and Tonle Sap rivers: Mekong-Stung Treng, Mekong-Kratie, Mekong-Kompong Cham, Mekong-Neak Loung, Bassac-Chaktomuk, Bassac-Koh Khel, Tonle Sap-Phnom Penh Port and Tonle Sap-Prek Kdam. The observers of the field stations transfer the data to DHRW by telephone.

Six monthly data transfer

DHRW receives the water level data from each Provincial Department of Water Resources and

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Meteorology as 2 times per year, so the data are sent to DHRW every 6 monthly to input to the 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 doesn't forecast flash floods. MOWRAM is responsible for making announcements 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 concerned agencies and FMMP/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, a Flood Forecasting Bulletin is printed, approved and then send by fax before 10:00 hour to the 45 end-users which are namely line agencies, TVs, Radio, Journalists, NGO, etc. The data flow and the flood forecasting tool is shown in Figures 4 and 5.

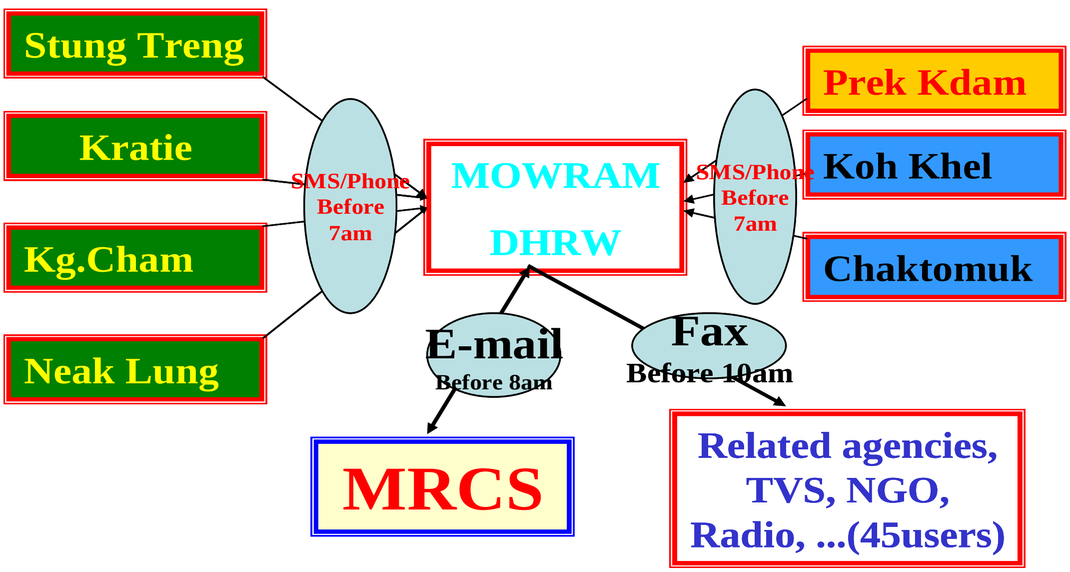

Figure 4. Data flow for flood forecasting

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 are shown in Figures 6 and 7 respectively.

Flood forecasting and early warning

DHRW cooperates 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. The flood forecasting was stopped since 2007 because there were no water level data readings sent anymore to DHRW. Under the FMMP-C5, DHRW improved the 16 flood marks and 8 flood information billboards of Peam Ro and 14 flood marks and 6 flood

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information billboards of Leuk Dek District (shown in Figure 8) for improving hydrological data, produce flood maps, flood duration, maximum flood depth, completion of draining and make flood forecasting to these two districts from 2009-2010.

The data flow for the Office of U.S. Foreign Disaster Assistance (OFDA) project, the water level reached to DHRW around 11:00 hour by headquarter offices of National Committee for Disaster Management (NCDM) and CRC in Phnom Penh via an e-mail, then the data were input the model for flood forecasting, after that the flood bulletin product is sent back to them by e-mail for taking further action.

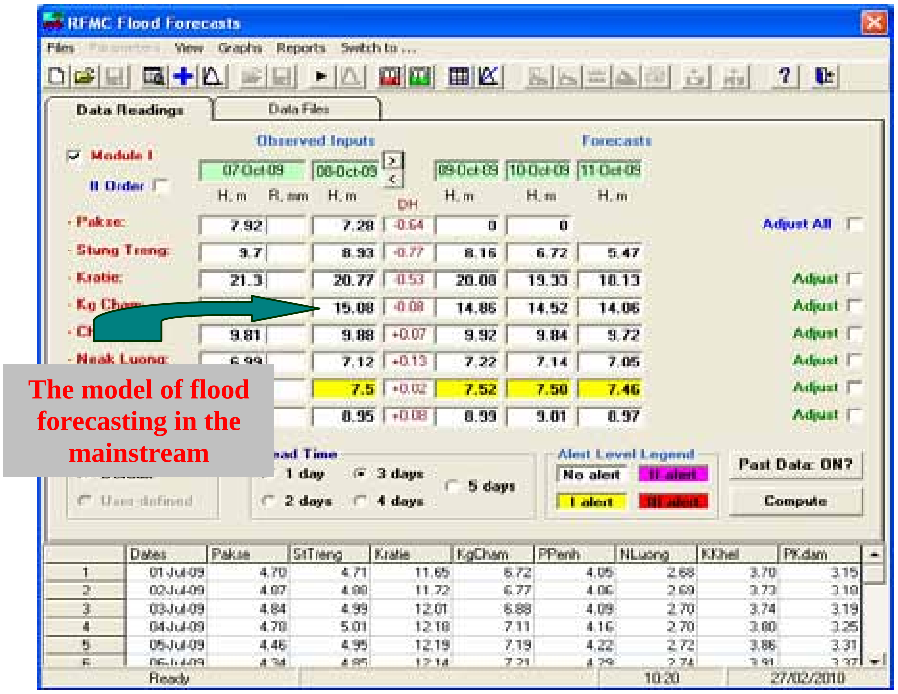

Figure 5. Flood forecasting tool

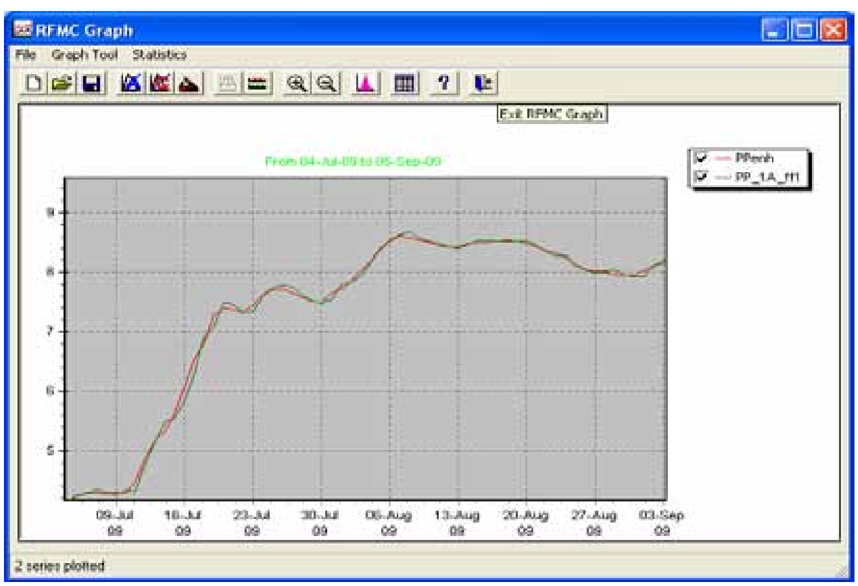

Figure 6. Comparison between the observation and simulation at Bassac-Chaktomuk Station

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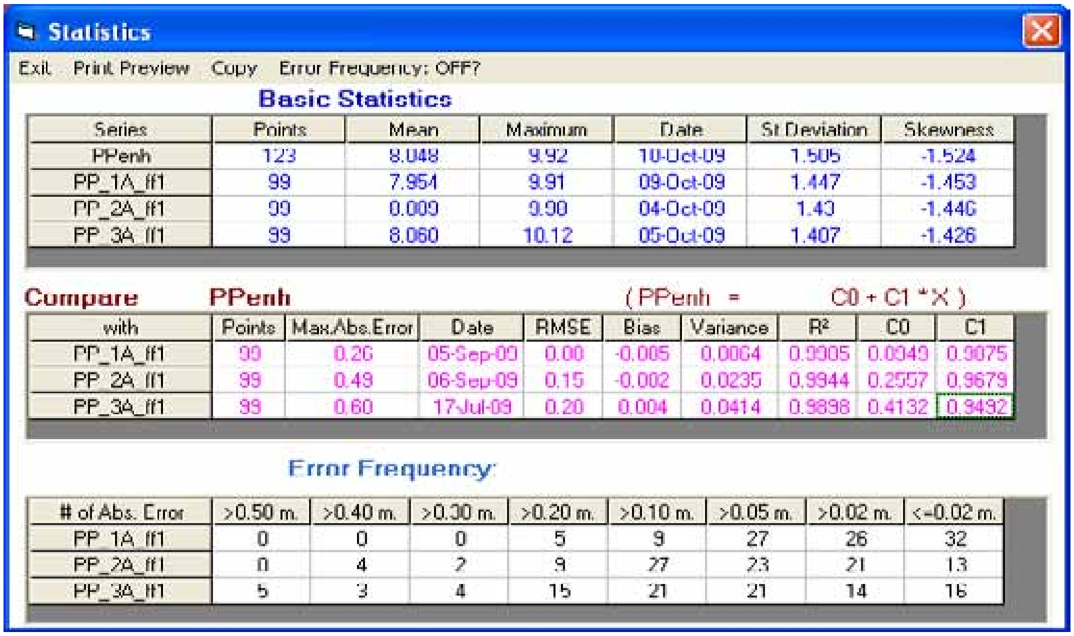
But during the FMMP-C5 funded by ‘Deutsche Gesellschaft für Technische Zusammenarbeit’ (GTZ), the water level is sent direct from observers to DHRW by phone to make forecasting and send back to observer for posting the water level on the flood billboards. The detailed information of data flow for the OFDA project and FMMP-C5 funded by GTZ is shown in Figure 9.


Statistics

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Basic Statistics

Series	Points	Mean	Maximum	Date	St Deviation	Skewness
PPenh	123	8.048	9.92	10-Oct-09	1.505	-1.524
PP_1A_ff1	99	7.954	9.91	09-Oct-09	1.447	-1.453
PP_2A_ff1	99	0.009	9.90	04-Oct-09	1.43	-1.446
PP_3A_ff1	99	8.060	10.12	05-Oct-09	1.407	-1.426

Compare PPenh (PPenh = C0 + C1 * X)

with	Points	Max.Abs.Error	Date	RMSE	Bias	Variance	R²	C0	C1
PP_1A_ff1	99	0.26	05-Sep-09	0.00	-0.005	0.0064	0.9905	0.0049	0.9075
PP_2A_ff1	99	0.49	06-Sep-09	0.15	-0.002	0.0235	0.9944	0.2557	0.9679
PP_3A_ff1	99	0.60	17-Jul-09	0.20	0.004	0.0414	0.9898	0.4132	0.9492

Error Frequency:

# of Abs. Error	>0.50 m.	>0.40 m.	>0.30 m.	>0.20 m.	>0.10 m.	>0.05 m.	>0.02 m.	<=0.02 m.
PP_1A_ff1	0	0	0	5	9	27	26	32
PP_2A_ff1	0	4	2	9	27	23	21	13
PP_3A_ff1	5	3	4	15	21	21	14	16

Figure 7. Statistical analysis between observation and simulation of 1 day, 2 days and 3 days at Bassac-Chaktomuk (Phnom Penh) station

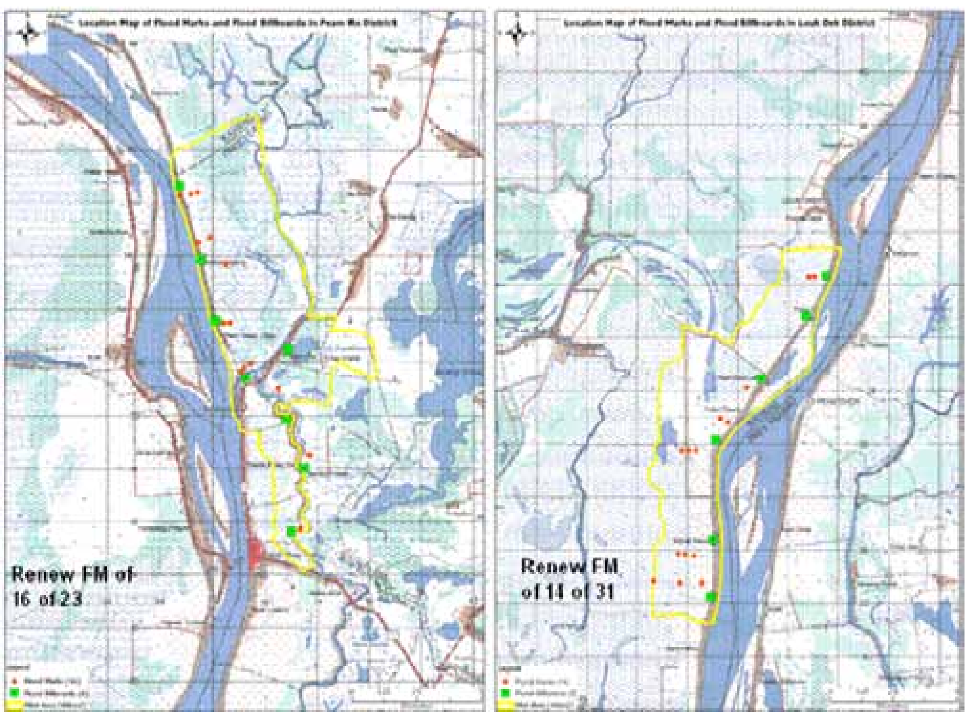

Figure 8. Location Map of Flood Marks and Flood Billboards in Peam Ro and Leuk Dek District

FLOOD PROBABILITY INFORMATION AND MAPS

With cooperation and supporting from Land Management of FMMP-C5, DHRW updated the hydrological data in the Mekong mainstream and floodplains of two pilot districts of Peam Ro and Leuk Dek to produce flood probability information and maps, which show the probability of flooding, maximum depth of flooding for a range of probabilities, duration of flooding for a range of probabilities, and completion of drainage for a range of probabilities.

Line Agencies, Organizations, concerned with Planning in Land Management and Land Use, Infrastructure and Construction, Agriculture, Environment, Rural Development, Water Resources and Disaster Management *make use of Flood Probability Maps* and other flood information to reduce, 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.

The product of flood probability maps that DHRW already produced in 2009 is shown in Figure 10: Flood probability map and disaster management planning, Figure 11: Maximum depth of flooding with 1% and 95% of probability, Figure 12: Duration of flooding with 1% and 95% of probability, Figure 13: Completion of draining with 20% probability of exceedance and Figure 14: Land use zoning in pilot villages of Peam Ro District.

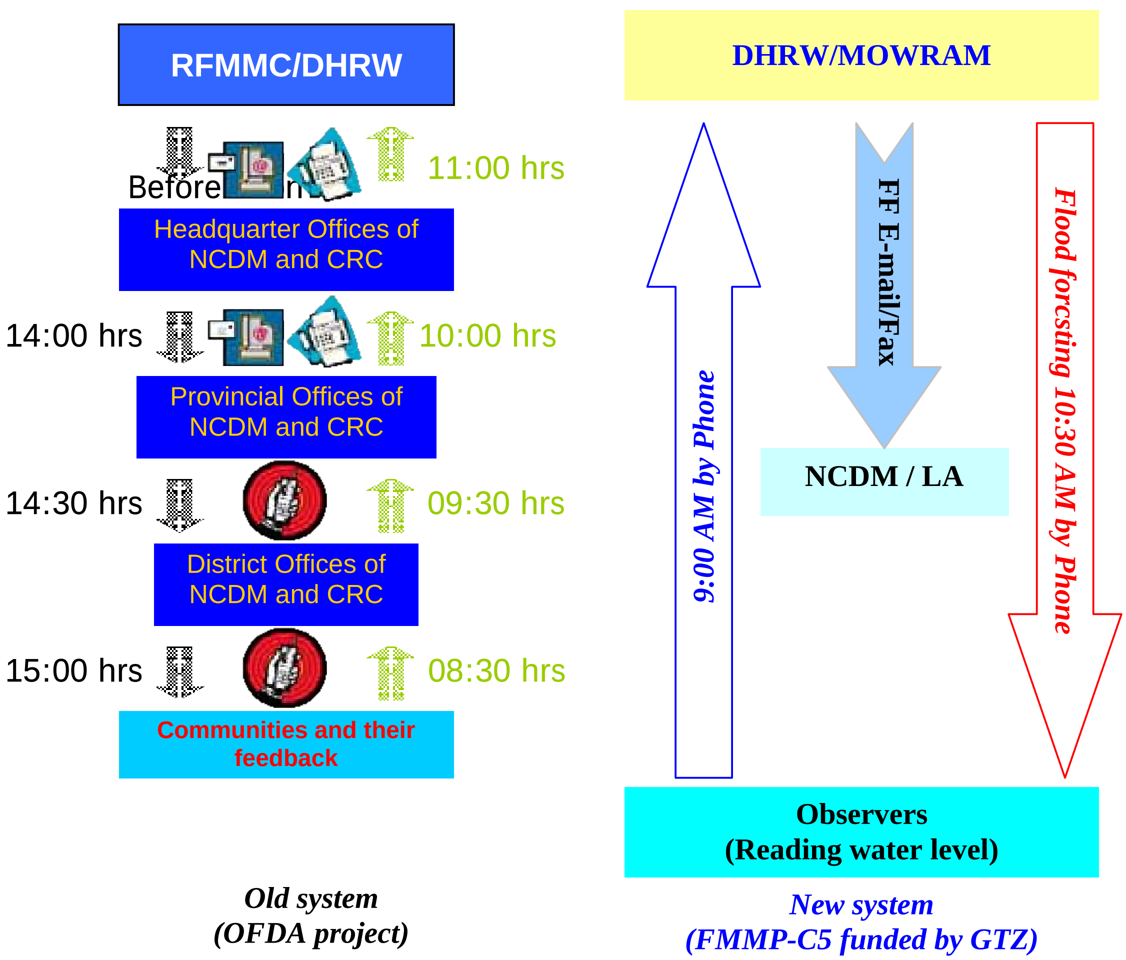

Figure 9. Detailed information of data flow for OFDA project and FMMP funded by GTZ

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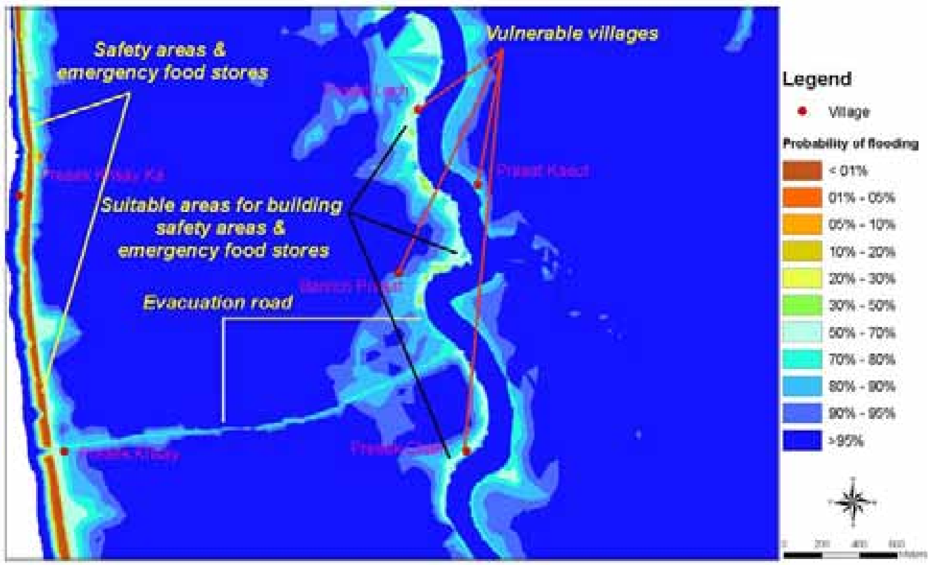
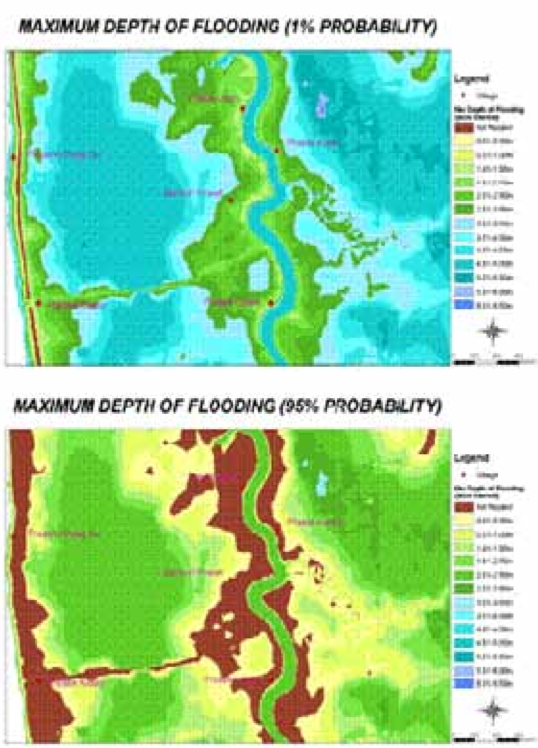


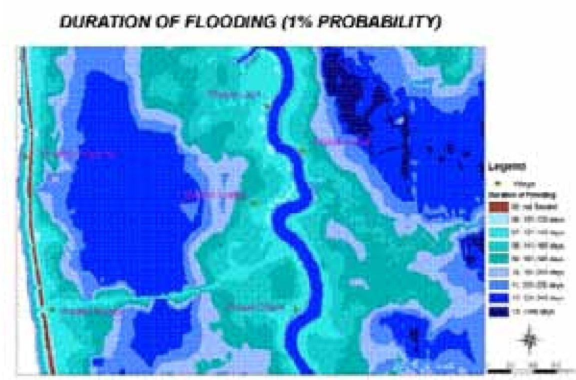
Figure 10. Flood probability map and disaster management planning



It provides us capability in analyzing:

- the seriousness of flood disaster (based on the flood depth);
- suitable areas for building safety areas;
- appropriate evacuation roads.

Figure 11: Maximum depth of flooding with 1% and 95% of probability



It provides us capability in analyzing:

- the most affected villages concerning food and sanitation (drinking water);
- the situation concerning livelihood and health in those most affected villages.

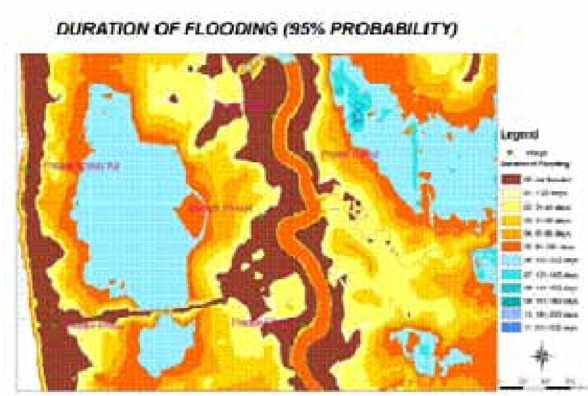
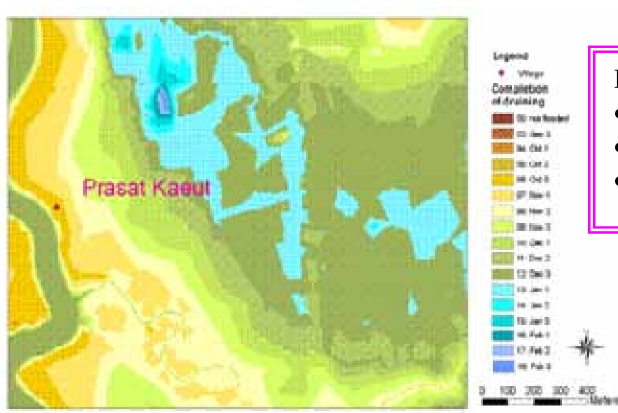


Figure 12. Duration of flooding with 1% and 95% of probability



It provides us capability in analyzing:

- the most suitable crop varieties;
- the crop calendar;
- the agricultural planning, etc.

Figure 13: Completion of draining with 20% probability of exceedance

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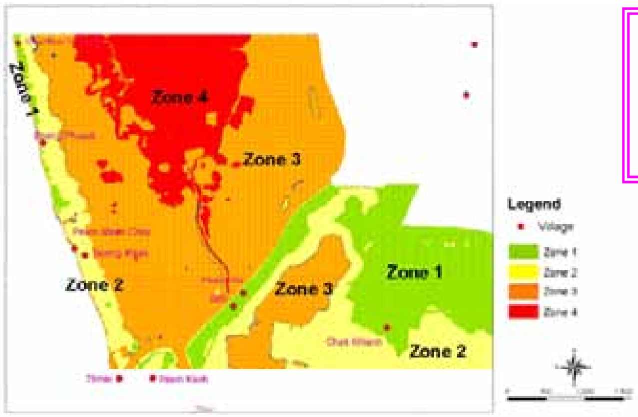

Criteria used for analyzing zoning:

- probability of flooding;
- maximum depth of flooding;
- duration of flooding.

Figure 14. Land use zoning derived from the maximum depth and duration of flooding information in pilot villages of Peam Ro District

LESSONS LEARNED

There are some challenges to make a good flood forecasting due to the delayed submission of hydro-meteorological data in upstream countries, unknown release of water from reservoirs in upstream countries, data transmission delayed in the country, sometimes communication problems, not properly working equipment, etc.

To improve the flood forecasting the above problems need to be solved, the frequency of sending real time data during extreme floods need to be increased, hydrological networks need to be improved and capacity building for DHRW as well as the provincial staff.

CONCLUSION

The flood forecasting in Mekong mainstream and floodplain provides important information to the public, line agencies, organizations, provinces and local authorities to warn, prepare before floods, take action during and after floods.

The flood probability maps are very important and a good benefit for line agencies and organizations that make planning in land management, infrastructure, agriculture, environment, rural development, water resources and disaster management in the near future.

The hydrological data provide the basis for planning, development and operation of water resources projects. 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.

Topic III

Structural measures and flood proofing

Paper 3-3-1

POTENTIAL USE OF ALOS PALSAR IN FLOOD HAZARD MAPPING, A CASE STUDY IN FIVE DISTRICTS, LAO PDR

A. BORMUDOI[1], M.K. HAZARIKA[1], R. SCHUMANN[2], L. SAMARAKOON[1]
V. PHAENGSUWAN[3] AND K. THANASACK[4]

[1]*Geoinformatics Centre, Asian Institute of Technology, Klong Luang, Pathumthani, Thailand*
[2]*RS-Tech Consulting Co., Ltd., Klong Luang, Pathumthani, Thailand*
[3]*Remote Sensing Centre, Vientiane, Lao PDR*
[4]*Department of Irrigation, Vientiane, Lao PDR*

ABSTRACT

PALSAR is an L band microwave remote sensor onboard ALOS satellite with day and night observation capability in all weather conditions. Its data products come with different observation modes such as fine beam single (FBS) polarization, fine beam dual (FBD) polarization etc. as well as processing levels. The proper selection of the modes and processing levels can give a clue to an actual physical change on the ground. Flood is an event that occurs almost every year in Lao PDR causing damage to lives and properties. With a pair of good ALOS PALSAR images of dry and wet conditions, it is possible to map quickly the areas that might have been flooded. The polarization plays an important role in the way the ground responds to the microwave backscattering. In August 2008, flood damage to the rice fields was about 36,000 hectares in Vientiane Capital province alone. This study was conducted to map the flooded area in 5 districts in that province. The mode was FBD, level 1.5 and the flood conditions on the ground were investigated with the change in the polarization.

INTRODUCTION

Lao PDR is a country often affected by floods of varying magnitudes. In the year 1995, flood in the Mekong River affected the townships of Paksane, Thakhek, Savannakhet, and Pakse. The Capital Vientiane came within a half a meter of being overtopped the levee protecting it. The flood detection method using satellite imagery and the traditional floodway mapping techniques can be complimentary to one another. An advantage of satellite based flood hazard mapping is that the actual flooded areas can be stored in an archival form necessary for an integrated flood hazard evaluation. ALOS PALSAR, an L band microwave sensor has been used in this case study to map the flooded area after the dry period. The flood map was of date September 3, 2008. That year Vientiane province was affected by this flood.

STUDY AREA

The study area covered five districts of Vientiane Capital province with an area of about 440 km^2. These districts were Sikhottabong, Chanthabully, Xaysettha, Sisattanak and parts of Hadaxaiphog. The area falls in the tropical climatic zone showing the effects of the monsoon. Rainfall occurs in the area predominantly due to the south- east monsoon starting from mid of May till mid of October with heavy rainfall towards the later part. The average rainfall is around

1,600 mm in Vientiane of which about 86% occurs from May to September. The temperature ranges from about 16 to 18 ^{o}C during the cold season of December to January and about 31 to 32 ^{o}C in the hottest months of March to May. According to a report of Government of Lao PDR (GOL), more than 36,000 ha of paddy fields were damaged by the year 2008 flood in this province alone.

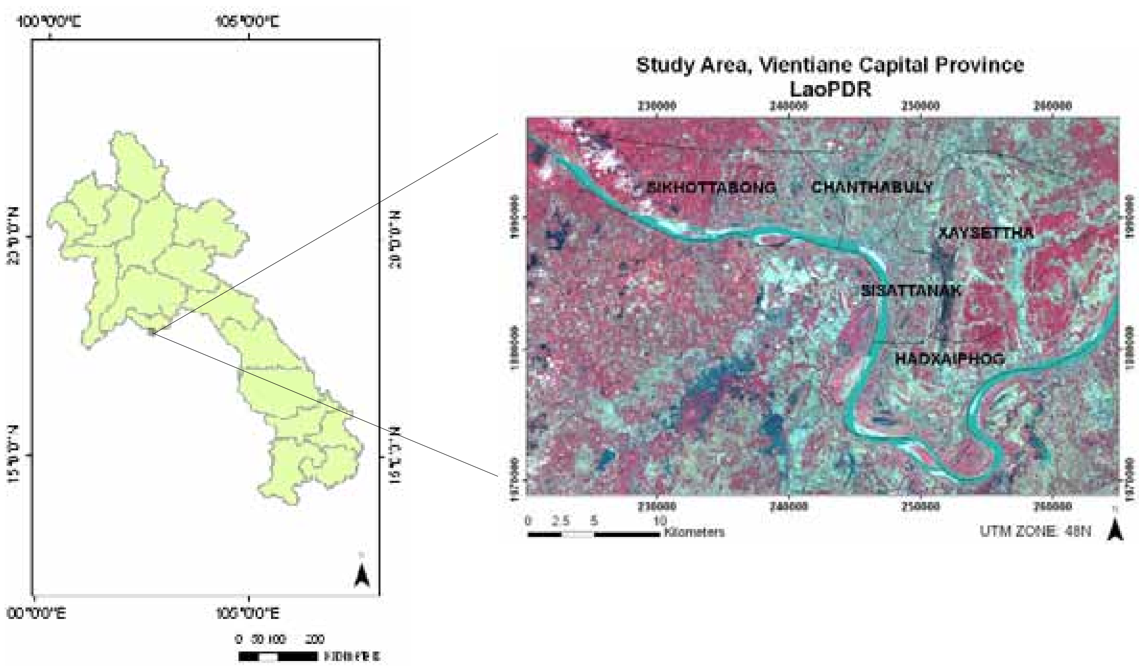

Figure 1. The study area

RESEARCH METHODOLOGY

The underlying methodology for the study was to examine the changes in the backscatter coefficients σ˚ (sigma nought) from dry to wet conditions. A significant change of the physical properties of objects at the ground is found when there is a 3decibel (dB) change in the backscatter coefficients from dry to wet conditions. After the initial analysis, three masks (+3dB, 0 dB, -3dB) for change detection were prepared for the Horizontal-Horizontal (HH) and Horizontal-Vertical (HV) pairs of dry and wet ALOS PALSAR datasets. These were compared and Region of Interest (ROIs) were selected in areas where there were significant changes from HV to HH polarization. Twenty three such ROIs were picked up for field verifications and the possible causes of changes from dry to wet condition were examined. It was found that there were mainly three areas where such changes were taking place: 1) floods under the paddy field; 2) increase of moisture over the tree canopy during wet season; 3) flood in open areas.

The third step was to measure the changes in σ˚ from dry to wet conditions in some of the known land use classes. While selecting the ROIs from these classes, care was taken to preserve their homogeneity.

RESULTS

The change of σ˚ values in the known land use classes are shown in the Table 1. In case of forests, change was more in HH than HV. The probable cause was the increase of overall wetness of the canopy volume during wet condition. For marshy lands, the change was again

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more in HH. Possibility was due to more areas under flood in the wet date but flood here was not conclusive. Over dry soil and sand, the change was far more in HH. The possible cause was the open water flood. In case of paddy, the change was more in HV than in HH. The likely cause was the multiple interaction of the reflected wave with the stems of the paddy over flood water detected more in HV signifying a volume scattering. On permanent water, the HH gave a picture of the surface roughness. The ROIs of the urban built up areas were not homogenous to derive a conclusion from the observation.

Table 1. Change of σ° per known land use classes in selected ROIs

Change of Σ° (dry to wet)		
Land use	HV	HH
Forest	-0.05	0.09
Marshy Lands	1.23	3.02
Dry Soil and sand	2.07	7.03
Paddy	-3.18	0.55
Permanent water	-0.09	0.97
Urban built up areas	-0.16	-0.29

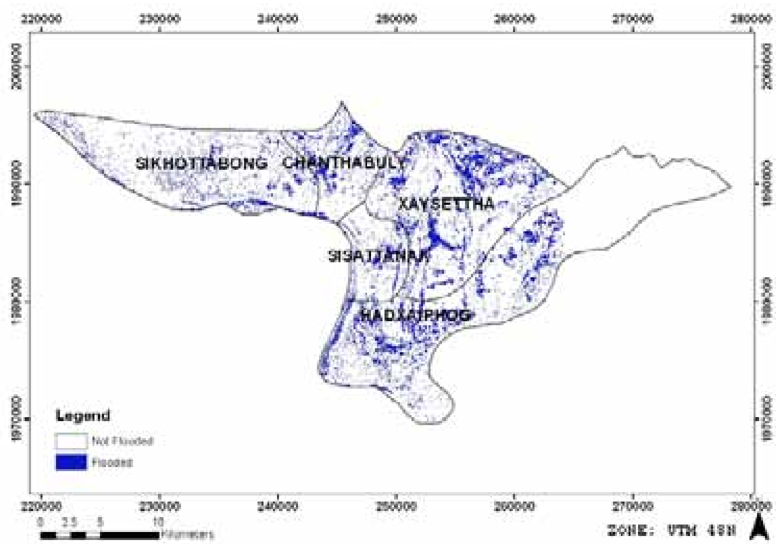

Figure 2. The Flood map 3 September 2008 of the study area, 5 districts

Figure 2 shows the possible flood map of the study area for the two land use classes, paddy and dry soil and sand. From that map, it was found that a total of 19 km^2 and 31 km^2 areas were under flood in paddy and over dry soil and sand. The highest flood affected district was Xaysettha with 28 km^2 followed by Hadxaiphog with 26 km^2 of landmass under water that day.

CONCLUSION

The study led to the conclusion that flooded land can be mapped with sufficient ground information with the use of two good PALSAR images. This approach can be helpful in areas where the modelling of flood remains a challenge due to the unavailability of a precise Digital Elevation Model (DEM) and other hydrologic information. The study had its own limitations as the ground visits were conducted at a time when the conditions on the ground were much different from either the dry or the wet date and the depth of floodwater in those places could not be revealed from the field visits.

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Paper 3-3-2

APPROPRIATE FLOOD MITIGATION FRAMEWORK THROUGH STRUCTURAL AND NON-STRUCTURAL MEASURES FOR THE CHI RIVER BASIN, THAILAND

KITTIWET KUNTIYAWICHAI[1], BART SCHULTZ[1], STEFAN UHLENBROOK[1,2], F.X. SURYADI[1] AND MICHA WERNER[1,3]

[1]*UNESCO-IHE Institute for Water Education, Delft, the Netherlands*
[2]*Delft University of Technology, Delft, the Netherlands*
[3]*Deltares, Delft, the Netherlands*

ABSTRACT

Flooding is among the most frequently occurring, devastating and costly natural hazards affecting the Chi River Basin, a Mekong River tributary in Thailand. Catastrophic flooding often causes widespread human suffering, as well as significant economic losses. Obviously, the impacts of flooding to the people, communities, and infrastructure throughout the river basin point to the need for a more integrated approach to flood management.

The main objective of this paper is to contribute to an integrated flood management framework related to the flooding characteristics encountered in the Chi River Basin by taking into account the likely impacts of activities at the river basin scale on local flood hazard. To meet this objective, a balanced approach (both structural and non-structural) is considered through flood mitigation measures appropriate to the location and acceptable to the local community. Special attention is devoted to proper selection of structural mitigation measures, i.e. river normalization, green river (bypass), retention basin, and dike construction, as they could reduce the possible impacts of flood hazards. However, it is unpractical and uneconomical to rely solely on structural measures to solve flooding problems at this study site, but instead other techniques are utilized, i.e. reservoir operation, and spatial planning in the context of adaptation to extreme flood events.

A combination of a widely used process-based hydrological model Soil and Water Assessment Tool (SWAT), and the hydraulic model 1D/2D SOBEK is used for the implementation of process-based and fully automated flood simulations. Flood simulations under design rainfall events are evaluated to fully assess the flooding potential and the effect on flood propagation behaviour can be identified. Furthermore, comparisons of damage estimates resulting from situations with and without flood mitigation measures are used to evaluate the effectiveness of alternative flood mitigation measures for prioritizing and selecting appropriate solutions. Preliminary results reveal that most of the downstream areas lying close to the floodplain of the Chi River are under severe threat during a 100-year flood event. The extent of the 100-year event is estimated to be approximately 56% larger than that of the 2001 flood, which was one of the most devastating in recent history. The results found provide a useful basis to formulate a comprehensive programme for integrated flood risk management in the Chi River Basin.

INTRODUCTION

Floods are part of a natural phenomenon which is regarded as a persistent hazard, causing

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tremendous negative socio-economic impacts, i.e. significant damages to lives, livelihoods, and infrastructure. Therefore, flood management has gained more attention recently, as a result of floods are becoming more frequent and catastrophic. The study area, Chi River Basin is heavily affected by floods mainly in the downstream part of the river basin which are densely populated. The experiences from the most damaged flood in 1978, 1980, 1995, 2000, and 2001 (Royal Irrigation Department (RID), 2005), various flood mitigation schemes have been proposed and adopted in the Chi River Basin. However, flood losses appear to be increasing despite mitigation efforts, as it is claimed that man-induced has significantly disturbed the natural equilibrium of the Chi River Basin, i.e. more people and property are situated in locations at risk. For minimising the losses due to floods, certain parts of the Chi River Basin are designated for various flood mitigation measures by means of a combination of structural and non-structural measures in ways that are appropriate to effectively address local situations. The combination would provide the benefits that would otherwise accrue from structural measures. While structural flood mitigation measures, i.e. river normalization, green river (bypass), retention basin, and dike construction will continue to be necessary, emphasis will also be on non-structural measures, i.e. reservoir operation, and spatial planning to minimise flood losses. (Note: although a variety of non-structural measures, e.g. flood proofing, flood warning and preparedness, have also proved to be valid approaches they are not investigated in this paper).

In this study, the hydrological and hydraulic modelling has been undertaken for the impact studies of the various flood mitigation scenarios. 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). Accordingly, the selection of an alternative measure is made through a comparative study of alternatives, considering the most effective mitigation and adaptation measures in the context of optimum solution for flood mitigation measures. To elaborate an Integrated Flood Management Framework for the Chi River Basin, the paper seeks to understand the various aspects of flood problem and its management by structural and non-structural measures, identify the flood management measures which accomplish a reduction in flood risk, and assess the damage due to catastrophic flooding. Model simulation results and comparisons of damage estimates resulting from situations with and without flood mitigation measures are used to evaluate the effectiveness of alternative flood mitigation measures for prioritizing and selecting appropriate solutions. As a result, part of a comprehensive flood management plan is prepared, aimed at providing effective and adequate flood mitigation to the Chi River Basin for the consequences of flood hazards, respond and recover from flood events.

METHODOLOGY

Study area

The Chi River Basin is located in the Northeast of Thailand (Figure 1). The total area is 4.9 million ha with a population of 6.6 million people. It is located in the tropical monsoon region, with the annual rainfall varies from 1,000 - 1,400 mm. The main river is the Chi River, which is the longest river in Thailand at 830 km, although it carries less water than the second longest river, the Mun. The river carries approximately $9.3 * 10^9$ m^3 of water annually (http://en.wikipedia.org/wiki/Chi_River). Average annual runoff of this basin is approximately 161 mm or $11.2 * 10^9$ m^3 (Srisuk et al., 2001).

The Chi River Basin has experienced rapid land use changes, increasing urbanisation and intensive and extensive agricultural land development. The dominant land use is agriculture

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(mainly paddy fields), which covers about 63% of the area. Forest covers about 31%, and water bodies about 3%. Only 3% of the area is urbanised.

Flooding in the Chi River basin has long been a recurrent problem (2 - 3 times a year), based on the historical data, significant flooding appears to occur every 2 to 3 years. The most devastating floods occurred in 1978, 1995, 2000 and 2001 (Royal Irrigation Department (RID), 2005). Topographically, the Chi River Basin is a semi-arid area characterized by a rolling topography and undulating hills. The slope of Chi River Basin is steep at the upstream mountainous area and is flat at the lower part especially near the confluence to the Mun River.

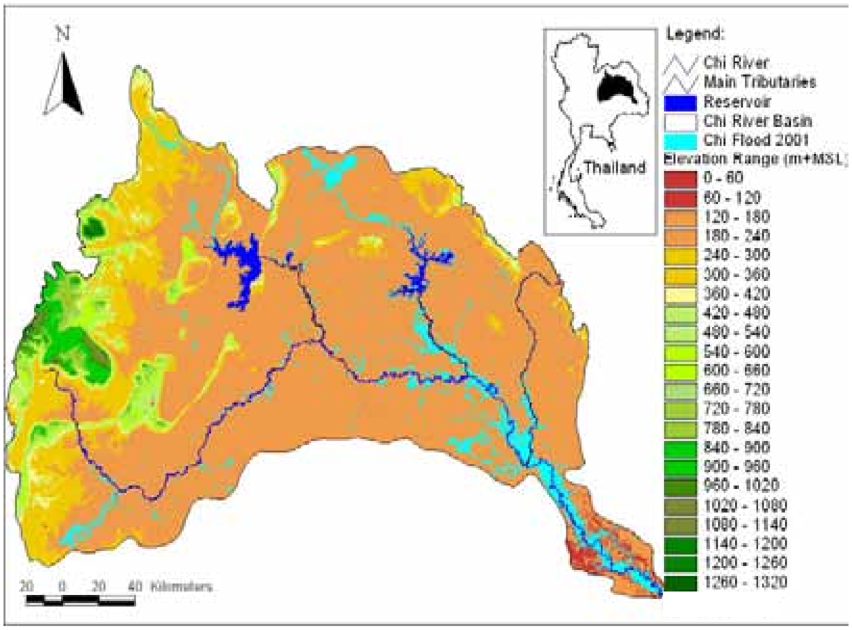

Figure 1. Topographic map of Chi River Basin study area including the inundated area during the 2001 flood event

Modelling approaches to flood impact assessment

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.

Hydrologic modelling

The process-based hydrological model SWAT 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:

$$SW_t = SW_0 + \sum_{i=1}^{t}\left(P_i - Q_{surf} - E_a - w_{seep} - Q_{gw}\right) \tag{1}$$

where: SW_t [mm d^{-1}] is the final soil water content, SW_0 [mm d^{-1}] is the initial soil water content on

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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 vadose 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., (in press).

Hydraulic modelling

With the application of the model 1D/2D SOBEK for riverine flood simulations, it 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 1D/2D 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.

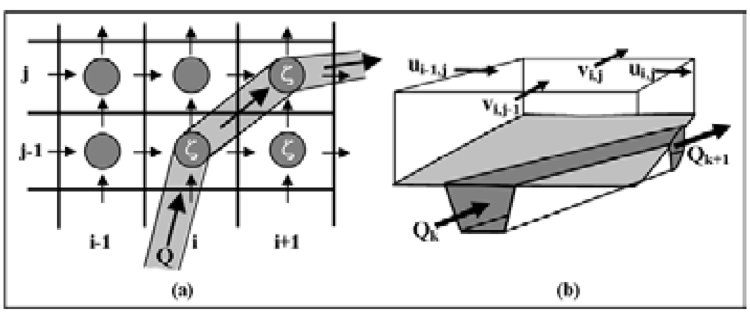

Figure 2. Schematisation of the hydraulic model: a) combined 1D/2D staggered grid; and b) combined continuity equation for 1D/2D computations (adapted from Frank et al., 2001)

Coupling flood modelling for an integrated flood management

The Chi flood modelling is established through the use of hydrological model to determine a design rainfall event and flow rates at various locations, and a hydraulic model to simulate the flow of water through rivers, channels and floodplains. The coupling of the two models is considered to give a better representation of flow attenuation through the river basin.

The coupling between SWAT and 1D/2D SOBEK is made via river links and it is assumed that there is no direct feedback of the overland flow onto the rainfall-runoff response. The coupled SWAT - 1D/2D SOBEK model performs as follows:

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- with rainfall-runoff module (SWAT), a well-developed and robust model that operates in daily time-steps. The hydrologic inputs define the magnitude of total storm flow from the various sub-basins;
- thereafter, flows at the outlet of each sub-basin are extracted from the SWAT model, which will then serve as inflow boundaries to the overland flow module (1D/2D SOBEK) at specified coupling nodes in the river network, the ensuing flood propagation is therefore simulated in 30 minutes time-steps. The *propagation* of catastrophic floods starting from the capacity of the river network is exceeded as a result of the one-dimensional flood propagation, excess flow spills into the two-dimensional model domain and eventually produces hourly outputs, i.e. flood extents and depths for the Chi River Basin. The outputs are used to estimate damage caused by floods.

The combination of the SWAT and 1D/2D SOBEK modelling (Figure 3) is able to identify the impact of the various flood mitigation scenarios, i.e. both structural and non-structural schemes, to be implemented in the context of complex relationships with factors related to floods, i.e. increased runoff volume and flashiness, increased flow retardation, etc.

Flooding occurs at many places in the Chi River Basin and is causing a great deal of damage and economic loss to the people affected. Therefore, flood mitigation works are needed all along the Chi River to protect the community and economic areas. Therefore, flood mitigation projects in the Chi River Basin deserve top priority.

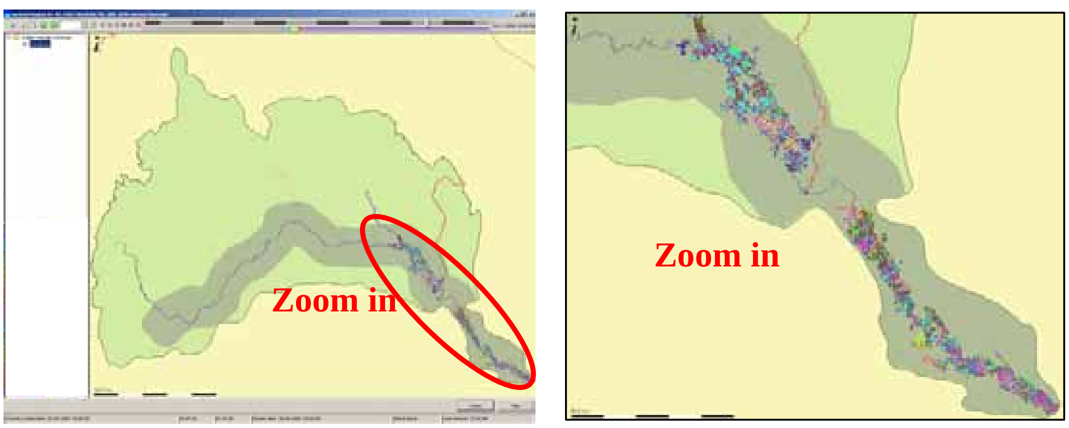

Figure 3. The modelled flooding extents as a result of coupling flood modelling during the September 2001 flood event

Flood mitigation measures and management schemes

Taking into consideration the scenarios for foresight future flood, the better understanding on the relationships among human activities and the flood occurrence will allow water authorities to make more comprehensible decisions on flood control and management.

Despite to the fact that the models might not be able to accurately predict future phenomena, however, they are used to simulate different land use and flood mitigation scenarios. Scenarios are in fact useful for investigating the potential flood management strategies under different options of future situations. Different alternatives are applied to all scenarios, and it can therefore be ensured that the differences produced for the different simulations are in fact a consequence of the applied scenario changes. Flood mitigation scenarios are investigated with the model for assessing the changes in flood risks and the likely impacts, in order to come up with the final strategy to be included in a comprehensive programme for integrated flood risk

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management in the Chi River Basin. However, it should be noted that this study does not necessarily cover every development scenario and for such cases outside the scope of this study.

However, it is not considered to be economically viable to provide flood mitigation measures that would alleviate the flood prone areas affected by the previous severe floods for a future event with similar magnitude. Therefore, the potential hydraulic impact of a flood mitigation option is investigated for the 100-year flood event. The flood mitigation option involves the following alternatives:

- the improvement of river channels, i.e. river normalization, to enlarge their discharge carrying capacity;
- reservoir operations for the temporary storage of floodwaters;
- the construction of bypass and diversion channels, i.e. green river measure, to carry some of the excess floodwater;
- retention basin to soak up floodwater then release it slowly back into the main river.

Quantitative analysis of flood mitigation benefit

The flood management interventions involve various alternative measures, i.e. structural and non-structural measures, which should be assessed and quantified. However, only the most common measures recommended today that strengthen the case for adopting an integrated approach to flood management will be discussed. Toward future inundation simulation according to 100-year flood disaster scenario, four possible flood mitigation alternatives are therefore analyzed to estimate their effectiveness in reducing floods in critical sites in the Chi River Basin. The potential hydraulic impacts of the flood mitigation are assessed by comparing pre and post mitigation flood depths, and inundation extents. The following involves the complete characterisation of the flooding scenarios, identifying the consequences of the scenario and evaluation of the alternative flood reduction measures.

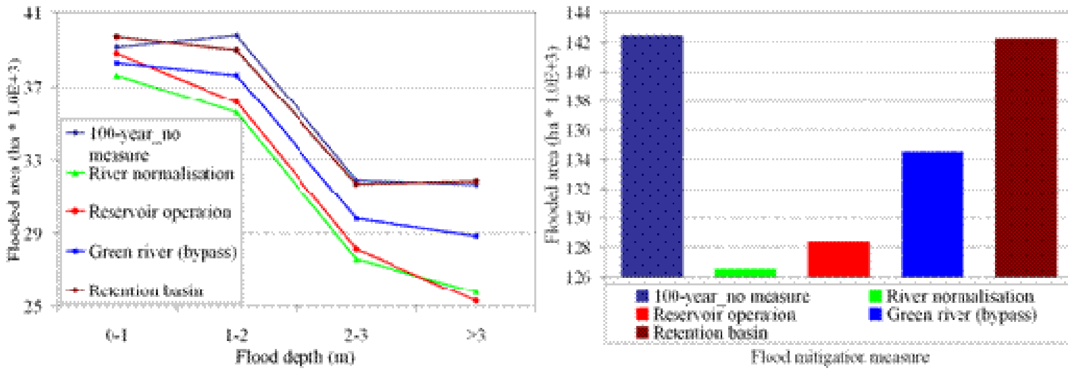
RESULTS AND DISCUSSION

Efficiency of alternative flood mitigation measures

In this study, various flood mitigation scenarios are subject to be functioning. Therefore, it is necessary to evaluate their hydraulic effectiveness as some measures would affect the flood behaviour and potentially exacerbate the flood risks in some areas. To assess the variation in flood behaviour, the relevance of each of these measures will be briefly described and considered to strengthen flood sustainability in the Chi River Basin.

Flood depths

The effect of various flood mitigation alternatives on potential adverse consequences is graphically depicted in Figure 4, by specifically referring to the effectiveness of mitigation and adaptation measures. The extent of flooding potential can be reduced through some flood mitigation measures, while other measures may increase the potential flood threat with detrimental impacts.



(a) (b)

Figure 4. Comparison of the 100-year flood extents from the four scenarios considered: a) each particular flood depth; b) total flood depth

As expected, the retention basin scenario yields the largest flood extent across the Chi floodplain. Correspondingly, this result is similar to results of previous studies done by Kuntiyawichai et al. (in press) and Kuntiyawichai et al. (2009), revealed that the increment of flood peak discharge associated with flood extent of retention basin is larger than the green river measure. Figure 3b illustrates that the flood extents along the Chi River are consistently lower for all the scenarios except retention basin than for the 100-year flood extent. These results clearly indicate that river normalization, reservoir operation, and green river (bypass) are indeed able to reduce the flood extents in the flood prone areas of the Chi River Basin.

Flood damage estimation

The damage caused by floods is a function of the certain flood characteristics, i.e. depth and duration of flood inundation, due to physical contact with floodwater per category of element at risk. The flood damage estimation has therefore been considered to facilitate the economic appraisal of flood mitigation measures. In this study, the damage potential is assessed on the basis of the calculated flood depth with a probability of 1 into 100 years for riverine flood events in order to evaluate the vulnerability to inundation, and to show the spatial distribution of potential damage across the Chi River Basin. As a result, the economic values to elements of flood risk are calculated in order to estimate the benefits of flood mitigation measures in terms of flood damage reduction, impacts such as human health or environmental damage are not considered in this study.

Spatial analysis techniques using GIS enables the integration of various data sets, flood depth and land use have been overlapped to evaluate which elements or assets are affected by the 100-year flood depth and how much they are affected in terms of inundation depth. The following land use categories are considered in damage assessment, i.e. residential, commercial, industrial, agriculture, and infrastructure. (Note: damage to institutional area, i.e. government offices, is considered as part of the commercial area).

The damage functions developed by Sahasakmontri (1989) are adopted for the quantification of different damage categories in monetary terms. It provides information about the susceptibility of the exposed elements to flooding. Based on the land use information, asset values and damage functions, direct damage caused by 100-year flood event is calculated (Lekuthai and Vongvisessomjai, 2001). However, according to Sahasakmontri (1989), direct damage to infrastructure has not been taken into consideration. Therefore, in this study the damage to infrastructure is estimated as a fixed fraction of the total damage and assumed to be 65% of all

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flood losses as it was estimated by MRC (1998). Using such damage function, economic damage to different land use categories is estimated and the summation provides the total direct flood damage as shown in Table 1.

To assess the costs and benefits of flood mitigation alternatives, economic analysis of different scenarios have been undertaken. The financial benefits together with the estimated implementation cost for each flood mitigation measure is then calculated below.

Financial benefits

All the alternatives have to be compared with the financial benefit before deciding the preferred options for flood mitigation in the Chi River Basin. The financial benefits for the identified flood mitigation option include reducing the total direct flood damage is shown in Table 1.

Table 1. Estimated damage costs and benefits of the identified flood mitigation alternatives

	100-year flood No measure	River normalisation	Reservoir operation	Green river (bypass)	Retention basin
Total direct flood damage costs (million US$)	166	142	142	155	166
Estimated benefits (million US$)	-	25	24	12	0

However, it should be noted that this value does not take into account any inflation rates, interest rates for bank loans or design lifetime of the mitigation options. Furthermore, the above analysis has also not taken into account indirect effects, losses, and their costs.

Estimated implementation costs for alternatives

The estimated implementation cost for each alternative and the basis of the cost is discussed below and summarised in Table 2. The implementation costs are estimated using the Thai Bureau of the Budget Handbook, based on April 2009 unit rates. (Note: these costs are very rough estimates). If any of the alternatives are promising enough to be considered further, a more detailed cost evaluation should be performed.

Table 2. Summary of estimated implementation costs for different alternatives

	100-year flood No measure	River normalisation	Reservoir operation	Green river (bypass)	Retention basin
Estimated implementation cost (million US$)	-	6.0	0.0	2.6	2.2

The results reveal that the reservoir operation alternative has no implementation costs due to a change in the operations rule curve for the reservoirs would not require construction, therefore no additional expense is anticipated. On the contrary, river normalisation option has the highest costs. However, it should be noted that the estimated implementation cost has not taken into account the cost of land acquisition where the proposed flood mitigation alternatives are to be located. Furthermore, the costs presented should be considered as preliminary and indicative only in this study and detailed investigations are necessary to obtain more accurate cost estimates as it is likely to be much higher in reality.

Optimum level of flood mitigation

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The effects of flooding can be mitigated, and thereby reduce the loss of life and damage to property. Adoption of a certain flood mitigation alternative depends critically on the hydrological and hydraulic characteristics of the river system. Flood mitigation measures cannot be evaluated from a single point of view. The technical performance of these measures, in terms of preventing inundation and the resulting damage, should be taken into consideration as it is important for an overall appraisal of the acceptability of each alternative. Hence, a decision matrix approach will be used to guide about which flood mitigation measures should be considered in integrated approach to flood management. At first the steps should be defined by generating a range of measures, assessing the expected performance of each measure against the evaluation criteria, and selecting the preferred options. The alternative flood mitigation measures will be considered, if they can meet the evaluation criteria. Once these criteria have been applied, selected measures will be discussed to which alternatives are the most applicable and desirable.

The optimum level of flood mitigation is unlikely to eliminate all flood risk. Realistically, it can be expected to only minimise the total flood mitigation costs and residual flooding. It refers to the point where the sum of implementation cost and damage are minimised for each flood mitigation alternative.

Table 3 Total cost comparison for each flood mitigation alternative

	100-year flood No measure	River normalisation	Reservoir operation	Green river (bypass)	Retention basin
Total cost (million US$)	166	148	142	157	168

From the above calculation of the corresponding costs, it is concluded that the alternatives, i.e. river normalization, reservoir operation, and green river (bypass), seem viable and found to be effective measures for sustainable flood management. However, the decision cannot be taken only with a single indicator which is the minimisation of the cost. It is therefore necessary to utilize more criteria, as a result, the technical effectiveness criteria associated with each scenario are then examined.

Selection of alternative measure

To guide about which flood mitigation measures should be considered in this study, the alternative measures are put through a screening process based on the decision matrix approach (Table 4). At first the steps should be defined by generating a range of measures, assessing the expected performance of each measure against the evaluation criteria, and selecting the preferred options. The alternative flood mitigation measures will be considered, if they can meet the evaluation criteria. Once these criteria have been applied, selected measures will be discussed to which alternatives are the most applicable and desirable. The following evaluation criteria are used to screen and prioritize proposed flood mitigation measures:

- economic feasibility, with a view to incorporating flood anticipated damage;
- technical effectiveness, in view of effectiveness in reducing flood extent.

Each flood mitigation measure is scored with respect to a set of indicators for each evaluation criteria, in order to assess and prioritize flood mitigation measures, by conducting a review of performance (Table 4). The indicators are chosen to represent criteria important for deciding which flood mitigation measure ultimately best meets the overall objective. Therefore, specific flood mitigation measures will be identified as important for some evaluation criteria and not others. In setting up the priorities, preference is given, first of all, to the flood mitigation

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measures able to reduce flood risk and damage in correspondence with designated evaluation criteria.

Table 4 Evaluation of all potential alternatives and screening matrix

Evaluation criteria[1]	100-year flood no measure	River normalisation	Reservoir operation	Green river (bypass)	Retention basin
Economic feasibility[2]	166 million US$	148 million US$	142 million US$	157 million US$	168 million US$
Technical effectiveness[2]	143,000 ha	127,000 ha	128,000 ha	135,000 ha	142,000 ha

Note: [1] = the evaluation criteria are not listed in order of importance
[2] = quantitative determination

This section will consider how the preferred alternatives can be scheduled to meet priorities for flood mitigation. As illustrated in Table 4, only the retention basin alternative does not meet all screening criteria. To achieve the optimal flood mitigation plan for the Chi River Basin, it is likely that a combination of river normalization, reservoir operation, and green river (bypass) will be devised and implemented in the upcoming phases.

Flood management through spatial planning

Settlement patterns including development of land and infrastructures in flood prone areas of the Chi River Basin have been changed dramatically with major portions of forest and agricultural lands being converted for urban use. Owing to the fact that inappropriate spatial planning can exacerbate the negative effects of extreme hydrological processes, therefore, flood losses appear to be increasing despite mitigation efforts, as more people and property are situated in locations at risk. As a result, the apparent increase in flood likelihood and severity appears to be addressed in the form of flood frequency, extent, and subsequent hazards.

To eliminate or reduce intolerable risks to an acceptable standard, this study attempts to define spatial planning options for adaptation to extreme flood events in order to incorporate this option more effectively into broader flood loss reduction strategies. The alternative spatial planning scenarios will be taken into consideration a series of management tasks to restrict flood prone areas to particular uses, specify where the uses may be located and establish minimum requirements for the uses, as including the following key objectives:

- to limit the construction of structures on land subject to periodic inundation;
- to ensure that development maintains the free passage and temporary storage of floodwaters in order to minimise flood damage;
- to ensure that the effect of inundation is not increased through development and will not cause any significant rise in flood level or flow velocity;
- to minimise development and settlement in flood prone areas and prevent inappropriate development occurring in potentially hazardous areas;
- to conserve and maintain the productive potential of prime crop.

The following steps are applied to ensure that spatial planning offer the optimal long term solution, i.e. the development is appropriately designed and to minimise the need for redesigns:

- to identify high hazard areas which have the greatest risk and frequency of being affected by flooding;
- to identify land liable to inundation by overland flow, i.e. areas which would be affected by a 100-year flood event.

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Spatial planning takes into consideration the inputs from flood inundation, flood hazard and flood risk zone maps. Therefore, further steps will *need to be explored* on how the hydraulic modelling outputs have incorporated into spatial planning due to anticipated flooding in order to assess whether the flood mitigation scheme can be combined with spatial planning.

Discussion of the next steps

The process to undertake a comparative assessment of the flood mitigation alternatives as described above is used in the next step in the development of comprehensive flood management plan. Alternative may be dropped from further consideration, i.e. retention basin, if there are too many fatal flaws. On the contrary, the alternatives which are likely to satisfy most of the detailed objectives and higher levels measures of success should be taken forward to the optimum combination of measures, i.e. river normalization, reservoir operation, and green river (bypass). However, these measures cannot prevent all floods, nor can they eliminate the possibility of loss if flooding occurs. In this case, it is crucial to account and prepare for the residual risks that follow the implementation of flood management measures. Therefore, the construction of dikes is considered to reduce some residual risk of flooding in the flood prone areas.

It is further recommended that the actual integration of the several flood mitigation scenarios should be implemented. Moreover, an assessment of the impact of changing land use patterns on flood dynamics should also be devised during upcoming phases of the development process.

CONCLUSIONS

The disastrous impacts of floods on people's livelihoods have been a major issue, especially in the Chi River Basin where agriculture is the major livelihoods. A decrease in space for rivers and high population density on floodplains has resulted directly in increased risk to human life and increased economic loss in any individual flood event. However, the extent of the flood risk is still poorly understood and managed, and remains largely unknown. Therefore, it is time to move into action toward an integrated approach to flood management to minimising loss of life, increase resilience, and maximising the efficient use of floodplains. To mitigate the flood hazard, scenario-based approaches have to be implemented to increase the insight of flood behaviour of the river basin.

In recent decades, traditional approaches to flood mitigation have relied heavily on the provision of structural measures for flood containment as they are generally efficient and allow mitigating the effects of the major floods. However, it is not always physically feasible to completely manage flood damage through structural measures due to technical, economic, environmental constraints, etc. The structural approaches are designed to protect only up to a certain level of flooding and can sometimes fail to reduce flooding or even increasing economic losses from floods, as economic losses are merely postponed and continue to rise. For these reasons, flood mitigation should be considered as a judicious combination of structural and non-structural measures to restore the natural functions of rivers and floodplains, in case there are no feasible structural measures that can be implemented or leaves some at high risk.

The optimum combination of measures will depend on further characterisation work and the specific design and layout chosen. In this study, optimum results can be obtained by combining spatial planning and reservoir operation with corrective technical-structural measures such as river normalization and green river (bypass). As a result, the overall effects of these measures in terms of optimal long term solution can be quantified with the proposed combined modelling approach. Moreover, the assessment of the impacts of combined flood mitigation measures and different land use scenarios will also be taken into consideration in further development of the comprehensive flood management plan for the Chi River Basin.

Finally, while floods can never be fully controlled, the beneficiary aspects of flooding are indeed appreciated as flood can bring new opportunities of livelihoods. Therefore, considerable efforts should be made by turning negative impacts of flood into positive aspects through the development of the notion of “living with flood” or “coping with flood”. To ensure a higher safety to floods, it is safer to ‘give room to water’ by restriction of human activities within the river basin, rather than relying on flood control infrastructure under all circumstances.

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Paper 3-3-3

DEVELOPMENT OF A ROAD MAP FOR FLOOD AND DROUGHT RISK MANAGEMENT IN THE GREATER MEKONG SUB-REGION

DIVAS B. BASNYAT, ARUP K SARMA, GANESH P SHIVAKOTI AND CHU TRAN DAO

VisionRI Connexion Services Private Limited

ABSTRACT

This paper describes the Road Maps for flood and drought risk management (F/DRM) in Cambodia, Lao PDR, Thailand and Viet Nam being prepared under the Asian Development Bank (ADB) Regional Technical Assistance. The main objectives of the paper are to identify and prioritize flood and drought issues regionally within the Greater Mekong Sub-region (GMS) and within each country through regional and national road maps developed to improve flood and drought risk management and to develop a prioritized program of structural and non-structural F/DRM interventions in each country. The road maps include regional and country needs, time frames and resource/capability requirements, prioritized list of country interventions and monitoring and evaluation plan. This paper however focuses on the country needs and issues and the interventions and measures proposed to address them. Summary of country specific and regional strategies plans and programs are presented that were used to define the country needs and issues and to develop the national goals and targets. Prioritization of the interventions is carried out using a multiple-criteria analysis framework. This will serve as the basis for investment project preparation for possible funding by ADB.

INTRODUCTION

The Greater Mekong Sub region (GMS) covers six countries- Cambodia, Lao PDR, Myanmar, Thailand, Viet Nam and Yunnan Province and Guangxi Zhuang Autonomous Region of the People's Republic of China. The Mekong River flows through the centre of the region and is an important source of livelihood and socio-economic development of GMS. While much of the total area of Cambodia and Lao PDR is within the Mekong River Basin, only parts of the total area of the other countries fall within the Basin. In a regional context, Mekong River is however an important trans-boundary river with scope for regional cooperation and development as envisaged by the establishment of the Mekong River Commission in 1995. The road map presented here focuses on the whole of Cambodia and Lao PDR but on only parts of Thailand and Viet Nam, namely on the sub-basins within Lower Mekong River Basin (LMB) in Thailand and the Cuu Long Delta in Viet Nam, as prioritized by the national government.

The economic and social indicators of the four countries vary significantly. On a per-capita basis, the Gross National Income (GNI) per capita (2007) (World Bank, 2008) is significantly different among the four countries, ranging from US$ 550 in Cambodia, to US$ 630 in Lao PDR, to US$ 770 in Viet Nam, and to US$ 3,400 in Thailand. Increase of rural income and welfare has been constrained by flood or drought in the last few years. Severe floods occurred in the LMB in 2000, 2001 and 2002 which were followed by droughts from 2003 to 2005. Late arrival of rain, early end of monsoon and longer dry spell may hamper agriculture. While historical floods and their impacts have been well documented, limited information and impact assessment of droughts are available.

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Many interventions to reduce the flood and drought risks are now ongoing with funding from national government and international development partners. There is however a need to develop a common road map to identify and prioritize flood and drought issues and to develop a prioritized program of structural and non-structural interventions in each country and the region.

GENERAL DESCRIPTION OF THE PROBLEM/ISSUE

Development in the Mekong River Basin is river-centric as the population density is more in the floodplains and adjacent land. As the people have been living with flood, damage due to flooding is more on agriculture in rural areas than on household properties and causalities. The Kok, Khong, Chi and Mun sub-basins in Thailand within the Lower Mekong River Basin (LMB) faces water shortages to meet the irrigation needs and the rising water demand due to socio-economic development. Flash floods occur in the highlands while overbank flooding in the middle stretches of the rivers and flooding in the confluences of the tributaries and mainstream rivers are common. In the case of Lao PDR, flood protection of important urban and semi-urban areas through embankments and early warning systems and irrigation development and rehabilitation were considered of priority. In the case of lower parts of Cambodia and Mekong Delta in Viet Nam, the natural flow regulation by the Tonle Sap Great Lake is important. Similarly, the concept of integrated flood risk management is important since normal annual floods bring huge benefits to the people in the region in terms of fishery and flood recession agriculture while extreme floods cause damage to agriculture and infrastructure.

Any flood control measure proposed should be for controlling extreme floods only while ensuring the benefits of normal floods. The low lying areas of the Cuu Long River Delta, a common name of the Mekong and Bassac Rivers in Viet Nam, is prone to flooding every year which is considered to be worsened due to impacts of climate change and sea level rise. Structural measures such as bank protection, embankments and flood proofing are considered important in the Delta. The need for establishment and/or strengthening of national level flow/flood forecasting and early warning system in conjunction with the regional flood forecasting system under the Mekong River Commission (MRC) is high on the agenda of all national governments and stakeholders.

APPROACH

The Road Map is basically answering three questions- (i) where are we now in terms of Flood/Drought (F/D) Risks? (ii) Where do we want to reach in say 20-30 years? (iii) How do we reach there (strategies and interventions)? It is prepared in close consultations with all stakeholders. A Technical Working Group (TWG) and National Steering Committee (NSC) guided the preparation of the road map. Tripartite meetings held between the government, ADB and the team preparing the road maps also provided directions. The possible interventions for flood and drought risk mitigation that were considered are presented in Figure 1.

The long list of possible interventions was identified and shortlisted by the TWG and relevant stakeholders. A multiple criteria analysis was then carried out to prioritize the interventions using six criteria, namely- (i) National and sectoral priority , (ii) Poverty alleviation (iii) Risk reduction (iv) Relevance to Integrated Water Resources Management (IWRM), (v) Relevance to Basin Development Plan and (vi) Project status. As the above six criteria are of conflicting nature i.e., one alternative will be better in terms of one criteria and another in terms of another criteria, weightages on the relative importance of the criteria were assigned with consultations with TWG and the National Steering Committee (NSC).

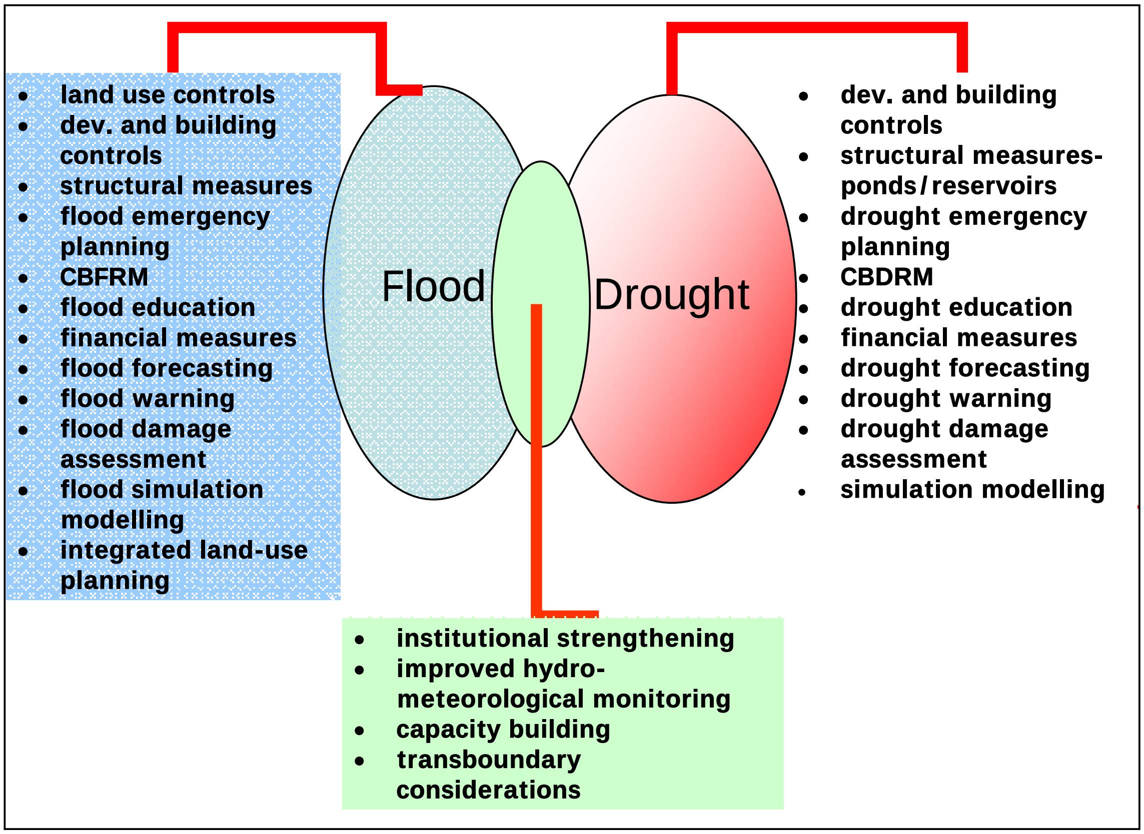

Figure 1. Possible interventions for flood and drought management

RESULTS

Enabling environment

The socio-economic profile and the institutional capacity to deal with flood and drought risk vary in the four countries. While Thailand has a well developed institutional framework with sub-basin level committees in place, other countries are still managed by sectoral agencies under the Central Government with province and district level offices. The provincial departments i.e. Provincial Department of Agriculture and Rural Development (Provincial DARD) in Viet Nam were however proactive in planning and implementation of interventions. The policy and legal framework was better established in Thailand and Viet Nam where national policy and vision on flood and drought risk management were in place. Master plans and integrated water resources development plans for each basin with interventions and targets identified were available in Thailand. Viet Nam had a number of strategic documents and action plans approved through decisions of the Prime Minister dealing with flood and drought risk management in Cuu Long Delta. Table 1 presents the status of the enabling environment of the four countries.

Flood and drought risk management

Kok and Khong sub-basins (Northern Thailand) and Chi and Mun basins (North-eastern Thailand) are important as watershed areas and sources of agricultural products, industries and tourism of the country. Northeast Basins have agricultural areas exceeding the water potential in the basins, topographic restrictions and social conflicts concerning large-scale project development.

Lao PDR faces mainstream flooding in the Central Region (Vientiane Plain), flash floods in high lands and flooding at the confluence of tributaries and Mekong River. Since large part of Lao population lives in rural areas and depends largely on subsistence agriculture, they are most vulnerable to periodic droughts. In recent years natural disasters resulting from climate abnormalities have resulted in frequent occurrences of drought and flood. The recent situation of March 2010 in the unusually low water level in Mekong River has severally affected the irrigation facilities which provide water for dry-season rice production. Similarly, water supply in Vientiane capital city was reduced to half compared to normal years.

Cambodia experiences mainstream flooding in the provinces located on the bank of Mekong River, Bassac River and Tonle Sap River including bank erosion problem in urban areas such as the Kratie Town. Tributary flooding occurs in the Kompong Chnang, Kampong Thom, Pursat, Seam Reap provinces while flash floods occur in the steep rivers of Pursat, Battambang, Binte Mean Chey, Siem Reap provinces. Late arrival of monsoon and unprecedented deficit rainfall, early end of monsoon and unexpected longer dry spell during monsoon period are the basic factors that are causing hydrological and agricultural drought.

After flowing to Phnom Penh, the Mekong River is divided into two tributaries that flow into Viet Nam: the Mekong (Tien Giang) and the Bassac (Hau Giang). Cuu Long is the common name of these two rivers, flowing inside Viet Nam. The infrastructure system in the Cuu Long River Delta quickly developed in the last 10 years, particularly since 1996, and has significant impacts on the submergence situation. Canal systems, roads, border and protecting dike routes, have been well developed. As a result, flood flow and submergence situation on The Cuu Long River Delta becomes more complicated. Clearly, the socio-economic activities significantly changed the hydrological and hydraulic regime. Climate change and salt water intrusion is said to be further exacerbating the problems of flood and drought. The present road map focuses on three provinces of the Plain of Reeds - Long An, Tien Giang and Dong Thap.

Tables 2 and 3 present the flood and drought risks in the four countries. Summary of the prioritized interventions in Cambodia, Lao PDR and Viet Nam for possible funding by ADB that have been selected in close consultation with the national governments are presented in Table 4. Prioritization of interventions in Thailand was not part of the scope of ADB TA.

CONCLUSIONS AND RECOMMENDATIONS

The country needs and issues for F/DRM are well documented. However, consistent strategy with clearly defined national targets and goals are still lacking. There were also limitations on defining specific milestones and indicators as updated data on all ongoing and committed programs were still not available. The road map presented here should however provide a basis for future interventions on F/DRM management. Some of the long-term interventions have potential trans-boundary impacts which need to be addressed at the River Basin level.

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Table 1. Enabling environment

Cambodia	Lao PDR	Thailand	Viet Nam
Policy and legal framework			
• National Water Resources Policy (2004) • Rectangular Strategy of the Government and Ministry of Water Resources and Meteorology (MOWRAM)	• 7th Five-Year National Socio-Economic Development Plan (2011-2015) • updating the National Resources Policy and Strategy at Water Resources and Environment Administration (under preparation)	• National Water Vision (2000) • National Water Policy (2000) • Comprehensive Water Act under preparation • River Basin Plans developed for 25 basins	• Strategic Direction of Water Resources Development to 2020 and toward 2050 (2009) • National Strategy for Natural Disaster Prevention, Response and Mitigation to 2020 (2007) • Action Plan and Program of MARD to implement The National Strategy for Natural Disaster Prevention, Response and Mitigation to 2020 (2008); • Water Resources Development Strategy to 2020 of MARD (2009) • Revision and Addition of the Cuu Long river delta planning from 2006 to 2010 and orientation to 2020 • Revised Mekong River Delta water resources master plan for period 2006-2010 and orientations to 2020.
Key institutions			
• MOWRAM • Ministry of Agriculture, Forestry and Fisheries (MOAFF) • National Disaster Management Committee (NDMC) • Cambodia National Committee (CNMC)	• NDMC • Laos NMC, Water Resources and Environment Agency (WREA) • Department of Irrigation, (DOI) • Department of Waterways/ Ministry of Public Works and Transport (MPWT)	• National Water Resources Council (NWRC) - Basin Committees in 25 basins • Department of Water Resources (DWR) under Ministry of Natural Resources and Environment (MONRE) • Royal Irrigation Department (RID) under MOAC • Dept. of Disaster Prevention and Management • Thailand National Mekong Committee (TNMC)	• National Committee for Search and Rescue • Central Committee for Flood and Storm Control (CCFSC) • Provincial, district and commune Committees for Flood and Storm Control • Committees for Flood and Storm Control of various ministries • Ministry of Agriculture and Rural Development (MARD) • Viet Nam National Mekong Committee (VNMC), MONRE

Table 2. Flood risk management

Cambodia	Lao PDR	Thailand[1]	Viet Nam[2]
Flood risks			
• mainstream flood: provinces located on the bank of Mekong River, Bassac River and Tonle Sap River, Kratie Province suffers from the bank erosion problem. • tributary flood: Kompong Chnang, Kampong Thom, Pursat, Siem Reap • flash flood: Pursat, Battambang, Binte Mean Chey, Siem Reap	• North part of Lao PDR, Luang Namtha, Phongsaly and Houaphanh provinces • Central part - Vientiane Plain • Southern part - flash floods and inundation in six provinces- Bolikhamxay, Khammoune, Savannakhet, Saravane, Champasack and Attapeu	• flash floods in highlands • over bank flooding • flooding in confluence of tributaries and mainstream • flooding in confluence of Mekong Tributaries and Mekong River	• flash floods and landslides in Central Highlands • Cuu Long River Delta - flooding in the Mekong and Bassac rivers and overflows over Viet Nam-Cambodia boundary • climate changes and sea level rise impacts
Non-structural interventions/measures			
• capacity building • enhance public participation and role of local administration organization • develop tools and mechanism for management e.g. National Water Information Centre, Decision Support System • flow (flood) forecasting system	• improving access to education, health/medical facilities, capacity building, community based FRM, land use planning • early warning systems • flow forecasting systems in tributaries	• forecasting and early warning system. • appropriate land utilization is flood and landslide risk area • land use planning/ zoning	• research in climate and sea level rise impacts/adaptation • completion of planning of resident areas to improve the local people's life in flooded areas in flood season**;** • updating of Master plan in Cuu Long River Basin including climate change adaptation and water use of upstream countries
Structural interventions/measures			
• protection and rehabilitation of upstream watershed (weirs, soil conservation) • rehabilitation of waterways, drainage and diversions (reservoirs, diversions, gates and sluices) • land use management and flood protection of economic areas • improve agricultural areas and flood retardation	• embankments, small-scale irrigation facilities • dike protection in major urban areas, embankments with sluices and gates to protect agricultural areas and river bank erosion protection	• water storage and retarding basin in order to reduce flood water e.g. Kwan Payao.Swamp (Kok/Khong) • dredging of natural stream to increase drainage capacity • reservoirs for flood routing • flood embankment, off-stream drainage canal, regulators, pump systems	• consolidation and development of flood control system from Long Xuyen quadrangle to the West Sea and in area between the Mekong and Bassac rivers; • completion of flood control system in border zone Viet Nam - Cambodia; • increase flood discharge capacity from the Plain of Reeds to the Mekong and Vam Co Tay rivers

[1] Kok and Khong Sub-basins (North Thailand) and Chi and Mun in North-eastern Thailand , [2] Cuu Long Delta in Viet Nam

Table 3. Drought risk management

Cambodia	Lao PDR	Thailand[1]	Viet Nam[2]
Drought risk			
• rainfed agricultural areas impacted by late arrival of rain, early end of monsoon and longer dry spell	• water shortage (drought) in provinces of Luang Namtha, Xayaboury, Vientiane Plain, Bolikhamxay, and Khammouane	• water scarcity for human and agriculture • rise in upstream water use in conflict with downstream needs	• low flows and impacts of salt water intrusion
Non-structural interventions/measures			
• training on water supply maintenance • research on drought mitigation • public awareness campaign on water conservation	• drought forecasting and early warning system based • drought risk maps and socio-economic assessment of drought impacts	• delineate drought risk areas • cropping pattern modification • demand side management- water conservation	• completion of fresh/ salt water boundary identification systems based on land use plan and optimal cropping pattern; • development of modern and advanced monitoring systems on water quality and quantity of major water resources systems
Structural interventions			
• increase water provision (weirs and irrigation development) • water distribution- improve conveyance system and field efficiency • optimal water management	• development and Rehabilitation of irrigation systems • pumping stations	• development of Small and medium water sources. • increase water conveyance efficiency • water grid project - Korn-Kok diversion • long term international projects - Khong (Mekong) Basin Development, Khong-Chi-Mun diversion, Se Bang Hiang-Amnat Charoen (Lao PDR)	• development and dredging main canal systems to take water from the Mekong and Bassac rivers; development of sluices and sea dike to stop salt water intrusion to bring fresh water to areas without fresh water resources available; • completion of fresh water preservation systems for areas of Go Cong, Ba Lai, Nam Mang Thit, enlarged Quan Lo – Phung Hiep and O Mon – Xa No

[1] Kok and Khong Sub-basins (North Thailand) and Chi and Mun in North-eastern Thailand , [2] Cuu Long Delta in Viet Nam

Table 4. Prioritized interventions for possible funding by ADB

Cambodia	Lao PDR	Viet Nam
• Damnak Choeu Krom Flood and Drought Management Project in Pursat Province • West of Bassac River (Takeo and Kandal Provinces) – Integrated Flood Risk Management (IFRM)/Polders • East of Mekong River (Prey Veng Province) – IFRM/Polders • bank protection (Kratie Town) • flow forecasting system in tributaries in conjunction with MRC FMMP system	• Flood Protection and Drought Management Project in South of Vientiane Capital • irrigation (drought management) projects in Saravane, Bolikhamxay/ Pakxan, Saravane/ Khongsedone, Savannakhet/ Songkhone, Champasack/ Sanasomboun, • capacity building for national agencies (WREA, DOI, DOW, DMH, PAFSO, NUoL) as well as vulnerable communities • establishment of National Flow (Flood and Drought) Forecasting and Early Warning Centre	• preparation of design criteria guideline for F/DRMM interventions in the Cuu Long River Delta; • assessment of flood situation and proposing of non-structural and structural interventions for flood mitigation and management of trans-boundary flooding in the Plains of Reed (Viet Nam – Cambodia border); • community-based model for flood and drought mitigation and management based on communities in the Cuu Long River Delta • dredging and rehabilitation of canals in Long An and Dong Thap provinces • bank protection in the Mekong river at Thuong Thoi Tien Town, Hong Ngu district • upgrading of salt water intrusion protection system in Go Cong area • flood control system for Ba Rai - Phu An orchards (orchard protection)

Topic V

Land use and climate change impacts on flood management

Paper 3-5-1

DEVELOPMENT OF CLIMATE CHANGE SCENARIOS FOR VIET NAM BY PRECIS MODEL

NGUYEN VAN THANG, HOANG DUC CUONG, NGUYEN DANG MAU, TRUONG BA KIEN

Viet Nam Institute of Meteorology, Hydrology and Environment, Viet Nam

ABSTRACT

Currently, Viet Nam Institute of Meteorology, Hydrology and Environment (IMHEN) runs Providing Regional Climates for Impacts Studies (PRECIS) for climate change scenarios of 21st century. The domain chosen is large which includes Viet Nam and adjacent regions with the resolution of 25 x 25 km. The study will use the scenarios of A2 and B2 and analysis in detail of the climate change scenarios for 7 climatic regions of Viet Nam. Results show that under A2 and B2 scenarios, average temperature increases all over the country and all the climate zones in comparison with the average for the 1980-1999. Increasing rates in the A2 scenarios are generally greater than those in the B2 scenario. On the other hand, in all climate zones, increasing rates in the second half of the 21st century are greater than those in the earlier century, in the coastal zones are lower than other parts, in the northern zones are higher than those in the southern zones. By the end of 21st century, temperatures in Viet Nam would rise about 2.1 to 2.7 ^{0}C under B2 scenario, and 3.0 to 3.8 ^{0}C under A2 scenario in different climate zones. Temperature in Northern and Northern Central climate zones of Viet Nam would increase faster than those in Southern zones. Annual rainfalls would decrease in the Central Highlands, South Delta; however they increase in other zones. For whole country, annual rainfall by the end of the 21st century would increase by 14% under A2 scenario and about 17 to 18% under B2 scenario compared to those of the period 1980 - 1999.

INTRODUCTION

Climate change is one of the most significant challenges facing human beings in the 21st century. Climate change will seriously affect life, production and environment worldwide. Temperature increase and sea level rise may cause floods and salt water intrusion, thus harm agriculture and pose risks to industries and socio-economic systems in the future.

According to the fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC), global warming and many changes in the global climate system during 21st century are unavoidable. To estimate and reduce risks and impacts of climate change, it is necessary to study and project how the climate will be in the future.

In Viet Nam, over the past 50 years, average temperature has increased about 0.5 - 0.7 ^{0}C, sea level has risen about 20 cm. Climate change has made natural disasters, especially typhoons, floods, and droughts more severe.

Consequences of climate change in Viet Nam are considered to be serious and present significant threats to hunger eradication and poverty reduction, and the country's sustainable development.

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For the addressing future climate change, the global climate models (GCM) are the most appropriate tool. However, in order to formulate adaptation policies in response to climate change impacts, reliable climate change information is usually required at finer spatial scales than that of a typical GCM grid-cell (which is usually about 300 x 300 km). Thus, although GCMs provide adequate simulations of atmospheric general circulation at the continental scale, they do not capture the detail required for regional and national assessments. This is particularly true for heterogeneous regions, where sub-GCM grid-scale variations in topography, vegetation, soils and coastlines have a significant effect on the climate. In addition, at coarse grid resolutions, extreme events such as cyclones or heavy rainfall are often not captured, or their intensity is unrealistically low. For resolving this problem, one solution is to use a regional climate model (RCM) with very high resolution, which will provide finer spatial and temporal detail than the GCM. Like a GCM, it is a comprehensive physical model representing the important components of the climate system. It has a higher resolution than a GCM and covers a limited area of the global, which is nested within a GCM. At its lateral boundaries the RCM is driven by winds, temperature and humidity variables output every 6 hours from the GCM. This is referred to as one-way nesting, since the RCM does not feed information back to the GCM.

Providing Regional Climates for Impacts Studies (PRECIS) is a regional climate model of the atmosphere and land surface with its characteristics of limited area and high resolution and locatable over any part of the global, designed by the Met office Hadley Centre of the United Kingdom.

Viet Nam Institute of Meteorology, Hydrology and Environment has been applying PRECIS model since 2006 for developing climate change scenarios.

CURRENT STATUS OF CLIMATE CHANGE

Climate change manifested mainly by global warming and sea level rise, is caused substantially by human activities that emit excessive greenhouse gases into the atmosphere.

According to the IPCC Fourth Assessment Report in 2007, global average temperature has risen about 0.74 ^{0}C for the period of 1906 - 2005 and the warming trend over the last 50 years is nearly twice that of previous 50 years (Figure 1). Temperature rise over the continents is higher than that over oceans (Intergovernmental Panel on Climate Change (IPCC), 2007).

In the past 100 years, rainfall had increasing trends in the areas with latitude higher than 300 mm. On the other hand, rainfalls had decreasing trends in tropical areas since the mid 1907s (Figure 2). Heavy rainfall events seem to take place more frequently in many regions of the world (Intergovernmental Panel on Climate Change (IPCC), 2007).

In Viet Nam, results of analysis of observed data indicated changes of climate parameters with the following noticeable features:

- *Temperature.* During the last 50 years (1958 - 2007), the annual average temperature in Viet Nam increased about 0.5 to 0.7 ^{0}C. Winter temperatures increased faster than those of summer and temperatures in Northern climate zones increased faster than those of Southern climate zones (Figure 3a). The annual average temperature for the last four decades (1961 to 2000) was higher than that of the three previous decades (1931 to 1960). Annual average temperatures of 1991 to 2000 in Ha Noi, Da Nang and Ho Chi Minh City were all higher than the average temperatures of 1931 - 1940 by 0.8, 0.4 and 0.6 respectively. In 2007, the annual average temperatures at these three locations were all higher than the average for 1931 - 1940 by 0.8 - 1.3 ^{0}C and similarly higher than the average for 1991 - 2000 by 0.4 - 0.5 ^{0}C *(NTP, MONRE, 2008);*

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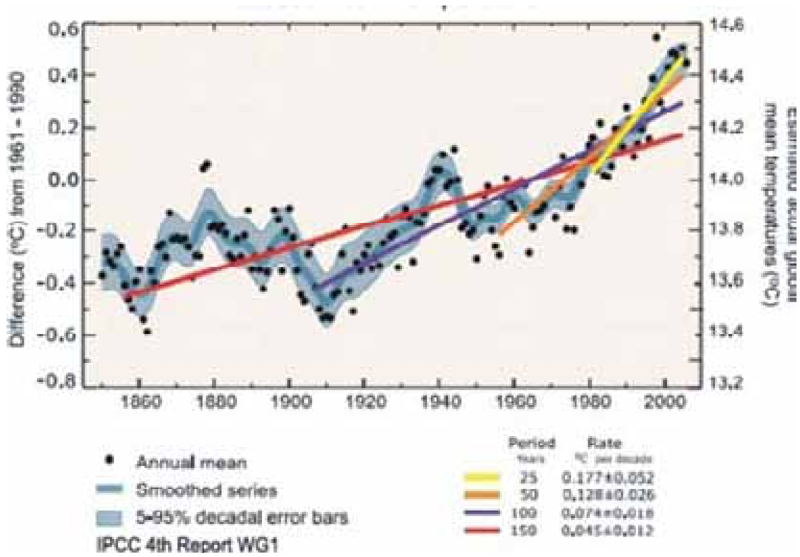

Figure 1. Anomalies of global annual mean temperature (Intergovernmental Panel on Climate Change (IPCC), 2007)

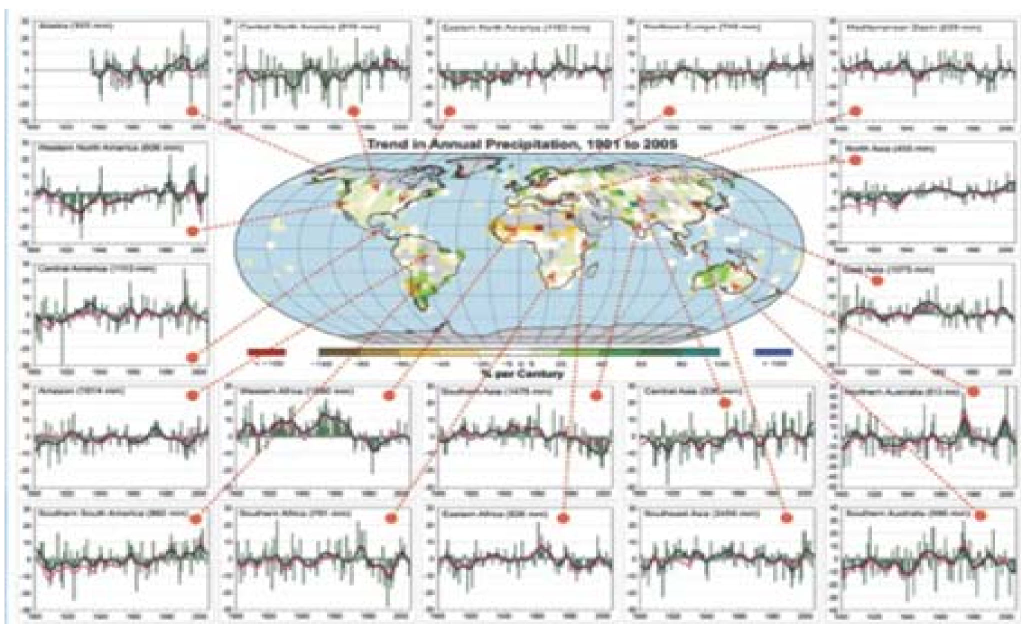

Figure 2. Changes in annual rainfall in different parts of the world. (Intergovernmental Panel on Climate Change (IPCC), 2007)

- *rainfall.* At every location, change of annual average rainfalls for the last 9 decades (1911 - 2000) was not distinct and not consistent with each other. There were ascending and also descending periods. The annual rainfall decreased over Northern climate zones while increased over Southern ones (Figure 3b). On average for the whole country, the rainfall over the past 50 years (1958 - 2007) decreased by about 2% (Ministry of Natural Resources and Environment (MONRE), 2008);

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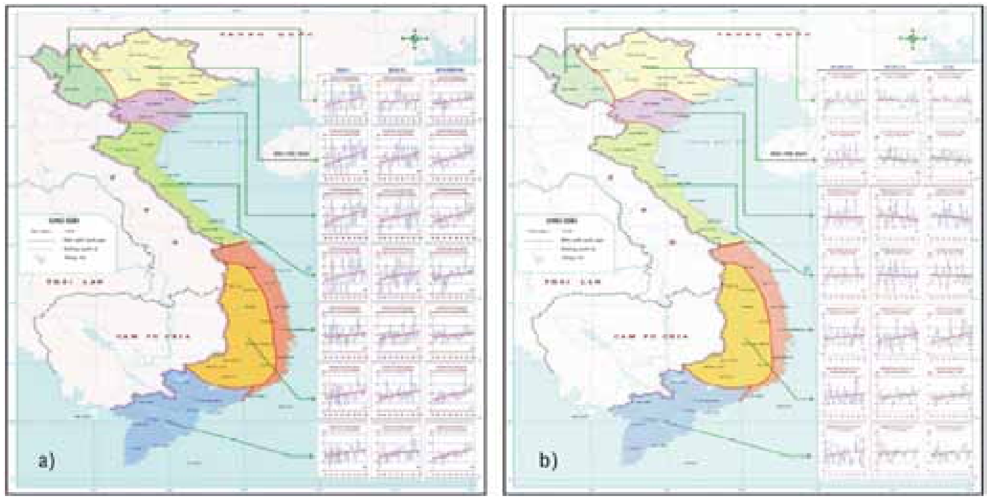

Figure 3. Trend of temperature (a) and rainfall (b) over Viet Nam for the last 50 years

- *cold fronts.* In the last two decades, the number of cold fronts affecting Viet Nam was reduced remarkably. Anomalous events, however take place more frequently such as the most recent extremely and damaging cold surge lasting consecutively 38 days during January and February 2008 in Northern Viet Nam (Ministry of Natural Resources and Environment (MONRE), 2008);
- *typhoons.* In recent years, there were more typhoons with higher intensity affecting Viet Nam. Typhoon track has a tendency of moving southward and typhoon season tends to end later. There were more typhoons with abnormal movement – Figure 4 (Viet Nam Initial National Communication under the United Nations Framework Convection on Climate Change, Ministry of Natural Resources and Environment (MONRE), 2003).

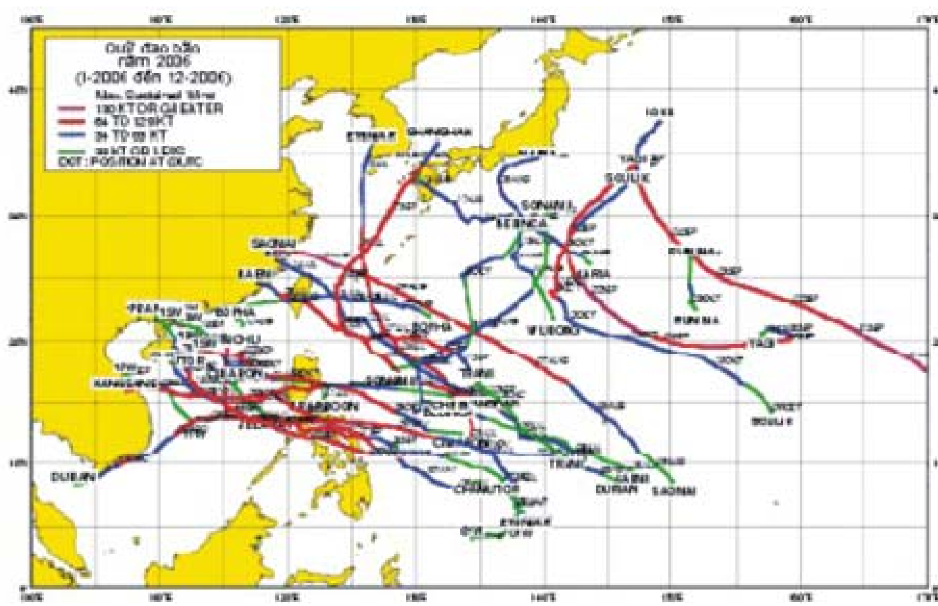

Figure 4. Typhoon tracks in the North Western Pacific Ocean and East Sea

- *drizzles.* The average number of drizzle days in Hanoi gradually decreased since the decade of 1981 - 1990 and in the last 10 years, there was only half (15 days/year) of the

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long-term average number (Nguyen Duc Ngu, Nguyen Trong Hieu, 2003).

EXPERIMENT DESIGN

The PRECIS model

PRECIS is based on the Hadley Centre's regional climate modelling system. It has been ported to run on a PC (under Linux) with a simple user interface, so that experiments can easily be set up over any region. The PRECIS used for developing high resolution climate change scenarios for limited area.

The PRECIS is an atmosphere and land surface model of limited area and high resolution which is locatable over any part of the globe. Dynamical flow, the atmospheric sulphur cycle, clouds and precipitation, radiative process, the land surface and the deep soil are all described. Boundary conditions are required at the limits of model's domain to provide the meteorological forcing for the RCM. Information about all the climate elements as they evolve through being modified by the processes represented in the model is produced.

Experiment design

The model configuration (domain, resolution, and the relation between them …) is an important issue for regional climate modelling (Seth and Giorgi 1998, Giorgi (2004)), but it is difficult a suitable model configuration for this region because of the local typical topography such as mountain Hymalya on the northwest of model domain… The experiments were performed with domain size and location so that main large - scale forcing as Inter-Tropical Convergence Zone (ITCZ), monsoons, TC, to be included. In this study, we use the model configuration of 25 km horizontal resolution, the domain covers a region of about 50 N – 350 N, 930 E – 1200 E. The ECHAM4 data is used to provide initial and boundary conditions for the atmosphere and sea surface temperature (SST) fields.

Greenhouse gas emissions selected for the development of climate change scenarios: Intermediate emission scenario of the medium scenario group (B2), and intermediate scenario of the high scenario group (A2).

Climate change scenarios for temperature and rainfall are developed for seven climate zones in Viet Nam: North West, North East, North Delta, North Central, South Central, Central Highlands, and South Delta. The baseline period is 1980 - 1999 (the same as that used in the 4th IPCC Assessment Report) and the future period is 2000 - 2100.

Preliminary results

Climate change scenarios for climate zones of Viet Nam in the 21st century (Tables 1, 2, 3 and 4) can be summarized follows:

a) *Scenarios for temperature:*
   Temperature in winter can increase faster than those in summer for all climate zones. Temperatures in Northern climate zones can increase faster than those in Southern climate zones.
   - *in medium emission scenario (B2).* By the end of the 21st century, annual mean temperatures would increase about 2.1 ^{0}C in the North West, 2.5 ^{0}C in the North East, 2.4 ^{0}C in the North Delta, 2.3 ^{0}C in the North Central, 2.3 ^{0}C in the South

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Central, 2.6 ^{0}C in the Central Highlands, and 2.7 ^{0}C in the South Delta (Mekong Delta) compared to the average of 1980 - 1999 (Table 1).

Table 1. Changes in annual mean temperature (^{0}C) relative to the period of 1980 - 1999 Medium emission scenario (B2)

Climatic regions	Decades in the 21st century								
	2020	2030	2040	2050	2060	2070	2080	2090	2010
North West	0.0	0.1	0.0	0.5	0.9	1.3	1.6	1.9	2.1
North East	0.2	0.3	0.4	1.0	1.0	1.7	2.0	2.3	2.5
North Delta	0.1	0.3	0.3	0.9	1.2	1.6	1.9	2.3	2.4
North Central	0.2	0.2	0.3	0.8	1.2	1.6	1.8	2.3	2.3
South Central	0.4	0.7	0.6	0.9	1.3	1.6	1.9	2.2	2.3
Central Highlands	0.6	0.9	1.0	1.2	1.5	1.9	2.2	2.4	2.6
South Delta	0.7	1.0	1.2	1.4	1.7	2.0	2.2	2.4	2.7

- *in high emission scenario (A2).* By the end of the 21st century, annual mean temperatures in Northern climate zones would increase about 3.3 to 3.8 ^{0}C relative to the average of 1980 - 1999, in which, North West: 3.4 ^{0}C, North East: 3.8 ^{0}C, North Delta: 3.6, and North Central: 3.3 ^{0}C. The change in temperature in the Southern climate zones is 3.1 ^{0}C in the South Central, 3.0 ^{0}C in the Central Highlands, and 3.4 ^{0}C in the South Delta (Table 2).

Table 2. Changes in annual mean temperature (^{0}C) relative to the period of 1980 - 1999 High emission scenario (A2)

Climatic regions	Decades in the 21st century								
	2020	2030	2040	2050	2060	2070	2080	2090	2010
North West	0.2	0.6	0.9	1.2	1.5	2.2	2.8	3.3	3.4
North East	0.3	0.8	1.1	1.4	1.5	2.6	3.6	3.8	3.8
North Delta	0.4	0.8	1.0	1.3	1.6	2.3	2.9	3.2	3.6
North Central	0.2	0.6	0.9	1.2	1.4	2.1	2.7	3.0	3.3
South Central	0.1	0.4	0.7	0.9	1.4	2.0	2.5	3.0	3.1
Central Highlands	0.1	0.4	0.6	0.9	1.3	1.8	2.3	2.8	3.0
South Delta	0.5	0.6	0.8	1.2	1.5	2.1	2.5	3.2	3.4

b) *Scenarios for rainfall:*

Precipitation changes are complicated and discriminated seasonal and regional. In both A2 and B2 scenarios, precipitation generally increases in all climatic regions, except in central highlands and the south delta in the 21st century. The Increasing rates under B2 scenario are greater than those under A2 scenario.

- *in medium emission scenario (B2).* Annual rainfall would increase in the 21st century, relative to the period of 1980 - 1999, in the North West, North East, North Central, and South Central. However, it would decrease in the North Delta, Central Highlands, and South Delta. By the end of the 21st century, annual rainfall would increase about 14 - 23% in all the climate zones. The increasing rates are more remarkable in the North West and South Central and the decreasing rates are more remarkable in the North Delta and South Delta (Table 3).

Table 3. Changes in annual rainfall (%) relative to the period of 1980 - 1999 Medium emission scenario (B2)

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Climatic regions	Decades in the 21st century								
	2020	2030	2040	2050	2060	2070	2080	2090	2010
North West	42	42	47	42	45	53	55	49	14
North East	-4	-1	5	1	7	6	9	1	15
North Delta	-30	-32	-14	-23	-25	-24	-29	-26	18
North Central	15	16	16	15	19	22	19	12	15
South Central	40	83	69	75	79	97	100	86	23
Central Highlands	-9	-10	-5	-9	-4	-2	-5	-3	22
South Delta	-16	-22	-23	-28	-36	-19	-22	-17	17

- *in high emission scenario (A2).* Under A2 scenario, annual rainfall would decrease in the Central Highlands and South Delta, increase in the other parts. By the end of the 21st century, annual rainfall would increase, relative to the period of 1980 - 1999, about 20 - 28% in the North West, North East, North Delta, North Central, and South Central (Table 4). However, it would decrease about 4% in the Central Highlands and 15% in the South Delta (Table 4).

Table 4. Changes in annual rainfall (%) relative to the period of 1980 - 1999 High emission scenario (A2)

Climatic regions	Decades in the 21st century								
	2020	2030	2040	2050	2060	2070	2080	2090	2010
North West	4	3	-2	15	7	6	8	19	28
North East	0	4	-2	16	4	9	17	27	22
North Delta	-1	9	-2	16	7	12	21	26	21
North Central	4	13	-2	16	7	12	18	16	26
South Central	17	3	1	3	5	10	15	15	20
Central Highlands	4	-6	-2	-18	-10	-12	-3	-5	-4
South Delta	-6	2	-21	-23	-9	-20	3	-30	-15

CONCLUSIONS AND FUTURE WORKS

Climate change scenarios for Viet Nam in the 21st century are developed by using PRECIS model based on different emission scenarios, namely, medium (B2) and high (A2).

Under A2 and B2 scenarios, average temperature increases all over the country and all the climate zones in comparison with the average for the 1980 - 1999 period. Increasing rates in the A2 scenarios are generally greater than those in the B2 scenario. On the other hand, in all climate zones, increasing rates in the second half of the 21st century are greater than those in the earlier century, in the coastal zones are lower than other parts, in the northern zones are higher than those in the southern zones.

By the end of 21st century, temperatures in Viet Nam would rise about 2.1 to 2.7 ^{0}C under B2 scenario, and 3.0 to 3.8 ^{0}C under A2 scenario in different climate zones. Temperature in Northern and Northern Central climate zones of Viet Nam would increase faster than those in Southern zones.

Annual rainfall would decrease in the Central Highlands, South Delta, however they increase in other zones. For whole country, annual rainfall by the end of the 21st century would increase by 14% under A2 scenario and about 17 to 18% under B2 scenario compared to those of the period 1980 - 1999.

There are high uncertainties contained in the above results. The possible reasons are: (i) Low

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confidence level of emission scenarios; (ii) Certain errors of models in simulating for a long period; (iii) Certain errors in the statistical downscaling method based on the global and regional data; (iv) Large differences of climate factors by locations.

In order to overcome the above mentioned uncertainties, IPCC recommended applying tolerance for climate change scenarios. For example, a tolerance for temperature by the end of the 21st century is 0.4 - 0.6 ^{0}C, for annual rainfall it is 1 - 2% and about 5% for monthly rainfall. Moreover, climate change scenarios need to be regularly updated in data, knowledge, models, and computation methods.

For future works, we are going to run PRECIS with more boundaries data and the climate change scenarios for Viet Nam is generated from assembling different PRECIS's outputs.

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Paper 3-5-2

THE WISDOM PROJECT
A PROGRESS REPORT FROM THE HYDROLOGIC AND WATER RESOURCES SUB-COMPONENT

E. PLATE, H. APEL, J. BIRKMANN, G. WAIBEL, S. GEBHARDT, T. WEHRMANN, F. RENAUD AND C. KUENZER

Karlsruhe Institute of Technology (KIT), Universität Karlsruhe (TH), Karlsruhe, Germany and German and Vietnamese Project Partners

ABSTRACT

The WISDOM project is a joint Vietnamese - German Project for developing a Water Information System as decision support for the Sustainable Development of the Mekong Delta, which is described in a companion paper by Moder and Kuenzer (2010). In order to demonstrate the use of the system, to perform pilot studies as examples, and to fill in missing information, a program of jointly executed research by German and Vietnamese scientists from various disciplines is accompanying the set up of the Information System, in which by means of demonstration projects the potential use of the system is documented. The focus of this presentation will be on results from these supportive researches.

INTRODUCTION

During the last two and a half years an intensive joint Vietnamese - German research initiative, called the WISDOM Project (Water Information System for the Sustainable Development of the Mekong Delta, www.wisdom.caf.dlr.de) has been conducted in close collaboration between Vietnamese and German scientists within a bilateral cooperation agreement. The purpose of the project is to design and implement a virtual storehouse for water- and land related information for the Mekong Delta, containing information from the fields of hydrology (water quantity and water quality parameters), sociology (socio-economy, vulnerability, demography), earth observation (land cover, land use, surface sealing, flood masks) and information technology, and to make this information easily available for purposes of regional planning. It is a result of a joint initiative of the Ministry of Science and Technology (MOST) in Viet Nam and the German Ministry for Education and Research (BMBF) in Germany. Project work started in spring 2007 and will - at present - last until end of August 2010. Extension of the project from fall 2010 until fall 2013 is anticipated.

The project in its first phase has six components, or work packages (WP): WP 1000 is the project management package, in which most of the organisational matters, such as coordinating the German partners, or the liaison to the Vietnamese partners, contacts to ministries, regional organisations and funding organisation for long term project sustainability, as well as the general administration of the project is conducted, WP 2000 is concerned with identifying all sources of organisations and administrative bodies who have functions in management of and research on water resource of the Mekong Delta, and to make available legal and administrative knowledge for inclusion into the Information System, and in general a better understanding also of the legislative parts of water law in Viet Nam. WP 3000 covers the design of the water information system. It stands in the centre of the WISDOM project, and all other research

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packages from the different disciplines are to feed into this system. The water information system is developed by the German Space Agency (Deutsches Institut für Luft- und Raumfahrt), details of which shall be presented in a companion paper. Its basic structure permits to store and analyze water- and land related data from many different sources, not only on water quantity, water quality, and basic geographic quantities, among them remotely sensed data –, but also social information and land use data. The data are stored in an extensive relational data bank. However, data storage is only the backbone of the system, which shall provide complex information for technical, environmental, social and other purposes via a web-based, easy to use online platform. It shall yield an interface which allows combining data: presenting them in GIS maps and other documentation media, including information derived from raster data, vector data, sensor in situ data, statistical yearbooks, as well as 'Yellow Pages' function and field photograph viewer (the subject of WP 6000), to show relevant interactions of all components for modern water management activities.

Focus of this paper is on WP 4000 and WP 5000. In WP4000 elements for water resources planning are obtained, by means of theoretical work and field experiments, with emphasis on environmental consequences of flooding and on water management issues associated with vulnerability against floods. WP 5000 addresses social issues: social conditions, social implications of floods, vulnerability characteristics, and impact of social parameters on water management.

For later decision makers it is crucial that all information gathered within the project will be available in an interrelated and easily accessible format. Furthermore, education and capacity building - not only in the different scientific disciplines but also through extensive workshops on components of the system is a key for making use of the information system after the project's end.

This paper will give a brief summary of the work undertaken within the field of hydrology / water resources, as well as with socio-economic components in the Mekong Delta. Parts of the hydrologic research are concerned with the whole Mekong river basin, with the purpose of detecting climate change effects and studying the stochastic nature of the discharge hydrographs. Parallel runs the evaluation of the discharge and water level gages for flood forecasting, as is reported separately in Shahzad and Plate (2010). But the major focus of the sub-components is on micro- situations, where water problems directly impact local populations. For the purpose of covering a wide range of issues representative of the whole Mekong Delta, in cooperation of German and Vietnamese project partners, two test areas - Can Tho Province and Tam Nong Province - have been identified and are extensively studied. The location of the two areas in the Mekong delta is shown in Figure 1.

In each of the study areas, water quantity and quality data were obtained and studied. These studies were accompanied by studies of the demographic and economic situation of the people of the area, to obtain a comprehensive assessment of the water-related vulnerability of the people of the area, and of the impact of flooding on people's livelihoods and their measures to prevent flooding.

LARGE SCALE INVESTIGATIONS

The strong focus of modern hydrological research on climate and land use change - including biological consequences of changes - makes it imperative to search for such effects in any hydrological environment. For the Mekong, the meteorology of the region is determined by interaction of the South West monsoon with typhoons coming across the South China Sea, with

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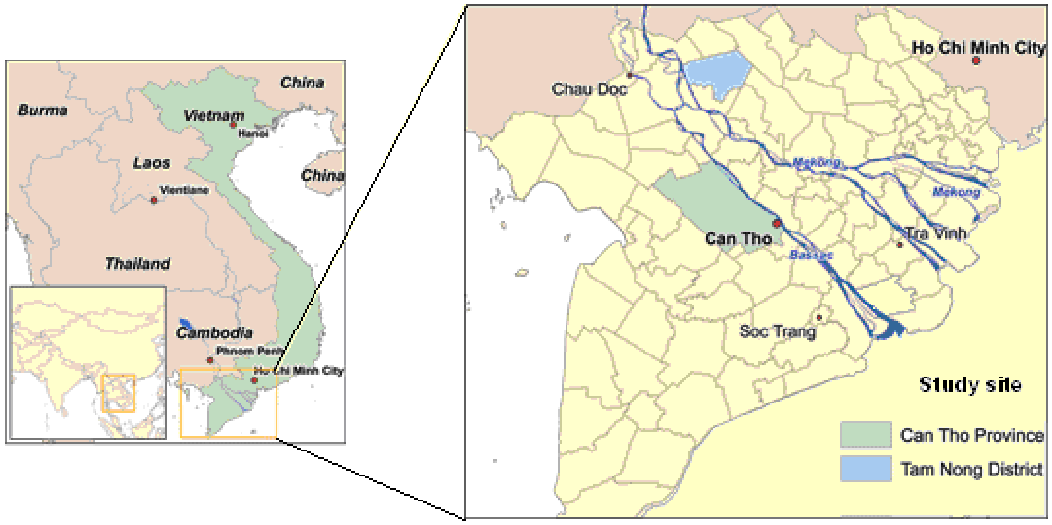

Figure 1. Study areas of the WISDOM project in South Viet Nam

the monsoon setting the basic climate pattern, and typhoons contributing to strong local peaks in discharge. Consequently, any climate change processes that effect either monsoon or typhoon activity will be felt in the discharges of the Mekong. An indication of the effect for typhoons of the 2006 season is shown in Figure 2. It is seen that although a direct correlation in time of typhoon landfall and discharge is not clearly discernible, a general tendency of increased discharge in the neighbourhood of typhoon landfall is evident. In case of the Xangsane typhoon of 2 October 2006, precipitation fell before and right after landfall, as can be seen in the records of stations Pakse and Mukdahan in Figure 2b. In other stations the rise occurred after landfall, such as in case of the typhoon on 25 September.

An indirect indication of climate change is the development of discharges in the main river. An in depth study was conducted within the WISDOM project of changes in discharges and in flood characteristics (Delgado et al., 2010). Annual maximum discharge is analyzed with regard to average flood trends and variability during the 20th century. Data shown in Figure 3 from four gauging stations for Vientiane and further downstream were used, covering two distinct hydrological regions within the Mekong basin. These time series span through over 70 years and are the longest daily discharge time series available in the region. The data of the flood peaks were fitted by a suitable extreme value probability distribution. A special feature of the analysis was that parameters of the distribution (especially the variance) were assumed to increase linearly with time, which seems to reflect the tendency of the last half of last century: Results showed an increasing likelihood of extreme floods although the probability of occurrence of an average flood decreased during the same period. More detailed analyses of the complete record of daily discharges based on wavelet theory allowed confirming a period of enhanced variance in the last quarter of the 20th century.

Perhaps the most threatening effect of climate change is increased sea level rise, which has to be anticipated. This effect can only be studied by means of mathematical models. A 1D hydrodynamic model of the Mekong Delta developed at the Southern Institute of Water Resources Research, SIWRR, which is also the coordinating organization of the WISDOM project on the Vietnamese side, was further improved by collecting more data on dike lines and elevations, and an improved representation of floodplains in the one-dimensional model domain. This was obtained by modelling channel flow by means of a 1 D model of the channel

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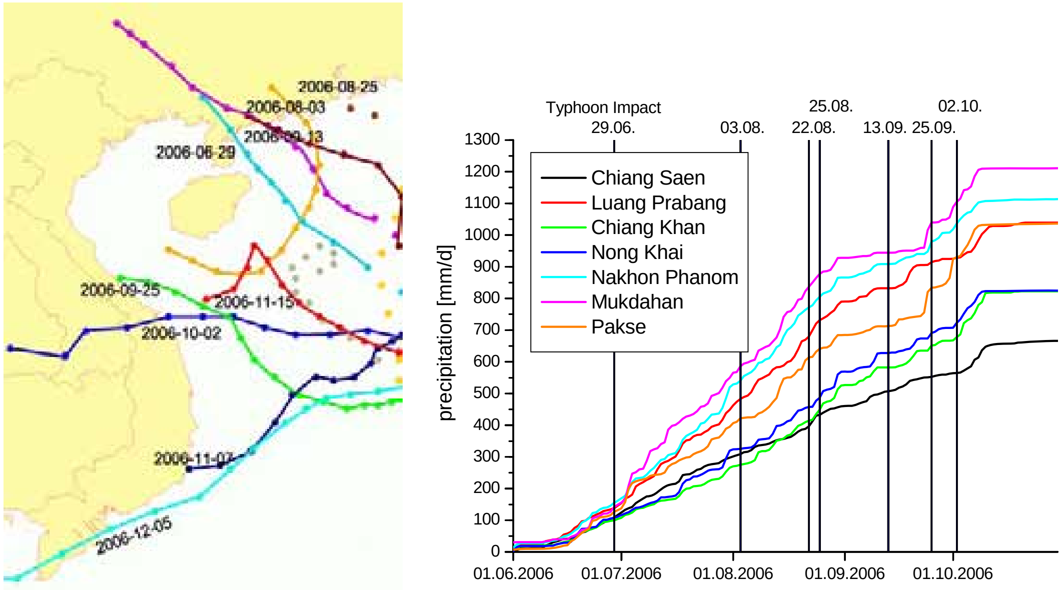

(a) (b)

Figure 2. a) Typhoon tracks that come near or hit the mainland in the vicinity of the MRB
b) Shows the precipitation depth of major stations in relation to the dates where the typhoons are near landfall

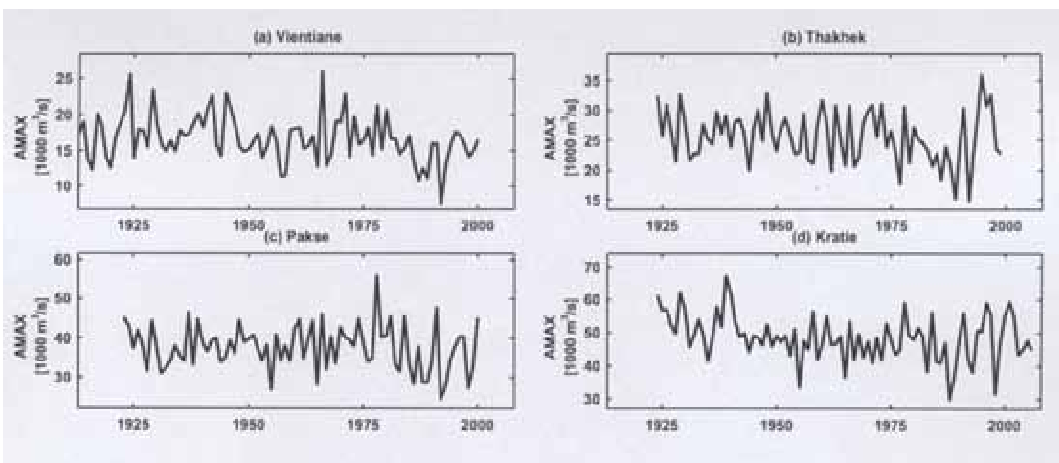

Figure 3. Trends of the maximum discharges observed at different stations between Vientiane and Kratie

system, and by using an overflow model for calculating the flow into dike enclosed rural areas. With the new data the model was calibrated against the record flood in 2000 and additionally validated by simulating the flood in 2001. Both calibration and validation runs show a very good agreement with recorded discharges. In a next step the simulated inundation depths in the channels and the innovative representation of the floodplains were interpolated to inundation maps. By this, a spatial representation of the inundation of the whole delta was reached, which has much larger information content than the point data from the 1D model alone. In a further step, the calibrated model was used to assess the impacts of projected sea level rises in the area. Figure 4 shows the inundation of the year 2000 with the current sea level and the inundation simulated with the same discharge but with a raised sea level by 50cm. It can be seen, that a much larger area is prone to inundation in this scenario. This information has to be included in future flood mitigation and management schemes.

REGIONAL STUDIES

A significant contribution to the Information System is obtained from regional studies. Two major test areas were selected for covering significantly different features of the region. Remote sensing information was coupled with field studies of the distribution of physical and chemical quantities, accompanied by social and economic surveys for vulnerability assessment. For all two WISDOM test sites satellite information was provided on regional land use. By means of watermasks, using automatic watermask processing of TerraSAR-X satellite images, time series of inundation depths were completed for the period from end of June to end of November 2009, as well as for the rainy seasons of the previous year 2008. Since during this period no extreme floods occurred, these masks can be used for calculating reference datasets showing the distribution of permanently flooded and seasonal flooded (e.g. due to irrigation and flooding of rice fields) areas. In total these investigations provide a comprehensive overview of water related conditions, which - through deposition in the Information System - are transferable to other, similar regions of the delta. Some results for the regional studies are summarized in this section.

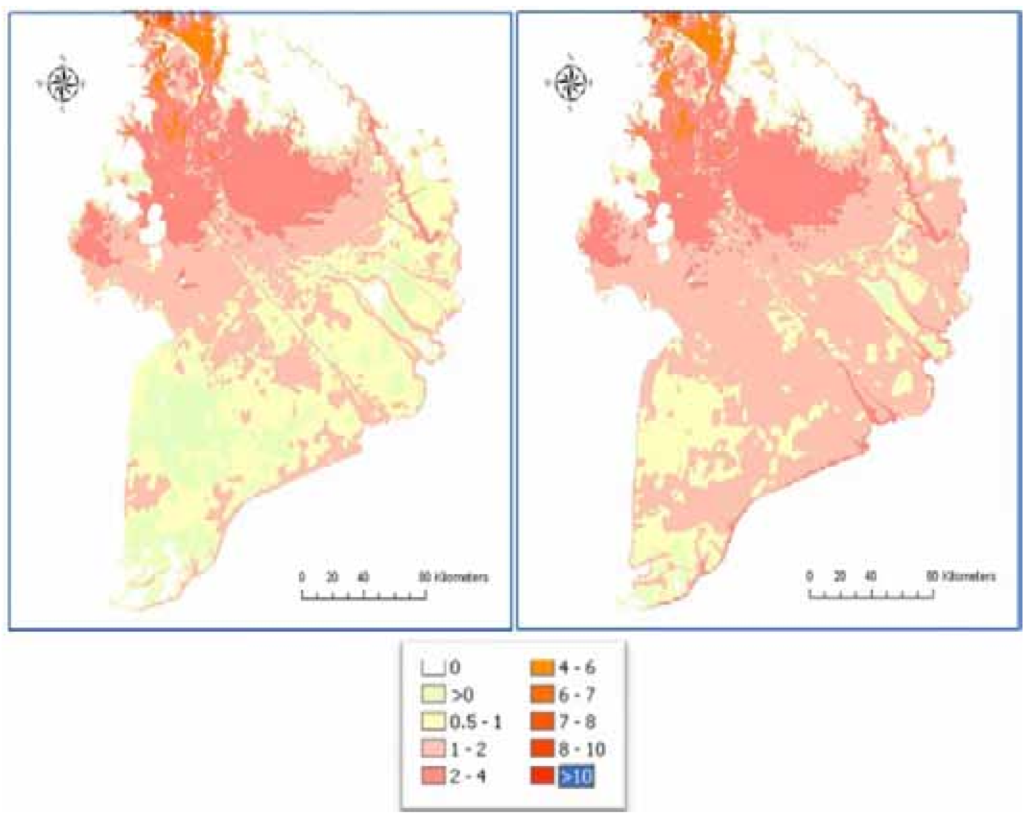

Figure 4. Simulated inundation of the Mekong Delta of the flood in 2000 (left) and simulated with the same discharge, but a raised sea level of 50 cm (legend in m).

Can Tho Province

Can Tho City, regarded as 'South-Western capital', with an estimated population of 1,187,000 as of 2009, is the biggest city in the Mekong Delta. The city is located on the south bank of Hau River, the bigger branch of the Mekong River. It is located 169 km west of Hồ Chí Minh City,

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Viet Nam's largest city. A map of the test area is shown in Figure 5. This area was selected to study, in particular, the specific vulnerability of urban areas subjected to Mekong flooding, as a basis for future decisions on remedial measures. In the context of vulnerability studies characteristics relevant for the WISDOM research topics are:

1. increasing urbanisation;
2. frequently inundated area;
3. large importance of agriculture: rice, aquaculture, pig, and poultry production, as well as the increasing expansion of so called 'industrial zones'. These not only contribute to the economy of the area, but they also contribute to the water pollution;
4. another strong effect is the use of pesticides for enhanced rice production, as well as endocrine dysruptors for aquaculture, which decreases water quality.

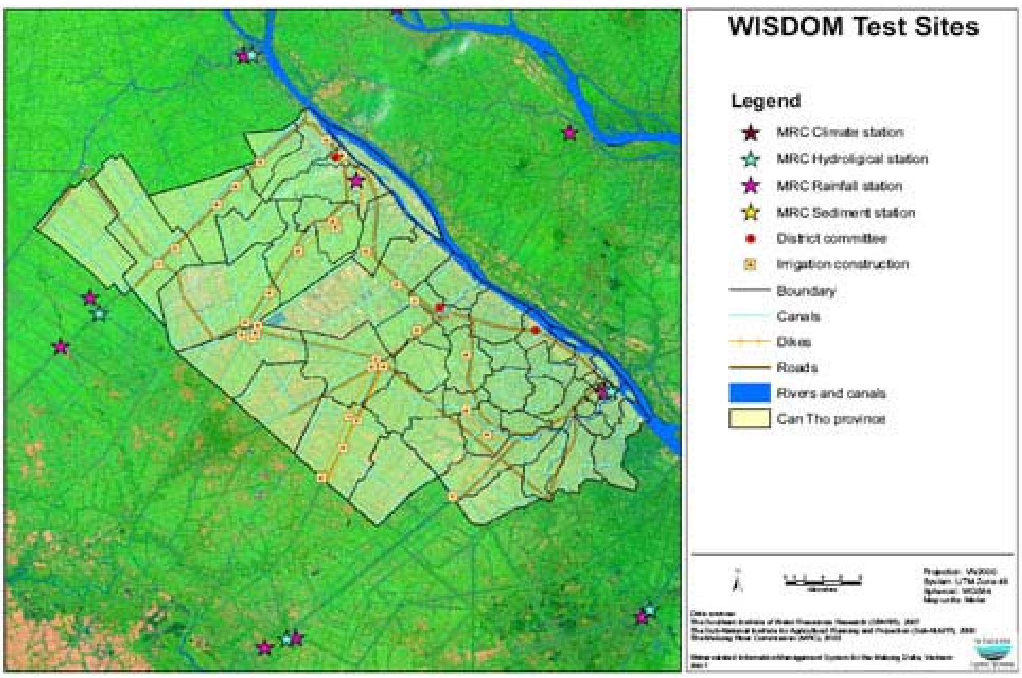

Figure 5. Overview map of the Can Tho Province

Vulnerability of people of the area to flooding was extensively investigated in 2009.Explorative research in Can Tho has produced insights on characteristics of urban and sub-urban vulnerabilities. Through combination of different methods, such as focus group discussions with experts, household interviews and the analysis of secondary (statistical) data and application of other participatory urban appraisal-methods like, for instance, wealth rankings, knowledge on vulnerability patterns and governance processes could be gained. Household interviews revealed that the houses directly along the river - mostly with poor housing conditions - are predominantly inhabited by low-income families. Hence, these households suffer from a multiple burden: First, they are highly exposed to water-related hazards such as floods, water-level rise and river bank erosion. Second, bank erosion forces these households to rebuild, shift or elevate their houses every couple of years, placing a considerable financial pressure on families whose financial resources are very limited anyway.

In view of scientific evidence one must be concerned about climate change effects (particularly due to sea level rise and the increase in storm and typhoon activity). The region of Can Tho seems to be specially endangered because Can Tho is located only approximately 70 km inland.

However, since at this time climate-related hazards have only limited impact on the city, the perceived risk from those hazards is very low.

The major impact of the flooding situation is on the maintenance efforts needed to keep the existing system of canals and dykes in working order. Soil sedimentation in river and canal beds occurs throughout the delta and impairs the proper functioning of the water supply system for irrigation. As a maintenance measure, canals have to be dredged every 6 to 7 years. This is normally organized during the dry season when water levels in the canals are low. Formerly, farmers were mobilized to dig by hand and huge irrigation labour campaigns assembled thousands of people to take part in the exercise. Today dredging is mostly done by machines, especially for the large canals. Though mechanization has reached the rural areas, labour input provided by farmers is still required for the preservation of irrigation canals of category III and other smaller on-field canals. Recent statistics show that within the period of 2006 to 2008, farmers of Can Tho City provided a total of 182,000 days of public labour invested in canal dredging. The labour force recruitment has been the highest in Phong Dien (46,000 days) and O Mon (33,000 days), respectively. During the same time, both districts have made comparatively small financial investments into the hydraulic sector.

Huu, et al. (2009) reviewed flood protection planning for the city of Can Tho. In view of the complexity of the issues involved it is difficult to obtain a solution which can satisfy every need. It is necessary to balance a multitude of different interests: damage prevention vs. maintenance and improving the flood protection works, and at the same time satisfying ecological and economic conditions. A compromise has to be found, as is exemplified by the existing plan for the improved flood protection of the city of Can Tho. The study of Huu et al. within the WSDOM project was concerned with the potential impact of the existing plan on the lives of common people. The study was performed by skilled scientists, who interviewed numerous persons involved in the planning or who will be affected by any dyke construction. It was concluded that although it is known that the building of a flood protection system in the delta region has special negative side effects (such as blocking off some sediment deposits which are natural fertilizers for the soils, as well as changes in the regime of flooding and draining of agricultural areas which are surrounded by dikes), the present plan has not given enough attention to non-technical issues, which should be studied using different non-stationary scenarios based on comprehensive hydraulic models with non-stationary flood input.

Tam Nong District

Tam Nong district in Dong Thap province is situated in the north-western part of the Mekong Delta also referred to as ‘Plain of Reeds’. It is characteristic of large areas within the Mekong flood plain which are annually flooded and where living with floods is part of annual life. It is ideally suited to study in- and outflows of Mekong flood waters, giving due regard to its transport capacity for moving sediment and carrying off fertilizer and pesticides used in agriculture, i.e. mainly for rice production. The area had other features which gave additional reason for its selection. One issue is the existence of the Tram Chi National Park, which is completely enclosed by dikes, and which provides an undisturbed upper boundary of the study area. A map of the study area is shown as Figure 6.

A measurement program was conducted to provide data for the estimation of parameters for appropriate models. The study area in Tam Nong was equipped with a large number of sensors to monitor inundation and sediment transport dynamics. Figure 6 shows locations and types of instruments. As is indicated in Figure 6, the instrument installation consists of:

- 2 stationary GPS buoys for monitoring of water levels in major rivers and canals;
- 7 main survey stations with probes for water level, suspended sediment and electric

conductivity with autonomous power solar supply;

- 14 satellite station for autonomous water level recording.

Field studies started in July 2009 and were terminated mid-December when the floodplains fell dry again in most places. German and Vietnamese scientist joined in operation of the systems. It was possible to get all instruments installed and operational for the flood season, and data could be obtained throughout the flood season. At present the data from the study are being analyzed, and results shall be presented to the user when they are available. However it is already evident that some of the pesticides used in the delta cause concentrations in flood water which are higher than permissible by international standards, and may even exceed critical levels of toxicity.

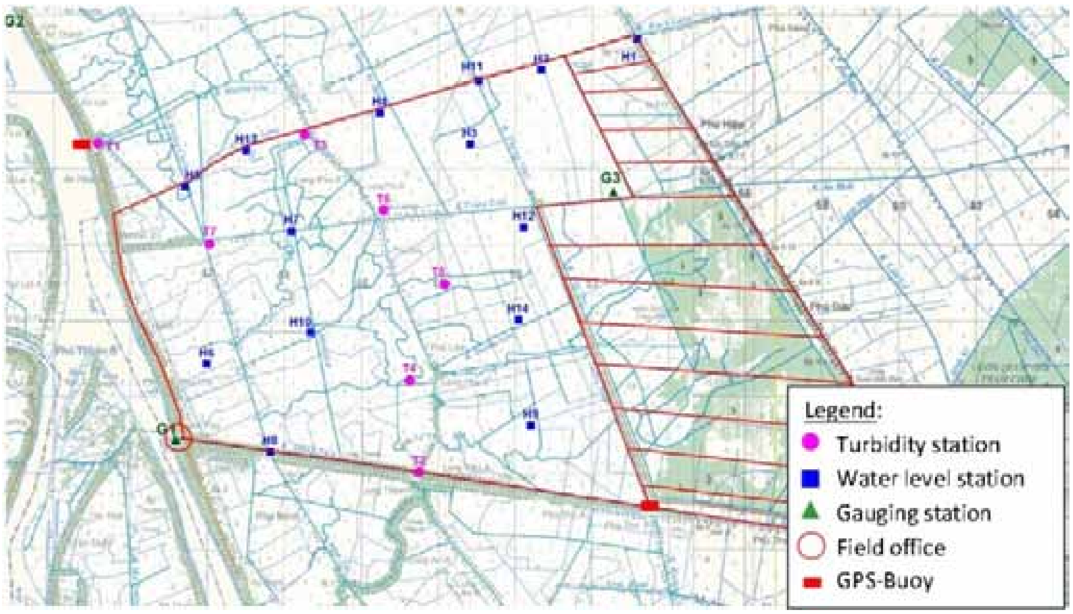

Figure 6. Study area Tam Nong. The figure shows the borders of the study area and the positions of the instruments. The hatched area indicates the Tram Chi National Park, which is completely enclosed by dikes.

Although the focus of studies in this area was mostly on characteristic physical and chemical processes, scientists of the WISDOM project also addressed issues of rural development, with some interesting results. A survey was made of social conditions in two communities within the area, Phu Hiep and An Hoa (both in Tam Nong district of Dong Thap province). Based on results of qualitative preliminary interviews and participatory rural appraisal (PRA), a questionnaire was developed which was used for household surveys in both communities, covering between 400 and 500 households. Pre-testing and adjustment of the questionnaire was finalized in December 2008. Surveys were conducted from January 2009 onwards. Methods applied included in-depth interviews with farmers and other PRA activities. Moreover, expert interviews and focus group discussions with decision makers from official planning and flood management institutions, like for instance, the local Committee for Flood and Storm Control (CSFC), have been conducted. Next to generating primary data sets on potential flooding effects on vulnerability of the people, also secondary data on past flood events were analyzed. This analysis shall play an important role in investigating causal relations between flood impact and hazard patterns, but the data have yet to be critically analyzed. For example, extremely high death tolls in Dong Thap during the flood of 2000 cannot (solely) be explained by an exceptional high flood peak (as other years show similar flood peaks but with much fewer losses). The same holds true with respect to economic losses. Hence, other aspects such as

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duration and timing of floods seem to be of higher significance here, along with seasonally different factors affecting coping capacities (like crop yields and, thus, overall food supply in particular years). Policy changes and related structural changes turned out to be of utmost importance for the vulnerability of households living in the two case study communes. Changes in livelihood patterns have a strong impact on vulnerability characteristics due to the fact that coping and adaptation potentials - such as the ability to buffer a loss of income in flood years or to repair damaged assets - are highly related to the overall livelihood situation. Interrelations among factors and evaluation of their importance are, however, still under research, and need to be quantified so that such data can be used in an assessment of flood risks and flood risk vulnerability.

CONCLUSION

The WISDOM project must be considered a major effort in information exchange of German and Vietnamese scientific knowledge on water resources planning. Central to the project is the development of a water- and land related Information System, and the studies of this paper are supplementing the system and provide a data basis for applications in water resources planning, and for development of mitigating measures against floods and water pollution. Remote sensing and GIS technology is applied to two very different regions of the Mekong delta in Viet Nam. For each of them, the existing water situation is investigated. Extensive field experiments, based on modern instrumentation and tools, with results analyzed by means of advanced modelling, is supplemented by studies of the social and economic conditions of the people of the areas experience, is combined with in depth knowledge of local conditions and experience with adapted technology and locally developed models. Field studies of physical and chemical properties, serve as ground truth for models based on remotely sensed data on land features and land use. These in combination with vulnerability analyses of the affected population yield a comprehensive picture of the water situation in the Mekong delta. The cooperative projects are continued, and because of the value of the information obtained through them it is hoped to continue the project for another three year period starting in fall 2010.

The paper is based on many progress reports of the WISDOM project, which are available through the webpage http://www.wisdom.caf.dlr.de. Please contact claudia.kuenzer@dlr.de for questions on the project.

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Paper 3-5-3

CLIMATE CHANGE AND FLOOD IN THE MEKONG DELTA

NGUYEN TAT DAC

Southern Institute for Water Resources Planning, Ho Chi Minh City, Viet Nam

ABSTRACT

The Mekong Delta is the lowest part of the Mekong Basin. Located downstream of Kratie to the South China sea, both high and low flow regimes in this area are affected by flow at Kratie, flow regulation of Tonle Sap Great Lake, flood plains along the Mekong River, road-dyke and infrastructure system, a dense canal and river network and, finally, tidal variation in the South China sea.

In view of management it has been reported by Ministry of Natural Resources and Environment of Viet Nam that, by 2050, due to climate change, for the Mekong Delta, sea level rise can be expected up to 30cm and rainfall will be increased by 6.3 - 8.3% resulting in more inundation and flooding for both Cambodia and Viet Nam Delta. It has been also reported that due to the system of hydropower dams which will be built along the main Mekong stream, the discharge at Kratie during the flood season will be decreased. For planning and adaptation purposes, all those mentioned facts need to be assessed. It is presented in this paper a modelling result set using 1D/2D coupling and 1D Delta models (developed by the author) for new flood situations in the delta. It is noted that for planning purposes, the more detailed level of new canal and river systems needs to be considered with the long time-series boundary simulation, so new Delta model can meet those requirements. Year of 2000 is taken as a base case for comparison.

INTRODUCTION

The Mekong River originates in the mountains of the Tay Tang area of Tibet and has a length of 4,800 km running through China, Myanmar, Thailand, Laos, Cambodia and Viet Nam (Figure 1).

The Mekong Delta is located mostly in Viet Nam and partly in Cambodia. Due to topographic features along the Mekong River upstream of Kratie flows are almost one direction during both low and high flow seasons, hence Kratie is considered as the gate to the Delta. Floods at Kratie dominantly come from the middle part of the basin and are found many peaks with high discharge at this boundary point and flows are quite different between the rainy season and the dry season.

During the rainy season lasting from June to November, flows account for almost 90% of the total annual volume.

Tonle Sap Great Lake has a very important role in regulation of the flow regime of the Mekong river downstream of Phnom Penh. This results in possibly increasing or decreasing of flood peak and releasing more or less water downstream during the dry season.

The Mekong Delta in Viet Nam is the last part of the Delta and occupies of approximately 3.9 million hectares sharing 5% of the whole basin area and is affected by a tropical monsoon

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climate which is warm year round.

With two distinct seasons the flow regime of the Mekong Delta in Viet Nam is affected by the inflows from Kratie of the Mekong River, the tides from the South China Sea the tides of the Gulf of Thailand and by in-land rainfall. The man-made canals, embankments, and rapidly developed infrastructures are also significant factors strongly influenced on rising inundation depth during the flood season of the Delta.

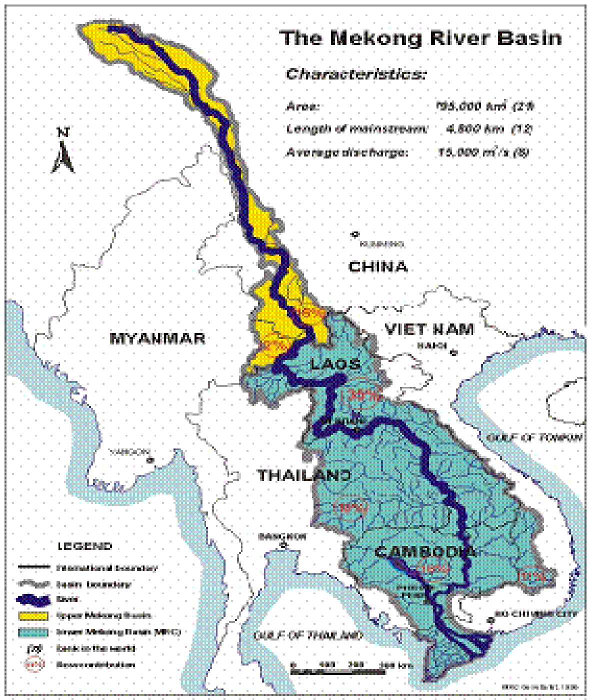

Figure 1. Mekong River Basin

Based on statistical data of high flood years it is seen that about 40,000 to 45,000 m^3/s flowing into the Viet Nam Delta of which about 80% flows is in the mainstream and 20% (~12,000 m^3/s) is overland flow. In recent years floods have been found increasing in the Northern part and at the border of the Viet Nam-Cambodia Delta due to intensification of new canal and inter-provincial road system resulting in much more overland flow.

In view of management and adaptation purposes, from the results of different studies it has been officially reported by Ministry of Natural Resources and Environment of Viet Nam (MONRE) that, due to climate change, for the Mekong Delta, sea level rise can be up to 30cm and 1m by 2050 and 2100, respectively, and rainfall will be increased by 6.3 - 8.3% resulting in more inundation and flooding for both Cambodia and Viet Nam Delta. According to MONRE if 1m of sea level rise is expected by the end of this century an area of 19 to 38% of the Mekong Delta will be flooded and inundated (Figure 2). It has been also reported that due to the system of hydropwer dams which will be built along the main Mekong stream, especially in the upstream part, the discharge at Kratie during the flood season will be decreased but flow during the dry season will be increased.

It is well understood that people living in the Mekong sub-region and especially in the downstream countries such as Cambodia and Viet Nam particularly worried about flooding, but drought threatens even more. Practically, people can prepare and cope with flooding better than drought. The casualties and damages from flooding, but most attention droughts can last longer

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than most devastating consequences and even incapable of self provides food for a country or a region.

It is also noted from China that '... *the Mekong dams will benefit downstream countries, by storing water in the rainy season to reduce flooding and releasing it when needed to increase flow in the dry season...'* but other experts, environmentalists, activists, non-government organizations, and downstream countries in the Lower Mekong Basin are concerned that China's Upper Mekong dams will have not only positive but also negative impacts.

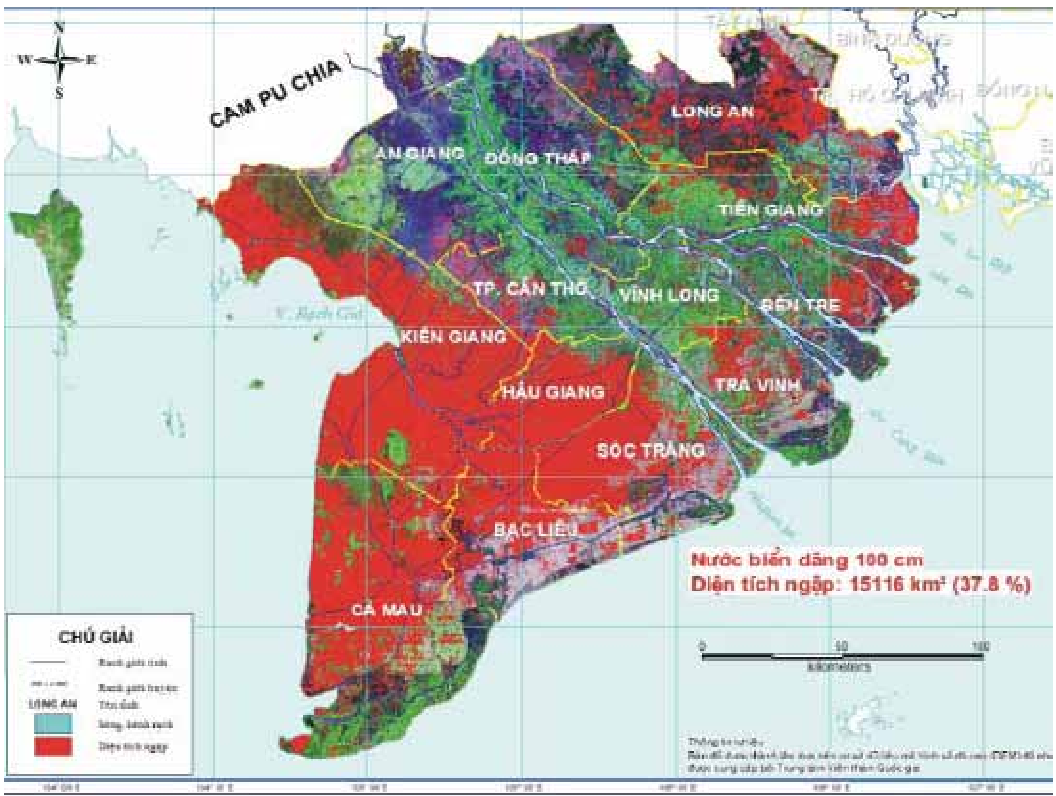

Figure 2. Inundation of the Viet Nam delta if mean sea level rise is 1 m

So those factors occur in the upstream part, at downstream sea boundary and in the Delta itself need to be assessed and checked carefully in order adaptation can be made.

In this paper results are presented of model simulations, checking some scenarios of inflows to Delta at Kratie and mean sea levels rise at the river mouths of the Delta.

MODEL APPLICATION

It is seen that the canal, road and embankment system of the Delta is quite complicated. The complicity is found increasing with the development of infrastructure in recent years causing rapid changes in flow regime. In that context only hydraulic model can be capable to simulate both local and global changes, especially, in case of climate change and mean sea level rise.

Being aware of the important role of hydraulic model in planning activities in the Delta, in recent years, much effort has been invested by the Southern Institute for Water Resources Planning (SIWRP) in development and application of the model in the Delta. The hydraulic

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models named VRSAP (Vietnam River System And Plain) and SAL (Salinity), and recently DELTA - a combined and improved version of VRSAP and SAL, developed at SIWRP, have been widely used by Viet Names engineers for a number of water control projects in the Delta. For those models two main components for flow computation are: flow in rivers and canals with existence of hydraulic structures (dams, gates,..), flow in the flood plains and their linkage to simulate real flood situation. For flow and water quality computation in rivers and canals both the two models are 1D and based on numerical solutions of 1D-Saint-Venant and mass transport equations. For simulation and scenario computation purposes the said models have a long history and have been well understood by Vietnamese engineers.

Since the change of the inflow at Kratie, the increase in water use in the Delta as well as sea level rise will alter water levels and conditions at the river mouths of the Delta, the traditional one-dimensional hydraulic model is no longer always used. So it is necessary to develop a coupling 1D/2D model so as to create boundary conditions for 1D model. By doing so the impact of mean sea level rise and other factors in the Delta itself can be taken into consideration. Such a model has been developed and applied to the Delta. In this model the one-dimensional model for river system is DELTA, while 2D for open sea is the depth-average Saint-Venant model with finite element triangular mesh. The coupling condition is to guarantee mass/volume conservation at river mouths.

Figure 3 is 1D/2D network layout developed for the Mekong delta, of which open sea boundary is over 100 km from the shore. The 1D schematization (Figure 4) consists of 2308 river branches, 6,435 cross-sections, 161 gates, 153 flood plains, 19 coupling points at river mouths where water level and salinity are output of the model. The 2D part consists of 353 triangular elements, 224 nodes and 32 open boundary points This model can be used for simulations of both low and high flow conditions as well as salinity intrusion.

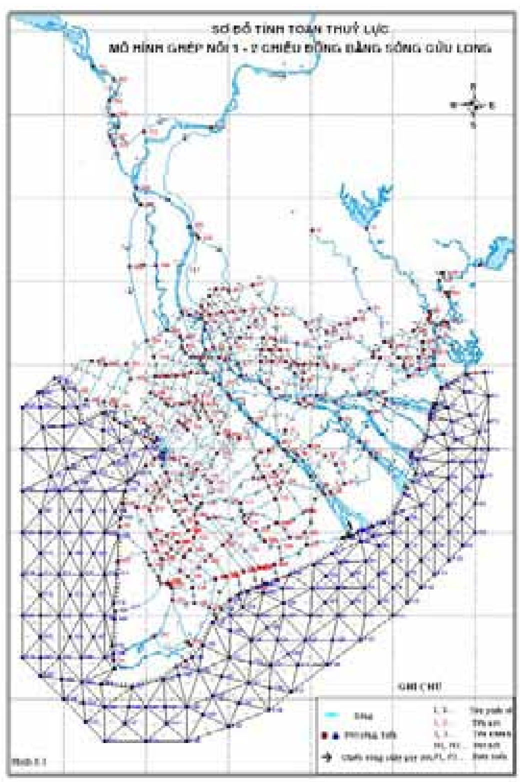

Figure 3. 1D/2D coupling model for the Mekong Delta

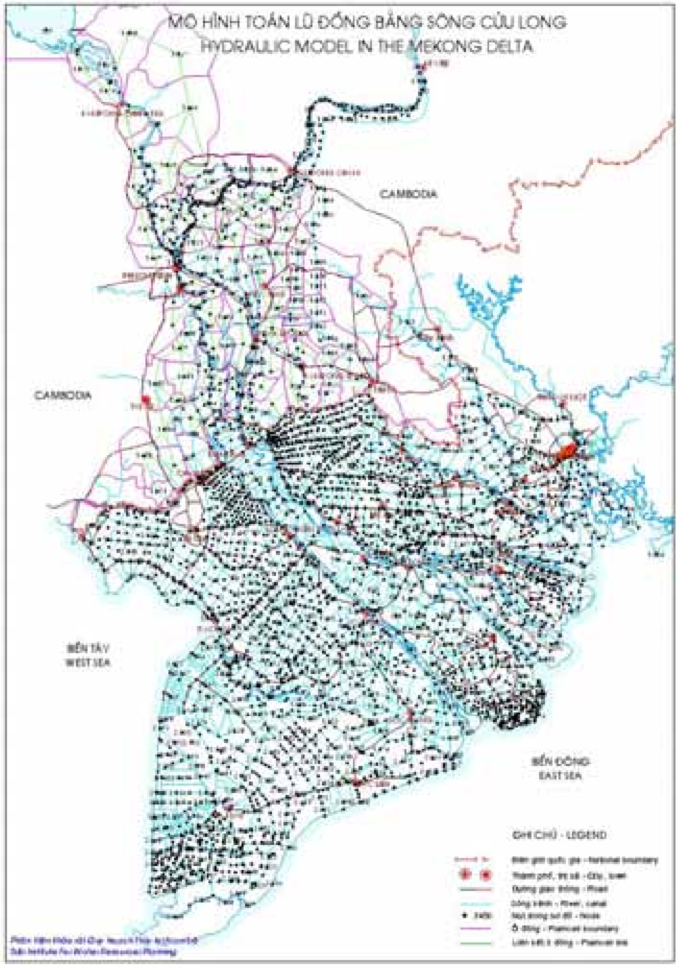

Figure 4. 1D model for the Mekong Delta

Figures 5, 6, 7 and 8 are some calibrations made for 2004 conditions. After adjustment the model has been used to simulate the scenarios corresponding to situations of 2000 and 2050 with mean sea level rises and reduce at 10% and 20% of 2000 flood flow at Kratie.

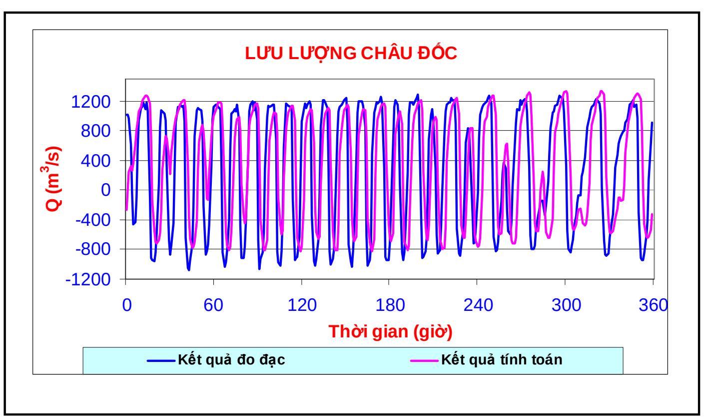

Figure 5. Discharge at Chau Doc (observed and computed)

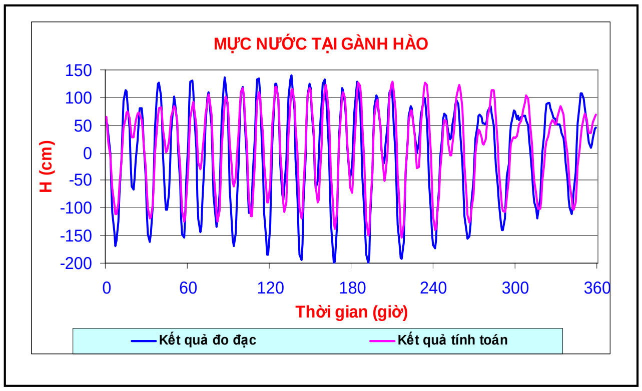

Figure 6. Water level (observed and computed) at Ganh Hao

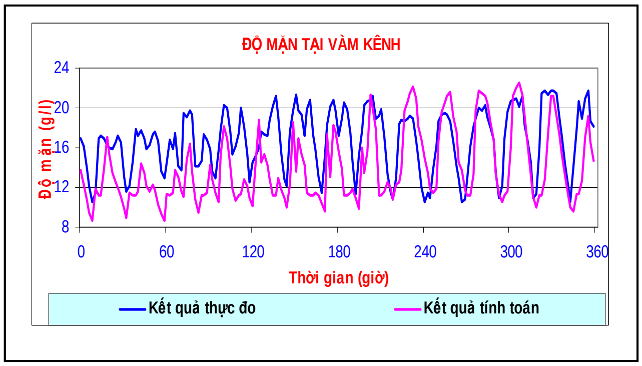

Figure 7. Salinity at Vam Kenh (observed and computed)

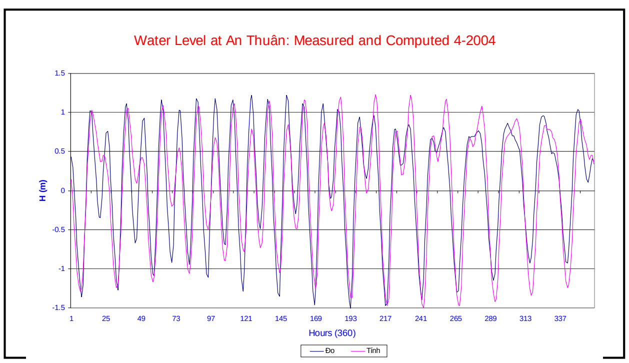

Figure 8. Water level (observed and computed) at An Thuan

COMPUTATION SCENARIOS AND REMARKS

To serve planning purpose a number of scenarios simulations have been made, below are some computations to check impact of inflow and sea level changes:

- *TH1:* flood of 2000 with 10% rainfall. This scenario is used as base case for comparison;
- *TH11:* flood of 2000 with 10% rainfall but discharge at Kratie decreases of 10%;
- *TH2:* TH1 and mean sea level rise of 30 cm;

- *TH3:* mean sea level rise of 30 cm and discharge of 2000 at Kratie decreases 10% (TH2+Q Kratie-10%);
- *TH4:* mean sea level rise of 30 cm and discharge of 2000 at Kratie decreases 20%;
- *LuTH1:* Predictive tide variations of 2050 at river mouths, discharge at Kratie of 2000;
- *LuTH11:* Predictive tide variations of 2050 at river mouths, discharge at Kratie of 2000 but decreases 10%;
- *LuTH4:* Predictive tide variations of 2050 at river mouths, discharge at Kratie of 2000 but decreases 20%.

Table 1. Maximum water level in m corresponding to scenarios along the Tien (Mekong) River

Location / Scenarios	TH1	TH11	TH2	TH3	TH4	LuTH1	LuTH11	LuTH4
K.PongCham	15.04	13.02	15.07	15.11	13.04	13.06	11.81	11.81
UPP-Me kong	10.26	9.16	10.29	10.3	9.23	9.24	8.35	8.34
Niec Luong	9.28	8.01	9.31	9.33	8.11	8.13	7.01	6.98
Tan Chau	5.28	4.69	5.39	5.41	4.75	4.73	4.55	4.51
VamNao MK	4.34	3.81	4.45	4.41	3.9	3.83	3.71	3.62
Cho Moi	3.92	3.48	4.05	4	3.59	3.51	3.43	3.34
My Thuan	2.38	2.2	2.6	2.45	2.43	2.25	2.37	2.19
Cho Lach	1.88	1.81	2.15	1.99	2.09	1.95	2.07	1.92
My Tho	1.68	1.66	1.98	1.82	1.96	1.81	1.94	1.8
Vam Kenh	1.54	1.54	1.84	1.73	1.84	1.73	1.84	1.73

Table 2. Average water level in m corresponding to scenarios along the Tien (Mekong) River

Location / scenarios	TH1	TH11	TH2	TH3	TH4	LuTH1	LuTH11	LuTH4
K.PongCham	6.67	6.24	6.75	6.73	6.32	6.3	5.93	5.9
UPP-Me kong	4.36	4.06	4.49	4.45	4.2	4.16	3.9	3.87
Niec Luong	3.69	3.39	3.84	3.8	3.55	3.51	3.26	3.22
Tan Chau	2.33	2.19	2.51	2.47	2.37	2.33	2.24	2.21
VamNao MK	1.87	1.75	2.07	2.02	1.95	1.91	1.85	1.8
Cho Moi	1.7	1.59	1.9	1.87	1.8	1.77	1.71	1.67
My Thuan	1	0.94	1.24	1.21	1.19	1.16	1.15	1.12
Cho Lach	0.6	0.58	0.87	0.86	0.85	0.84	0.83	0.82
My Tho	0.4	0.39	0.68	0.68	0.67	0.67	0.66	0.66
Vam Kenh	0.08	0.08	0.38	0.38	0.38	0.38	0.38	0.38

Table 3. Minimum water level in m corresponding to scenarios along the Tien (Mekong) River

Location / Scenarios	TH1	TH11	TH2	TH3	TH4	LuTH1	LuTH11	LuTH4
K.PongCham	1.41	1.3	1.54	1.46	1.35	1.45	1.37	1.28
UPP-Me kong	0.74	0.7	0.96	0.92	0.88	0.94	0.91	0.87
Niec Luong	0.55	0.52	0.79	0.75	0.69	0.79	0.77	0.74
Tan Chau	0.21	0.17	0.46	0.42	0.38	0.55	0.53	0.51
VamNao MK	0.03	0	0.29	0.26	0.24	0.42	0.41	0.39
Cho Moi	-0.01	-0.04	0.25	0.22	0.2	0.37	0.36	0.34
My Thuan	-0.31	-0.32	-0.05	-0.06	-0.08	0.06	0.04	0.04
Cho Lach	-0.62	-0.62	-0.35	-0.36	-0.37	-0.37	-0.37	-0.38
My Tho	-0.81	-0.81	-0.56	-0.56	-0.57	-0.61	-0.61	-0.62
Vam Kenh	-2.09	-2.09	-1.79	-1.79	-1.79	-1.86	-1.86	-1.86

From Tables 1, 2 and 3 some following remarks can be made:

- impact of Kratie flow reducing can be seen mainly on the part below Kratie to My Thuan

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station on the Mekong. The Cambodia part is more sensitive to the changes (See scenarios TH1 and TH11 and LuTH1 and LuTH11);

- the area below Tan Chau is dominated by tide variation so impact of mean sea level rise can be seen mainly in the Viet Nam part of the delta from the border. So Viet Nam delta is more sensitive with the rising of mean sea level;
- from figures of the above tables it can be seen that if flooding is less (year by year in recent years) it surely leads to less sediment, fish products and more insect. That is not desire of the farmer living in the delta;
- it is also understood that the upstream dams are mainly for power generation, they try to store water as much as possible from beginning of the rainy season and it depends the way to operate the dams, so that, flow of downstream will be strongly affected in the dry year or dry season.

CONCLUDING REMARK

Above are only some simulation results regarding flood in the Mekong delta in case of climate change leading to mean sea level rise and reducing flow at Kratie due to operation of upstream dams. Impact levels depend on area location of the delta. In general the Cambodian part is sensitive with the change at Kratie, while Vietnamese part is strongly influenced by mean sea level rise.

Climate change leading to mean sea level rise, and changes of rainfall pattern are natural phenomena, we must find the way how to adapt it but the upstream flow changes are caused by human activities. To the delta it causes both positive and negative effects, but it seems that the negative one is dominant and is not desired of the farmers living in the delta. How to cope with that is life of the Mekong countries.

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SESSION 4

SUMMARY OF DAY 1, PLENARY PAPER PRESENTATIONS AND DISCUSSIONS

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Report of Day 1

LAM HUNG SON

[1] *Programme Coordinator, Flood Management and Mitigation Programme (FMMP), Mekong River Commission (MRC), Phnom Penh, Cambodia*

Inaugural session:

- *Mr. Jeremy Bird:*
    - * man induced and climate changes will have their impacts on regime of Mekong River. This will impact the quality of flood forecasts. Closer coordination with Dialogue Partners, especially China, is of importance;
    - * formulation of FMMP follow-up is on-going;

- *Mr. Phonechaleun Nonthaxay on behalf of H.E. Ms. Khempheng Pholsena:*
    - * stressed importance of the Forum Theme for Lao PDR;
    - * need for capacity building;
    - * better understanding of relationship between flood risk and intensification of agriculture;

- *Mr. Martien Beek:*
    - * don't underestimate nature with respect to flood risk;
    - * Netherlands will allocate Euro 500,000 for bridging in 2011;
    - * stressed importance joint donor support;

- *Ms. Sezin Tokar:*
    - * referred to her 5 years flood forum experience and the progress made;
    - * stressed the link between floods and poverty;
    - *

- *Ms. Petra Shill representing GTZ:*
    - * recent and future changes in variations of water levels underline importance of sharing and exchanging state of the art knowledge*;*

- *Mr. Ian Makin:*
    - * stressed importance of gradual transfer from donor funding to National funding;
    - * leadership of MRC Member Countries to identify future core functions of MRC-RFMMC.

After the inaugural addresses Dr. Hatda Pich An presented an overview of AMFF-7. Most of the recommendations have been implemented. Dr. Lam Hung Son provided a summary outline of FMMP, and the Objectives and Expected Outcomes of AMFF-8.

Session 1: Country reports and presentations of Dialogue Partners

- mainstream floods in LMB were normal or below and beneficial floods. So not much to report;
- Typhoons Ketsana and Mirinea caused casualties and damage. In total: 241 death, 5 million affected people, US$ 900 million damage;
- flow in Mekong was impacted by operation of upstream reservoirs in the mainstream and in tributaries, with on-going developments better exchange of information and studies on

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possible changes in the regime of Mekong River will be of importance;

- some signals of climate change were observed although this was debated;
- for the typhoons of 2009 to a certain extent warnings were issued, but quite some improvement in flash flood guidance systems will be required.

Session 2: Achievements and perspectives of the Flood Management and Mitigation Programme (FMMP):

- the mainstream flood forecasting system is fully operational;
- the flash flood guidance system is being introduced and will be gradually fine tuned in such away that countries can use it for issuing their warnings;
- much work was done on the topics *Structural measures and flood proofing* and on *Trans-boundary issues*. Results are well documented and available trough MRCS website;
- *Flood information based land management* has been implemented in three pilot areas in Cambodia, combined with flood probability maps. These are very useful for planning and disaster management, etc.

Session 3: Parallel paper presentations from the Mekong Region on the five topics followed by parallel group discussions

- there were four parallel sessions on the Topics I, II, III and V;
- for each session three papers were submitted;
- results will be separately reported in the final session;
- discussions were lively and to the point.

Paper 4-1

PRACTICAL APPLICATION OF FLOODPLAIN HYDRAULIC MODELLING FOR DISASTER RISK MANAGEMENT IN CENTRAL VIET NAM

IAN WOOD[1] AND BUI DUC THAI[2]

[1]*Natural Disaster Risk Management Project*
[2]*Centre for Management and Mitigation of Natural Disasters, Hanoi, Viet Nam*

ABSTRACT

Vietnam is one of the most disaster prone countries in the world. Its geography and topography make it vulnerable to typhoons, tropical storms, floods, storm surge, landslides and coastal erosion. Annually on average natural disasters result in the loss of over 500 lives and over US$ 330 million in damages. Trends in the damage statistics indicate that while the impact in terms of human lives lost is steady or decreasing, the economic cost is increasing.

This trend is consistent with many rapidly developing nations where improvements in preparedness and disaster response save lives, but continued urban and rural development in disaster prone areas results in greater potential for economic loss. Without improvements in disaster risk management, current trends are likely to continue and will be further exacerbated by the ongoing influences of climate change.

Improved disaster risk management requires sound planning to avoid the potential for future damage while still addressing more immediate needs. Underpinning this is access to relevant and accurate information on existing natural hazards and a thorough understanding of the potential for change.

In this context, the authors examine the issue of flood risk management in the central coastal provinces of Vietnam. This includes a description of the development of floodplain hydraulic models and the integration of the outcomes into flood risk management planning in Quang Ngai Province.

INTRODUCTION

In response to the particularly devastating storm season of 1999 in the central region of Vietnam, the international donor community came together to coordinate development aid programs and formed the Natural Disaster Mitigation Partnership (NDMP). Following this, AusAID (the Australian Government agency responsible for managing Australia's overseas aid program) formulated the A$ 14 million Quang Ngai Natural Disaster Mitigation Project (QN NDMP).

Engineering firm Kellogg Brown & Root Pty Ltd (KBR) was appointed as managing contractor to implement the project over the period from 2003 to 2006.

The project objectives were to save lives and to reduce the economic impact of natural disasters through an integrated program of disaster mitigation infrastructure, community-based disaster risk management and river basin management planning. This third component included detailed hydraulic modelling of the rivers and floodplains of Quang Ngai and the development of an integrated flood risk management plan (IFRMP).

While the coastal floodplains of Quang Ngai Province are fertile and highly productive, they are densely populated and many households are affected by poverty, making them highly vulnerable to the impacts of natural disasters - particularly floods and storms. Changes in land use through development and other long-term factors such as climate change have the potential to further disadvantage these vulnerable communities. The priority for the IFRMP was to address the existing flood risk issue as well as manage land use change to control future flood risk.

The scope of the IFRMP included identifying key flood management issues (based on data from the flood models); describing a program of management measures; and providing planning guidelines for future development in the flood zone. The plan also included a series of GIS-based flood maps for a range of flood frequencies. Capacity development in the provincial flood management agencies was a key priority to ensure long-term sustainability.

Following the establishment of the QN NDMP, major flood modelling tasks were nominated for three central region provinces in the World Bank funded Natural Disaster Risk Management Project (NDRMP). While this paper mainly concerns the Quang Ngai project, the author also draws upon his own experiences in the NDRMP.

BACKGROUND

Quang Ngai Province (Figure 1) is located on the coast in Central Vietnam approximately 140 km south of Da Nang. The province has a population of 1.2 million, of which 80% lives and works in small farming and fishing communities along the relatively flat coastal plain. Quang Ngai town itself has a population of 114,000 and is protected from small floods by a system of levees. In all, a population of over 600,000 (or 50% of the total province) is affected by flooding, and in some particularly vulnerable areas, flood depths are over 3 m for 5 year and 10 year average recurrence interval (ARI) events.

The combined pressures of poverty through low income-earning potential and the annual threat of disaster through flood or storm during the monsoon season have a severe impact on the prosperity and long-term prospects of the region. For example, in the five year period from 1996 to 2000, natural disasters (mainly flooding) resulted in 325 deaths, the flooding of 207,000 houses, including the loss of 5,500 houses and the destruction of, or damage to, 1400 classrooms. Total damage costs for this period exceeded US$ 130 million. Poor families in rural areas are particularly vulnerable to the effects of natural disaster because they have little capacity to absorb impacts such as the loss or damage to their dwellings, the loss of livestock or destruction of their crops.

In the broader context of natural disasters in Vietnam, the central region including Quang Ngai suffers the highest losses of life due to natural disasters as a proportion of population and the highest economic losses as a proportion of the Gross Domestic Product (GDP) (KBR, 2008). The Mekong Delta region suffers the greatest losses in terms of absolute figures because of the large population and high level of economic productivity.

Damage statistics published by the Central Committee for Flood and Storm Control (CCFSC) show that, across Vietnam, natural disasters annually result in the loss of over 500 lives and over US$ 330 million in damages (Central Committee for Flood and Storm Control (CCFSC), 2010). Figures 2 and 3 compare the lives lost and economic damage in Vietnam due to natural disasters between 1997 and 2008. There is a distinct trend indicating that the number of lives lost is steady or decreasing, while the economic cost is increasing.

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A steady or decreasing trend in lives lost suggests that the preparedness and response to natural disasters is improving. That is, communities are better informed and have the capacity to evacuate or shelter from the disaster event. The increasing trend in economic losses is consistent with many rapidly developing nations where continued urban and rural development in disaster-prone areas results in greater potential for economic loss. Without appropriate management this trend will be further exacerbated by the ongoing influences of climate change.

These trends highlight the importance of appropriate disaster risk management planning. New development in disaster-prone areas needs to be designed to withstand natural hazards without creating adverse impacts on existing vulnerable communities. For example, a new major road on a floodplain should be designed for suitable flood free access while at the same time having sufficient cross-drainage so that upstream flood levels are not increased. A comprehensive and reliable flood model is a vital tool for providing input to the design process and for assessing impacts.

MODEL DEVELOPMENT

The project area encompasses four major river systems: Tra Bong River, Tra Khuc River, Ve river and the Thoa/Tra Cau river system. The catchment areas are 700 km2, 3,250 km2, 1,260 km2 and 558 km2 respectively. The rivers mainly run from west to east crossing the flat coastal plain which typically varies in width from 10 km to 16 km. The Tra Bong River is the northernmost river system in the province and is not hydraulically connected to the other systems. The lower floodplain area bifurcates several times into a network of interconnected waterways. The flood-affected low land area is 75 km2. The lower floodplains of the three larger rivers, the Tra Khuc, Ve and Thoa/Tra Cau, combine via a coastal waterway and a complex system of floodplain channels. The combined floodplain area is over 600 km2.

The SOBEK 1D/2D hydraulic modelling system from Deltares was implemented across the river and floodplain systems. The majority of the area was modelled in a rectangular 2-dimensional grid with separate 1-dimensional elements to model specific features such as rail and road culverts. A digital elevation model (DEM) was developed from existing 1:10,000 survey combined with new survey commissioned for key features such as embankments, rivers and estuary areas.

The hydraulic models were calibrated to the available peak flood level information recorded after the major floods of December 1999. Ensuring consistency in the survey information from the various sources was a major challenge during the model development and calibration phases.

The modelling work was highly valued by the province, and after the initial phases of work, the province sought an extension of the activity to include further enhanced training and capacity building. The models, hardware and software are housed in the newly constructed Quang Ngai Centre for the Management and Mitigation of Natural Disasters (CMMND). Training in both hydraulic modelling and GIS was provided to a small number of provincial staff who now maintain the systems.

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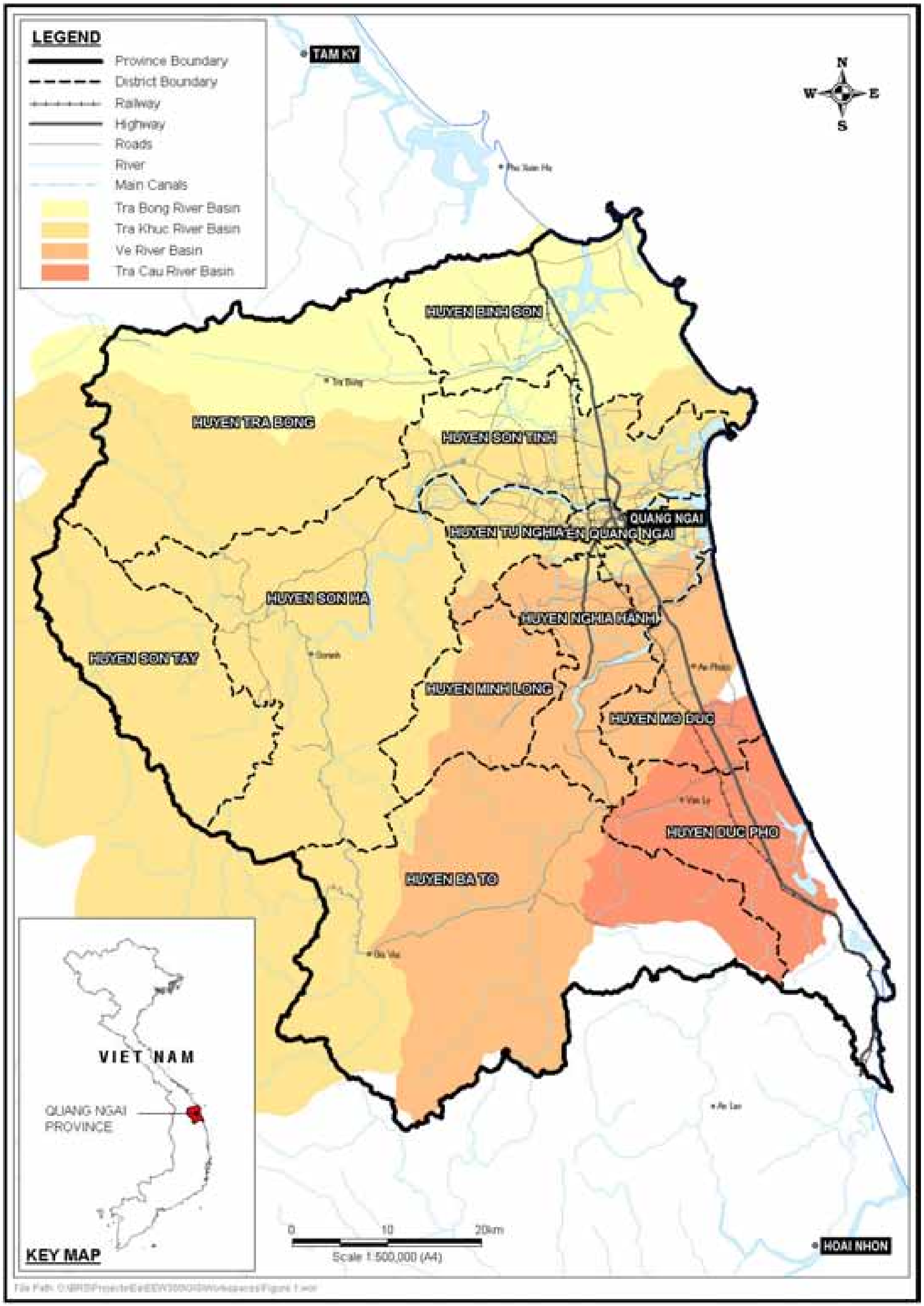

Figure 1. Quang Ngai Province river systems

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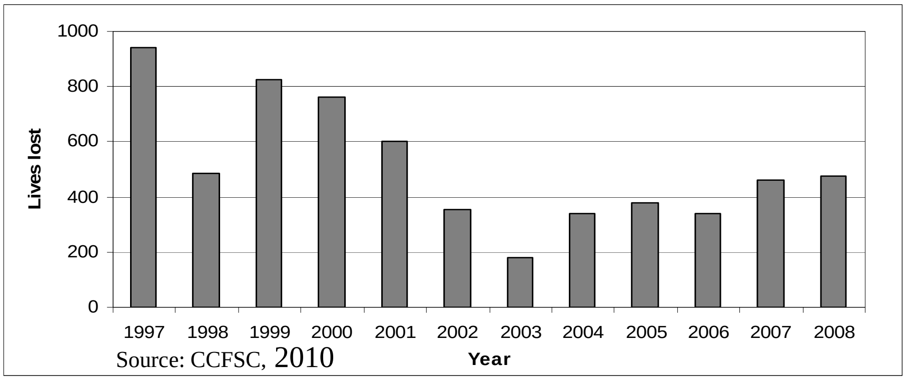

Figure 2. Lives lost from natural disasters in Viet Nam

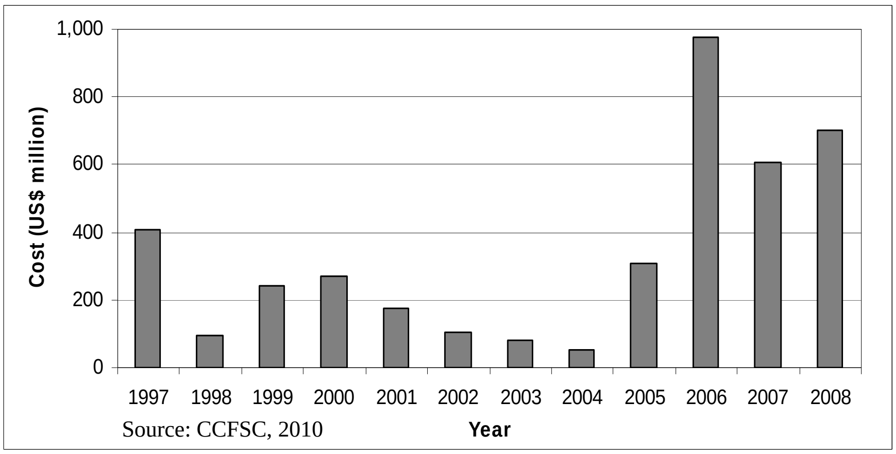

Figure 3. Economic damage from natural disasters in Viet Nam

APPLICATION OF THE MODELLING AND DEVELOPMENT OF THE INTEGRATED FLOOD RISK MANAGEMENT PLAN

An integrated flood risk management plan (IFRMP) was prepared to provide a framework to mitigate or manage existing flood issues and control future development to ensure no excessive adverse impacts. The IFRMP incorporated many of the modelling outcomes.

The hydraulic model was used to simulate the 2, 5, 10, 20, 50 and 100 year ARI design flow events. Maps were prepared in GIS to show flood depth, flood level, flow velocity and the product of depth and velocity. The latter was used to identify the major conveyance routes through the floodplain areas and to highlight problem areas and evacuation routes. Figures 4 and 5 show extracts from the map of flood depths and peak velocities for the Tra Bong River. Figure 6 shows an example from the depth x velocity map.

The flood model results were used to assess the main patterns of flow across the flood prone areas. Maps were developed to identify three separate zones or floodways, referred to as core floodway, flood fringe and supporting floodway (Figure7). Planning provisions define constraints for activities in each zone to ensure that the hydraulic function of the floodplain and river system is maintained. Core floodways are considered major flow routes for floodwaters across the floodplain. Development is restricted to ensure no net loss in conveyance capacity.

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Flood fringe land is defined as the zone at the edge of the core floodway or the supporting floodway areas. Encroachment into flood fringe areas will not cause significant impact.

Supporting floodways are the areas between the flood fringe and the core floodways. They provide significant storage for floodwaters and/or redistribute flow into and out of the core floodway areas. Management of changes in the supporting floodway area is directed to ensure that the cumulative effect over time does not adversely influence the function of the area.

Guidelines were developed to ensure that future development activity does not result in an increase in the population exposed to significant flood hazard. Criteria for high and low hazard categories include consideration of the depth–velocity product, the potential for damage, ease of evacuation and warning time as set out in Table 1. No new development for residential, industrial, or commercial purposes is allowed for which occupants shall be exposed to a high category flood hazard. No new development is allowed which results in an increase in the hazard category from low to high for occupants of adjacent or nearby land.

The IFRMP includes minimum risk standards for new facilities which were developed through a consultation process with a range of provincial government authorities. All new facilities on the floodplain shall be constructed at a floor level that will provide immunity from a flood of at least the specified annual exceedance probability (AEP) as shown in Table 2.

During the latter stages of the project, the opportunity arose to apply the planning principles from the IFRMP. The provincial government was assessing a proposed road and residential development along the northern banks of the Tra Khuc river downstream of the main town area (shown highlighted in Figure 8). The road effect of the embankment and the fill zone were included in the model to assess the impact on flood levels. Areas of increased level are shown in shades of blue in Figure 8 and areas of decreased level are shown in shades of red.

Significantly, the proposed development was shown to increase upstream flood levels in the 10 year ARI event to the point that the dyke protecting the city of Quang Ngai is over topped. The value of the model as a tool to display this effect was highly regarded by the provincial authorities.

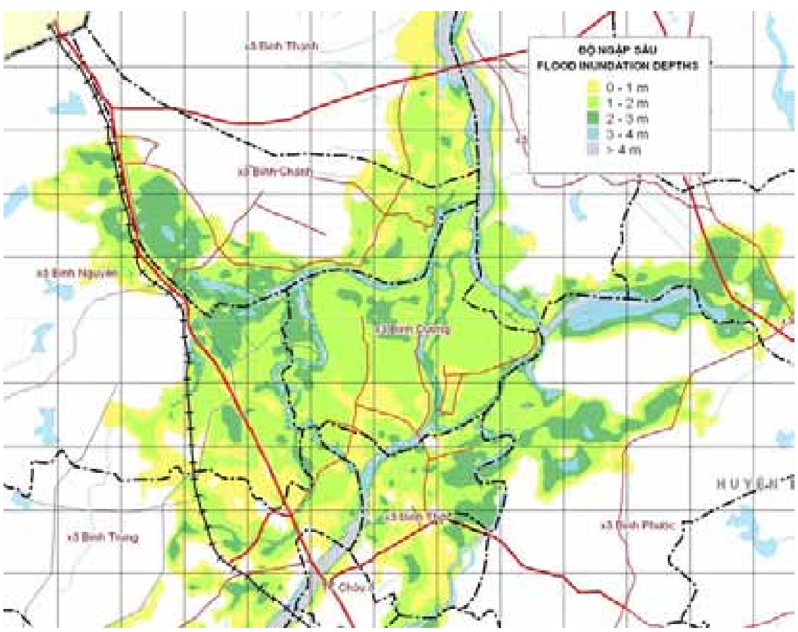

Figure 4. Flood depths in Tra Bong River, 100 year ARI

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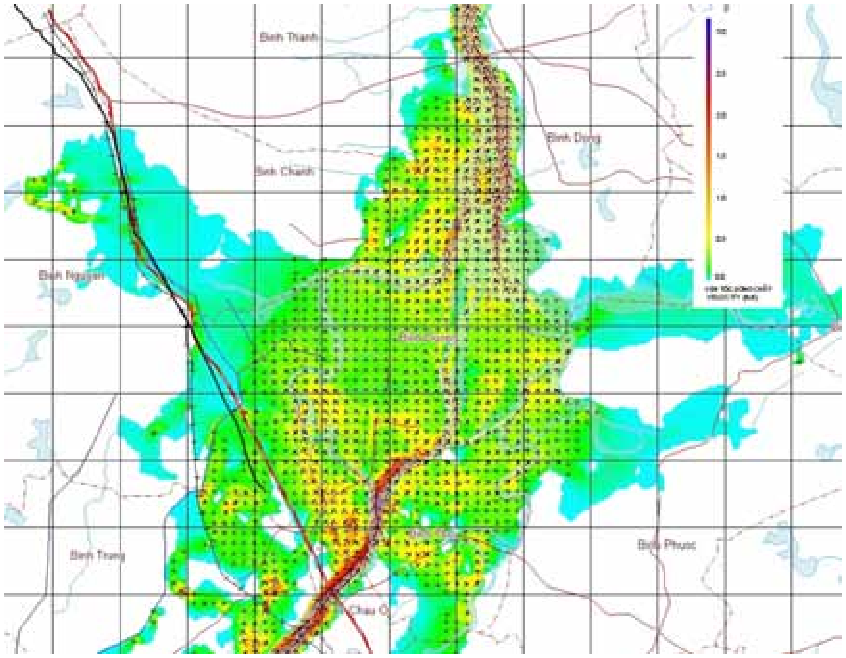

Figure 5. Flood velocity in Tra Bong River, 100 year ARI

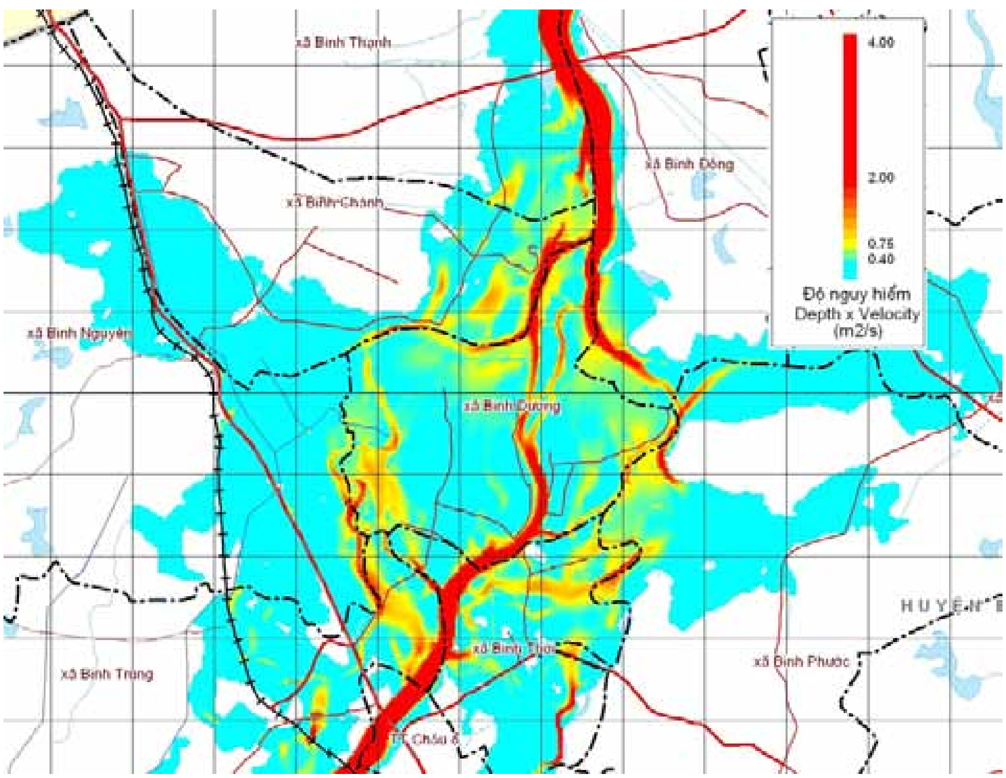

Figure 6. Flood depth x velocity in Tra Bong River, 100 year ARI

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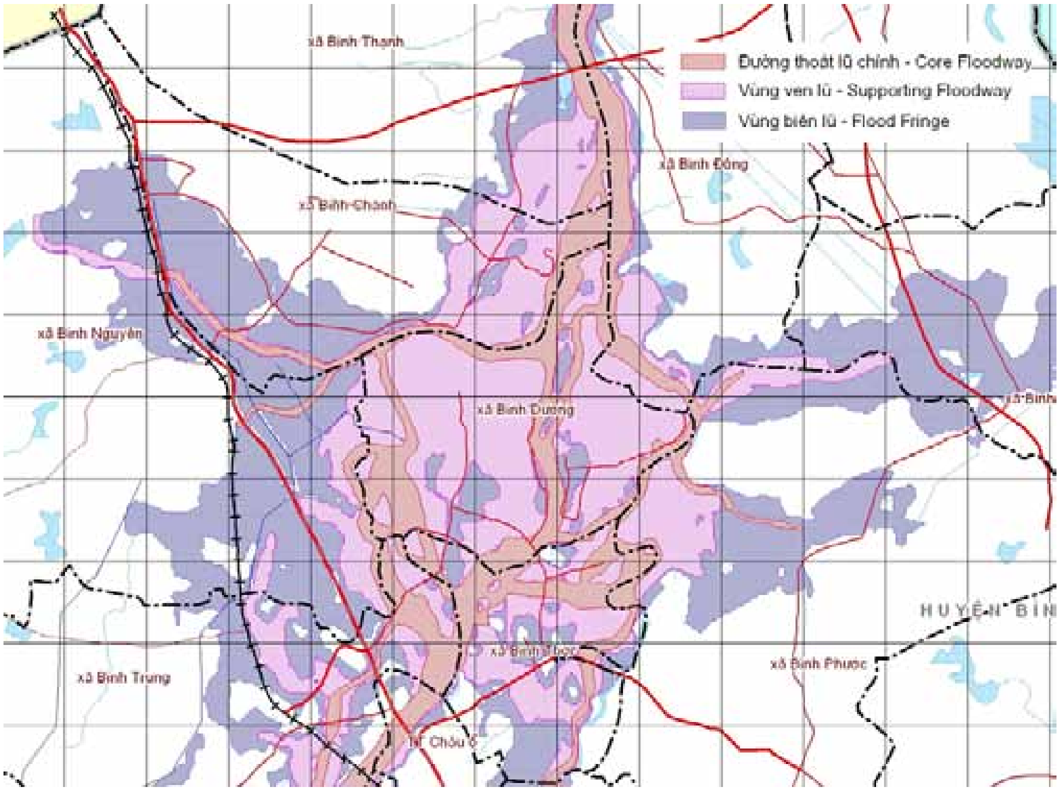

Figure 7. Floodway zones in Tra Bong River

Table 1. Flood hazard categories

Criteria	Low flood hazard	High flood hazard
Hydraulic characteristics	Depth x velocity for the 100 year ARI event is less than 0.75 m^2/s	Depth x velocity for the 100 year ARI event is greater than 0.75 m^2/s
Potential damage	Sufficient number of private and public structures of sound construction[1] to house the at risk population	Insufficient number of private and public structures of sound construction[1] to house the at risk population
Ease of evacuation	Evacuation to high ground for people possible during the rising stages of the flood	Evacuation difficult due to distance to high ground or normal transport routes cut off due to floodwaters (e.g. islands)
Timing	Ample time for flood warning while evacuation routes remain open (more than 5 hours)	Insufficient evacuation time (less than 5 hours)

Note 1 ‘Sound construction’ includes engineered reinforced concrete and brick structures

Table 2. Flood risk standards for new development

Land use	Minimum flood AEP (%)
New provincial highway	10% AEP
Upgrade to national or provincial highway	10% AEP
Residential houses	10% AEP
Commercial properties	5% AEP

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Industrial areas	2% AEP
Hospitals	1% AEP
Public and administrative facilities	10% AEP
Places of refuge	0.5% AEP
Regional telecommunications facilities	1% AEP
Food storage areas	2% AEP

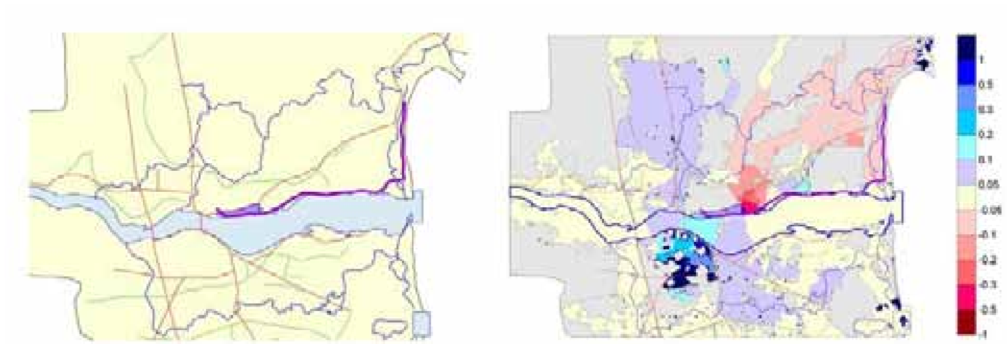

Figure 8. Impact of My Khe Road Proposal on flood levels

CONCLUSIONS AND RECOMMENDATIONS

Trends in Vietnamese damage statistics indicate that, while in recent years the number of human lives lost is steady or decreasing, the economic losses are increasing. This highlights the urgent need for appropriate planning processes and analysis tools to manage the changes occurring in Vietnam due to rapid development. With this intention, an IFRMP was developed for Quang Ngai Province as part of an AusAID funded development aid project. The IFRMP was supported by detailed flood modelling of the coastal river systems.

The work undertaken in the QN NDMP clearly demonstrates the value of hydraulic modelling for flood risk management planning in the Vietnamese context. The concept of flood modelling for application in flood risk management was warmly greeted by the province and the outcomes have been implemented in several real life applications since the conclusion of the project. The project has also demonstrated that, with extensive training and capacity building, it is possible to put into practice a technically complex modelling system in a provincial context.

The lessons learned regarding the value of the planning process and the modelling can be applied through Vietnam. There is a definite need for this capability to address the issues of existing flood risk and future risks due to rapid development.

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Paper 4-2

ENHANCING REGIONAL CAPACITY TO ADDRESS TRANS-BOUNDARY FLOOD ISSUES IN THE LOWER MEKONG RIVER BASIN

WIM DOUVEN[1], NGO LE AN[2], KHAMKENG CHANTHAVONGSA[3], SUPANAT PERMPOONWIWAT[4], NGUYEN DANG TINH[2], HOY SEREIVATHANAK REASEY[5], LÉNA SALAMÉ[6], JUTAMAS THONGCHAROEN[7],VA VUTHY[5], SINXAY VONGPHACHANH[3], PIETER VAN DER ZAAG[1].

[1]*UNESCO-IHE, Delft, The Netherlands*
[2]*Water Resources University (WRU), Hanoi and Ho Chi Minh City, Vietnam*
[3]*National University of Laos (NUoL), Vientiane, Lao PDR*
[4]*King Prajadhipok's Institute (KPI), Bangkok, Thailand*
[5]*Royal University of Phnom Penh (RUPP) Phnom Penh, Cambodia*
[6]*UNESCO-PCCP, Paris, France*
[7]*The Mekong Institute (MI), Khon Kaen, Thailand*

ABSTRACT

Capacity to address trans-boundary issues in river basins is an important condition for successful river basin management. Enhancing and sustaining this capacity, however, is a key challenge for (riparian) countries with high ambitions on implementing integrated water resources management at basin boundaries. This is particularly the case in regions with limited capacity or considerable variations in capacity between regions like in the Lower Mekong River Basin. Component 3 of the Flood Mitigation and Management Programme of the Mekong River Commission (MRC) aims to enhance the cooperation between MRC member countries through building skills and strengthening knowledge and capacities of relevant organisations. A dedicated capacity building programme is being implemented, targeting professionals and decision makers and consisting of training workshops and exposure visits aimed at building the right mix of knowledge and skills to address trans-boundary flood issues. Knowledge areas cover the Mekong system, anticipating and resolving issues, and the role of technical tools. To ensure sustainability a key aspect of the programme is the involvement of regional institutes and universities.

Evaluation of the Phase 1 implementation of the programme (2009 until early 2010) shows that the learning objectives for the participants have largely been met. Selected staff of universities participated in the programme to become *acquainted* with the subjects and teaching methods. Some universities have started incorporating curriculum developed in their own educational programmes. In Phase 2 (2010) the (updated) training programme will be implemented again to a similar audience with more attention to the application in real life cases. The university staff involved will follow an intensive training-of-trainers programme and play a larger role in the delivery of the programme. Moreover, during this phase also ideas and plans for strengthening the emerging regional partnership between knowledge institutions in the Lower Mekong Region will be discussed that could promote in a joint manner university curricula, training, applied research and other key ingredients for the long-term support of the Flood Management and Mitigation Programme (FMMP) and related MRC programmes.

The paper will discuss challenges in capacity building in the Lower Mekong Region. Then, the paper will present the capacity building approach followed in Phase 1, and the outline for the

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second phase including first ideas for the emerging regional university partnership on addressing trans-boundary (flood) issues.

INTRODUCTION

Floods are a yearly recurrent phenomenon in the Mekong basin that bring risks and damage to local livelihoods as demonstrated by the devastating 2000 floods, but also benefits like fertile grounds and fish production. Basin developments are taking place at a fast pace, and impact on these risks, damages and benefits often having trans-boundary implications. The concept of Integrated Flood Risk Management underpinning MRCs Flood Management and Mitigation Programme (FMMP) advocates an approach that takes into account the advantages and disadvantages of flood risk measures for all stakeholders, sectors and regions. This requires cooperation in the Lower Mekong River Basin involving local stakeholders and communities. The MRC provides an effective framework for such cooperation, and the trans-boundary dimension is at the core of its cooperation.

The water users in a river basin are linked through the water flow. These water links or water dependencies are frequently seen as a potential problem, especially when they are not institutionalised. This may lead to sub-optimal river management, as certain interventions in upstream tributaries with positive impacts downstream may not be economically feasible if considered in isolation. As a result differences may emerge between water users in different parts of a river basin. This is especially true in trans-boundary river basins, where water has created links between riparian countries. A solution to this potential problem is that the countries, sectors and water users involved are aware and recognise the upstream-downstream interdependencies that inevitably exist, and find ways of institutionalising them. Institutionalising interdependencies will strengthen the ties between riparian water users and such intensified social and economic cooperation may boost economic development. This manifesto is inspired by the ‘from potential conflict to cooperation potential’ movement (see Box 1). Its success hinges on societies and citizens being well-informed and water-wise. Hence, the importance of capacity building as a touchstone for trans-boundary water management.

Box 1. PCCP - From Potential Conflict to Conflict Prevention.

PCCP is one of UNESCO’s International Hydrological Programme (IHP) contributions to the United Nations’ World Water Assessment Programme (WWAP). PCCP facilitates multi-level and interdisciplinary dialogues in order to foster peace, co-operation and development related to the management of shared water resources. PCCP helps water resources management authorities foster co-operation potential and avoid potential conflict by contributing research studies, educational materials, and conflict resolution courses and trainings. Since its inception in 2001, the project has been guided by UNESCO’s paramount mandate: to nurture the idea of peace in human minds, and has developed tools for the anticipation, prevention and resolution of water conflicts. It has developed training courses jointly with relevant universities and experts in various regions, including Southern Africa, Latin America, the Balkan and currently the Middle East. See the PCCP website: http://www.unesco.org/water/wwap/pccp/index.shtml.

The paper will first discuss capacity development needs in the Lower Mekong region. Then, the paper will present and discuss the capacity development approach followed, also based on the Phase 1 evaluation results. Finally, the outline for the second phase of the capacity building programme will be presented together with first ideas for the emerging regional university partnership on addressing trans-boundary (flood) issues.

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CAPACITY DEVELOPMENT NEEDS AND APPROACHES

Capacity to address trans-boundary issues in river basins is an important condition for successful river basin management. Enhancing and sustaining this capacity, however, is a key challenge for (riparian) countries with high ambitions on implementing integrated water resources management at basin boundaries. This is particularly the case in regions with limited capacity or considerable variations in capacity between riparian countries like in the Lower Mekong River Basin. According to the United Nations Development Programme (UNDP), capacity development is the process by which individuals, organizations, institutions and societies develop abilities (individually and collectively) to perform functions, solve problems and set and achieve objectives (United Nations Development Programme (UNDP), 1997). Within the water sector Capacity Development is defined as the process to provide individuals, organizations, and the other relevant institutions with the capacities that allow them to perform in such a way that the sector as an aggregate can perform optimally, now as well as in the future (Alaerts et al., 1991). In that sense, a nation's capacity can be defined as the combination of three distinct levels: an appropriate policy and legal framework (the enabling environment), effective, flexible and adaptive organizations (institutional capacity), and individual capacities (human resources). The first level is assumed to be covered by the framework of the MRC and related national agencies, and is beyond the scope of the FMMP-C3 capacity development programme. In this paper we will focus on the second and third level. The second level - institutional capacity - less explicitly, but with the intention that targeting individual capacities, especially of high-level decision-makers - on the longer term - might induce changes in the way organisations support integrated river basin management. Box 2 presents the main knowledge areas and related skills to be targeted in the capacity development programme.

Box 2. Main knowledge areas and related skills required.

Water Resources Development and Flood Management in a Trans-boundary Context
This knowledge area focuses on the Mekong system and concepts and approaches of Integrated Water Resources Management (IWRM) and flood management. It also aims developing a shared understanding of key concepts, including upstream-downstream interactions and asymmetries, water allocation, benefits sharing, hydrosolidarity and the payment for environmental services.

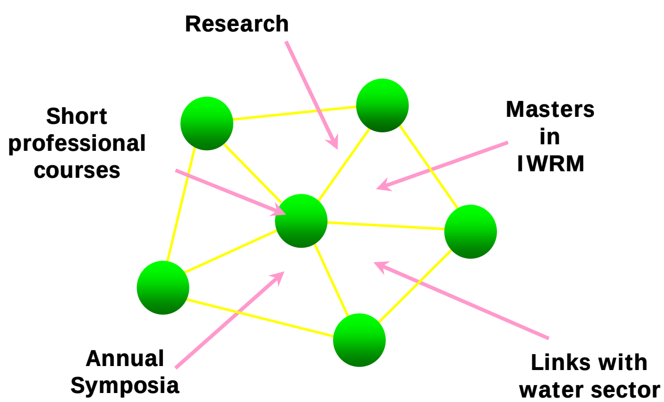
Trans-boundary Water Conflict Management and International Water Governance
This knowledge area addresses the principles of international law and treaties relevant for the Mekong context like the Mekong Agreement of 1995. It also addresses the components of negotiation and the skills and tools that are needed for successful resolution of conflicts. Also an overview of international and regional best practices, instruments and case studies in the field of water conflict management. Skills address how to prepare and handle negotiations also in light of the Mekong agreement

Technical Tools to Address Trans-boundary Issues
This knowledge area deals with technical tools in general and at MRC and the role they may play in the process of anticipating and resolving trans-boundary flood issues in line with the Mekong Agreement. Participants will learn how to use these methods and tools in various phases of anticipation and resolution through lectures, discussions and a series of exercises to develop the necessary skills and to practice them.

To address capacity development needs different approaches are possible, either through resolving immediate needs (e.g. implementation of generic courses, tailor-made courses), or to enhance local capacity (e.g. Joint Curriculum Development, Course Transfer and Adjustments, Staff Development (PhD, MSc), improvement of facilities, research and development, improvement of management systems). Box 3 presents the Waternet model as an example of the second approach.

Box 3. Strengthening capacity in water resources in Southern Africa - WaterNet.

Established in 2000, WaterNet now links some 50 universities and institutions in 14 countries in Southern and Eastern Africa that have a common interest and expertise in water-related issues. Individually they are unable to cover the broad field of water resources management, but by pooling their expertise they can cover all aspects, from hydrology to water and sanitation technologies, from environmental engineering to economics and law. WaterNet is therefore in a position to offer a unique regional Masters programme in Integrated Water Resources Management, in which the staff of six Southern African universities are directly involved, as well as guest lecturers from other WaterNet member institutions. Connecting institutions within a region makes sense not only because they can pool their resources, but also because water has a trans-boundary dimension. Connecting universities regionally means that knowledge capacities can be spread and shared, which will contribute to greater equity and will be more cost effective than doing so at national level. Further, students from different countries sit in the same class and learn the same concepts, enhancing mutual respect and understanding. Moving these students around in the region further exposes them to a regional perspective. All this encourages future cooperation on water, and thus represents an investment in future peace. The WaterNet programme involves 12 months' course work and 6 months thesis research. By 2009 more than 200 students from 15 countries, one third of them women, have graduated.



CAPACITY DEVELOPMENT PROGRAMME TO ADDRESS TRANS-BOUNDARY FLOOD ISSUES IN THE LOWER MEKONG RIVER BASIN (FMMP-C3)

Component 3 of the MRC Flood Mitigation and Management Programme aims to enhance the cooperation between member countries through building skills and strengthening knowledge and capacities of relevant organisations. A dedicated capacity building programme is being implemented, targeting high-level decision makers and professionals. The programme consists of training workshops and exposure visits aimed at building the right mix of knowledge and skills to address trans-boundary flood issues (Box 2). The capacity building programme develops gradually in 3 phases (Table 1) which allows for adjustments based on in-depth evaluation. In the first phase of the programme (2009), the high-level decision makers and mid-level professionals were addressed simultaneously to build capacity at mid-level professionals level and to create an enabling environment by addressing the decision-makers level. In the second phase (2010) only the mid-level professionals will be targeted. Phase 3, scheduled to be

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implemented after November 2011 under FMMP Phase 2, will mainly focus at professionals at the national level.

Targeting the three above-mentioned target groups has implications for the design and structure of the capacity building programme. Three different, but inter-related, training packages blending different training modalities to create a stimulating and challenging learning environment address the specific objectives of each target group (Table 1). The design of the training programme over the nine months period, allows for incremental learning, whereby the participants learn during each training workshop and are given assignments at the end of the first and second workshop which are presented during the subsequent training. This approach is meant to ensure that the knowledge and skills learned take root and are sustained. It also instils self-confidence as well as respect and trust among the participants.

Table 1. Summary of the capacity building programme (MRC-FMMP, 2008).

Modalities	Phase 1 (2009)		Phase 2 (2010)	Phase 3
	Decision-Makers	Professionals	Professionals	National professionals
Training Workshop 1 ‘*Water Resources Development and Flood Management in a Trans-boundary Context*’		V	V	V
Training Workshop 2 ‘*Trans-boundary Water Conflict Management and International Water Governance*’		V	V	V
Seminar during TW2 ‘*Trans-boundary Water Conflict Management*’	V			
Training Workshop 3 ‘*Technical Tools to Address Trans-boundary Issues*’		V	V	V
Group Assignments		V	V	V
European Exchange Study Visit	V			
China Exchange Study Visit		V		
Pilot Studies			V	

A key idea behind the Capacity Development Programme is that the investment under this programme should be sustained and continue to develop beyond the project period. Main approach to ensure such sustainability is through the involvement of suitable national and regional training institutions and universities (Table 2) and building of capacity of Regional Training Specialists working in these institutions. The capacity building activities of Phases 1 and 2 (proposed) are aimed at building a long-term partnership between national and regional Mekong training institutes linked to the MRC and supported by international institutes, like UNESCO-IHE, on the subject of ‘Anticipating and resolving flood issues, differences and disputes in the Lower Mekong River Basin’ which could lead to a shared curriculum and / or programme on the longer term.

Table 2. Mekong knowledge institutes currently involved in the programme.

Country	Knowledge institute
Cambodia	Royal University of Phnom Penh (RUPP), Phnom Penh
Lao PDR	National University of Laos (NUoL), Vientiane
Thailand	King Prajadhipok’s Institute (KPI), Bangkok
Viet Nam	Water Resources University (WRU), Hanoi and Ho Chi Minh City
Region	The Mekong Institute (MI), Khon Kaen

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OUTCOMES AND EXPERIENCES PHASE 1, 2009

Phase 1 of the capacity development programme has resulted in the following outcomes:

- 15 policy- and decision-makers made aware on the subject and internationally exposed;
- 35 mid-level professionals trained on the subject, including 8 university teachers;
- quality assured training material made accessible for use in later phases and regional institutes;
- background material on the Exchange Study Visits.

The learning objectives set for the capacity building programme have been largely achieved. The programme for the high-level decision-makers was highly appreciated (Box 3). The evaluation of the programme for the mid-level professionals was overall very positive (Box 4), although training workshop 3 scored slightly lower compared to the other training modalities. During the evaluations of the programme suggestions have been made for improvement, like:

- examples and case studies: more of them should be included to illustrate the theory;
- the workshops as such should be shorter and more time should be given for the participants to absorb the training material and lectures;
- importance of setting and testing the learning objectives. Not only by evaluating at the end of the programme, but also by monitoring how the participants use what they have learned after the training is over;
- importance of selecting the right participants, and the difficulty to select participants who can follow the whole programme, as only 14 of the 35 participants attended all modalities.

Box 3. Evaluation Exchange Study Visit 'Trans-boundary river basin and flood management in North-Western Europe' for MRC High-Level Decision-Makers (September 2009).

The learning objectives for the participants of the Exchange Study Visit were the following:

- to get acquainted with cases of trans-boundary cooperation in European river systems which are physically different from the Mekong, but offer similar challenges from a management perspective;
- to share experiences by visiting key institutions dealing with trans-boundary river management;
- to get an up-date of modern thinking and methods concerning preventing and resolving of differences.

In your opinion, did the Exchange Study Visit meet the above-mentioned learning objectives?

Yes	14
Partly	0
Not at all	0

Box 4. Evaluation of the Capacity Building Programme for Mid-Level Professionals (Vientiane November 2009) (Response=23)

The FMMP-C3's capacity building programme FMMP 'aims at strengthening the capacity of riparian decision-makers and professionals on anticipating and resolving (trans-boundary) flood issues, differences and disputes in the Lower Mekong River Basin'.
In your opinion, have the training events succeeded in strengthening your capacity to anticipate and resolve (trans-boundary) flood issues, differences and disputes in the Lower Mekong River Basin?

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Yes	14
Partly	7
Not at all	1

Organising the three training workshops at the regional institutes and universities involved was very successful and appreciated by most participants. Also, institutes and universities started incorporating parts of the curriculum developed in their own curriculum. All regional training specialists expressed strong interest in contributing to the training activities of Phase 2, but also indicated the needs for additional training in fields like conflict resolution, Integrated Water Resources Management, Models and impact assessment for flood management and MRC Decision Support System (DSS).

PLANS FOR PHASE 2, 2010, AND FUTURE OUTLOOK

The second phase of implementation will largely be a replication of the materials developed and training conducted during Phase 1 (Table 1). The outcomes of the review/evaluation and the lessons learned will be used to adjust the design of Phase 2 and to make Phase 2 more adequate and effective. Main additional features in Phase 2 are the pilot studies and stronger involvement of national universities and institutes. Both will be further detailed below.

Pilot studies

The objective of the Pilot Studies is to allow participants to apply the knowledge gained and skills acquired during the three training workshops. They will practice how to address and resolve trans-boundary flood issues by applying the Mekong Agreement 1995 process and will be supported by a mix of technical tools available. For this reason it is proposed to combine the Pilot Studies with Training Workshop 3 on technical tools. The development and implementation of the Pilot Studies will be done in close interaction with the MRC and with involvement of the Regional Training Specialists.

Stronger involvement regional universities and institutes

Phase 2 of the programme is focused on further embedding training at national / regional training institutes. The Regional Training Specialists, who participated in Phase 1, will also participate in the training modalities of Phase 2. As planned, the Regional Training Specialists will - to various degrees - contribute to the training modalities. The precise input and preparations needed for their involvement will be discussed at the beginning of Phase 2. Their contributions are mainly expected to take place during Training Workshop 1 and the Group Assignments. To strengthen the training specialist's capacity a Training-of-trainers programme is designed (Table 3).

Table 3. Training-of-trainers programme of the regional training specialists in Phase 2.

Training-of-trainers programme	Description / learning objective	Proposed date
Preparation meeting Phase 2	Planning of lecturing / facilitation activities	Early April 2010
Short courses in various subjects	Knowledge and skills building on specific subjects, plus curriculum development	April - July
Testing Pilot Studies (Training Workshop 3)	Understanding Pilot Studies incl. facilitation	End of August
Preparation training workshops	Preparation / rehearsal of lectures,	1-2 days preceding each

	exercises, role play	Training Workshop
Training Workshop 1, 2 and 3 (including Pilot Studies)	Implementing lecturing / facilitation and evaluation	18-22 May 2010 (TW1) 5-10 July 2010 (TW2) 13-20 October 2010 (TW3)

A future (medium-term) perspective on sustainability and the role of national/regional training institutes and universities, link to MRC and support from international partners, like UNESCO-IHE and its global Partnership of Water, Research and Education (PoWER), has to be developed. Such a partnership could strengthen in a joint manner university curricula, trainings, mutual support and other such key ingredients for the long-term follow-up of this MRC-FMMP programme. At the end of Phase 2, the training institutes and universities involved will jointly develop a future (medium-term) perspective on the use of the curriculum and further partnership development.

CONCLUSIONS

Capacity to address trans-boundary issues in river basins is an important condition for successful river basin management, in particular also the Lower Mekong River Basin with considerable variation in capacity between riparian countries. Component 3 of the Flood Mitigation and Management Programme of the Mekong River Commission (MRC) aims to enhance the cooperation between member countries through building skills and strengthening knowledge and capacities of relevant organisations. To achieve this goal, a dedicated capacity building programme is being implemented, targeting professionals and decision makers. Evaluation of the Phase 1 implementation of the programme (2009 until early 2010) showed that the learning objectives for the participants have been largely met. Evaluation results are used to further improve the programme. In Phase 2 (2010) the (updated) training programme will be implemented again to a similar audience with more attention to the application in real life cases. The university staff involved will follow an intensive training-of-trainers programme and play a larger role in the delivery of the programme. Moreover, during this phase also ideas and plans for strengthening the emerging regional partnership between knowledge institutions in the Lower Mekong Region will be discussed that could promote in a joint manner university curricula, trainings, applied research and other key ingredients for the long-term follow-up of this MRC programme.

ACKNOWLEDGEMENTS

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Paper 4-3

IMPACT OF CLIMATE CHANGE AND SEA WATER LEVEL RISE TO THE INUNDATION CONDITION IN THE MEKONG DELTA

TO QUANG TOAN[1], TANG DUC THANG[1] AND NGUYEN ANH DUC[2]

[1]*Southern Institute of Water Resources Research, Ho Chi Minh City, Viet Nam*
[2]*Viet Nam National Mekong Committee, Hanoi, Viet Nam*

ABSTRACT

The Mekong Delta in Viet Nam has a total area of 3.9 million ha, of which 2.4 million ha is agriculture land. The Mekong Delta is very flat and low, an average of the elevation is about 1 m above the mean sea level. It is considered as the main rice bowl of Viet Nam, it contributes 40% of the national food product and more than 85% of annual exported rice product. The Mekong Delta in Viet Nam is located at most downstream of the Mekong River and it is affected by annual flood and drought. In the situation with climate change and sea water level rise, the floods and drought may become more severe, inundation may happen in the normal condition with the sea water level rise, this will be a threat to sustainable agriculture development of the Mekong Delta and food security of Viet Nam. The possible impact of climate change and sea water level rise to the inundation condition of the Mekong Delta is evaluated and assessed in this study. The coordination for sustainable development of the Mekong River Basin for the next period is taken into account in this study.

INTRODUCTION

The Mekong Delta in Viet Nam is located at most downstream of the Mekong river, it has a total area of about 3.9 million ha, bordered with Cambodia in the North, and bounded by sea in the East and the West. The Mekong Delta is very flat and low, an average of the elevation is about 1 m above the mean sea level, it is affected by tidal variation and seasonal salinity intrusion with an annual affected area by saline water of about 1.7 million ha. It has an affected area by annual flooding of about 1.6 million ha.

The Mekong Delta is considered as the granary of Viet Nam, the total food product was increased from 6.3 million tons in 1985 to 21 million tons in 2008, and it contributes 48% of the national food product and more than 85% of annual exported rice product. Therefore, a strategy to maintain sustainable agriculture development in the Mekong Delta is considered as a top priority for food security of Viet Nam.

However, seasonal flooding is considered as an unavoidable natural factor, due to the low topography, the total flooded area was accounted for only 3% of the total basin area while the Mekong river flood flow is extremely high, with the maximum flow of 65,000 m^3/s(1939). Considering the flood damages, the advantages of the floods and possible negative impacts of the embankment for flood control, until now ‘Adaptive leaving with floods’ is still a popular measure. Only a few areas were fully protected again floods.

The Viet Nam’s National scenarios for sea water level rise (SLR) shown that by the end of this century (2100) the sea water level may rise up to 1m. The floods, tidal inundation and salinity

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intrusion phenomenon in the Mekong Delta may has much change since it has more than 600 km coast long and river mouths open link to the sea. This study was concentrated to evaluate the possible tidal impacts to inundation condition in the Mekong Delta, and the Mekong river riparian countries coordination needs against the climate change and sea water level rise.

DATA, METHODOLOGY AND SIMULATED SCENARIOS

Present flooding and spring tidal intrusion in the Mekong Delta

The Mekong Delta has annual flooding. During the flood season, the high river flood flow, whose maximum values appear by the end of September or early October, causes flooding and inundation of a large area in the Mekong Delta. The total flooded area is 3 to 4 million ha, flood duration was about 2 to 5 months and flood depth ranges from 0.5 m to more than 4 m. Continuous high floods in 2000 to 2002 caused large damages to people and properties.

From 2005 to now, the highest tidal level within about 47 to 50 yearly occurrence occur during the spring tidal period in October to December each year, which causes inundation in a large area in the coastal zones and leads to a lot of damages to agriculture and affect to the life of city's people in Cantho, Tan An and Ho Chi Minh City.

National climate change and sea water level rise

Climate change is considered as the most threat to the life of people in this 21st century. The unusual climate events like typhoons, floods and droughts happen more often in most parts of the world, the temperature is gradually extent increase and cause of sea water level rise.

Viet Nam's National climate change scenarios, in low development scenario (B1), medium development scenario (B2) and high development scenario (A1FI), temperature may increase 30c, rainfall may increase 5% to 10%, and sea water level rise rangers from 65 cm to 100 cm (Table 1).

Table 1. SLR (cm) in National climate change scenarios compared with the period 1980-1999

Scenarios	Periods								
	2020	2030	2040	2050	2060	2070	2080	2090	2100
Low development (B1)	11	17	23	28	35	42	50	57	65
Medium development (B2)	12	17	23	30	37	46	54	64	75
High development (A1FI)	12	17	24	33	44	57	71	86	100

Hydraulic modelling for the Mekong Delta

This study applied the Mike11 model to simulate the impact of the upstream flow and sea water level rise for the inundation phenomenon in the Mekong Delta with special concerns for the coastal zone. The Mike 11 schematization for Mekong Delta is given in Figure 1.

This model application was calibrated, validated and applied in number related studies (To Quang Toan et al, 2009a; 2009c and 2009d). Further details, can be referred to the references.

Summary of Mike 11 application:

- the schematization starts from Kratie, covers the flood prone areas and around the Tonle Sap Great Lake in Cambodia;
- the whole Mekong Delta and a part of Saigon-Dongnai river basin;
- including more than 3,900 rivers, canals and branches with total length of 24,200 km;

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- more than 5,000 hydraulic works represent irrigation sluices, salinity protection sluices, over road floods, roads;
- more than 25,900 water level points and 18,500 water flow calculation points, an average 500 m/point;
- water demands and rainfall;
- inflow boundaries, at Kratie, around Tonle Sap Great Lake, Cambodia area and Saigon-Dongnai River Basin;
- tidal boundaries at river mouths.

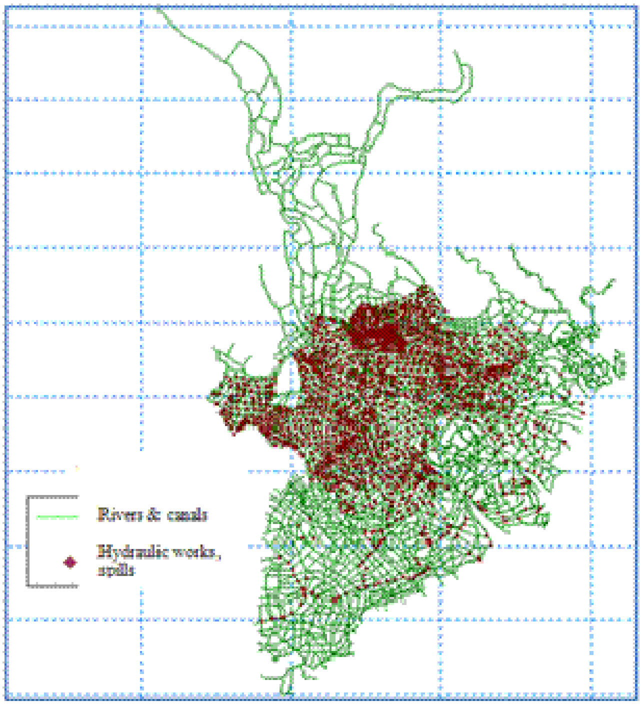

Figure 1. Hydraulic and water quality model application in the Mekong Delta, Mike 11

Simulated scenarios and its boundaries

If the sea level rise is not taken into account , the flooding and inundation condition in the Mekong Delta may already become complicated in the combination conditions of upstream development scenarios, especially for hydropower developments as well as the hydrological changes in climate change scenarios. This study was considered only the inundation changes due to sea water level rise in order to propose an innovative strategy for flood protection as well as in the coordination needs for sustainable development of the Mekong River Basin. Summary of simulated scenarios is given in Table 2.

The simulated conditions in these selected scenarios are:

- Mekong Delta: Development condition in 2005, both agriculture development and hydraulic works;
- hydrological and meteorological and tidal condition in Delta as 2005 (drought year);
- upstream development condition as 2005;
- Kratie boundary as 2005 (drought year);
- simulated period from January to April (dry season);
- most of hydraulic works were operated as of 2005, exception for the South Mang Thit

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Irrigation Scheme;
- in order to evaluate the possible measures to control the water in the Mekong Delta in sea water level rise scenarios, in South Mang Thit irrigation project area, local ring dikes were implemented and salinity intrusion sluices were operated to maintain the water level inside the project area with a target of about 0.5 m.

Table 2. Summary simulated scenario for salinity intrusion

No.	Abbre-viation	Description of scenario	Remark
1	BL05	Basin development condition: 2005 Kratie flows: 2005 Tidal and meteorological condition: 2005	Baseline for comparison
2	SLR50	Basin development condition: 2005 Kratie flows: 2005 Tide 2005+SLR 50 cm, meteorological condition: 2005	Inundation change due to SLR 50 cm
3	SLR1m	Basin development condition: 2005 Kratie flows: 2005 Tide 2005+SLR 100 cm, meteorological condition: 2005	Inundation change due to SLR 100 cm

It was expected that with the proposed conditions in these simulated scenarios as mentioned above, the changes of inundation patterns would be mainly due to the impact of sea water level rise and seem not to be impacted by the upstream flow in these simulated scenarios.

RESULTS AND DISCUSSIONS

The simulated results of inundation changes in simulated scenarios are shown in from Figure 2.1a to Figure 2.3c, in which (a) for inundation depth and (b) for inundation duration above 0.5 m and (c) for inundation duration above 1.0 m.

As can be seen from the figures, inundation in the Mekong Delta due to sea water level rise is a very serious problem, inundation may happen during the dry season in case of SLR. The most affected areas are the coastal zones, areas along the main rivers and the lowland areas in the central part of the Delta. The inundation condition with its depth and duration and the affected area are given in Table 3.

It was find out that 69% of the Mekong Delta can be flooded and inundated by SLR of 1m, in which, the inundated area with depth above 1m is accounted for 41%, more danger than that the affected area with more than 1 m depth and happen in more than 50% of the time accounted for 22%. The inundated area with water above 0.5 m with the occurrence above 50% of time is accounted for 62% of the delta. Therefore, it can be seen that 22% of the delta area may beseverely impacted and other 40% of the delta may be considerably impacted if there are no proper measures taken. A few areas in Cambodia near the border may be affected in this scenario.

In SLR 50 cm scenario, the inundated area above 0.5 m is accounted for 34% of the delta area, in which area with inundation of more than 1 m is accounted for 9% of the delta. The area with inundation depth of more than 1m with the occurrence above 50% of time is accounted for 3% and the area with inundation depth above 0.5 m with the occurrence of more than 50% of time accounted for 17% of the delta. The impact of SLR in this scenario to Cambodia is small, may mainly due to the rise of water level on the main river.

Medium scale of ring dikes and proper operation measures illustrated in the South Mang Thit

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project shows that the tidal high can be prevented by closed sluices and inundation depth can be avoided by operating the sluices during the leap tidal cycles. However, the drainage capacity of sluices in case of heavy rainfall and upstream floods was not yet taken into account.

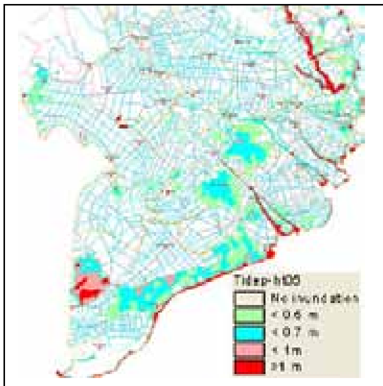	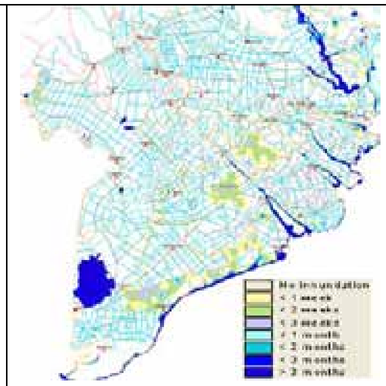	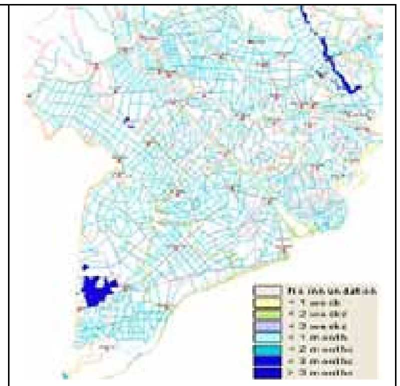
Figure 2.1a. Tidal 2005, inundation depth	*Figure 2.1b. Tidal 05, duration above 0.5 m*	*Figure 2.1c. Tidal 05, duration above 1 m*
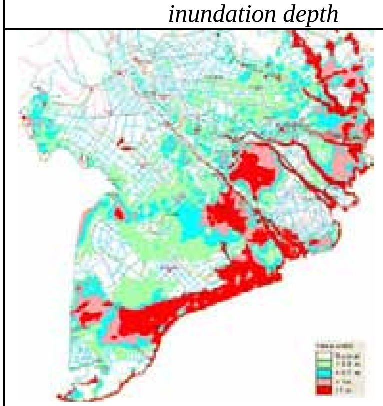	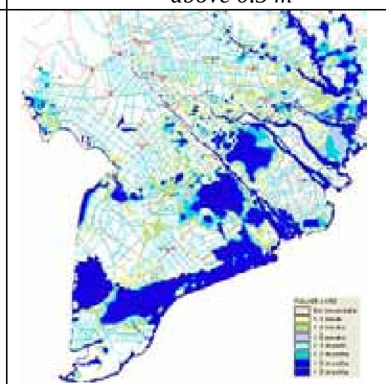	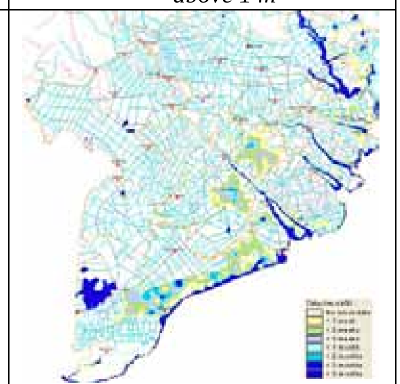
Figure 2.2a. SLR 50 cm, inundation depth	*Figure 2.2b:SLR 50 cm, duration above 0.5 m*	*Figure 2.2c: SLR 50 cm, duration above 1 m*
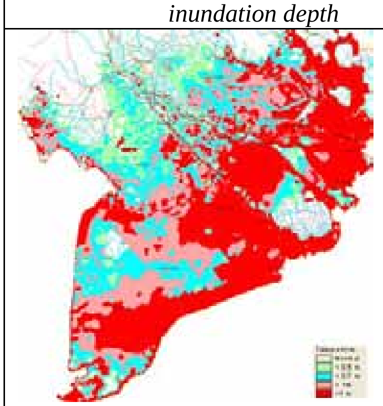	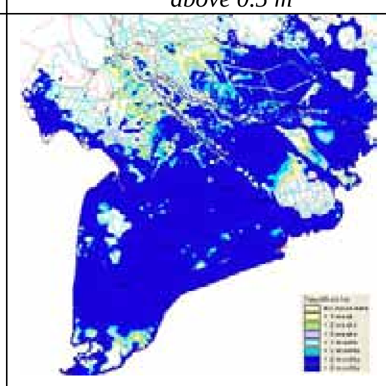	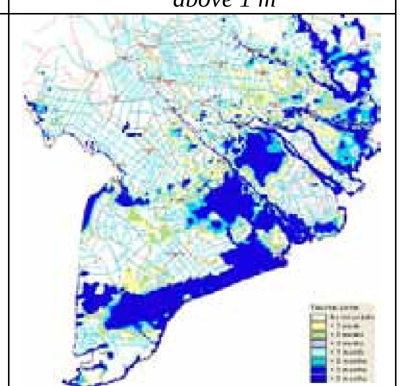
Figure 2.3a. SLR 1 m, inundation depth	*Figure 2.3b. SLR 1 m, duration above 0.5 m*	*Figure 2.3c. SLR 1 m, duration above 1 m*

CONCLUSIONS AND RECOMMENDATIONS

Based on the simulated results on the changes of inundation condition in the Mekong Delta, some conclusions were made:

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- in addition to the annual flooding problem caused by the Mekong river flood, the Mekong Delta of Viet Nam is considered to be severely impacted by high spring tide and sea water level rise. With consideration of sea water level rise only, 69% of the Mekong Delta may be inundated in SLR 1m scenario, in which 22% of the delta may be deeply inundated (> 1 m) and occurs very often with more than 50% of times; 34% of the delta to be inundated in SLR 50 cm scenario and 9% of the delta to be frequent flood of 50% of time and more than 1 m depth;
- inundation area and frequently inundation area may be higher in consideration with additional impacts of the upstream flood flow and heavy rainfall in climate change conditions. This is considered as a high potential threat that may affect to the strategy for Viet Nam's national food security as well as for the sustainable development of the delta. To avoid these impacts, it is required not only the national action plan but also the actions from outside, Mekong River Basin and the world;
- the implementation of medium ring dike systems in combination with the adjustment of the sluices for initiative operation may reduce inundation area in sea water level rise at the coastal zone.

Table 3. Summary of inundation condition with % area in simulated scenarios

No.	Scenario	% inundated area compare with delta area		% inundated period above 1 m		% inundated period above 0.5 m	
		Shallow (< 1 m)	Deep (> 1 m)	< 50% of times	> 50% of times	< 50% of times	> 50% of times
1	SLR 100 cm	28	41	26	22	19	62
2	SLR 50 cm	25	9	14	3	27	17
3	Present 2005	8		2		12	

Remark: *% area was compared with the total area the Mekong Delta of Viet Nam*

Recommendation

Viet Nam is considered to be severely impacted by climate change and sea water level rise, while some of the adaptive measures may beyond the reach of Viet Nam as upstream flood control and dry season flow regulation, therefore it was required to consider some protection measures at the basin level for flood and drought control.

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Paper 4-4

DATA BASED FLOOD FORECASTING FOR THE MEKONG

MUHAMMAD K. SHAHZAD AND ERICH J. PLATE

Universität Karlsruhe (TH) = Karlsruhe Institute of Technology, Karlsruhe, Germany

ABSTRACT

A report is given of recent progress in developing data based forecasts for middle reaches of the Mekong River between Vientiane and Stung Treng or Kratie. Two models were developed, one based on statistics of river discharges only, and one based on a linear system function applied to area averaged rainfall from sub-catchments between river gages. Forecasts with the model based on river flow regression were presented in the 2009 Forum. It was shown that daily water levels could be forecast well for two days in advance, but for larger times the model did not perform so well. It was evident that rainfall data would have to be considered also, and in such a way that rainfall was to be distributed over the time, to allow for retention of flood water during overland flow. A three parameter function was adopted to describe the systems response: one for the runoff coefficient and two for a linear systems response function in form of a gamma distribution (Nash cascade). Runoff coefficients were found to depend on seasons of the year. A well fitting relation was found to exist between cumulative rainfall and cumulative discharge for each reach between gauging stations - an indication of a well structured meteorological pattern due to regularity of the South West Monsoon. The other two parameters describing the gamma distribution were obtained by trial and error optimization, yielding a stretching of rainfall responses over about 15 days with a peak after about 3 to 5 days, so that this approach fits the data fairly well for longer time forecasts. Because of this behaviour, the statistical regression model fits data better for short forecast times. As a consequence, it was found that the average of the two approaches was better for overall fitting of forecasts.

INTRODUCTION

Forecasts for large rivers are traditionally based on fitting existing models to the data base of measured discharges and/or stages at different gages. Consequently, forecast quality is first of all a function of the model used. The earliest type of models used were based on regressions only of discharges from upstream gages regressed on time delayed downstream discharges (Model Type 1). More sophisticated models use rainfall - runoff components and routing models for stream flow routing (Model Type 2). The simplest form of a Type 2 model is a conceptual model of unit hydrograph type, modelled by means of a linear system. More complex Type 2 models are physical models, which use physical process equations to describe each component of the rainfall runoff process. There is a plethora of such models available (see for example Woolhiser et al., 2000), all of which are fundamentally structured in the same way: input is effective rainfall, with important differences among different models due to the method of determining the runoff coefficient. The effective rainfall is converted into runoff through surface processes. Runoff from effective rainfall is usually based on either a pixel oriented grid structure or a decomposition of the basin into sub-basins, which are connected through a network of channels (Plate, 2009).

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The writers´ preference is to approach forecasting not from use of any existing model, but to develop a forecast model from the data base, where it is less important that models are physically complete, than that forecasts are as accurate as possible. Because perfect forecasts are not possible in view of uncertainty of the many factors contributing to the discharge formation process an error band must be expected, and quality of the forecast must be based on two factors: on mean value of the forecast, which should be as bias-free as possible, and on spread of error bands, which should be as narrow as possible. In contrast to physical models based on analytical descriptions of all discharge forming processes, which have to consider uncertainties in all parameters of individual processes, a data based model lumps all errors into one probability distribution (pdf) for the forecast, whose standard deviation is to be minimized regardless of physical meaning of forecast model used.

In this paper, two different data based models are described and applied. For a large river with many gages discharges at upstream reaches of the river as measured at upstream gages is an invaluable source of information which must be mobilized for forecasts. In a simple manner, this is done by regression models, and the first approach to be used is a Type 1 model, i.e. a regression model using only river stages, or river discharges. Considering the inertia of a large river, this procedure should be entirely adequate for forecast over a short time, of order of 1 day. Consequently, regression was used as a first approximation. For longer forecast times it is necessary to use additional information from tributary areas, including local rainfall inputs. Therefore, a simple Type 2 model was used to convert rainfall into runoff. Details of these models are described in the following sections, followed by applications to the Mekong River, for which it was found that best forecasts are obtained by taking averages of Type 1 and Type 2 model outputs.

THEORETICAL CONSIDERATIONS

Continuity and general definitions

The structure of forecast models for large rivers is determined by combination of flows in the main river channel which are measured at stream gages, and lateral inflows from sub-catchments between gages which have to be inferred from local information: tributary discharges and runoff from sub-basins. Consequently, a model for this situation has to have these components: an initial input of discharges from upstream stations, and an estimate for lateral inflows between stations. This is shown in Figure 1, where the geometric notation used in this paper is introduced. The point at which a forecast is to be made has index 0, and stations upstream are identified by index j, where j goes from 0 to m. Consequently, the station directly upstream of station 0 is station 1. Stations are supposed to be located in flow time 1 day apart, i.e. Δt = 1 day: it takes one day for discharges at point 1 to reach point 0. In particular, the station with index m is located exactly m time intervals upstream of station zero, where m is the number of intervals in the forecast time.

Let index i denote time, as referred to station 0. That is, real time at time of forecast has index i, which implies that at time t = i days a forecast $Q_0(i+m)$ is to be made for m days ahead. In this situation it is evident that discharges at station j= m and all stations further upstream of station m are know exactly (within the error of measurement).

To describe the forecast situation, Figure 1 is redrawn for the forecast mode as in Figure 2.In this figure:

$$DQ_j(i) = QI_{j,j-1}(i, i+1) - QO_{j,j-1}(i, i+1) \qquad (1)$$

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is the net lateral inflow between stations j and j-1 in any time interval i,i+1. It is generated by rainfall on the sub-basin, and inflows from tributaries. With this notation, the continuity equation applied to the stretch between gage 0 (the gage for which discharges are to be forecast) and station m upstream yields:

$$Q_0(i+m) = Q_m(i) + \sum_{j=1}^{m} DQ_j(i+m-j) + \varepsilon_0(i+m) \tag{2}$$

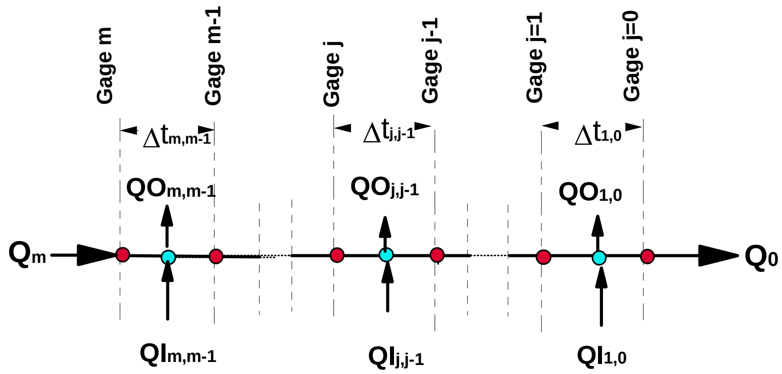

Figure 1. Notation definitions.

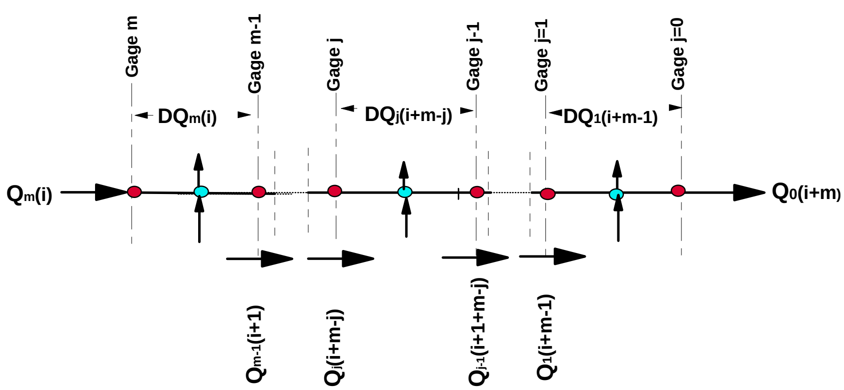

Figure 2. Figure 1 redrawn to reflect forecast conditions

This equation expresses the condition of continuity and is generally valid, independently of whether forecasts are considered or not. Q_m is the discharge at point m, and ε_0 is the error due to measurement uncertainties. For applications, Eq.2 has to be considered in analysis mode and in forecast mode. In the analysis mode, Eq.2 is used to set up the forecast model, and in the forecast mode it is used to make actual forecasts.

Analysis mode

Quantities in Eq. 1 cannot be measured directly. In the analysis mode they are determined by taking the difference:

$$DQ_j(i) = Q_{j-1}(i+1) - Q_j(i) \tag{3}$$

which yields a family of time functions $DQ_j(i)$ for each station j. As a first step in the data analysis, this series of time functions has to be checked for consistency, by observing differences between three adjacent stations – consistency implies that when there is no overflow of the river banks then there cannot be a lower flow at the downstream gage than at the upstream one. Other features, such as finding errors yielding strange outliers and other irregularities can be spotted and corrected in parallel inspectional analysis of these time functions. This inspectional analysis is a time consuming but important and integral part of data analysis, in particular in the Mekong area, where war and civil unrest has substantially interfered with correct data collection and determination of rating curves.

Forecast mode

In the forecast mode Eq.2 is written:

$$QF_0(i+m) = Q_m(i) + \sum_{j=1}^{m} DQF_j(i+m-j) + \varepsilon_{F0}(i+m) \qquad (4)$$

where index F denotes forecasts, whereas quantities without this index - i.e. $Q_m(i)$ - are real time observed values. Error terms ε_0 and ε_{F0} are stochastically independent random variables. For example, for m = 1 and 2 one obtains:

$$QF_0(i+1) = Q_1(i) + DQF_1(i) + \varepsilon_{F0}(i+1)$$

$$QF_0(i+2) = Q_2(i) + DQF_2(i) + DQF_1(i+1) + \varepsilon_{F0}(i+2) \text{ etc.}$$

Terms DQF in Eq. 3 have to be determined ahead of time. It is assumed that $DQF_j(i) =$ function of known quantities + error term. This is written for the terms of Eq. 3:

$$DQF_j(i+m-j) = DQ1_j(i+m-j) + DQ2_j(i+m-j) \qquad (5)$$

where DQ1 is a deterministic part exactly known at time i, and DQ2 is the unknown part that has to be forecasted. $DQF_j(i)$

Modelling

Up to this point, the analysis was quite general, and all forecast models can be fitted to this scheme. When physically based models are used, functional dependencies are structured from flood routing and rainfall - runoff models, and from the data base only parameters of the model are determined. For a data based model, differences are directly correlated with other data, with only conceptual intermediate model structures[9]. Two different approaches are used: a method based on unit hydrograph, or linear systems theory, and a regression model.

[9] Here the hydrological distinction is made between physical models and conceptual models. Physical models describe the physical processes of the hydrological cycle as closely as possible. In contrast, conceptual models are simple empirical models, such as the unit hydrograph model to fit the rainfall - runoff process.

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Unit hydrograph model: analysis mode

It is assumed that $DQ_{M+1}(i)$ is only due to tinput from rainfall and tributaries. Then this quantity can be calculated by means of a simple unit hydrograph analysis, with the main parameter being a seasonal and location specific runoff coefficient. A unit hydrograph u(t) in form of a gamma distribution (Nash Cascade) is used:

$$u(t, n) = \frac{k}{\Gamma(n)} \cdot (k \cdot t)^{n-1} \cdot e^{-kt} \qquad (6)$$

k and n are parameters to be obtained from calibration, $\Gamma(n)$ is the gamma function of n, and t = $i\Delta t$. In context of Eq.5 it yields the contribution due to rainfall on sub-basin j with area A_{0j}:

$$DQ_j(i) = KN_j(s) \cdot A_{0j} \sum_{\omega=1}^{i} PF_j(\omega) \cdot u_j(i - \omega) \qquad (7)$$

In this equation, ω is the time coordinate for rainfall, $P_j(\omega)$ is rainfall during time interval $\omega + \Delta t$, and KN is a coefficient which basically is the runoff coefficient, but which also yields an empirical compensation for non-uniformity of rainfall distribution on sub-basin j.

In the analysis mode, Eq. 7 is used on known input - output results from the situation to be studied. This analysis yields coefficients n and k of the gamma distribution, and coefficient KN. They were determined by means of area averaged daily rainfall data, obtained by simply adding daily data from a selected set of rainfall stations for each catchment. The unit hydrograph is determined by means of standard methods of unit hydrograph analysis, using the assumption of a gamma distribution as unit hydrograph. Discharge differences for each reach are used as runoff, with daily values of area averaged rainfall as input.

Of major importance is coefficient KN. For each month, an average is found by simply closing the mass balance between area-averaged rainfall and runoff, i.e. through relation:

$$\sum_{i} Q_j(i) = \varphi \cdot KN_j(s) \cdot A_{0j} \cdot \sum_{i} P_j(i) \qquad (8)$$

where φ is a unit-conversion factor and $KN_j(s)$ is the adjustment factor for reach j and month s. KN depends on season and reach, and parameters n and k for each reach depend on the hydrological basin characteristics and must be analyzed for each application separately.

Unit hydrograph model: forecast mode

Application of unit hydrograph models for forecasting is schematically shown in Figure 3. For implementation of this schematic presentation, Eq.7 has to be combined with Eq. 4. Because part of the rainfall of today will be runoff in the future, the forecast DQF has two components DQ1 and DQ2:

$$DQ1_j(i + m - j) = KN_j(s) \cdot A_{0j} \cdot \sum_{\omega=0}^{i} P_j(\omega) \cdot u_j(i - \omega) \qquad (9)$$

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All quantities for DQ1 for the forecast are known at time t and can be calculated exactly. DQ2 is not known and has to be forecasted to read:

$$DQ2_j(i+m-j) = KN_j(s)\cdot A_{0j}\sum_{\omega=i}^{i+m-j} PF_j(\omega)\cdot u_j(i-\omega) \qquad (10)$$

What makes Eq.10 unknown is that no future rainfall is known. In the absence of a weather forecast model which generates accurate forecasts five days ahead one has to make assumptions. This can be done in a number of ways. For example, the lowest runoff comes if no rainfall occurs after time i. For flood forecasts, this assumption would lead to unsafe forecasts. A reasonable forecast is to use a constant rainfall PF, for example (as is used here) averages of rainfall over the last five days. Other ways, such as using long term weather forecasts have been used and should be used in the future. For example, in the Mekong region rainfall fields form due to an interaction of monsoon rains and typhoon downpours.

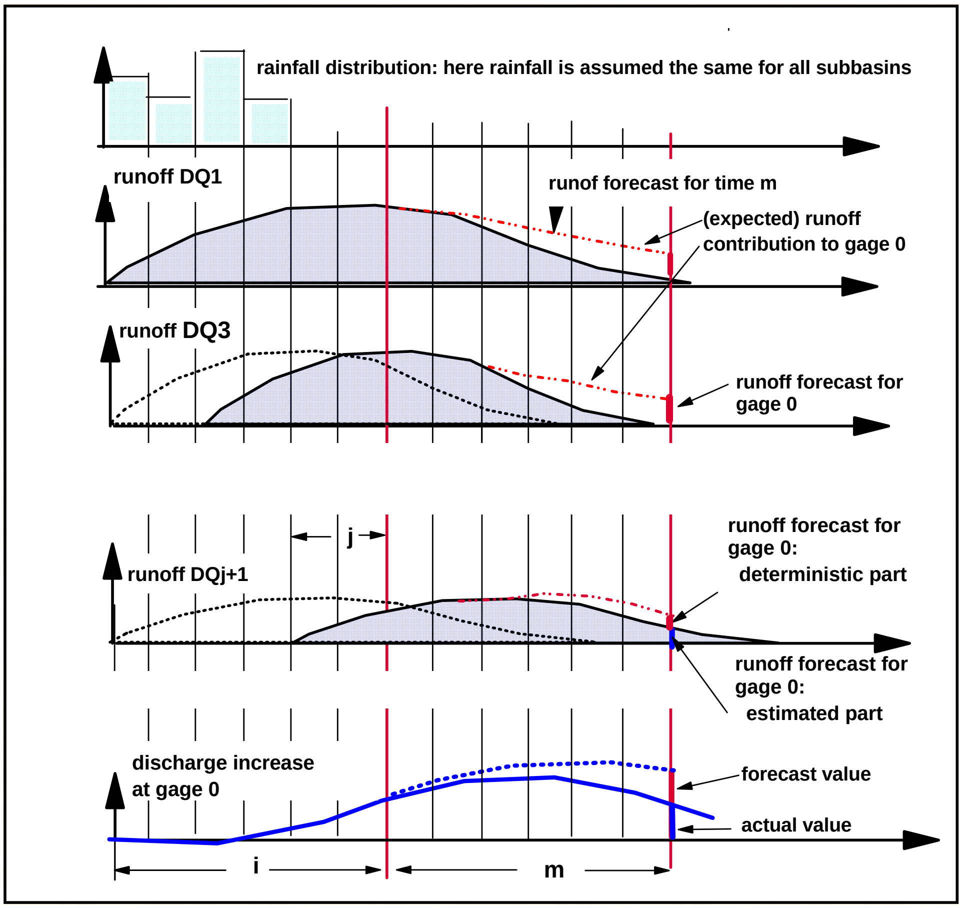

Figure 3. Unit hydrograph approach to forecasting: schematic presentation

Regression model

The regression model and its results has been described in detail in paper (Shahzad et al., 2009). to the 7th Annual Mekong Flood Forum. For this model, the first term of Eq.4 is zero, and the

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second one was assumed to read:

$$DQ2_j(i+m-j) = \rho_j(i+m-j) + \sigma_j(i+m-j) \cdot DQ_j(i) + \varepsilon_j(i+m-j) \qquad (11)$$

In the analysis mode, the empirical coefficients ρ and σ are found by least squares optimization, i.e. minimizing the standard deviation of ε_j. These coefficients then are used as known input into the forecasting model.

APPLICATION

Both models are applied to middle reaches of the Mekong River, from Vientiane to Stung Treng. Details of the river system have been described elsewhere, for example by Plate and Insigsiengmay (2005). Results from the regression model were presented previously in Shahzad et al. (2009). Here application of unit hydrograph models is discussed.

Application of unit hydrograph model

Unit hydrograph determination requires to find three parameters, adjustment factor KN, and two parameters k and n of the Nash cascade. For a data based approach, these have to be determined directly from data, as was described above.

For calibration one needs rainfall data $P_j(i)$ on sub-catchment A_{0j} and discharge increases $DQ_j(i)$ for reaches between adjacent stages. The basic idea was to use rainfall data from all stations with reliable records as input, and to put all systematic errors into adjustment factor KN, which thus also compensates for distribution of rainfall in sub-basins. For each sub-basin area averaged daily rainfall $P_j(i)$ was calculated from rainfalls recorded for all stations in the area. For four reaches VN = Vientiane - Nakhon Phanom, NM = Nakhon Phanom - Mukdahan; MP = Mukdana - Pakse, PS = Pakse - Stung Treng the rainfall measurement stations are listed in Table 1.

Table 1. Rainfall stations used in analysis

Reach VN	Reach NM	Reach MP	Reach PS
Ban Nape	Mukdahan	Mukdahan	Pakse
Muong May	Thakek	Savannakhet	Mounlapamok
Muong Kao	Signo	Seno	Soukhouma
Thabok	Naknon Phanom	Ban Kengkok	Muang Champasack
Paksane		Muong Tchepon	Attopeu
Nakhon Phanom		Thakek	Nonghine
Vientiane		Signo	Sekong
		Khongsedone	Stung Treng
		Saravan	Pakse

Typical empirically calculated adjustment factors KN calculated from Eq.8 for four reaches are shown in Figures 4a and b as functions of the month. As is seen in Figures4a and b. there is a significant trend, with very small coefficients at the season´s beginning. Further into the season, KN increases with progress in time until reaching a maximum at the end of the season. Because adjustment factor KN basically is a runoff coefficient (with a theoretical maximum of 1), it can be suspected that the trend reflects the special seasonal conditions of the Mekong region: at beginning of the season before advent of the monsoon, the soil is dried out. It is saturated gradually: further into the season KN increases and reaches a maximum at end of season. Note that the large increases at the end of the season, which are observed for some of the years, are

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due to the fact that low discharges are divided by small numbers of rainfall. Apart from these anomalies, the average trend is clearly significant. One can further infer from these figures that if in a particular month of the year and in a particular year a large value of KN occurs, then KN of the following month also falls above the average curve.

This suggests modelling the seasonal dependency of KN by a linear regression model:

$$KN_l(s) = \alpha_l(s) + \beta_l(s) KN_l(s-1) + \varepsilon_{cl}(s) \quad (12)$$

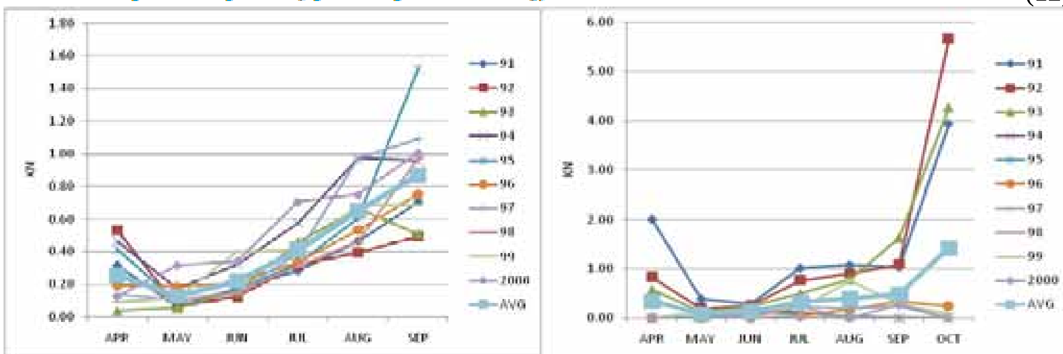

Figure 4a. Typical adjustment factors for VN (left) and NM (right) for the years 1991 to 2000

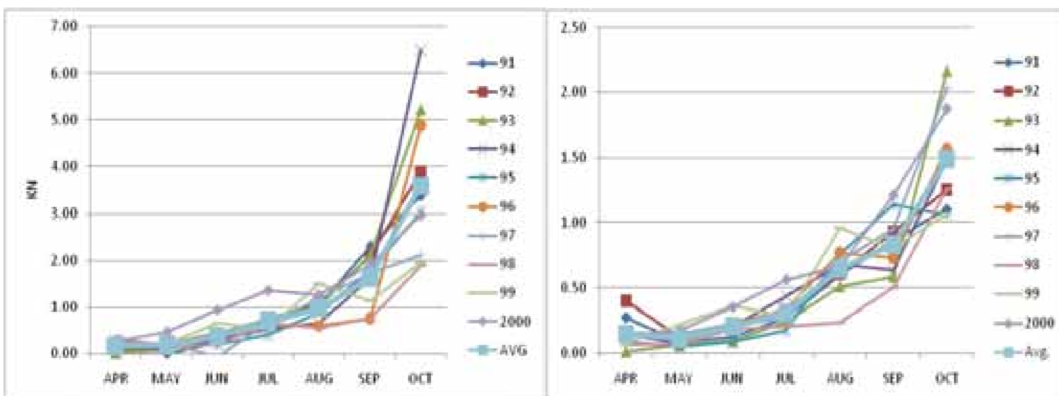

Figure 4b. Typical adjustment factors for MP (left) and PS (right) for the years 1991 to 2000

where coefficients α and β are empirical constants depending on month and area $A_{k,}$, and s denotes the month of the year. Term ε_C is an error term. This approach has the advantage, that non-linearity of the dependency of KN on season is covered by means of a piecewise linear relationship. Error term $\varepsilon_{cl}(s)$ was further regressed on other factors, and some improvements were found, whose effect is reflected in the final results. Coefficients n and k of the unit hydrographs were obtained from data of effective rainfall = $KN_l(s) \cdot P_{lk}(i)$ and discharges $DQ_l(i)$ with results shown in Table 2 for different reaches. These coefficients indicate unit hydrographs with fairly long recession branches, so that contributions due to rainfall arrive only after some time at stations on the river.

Table 2: n and k values for different reaches

Reach	n	k
VN	1.2	7.1
NM	2.4	1.6
MP	2.1	2.3
PS	2.4	3.2

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Since the regression model had been shown to give good results for short lead times (m = 1 or 2), it is suggested to use a combination of both methods for forecast, which gives regression a strong effect at short lead times, and rainfall effects a strong persistence effect for longer forecasts. Trial and error analyses have shown that a better forecast than by using either unit hydrograph or regression model is obtained by taking the average of Eq. 9 and Eq. 12. As is shown for the example of station Stung Treng in Figure 5, good results were obtained by giving equal weight to each of the two methods, although it may be useful to adjust the weights, as shall be tried in future.

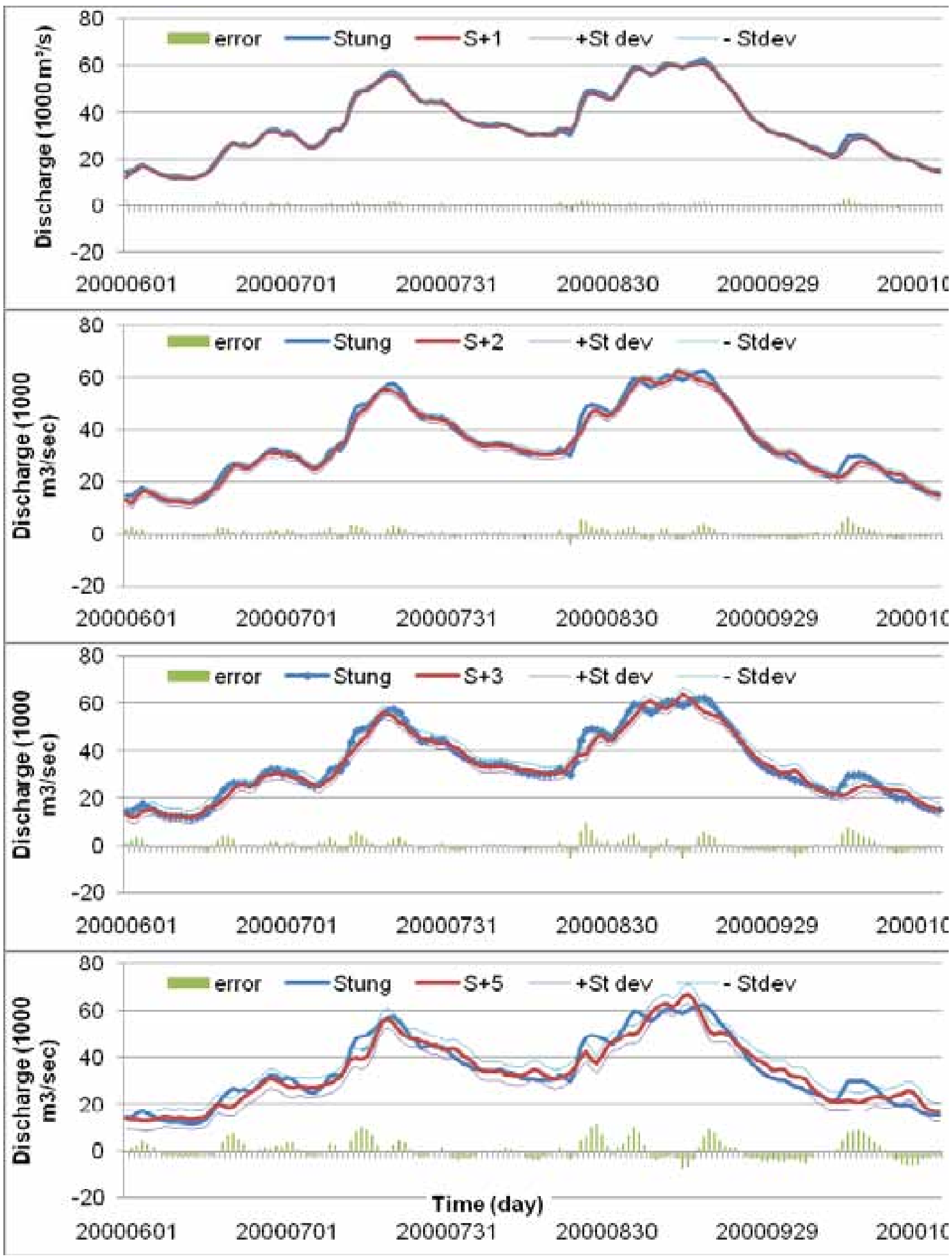

Figure 5. Rainfall runoff model with known rainfall input: flood forecast with 1-5 days lead time for 1994, indicated by notation: S+1 = Stung Treng discharge with 1 day forecast.

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Quality of forecasts is measured by different criteria, the one most useful is the coefficient of persistence (Kitanides and Bras, 1980, see also Plate and Lindenmaier, 2008). As shown in Table 3, even when models are used with known data instead of forecast rainfall there is no perfect agreement of model output and observation. This is seen in Figure 5, which show flood forecasts in hindcast mode, that is by using actual data of future rainfall - a case which may be called 'benchmark case'. The parameters for the probability distributions of errors for the four benchmark cases of Figure 5 are shown in Table 3. They show a standard deviation which increases with forecast time, indicating an error progression which is unavoidable with the present model. Naturally, because the benchmark case does not include the uncertainty due to the forecast, it will in most case have the smallest error band. Thus, the best forecast is obtained by a rainfall forecast model which comes closest to the error band of the benchmark case. At present, different possibilities of combining rainfalls into effective rainfall are being tested, as an example also included in Table 3 is the standard deviation of the errors obtained with a forecast consisting of the average of rainfall of the last 5 days for station Stung Treng.

Table 3. Parameters for the probability distributions of errors for the four benchmark cases of Figure 5

Stung Treng forecasts	s+1	s+2	s+3	s+5	Forecast with 5 day average s+5
Mean error	10	48	42	-23	298
Max error	6,465	11,457	14,198	17,436	23,646
Min error	-10,468	-11,272	-11,645	-13,581	-12,920
PV=Peak value	69,803	69,803	69,803	69,803	69,803
MT=Mean total	25,169	25,169	25,169	25,169	25,169
SA=Std.Abw	931	1,768	2,418	3541	4,786
SA water level 2000	0.10	0.23	0.34	0.53	0.73
Mean abs error 2000	0.06	0.17	0.26	0.42	0.59
SA/MT	0.037	0.07	0.096	0.14	0.19

DISCUSSION

As is evident from Figure 5 and Table 3, the forecast model based on the data base yields forecasts with considerable errors even in hindcast mode. Certainly, errors are partly due to model insufficiency, and more work needs to be done to improve the model. However, forecast errors are not the only uncertainty of forecasting models. Forecasts with linear systems depend on the quality of rainfall. Different sources of rainfall data exist, of which data from the HYMOS data base are the most complete, although their quality is uncertain. Rainfall inputs into lateral sub-basins between gauging stations were obtained by taking area averages of rainfalls from all stations in the sub-basin. The assumption that this yields accurate rainfall fields is, of course rather crude, and inclusion of uncertainties into adjustment factor KN is a first approximation only. For a forecast longer than 3 to 6 days it is necessary that rainfall forecasts are being made. This forecast must consider both, development and tracking of typhoons, as well as progress of Monsoon fronts across South- and South East Asia. It seems to be most advisable to improve forecasts through a well organized system of weather and rainfall forecasting for the whole of the Southeast Pacific, as was recommended by Koh and Teo (2009). They propose as a first step to make available results from all weather radar instruments existing in the region, which should cover not only South Asia, but also most of the Mekong region.

At present, accuracy of existing rating curves is also a factor. Stage discharge curves change considerably due to sediment motion, but they are measured only infrequently. As a consequence any model that is used to develop forecasts from this data base will suffer from considerable uncertainty. According to Krystoforovich (2001), we must distinguish uncertainty of two processors: one for hydrology and one for meteorology. Hydrological processors describe the reaction of the system, including generation of rainfall inputs. It reflects uncertainty of the hydraulics and hydrology parts of the forecast model, including data uncertainty due to measurement errors of discharges. Meteorological processors describe uncertainty of precipitation forecasts, which in the Mekong basin are almost exclusively forecasts of rainfall. For the middle reach of the Mekong, it furthermore includes input coming in from China and Myanmar, because the first station which has a continuous record of discharges is located in Laos. Because of these sources of uncertainty, we must compare forecasts with the case of perfect forecast – i.e. the case where input data are known (hindcast mode). This case yields that uncertainty with which one will have to live. No forecast model of rainfall can improve the system performance beyond this uncertainty. Additional uncertainties of the assumed rainfall field needed for forecasts based on rainfall must be assessed separately, and a comparison of results from the two cases: a. with perfect forecast (i.e. the hindcast with the model) and b. with different forecast rainfall inputs as given in column 6 of table 3, which shows that other factors than uncertainty of rainfall forecasts are responsible for most of the uncertainty.

As a final remark: a data based forecast model of the described type cannot replace good physical models, which are needed if effects of land use changes and structural modifications of the river channel are to be predicted, but it may be well suited to forecasts under stationary conditions, or if the non-stationarity is due to rainfall changes

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Paper 4-5

BIAS ADJUSTED SATELLITE-BASED RAINFALL ESTIMATES FOR FLOOD PREDICTION: CASE STUDY NARAYANI BASIN, NEPAL

MANDIRA S. SHRESTHA[1], GULEID A. ARTAN[2], SAGAR R. BAJRACHARYA[1], DILIP P. GAUTAM[3] AND SEZIN A. TOKAR[4]

[1]International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal
[2]ASRC, United States Geological Survey (USGS) Earth Resources Observations and Sciences (EROS) Centre, Sioux Falls, USA
[3]Department of Hydrology and Meteorology (DHM), Babarmahal, Kathmandu, Nepal
[4]United States Agency for International Development, Office of US Foreign Disaster Assistance (USAID/OFDA), Washington, DC, USA

ABSTRACT

In this study we investigated the use of satellite-based rainfall datasets for flood forecasting purposes. We utilized a rainfall/runoff model (GeoSFM) with the National Oceanic and Atmospheric Organization (NOAA) Climate Prediction Centre (CPC) CPC_RFE2.0 product to predict the discharge of the Narayani River in Nepal. We calibrated and validated the GeoSFM utilizing rainfall data collected by a network of 45 rain gauge stations located within or close proximity to the Narayani Basin. When the rain gauge rainfall data was used the Nash Sutcliff Coefficient of Efficiency (NSCE) and coefficient correlation (r) of the simulated and observed discharge were 0.84 and 0.94 during the calibration period and 0.77 and 0.92 during the validation. When the GeoSFM was run with the CPC_RFE2.0 the NSCE was -1.23 and r was 0.75. The CPC_RFE2.0 compared with rain gauge data underestimated by about 33% (r = 0.6). To improve the performance of the discharge simulated with the CPC_RFE2.0, a de-biasing scheme was tested. After the de-biasing the agreement between the discharge estimated with the CPC_RFE2.0 and the observed discharge improved considerably with the NSCE increasing from -1.23 to 0.52 and the correlation coefficient increasing from 0.75 to 0.90. Our results suggest that CPC_RFE2.0 could supply a useful rainfall datasets for flood forecasting purposes if de-biased.

BACKGROUND

Sparseness of rain observing stations in some areas of the globe and limitations of data sharing across international borders among riparian countries of many trans-boundary basins makes challenging the implementation of traditional flood forecasting systems (Artan et al., 2007a, Hossain and Lettenmaier, 2006 and Shrestha et al., 2008). In such areas, with limited rain gauge network, rainfall estimated from satellite data could offer an alternative rainfall data source for flood forecasting purposes (Adler et al., 2003, Artan et al., 2007a, Asante et al., 2007a, Hong et al., 2007 and Shrestha et al., 2008). Several high resolution satellite-based rainfall (RFE) products with global coverage are currently available from various agencies (Huffman et al., 2007, Ebert et al., 2007 and Kubota et al., 2009). Among the most popular RFE are the National Oceanic and Atmospheric Organization (NOAA) Climate Prediction Centre (CPC) CPC_RFE2.0 (Xie et al., 2002), the CMORPH (Joyce et al., 2004), and the Tropical Rainfall Measuring Mission (TRMM).

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There has been several studies that have looked into the utility of the available merged satellite- and ground-based rainfall estimation (RFE) products for hydrological modelling purposes (Yilmaz et al., 2005, Asante et al., 2007a, Artan et al., 2007a and Hong et al., 2007) but there have not been much research on the effects of de-biasing schemes of RFE on simulated discharge produced by hydrologic models forced with RFE data as input rainfall data. In this study we investigated the consequences of de-biasing RFE has on simulated discharge of the Narayani River in Nepal. In the subsequent sections we describe the validation and calibration of the hydrologic model and the improvement obtained in flood prediction by using bias adjusted satellite-based rainfall estimates.

STUDY SITE

The Narayani Basin is centrally located in Nepal (Figure 1) and has a drainage area of about 34,200 km^2. The Narayani River originates from the Tibetan Plateau in China and generally runs north to south direction. Basin elevation ranges from a low elevation of 60 m in the south to as high as 8,167 m in the north where it passes through the high Himalayas, which contain the Dhaulagiri (8,167 m) and Annapurna (8,091 m) peaks. Given the topographic variation of the Narayani Basin, the climate with the basin varies from a sub-tropical in the south to alpine conditions in the high Himalayas in the north with a mean annual precipitation that varies from 200 mm to more than 6000 mm (Sharma, 1977). Most of the precipitation in the basins falls in the monsoon season from June to September.

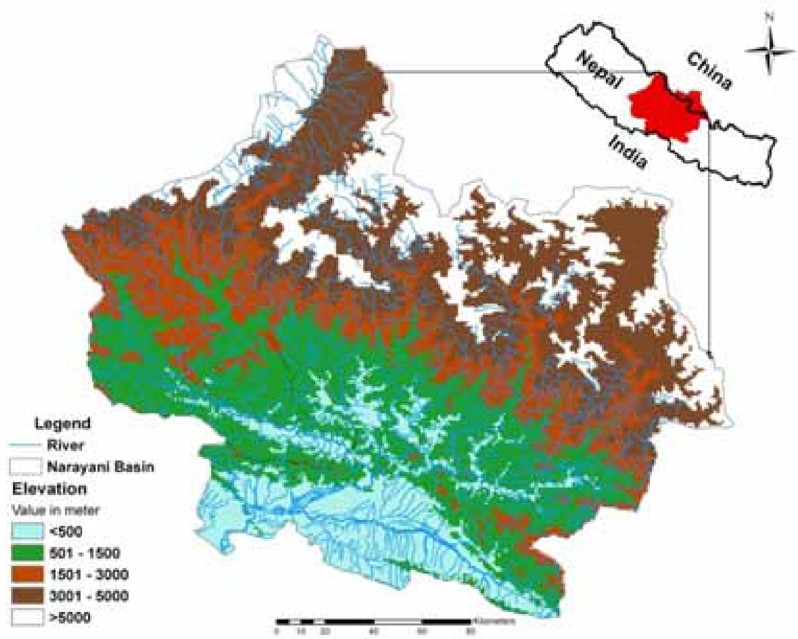

Figure 1. Topographic feature and geographic location of the Narayani Basin

DATA

The main hydrometrological data used for this study included: daily CPC_RFE2.0, daily global reference evapotranspiration (ETo), rain data from a network of 45 rain gauges located inside or close to the basin, and two years of daily observed discharge recorded at the Devghat hydrometric station.

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Two years of daily RFE data (Xie and Arkin, 1997) were used in this study, the RFE has spatial resolution of 0.1 degree. The CPC_RFE2.0 product is made from the blending satellite imagery from the Advanced Microwave Sounding Unit (AMSU-B), Special Sensor Microwave Imager (SSM/I), and near infrared imagery from geostationary satellites with rain gauge from the Global Telecommunications System (GTS) of the World Meteorological Organization. The daily reference ETo data are produced at U.S. Geological Survey (USGS)/Earth Resources Observation and Science (EROS) Centre from 6-hourly Global Data Assimilation System (GDAS) climate parameters using the standardized Penman-Monteith Equation and downscaled to 0.1 degree for this study (Senay et al., 2008). The rain gauge data were provided by the Department of Hydrology and Meteorology (DHM) of the Government of Nepal. The DHM also provided observed discharge data recorded at the Devghat station located at the downstream of the basin. Both rain and stream gauges data were checked for consistency and accuracy.

Basin boundaries and stream networks were derived from the USGS GTOPO30 digital elevation database (http://edcdaac.usgs.gov/gtopo30/gtopo30.html). The GTOPO30 global topographic data set (Gesch et al., 1999) that describes elevation values at a regular spacing of 30 arcseconds of latitude and longitude. The GeoSFM uses sub-basins as its basic unit of modelling; the total area of Narayani Basin was sub-dived into 39 sub-basins.

METHODOLOGY AND APPROACH

We have used the GeoSFM (Artan et al., 2007b; Asante et al., 2007b) to simulate the rainfall/runoff processes. The GeoSFM is a semi-distributed physically-based hydrologic model developed by the USGS. The model simulates the dynamics of runoff processes by using remotely sensed, ground observation, and globally available geomorphologic and environmental datasets. The GeoSFM model assimilates spatially distributed data to simulate the discharge on daily or hourly basis. The model has a Graphical User Interface that simplifies model setup and parameter estimation. Modelling was limited to two years (2003 - 2004) where all the hydrometeorological data was available. We focused on monsoon months (June - September). The gridded gauge observed rainfall data for the monsoon of 2003 and 2004 were used in the GeoSFM to predict floods. Daily observed river discharge data from the 2003 monsoon were used for GeoSFM model calibration and data from 2004 for validation.

First, the GeoSFM was calibrated and validated using rainfall data recorded by ground-based stations for the monsoon seasons of 2003 and 2004. Second, the hydrologic model was run with the CPC_RFE2.0 datasets for the same period as the rain gauges. In theory the CPC_RFE2.0 algorithm incorporates all GTS data; we found that in our area of interest no GTS station reported during the monsoon season of 2003. We implemented de-biasing scheme for the CPC_RFE2.0 product using the algorithm described by Xie and Arkin (1997) using rainfall recorded by the 45 stations. Finally, the GeoSFM was run with the improved CPC_RFE2.0 as rainfall input data.

RESULTS

The GeoSFM was calibrated using data collected during the monsoon season of 2003, the model was driven with rainfall data from the above described rain gauge network. Figure 2a shows time series plots of simulated and observed hydrographs with the rainfall histogram. There was a good agreement between the two hydrographs both in timing and magnitude. Figure 2b shows the scatter plot of the two hydrographs and confers that the model simulated discharge was significantly correlated with the observed streamflow (NSCE = 0.84, R^2 = 0.89).

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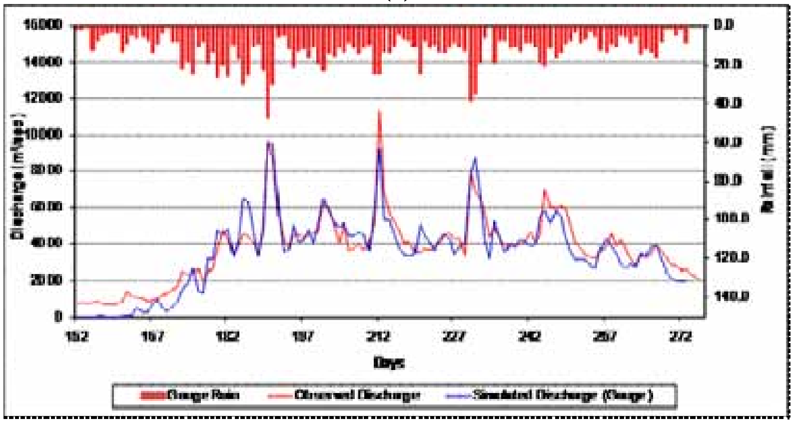
(a)



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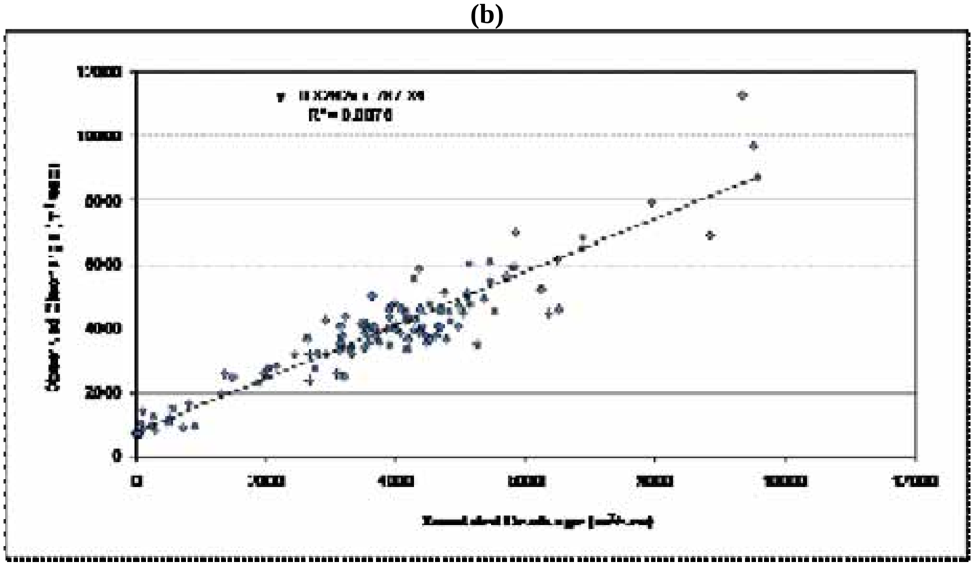

Figure 2. Observed and simulated discharge at Devghat station during 2003 monsoon season using rainfall data from rain gauge network.

To validate the simulated discharge the GeoSFM was run with rain gauge data from the monsoon season of 2004. The agreement between simulated and observed discharge was also highly significant during the validation period as it was the calibration period (Figure 3).

Subsequent to the GeoSFM calibration and validation with rain gauge data, the GeoSFM model was forced with the CPC_RFE2.0 rainfall estimates for the period June to September 2003. No change was made in the values of the model parameters obtained from the calibration of the GeoSFM with the rain gauge recorded rainfall data. There was an underestimation bias in the simulated discharge compared with the observed (Figure 4). The NSCE between simulated and observed discharges was -1.23, indicating that the mean value of the observed discharge would have been a better predictor than the model, and the correlation coefficient of 0.52.

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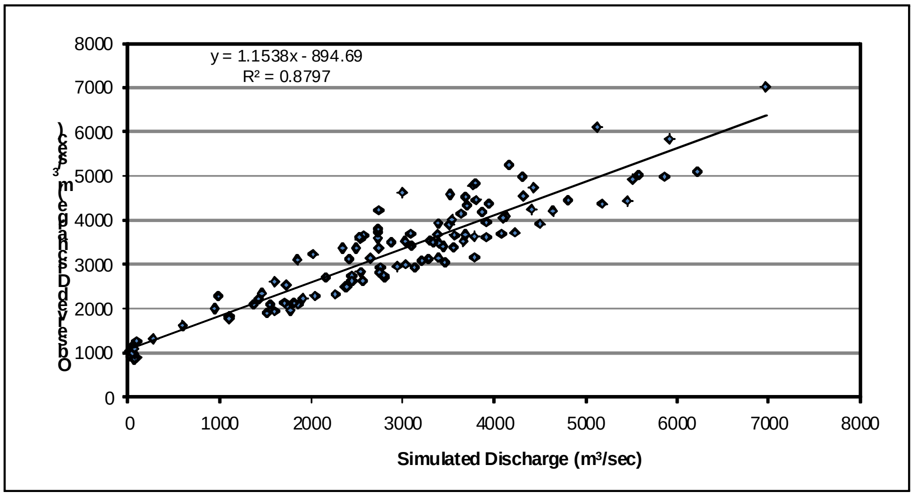

Figure 3. Scatter plot of observed and simulated discharge for the validations period (June to September 2004).

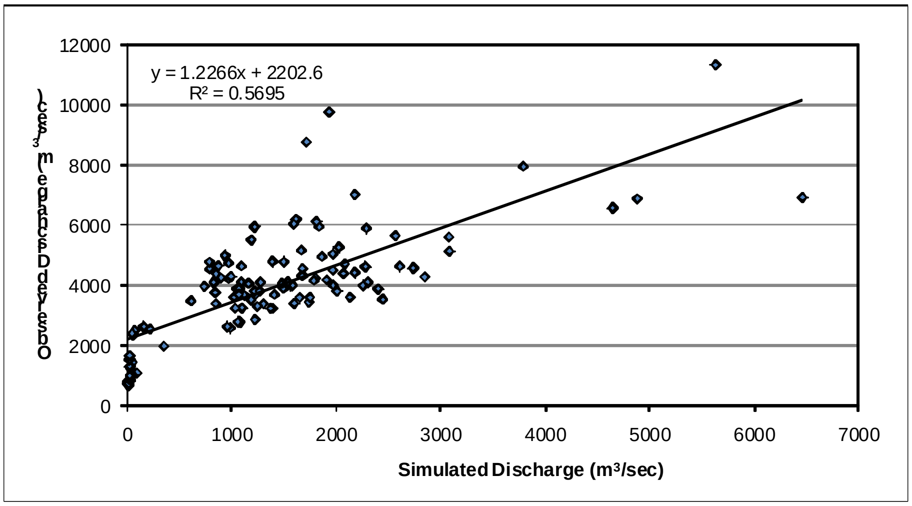

Figure 4. Observed and simulated discharge for period between June to September 2003 when the CPC_RFE2.0 rainfall estimates was used.

After comparing the CPC_RFE2.0 rainfall data with rainfall fields estimated from the rain gauge network, only grids with one or more stations were included in the comparison, we found that the satellite-based rainfall estimates captured the trends, but had an underestimation bias (Figure 5). After implementing bias adjustment scheme described by the Xie and Arkin (1997) using the rain gauge data, the statistics of the discharge simulated with the CPC_RFE2.0 rainfall estimates improved significantly when compared with the observed discharge. The NSCE changed from a value of -1.23 to 0.53 while the correlation coefficient increased from 0.52 to 0.90.

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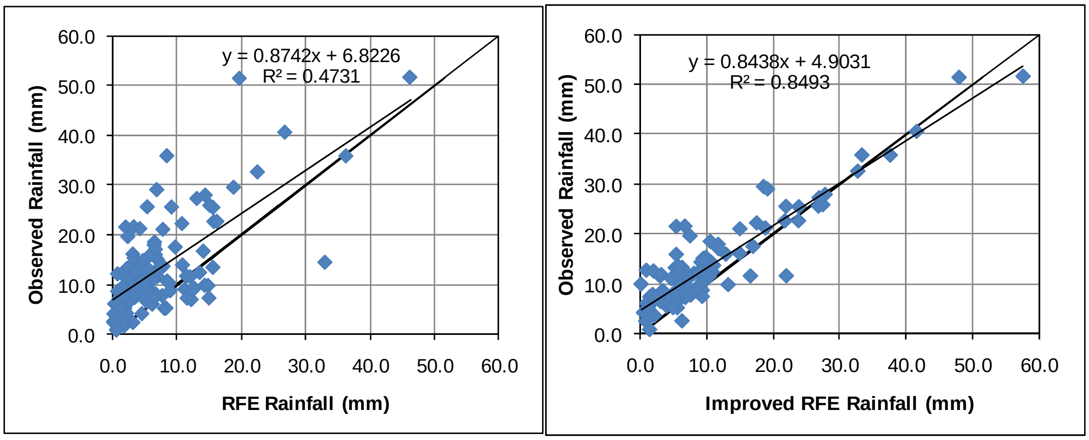

Figure 5. Comparison of the CPC_RFE2.0 rainfall estimates with the rainfall recorded by the ground stations (A) before the de-biasing scheme was applied and (B) after de-biasing.

CONCLUSIONS AND RECOMMENDATIONS

Real-time satellite-based rainfall estimates for all parts of the global between 60^0 North and 60^0 South are becoming available. In this study we have investigated the utility of such data for streamflow modelling. A distributed rainfall/runoff model was calibrated using combinations of rain gauge measured and remotely sensed rainfall estimates. The remotely sensed rainfall estimates had under-estimation bias and a negative NSCE but the satellite-based rainfall estimates were de-biased with rain gauge data there was a good agreement between simulated and observed discharge. This suggests that the remotely sensed rainfall estimates could be an excellent source of rainfall data for hydrologic modelling if used in conjunction with locally observed rainfall.

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Paper 4-6

FLOOD RISK MANAGEMENT AND MITIGATION – FLOOD FORECASTING AND WARNING IN INDIA

S.K. CHAUDRI

Central Water Commission, New Delhi, India

INTRODUCTION

- geographical location, topographical features and meteorological conditions make any country vulnerable to flood and drought;
- Indian sub-continent generally receives heavy rainfall due to south-west monsoon. Starting from April to October every year;
- floods have been recurrent phenomenon in many parts of India, causing loss of lives and public property and bringing untold misery to the people, especially those in the rural areas;
- Indian continent has peculiar climatic conditions since it has floods in some parts whereas drought in other parts;
- despite the various steps undertaken over the last five decades, the trend of increasing damage and devastation brought by floods has posed a challenge to the Government as well as to the people;
- the approaches to flood management presently exercised in India is under systematic review for upgrading the system.

FLOODS

Causes of floods

- long duration heavy rainfall;
- unplanned sudden release of water from reservoirs;
- inadequate channel capacities;
- landslides / river blockages;
- poor drainage.

Impacts of floods

- heavy losses, annual average damages are more than US$ 383 million (INR 18,000 millions);
- disrupt normal life;
- on the contrary, floods also turn to benefits as millions of people grow their rice, wheat, millet and corn on floodplains in India, China and countries in the East.

Flood prone area in India

- geographical area of India : 329 mha (million hectares);
- total flood prone area 45.7 mha as reported by the States to the Working Group on Flood Control Programme for 10th and 11th Plan.

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RIVER SYSTEMS AND ASSOCIATED FLOOD PROBLEMS

The rivers in India can be broadly divided into the following four regions for study of flood problems:

- Brahmaputra Region;
- Ganga Region;
- North West Region;
- Central India and Deccan Region.

Brahmaputra Region

- this region consists of the rivers Brahmaputra & Barak and their tributaries covering seven states in the North Eastern part out of the total of 28 States and 7 Union Territories of India;
- the catchments of these rivers receive very heavy rainfall ranging from 1,100 mm to 6,350 mm a year, which occurs mostly during the months of May / June to September resulting severe and frequent floods in this region;
- the predominant problems in this region are the flooding caused by spilling of rivers over their banks, drainage congestion and tendency of some of the rivers to change their courses.

Ganga River Region

- the river Ganga and its numerous tributaries, of which important ones are the Yamuna, the Sone, the Ghaghra, the Gandak, the Kosi and the Mahananda, constitute this river region. It covers from North to East of the country;
- the normal annual rainfall in this region varies from 60 cm to 190 cm of which more than 80% occurs during the south west monsoon. The rainfall increases from West to East and from South to North;
- the flood problem is mostly confined to the areas on the northern bank of the river Ganga which is mainly caused by northern tributaries which spill their banks.

North West River Region

- the main rivers in this region are the Sutlej, the Beas, the Ravi, the Chenab and the Jhelum, the tributaries of Indus, all flowing from the Himalays;
- the flood problem is little less in this region compared to Ganga.

Central India and Deccan Region

The important rivers in this region are the Narmada, the Tapi, the Mahanadi, the Godavari, the Krishna and the Cauvery. These rivers have mostly well defined stable courses. They have generally adequate capacity within the natural banks to carry the flood discharge except in the delta area. The lower reaches of the important rivers on the East Coast have been embanked, thus largely eliminating the flood problem.

FLOOD MANAGEMENT IN INDIA

Statutory provisions

- in India, the subject of flood control does falls within the purview of the State Governments;
- the schemes of flood management are planned, investigated and implemented by the

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States. The role of the Central Government technical, advisory, catalytic and promotional in nature.

Existing mechanisms

- State Level Mechanism - The State Level Mechanism includes the Water Resources / Irrigation Departments, State Technical Advisory Committee and Flood Control Board;
- Central Government Mechanism - The Union Government has set up following organisations to address issues on flood problems in a comprehensive manner:
  * Central Water Commission;
  * Brahmaputra Board;
  * Ganga Flood Control Commission;
  * Farakka Barrage Project Authority;
  * National Disaster Management Authority;
  * Various Expert Committees.

Central Water Commission (CWC)

- CWC, the national apex organisation was setup in 1945 by Govt. of India for achieving the goal of furthering and promoting measures of flood control, conservation and utilisation of water resources in the areas of irrigation, hydro power generation, flood management and river conservation;
- by now, CWC, has gained considerable know-how in planning, investigation, management and design for water resources development schemes.

National Disaster Management Authority (NDMA)

The Government of India has set up a National Disaster Management Authority (NDMA) in 2005 under the Chairmanship of Hon'ble Prime Minister of India for prevention and mitigation of effects of disasters including flood disasters and for undertaking a holistic, coordinated and prompt response to any disaster situation. It includes:

- preventive measures;
- setting up response force;
- State and district level Disaster Management Authorities;
- preparation of Disaster Management Plans.

National Flood Commission - 1980 (important recommendations):

- data collection for providing information on their long term performance and their impact on various socio-economic factors;
- legislation and enforcement by States to prevent unauthorized river bed cultivation and encroachments into drains etc.;
- separate reporting of flood damage for (i) Unprotected areas (ii) Protected areas and (iii) Areas situated between the embankments;
- legislation for management of floodplains;
- a comprehensive dynamic and flexible approach to the problem of floods as a part of a comprehensive approach for the utilization of land and water resources;
- priority for measures to modify the susceptibility of life and property to flood damage;
- forming a national council for mitigating disasters.

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NATIONAL WATER POLICY

- there should be a master plan for flood control and management for each flood prone basin;
- adequate flood cushion should be provided in water storage projects, wherever feasible, to facilitate better flood management. In highly flood prone areas, flood control should be given overriding consideration in reservoir regulations policy even at the cost of sacrificing some irrigation or power benefits;
- while physical flood protection works like embankments and dykes will continue to be necessary, increased emphasis should be laid on non-structural measure such as flood forecasting and warning, floodplain zoning and flood proofing for the minimization of losses and to reduce the recurring expenditure on flood relief;
- there should be strict regulation of settlements and economic activity in the floodplain zones along with flood proofing, to minimize the loss of life and property on account of floods;
- the flood forecasting activities should be modernized, value added and extended to other uncovered areas. Inflow forecasting to reservoirs should be instituted for their effective regulation;
- the erosion of land, whether by the sea in coastal areas or by river waters inland, should be minimized by suitable cost-effective measures. The States and Union Territories should also undertake all requisite steps to ensure that indiscriminate occupation and exploitation of coastal strips of land are discouraged and that the location of economic activities in areas adjacent to the sea is regulated;
- each coastal State should prepare a comprehensive coastal land management plan, keeping in view the environmental and ecological impacts, and regulate the developmental activities accordingly.

FLOOD MANAGEMENT MEASURES PRACTICED IN INDIA

- structural measures:
  - reservoirs;
  - detention basins;
  - embankments;
  - channelisation of rivers;
  - channel improvements;
  - drainage improvements;
  - diversion of flood waters;
  - watershed management.
- non-structural measures:
  - flood forecasting and warning;
  - floodplain zoning;
  - flood proofing;
  - disaster preparedness and response planning;
  - disaster relief.

Table 1. Floodplain zoning regulation

Priority - I	Priority – II	Priority - III
• industries, public utilities like hospitals, power houses, water supply, telephone exchange, aerodromes,	• public institutions, Government offices, universities, public libraries, residential areas, etc.	parks, play grounds, etc less economic and community activity in areas vulnerable to frequent floods.

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railway stations, etc. • activity limited to water levels corresponding to 100 years flood frequency and drainage congestion for 50 years rainfall.	• activity limited to levels corresponding to 25 years flood frequency and drainage congestion for 10 years rainfall frequency.	

Table 2. Flood forecasting network of Central Water Commission. Basin-wise flood forecasting stations

SN	River-system	Level	Inflow	Total
1	Ganga and tributaries	77	10	87
2	Brhamaputra and Tributaries	27	-	27
3	Barak-system	5	-	5
4	Eastern-rivers	8	1	9
5	Mahanadi	3	1	4
6	Godavari	14	4	18
7	Krishna	3	6	9
8	West flowing rivers	9	6	15
9	Pennar	1	-	1
	Total	147	28	175

General Flood Management Measures practiced in India

Modernisation of flood forecasting system

In order to meet the requirement of real-time data collection, automatic data transmission and flood forecast formulation, expeditious data / information dissemination, the Central Water Commission, Govt. of India, has undertaken modernization of its data collection and flood forecast network by Telemetry System.

Modernisation of FF Network of CWC

- data collection: with sensor based equipment in place of manual;
- data transmission/dissemination: through satellite / VSAT system;
- Forecast Formulation: with Automated mathematical models (MIKE-11).

International Dimensions of Flood Management in India

India-Bangladesh cooperation
An Indo-Bangladesh Joint Rivers Commission (JRC) is functioning since 1972 with a view to maintain liaison in order to ensure the most effective joint effort in maximizing the benefits from common river systems which is headed by Water Resource Ministers of both the countries

India-China cooperation

The Government of India has signed MOUs with Government of People's Republic of China for provision of hydrological information of Chinese Stations on rivers Yaluzangbu/ Brahmaputra and Langquinzangbu (Sutlej) during monsoon season. Both the countries have also set up an Expert Level Mechanism in 2006 for addressing issues pertaining to trans-boundary rivers.

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Indo-Pakistan cooperation

India and Pakistan signed Indus Waters Treaty in 1960, and two permanent posts of Commissioners were created, one each in India and Pakistan. Each Commissioner is representative of his Government for all matters arising out of the Treaty and is to serve as the regular channel of communication on all matters relating to implementation of the Treaty. The two Commissioners together form the Permanent Indus Commission.

In fulfilment of the requirements of Indus Water Treaty, the daily data of 280 hydrological sites on six basins, The Indus, The Jhelum, The Chenab, The Ravi, The Beas and The Sutlej of Indus system was is regularly sent from India to Pakistan every month. Besides, Flood warnings are transmitted by India to Pakistan through Telegrams, Telephones and Radio Broadcasts during every monsoon for Indus River system.

SESSION 6

CONCLUDING SESSION

Reports presented during the concluding session

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Report plenary session 1

LESSONS LEARNED FROM 2009 FLOODING AND NATIONAL AND MRC-RFMMC EXPERIENCES WITH FLOOD RISK MANAGEMENT AND MITIGATION IN THE MEKONG RIVER BASIN

RAPPORTEUR: HAK SOCHEAT

National Coordinator Flood Management and Mitigation Programme (FMMP), Cambodia National Mekong Committee, Phnom Penh, Cambodia

Presentations by MRC Member Countries:

- *Cambodia presentation:*
  - 2009 mainstream flood was normal (beneficial flood). Severe damage occurred due the flash flood caused by Typhoon Ketsana (56 people died and 61,271 ha of crops was flooded);
  - lack of flash flood forecasting, warning and preparedness plans;
- *Lao PDR presentation:*
  - flooding as usual in the low-lying areas along Nam Sane and Sebangfai rivers. Flash flood caused by Typhoon Ketsana (30 people died and US$ 58 million damage;
  - flood forecasting and disaster management agencies are in place;
- *Thai presentation:*
  - average rainfall in 2009 was slightly lower than the 30 years average rainfall, but higher than the 2008 average rainfall. The distribution was not homogenous. There were a number of floods (May - November). There is a disaster management mechanism, flood forecasting system and the political commitment of the Government on this issue:
  - lack of an action plan, promotion, integrated database system and water management legislation;
- *Viet Nam presentation:*
  - flooding in the Central part and highlands was caused by an extreme flood event. Typhoon Ketsana caused severe damage (79 people died and US$ 91.4 million damage);
  - in the Mekong Delta the 2009 flood was lower than the normal flood. There was flooding by Mekong and Bassac rivers. There is a signal of impact of climate change causing extreme events in Viet Nam.
  - flow in the river was affected by operation of upstream reservoir systems in China and by other storages in the tributaries.

Presentations by Dialogue Partners:

- *China presentation:*
  - China recognized the importance of the role of the Mekong River Commission (MRC) in water resources management, economic development and regional cooperation. Recent 1st MRC Summit showed the strong support and commitment of the Head of States of the MRC Member Countries to cooperation;

  * continue the cooperation with MRC by providing data, receiving delegates and providing training;
  * a well set up mechanism for disaster management and adequate financial and technical resources lead to better management with less casualties;

- *Myanmar presentation:*
  * to manage drought and flood Myanmar introduced the river training activities (structural measures) with various river works activities. The result was good with no casualty recorded.

Presentation of the Mekong River Commission Secretariat (MRCS):

- flood volumes in 2009 were very low and the flood season ended very early contributing to development of regional hydrological drought;
- water levels in the upper part were low and in the lower part from Kratie down they were about the average;
- flash floods occurred in tributaries and caused severe damage. They need to be carefully monitored at the regional level;
- there is no evidence that the frequency of tropical storm is currently increasing.

Key recommendations for next steps of the Flood Management and Mitigation Programme (FMMP):

- strengthening cooperation in exchange of meteo-hydrological data, information and regulation mechanisms of reservoirs in Mekong River Basin for the mainstream and tributaries.
- additional electronic gauging stations along Mekong River would have to be set up;
- investment in research and technologies to ensure the quality of longer period forecasting;
- further development of knowledge, data quality and forecasting tools, especially the Flash Flood Guidance System needs to be built or strengthened;
- MRCS is still a key player in helping with flood management in the region both in terms of financing and technical;
- standards for damage assessment need to be set up;
- sustainable financing for flood management and network maintenance need to be ensured.

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Report plenary session 2

ACHIEVEMENTS AND PERSPECTIVES OF THE FLOOD MANAGEMENT AND MITIGATION PROGRAMME (FMMP)

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

During the session the five components of the Flood Management and Mitigation Programme (FMMP) were presented and discussed.

Presentation Component 4. *Flood emergency management strengthening - people-centred approach in integrated flood risk management* by Aslam Perwaiz:

- FMMP includes flood preparedness programs, priority activity implementation, capacity building for flood risk reduction, flood awareness and education, flood knowledge sharing and documentation, integration of flood risk reduction into local development planning process, trans-boundary (province to province) joint planning and information exchange;
- there were activities in 11 provinces and 28 districts distributed as follows: in Cambodia 4 provinces and 10 districts, in Viet Nam 4 provinces and 10 districts, in Lao PDR 2 provinces and 6 districts and in Thailand 1 province and 2 districts;
- the Project has worked with chiefs of villages to supply posters, information, booklets, billboards, etc.;
- made warnings to the communities;
- for sustaining the project there was coordination with the National Plans;
- for the future the direction will be an Integrated Water Resource Management approach to flood preparedness and emergency response;
- up-scaling (geographical + thematic areas) with lead in implementation by the MRC Member Countries.

Presentation Component 1. *Flood forecasting and flash flood guidance systems at the MRC Regional Flood Management and Mitigation Centre* by Nguyen Tien Kien:

- MRC River Flood Forecasting System consists of Unified River Basin Simulation model (URBS), ISIS Hydrodynamic model and Delft-FEWS. URBS is used between Chiang Saen and Pakse and ISIS + Regression between Strung Treng and Chau Doc;
- performance indicators;
- evaluation of 2008 and 2009 flood forecasting accuracies. Conclusion: forecast accuracy assessment of URBS and SSARR indicated that in general URBS performed better than SSARR;
- MRC Flash Flood Guidance System (FFGS). FFGS was applied on the small basin scale and satellite rainfall estimates need to be further developed for more accuracy while rainfall was now about 30% under estimated;
- The Flood Management and Mitigation Centre (MRC-RFMMC) will officially operate the new Mekong FFGS from 2010 onwards. Approval for this was obtained from MRC Technical Task Group and MRC-Member Countries;
- However, further system performance improvement towards better forecast accuracies for

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all forecast stations needs to be further pursued by MRC-RFMMC.

Presentation Component 2. *Improved flood risk reduction through implementation of structural measures and flood proofing under the FMMP* by Nicolaas Bakker and G.J. Sluimer:

- *immediate objective:* reduced vulnerability of people living in Mekong River Basin to negative impacts of floods and management capacity established for development and refinement of the FMMP;
- implementation and flood risk assessment and management: The preparation of the document for this component resulted in 17 reports within 28 months;
- *lessons learnt:* topographic and hydrographic surveys are required, as well as adjustments of the ISIS model, while major problems were identified with application of the ISIS model in 2008 and 2009. The ISIS model would have to apply a 1D/2D configuration to significantly improve representation of floodplain hydrodynamics;
- generate the flood depth probability and damage curves to identify damage probability relation;
- key material would have to be selected, translated and disseminated under Line Agencies of MRC Member Countries;
- *future perspective:* use of all Component 2 deliverables by the 'Floods and Droughts project' of the Asian Development Bank (ADB) is a great opportunity for MRC Member Countries to select Component 2 projects for feasibility studies and later implementation;
- additional practical applications of flood risk assessment and management principles is required to support Line Agencies of MRC Member Countries;
- close cooperation with the Basin Development Programme, Environment Programme and Information Knowledge Management Programme on flood- and climate change related issues is required;
- demonstration projects in Thailand and Lao PDR need to be followed up by implementation.

Presentation. Component 3. *Enhanced cooperation in addressing trans-boundary flood issures between the MRC Member Countries under FMMP* by Nicolaas Bakker:

- *immediate objective:* in 2007 the component was changed from mediation of trans-boundary flood issues to this name;
- structure and implementation:

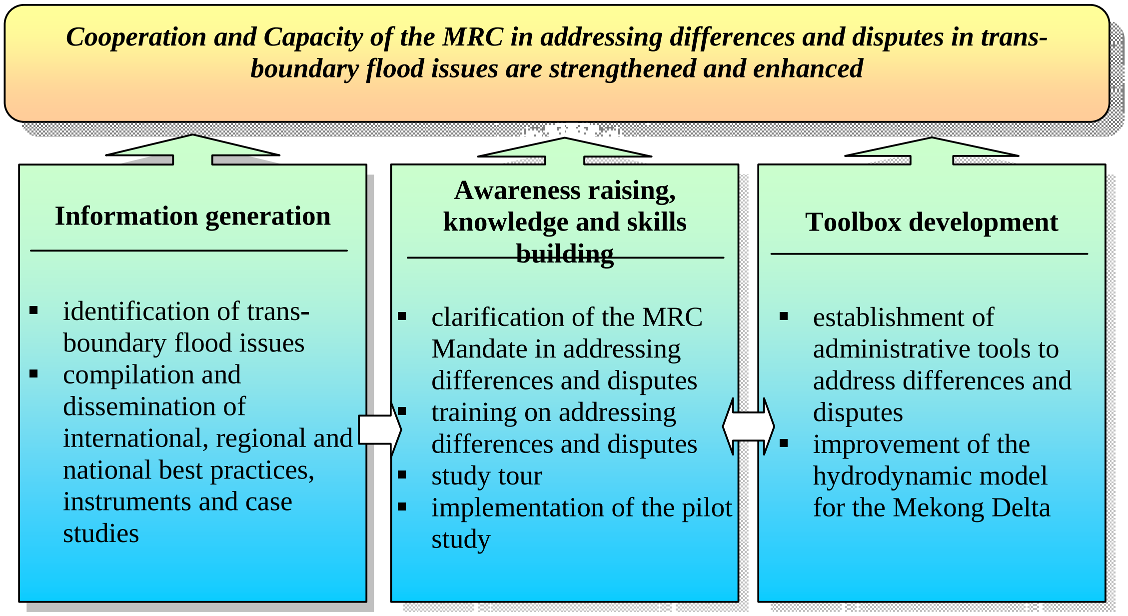

Figure 1. Details of the three outputs of Component 3

- *products:*
  - * 4 National reports 'Identification of Trans-boundary Flood Issues at National Level';
  - * 4 National reports of 'National Practices and Instruments on Addressing Inter-State Contentious Issues, Differences and disputes over Trans-boundary Water and Related Natural Resources Management Issues';
  - * 'Legal Aspects of the Mandate of the 1995 Mekong Agreement for Enhancing Cooperation in Addressing Trans-boundary Flood and Related Issues' (Working Paper);
  - * 'Explanatory Note', supplement to the Working Paper will be the 'Pocket Book' version;
- *for the Capacity Building Programme, Phase 1:*
  - * there have been 3 training and 3 exchange study tours;
  - * in the second part of 2010 a 'pilot study' will be conducted under 'Capacity Building Programme, Phase 2';
  - * *lessons learnt:* exchange study visits to Europe and China provided substantial added-value;
  - * *future expectations:* it may be expected that in future the need for trans-boundary coordination and cooperation will increase.

Presentation Component 5. *Flood information based land management (FIBLM) under FMMP* by Martin Falke:

- *objective:* land management in the Mekong floodplains is more effective when using reliable flood-related information and relevant authorities and organisations at various levels of the four riparian countries;
- this component produces flood probability maps (FPM) on the scale of 1 : 10,000 or larger for supply to decision makers;
- *Phase 1 and 2 (2004 to 2010) methodology:* the creation of reliable flood probability

maps for subsequent use in land management and land use planning by the relevant authorities and organisations;

- installation of river level stations, flood marks and flood information billboards;
- creation of data on the probability of flooding, start of the flooding, maximum depth, duration and completion of drainage of flooding for a range of probabilities;
- *result:* application in land management policy formulation, disaster management planning, infrastructure planning, irrigation planning and agriculture planning.

Conclusion: an alternative approach is needed for the districts in Lao PDR and Thailand, apart from the lack of flood mark data, caused by the absence of flooding in 2009, due to ongoing flood protection works in the pilot districts causing instabilities of the statistical description of river hydrographs and because the Map Stat-Procedure is not applicable when the flood waters are not related to river levels throughout the flood season

Recommendations:

- the planning authorities in the four MRC Member Countries as well as the Climate Change and Adaptation Initiative of MRC (MRC-CCAI) would have to use the FMMP-C5 approach and its maps for their strategy against climate change effects (e.g. increase of flooding) as an adaptation and mitigation tool;
- Thailand and Lao PDR can find the best area to study FPM production or use a hydraulic model such as ISIS applied to each flood event and based on observed data;
- the area modelled would have to be expanded from the present pilot areas, including an extension of the Digital Elevation Model (DEM)/ Digital Terrain Model (DTM) and the number of flood marks, supported by high quality satellite based flood extent mapping.

Future expectations for next phase of FMMP from the Thai National Mekong Committee Secretariat (TNMCS):

- close cooperation with the Drought Programme of the MRC to study in a parallel way with FMMP;
- close cooperation for technology transfer, exchange knowledge and on the job training;
- capacity building on new technologies;
- continue study on the projects that cannot meet the envisaged results in this phase;
- continue with and expand the data base of the impact issues from flood damage;
- linkage for data transfer from line agencies, National Mekong Committee Secretariats (NMCS) and the Regional Flood Management and Mitigation Centre (MRC-RFMMC).

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Report plenary session 4

SUMMARY OF DAY 1, PLENARY PAPER PRESENTATIONS AND DISCUSSIONS

RAPPORTEUR: PHONEPASEUTH PHOULIPHANH

Coordinator of Lao PDR National Mekong Committee Flood Management and Mitigation Programme, Vientiane, Lao PDR

Practical application of flood plain hydraulic modelling for disaster risk management in Central Vietnam by Ian Wood:

- this presentation introduced the geographical and socio-economic characteristics of the three central region provinces of Viet Nam and made them particularly exposed to water related disasters;
- the trends are consistent with a rapidly developing nation where improved awareness and response saves lives, but greater economic losses continue;
- modelling of natural disasters risk management in Central Viet Nam is accessing to broad scale consistent and accurate flood modelling data and it is also essential for the detailed assessment of disaster risk;
- hydraulic modelling provides a vital planning tool, but it must be reliable and trusted at the local level.

Enhancing regional capacity to address trans-boundary flood issues in the Lower Mekong River Basin by Wim Douven:

- capacity to address trans-boundary issues in river basins is an important condition for successful river basin management;
- enhancing and sustaining this capacity is a key challenge for member countries of the Mekong River Commission (MRC) with high ambitions on implementing integrated water resources management at basin boundaries;
- the Flood Management and Mitigation Programme Component 3 (FMMP-C3) of MRC aims to enhance the cooperation between MRC member countries through building skills and strengthening knowledge and capacities of relevant organizations;
- evaluation of the Phase 1 implementation of the programme shows that the learning objectives for the participants have largely been met;
- Phase 2 of the training programme will be implemented again to a similar audience with more attention to the application in real life cases;
- the Training of Trainers (TOT) will follow intensive training courses and play a larger role in the delivery of the programme.

Impact of climate change and sea water level rise to the inundation condition in the Mekong Delta by To Quang Toan:

- the Mekong Delta is very flat and low, average elevation is about 1 m above the mean sea level. Therefore it is affected by annual flood and drought;
- in the situation with climate change and sea water level rise, the flood and drought may become more severe and inundations may also occur in normal conditions. This will be a

threat to sustainable agriculture development of the Mekong Delta and will affect food security of Viet Nam;

- the possible effects of climate change and sea water level rise to inundation conditions of the Mekong Delta have been assessed and evaluated in the study.

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Report on Topic I

COMMUNITY FOCUSED APPROACH TO FLOOD RISK MANAGEMENT AND MITIGATION

RAPPORTEUR: SOK BUN HENG

National Flood Expert, National Flood Unit, Cambodia National Mekong Committee, Phnom Penh, Cambodia

WISDOM information system prototype for the Mekong Delta by Florian Moder:

- the WISDOM Project is a bilateral project of the Federal Republic of Germany and the Socialist Republic of Viet Nam. Phase I: 3 provinces, ended May 2010; Phase II (most likely): 13 provinces till 2013;
- the aim of the WISDOM project is design, implementation and training of integrated water resources management (IWRM). Large amounts of scientific data, originating from multiple scientific domains and knowledge management amongst others have been generated, collected and archived by the WISDOM Project since 2007. Two thematic domains: scientific domain focuses on multidisciplinary issues of water management and knowledge and data dissemination by designing and implementing a borderless customized web based information system application;
- the WISDOM System - which is currently in prototype stage and will be further developed over the next year – will provide a neutral platform for exchange and dissemination of water management relevant data and knowledge over the internet;
- all different interests and requirements resulting from different institutional as well as different disciplinary background were compiled and finally poured in an overall technical system definition for the WISDOM Information System Prototype.

Monitoring spatial and temporal dynamics of major floods in the lower reach of Songkhram River, Northeastern Thailand by Thiha and Rojchai Satrawaha

The study analyzes the temporal and spatial dynamics of major floods in the lower reach of Songkhram River, one of the most important areas for aquatic biological production in the Lower Mekong River Basin:

- *rational*. Current wetland inventories and surveys are not inadequate, emergence of holistic approaches and collection of space and time dependent data. There is lack or limited accessibility to available data, Remote Sensing (RS)/Geographic Information System (GIS) aided approaches were found to be most effective in monitoring extent, damage and frequency of floods, but application is limited to a small community;
- *area.* Lower reach of the Songkhram River Basin that covers about 55% of the total basin area, and is home to about 2.5 million people. It is an agriculture and human settlements area. Floods extend up to 2,000 km^2 in wet years, with water depths of 1 - 2 metres;
- *results.* Classified maps showing spatial dynamics of major floods, temporal dynamics of major floods, the accumulated extent of major floods, the extent of land uses that are being affected and the extent of low-lying areas;
- *use.* Inputs for flood height modelling and inputs for mapping flood risk areas:
    - *timely information and easy access* of flood information to communities;

* *create awareness and train community* and local authorities for flood risk management;
* all *scientific information must be backed by capacity building* initiatives;
* *involve community in decision making* process and community participation;
* community flood risk *mapping prioritizing different danger zones* and type of danger and vulnerability assessment;
* a *platform* for sharing information and synergy with stakeholders;
* *up-scaling* of community initiatives to national scale to cover at risk communities;
* *provide hazard and risk maps* to communities to use and practice;
* *use other media (TV, radio, etc.)* to promote community awareness;
* assist in *determining roles and responsibility* of communities and local authorities;
* *provide necessary 'hardware'* to communities to respond to flooding (boats, dykes, etc.) and training to community how to use them;
* *increase community awareness* before floods;
* conduct *community capacity assessment;*
* *re-assessment of community preparedness* before floods, such as check lists and drills;
* *strengthen institutional mechanisms* at community and above levels for better coordination;
* *incentives to communities* to be part of the Community Based Flood Risk Management (CBFRM) processes;
* *identify and address the needs of vulnerable groups* within the community such as children, women, old aged, widows, etc.;
* *planning for livestock evacuation* is important in CBFRM processes;
* *establish two way flood early warning* communication;
* *create community volunteers* like Red Cross volunteers to promote CBFRM initiatives;
* *establish emergency response* systems for communities;
* *assistance from outside* to overcome flood damage.

Report on Topic II

FLOOD FORECASTING AND FLASH FLOOD GUIDANCE

RAPPORTEUR: DAO TRONG TU

Deputy Secretary General, Ministry of Agriculture and Rural Development (MARD), Viet Nam National Mekong Committee (VNMC), Hanoi Viet Nam

Achievements:

- *Vietnam.* Flash flood forecasting and warning are made daily for the areas with high risk of flash flood occurrence in 6 steps and in the process of the Flash Flood Guidance System (FFGS) trial. FFGS has a friendly interface, is easy to use, provides information in real time diagnostics, which can be used by forecasters associated with other local forecasting information to disseminate reliable flash flood warnings;
- *Thailand:*
  - warning criteria for flash floods have been established for Chi and Lower Mun river basins;
  - to develop an automatic remote monitoring system (meteorological, hydrological and water quality telemetry system);
  - to develop water resources models and database software;
  - to develop criteria that are being used for flood warning, flood inundation and flash flood guidance;
- *Cambodia:*
  - flood forecasting and flood early warning for 40 flood marks for 3 days ahead are in operation;
  - flood probability maps and disaster management planning have been established.

Weaknesses/gaps:

- variety of information, but no grouping has been systematically arranged under the same standard. Therefore it is quite difficult to access the databases;
- lack of connection, linkage of complete and modest information;
- lack of skilful personal;
- lack of information system and knowledge base centre for national water resources;
- problem of integrated participation in management of stakeholders in public, private sectors, local government and people;
- human resources and capacity of provincial staff are limited;
- continuous data collection is needed;
- networks need to be improved;
- limitation of sending the flood product and warning to the local community.

Recommendations:

- improve effective warning communication;
- finding user's needs and users feedback;
- improve cooperation, communication and coordination among countries in the region;
- use advanced technologies for forecasting;

- develop exchange programs and internships among/between riparian countries;
- evaluate regional approaches in monitoring network sustainability;
- evaluate availability and capability of spatial and temporal resolution of rainfall forecast for hydrological application.

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Report on Topic III

STRUCTURAL MEASURES AND FLOOD PROOFING

RAPPORTEUR: VIRANA SONNASINH

National Flood Expert, National Flood Unit, Lao National Mekong Committee Secretariat
Water Resources and Environment Administration, Vientiane, Lao PDR

Presented papers:

- Potential use of ALOS PALSAR in flood hazard mapping , a case study in 5 district in Lao PDR;
- Appropriate flood mitigation framework through structural and non structural measures for the Chi River Basin, Thailand;
- Development of a roadmap for flood and drought risk management in the Greater Mekong Sub Region.

Potential use of ALOS PALSAR in flood hazard mapping, a case study in 5 districts in Lao PDR:

- Use of ALOS PALSAR for rapid flood mapping for 2008 floods in Lao PDR;
- help to map flood in the clouded situation;
- requires good technology, good capacity and real time flood mapping;
- with the help of two proper PALSAR Fine Beam Dual polarization images flood extent can be delineated with sufficient ground truth information.

Appropriate flood mitigation framework through structural and non structural measures for the Chi River Basin, Thailand:

- Chi river is characterized by high intensity rainfall, high development, deforestation and flood mitigation structures;
- proposed measures – combination of structural and non structural measures (river normalization, green river, retention storage, land use zoning and appropriate operation).

Development of a roadmap for flood and drought risk management in the Greater Mekong Sub-region (GMS) (Cambodia, Lao PDR and Viet Nam):

- flood and drought mitigation and management in GMS region;
- risk vulnerability assessment;
- identify appropriate intervention with the countries;
- focusing on three issues: risk, time frame, strategy and intervention;
- multi criteria for selection and prioritization, mix of measures for structural and non-structural.

Recommendations:

- full participation of riparian countries;
- structural measures and non-structural measures require cost benefit considerations;
- strengthening the capacity on technical and knowledge of local administration, knowledge sharing among riparian countries;

- basin wide assessment of structural measures needs to be made prior to the planning and with regard to Integrated Water Resources Management (IWRM) and Integrated Flood Risk Management (IFRM) approaches;
- integrated management considering the combination of floods and droughts;
- how to reduce the flash floods and mud flows by risk assessment, exploration of methods and tools for the structural measures to mitigate the impact from flash floods (for community, etc);
- Mekong River Commission (MRC) role in managing the structures in the Mekong River Basin (MRB), multi purpose operation (water supply, recreation, etc.).

Report on Topic V

LAND USE AND CLIMATE CHANGE IMPACTS ON FLOOD MANAGEMENT

RAPPORTEUR: VU MINH THIEN

Viet Nam National Mekong Committee, Ha Noi, Viet Nam

There were three presentations under this Topic:

- *Using regional climate model to generate climate change scenarios for Mekong River Delta* by Nguyen Van Thang and Nguyen Dang Mau;
- *Project WISDOM: a progress report from the hydrologic and water resources sub-component* by Erich J. Plate and the WISDOM Project Team;
- *Climate change and flood in the Mekong Delta* by Nguyen Tat Dac.

Using regional climate model to generate climate change scenarios for Mekong River Delta by Nguyen Van Thang and Nguyen Dang Mau:

- *introduction:* climate change during the 21st century will be unavoidable. In Viet Nam: in 50 years, the temperature has increased 0.5 - 0.7 ^{o}C and has made natural disasters more severe;
- the PRECIS model was applied for two scenarios (A2, B2);
- *conclusions (end of 21st Century):* temperature increase 2.1 - 2.7 ^{o}C (B2), rainfall increase in the flood season and reduction in the dry season; increase of inundation 19% in Mekong Delta in case of sea level rise of 0.75 m; with severe consequences on salinity intrusion.

Project WISDOM: a progress report from the hydrologic and water resources sub-component by Erich J. Plate and the WISDOM Project Team:

- WISDOM permits to store all water and land related data from different sources, analysis, models and provides to user online access;
    * use is made of remote sensing, GIS and field surveys;
- *field studies show:* tidal influences are very strong, turbidity is mainly influenced by tide, acidity of water strongly influences turbidity;
- more extreme events may be expected and likelihood of flooding is increasing.

Climate change and flood in the Mekong Delta by Nguyen Tat Dac:

- the Mekong Delta is affected by a tropical monsoon climate, it has two seasons and tides in the sea;
- Climate Change leads to change in sea level, rainfall and temperature;
- Application of the DELTA model for 8 scenarios (combination of the changed discharge in Kratie, rainfall, sea level rise);
    * impact of the change flow in Kratie mainly below Kratie to Tan Chau;
    * the area below Tan Chau is dominated by tidal variation.

Recommendations:

- the WISDOM data bank would have to be available to users, and become regional;

- meteorology needs to be studied in more detail in order to improve rainfall forecasts (combination of typhoon and rainfall data for analysis);
- close cooperation between WISDOM and the Mekong River Commission (MRC);
- develop feasible action plans (Line Agencies of the MRC Member Countries) based on Climate Change related findings of the projects (WISDOM and Vietnamese NPT);
- capacity building and awareness raising among communities based on the Climate Change related findings of the projects (WISDOM and Vietnamese NPT);
- develop dam operation rules to optimize the water resources management.

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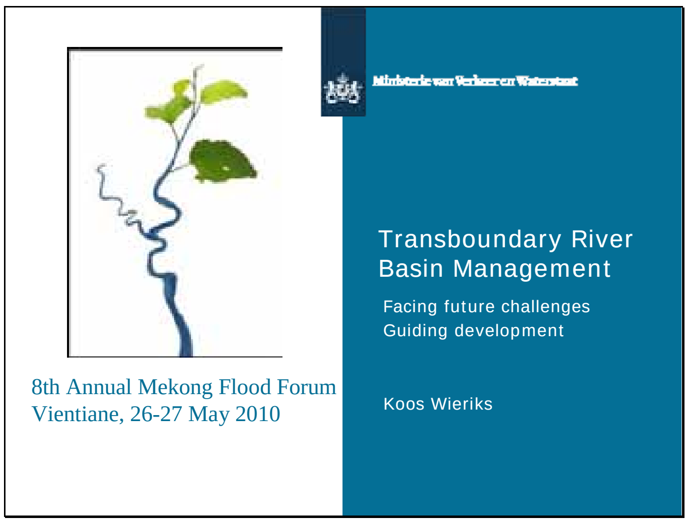
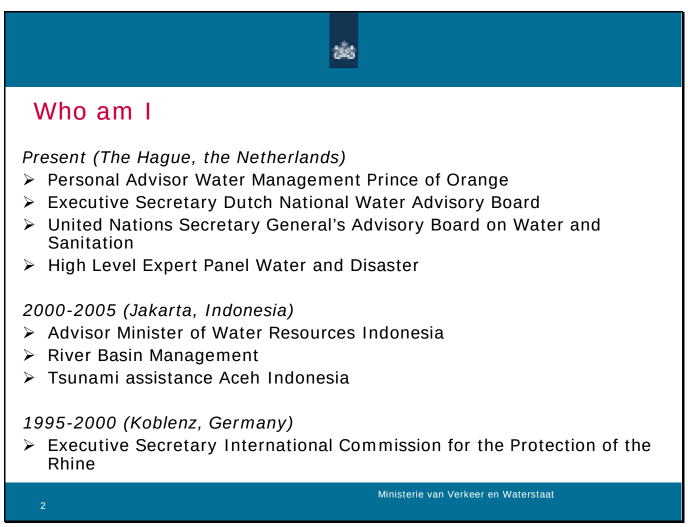
Special presentation

TRANS-BOUNDARY COOPERATION IN THE RHINE RIVER BASIN

KOOS WIERIKS

Personal Advisor Water Management of H.R.H. the Prince of Orange
General Secretary of the Netherlands Advisory Commission Water, the Hague, the Netherlands





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River Basins over the world

- 260 major international rivers
- 45% of earth's surface
- home to 40% of the world population

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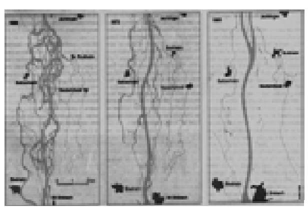
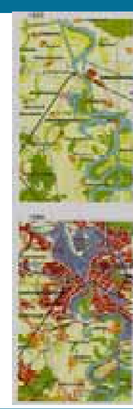
Importance of rivers

- Early settlements Rhine, Nile, Ganges
- Water provision and discharge
- Basis for socio-economic development
- Carrier for sustainable development





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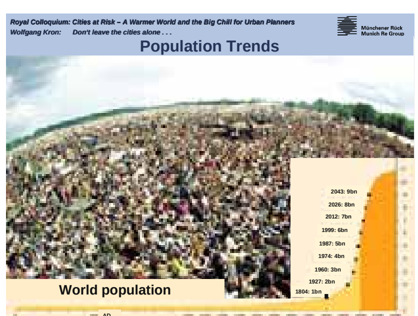
Trends

- Population Growth



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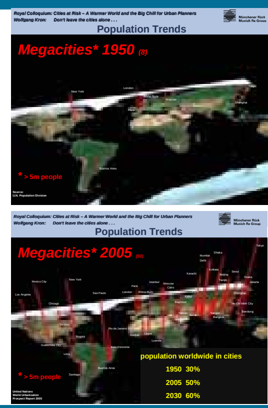
Trends

- Population growth
- Urbanization



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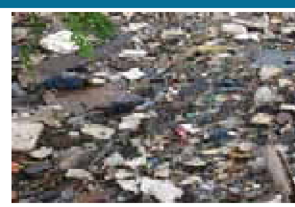
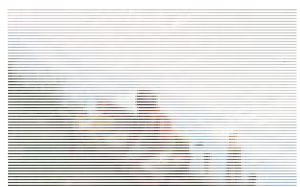
Trends

- Population growth
- Urbanization
- Pollution





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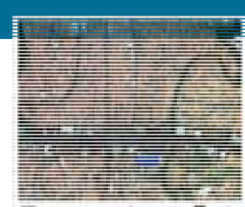
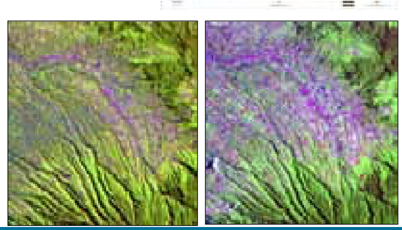
Trends

- Population growth
- Urbanization
- Pollution
- Intensified landuse





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Trends

- Population growth
- Urbanization
- Pollution
- Intensified landuse
- Deforestation

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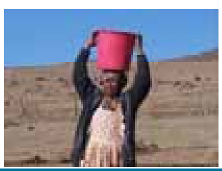
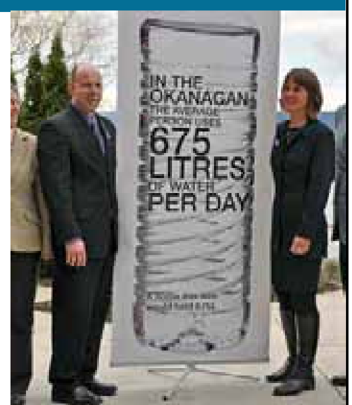
Trends

- Population growth
- Urbanization
- Pollution
- Intensified landuse
- Deforestation
- Growing demand for water, food energy





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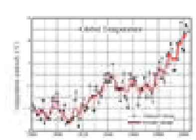
Trends

- Population growth
- Urbanization
- Pollution
- Intensified landuse
- Deforestation
- Growing demand for water,food, energy
- Climate change



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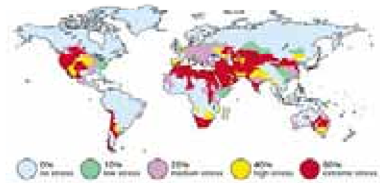
Consequences

- Water stress



40% global water gap by 2030

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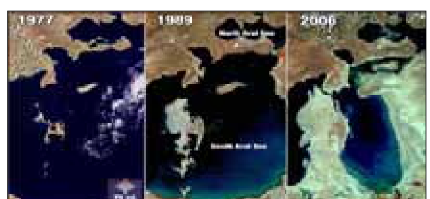
Consequences

- Water stress
- Drought



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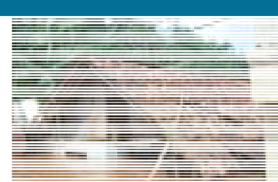
Consequences

- Water stress
- Drought
- Flood



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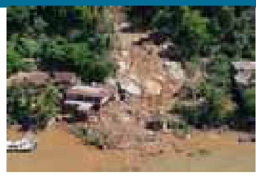
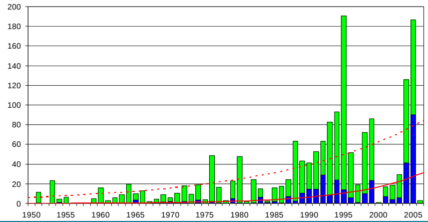
Consequences

- Water stress
- Drought
- Flood
- Water related disasters





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Consequences

- Water stress
- Drought
- Flood
- Water related disasters
- Hunger, disease

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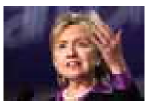
Consequences

- Water stress
- Drought
- Flood
- Water related disasters
- Hunger, disease
- Conflict



"Perhaps no two issues are more important to human health, economic development, peace and security than basic sanitation and access to sustainable supplies of water"

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Message 1
Plan now to avoid problems tomorrow

Necessary because:

- More people need more space, more food, more water and produce more waste
- climate change will cause more rain, more drought, sea level rise
- further uncontrolled changes in land use
- further uncontrolled growth of urban areas

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Message 2
Integrated river basin approach is essential

- Problems cannot be solved by one partner alone, cooperation is needed
- Need for systematic basin planning and management
- Need for basin manager

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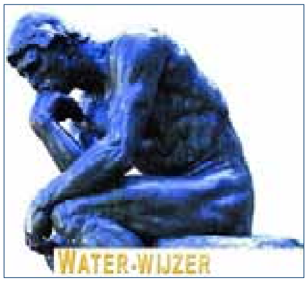
Message 3
Don’t invent the wheel again

- Much experience available from other countries and basins
- Regional differences in geo-political situation, but basic principles for basin management can be applied everwhere
- Don’t copy but learn
- Avoid different tracks for water management (IWRM) and climate change adaptation (NAPAs)



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Message 4
It's all about cooperation

- For the people
- Integrated, holistic approach
- Community based
- Basin wide
- Stakeholder involvement
- Cooperation model, together
- Visible results
- Solidarity
- Preventive approach
- Role sharing, cost sharing

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Message 5
It only works when all basic requirements are met

- Organizational structure
- Legal basis + law enforcement
- Financial basis, cost recovery
- Data
- Implementation
- Transparency
- Ambition
- Political will

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Message 6
The whole is greater than the sum of its parts

- Cooperative approach in Rhine, Danube, Mekong
- Non-cooperative in Nile, Euphrat, Tigris, Jordan
- Trust and understanding can be supported by negotiated trade-off or legal action
- Try to maximize gains; not per definition optimal for all
- Start simple, expand on positive experiences

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Message 7
Beware of the pittfalls

- Without sound data and knowledge about the basin no sound decisions can be made
- Plans and agreements are only paper; don't forget the implementation; it's about the people and for the people!
- Without local capacity implementation will be hampered
- Make sure that planning is accompanied by budgetlines and budget reservations
- Don't use blueprint planning, be flexible and give guidance for development

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Example: flood management

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France - Tenessee – Rio de Janeiro - Poland

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Guideline for solutions

- Anticipating instead of reacting
- Not passing on water management problems, and not passing on administrative responsibilities (incl costs)
- The three step strategy: Retaining, storing and draining
- Think out of the water box: Spatial planning in addition to technological measures

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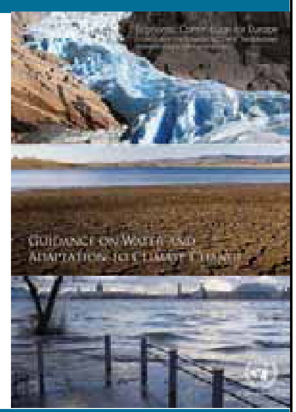
ECE

- European Commission for Europe
  Guidance on Water and Adaptation to Climate Change



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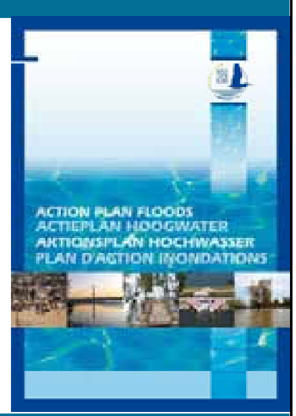
Rhine Action Plan on Floods

- Reduce damage potential
- Reduce floods levels
- Increase awareness
- Improvement of flood forecasting
- Be prepared, absolute safety doesn't exist



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Example: the Netherlands

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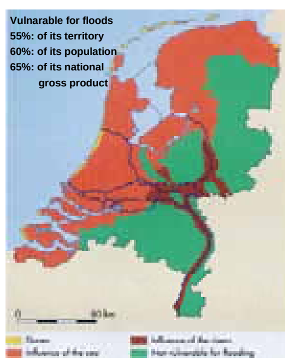

The Netherlands: delta area

- Long coastline: 350 km
- Large rivers: Rhine, Meuse
- Large fresh water reservoir

- 55% of at risk for flooding
- 60% of its population at risk
- 65% of GNP earned at risk

- 3600 km of flood defences
- hundreds of sluices, storm surge barriers and pumping stations

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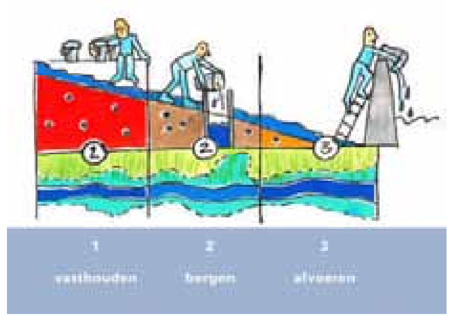
Retaining – Storing - Draining



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Space for Water

More space for the river can be created by
A inland relocation of the winter dykes,
B lowering the floodplains,
C removing obstacles in the flood plains; and
D creating retention areas outside the riverbed.

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Delta Committee 2008:

The threat is not *acute*,
but it is very *urgent* to address
safety against floods and
ensure sufficient fresh water supply

Recommendations:

-Technical	*Delta Programme*
-Legal	*Delta Act*
-Financial	*Delta Fund*
-Institutional	*Delta Commissioner*

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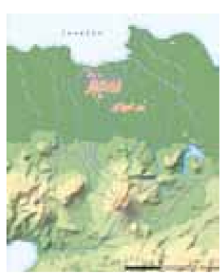
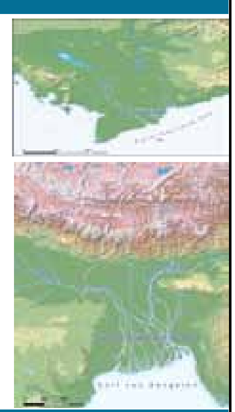
Five Deltas Cooperation





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13th UNSGAB meeting December 1st 2009

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Final message
Move forward and ..

- Be ambitious
- Be realistic
- Be patient

because

- *Water is development*
- *Water is health*
- *Water is dignity*
- *Water is life*

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Contact

- Koos.wieriks@minvenw.nl
- Koos.wieriks@gmail.com
- +31 70 351 8522

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Ministerie van Verkeer en Waterstaat

SUMMARY OF PROCEEDINGS AND RECOMMENDATIONS FOR FOLLOW-UP

BART SCHULTZ

Land and Water Development, UNESCO-IHE, Delft, the Netherlands

INTRODUCTION

Flood risk management is of increasing concern for authorities and citizens of many countries with flood prone areas. Flood vulnerability is generally increasing due to population growth and 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 risk management and mitigation approaches and measures.

In light of these developments in the Mekong River Basin (MRB), during the preparation of the 8th Annual Mekong Flood Forum (AMFF-8) there was a commonly felt need to select as a theme for the Forum *Flood risk management and mitigation 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 relevant aspects under the theme, focus was on five topics:

I. Community focused approach to flood risk management and mitigation;
II. Flood forecasting and flash flood guidance;
III. Structural measures and flood proofing;
IV. Trans-boundary cooperation for managing floods and related issues;
V. Land use and climate change impacts on flood management.

This summary of proceedings and recommendations for follow-up of AMFF-8 describes the main issues as presented and discussed during the forum and summarises the recommendations for follow-up.

BACKGROUND

Flood preparedness and emergency management of local authorities and communities is at the forefront to encounter flood disasters. This non-structural community focused approach forms an important part of flood risk management and mitigation, which is only recently being applied in the Lower Mekong River Basin (LMB). Programmes of enhancing the competence of civil authorities at various levels, emergency managers and communities in flood preparedness and mitigation will help facilitate the objective that emergency management systems in the riparian countries are more effectively dealing with Mekong floods. Therefore assistance and technical support to disaster management authorities, particularly at province, district and commune level may help to fill the gaps and needs of existing systems. Local disaster management authorities may take the lead in the development and implementation of flood preparedness programs in which clear roles and responsibilities are defined for line departments of provincial, district and

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commune disaster management offices. Various innovative approaches to flood risk reduction can be carried out in support to flood preparedness programmes, including promoting local, national and regional knowledge sharing, province to province cooperation in flood emergency assistance, and in ensuring sustainability of flood preparedness programme activities by integrating them into the local development planning process. People-centred approaches are generally low-cost, effective, and relevant to local conditions in a flood prone area. Ownership may gradually evolve and sustainability can be secured.

Meteorology, weather forecast and conditions in a river basin create the basis for producing flood forecasts and early warnings. An efficient data collection, processing and retrieval system for meteorological and weather forecast data will be of utmost importance to enable adequate input to river flow modelling and finally the issuing of forecasts. In case of the MRB most of the data are collected by the agencies in the riparian countries, while forecasts for the mainstream of the Mekong River are given by the MRC-RFMMC as well as by most of the riparian countries. This requires a good compatibility and timely provision of data, based on agreed accuracy and protocols. The 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. In addition to floods in the mainstream, increasingly flash floods occur in tributaries, especially in sloping and urbanised areas. The preparation of such forecasts requires different ways of data/information collection and forecasting mechanisms. With respect to these two aspects a wide range of new developments need to be employed such as weather models, satellite technology, remote sensing techniques, global positioning systems, geographic information systems, automation in data collection, transmission, storage and retrieval, and actual issuing of forecasts and warnings.

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. The main objective of structural measures and flood proving in the LMB will be to reduce the vulnerability of people living in the LMB to the negative impacts of floods. This requires preparation of concrete measures at the steps that are crucial for a socio-economic and environmentally sound integrated flood risk management (IFRM) by applying the most effective mix of possible measures, hard and soft, for the reduction of flood damage risk. This is generally implemented in five steps. The first step is the proper assessment of flood damage risk. Secondly comes the formulation of structural flood risk management and mitigation measures. The third step involves the evaluation of the effects and impacts of the different types of measures and development of 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 three previous steps. The 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 MRB 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 an upstream country may have negative impacts in a downstream country. Under certain conditions measures in a downstream country may even have impacts in an upstream country. In several river basins experience has been, or is being obtained with approaches to cooperation among the riparian countries. In light of the on-going developments in the MRB such experiences are of importance, both for the MRB, as well as for other trans-boundary river basins in the World.

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Rapid population growth, a significant increase in agricultural exploitation, urbanisation and industrialisation may be observed in most of the flood prone areas. In addition there may be impacts of land subsidence and climate change. Although the changes due to these processes may be of different speed and magnitude, they all result in an increase in vulnerability for extreme weather conditions and the requirement of an increase in measures to be taken with respect to flood management. Therefore countries would have to develop a strategy and approach with respect to flood probability based land management. Current land management practices may be an important factor contributing to a situation where already regular floods may cause substantial damage to agriculture, buildings and infrastructure. More effective decision making in these fields, as well as disaster management, require on the one hand the provision of more relevant and accurate flood related information and on the other hand how conditions with respect to flood vulnerability may change in the short and longer term future under the influence of the impacts of changes as mentioned above. Improvements in land management by considering flood probability information do not only provide direct positive impacts through the reduction of damage to agriculture, buildings and infrastructure, but also indirect benefits through the avoidance of damage to the most vulnerable parts of the population living and working in the flood prone areas. The various issues as mentioned before have resulted in a set up of the Forum programme along the following main lines:

- presentation of a summary of the 7th Forum (AMFF-7) on the theme *Integrated flood risk management in the Mekong River Basin*, as well as on the set-up and expectations with respect to the 8th Forum;
- presentations on *Lessons learned from 2009 floods and flooding and National and MRC-RFMMC experiences with flood risk management and mitigation in the Mekong River Basin* by the MRC Member Countries and Dialogue Partners, and by the MRC-RFMMC;
- presentations by staff and consultants of MRC-RFMMC on the five components of the Flood Management and Mitigation Programme (FMMP);
- the above presentations were followed by parallel paper presentations with primarily papers from the region on Topics I, II, III and V. The presentations were followed by discussions. Unfortunately there was only one paper submitted on Topic IV. This paper was presented in plenary session 4. In addition attention was paid to this topic by a paper of MRC-RFMMC and by the Special Presentation;
- the initial observations and results of the plenary and parallel sessions were presented by the FMMP coordinator and briefly discussed in the plenary session at the start of the second day. In addition seven papers were presented on the various topics;
- this was followed by discussions on the topics I, II, III and V that resulted in reports by the rapporteurs with conclusions and recommendations on each of the four topics;
- the 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 on *Trans-boundary River Basin Management. Facing future challenges guiding development* was given by Mr. Koos Wieriks. At present Mr. Wieriks is: Personal Advisor Water Management of the Prince of Orange, Executive Secretary of the Netherlands National Water Advisory Board and of the United Nations Secretary General's Advisory Board on Water and Sanitation and High Level Expert Panel Water and Disaster;
- at the end of this session the Forum Statement was adopted.

SOME GENERAL POINTS

The Forum was held on 26 and 27 May 2010 in Vientiane, Lao PDR. It was attended by about 125 participants coming from the MRC Member Countries and Dialogue Partners, organisations working in the MRB, international organisations, civil society organisations, institutions and

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companies, attended it. There were 33 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-8

The objective of AMFF-8 was that 'Based on the outcome of the 8th Annual Mekong Flood Forum, the MRC-RFMMC, MRC member countries, CSOs and IOs will be able to improve their services, and strengthen their capability and collaboration mechanisms for improving flood risk management and mitigation practices in the LMB in order to better address the aspects of human security due to floods, development and environment'.

More specifically, AMFF-8 was set to discuss the following aspects:

- lessons learned from the 2009 floods by the Line Agencies of the MRC Member Countries;
- achievements, progress and future outlook with respect to the five components of the FMMP, being: *1. Establishing a Regional Flood Management and Mitigation Centre; 2. Structural measures and flood proofing; 3. Enhancing cooperation in addressing trans-boundary flood and related issues; 4. Flood emergency management strengthening; 5. Land management*;
- current status of and outlook for flood risk management and mitigation approaches and measures;
- experiences with the Mekong River Flood Forecasting System and systems for flood forecasting and early warning in use and under development by the National Centres. To keep the MRC Member Countries, their Line Agencies and CSOs informed about the progress with respect to the MRC-RFMMC flood forecasting database system, as well as the exchange of data among the MRC Member Countries and the MRC-RFMMC, which is essential for operational medium-term flood forecasting for the mainstream of Mekong River, based on basin wide rainfall and water level data availability;
- experiences and best practices with CSOs, International Organisations (IO), academic institutions, consultants, manufacturers on the various elements of flood risk management and mitigation. To strengthen cooperation and information exchange among the international community, IOs and CSOs;
- information on the requirements that the different types of land-use and various types of measures pose to flood risk management and mitigation in the conditions of MRB;
- information as to what extent flood risk management and mitigation results in

information that enables institutions or individuals to take the best possible measures to reduce damage and number of casualties;

- how lessons learnt from the flood season 2008 and subsequent Action Plans were implemented in 2009.

The Forum was result oriented to ensure that it really benefited the MRC-RFMMC and MRC Member Countries for their improved flood risk management and mitigation services; especially the provision of flood information and early warning systems to the vulnerable communities in the LMB. The goal was that the countries use the Annual Mekong Flood Forum as a platform to review and improve their own flood policies, plans and implementations.

Envisaged outcome of AMMF-8

The main expected outcome of the Forum was formulated as follows:

> *Based on the outcome of the 8th Annual Mekong Flood Forum, the MRC-RFMMC and MRC Member Countries will be able to improve their integrated approaches to flood management and mitigation. This implies improved data and information exchange, improved systems and tools for dissemination of flood forecasting, flash flood guidance and early warning products, improved application of a flood risk assessment and management, the development of guidelines for preparation of flood risk reduction plans and for evaluation of the impacts of flood risk reduction and management measures, strengthened identification of potential trans-boundary issues for negotiation, mediation and conflict prevention.*

INAUGURAL SESSION

In the opening addresses the following items of relevance for the proceedings were mentioned. These are:

- *Jeremy Bird,* Chief Executive Officer of the Mekong River Commission Secretariat:
  - regional forecasts become more and more important;
  - man induced and climate changes will have their impacts on the regime of the Mekong River. This will give challenges to maintain the quality of flood forecasts;
  - there is a strong need to continue with flood risk management and mitigation measures both at National and Regional level;
  - formulation of the next phase of the FMMP programme is on-going. With respect to this regional cooperation on flood forecasting is considered a core function of the MRC;
  - in the next phase there has to be a gradual transfer to fully locally funded operations;
  - innovative ideas for community involvement in flood management will have to be encouraged and where possible implemented;

- *H.E. Ms. Khempheng Pholsena,* Minister to the Prime Minister’s Office, Head of Water Resources and Environment Administration, Chairperson of the Lao National Mekong Committee, and Member of the MRC Council for Lao PDR represented by *Mr. Phonechaleun Nonthaxay:*
  - the importance of Forum theme for the Lao PDR society was stressed, as well as the general importance of the MRC programme;

- *Martien Beek,* Royal Netherlands Embassy, Ha Noi, Viet Nam:

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  * in order to enable a careful preparation of the next phase of the FMMP, the Netherlands will provide a bridging fund for 2011;
  * funding of follow-up would increasingly require National funding by the riparian countries and a gradual reduction of donor funding;

- *Ms. Sezin Tokar*, U.S. Agency for International Development (USAID) remembered well her five years of participation, recognised the significant progress that has been made over the years and raised the following points:
  * strong basin wide cooperation is crucial;
  * the cooperation in the MRB is considered to be an example for basin wide cooperation;
  * she offered continued support in cooperation with partners;

- *Ms. Petra Shill.* Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), stressed the following points:
  * GTZ is supporting Component 4 and 5 of FMMP;
  * importance of the networking function of the Forum;
  * recent years gave the fifty years lowest and highest discharge of the Mekong River at Vientiane;
  * due to hydropower development, land use changes and climate changes that are taking place in the MRB there are increasing uncertainties;

- *Ian Makin*, Asian Development Bank (ADB):
  * It is a critical time for MRC and flood risk management. Question is what the critical functions for MRCS/RFMMC are;
  * so far funding has been donor dominated. If countries value these services they need to contribute as well. There has to be a gradual transition;
  * ADB will give support to formulation of the follow-up;

- *Dr. Hatda Pich An*, Operations Manager MRC-RFMMC presented a summary of 7th Forum;

- *Dr. Lam Hung Son*, Coordinator FMMP presented the objectives and expected outcome of AMFF-8.

The inaugural session was concluded with a demonstration of the MRCs Flood Forecasting and Flash Flood Guidance systems that have been developed for the MRB.

LESSONS LEARNED FROM 2009 FLOODING AND NATIONAL AND MRC-RFMMC EXPERIENCES WITH FLOOD RISK MANAGEMENT AND MITIGATION

During the Forum the MRC Member Countries presented their country flood reports for 2009. In addition there were presentations by the Dialogue Partners China and Myanmar, as well as by MRC-RFMMC on the 2009 flood report. The flood reports contain a good overview on the situation with respect to flood and flooding in 2009, as well as how the countries are organising their flood risk management and mitigation 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 rapporteurs of several key points are listed underneath:

- *general:*
  - * strong political commitment is very crucial for successful large-scale flood preparedness. The recent 1st MRC Summit showed the strong support and commitment of the Heads of States of the MRC Member Countries to cooperation;
  - * mainstreaming of disaster risk management (DRM) into the national planning cycle is crucial for its successful implementation. Better coordination and cooperation between institutions responsible for land use planning and institutions responsible for flood management, flood forecasting and early warning is of importance. In relation to this institutional strengthening for disaster risk reduction (DRR) is urgently needed. An internal and external coordination mechanism is important for resources mobilization;
  - * a comprehensive review and sector wide program approach are required for DRM in support of effective implementation (standard operation procedures, hazard mapping, clear mandate of Disaster Management Centres (DMC) at all levels);
  - * the FMMP would have 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;
  - * to respond to flood damage, the Royal Thai Government has set some Policy Statements related to flood disasters. These include implementation of a flood management plan, to develop and install early warning systems in mountainous areas, to set telemetry in low lying flood prone areas, to set up closed circuit television (CCTV) and installation of water level staff gauges to check, look out, and follow-up by action during flood events. Moreover the government attempts to set a Water Act by the National Water Resources Committee, to set up River Basin Committees in 29 basins, which consist of key persons 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 the comments of involved government agencies and committees and that it will present the draft revised Water Act to the Cabinet for approval;
  - * China recognizes the importance of the role of MRC in water resources management, economic development and regional cooperation. It will continue the cooperation with MRC by providing data, receiving delegates and providing training;
  - * to manage drought and flood Myanmar introduced river training activities (structural measures) with various river works activities. The result has been good with no casualty recorded;

- *2009 flood events:*
  - * *Mainstream Mekong River floods:*
    - \+ flood volumes in 2009 were very low and the flood season ended very early contributing to development of regional hydrological drought. Water levels in the upper part were low and in the lower part from Kratie downstream they were about the average;
    - \+ in Cambodia, Lao PDR and Viet Nam Mekong floods in 2009 can be considered as normal floods with more benefits and less damage compared to floods in other years. Damage by Mekong floods in 2009 was very small;
    - \+ in Thailand there was heavy rainfall from 11 to 31 August with overbank flooding of the Mekong River. It has caused trouble to the people along Mekong River and in sub-basins;

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- *flash floods:*
  - + flash floods occurred in tributaries and caused severe damage. They need to be carefully monitored at the regional level;
  - + there is no evidence that the frequency of tropical storms is currently increasing;
  - + Cambodia got affected by two main flash floods. Most devastating were the flash floods due to the Typhoon Ketsana. Due to these flash floods 56 people died, 80,000 families were affected, 2,030 houses, 66,700 ha of rice and some infrastructure were damaged;
  - + in Lao PDR the flooding in 2009 was dominated by flash floods in the major tributaries of the Mekong River. Particularly the flash flood in the Southern part of Lao PDR induced by the Typhoon Ketsana, caused heavy rainfall, recorded between 53 and 201 mm. The 28 storm-related deaths, more than 180,000 directly affected people and US$ 58 million damage caused by Typhoon Ketsana was considered as national a catastrophe and the national relief campaign was launched. The disaster management committees at national, provincial and district levels functioned and the national fiscal plan was revised to support the emergency response. However, the national effort was considered insufficient and international relief support was called in;
  - + in Thailand the average rainfall in 2009 was slightly lower than the 30 years average rainfall, but higher than the 2008 average rainfall. The distribution was not homogenous. On 30 September and 1 October there has been the Tropical Storm Mekkhala and on 19 and 20 November the Tropical Storm Noul. Due to the flooding 65 provinces: 67 people died, 4,494,189 people of 1,197,253 households were affected, about 18,300 houses and about 4,840 km^2 agricultural areas were damaged. The total damage was US$ 72 million;
  - + the meteorological conditions in Viet Nam were very complicated with several extreme food events in the central part and in the highlands. Six tropical storms and one tropical depression exerted their direct impacts on Viet Nam's territory. There were series of typhoons that landed in Viet Nam, namely Soudelor, Mujigae, Ketsana, Parma, and Mirinae. Nine serious floods occurred in the main rivers, of which two were historical flood events in rivers in the Central Region and Central Highlands and in the South. 79 people died and the damage was US$ 91.4 million;

• *community focussed approach to flood risk management and mitigation:*

- a well set-up mechanism for disaster management and adequate financial and technical resources lead to better management with less casualties;
- the attitude of the population towards flooding is vital for the effective implementation of flood preparedness plans. Community resilience is important, awareness on basic flood risk reduction and mitigation measures and knowledge to use hydro-meteorological information have to be provided to communities at flood risk so that they can help themselves to some extent to reduce flood risk;
- community based flood risk management needs to be strengthened. Community self reliance for flood management and mitigation has proved to be effective. The Disaster Management Committees would have to focus on building capacity of the local community in flood preparedness and emergency responses;
- a financing mechanism and a capacity building program for DRM needs to be established in support of comprehensive flood risk management;
- agencies carrying out flood forecasting and early warning would have to 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;

* people who are involved in recession agriculture along the Mekong River and around the Tonle Sap Great Lake in Cambodia need seasonal forecasts to enable them to plan properly the planting time, which is presently not available;
* regular meetings and workshops need to be arranged to exchange information, knowledge and experiences among community members and centres;
* more involvement of communities in preparedness programmes and provision of appropriate training to help them better understand flood related issues is considered to be of importance;
* for Thailand it was reported that there was lack of an action plan, promotion, integrated database system and water management legislation;

- *flood forecasting and flash flood guidance:*

  * in order to improve the flood forecasting and warning, a review of hydrometeorological network coverage is needed to ensure sufficient data input for forecasting analysis. Improvement of data coverage is important for comprehensive flood forecasting and warning dissemination;
  * there is a need to conduct topographic surveys, prepare land use and topographic maps of the flood prone zones and to collect relevant hydrological data. This comment has been more or less made in each Forum, but still remains to be implemented to a large extent. National flood hazard mapping needs to be developed as well to facilitate the implementation of flood preparedness plans;
  * it was stated that the flow in Mekong River was impacted by the operation of upstream reservoir systems. In order to improve the accuracy of and be able to provide longer-term flood forecasts, it has been proposed:
    + to strengthen the cooperation with MRC in exchange of meteo-hydrological data, information and also the regulation mechanisms of reservoirs in the MRB (on mainstream and tributaries);
    + to supplement electronic gauge stations along Mekong River, especially in the upstream part of the river;
    + to invest in research and technologies to improve the longer term forecasts.
  * in Cambodia there are many kinds of efforts to disseminate forecast and warning products to flood-at-risk communities. However, mostly those activities are carried out under programs and projects with limited time frame and usually stop after completion of the project;
  * in Cambodia due to the lack of capacity and financial support, the forecasts and the products that can be made reach only limited areas. Because of the low level of education not all community members in those areas can access and understand the provided information;
  * in Lao PDR 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;
  * recently training has been given by MRC-RFMMC to staff of National Centres on the new flash flood guidance system;
  * MRC-RFMMC would have to continue to help taking care of some manual hydrological and meteorological systems as they will continue to serve as back up;
  * the MRC flood forecasting and dissemination would have to focus on establishing the link with the national flood forecasting agencies, so that the MRCS as the knowledge based river basin organization can provide its products to benefit the flood forecasting at the national level;
  * MRC-RFMMC would have to help strengthening capability of national forecasting

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institutions, from data collection, processing to development of forecasting models;
* MRC-RFMMC would have to allocate funds for longer term data collection and assistance in installation of more hydrological stations to extend the coverage areas, so that also main tributaries can be covered;

- *structural measures and flood proofing:*

  * there is no standard format for assessing flood damages, which results in misuse of resources. Therefore a standard format for assessing direct and indirect flood damages and losses needs to be developed in support of better flood management and mitigation, and of resources allocation in particular;

- *trans-boundary cooperation for managing floods and related issues:*

  * various joint working groups and committees, from national level down to local level, have been established by Cambodia and Viet Nam;
  * affordability for flood forecasting needs to be considered, as well as appropriate technology and trans-boundary cooperation on data and information exchange;

- *land use and climate change impacts on flood management:*

  * flood management and mitigation need to be well placed in modern planning and operation;
  * in the Mekong Delta there is a signal of impact of climate change causing extreme events, although this was debated.

Key recommendations for next steps of the FMMP**:**

- it will be of importance to strengthen cooperation in exchange of meteo-hydrological data, information and regulation mechanisms of reservoirs in the MRB for the mainstream and tributaries;
- the MRCS is still a key player in helping MRC member countries with flood management in terms of both financing and technical;
- additional electronic gauging stations along Mekong River would have to be set up;
- it is required to invest in research and technologies to ensure the quality of longer period forecasting;
- further development of knowledge, data quality and forecasting tools, especially with respect to the Flash Flood Guidance System needs to be further enhanced and strengthened;
- sustainable financing for flood management and network maintenance needs to be ensured;
- standards for damage assessment need to be set up.
- close cooperation with the Drought Programme of the MRC is needed to study in a parallel way with FMMP.

ACHIEVEMENTS AND PERSPECTIVES OF THE FLOOD MANAGEMENT AND MITIGATION PROGRAMME (FMMP)

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: Short and medium-term flood forecasting at the Regional Flood Management and Mitigation Centre

The MRC Flood Forecasting System consists of Delft-FEWS, the Unified River Basin Simulation model (URBS) and the ISIS Hydrodynamic model. URBS is used between Chiang Saen and Pakse and ISIS + Regression between Strung Treng and Chau Doc. The performance of the first test has been evaluated and was compared with 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. The 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 medium-term forecasts (up to 10 days). However, there is a need for further development and continuous improvement in order to obtain more accurate forecasts. A very clear website has been developed with links to the flood forecasting websites of the MRC Member Countries (Figure 1).

The MRC Flash Flood Guidance System (FFGS) has been applied on the small basin scale. FFGS has a friendly interface, is easy to use, it provides information in real time diagnostics, which can be used by forecasters associated with other local forecasting information to disseminate reliable flash flood warnings. It was found that satellite rainfall estimates need to be further developed for more accuracy while rainfall was now about 30% under estimated.

The MRC-RFMMC will officially operate the new Mekong FFS from 2010 onwards and the MRC-FFGS will be operated in a testing mode in 2010. Approval for this was obtained from the MRC Technical Task Group and the MRC Member Countries. However, further system performance improvement towards better forecast accuracies for all forecast stations needs to be further pursued by the MRC-RFMMC.

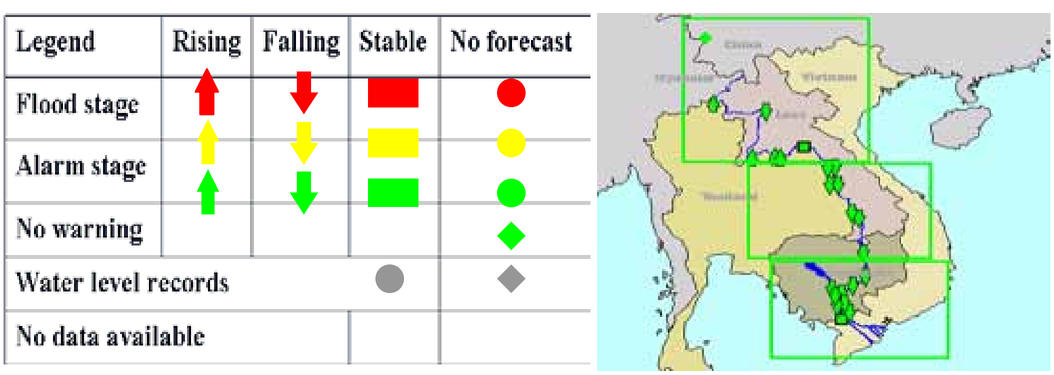

Figure 1. Key information on the flood forecasting website of MRCS

Component 2: Structural measures and flood proofing

To reduce the vulnerability of people living in the LMB to the negative impacts of floods the first objective of structural measures and flood proofing requires the preparation of concrete measures at the steps that are crucial for a socio-economic and environmentally sound IFRM.

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Flood depth probability and damage curves were generated to identify damage probability relations. By doing this it was found that topographic and hydrographic surveys are required, as well as adjustments of the ISIS model, while major problems were identified with application of the ISIS model in 2008 and 2009. The ISIS model would have to apply a 1D/2D configuration to significantly improve the representation of floodplain hydrodynamics. In aaddition practical applications of flood risk assessment and management principles are required to support Line Agencies of MRC Member Countries. Close cooperation with the Basin Development Programme, Environment Programme and Information Knowledge Management Programme on flood- and climate change related issues is required. The demonstration projects in Thailand and Lao PDR need to be followed up by implementation.

Capacity building has been applied through the implementation of selected demonstration projects. During the implementation of the demonstration projects IFRM planning exercises were applied in a limited number of focal areas. From these exercises 'best practice' guidelines for the preparation of flood risk management plans and for the evaluation of impacts of flood risk management measures are being developed. To establish sustainable capacity in the MRCS, National Mekong Committees (NMC) and national Line Agencies a series of consultations and training sessions to the MRC, National Mekong Committees and national Line Agencies will be conducted.

It was stated that key material would have to be selected, translated and disseminated under the Line Agencies of MRC Member Countries and that the use of Component 2 deliverables by the 'Floods and Droughts project' of the Asian Development Bank (ADB) would be a great opportunity for MRC Member Countries to select Component 1 projects for feasibility studies and later implementation.

Component 3: Enhancing cooperation between the MRCS and the MRC Member Countries in addressing trans-boundary flood and related issues

Enhancing cooperation between MRC Member Countries in addressing trans-boundary flood and related issues is intended 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, 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 and an Explanatory Notes - Manual.

The capacity building programme aims at to provide tailor–made training to the MRC, NMCs and Line Agencies in addressing trans-boundary floods and related issues, which is also the ultimate goal.

Implementation of the component started 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 was completed in November 2009. Implementation of Phase 2 will take place during 2010. Summarised information on programme products is as follows:

- 4 National reports 'Identification of Trans-boundary Flood Issues at National Level';
- 4 National reports of 'National Practices and Instruments on Addressing Inter-State

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Contentious Issues, Differences and disputes over Trans-boundary Water and Related Natural Resources Management Issues';

- 'Legal Aspects of the Mandate of the 1995 Mekong Agreement for Enhancing Cooperation in Addressing Trans-boundary Flood and Related Issues' (working paper);
- 'Explanatory Note', supplement to the Working Paper will be a 'Pocket Book' version;
- there have been three training and three exchange study tours;
- in the second part of 2010 a 'pilot study' will be conducted;
- exchange study visits to Europe and China provided substantial added-value.

It may be expected that in future the need for trans-boundary cooperation will increase.

Component 4: Flood emergency management strengthening. People-centred approach in integrated flood risk management

Flood emergency management strengthening based on a 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. Focus is 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.' There were activities in 11 provinces and 28 districts distributed as follows: in Cambodia 4 provinces and 10 districts, in Lao PDR 2 provinces and 6 districts, in Thailand 1 province and 2 districts and in Viet Nam 4 provinces and 10 districts.

The project has been providing assistance and technical support to disaster management 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 an Institutional Role Analysis and Improvement Identification that identified the gaps and needs.

Local Disaster Management 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 Provincial and District Disaster Management Offices. Various innovative approaches to flood risk reduction were carried out in support to FPP, including promoting local, national and regional knowledge sharing and trans-boundary province to province cooperation in flood emergency assistance, as well as ensuring sustainability the FPP activities by integrating them into local development planning processes.

The developed people-centred approach is low-cost, effective, and relevant to the 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 with lead in implementation by the MRC Member Countries.

Component 5: Flood information based land management (FIBLM)

Phase 1 (2004 - 2008) of flood information based land management (FIBLM) focused on the development of an approach to generate flood probability information by installation of river level stations, flood marks and flood information billboards, for floodplains of the LMB, particularly flood probability maps in three pilot districts in Cambodia. An alternative approach

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will be needed for the districts in Lao PDR and Thailand, apart from the lack of flood mark data, caused by the absence of flooding in 2009, due to ongoing flood protection works in the pilot districts causing instabilities of the statistical description of river hydrographs and because the Map Stat-Procedure is not applicable when the flood waters are not related to river levels throughout the flood season

Phase 2 commenced by August 1, 2008 and will run until December 31, 2010. Focus is on the adaptation of the developed technical tools (software) by the respective Line Agencies of all four riparian countries (Cambodia, Laos, Thailand, Viet Nam) 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 the four countries and supports the implementation of flood probability based land management in seven pilot districts (two in respectively 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. They are based on data on the probability of flooding, start of the flooding, maximum depth, duration and completion of drainage of flooding for a range of probabilities. Therefore they 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.

The Training of Trainers (TOT) programme, which addresses the data processing and the data using Line Agencies in the four countries, includes components designed to show how the maps can be used independently or in combination in a GIS application to answer complex planning questions related to land management, agriculture, irrigation, disaster preparedness and rural infrastructure development.

Recommendations:

- the planning authorities in the four MRC Member Countries as well as the Climate Change and Adaptation Initiative of MRC (MRC-CCAI) would have to use the FMMP-approach and its maps for their strategy against climate change effects (e.g. increase of flooding) as an adaptation and mitigation tool;
- Thailand and Lao PDR can find the best area to study flood probability maps or use a hydraulic model such as ISIS applied to each flood event and based on observed data;
- the area modelled would have to be expanded from the present pilot areas, including an extension of the Digital Elevation Model (DEM)/ Digital Terrain Model and the number of flood marks, supported by high quality satellite based flood extent mapping.

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RESULTS OF THE PLENARY AND PARALLEL SESSIONS

The content and summarised results of the plenary and the parallel sessions on the five 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, as well as in the formulation of a follow-up to the FMMP programme.

General items

Flood preparedness and flood emergency management strengthening remain core elements of the FMMP, as these address directly the needs of the flood vulnerable communities, and also indicate/guide the strengthening and operations of government agencies in the MRC Member Countries (at different levels: nation, provincial, district and communes) and of national and international NGOs. This is vital for enhancing communication, coordination and cooperation between these stakeholders, as well as the consistency of national disaster management and mitigation policy implementation.

Experiences clearly show that increased capacity of key officials of the provincial, district and commune Disaster Management Committees has led to a better flood preparedness in the selected provinces in the MRC Member Countries, mainly Cambodia, Lao PDR and Viet Nam. Active involvement of national government and local authorities at provincial, district and commune levels in the formulation and implementation of FPPs has been a major step to ensure consistency, ownership and sustainability, in addition to the activity of integrating Flood Risk Reduction (FRR) into local development plans. The flood preparedness and emergency management initiatives in the MRC member states have helped target provinces to be better prepared for floods.

While the FMMP contributions are widely recognised by the MRC Member Countries as time-bound ‘pilot’ initiatives, covering some of the vulnerable provinces and districts, and improving the competence in dealing with the Mekong floods, a longer term programmatic approach and up-scaling to a wider geographical area is required to ensure that the flood management and mitigation policy objectives are solidly embedded into the national disaster management strategies of the MRC Member Countries.

The role and mandate of the MRC, being an inter-governmental regional organization, provide the MRCS the unique position and niche, which allows connecting the FMMP with national, provincial and district disaster management agencies, as the MRCS works through the MRC member countries to implement programs at the national, provincial and district levels. The MRCS has thereby created a receptive environment for the implementation of a range of dedicated interventions at the commune level. It looks now on mainstreaming the FRR activities in line with the national DRR strategies into local development planning processes. The flood management and mitigation tools developed by MRCS have a basin wide approach and can be applied to support local level interventions.

With the follow-up of the current FMMP phase, the formulation of FMMP phase II, the MRCS seeks a long-term partnership with the European Commission under its long-term Disaster Preparedness European Commission Humanitarian Aid Office (ECHO) modality to continue focus on enhancing capacities on FRR. With the lessons learnt from the various components of FMMP and particularly from Component 4: ‘Flood Preparedness and Emergency Management Strengthening’, continuance of innovative flood focussed activities are crucial to reduce the risk of negative impacts by floods on the livelihoods of the people living in the LMB.

Topic I. Community focussed approach to flood risk management and mitigation

Based on the three presented papers and the discussion the following conclusions and recommendations were formulated:

- the aim of the WISDOM project is design, implementation and training of integrated water resources management (IWRM). Large amounts of scientific data, originating from multiple scientific domains and knowledge management amongst others have been generated, collected and archived by the WISDOM Project since 2007. The scientific domain focuses on multidisciplinary issues of water management and knowledge and data dissemination by designing and implementing a borderless customized web based information system application. The WISDOM System - which is currently in prototype stage and will be further developed over the next year - will provide a platform for exchange and dissemination of water management relevant data and knowledge over the internet. All different interests and requirements resulting from different institutional as well as different disciplinary background were compiled and finally poured in an overall technical system definition for the WISDOM Information System Prototype;
- the study on monitoring spatial and temporal dynamics of major floods in the lower reach of Songkhram River, Northeastern Thailand analyzes the temporal and spatial dynamics of the major floods. This is one of the most important areas for aquatic biological production in the LMB: Current wetland inventories and surveys are inadequate. There is lack or limited accessibility to available data, Remote Sensing (RS)/Geographic Information System (GIS) aided approaches were found to be most effective in monitoring extent, damage and frequency of floods, but application is limited to a small community. Classified maps were made showing spatial and temporal dynamics of major floods, the accumulated extent of major floods, the extent of land uses that are being affected and the extent of low-lying areas;
- with respect to community focussed approaches the following issues are at stake:
    * community flood risk mapping may show priority of different danger zones, types of danger and vulnerability. It may assist in determining roles and responsibility of communities and local authorities. It provides timely information and easy access of flood information to communities to be used in practice. It may also serve as platform for sharing information and synergy with stakeholders. Use would have to be made of various media like TV, radio, etc. to promote community awareness;
    * create awareness and train communities and local authorities for flood risk management. Provide incentives to communities to be part of the Community Based Flood Risk Management (CBFRM) processes. Create community volunteers like Red Cross volunteers to promote CBFRM initiatives. Establish two way flood early warning communication. Transfer scientific information by capacity building initiatives;
    * it will be of importance to up-scale community initiatives to national scale to cover at risk communities;
    * involve communities in decision making processes and promote community participation. Strengthen institutional mechanisms at community and above levels for better coordination;
    * increase community awareness before floods and conduct assessments of community capacity and community preparedness before floods. Provide necessary ‘hardware’ to communities to respond to flooding (check lists, drills, boats, dykes, etc.) and training how to use them;
    * identify and address the needs of vulnerable groups within the communities such as children, women, old aged, widows, etc.;
    * planning for livestock evacuation is also important in CBFRM processes;
    * if required, mobilise assistance from outside to overcome flood damage.

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Topic II. Flood forecasting and flash flood guidance

Under Topic II papers were submitted by Cambodia, Thailand and Viet Nam.

Achievements:

- *Cambodia:*
    - * flood forecasting and flood early warning for 40 flood marks for 3 days ahead are in operation;
    - * flood probability maps and disaster management planning have been established;
- *Thailand:*
    - * warning criteria for flash floods have been established for Chi and Lower Mun river basins;
    - * is developing an automatic remote monitoring system (meteorological, hydrological and water quality telemetry system);
    - * is developing water resources models and database software;
    - * is developing criteria that are being used for flood warning, flood inundation and flash flood guidance;
- *Viet Nam.* Flash flood forecasting and warning are made daily for the areas with high risk of flash flood occurrences in six steps and in the process of the FFGS trial.

Weaknesses/gaps:

- continuous data collection is needed and the networks need to be improved. Although there is a variety of information, no grouping has been systematically arranged under the same standard and there is a lack of connection and linkage of complete and modest information. Therefore it is quite difficult to access the databases;
- there is a lack of skilful personal. Human resources and capacity of provincial staff are limited;
- in some of the MRC Member Countries there is no information system and knowledge base centre for national water resources;
- there is a problem of integrated participation in management of stakeholders in public, private sectors, local government and people. In addition there is a limitation of sending the flood products and warnings to the local community.

Recommendations:

- evaluate availability and capability of spatial and temporal resolution of rainfall forecast for hydrological application;
- evaluate regional approaches in monitoring network sustainability and use advanced technologies for forecasting;
- improve effective warning communication by finding user's needs and obtaining users feedback;
- improve cooperation, communication and coordination among/between countries in the region;
- develop exchange programs and internships among/between riparian countries.

Topic III. Structural measures and flood proofing

Based on the three presented papers and the discussion the following conclusions and recommendations were formulated:

- the potential use of ALOS PALSAR in flood hazard mapping has been investigated in 5 districts in Lao PDR based on the 2008 floods. It was found that with the help of two

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proper PALSAR Fine Beam Dual polarization images the flood extent can be delineated with sufficient ground truth information;

- Chi River Basin is characterized by high intensity rainfall, high development, deforestation, and flood mitigation structures. An appropriate flood mitigation framework through structural and non structural measures has been investigated. Proposed measures concern river normalization, green river, retention storage, land use zoning and appropriate operation;
- development of a roadmap for flood and drought risk management in the Greater Mekong Sub Region involved a risk vulnerability assessment, identification of appropriate interventions focusing on three issues: risk, time frame, strategy and intervention. A multi criteria analysis was applied for selection and prioritization of a mix of structural and non-structural measures.

Recommendations:

- basin wide assessment of structural measures needs to be made prior to the planning and with regard to IWRM and IFRM approaches. In determining an optimal set of measures integrated management considering the combination of floods and droughts will be required with full participation of riparian countries and cost benefit considerations;
- strengthening the capacity on technical and knowledge of local administration, knowledge sharing among riparian countries;
- risk assessments are needed on how to reduce the flash floods and mud flows, including exploration of methods and tools for structural measures to mitigate the impact from flash floods (for community, etc);
- MRCs role in managing structures in the MRB, multi purpose operation (water supply, recreation, etc.) needs consideration.

Topic V. Land use and climate change impacts on flood management

Based on the three presented papers and the discussion the following conclusions and recommendations were formulated:

- climate change during the 21st century will be unavoidable. In Viet Nam: in 50 years, the temperature has increased 0.5 - 0.7 ^{o}C and has made natural disasters more severe;
- the PRECIS model was applied for two scenarios based on temperature increase of 2.1 - 2.7 ^{o}C. In case of a sea level rise of 0.75 m the rainfall increase in the flood season is expected to result in an increase of inundation of 19% in Mekong Delta. Reduction of river discharge in the dry season will have severe consequences for salinity intrusion;
- WISDOM permits to store water and land related data from different sources, analysis, models and provides the user online access. Use is made of remote sensing, GIS and field surveys. It was found that tidal influences are very strong and that turbidity is influenced by tide and acidity of water. More extreme events may be expected and the likelihood of flooding is increasing;
- the Mekong Delta is affected by a tropical monsoon climate, it has two seasons and tides in the sea. Climate change leads to changes in sea level, rainfall and temperature. The DELTA model was applied for 8 scenarios (combination of the changed discharge in Kratie, rainfall and sea level rise). Impact of the change flow was mainly below Kratie up to Tan Chau.

Recommendations:

- close cooperation between WISDOM and the MRC is recommended. The WISDOM data bank would have to be available to users, and become regional;

- meteorology needs to be studied in more detail in order to improve rainfall forecasts (combination of typhoon and rainfall data for analysis);
- develop feasible action plans (Line Agencies of the MRC Member Countries) based on climate change related findings of the projects (for example WISDOM and Vietnamese NPT);
- promote capacity building and awareness raising among communities based on the climate change related findings of the projects;
- develop dam operation rules to optimize the water resources management.

FOLLOW-UP

Follow-up actions at three levels were formulated, being follow-up actions directly after the Forum, recommendations for the 9th Annual Mekong Flood Forum (AMFF-8) 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 has also been 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

The present Forum was the last one that was organised as a component of the FMMP. Formulation of the envisaged next phase of the programme started shortly after the Forum. It will strongly depend on this formulation and the decisions thereafter whether a 9th Mekong Flood Forum will be held and what will be the format, frequency and participation of it. It is therefore considered premature to recommend a theme and topics for a next forum in 2011, as was the practice with the previous Forums.

More comprehensive follow-up

Phase I of the Flood Management and Mitigation Programme will be completed by the end of 2010. Therefore the recommendations for a more comprehensive follow-up of the AMFF-8 will focus on the envisaged second phase of the FMMP. Without pretending to be completed and based on the outcomes of the eight Annual Mekong Flood Forums the following recommendations may be useful for the formulation of FMMP-II:

- in the MRB with so many developments and interactions in and among the riparian countries with respect to flood management and mitigation governments and citizens may strongly benefit from an FMMP-II;
- formulate the components of FMMP-II based on the requirements of the MRC Member Countries;
- define clearly what the MRC Member Countries can do themselves and what specifically

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can be best pursued under the FMMP-II;

- promote staff secondment from the MRC Member Countries to the MRC-RFMMC;
- continue with Mekong mainstream and flash flood forecasting by the MRC-RFMMC;
- make a good Digital Elevation Model (DEM) for the flood prone areas, especially for the densely populated and highly valuable areas;
- focus on a people centred approach;
- focus on capacity building of Line Agency staff with respect to improved implementation of flood management and mitigation programmes;
- focus on joint studies on trans-boundary issues;
- make clear that the costs for the FMMP-II are only a limited part of the benefits by means of reduction of casualties, affected people and damage to public and private property;
- continue with the Flood Forums as a means to exchange information on new developments and practical experiences with flood management and mitigation, but adjustment has to be made on the format, the frequency and the composition of the participants.

CONCLUDING REMARKS

I like to conclude this summary of proceedings with some final remarks:

- the eight Forums have brought together a wealth of information on flood risk management and mitigation in the MRB as well on international developments and experiences. This is all well documented in proceedings that are freely available;
- National and the MRCS Flood Reports have been improved significantly over the years and provided a better match with the role of the MRCS/FMMP. It would be interesting to prepare a summarising compilation of National and the MRCS flood reports;
- there is much more awareness of ‘lessons learned’ and ‘good practices’ to design adequate measures to manage and mitigate flood risks in the LMB. It is hoped that this solid know-how will be effectively used in designing flood risk management and mitigation programmes.

Prof. Bart Schultz, PhD, MSc
Forum Facilitator
Phnom Penh, CAMBODIA
30 July 2010

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8th Annual Mekong Flood Forum (AMFF-8)

FORUM STATEMENT

Preamble

About 125 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 8th Annual Mekong Flood Forum, on 26 and 27 May 2010, Vientiane, Lao PDR. The Forum was organised by the MRC's Regional Flood Management and Mitigation Centre (MRC-RFMMC) in cooperation with the Lao National Mekong Committee. The theme was 'Flood risk management and mitigation in the Mekong River Basin'. The participants were involved in two days of 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 *'Flood risk management and mitigation 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 on the situation with respect to 2009 floods in their respective countries and on the progress made with flood risk management and mitigation. In 2009 floods in the mainstream of the Mekong River were normal and beneficial. On the contrary flash floods were damaging, primarily those caused by the Typhoon Ketsana. In total there have been 241 deaths, 5 million people affected and US$ 900 million damages in the basin.

III. In addition there were presentations on the progress and completion of the five Components of the Flood Management and Mitigation Programme (FMMP) and on the five Topics of the Forum: (i) *Community focussed approach to flood risk management and mitigation; (ii) Flood forecasting and flash flood guidance; (iii) Structural measures and flood proofing; (iv) Trans-boundary cooperation for managing floods and related issues: (v) Land use and climate change impacts on flood management.* The papers gave good overview of the on-going activities in the Mekong River Basin and of achievements and plans with respect to flood risk management and mitigation.

IV. It has been observed that the wet season flow in the Mekong was possibly influenced by impounding of reservoirs upstream. In addition there were some signals of impacts of climate change although this was debated. Such changes will impose significant challenges to maintain the quality of flood forecasts. With the on-going developments a better exchange of information and joint studies on possible unusual changes in the regime of the Mekong River will be of importance.

V. Proper completion of phase I of the FMMP is needed in order to enable the stakeholders, especially the MRC Member Countries, to make best use of the products.

VI. The importance of long-term flood forecasting and flash flood guidance for the region as a core function of the MRCS/RFMMC is being recognised. Especially with respect to flash flood guidance for which more experience has to be gained and improvements have to be made. In the Mekong River Basin there have been many developments and interactions in and among riparian countries with respect to flood management and mitigation and this will continue in the future. Therefore the governments and citizens of the LMB may substantially benefit from a continuation of regional cooperation with respect to flood risk management and mitigation. It is recommended to formulate the elements of the FMM in such a way that permanency of products and services on regional issues with respect to the FMM is secured as much as possible.

VII. The AMFF-8 is the last Forum under the current phase of the Flood Management and Mitigation Programme (FMMP). The participants support continuation of the Annual Mekong Flood Forums as a mean to exchange information on practical experiences and new developments on flood risk management and mitigation. However, the format, frequency and participation would have to be formulated in line with the elements of a follow-up phase.

VIII. There was a limited representation of Civil Society Organisations in the Forum. In light of their different roles with respect to Flood Management and Mitigation in the Mekong River Basin efforts will have to be made towards better representation of these organisations in the futur

IX. The participants would like to thank the governments of the Netherlands, USA, Germany and the Asian Development Bank for their support of this 8th Annual Mekong Flood Forum, the MRC Regional Flood Management and Mitigation Centre for organising AMFF-8 and the Lao National Mekong Committee for hosting this important event.

Vientiane, Lao PDR
Thursday 27 May 2010

CLOSING ADDRESS

JEREMY BIRD

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

Mr. Phonechaleun Nonthaxay
Director General, Department of Water Resources
Water Resources and Environment Administration (WREA)
Alternate MRC Joint Committee Member for Lao PDR

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

I would like to thank all participants for their active contribution at this 8th Annual Mekong Flood Forum. We have reflected on and discussed the work of the recent year's flood season, technical advances in flood management and the outputs of MRCS' Flood Management and Mitigation Programme. This provides excellent material for us as we start to formulate the scope and direction of the next phase of the Flood Management and Mitigation Programme (FMMP) for 2011 - 2015.

Climate change is clearly a major factor that we need to consider together with its associated extremes and variability. Other pressures include rapid population growth in the Mekong River Basin; urbanisation; intensification of agriculture; change in land use and river morphology. All these will render FMMPs work in the next five year period a great challenge.

And it is clear from last year's flood season that more attention is needed to address tributary flash floods as well as mainstream flooding.

You will, I hope, agree that we have enjoyed spirited and constructive discussions over the five topics under the Forum theme this year '*Flood risk management and mitigation in the Mekong River Basin*'.

We are pleased that this has again included contributions from our Dialogue Partners, China and Myanmar, who shared with us useful experiences of controlling, mitigating and preparing for floods and disasters.

The first of the four discussed topics covered community involvement, which is key to flood risk management and mitigation and constitutes an important part of flood risk management and mitigation. Innovative approaches are necessary if we are to build people's ownership and ensure sustainability of the flooded warnings and preparedness systems.

On the second topic, I am glad to hear that we've made encouraging progress towards the Mekong mainstream and flash flood forecasting. Improvements have been made in our forecasting capability, but there is no room for complacency. Climate change effects will add new challenges to the service that MRC provides to its Member Countries. At field level, improvements in communication systems and involvement of villagers in reporting floods in pilot areas have shown promising results.

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Third, we have seen the implementation of different methods, both hard and soft and various steps to reduce flood damage risks in the context of the MRC Member Countries and the Greater Mekong Sub-region. We have also focused on the importance of and agreed to the need to continue with our efforts to improve structural measures, flood proofing and the preparedness for floods by improved flood forecasting and early warnings, and to increase our cooperation in reducing flood risks and flood damage in the Mekong River Basin.

Fourth, the presentation and discussion over the impacts of land use and climate change on flood management were particularly interesting in that they allowed us to understand the interrelation between climate change and current development pressures that I mentioned earlier. In this regard, we were informed of how climate change influences floods in the Mekong Delta and how a regional climate model works in developing climate change scenarios for the Mekong Delta.

A synthesised report of these sessions will be prepared and shared with you later.

The Forum Statement has captured some of the valuable recommendations from discussions over the two day period.

I do not wish to repeat the presentation of the Statement, but would rather just highlight some of the key messages that I picked up from the Forum, which will be important in our consideration of next steps. These include:

- *showing results and addressing the weakest link* - helping to develop the capacity to deliver warnings on the ground and disseminating the outputs of our work so it finds its way into everyday use;
- *building a regional network of implementing agencies* - closer links and interactions between FMMP and the national agencies responsible for forecasting and warnings, as well as between those agencies in MRC Member Countries and upstream, are essential if MRC is to be relevant in this sector;
- *ensuring the sustainability of our work* - preparing a roadmap towards financial sustainability of the FMMPs work including domestic resource mobilisation;
- *bridging the capacity gap* - taking steps to proactively develop flood management capacity in countries with less advanced systems;
- *considering climate change* - adapting to a greater level of uncertainty;
- *taking a whole basin perspective* - building on existing foundations and further strengthening cooperation with our Dialogue Partners

Distinguished Delegates;
Ladies and Gentlemen

We are indebted to the support of our Development Partners over the past six years of the FMMP without whom FMMP would not have been possible. For this Forum, I would like to particularly thank the governments of Germany, the Netherlands, and the United States and the Asian Development Bank for their support.

Allow me, in closing, to also thank the staff of the Lao National Mekong Committee Secretariat and the staff of FMMP for their hard work in the preparation of this 8th Annual Mekong Flood Forum.

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I would like to express my sincere thanks to all presenters, facilitators, chairpersons and rapporteurs for the spirit of partnership and constructive engagement you have brought to this process.

With this I would like to declare the 8th Annual Mekong Flood Forum closed.

Thank you and wish you a pleasant journey back home.

ANNEXES

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ANNEX I. Abbreviations and acronyms

ACF/AAG	Action Contra La Faim/Action Against Hunger
ADB	Asian Development Bank
ADCP	Acoustic Doppler Current Profiler
ADPC	Asian Disaster Preparedness Centre
AEP	Annual Exceedance Probability
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
AJAX	Asynchronous JavaScript and XML technology
AMFF	Annual Mekong Flood Forum
AMFF-1	1st Annual Mekong Flood Forum, *Flood Preparedness*, 23 - 24 April 2002, Ho Chi Minh City, Viet Nam
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*, 27 - 28 May 2008, Phnom Penh, Cambodia
AMFF-7	7th Annual Mekong Flood Forum, *Integrated flood risk management in the Mekong River Basin*. 13 - 14 May 2009, Bangkok, Thailand
AMFF-8	8th Annual Mekong Flood Forum, *Flood risk management and mitigation in the Mekong River Basin*. 26 - 27 May 2010, Vientiane, Lao PDR
AMSU	Advanced Microwave Sounding Unit
APFM	Associated Programme on Flood Management
API	antecedent precipitation index
ARI	Average Recurrence Interval
ARIMA	autoregressive integrated moving average
ARMA	autoregressive moving average
ARTS	ASRC Research and Technology Solutions
ARW	Advanced Weather Research Forecasting
ASM	Areally averaged soil water content
AusAID	Australian Agency for International Development
AWCI	Asian Water Cycle Initiative
AWS	Automatic Weather Station
BCM	billion cubic metres
BDP	Basin Development Plan
BMBF	German Federal Ministry of Education and Research
BMD	Bangladesh Meteorological Department
BMZ	German Federal Ministry for Economic Cooperation and Development
BOH	Bureau of Hydrology
BPG	Best Practices Guidelines
BWDB	Bangladesh Water Development Board
CAFFG	Central America Flash Flood Guidance
CBDRM	Community Based Disaster Risk Management

CBDRR	Community Based Disaster Risk Reduction
CBFM	Community Based Flood Management
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
CHR	Commission for the Hydrology of the Rhine
CIFOR	Centre for International Forestry Research
CMMND	Centre for the Management and Mitigation of Natural Disasters
CNMC	Cambodia National Mekong Committee
CPC	Climate Prediction Centre
CRC	Cambodian Red Cross
CRHMC	Central Region Hydrometeorological Centre
CSFC	Committee for Flood and Storm Control
CSCFSC	Central Steering Committee for Flood and Storm Control
CSO	Civil Society Organisation
CSS	Cascading Style Sheets
CTA	Chief Technical Advisor
CWC	Central Water Commission
CWRC	Yangtze (Changjiang) Water Resources Commission
DACA	Damage and Casualties Assessment
DAE	Department of Agriculture Extension
DANA	Damage and Needs Assessment
DANIDA	Danish International Development Agency
DAO	Data Access Object pattern
DARD	Department of Agriculture and Rural Development
DCDM	District Committee for Disaster Management
DDMFCSP	Department of Dike Management, Flood Control, and Storm Preparedness
DDPM	Department of Disaster Prevention and Mitigation
DEM	Digital Elevation Map
DEM	Digital Elevation Model
DFD	German Remote Sensing Data Centre
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
DLR	German Aerospace Centre
DM	Disaster Management
DMB	Disaster Management Bureau
DMC	Disaster Management Centre
DMH	Department of Meteorology and Hydrology
DMO	Disaster Management Organisation
DMP	Disaster Management Plan
DMR	Department of Mineral Resources
DOE	Department of Environment

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DOLA	Department of Local Administration
DOM	Department of Meteorology
DONRE	Department of Natural Resources and Environment
DONRES	District branches of the MONRE
DOR	Department of Roads
DORW	Department of River Works
DRFDA	Day River Flood Diversion Area
DRM	Disaster Risk Management
DRP	Disaster Reduction Plan
DRR	Disaster Risk Reduction
DSF	Decision Support Framework
DSS	Decision Support System
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
EC	European Commission
ECHO	European Commission Humanitarian Aid Department
ECMWF	European Centre for Medium-range Weather Forecasts
EFS	Empirical Forecasting Schemes
EIA	Environmental Impact Assessment
ENSO	El Nĩno – Southern Oscillation
EO	Earth Observation
EOI	Expression of Interest
EP	Environment Programme
EROS	Earth Resources Observation and Science
EU	European Union
EW	Early Warning
EWFD	European Water Framework Directive
EWS	Early Warning System
FAO	Food and Agriculture Organisation of the United Nations
FAR	False Alarm Ratio
FBD	fine beam double polarization
FBS	fine beam single polarization
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
FFW	Flash Flood Warning
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 trans-boundary issues for negotiation, mediation and conflict prevention; and develop mediation and conflict management capacity

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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
FMMP-CTA	Chief Technical Advisor Flood Management and Mitigation Programme
FMMSIP	Flood Management and Mitigation Strategy Implementation Plan
FPM	Flood Probability Map
FPP	Flood Preparedness Plan
FPP	Flood Preparedness Program
FRMP	Flood Risk Management Plan
FRA	Flood Risk Assessment
FRG	Federal Republic of Germany
FRI	Flood Risk Index
FSC	Flood and Storm Control
FTP	File Transfer Protocol
FVI	Flood Vulnerability Index
GBM	Ganges, Brahmaputra and Meghna
GCM	General Circulation Model
GCM	Global Climate Models
GCOS	Global Climate Observing System
GDAS	Global Data Assimilation System
GDP	Gross Domestic Product
GeoSFM	USGS Geospatial Streamflow Model
GFAS	global flood warning system
GFS	Global Forecast System
GIS	Geographic Information System
GISTDA	Geo-informatics and Space Technology Development Agency
GMS	Greater Mekong Sub-region
GMT	Greenwich Mean Time
GNI	Gross National Income
GNP	Gross National Product
GNSS	Global Navigation Satellite System
GOB	Government of Bangladesh
GOC	Geomatics Centre
GOL	Government of Lao PDR
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
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
GUI	Graphical User Interfase
HE	Un-biased corrected rainfall
HEC	Hydrologic Engineering Centre
HEC-RAS	Hydrologic Engineering Centres River Analysis System
HECgeoRAS	Hydrologic Engineering Center's Geo River Analysis System
HF/SSB	High Frequency / Single Slide Band
HH	Horizontal-Horizontal
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)

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HRC	Hydrologic Research Centre
HRM	High Resolution Model
HV	Horizontal-Vertical
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
ICG	International Coordination Group
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
IEC	Information, Education and Communication
IFAS	Integrated Flood Analysis System
IFM	Integrated Flood Management
IFRC	International Federation of Red Cross
IFRM	Integrated Flood Risk Management
IFRMP	Integrated Flood Risk Management Plan
IHP	International Hydrological Programme
IID	Imperial Irrigation District
IKMP	Information and Knowledge Management Programme
IMDMCC	Inter-Ministerial Disaster Management Co-ordination Committee
IMHEN	Institute of Meteorology, Hydrology and Environment
INGO	International Non-Governmental Organization
IO	International Organisation
IPCC	Intergovernmental Panel on Climate Change
IRCI	Inland River Channel Improvement
ISO	International Standard Organisation
IT	Information Technology
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
IWRM	Integrated Water Resources Management
JAXA	Japan Aerospace Exploration Agency
JC	Joint Committee
JICA	Japanese International Cooperation Agency
JMA	Japan Meteorological Agency
JSP	Java Server Page
JTWC	Joint Typhoon Warning Centre
KBR	Kellogg Brown & Root Pty Ltd
KIT	Karlsruhe Institute of Technology
KPI	King Prajadhipok's Institute
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
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

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LRIAD	Land Resources Inventory for Agricultural Development
LUP	Land Use Planning
MAE	Mean Absolute Error
M&E	Monitoring and Evaluation
MAP	Mean areal precipitation
MAF	Ministry of Agriculture and Forestry
MAFF	Ministry of Agriculture Forestry and Fisheries
MARD	Ministry of Agriculture and Rural Development
MCFSC	Ministerial Committee for Flood and Storm Control
MCM	million cubic metres
MDG	Millennium Development Goal
MDV	Mekong Delta in Vietnam
M-HYCOS	Mekong Hydrological Cycle Observing System
MI	Mekong Institute
MLMUPC	Ministry of Land Management Urban Planning and Construction
MM5	Fifth Generation Mesoscale Model
MOAFF	Ministry of Agriculture, Forestry and Fisheries
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
MOST	Ministry of Science and Technology
MOU	Memorandum of Understanding
MOWA	Ministry of Women's Affairs
MOWRAM	Ministry of Water Resources and Meteorology
MPI	Ministry of Planning and Investment
MPWT	Ministry of Public Works and Transport
MRB	Mekong River Basin
MRBV	Mekong River Basin of Vietnam
MRC	Mekong River Commission
MRC-CCAI	Climate Change and Adaptation Initiative of MRC
MRC-IS	MRC Information System Portal
MRCFFG	Mekong Flash Flood Guidance
MRCFFGS	Mekong Flash Flood Guidance System
MRCFFGCS	Mekong Flash Flood Guidance System Computational Server
MRCFFGDS	Mekong Flash Flood Guidance System Dissemination Server
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
MRFFS	Mekong River Flood Forecasting System
MSC	Mediation and Coordination Section
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
NDM	National Disaster Management

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NDMA	National Disaster Management Authority
NDMC	National Disaster Management Committee
NDMO	National Disaster Management Office
NDMP	National Disaster Management Plan
NDMP	Natural Disaster Mitigation Partnership
NDRMP	Natural Disaster Risk Management Project
NDVI	normalized difference vegetation index
NESDIS	National Environmental Satellite, Data, and Information Service
NESDP	National Socio Economic Development Plan
NFFS	National Flood Forecasting System
NFR	National Flood Report
NFU	National Flood Unit
NGO	Non Government Organisation
NGPES	National Growth & Poverty Eradication Strategy
NHMFC	National Hydro-Meteorological Forecasting Centre
NMC	National Mekong Committee
NMHS	National Meteorological and Hydrologic Service
NOAA	National Oceanic and Atmospheric Administration
NREM	Natural Resources and Environmental Management
NSC	National Steering Committee
NSCE	Nash-Sutcliffe Efficiency Coefficient
NUoL	National University of Laos
NWP	Numerical Weather Prediction
NWRC	National Water Resources Council
NWRD	National Water Resources Database
NWS	National Weather Service
OCI	Office of Information and Culture
ODA	Overseas Development Assistance
OECD	Organisation for Economic Co-operation and Development
O&M	Operation and Maintenance
OFDA	Office of U.S. Foreign Disaster Assistance
OGC	Open Geospatial Consortiums
OOG	Office of the Government
PAFO	Provincial Agriculture and Forestry Office
PCCP	Potential Conflict to Conflict Prevention.
PCDM	Provincial Committee for Disaster Management
PCFSC	Provincial Committee for Flood and Storm Control
PCHMF	Provincial Centres for Hydro-meteorological Forecasting
PCVA	Participatory Capacity and Vulnerability Analysis
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
PFFT	Persistent Flash Flood Threat
PFSC	Provincial Flood and Storm Control
PHMFC	Provincial Hydrometeorological Forecasting Centre
PI	Performance Indicator
PLUP	Participatory Land Use Planning
PHMO	Provincial Hydro Meteorological Office
PMHO	Provincial Meteorology and Hydrology Office
POD	Probability of Detection
POE	Probability of Exceedance
POR	Plain of Reeds
PoWER	Partnership of Water, Research and Education
PRA	Participatory Rural Appraisal
PRECIS	Providing Regional Climates for Impacts Studies
ProDIP	Project Development and Implementation Plan

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PSDD	Programme to Support Democratic Development through Decentralization and Deconcentration
PUB	prediction in ungauged basin
PWRI	Public Works Research Institute
QN NDMP	Quang Ngai Natural Disaster Mitigation Project
QPE	Quantitative Precipitation Estimates
RAP	Rhine Action Plan
RBO	River Basin Organisation
RCM	Regional Circulation Model
RCM	Regional Climate Model
RCV	Red Cross Volunteers
RFE	merged satellite- and ground-based rainfall estimation
RFFS	River Flow Forecasting System
RFP	Request for Proposal
RHMC	Regional Hydro-meteorological Centres
RID	Royal Irrigation Department
RMSE	root mean square error
RNE	Royal Netherlands Embassy
ROFFG	Rumania Flash Flood Guidance
ROI	Region of Interest
RORB	runoff and streamflow routing program
RRD	Red River Delta
RS	Remote Sensing
RTH	regional telecommunication hub
RUA	Royal University of Agriculture
RUPP	Royal University of Phnom Penh
SAL	Salinity
SAFFG	South Africa Flash Flood Guidance
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
SIWRP	Sub-Institute for Water Resources Planning
SIWRR	Southern Institute for Water Resources Research
SLC	scan-line corrector
SLR	Sea Level Rise
SMAR	Soil Moisture Accounting and Routing
SNAP	Strategic National Action Plan
SPI	Standardized Precipitation Index
SPWG	Scientific Partnership Working Group
SRE	Satellite Rainfall Estimate
SREFS	Short-Range Ensemble Forecast System
SRHMC	Southern Region Hydrometeorological Centre, Viet Nam
SRTM	Shuttle Radar Topography Mission
SSARR	Streamflow Simulation and Reservoir Regulation
SST	Sea Surface Temperature
STS	Severe Tropical Storm
SWAT	Soil and Water Assessment Tool
SWOT	Strengths, Weaknesses, Opportunities, and Threats
SWOT	Surface Water Ocean Topography
TA	Technical Assistance
TBFI	Trans-boundary Flood Issues

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TBFII	Trans-boundary Flood Issues Identification
TBI	Trans-boundary Issues
TBIDD	Trans-boundary Flood Issues, Differences and Disputes
TCAid	Assisting Tropical Cyclone Forecasting
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
TNMC	Thai National Mekong Committee
TOR	Terms of Reference
TOT	Training of Trainers
TRFIC	Tropical Rain Forest Information Centre
TRMM	Tropical Rainfall Measuring Mission
TS	Tropical Storm
TSD	Technical Support Division
TSU	Technical Support Unit
TTG	Technical Task Group
TWG	Technical Working Group
UDMC	Union Disaster Management Committee
UMB	Upper Mekong River Basin
UN	United Nations
UNDMT	United Nations Disaster Management Team
UNDP	United Nations Development Programme
UN ISDR	United Nations International Strategy for Disaster Reduction
URBS	Unified River Basin Simulator
USAID	U.S. Agency for International Development
USG	U.S. Government
USGS	U.S. Geological Survey
UTC	Universal Time Coordinate
VB	Vertical Beam
VDRP	Village Disaster Reduction Plans
VIC	Village Implementation Committee
VLF	Very Low Frequency
VND	Vietnamese Dong
VNMC	Viet Nam National Mekong Committee
VNRC	Viet Nam Red Cross
VNU	Viet Nam National University
VRSAP	Vietnam River System And Plain
WAD	Waterways Administration Division
WAM	Wave Model
WAN	Wide Area Network
WCRR	World Conference on Risk Reduction
WCS	Web Coverage Service
WFP	World Food Programme
WFS	Web Feature Service
WGEF	WISDOM Geodata Exchange Format
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
WISDOM	Water related Information System for Sustainable Development of the Mekong Delta
WMO	World Meteorological Organization

WP	Work Package
WPS	Web Processing Service
WRD	Water Resources Department
WREA	Water Resources and Environment Administration
WRF	Weather Research Forecast
WRS	World Resources Satellite
WRU	Water Resaources University
WUP	Water Utilization Programme
WWAP	World Water Assessment Programme
XML	Extensible Markup Language
1D	One Dimensional
2D	Two Dimensional

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ANNEX II. Glossary

nabranch	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'.
Average categorical errors	The amount the forecast would have to be changed to reach the observed category.
Average lead time	The number of hours from the time of forecast issuance to the time of the forecast hit (i.e., when river conditions enter the category forecast).
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.
False Alarm Ratio	The number of missed categorical flood forecasts divided by the total number of categorical flood forecasts issued.
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

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	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 meteorological 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 inundated.
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

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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.

Integrated Flood Risk Management (IFRM) — Application of the most attractive mix of all possible measures, hard and soft, for the reduction of flood damage risk

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.

Non-structural measures — The measures that alter the exposure of life and property to flooding (floodplain land use planning, flood forecasting and warning, flood-proofing,

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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.

Probability of Detection — The number of categorical flood forecast hits divided by the total number of categorical flood forecasts observed.

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 surcharge during a determined time period.

Structural measures — The measures that alter 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

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ANNEX III. Characteristic data on the Mekong River Basin

WATER RESOURCES SITUATION

The Lower Mekong River Basin (LMB) covers the Cambodian, Lao PDR, 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 III.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.

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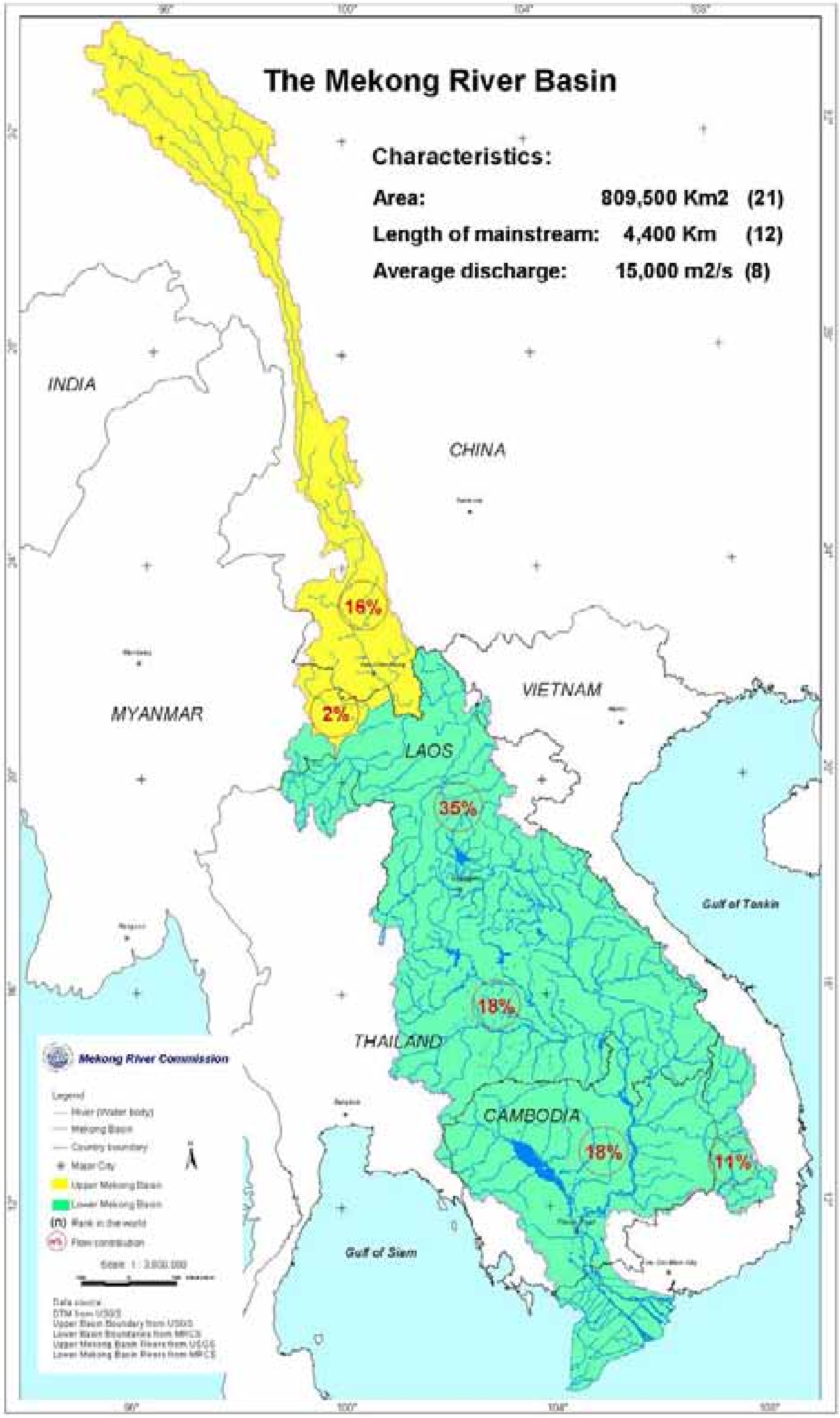

Figure III.1. Mekong River Basin (MRB)

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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 PDR 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

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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 m3.

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%.

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ANNEX IV. Forum programme

PROGRAMME 8TH ANNUAL MEKONG FLOOD FORUM (AMFF-8) DON CHAN PALACE HOTEL, VIENTIANE, LAO PDR	
WEDNESDAY, 26 MAY 2010	
08:00-08:30	Registration
08:30-12:30	*MORNING SESSION*
08:30-10:00	***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 *H.E. Ms. Khempheng Pholsena*, Minister to the Prime Minister's Office, Head of Water Resources and Environment Administration, Chairperson of the Lao National Mekong Committee, and Member of the MRC Council for Lao PDR, represented by *Phonechaleun Nonthaxay*
	Statement by *Martien Beek*, Royal Netherlands Embassy, Hanoi
	Opening remarks by *Ms. Sezin Tokar*, U.S. Agency for International Development (USAID)
	Opening Statement by *Ms. Dr. Petra Shill*, Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)
	ADB Statement by *Ian Makin*, Asian Development Bank (ADB)
	Summary of the AMFF-7 *Hatda Pich An, MRC-RFMMC*
	Objectives and expected outcome of the AMFF-8 *Lam Hung Son and Nicolaas Bakker*
	Demonstration of the MRC's flood forecasting and flash flood guidance systems
10:00-10:30	Coffee Break, Posters and Exhibition
10:30-12:30	***Session 1: Lessons Learned from 2009 Flooding and National and MRC-RFMMC Experiences with Flood Risk Management and Mitigation*** Chairperson: *Phonechaleun Nonthaxay*, Head of the Lao PDR Delegation Rapporteur: *Hak Socheat*, Coordinator of CNMC-FMMP
	Cambodia country flood report for 2009 *Sok Bun Heng*
	Lao PDR country flood report for 2009 *Virana Sonnasinh*
	Thailand country flood report for 2009 *Presented by Ms. Rutima Aramrung*
	Viet Nam country flood report for 2009 *Dao Trong Tu and Bui Duc Long*
	Characteristics of 2009 flood and flood control and disaster mitigation in China *Ms. Chu Minghua*
	River training activities in the Union of Myanmar One of the structural measures for flood protection *U Sein Tun and Tint Lwin*
	2009 annual Mekong flood report *Phung Katry, Nguyen Tien Kien and Peter Adamson*
	Panel discussion facilitated by *Hatda Pich An*
12:30-13:30	Lunch

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13:30-17:00	*AFTERNOON SESSION*
13:30-15:00	***Session 2: Achievements and perspectives of the Flood Management and Mitigation Programme (FMMP)*** Chairperson: *So Sophort*, Head of the Cambodian Delegation Rapporteur: *Burachat Buasuwan*, Coordinator of TNMC-FMMP
	Flood emergency management strengthening - people-centred approach in integrated flood risk management *Aslam Perwaiz*
	Flood forecasting and flash flood guidance systems at the MRC Regional Flood Management and Mitigation Centre *Janejira Tospornsampan, Phung Katry and Hatda Pich An*
	Improved flood risk reduction through implementation of structural measures and flood proofing under the FMMP Component 2 *Nicolaas Bakker, Sluimer G.J., and Lam Hung Son*
	Enhanced cooperation in addressing trans-boundary flood issues between the MRC Member Countries under the FMMP Component 3 *Nicolaas Bakker and Lam Hung Son*
	FMMP Component 5 and flood information based land management (FIBLM) *Martin Falke*
	Panel discussion facilitated by *Lam Hung Son*
15:00-15:30	Coffee Break, Posters and Exhibition
15.30-17.00	***Session 3: Parallel Paper Presentations from the Mekong Region on the five Topics Followed by Parallel Group Discussions***
	Topic I: Community focused approach to flood risk management and mitigation Chairperson: *Tran Duc Cuong*, Head of the Vietnamese Delegation Facilitator: *Aslam Perwaiz* Rapporteur: *Sok Bun Heng*
	WISDOM information system prototype *Florian Moder and Claudia Künzer*
	Monitoring spatial and temporal dynamics of major floods in the lower reach of Songkhram River, Northeastern Thailand *Thiha, Rojchai Satrawaha, Komgrit Wongpakam, Weerachai Saijuntha and Sudarat Thanonkeo*
	Flood situation in Mekong-Chi-Mun River Basin. (3T and 5T areas) *Chongkol Pimwapee*
	Topic II: Flood forecasting and flash flood guidance Chairperson: *So Sophort*, Head of the Cambodian Delegation Facilitator: Robert Jubach Rapporteur: *Dao Trong Tu*
	Flash flood guidance system (FFGS) experimental application on warning flash floods in Viet Nam *Phung Tien Dung and Bui Duc Long*
	Flood forecasting in Chi and Lower Mun Basin by Department of Water Resources *Supapap Patsinghasanee*
	Recent developments in flood forecasting and early warning in Cambodia *Yin Savuth*
	Topic III: Structural measures and flood proofing Chairperson: *Suwit Thanopanuwat*, Head of the Thai Delegation Facilitator: *Ms. Sezin Tokar* Rapporteur: *Virana Sonnasinh*
	Potential use of Alos Palsar in flood hazard mapping, a case study in five districts, Lao PDR *A. Bormudoi, M.K. Hazarika, R. Schumann, L. Samarakoon, V. Phaengsuwan and K. Thanasack*

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	Appropriate flood mitigation framework through structural and non-structural measures for the Chi River Basin, Thailand *Kittiwet Kuntiyawichai, Bart Schultz, Stefan Uhlenbrook, F.X. Suryadi and Micha Werner*
	Development of a road map for flood and drought risk management in the Greater Mekong Sub-region *Divas B. Basnyat, Arup K. Sarma, Ganesh P. Shivakoti and Chu Tran Dao*
	Topic V: Land use and climate change impacts on flood management Chairperson: *Phonechaleun Nonthaxay,* Head of the Lao PDR Delegation Facilitator: *Martin Falke* Rapporteur: *Vu Minh Thien*
	Using regional climate model to generate climate change scenarios for Mekong River Delta *Nguyen Van Thang, Hoang Duc Cuong, Nguyen Dang Mau and Truong Ba Kien*
	Project WISDOM: a progress report from the hydrologic and water resources sub-component *Erich J. Plate and the WISDOM Project Team*
	Climate change and flood in the Mekong Delta *Nguyen Tat Dac*
18:30-20:30	Forum Dinner

THURSDAY, 27 MAY 2010	
08:30-12:30	*MORNING SESSION*
08:30-10:30	***Session 4: Summary of Day 1, Plenary Paper Presentations and Discussions*** Chairperson: *Suwit Thanopanuwat*, Head of the Thai Delegation Rapporteur: *Phonepaseuth Phouliphanh*, Coordinator of LNMC-FMMP
	Summary of Day 1 of AMFF-8 by *Lam Hung Son*, Coordinator, Flood Management and Mitigation Programme (FMMP)
	Practical application of floodplain hydraulic modelling for disaster risk management in Central Viet Nam *Ian Wood and Bui Duc Thai*
	Enhancing regional capacity to address trans-boundary flood issues in the Lower Mekong River Basin *Wim Douven, Ngo Le An, Khamkeng Chanthavongsa, Supanat Permpoonwiwat, Nguyen Dang Tinh, Hoy Sereivathanak Reasey, Léna Salamé, Jutamas Thongcharoen, Va Vuthy, Sinxay Vongphachanh and Pieter van der Zaag*
	Impact of climate change and sea water level rise to the inundation condition in the Mekong Delta *To Quang Toan, Tang Duc Thang and Nguyen Anh Duc*
	Plenary discussion facilitated by *Lam Hung Son*
10:30-11:00	Coffee Break, Posters and Exhibition
11:00-12:30	***Session 4: Summary of Day 1, Plenary Paper Presentations and Discussions (continued)*** Chairperson: *So Sophort*, Head of the Cambodian Delegation Rapporteur: *Dao Trong Tu*
	Data based flood forecasting for the Mekong *Muhammad K. Shahzad and Erich J. Plate*
	Bias adjusted satellite-based rainfall estimates for flood prediction: case study of Narayani Basin, Nepal *Mandira S. Shrestha, Guleid A. Artan, Sagar R. Bajracharya, Dilip P. Gautam, and Ms. Sezin A. Tokar*
	Flood risk management and mitigation – Flood forecasting and warning in India *S.K. Chaudri*
12:30-13:30	Plenary discussion facilitated by *Hatda Pich An*
13:30-17:00	Lunch

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13:30-14:30	*AFTERNOON SESSION*
	Session 5: Parallel Group Discussions, Formulation of Recommendations on the Topics
	Topic I: Community focused approach to flood risk management and mitigation Chairperson: *Tran Duc Cuong*, Head of the Vietnamese Delegation Facilitator: *Aslam Perwaiz* Rapporteur: *Sok Bun Heng*
	Topic II: Flood forecasting and flash flood guidance Chairperson: *So Sophort*, Head of the Cambodian Delegation Facilitator: *Robert Jubach* Rapporteur: *Dao Trong Tu*
	Topic III: Structural measures and flood proofing Chairperson: *Suwit Thanopanuwat*, Head of the Thai Delegation Facilitator: *Ms. Sezin Tokar* Rapporteur: *Virana Sonnasinh*
	Topic V: Land use and climate change impacts on flood management Chairperson: *Phonechaleun Nonthaxay*, Head of the Lao PDR Delegation Facilitator: *Martin Falke* Rapporteur: *Vu Minh Thien*
14:30-15:00	Coffee Break, Posters and Exhibition
15:00-17:00	***Session 6: Concluding Session*** Co-chairpersons: *Te Navuth*, Director of Technical Support Division *Nicolaas Bakker*, FMMP Chief Technical Advisor
	Presentations by the rapporteurs of the plenary sessions 1, 2 and 4 and of the parallel sessions (3 and 5) on the 5 Topics
	Questions and answers; general comments from the floor facilitated by *Te Navuth*
	Special presentation on trans-boundary river basin management - facing future challenges in guiding river basin development *Koos Wieriks*
	Summary of proceedings and recommendations for follow-up *Bart Schultz*
	Remarks by representative(s) of participants
	Presentation of the Forum Statement by *Hatda Pich An*
	Closing Address by *Jeremy Bird*, MRCS-CEO

ANNEX V. List of participants

Cambodia - Cambodia National Mekong Committee (CNMC)

1. H.E. Mr. So Sophort
   Deputy Secretary General
   Cambodia National Mekong Committee
   # 23 Mao Tse Toung Rd, Phnom Penh, Cambodia
   Tel: +855-23-218-727 or 216-514, HP: +855-12-886-601
   Fax: +855-23-218-506
   sophort@cnmc.gov.kh

2. Mr. Chheang Hong
   Deputy Director
   Project Department, Cambodia National Mekong Committee
   # 23 Mao Tse Toung Rd, Phnom Penh, Cambodia
   Tel: +855-23-218-727 or 216-514, HP: +855-11-918-195
   Fax: +855-23-218-506
   hong@cnmc.gov.kh

3. Mr. Hak Socheat
   National FMMP Coordinator
   National Flood Unit, Cambodia National Mekong Committee
   # 23 Mao Tse Toung Rd, Phnom Penh, Cambodia
   Tel: +855-23-216-514, HP: +855-011-796-998
   Fax: +855-23-218-506
   socheat@cnmc.gov.kh

4. Mr. Sok Bun Heng
   National Flood Expert
   National Flood Unit, Cambodia National Mekong Committee
   # 23 Mao Tse Toung Rd, Phnom Penh, Cambodia
   Tel: +855-23-216-514, HP: +855-12-773-590
   Fax: +855-23-218-506
   bunheng67@yahoo.com

Cambodia - Department Hydrology and River Works, MOWRAM (DHRW)

5. Mr. Yin Savuth
   Deputy Director
   Hydrology and River Works Department, Ministry of Water Resources and Meteorology
   # 576, National Road 2, Angre Krom, Meanchey, Phnom Penh, Cambodia
   Tel: +855-23-425-645, HP: +855-011-974-322
   Fax: +855-23-425-645
   savuthyin@yahoo.com

Cambodian - Department of Meteorology (DoM), MOWRAM

6. Ms. Peou Phalla
   Programme Officer
   Department of Meteorology
   Ministry of Water Resource and Meteorology (MOWRAM),
   # 47, Norodom Boulevard, Phnom Penh, Cambodia
   Tel: +855-23-890-034, HP: +855-16-616-927
   Fax: +855-23-890-034
   phalla@yahoo.com

Cambodia - National Committee for Disaster Management (NCDM)

7. Mr. Khun Sokha
   Director of Preparedness and Training Department,
   National Committee for Disaster Management,

Phnom Penh, Cambodia
Tel: +855-23-882-045, HP: +855-12-882-198
Fax: +855-23-882-045
khunsokha.ncdm@everyday.com.kh
sokhakhun@yahoo.com

Cambodia - Cambodia Red Cross (CRC)
8. Mr. Te Sokkheun
Programme Manager
Community Base Disaster Preparedness Programme,
Cambodia Red Cross, # 16A Street 652/271, O Bek Kaom,
Toeuk L'ork III, Tuol Kork, Phnom Penh, Cambodia
HP: +855-12-666-097, Fax: +855-23-881-522
tesokkhoeun@yahoo.com

Cambodia – Inland Fisheries Research and Development Institute (IFRID), MAFF
9. Ms. Hap Navy
Deputy Director
Inland Fisheries Research and Development Institute, Fisheries Administration,
Ministry of Agriculture Forestry and Fisheries,
186 Norodom Blvd., Phnom Penh, Cambodia
Tel: +855-23-221-485, HP: +855-12-353-683
Fax: +855-23-221-485
ifric@online.com.kh

Lao PDR – Water Resources Department (WRD), WREA
10. Mr. Phonechaleun Nonthaxay
Director General
Water Resources Department,
Water Resources and Environment Administration,
Souphanouvong Avenue, P.O. Box 2903,
Vientiane, Lao PDR

Lao PDR - Lao National Mekong Committee (LNMC)
11. Mr. Phonepaseuth Phouliphanh,
National FMMP Coordinator
Water Resources Department, Lao National Mekong Committee Secretariat
Prime Minister's Office, Lane Xang Avenue, Vientiane, Lao PDR
Tel: +856-21-260-981-3, HP: +856-20-220-7415
Fax: +856-21-260-984
phonepaseuthp@gmail.com or
seuth06@hotmail.com

12. Mr. Virana Sonnasinh
National Flood Expert
Water Resources and Environment Administration, LNMC Secretariat
Prime Minister's Office, Lane Xang Avenue, 01000, Vientiane, Lao PDR
Tel: +856-021-260-981 – 3, HP: +856-020-540-7583
Fax: +856-021-260-984
virana@lnmc.gov.la

13. Mr. Ketsana Xayasarn
Official
Water Resources and Environment Administration, LNMC Secretariat,
Prime Minister's Office, Lane Xang Avenue, 01000, Vientiane, Lao PDR
Tel: +856-021-260-981 – 3, Fax: +856-021-260-984

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14. Ms. Bounsanong Aphay
Administrative Assistant of NFU
LNMCS, Prime Minister's Office, Lane Xang Avenue, Vientiane, Lao PDR
Tel: +856-021-260-981 – 3, HP: +856-020-333-3318
Fax: +856-021-260-984

15. Ms. Malayvieng Mongkhonvilay
Secretary
LNMCS, Prime Minister's Office, Lane Xang Avenue, Vientiane, Lao PDR
Tel: +856-021-260-981 – 3, HP: +856-020-788-2160
Fax: +856-021-260-984

Lao PDR - Department of Meteorology and Hydrology (DMH)

16. Mr. Singthong Pathoummady
Director of Meteorology Network Division
Department of Meteorology and Hydrology, Water Resources and Environment Administration, Souphanouvong Avenue, P.O. Box 2903, Vientiane, Lao PDR
Tel: +856-21-215-010, HP: +856-20-538-9651
Fax: +856-21-223-446
singthong_dmh@etllao.com

17. Mrs. Souvanny Phonevilay,
Assistant to Director General/Chief of Weather Forecasting Division
Department of Meteorology and Hydrology (DMH), Water Resources and Environment Administration, Souphanouvong Avenue, P.O. Box 2903, Vientiane, Lao PDR
HP: +856-20-220-4729
s_phonevilay@yahoo.com or weatherforecast_dmh@etlao.com

18. Mr. Somphanh Vithaya,
Deputy Chief of Hydrological Division
Department of Meteorology and Hydrology (DMH), Water Resources and Environment Administration, Souphanouvong Avenue, P.O. Box 2903, Vientiane, Lao PDR
HP: +856-20-541-9021
Lao PDR – Lao Red Cross (LRC)

Lao PDR – Lao Red Cross (LRC)

19. Mr. Phaypaseuth Oudomkham
Technical Official
Lao Red Cross, Vientiane, Lao PDR

Lao PDR - National Disaster Management Office, MLSW (NDMO)

20. Mr. Vilayphong Sisomvang
Deputy Director of National Disaster Management Office,
Ministry of Labour and Social-Welfare,
P.O Box 347, Pangkhan Road, Chanthabuli Vientiane, Lao PDR
Tel: +856-021-219-450, Fax: +856-021-213-287

Lao PDR – Department Waterways (DW), MPWT

21. Mr. Bounleune Chanthachack
Chief of Bank Protection and Flooding Unit,
Department of Waterways, Ministry of Public Works and Transport,
Vientiane, Lao PDR

Lao PDR – Department Irrigation (DI), MAF

22. Mr. Nouandeng Rajvong
Deputy Director General
Department of Irrigation, Ministry of Agriculture and Forestry
P.O. Box 811, Vientiane, Lao PDR

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Lao PDR – Lao National University

23. Mr. Sinxay Vongphachan
Lecturer
Lao National University, Vientiane, Lao PDR

Thailand – Department of Water Resources (DWR), MNRE

24. Mrs. Wandee Pattanasatienpong
Scientist, Senior Professional Level
Bureau of Research and Hydrology, Department of Water Resources,
Ministry of National Resources and Environment,
c/o TNMC, 180/3 Rama 6 Road, Soi Phibul Watana Building, , Phayathai,
Bangkok 10400, Thailand
HP: +66-89-690-23866

25. Mr. Phiphat Gunjanaphurk
Director of Legal Affairs Group
Department of Water Resources,Ministry of National Resources and Environment,
c/o TNMC, 180/3 Rama 6 Road, Soi Phibul Watana Building, , Phayathai,
Bangkok 10400, Thailand
Tel: +66-2-271-6287, Fax: +66-2-298-6601

26. Mr. Supapap Patsinghasanee
Civil Engineer, Practitioner Level,
Water Crisis Prevention Centre, Department of Water Resources,
Ministry of National Resources and Environment,
c/o TNMC, 180/3 Rama 6 Road, Soi 34, Phibul Watana Building, , Phayathai,
Bangkok 10400, Thailand
Tel: +66-2-271-6000, ext. 6411, HP: +66-89-772-4611
Fax: +66-2-271-6000
supapap@dwr.go.th
supapap@gmail.com

27. Ms. Rutima Aramrung
Policy and Plan Annalist, Practitioner Level,
Bureau of International Cooperation,
Department of Water Resources, Ministry of National Resources and Environment,
c/o TNMC, 180/3 Rama 6 Road, Soi Phibul Watana Building, , Phayathai,
Bangkok 10400, Thailand
Tel: +66-2-268-6605, Fax: +66-2-268-6605
rutima.a@hotmail.com

Thailand – Thai National Mekong Committee (TNMC)

28. Mr. Burachat Buasuwan
Senior Policy and Plan Analyst/ FMMP National Coordinator
TNMC, Department of Water Resources,
180/3 Rama 6 Road, Soi Phibul Watana Building, , Phayathai,
Bangkok 10400, Thailand
Tel: +66-2-298-6605, +66-818-445-323
Fax: +66-2-298-6605
burachatster@gmail.com

Thailand –Water Resources Engineering Department (WRED)

29. Dr. Chaiyuth Sukhsri
Head of Water Resources Engineering Department,
Faculty of Engineering, Chulalongkorn University,
Bangkok, Thailand

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Thailand – Royal Irrigation Department (RID), MAC

30. Mr. Suwit Thanopanuwat
Professional Engineer for Planning
Royal Irrigation Department, Ministry of Agriculture and Cooperation,
#811, Samsen Road, Dusit 10300, Bangkok, Thailand
Tel: +662-241 3028, Fax: +662- 241 3028
thanopanuwat@yahoo.com

Thailand – Department of Disaster Prevention and Mitigation (DDPM), MOI

31. Mr. Paitoon Naktae
Senior Civil Engineer
Department of Disaster Prevention and Mitigation, Ministry of Interior,
Bangkok, Thailand
HP: +66-819-771-146’

Viet Nam – Viet Nam National Mekong Committee (VNMC)

32. Mr. Tran Duc Cuong
Deputy Director General
Viet Nam National Mekong Committee
23 Hang Tree, Hanoi, Viet Nam
Tel: +844-934-3565, Fax: +844-825-6929

33. Dr. Dao Trong Tu
National Flood Expert
Viet Nam National Mekong Committee
23 Hang Tree, Hanoi, Viet Nam
Tel: +844-934-3565, HP: +840-913-234-562
Fax: +844-825-6929
tudaotrong49@yahoo.com.vn

34. Mr. Vu Minh Thien
National FMMP Coordinator/Programme Officer
Viet Nam National Mekong Committee
HCMC Representative Office, # 19, Nguyen Thi Minh Khai Street, District 1,
Ho Chi Minh City, Viet Nam
Tel: 84-8-3827-2652
HP: 84-091-917-5647
Fax: 84-8-3827-2609
vumthien@gmail.com

Viet Nam – Hydro-Meteorological Service, MONRE

35. Mr. Tran Van Sap
Deputy Director General
Hydro-Meteorological Service of Southern Regional Hydrometeorological Centre,
Ministry of National Resources and Environment
4 Dang Thai Than, Hanoi, Viet Nam
Tel: +844-3826-8394, Fax: +844-3826-7740
tvsap@yahoo.com
tvsap@kttv.gov.vn

Viet Nam – National Centre for Hydrometeorological Forecasting (NCHMF), MONRE

36. Mr. Bui Duc Long
Chief of Division of National Centre for Hydrometeorological Forecasting,
Ministry of Natural Resources and Environment,
4 Dang Thai Than Street, Hanoi, Viet Nam
Tel.: +844-3824-4922, HP: +84-91-267-1565
Fax: +844-3824-4921
bui_duclong@yahoo.com

Viet Nam – Department of Dyke Management and Flood Storm Control (DDMFSC), MARD

37. Mr. Lu Ngoc Lam
Officer
Department of Dyke Management and Storm Control,
Ministry of Agriculture and Rural Development,
A4 Building No. 2 Ngoc Ha, Ba Dinh District, Hanoi, Viet Nam
Tal: +844-3733-5695, HP: +844-3827-3408
Fax: +844-3733-5701
lungoclam78@yahoo.com

Viet Nam – Department of Water Resources Management (DWRM), MONRE

38. Ms. Nguyen Thanh Thao
Senior Officer
Department of Water Resources Management,
Ministry of National Resources and Environment,
68 Bui Thi Xuan, Hoan Kien, Hanoi, Viet Nam
Tal: +844-3832-1568, HP: +84-915-116-262

Viet Nam – Southern Institute for Water Resources Planning (SIWRP), MARD

39. Prof. Dr. Nguyen Tat Dac
Senior Project Manager/Flow and Water Quality Modeling Expert
Southern Institute for Water Resources Planning,
Ministry of Agriculture and Rural Development,
271/3 An Duong Vuong Street, District 5, Ho Chi Minh City, Viet Nam
Tel: +848-3835-0850, HP: +848-091-8479-375
Fax: +848-3835-1721
tatdac45@gmail.com or dac_thu@yahoo.com or
ntdac@hcm.vnn.vn

40. Mr. To Quang Toan
Deputy Head of Division
Southern Institute for Water Resources Research,
Ministry of Agriculture and Rural Development,
28 Hamtu Street, District 5, Ho Chi Minh, Viet Nam
Tel: +848-3923-8320, Fax: +848-3923-3028
toan_siwrr@yahoo.com

Dialogue Partners from Upstream Countries

China – Ministry of Water Resources (MWR)

41. Ms. Chu Minghua
Project Officer
Office of the State Flood Control and Drought Relief Headquarters,
No. 2, Lane 2 Baiguang Road, Xuanwu District, Beijing 100053, China
Tel: +8610-6320-2499, Fax: +8610-6354-0119
chumh@mwr.gov.cn

42. Mr. Jin Xingping
Deputy Chief Engineer
Chanjiang Water Resources Commission,
Ministry of Water Resources, # 1863 Jiefang Avenue, Wuhan, China
Tel: +862-7828-20052
jinxp@cjh.com.cn

43. Mr. Hu Wenjun
Deputy Division Director
The International Economics and Technical Cooperation and Exchange Centre,
Ministry of Water Resources,
2, Lane 2 Baiguang Road, Xuanwu District, Beijing 100053, China
Tel: +8610-6320-2043, Fax: +8610-63202274
whu@mwr.gov.cn

44. Ms. Sun Gaohu
Engineer
China Institute of Water Resources and Hydropower Research,
No. 20 Chegong Zhuang West Road, Haidian District, Beijing 100048, China
Tel: +86-10-6320-3272, Fax: +86-10-6354-8037
sungh@iwhr.com

Myanmar – Ministry of Transport (MOT)

45. Mr. U Sein Tun
Deputy Director
Directorate of Water Resources and Improvement of River System,
Lower Pazundaung Road, Pazundaung Post Office, Yangon, Union of Myanmar
Tel: +951-292-961, HP: +095-035-127
Fax: +951-290-230
seintunstar@gmail.com or seintunstar@googlemail.com

46. Mr. U Tint Lwin
Assistant Engineer
Directorate of Water Resources and Improvement of River System, Region (5),
Mandalay, Union of Myanmar
Tel: +952-60257, HP: +09-201-8504
Fax: +952-60307
dwir@myanmar.com.mm
t1dwir@gmail.com

Donor Representatives

Asian Development Bank (ADB) – Philippines

47. Mr. Ian William Makin
Senior Water Resources Management Specialist, SEAE
Asian Development Bank,
P.O. Box 789, No. 6 ADB Avenue, Mandaluyong City, 0980 Manila, Philippines
Tel: +632-632-6973, HP: +63-917-519-1954
Fax: +632-636-2231
imakin@adb.org

GTZ – Lao PDR

48. Dr. Pretra Shill
Representative GTZ Lao
MRC Secretariat
P.O. Box 6101, # 184 Fa Ngoum Rd., Unit 18,
Ban Sithane Neua, Sikhottabong,
Vientiane 01000, Lao PDR
Tel: +856-021-263-263, Fax: +856-021-263-264

Hydrologic Research Centre (HRC) - USA

49. Mr. Robert Walter Jubach
General Manager
Secretary – Board of Directors, Hydrologic Research Centre
12780 High Bluff Drive, San Die0go, CA 92130, California, USA
Tel: +858-794-2726 or +858-345-1360, HP: +240-422-3626
Fax: +858-792-2519
RJubach@hrc-lab.org
www.hrc-lab.org

Embassy of the Kingdom of the Netherlands – Viet Nam

50. Mr. Martien Beek
First Secretary of Water Sector
Embassy of the Kingdom of the Netherlands. Daeha Office Tower, 6th Floor, 360 Km Ma Street,
Ba Dinh District, Hanoi, Viet Nam
Tel: +844-3831-5650, ext. 230
Fax: +844-3831-5655
martien.beek@minbuza.nl
www.vietnam.nlembassy.org

USAID Office of US Foreign Disaster Assistance – USA

51. Dr. Sezin Ayse Tokar
Hydrometeorological Hazard Advisor
USAID Office of US Foreign Disaster Assistance, DCHA/OFDA RRB 8.06.46, 1300
Pennsylvania Ave., NW Washington, DC 20523-8602, USA
Tel: +202-712-4033
Fax: +202-216-3706/07
stokar@usaid.gov

International Organizations and Civil Society Organizations

5T Sub-area – Thailand

52. Dr. Chongkoi Pimwapee
Programme Officer
5T Sub-area 17 Moo 21, Soi Wat Pa Sitawan, Mueang District
Khon Kaen Province, 40000, Thailand
HP: +66-868-609-934, Fax: +66-433-347-943

Asian Development Bank (ADB) – Philippines

53. Mr. Hisashi Mitsuhasi
Water Resources Management Specialist
Sustainable Infrastructure Division, Regional and Sustainable Development
Department, Asian Development Bank,
No. 6 ADB Avenue, Mandaluyong City 1550, Metro Manila, Philippines
Tel: +63-2-632-5959, HP: + 63-91-7888-9061
Fax: +63-2-636-2375
hmitsuhashi@adb.org
www.adb.org

ADB – VisionRI/ADB TA 6456 Project – India

54. Dr. Divas B Basnyat
Team Leader/CTA
VisionRI/ ADB TA 6456 Project, New Delhi, India.
c/o Regional Flood Management and Mitigation Centre,
576 National Road No. 2, Chak Angre Krom, Meanchey,
P.O. Box 623, Phnom Penh, Cambodia
dbasnyat@visionri.com

55. Mr. Khadananda Lamsal
Consultant of ADB-TA Project on Preparing Flood and Drought
Risk Mitigation and Management in the GMS Region,
VisionRI Connexion Services Pvt. Ltd,
CSC – 3, DDA Market, Sector 11, New Delhi – 85, India
Tel: 91-11-65817403, HP: 977-9841549971
Fax: 91-11-27572278
klamsal@mos.com.np

ADB – VisionRI/ADB TA 6456 Project – Cambodia

56. Mr. Kimhor Chhit
Water Resources Specialist
VisionRI/ADB TA 6456 (Consultants),
C/o Regional Flood Management and Mitigation Centre,
576 National Road No. 2, Chak Angre Krom, Meanchey,
P.O. Box 623, Phnom Penh, Cambodia
Tel: +855-23-425-353, Fax: +855-23-425-363
chkimhor@yahoo.com

57. Mr. Ponh Sachak
Deputy Director General
VisionRI/ADB TA 6456, Ministry of Water Resources and Meteorology,
49, Norodom Boulevard, Phnom Penh, Cambodia
HP: +855-12-908-751
Sachak_p@yahoo.com

ADB – VisionRI/ADB TA 6456 Project – Lao PDR

58. Ms. Ounla Sivanpheng
Official
ADB TA 6456 (Consultants), Laos, Vientiane, Lao PDR
HP: +856-20-222-3083/562-2119

ADB – VisionRI/ADB TA 6456 Project – Viet Nam

59. Mr. Chu Tran Dao
Consultant
VisionRI india,1 /189/82 Kim Ma Ba Dinh,
Hanoi, Viet Nam

60. Mr. Nguyen Trong Hoang
Consultant
VisionRI india,1 /189/82 Kim Ma Ba Dinh, Hanoi, Viet Nam
Tel: +843-782-2373, HP: +091-332-4122
tronghoangcpo@gmail.com

61. Mr. Vu Dinh Xiem
Deputy Manager of the TA 6456 Project
Central Project Office, Ministry of Agriculture and Rural Development,
Hanoi, Viet Nam Viet Nam
Tel: +84-439918200, HP: +84-912738627
Fax: +84-438242372
vudinhxiem@gmail.com

62. Mr. Nguyen The Anh
Official of the TA 6456 Project Management Unit
The Central Project Office, Ministry of Agriculture and Rural Development,
Hanoi, Viet Nam
Tel: +84-439918200, HP: +84-982507895, Fax: +84-438242372
nguyentheanh1972@gmail.com

63. Mr. Phan Ba Ngoc
Official
VisionRI/ADB TA 6456 Project Management Unit,
The Central Project Office, Ministry of Agriculture and Rural Development,
Hanoi, Viet Nam
Tel: +84-439918200, HP: : +84-912928112
Fax: +84-438242372
ngoc_21_09@yahoo.com.vn

64. Mr. Nguyen Thanh Dam
Official
VisionRI/ADB TA 6456, International Cooperation Department, Ministry of Agriculture and Rural Development, 2 Ngoc Ha Str. Ha Noi, Viet Nam
Tel: +84 4 3733 2205
HP: +84 942 372 486
Fax: +84 4 3733 0752
ntdam.htqt@gmail.com

Asian Disaster Preparedness Centre (ADPC) – Thailand

65. Mr. Loy Rego
Deputy Executive Director
Asian Disaster Preparedness Centre (ADPC)
SM Tower, 24th Floor 979/69, Paholyothin Road, Samsen Nai, Phayathai,
Bangkok 10400, Thailand
Tel: +66-2-298-0681-92, ext. 300, HP: +66-8-1755-5375
Fax: +66-2-298-0012-13
ajrego@adpc.net
http://www.adpc.net

66. Mr. Thanongdeth Insisiengmay
Senior Project Manager
Asian Disaster Preparedness Centre (ADPC)
SM Tower, 24th Floor 979/69, Paholyothin Road, Samsen Nai, Phayathai,
Bangkok 10400, Thailand
Tel: +66-2-298-0681-92, ext. 309, HP: +856-20-570-0136
Fax: +66-2-298-0012-13
thanongdeth@adpc.net http://www.adpc.net

67. Mr. Aslam Perwaiz
Program Manager
Asian Disaster Preparedness Centre (ADPC). SM Tower,
24th Floor 979/69, Paholyothin Road, Samsen Nai, Phayathai,
Bangkok 10400, Thailand
Tel: +66-2-298-0681-92, ext. 309, HP: +66-8-1617-3710
Fax: +66-2-298-0012-13
aslam@adpc.net http://www.adpc.net

CARE International – Lao PDR

68. Mr. Henry Braun
Country Director
CARE International in Lao PDR, P.O. Box: 4328,
329/25 Sibounheuang Rd, Ban Sibounheuang, Chanthabouly District,
Vientiane Capital, Lao PDR
Tel: +856-21-217-727, HP: +856-20-552-7980
Fax: +856-21-214-415
henry.braun@carelaos.org

European Commission – Thailan

69. Mr. Thearat Touch
ECHO Representative/ Disaster Risk Reduction Assistant
Disaster Preparedness Programme (DIPECHO) for South East Asia,
Regional Support Office for East and South East Asia,
the Pacific, EUROPEAN COMMISSION
4th Floor, Indosuez House, 152 Wireless Road Pathumwan,
Bangkok 10330, Thailand
Tel: +66-2255-1035/6, 2651-4091/2, ext. 110
HP: +66-81-841-5200, 66-81-449-1777
Fax: +66-2255-1034
drra@echo-bangkok.org
http://ec.europa.eu/echo/

FAO Regional Office for Asia and the Pacific – Thailand

70. Mr. Bruce Isaacson
Chief Technical Adviser
FAO Regional Office for Asia and Pacific, # 39 Phra Atit Road,
Bangkok 10200, Thailand
Tel: +66-84-439-5213
bruce.isaacson@fao.org

FAO – Cambodia

71. Ms. Botumroath Keo Lebun
Information & Communication Consultant
Linking Information and Decision-Making to Improve Food Security,
FAO Representation Office, No. 5 Street 370, Boeung Keng Kang I,
P.O. Box 53, Phnom Penh, Cambodia
Tel: +855-23-211-702, HP: +855-12-885-727
Fax: +855-23-216-547
botumroath.lebun@fao.org

Geoinformatics Centre, AIT – Thailand

72. Dr. Manzul K. Hazarika
Associate Director
Geoinformatics Centre, School of Engineering and Technology,
Asian Institute of Technology (AIT)
P.O. Box 4, Klong Luang, Pathumthani 12120, Thailand
Tel: +66-2-524-6184, Fax: +66-2-524-6147
manzul@ait.ac.th
www.geoinfo.ait.ac.th

GTZ/FMMP C5 – Cambodia

73. Dr. Martin Falke
International Team Leader/Technical Adviser (GFA- Consulting Group)
GTZ/FMMP – C5, Regional Flood Management and Mitigation Centre,
576 National Road No. 2, Chak Angre Krom, Meanchey, P.O.
Box 623, Phnom Penh, Cambodia
Tel: +855-23-425-353, ext. 2077, HP: +855-12-502-147
Fax: +855-23-425-363
falke@mrcmekong.org or
martin.falke@gfa-group.de

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Print

74. Mr. Prak Chamroeun
National Coordinator
GTZ/FMMP – C5, Regional Flood Management and Mitigation Centre,
576 National Road No. 2, Chak Angre Krom, Meanchey,
P.O. Box 623, Phnom Penh, Cambodia
Tel: +855-23-425-353, ext. 2075, HP: +855-12-988-894
Fax: +855-23-425-363
chamroeun@mrcmekong.org

75. Ms. Bou Niwath
Administrator and Finance Officer
GTZ/FMMP – C5, Regional Flood Management and Mitigation Centre,
576 National Road No. 2, Chak Angre Krom, Meanchey, P.O.
Box 623, Phnom Penh, Cambodia
Tel: +855-23-425-353, ext. 2071
HP: +855-12-622-687
Fax: +855-23-425-363
niwathmrcmekong.org

Institute of Development Studies – United Kingdom

76. Mr. Emily Polack
Research Officer
Climate Change and Development Centre, Institute of Development Studies (IDS),
The University of Sussex, Brighton, United Kingdom
Tel: +44-12-7391-5758, HP: +44-77-5990-4127
Fax: +44-12-7362-1202
e.polack@ids.ac.uk
www.ids.ac.uk/climatechange

Institute of Meteorology, Hydrology and Environment (IMHEN) – Viet Nam

77. Mr. Nguyen Dang Mau
Researcher
Centre for Meteorology and Climatology (CMETC),
Institute of Meteorology, Hydrology and Environment (IMHEN)
23/62 Nguyen Chi Thanh Road, Hanoi, Viet Nam
Tel: +84-43-835-7159 (office), Tel: +84-66-71-2884 (home)
HP: +84-94-664-7228
mau_imh@kttv.edu.vn or mau.imhen@gamil.com
http://www.imh.ac.vn

International Centre for Water Hazard and Risk Management (ICHARM) – Japan

78. Dr. Ali Chavoshian
Specialist Researcher
Flood Risk Management, International Centre for Water Hazard and Risk Management,
Public Works Research Institute (PWRI)
1-6 Minamihara, Tsukuba, Ibaraki 305-8516, Japan
Tel: +81-29-879-6809, HP: +81-80-5536-0391
Fax: +81-29-879-6709
ali55@pwri.go.jp

79. Dr. Rabindra Osti
Senior Researcher
International Centre for Water Hazard and Risk Management,
Public Works Research Institute (PWRI)
1-6 Minamihara, Tsukuba, Ibaraki 305-8516, Japan
Tel: +81-29-879-6809, HP: +81-90-3975-9018
Fax: +81-29-879-6709
osti55@pwri.go.jp

Back to contents
Print

80. Mr. Atsuhiro Yorozuya
Research Specialist
International Centre for Water Hazard and Risk Management,
Public Works Research Institute (PWRI)
1-6 Minamihara, Tsukuba, Ibaraki 305-8516, Japan
Tel: +81-29-879-6779, Fax: +81-29-879-6709
yorozuya@pwri.go.jp

International Centre for Integrated Mountain Development (ICIMOD) – Nepal

81. Ms. Mandira Singh Shrestha
Water Resources Specialist
Water and Hazard (upstream Downstream Linkages),
International Centre for Integrated Mountain Development (ICMOD)
Khumaltar, Lalitpur, GPO Box 3226, Kathmandu, Nepal
Tel: +977-1-500-3222, ext. 258, HP: +977-1-447-3177
Fax: +977-1-500-3277
mshrestha@icimod.org
www.icimod.org

Japan International Cooperation Agency (JICA) – Lao PDR

82. Mr. Kazumitsu Muraoka
Expert
Japan International Cooperation Agency, JICA Laos Office,
P.O. Box 3933, Vientiane, Lao PDR
Tel: +856-21-414-896, HP: +856-20-550-9255
Fax: +856-21-414-893
kazumitsu.muraoka@gmail.com

Mahasarakham University – Thailand

83. Dr. Rojchai Satrawaha
Associate Professor/Director
Walai Rukhavej Botanical Research Institute (WRBRI), Maharakham University
Khamrieng campus, Kanatara Wichai District, Mahasarakham Province 44150, Thailand
Tel. +66-43-754-333/40 ext. 1176, HP: +66-43-8986-30412
Fax. +666-43 754-407
rojchai.s@msu.ac.th
www.walai.msu.ac.th

84. Dr. Thiha
Lecturer
Walai Rukhavej Botanical Research Institute, Maharakham University
Khamrieng campus, Kanatara Wichai District, Mahasarakham Province 44150, Thailand
Tel. +66-43-754-322/40 ext. 1174, HP: +66-85-1611-5464
Fax. +666-43 754-175
thiha@msu.ac.th

Ministry of Transport, Public Works and Water Management – The Netherlands

85. Mr. Koos Wieriks
Personal Advisor Water Management of H.R.H. the Prince of Orange
General Secretary of the Netherlands Advisory Commission Water,
Ministry of Transport, Public Works and Water Management,
The Hague, The Netherlands
Tel: +31-703-518-522, HP: +31-65-328-1835

Ministry of Water Resources – India

86. Mr. Suhas Kumar Chaudhuri
Chief Engineer (FM)
Central Water Commission, Ministry of Water Resources, Room 212 (S) CWC, Sewa Bhawan,
R.K. Puram, New Delhi 110066, India
Tel: +91-11-2610-2112, HP: +91-971-119-2096
Fax: +91-11-2610-2112
Skccwes1972@yahoo.com

87. Mr. Satya Pal Kakran
Commissioner (Ganga Bansin)
Ministry of Water Resources, Room No. 212, 8th Floor, 11th Block,
CGO Complex Wodhi Road, , New Delhi 03, India
Tel: +11-2436-8238, HP: +981-8616963
Fax: +11-2436-2780
commer-mowr@nic.in

Ministry of Science and Technology (MOST), WISDOM - Viet Nam

88. Mr. Florian Moder
Integrated Expert for GIS and RS
Ministry of Science and Technology (MOST)/WISDOM,
31 Han Thuyen Street, District 1, Ho Chi Minh City, Viet Nam
Tel: + 848-3824-1479, HP: +84-16-5399-5521
Fax: +848-3829-4453
florian.moder@cimonline.de
www.wisdom.caf.dlr.de

Natural Disaster Risk Management Project – Viet Nam

89. Mr. Ian Wood
Hydrodynamic Modeling Specialist
Kellogg Brown & Root Pty Ltd.,
Technical Assistance for Natural Disaster Risk Management (TANDRM),
An Australian Government, AusAID initiative
Room B230 3rd Floor, Binh Minh Hotel, # 27 Ly Thai To Street,
Hoan Kien District, Hanoi, Viet Nam
Tel: +84-4-3926-4435, HP: +84-914-027-709
Fax: +84-4—3926-4436
ian.wood.ndrmp@gmail.com

Royal Haskoning – The Netherlands

90. Mr. Gert Sluimer
Senior Project Manager
Royal Haskoning, Barbarossastraat 35, Nijmegen, The Netherlands
Tel: +31-24-328-4443, HP: +31-6-5236-1988
Fax: +31-24-323-1603
g.sluimer@royalhaskoning.com

Sea and Land Technologies Pte Ltd./Sontek/YSI Inc, - Singapore

91. Mr. Floyd Ng
Sea and Land Technologies Pte Ltd.,
65 Tuas Avenue 1, Singapore 639508
c/o T. Elizabeth, BDM, Sea and Land Technologies Pte Ltd.
Tel: +65-6518-0777, Fax: +65-6563-0366
c/o. elizabeth@sea-landtech.com.sg

92. Mr. Mark Tepper
Technical Marketing Manager of Asia – Pacific Region
SonTek/YSI Incooperated, Sea and Land Technologies Pte Ltd.,
Postal Code: 200030, Room 501, Shengai Building,
No. 88 Caoxi North Road, Shanghai, PR China
c/o T. Elizabeth, BDM, Sea and Land Technologies Pte Ltd.
Tel: +86-21-6469-3325/6, HP: 86-138-1818-2515
mtepper@sontek.com
www.sontek.com
c/o elizabeth@sea-landtech.com.sg

UNESCO-IHE Institute for Water Education – The Netherlands

93. Dr. Wim J.A.M. Douven
Associate Professor IRBM
Integrated River Basin Management, UNESCO-IHE
Westvest 7, 2601 AX Delft, The Netherlands
Tel: + 31-15-215-1712
Fax: + 31-15-212-2921
w.douven@unesco-ihe.org

94. Mr. Kittiwet Kuntiyawichai
PhD Student
UNESCO-IHE Institute for Water Education, Westvest 7, 2601 DA Delft,
The Netherland
Tel: +31-15-2151-892 or 2151-821, HP: +31-6-4252-8665
Fax: +31-15-2122-921
k.kuntiyawichai@unesco-ihe.org
kittiwet_k@hotmail.com

University of Karlsruhe – Germany

95. Prof. Dr. Erich J Plate
Professor for Hydrologic and Water Resources
University of Karlsruhe
Am Kirchberg 49, 76229 Karlsruhe
Germany
Tel: +49-721-468 752, Fax: +49-721-9463 984
plate@iwk.uka.de

USAID Office of US Foreign Disaster Assistance – Thailand

96. Mr. Brian Heidel
Regional Advisor
USAID Office of US Foreign Disaster Assistance,
63 Wireless Road, Bangkok, Thailand
Tel: +66-2-257-3225, HP: +66-89-816-3039
Fax: +66-2-257-3228
bheidel@usaid.gov

Ms. Liza Isabel Mantilla
97. Senior Information Officer
Office of US Foreign Disaster Assistance (OFDA),
U.S Agency for International Development, Regional Development Mission Asia,
Athenee Tower, 25th Floor, 63 Wireless Road, Lumpini, Pathumwan,
Bangkok 10330, Thailand
Tel: +662-257-3227/257-3000, HP: +66-89-816-2667
Fax: +662-257-3228
lmantilla@usaid.gov; imantilla@ofda.gov

Vaisala Oyj – Malaysia

98. Mr. Yap Kian Wei
Sales Manager
Vaisala Oyj, Level 9 West Block, Wisma Selangor, Dredging, 50450 Kuala Lumpur, Malaysia
Tel: +60-3-2163-3363, HP: +60-12-299-6878
Fax: +60-3-2164-3363
kwyap@vaisala.com

Water Matter International – Australia

99. Dr. Christopher Joy
International Consultant/Principal
Water Matters International, Unit C5-3, 75 Brighton Parade,
South Part of Australia 4215
Tel: +61-4127-23815, Fax: +61-3289-1677
christopherjoy@mac.com

World Meteorological Organization – Switzerland

100. Dr. Wolfgang Eric Grabs
Chief
Hydrological Forecasting and Water Resource Division,
Climate & Water Department, World Meteorological Organization (WMO),
Case postale No. 2300, 7 bis, Avenue de la Paix, 1211 Geneva 2, Switzerland
Tel: +41-22-730-8358, HP: +41-79-253-7349
Fax: +41-22-730-8043
wgrabs@wmo.int
www.wmo.int

MRC Secretariat

101. Mr. Jeremy Bird
Chief Executive Officer
MRC Secretariat
P.O. Box 6101, # 184 Fa Ngoum Rd., Unit 18,
Ban Sithane Neua, Sikhottabong,
Vientiane 01000, Lao PDR
Tel: +856-21-263-263, ext. 4131, HP: +856-20-550-5344
Fax: +856-21-263-264
jbird@mrcmekong.org

102. Mr. Te Navuth
Director of TSD
Technical Support Division, MRC Secretariat
P.O. Box 6101, # 184 Fa Ngoum Rd., Unit 18,
Ban Sithane Neua, Sikhottabong,
Vientiane 01000, Lao PDR
Tel: +856-21-263-263, ext. 3031, HP: +856-20-555-5135
Fax: +856-21-263-264
navuth@mrcmekong.org

103. Mr. Sourasay Phoumavong
Director of PD
Planning Division, MRC Secretariat
P.O. Box 6101, # 184 Fa Ngoum Rd., Unit 18,
Ban Sithane Neua, Sikhottabong,
Vientiane 01000, Lao PDR
Tel: +856-21-263-263, ext. 2111, HP: +856-20-552-6758
Fax: +856-21-263-264
sourasay@mrcmekong.org

104. Mr. Tran Van Tuan
IKMP Coordinator
Information and Knowledge Management Programme, MRC Secretariat,
P.O. Box 6101, # 184 Fa Ngoum Rd., Unit 18, Ban Sithane Neua, Sikhottabong,
Vientiane 01000, Lao PDR
Tel: +856-21-263-263, ext. 3049, HP: +856-20-435-9678
Fax: +856-21-263-264
tuan@mrcmekong.org

105. Dr. Anthony Green
Senior Modeling Advisor
Information and Knowledge Management Programme, MRC Secretariat,
P.O. Box 6101, # 184 Fa Ngoum Rd., Unit 18, Ban Sithane Neua, Sikhottabong,
Vientiane 01000, Lao PDR
Tel: +856-21-263-263, Fax: +856-21-263-264
green@mrcmekong.org

106. Mr. Nguyen Nhan Quang
Interim Coordinator of Mekong-IWRM Project
Planning Division, MRC Secretariat, P.O. Box 6101,
184 Fa Ngoum Rd., Unit 18, Ban Sithane Neua, Sikhottabong,
Vientiane 01000, Lao PDR
Tel: +856-21-263-263, HP: +856-20-937-5691
Fax: +856-21-263-264
quang@mrcmekong.org

107. Ms. Birgit Vogel
Chief Technical Advisor of Mekong-IWRM
Planning Division, MRC Secretariat, P.O. Box 6101,
184 Fa Ngoum Rd., Unit 18, Ban Sithane Neua, Sikhottabong,
Vientiane 01000, Lao PDR
Tel: +856-21-263-263, Fax: +856-21-263-264
birgit@mrcmekong.org

108. Dr. Khem Sothea
Operational Hydrologist
Information and Knowledge Management Programme, MRC Secretariat,
P.O. Box 6101, # 184 Fa Ngoum Rd., Unit 18, Ban Sithane Neua, Sikhottabong,
Vientiane 01000, Lao PDR
Tel: +856-21-263-263, ext. 3073, HP: +856-20-4417-1728
Fax: +856-21-263-264
khem@mrcmekong.org

109. Ms. Lalita Rammont
Programmme Officer
Technical Cooperation Unit (TCU), MRC Secretariat, P.O. Box 6101,
184 Fa Ngoum Rd., Unit 18, Ban Sithane Neua, Sikhottabong,
Vientiane 01000, Lao PDR
Tel: +856-21-263-263, ext. 4122, HP: +856-20-781-2920
Fax: +856-21-263-264
lalita@mrcmekong.org

110. Dr. Vitoon Viriyasakultorn
Technical Coordination Advisor
MRC Secretariat, P.O. Box 6101, # 184 Fa Ngoum Rd., Unit 18,
Ban Sithane Neua, Sikhottabong, Vientiane 01000, Lao PDR
Tel: +856-21-263-263, Fax: +856-21-263-264
vitoon@mrcmekong.org

Back to contents
Print

111. Mr. Khy Lim
Communication, Partnerships and Public Participant Officer
MRC Secretariat, P.O. Box 6101, # 184 Fa Ngoum Rd., Unit 18,
Ban Sithane Neua, Sikhottabong,
Vientiane 01000, Lao PDR
Tel: +856-21-263-263, Fax: +856-21-263-264
khy@mrcmekong.org

112. Mr. Bonheur Neou
MRC Secretariat, P.O. Box 6101, # 184 Fa Ngoum Rd., Unit 18,
Ban Sithane Neua, Sikhottabong,
Vientiane 01000, Lao PDR
Tel: +856-21-263-263, Fax: +856-21-263-264
Bonheur@mrcmekong.org

113. Mr. Tran Mai Kien
Climate Change Programme Officer
MRC Secretariat, P.O. Box 6101, # 184 Fa Ngoum Rd., Unit 18,
Ban Sithane Neua, Sikhottabong,
Vientiane 01000, Lao PDR
Tel: +856-21-263-263, ext. 2418, HP: +856-20-744-9364
Fax: +856-21-263-264
kien@mrcmekong.org

114. Ms. Silivanhxay Xayamoungkhoun
FMMP Secretary
MRC Secretariat, P.O. Box 6101, # 184 Fa Ngoum Rd., Unit 18,
Ban Sithane Neua, Sikhottabong,
Vientiane 01000, Lao PDR
Tel: +856-21-263-263, ext. 3061, HP: +856-20-222-6625
Fax: +856-21-263-264
silivanhxay@mrcmekong.org

Regional Flood Management and Mitigation Centre

115. Dr. Lam Hung Son
FMMP Coordinator
Regional Flood Management and Mitigation Centre,
576 National Road No. 2, Chak Angre Krom, Meanchey,
P.O. Box 623, Phnom Penh, Cambodia
Tel: +855-23-425-353, ext. 2021, HP: +855-85-984-872
Fax: +855-23-425-363
son@mrcmekong.org

116. Ir. Nicolaas Bakker
FMMP Chief Technical Advisor
Mekong River Commission
Regional Flood Management and Mitigation Centre,
576 National Road No. 2, Chak Angre Krom, Meanchey,
P.O. Box 623, Phnom Penh, Cambodia
Tel: +855-23-425-353, ext. 2022, HP: +855-12-737-648
Fax: +855-23-425-363
bakker@mrcmekong.org

117. Dr. An Pich Hatda
Operations Manager
Regional Flood Management and Mitigation Centre,
576 National Road No. 2, Chak Angre Krom, Meanchey,
P.O. Box 623, Phnom Penh, Cambodia
Tel: +855-23-425-353, ext. 2091, HP: +855-11-913-786
Fax: +855-23-425-363
hatda@mrcmekong.org

118. Dr. Phung Katry
Hydrologist
Regional Flood Management and Mitigation Centre,
576 National Road No. 2, Chak Angre Krom, Meanchey,
P.O. Box 623, Phnom Penh, Cambodia
Tel: +855-23-425-353, ext. 2116, HP: +855-11-837-056
Fax: +855-23-425-363
katry@mrcmekong.org

119. Mr. Nguyen Tien Kien
Operational Meteorologist/Forecaster
Regional Flood Management and Mitigation Centre,
576 National Road No. 2, Chak Angre Krom, Meanchey,
P.O. Box 623, Phnom Penh, Cambodia
Tel: +855-23-425-353, ext. 2112, HP: +855-97-976-6369
Fax: +855-23-425-363
tienkien@mrcmekong.org

120. Mr. Pich Sambo
Assistant Hydrologist
Regional Flood Management and Mitigation Centre,
576 National Road No. 2, Chak Angre Krom, Meanchey,
P.O. Box 623, Phnom Penh, Cambodia
Tel: +855-23-425-353, ext. 2113, HP: +855-12-925-508
Fax: +855-23-425-363
sambo@mrcmekong.org

121. Mr. Phet Sokhavuthea
Senior Programme Coordinator Assistant
Regional Flood Management and Mitigation Centre,
576 National Road No. 2, Chak Angre Krom, Meanchey,
P.O. Box 623, Phnom Penh, Cambodia
Tel: +855-23-425-353, ext. 2011, HP: +855-12-287-255
Fax: +855-23-425-363
sokhavuthea@mrcmekong.org

122. Mr. Chen Boly
Senior IT Assistant
Regional Flood Management and Mitigation Centre,
576 National Road No. 2, Chak Angre Krom, Meanchey,
P.O. Box 623, Phnom Penh, Cambodia
Tel: +855-23-425-353, ext. 2171, HP: +855-17-789-555
Fax: +855-23-425-363
boly@mrcmekong.org

123. Ms. Cheap Sotheavy
Secretary
Regional Flood Management and Mitigation Centre,
576 National Road No. 2, Chak Angre Krom, Meanchey,
P.O. Box 623, Phnom Penh, Cambodia
Tel: +855-23-425-353, ext. 2111, HP: +855-12-628-624 or 97-702-20797
Fax: +855-23-425-363
sotheavy@mrcmekong.org

RFMMC International Consultants

124. Prof. Dr. Bart Schultz,
International Consultant – Forum Facilitator (AMFF-8)
UNESCO-IHE, P.O. Box 3015, 2601 DA Delft, The Netherlands
Tel.: +31-152151734, HP : +31-651870709
Fax. : +31-152122921
b.schultz@unesco-ihe.org

125. Dr. Peter Adamson
International Consultant
3 The Manor, PEWSEY, Viltshire, SNO 5DW, United Kingdom
C/o: MRC Secretariat, P.O. Box 6101, # 184 Fa Ngoum Rd., Unit 18, Ban Sithane Neua, Sikhottabong, Vientiane 01000, Lao PDR
Tel : 44 1672 563 066, UK
petadamson@aol.com or adamson@mrcmekong.org

Mekong River Commission

Office of the Secretariat in Phnom Penh
P.O. Box 623, 576 National Road #2, Chak Angre Krom, Phnom Penh, Cambodia

Telephone: (855 23) 425 353 Facsimile: (855 23) 425 363
E-mail: mrcs@mrcmekong.org Website: www.mrcmekong.org