Report on

Regional Technical Workshop on Application of Modelling Tools for Climate Change Impact and Vulnerability Assessment of Mekong River Basin

Organized by the Mekong River Commission Secretariat

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List of Abbreviations and Acronyms

ANU-ICAM	Integrated Catchment Assessment and Management Centre, Australian National University
AusAID	Australian Agency for International Development
BDP	MRC Basin Development Plan Programme
CCAI	MRC Climate Change and Adaptation Initiative
CEO	Chief Executive Officer (of MRC Secretariat)
CSIRO	Australian Commonwealth Scientific and Research Organisation
Danida	Danish International Development Assistance
DSF	MRC Decision Support Framework
EP	MRC Environment Programme
FAO	Food and Agriculture Organisation of the United Nations
GCM	Global Circulation Model
GEF	Global Environment Facility
GHG	Greenhouse Gas
GMS	Greater Mekong Sub-Region
GTZ	German Agency for Technical Cooperation
IPCC	Intergovernmental Panel on Climate Change
IWMI	International Water Management Institute
IWRM	Integrated Water Resources Management
LMB	Lower Mekong Basin
MDG	Millennium Development Goals
MRC	Mekong River Commission
MRCS	Mekong River Commission Secretariat
NAPA	National Adaptation Programme of Action to Climate Change
NGO	Non-Governmental Organisation
NMC	National Mekong Committee
SEI	Stockholm Environment Institute
SEA START RC	Southeast Asia START Regional Centre
SENSA	Swedish Environment Secretariat for Asia
Sida	Swedish International Development Cooperation Agency
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WWF	World Wildlife Fund

Foreword

The Mekong River Commission Secretariat (MRCS) in collaboration with Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia, the Southeast Asia SysTem for Analysis, Research and Training Regional Center (SEA START RC), Bangkok, and the International Water Management Institute (IWMI) began a collaborative study on Climate Change Impact and Vulnerability Assessment on Food Security for the Lower Mekong River Basin in February 2008. The study will be completed by the beginning of 2010. It aims to:

- provide information on the likely impacts of climate change on water resources and food security in the Lower Mekong Basin;
- indicate potential adaptation strategies to reduce vulnerability;
- build MRC capacity on climate change and water resources knowledge; and
- enhance country and agency cooperation in Mekong water-related studies.

The expected outputs include data and information on hydrological and climate-related conditions and projections, which will be summarised in the final study report. The collaborative study is progressing towards a finalisation phase.

In order to gain comments form experts and Member Countries and to discuss the obtained results, a regional technical workshop on application of modelling tools for climate change impact and vulnerability assessment of Mekong River Basin was organised by the MRCS.

The workshop was attended by about 50 experts from the four riparian countries, regional organisations and international experts from Japan, Australia and the United States.

The study team received many comments that will improve the value of their report; extensive discussions took place not only in the meeting room but also during coffee breaks and during the cocktail reception; and recommendations were made as to how the approaches and results can be taken one step further by the implementation of the MRC Climate Change and Adaptation Initiative (CCAI).

Numerous attempts are made at the present time to downscale the General Circulation Models (GCM) to regional and even national scales to establish more localised information about climate change impacts. The regional workshop provided a status on some of the efforts made for the Lower Mekong River Basin. It also indicated that much effort will continue to be put into the modelling of climate change impacts and that these multiple approaches are one way to try to reduce uncertainty.

One of the points made in line with the international debate on climate change adaptation is that we all know the predictions are uncertain and they can surely be improved by improving the modelling techniques. However do we need super-precise models? Perhaps what we have now is good enough for many applications. We should make sure that we utilise the results we have for impact and vulnerability assessments identifying solutions on a local scale while at the same time continue to improve the models.

This is the approach that the MRC will take for the CCAI implementation - to use the results presented at this workshop for impact and vulnerability assessments in order to identify adaptation options, as well as in parallel to work with partners to update the climate change hydrological modelling as the knowledge and techniques in this field improves.

Executive Summary

The Regional Technical Workshop on climate change modelling 8-9 September 2009 discussed the advances of climate change modelling and the impact that this will have on vulnerability studies in the Lower Mekong Basin (LMB).

Climate change adaptation strategies are built on knowledge about climate change impacts and vulnerability assessments. The modelling on the global scale provides overall information on the patterns of climate change, climate threats and key vulnerabilities. One example is the identification of the large river deltas as key vulnerable areas. Decisions about adaptation involve large investments and governments therefore ask for more specific information on which to base their decisions. This has triggered work to downscale global modelling results to provide local details; for instance within the Mekong River Basin. It is however not a trivial task. Many research groups internationally and in the region work to improve the modelling capabilities as well as other impact assessment tools to support decision making.

It was made clear during the workshop that in conducting climate change impact modelling in the Mekong River Basin one can learn from international good practices, (some of these were presented at the workshop) and that the sharing of approaches and results is essential to moving the work forward. Compared with other parts of the world the Mekong River Basin is faced with particular challenges related to climate change impacts such as limited bio-physical and socio-economic data, insufficient knowledge on potential climate change impacts and poverty being a barrier for the adaptive capacity in communities.

The workshop provided a general overview of the climate change issue and the global modelling efforts, including the limitations of the global scenarios and models. The current discussions on improvement of the scenarios and global circulation models towards representative concentration pathways and earth circulation models were presented. This development is expected to result in improved understanding of the climate change threats in the near future and needs to be taken into account in the future works also at the regional scale.

Examples were presented of methodologies for climate change impact and vulnerability assessment applied in other river basins and catchments looking at particular sectors, for example agriculture, water resources and natural systems like wetlands. The presentations not only looked at the impacts but also adaptation to climate change.

On this background the main focus was the modelling of climate change and hydrology related to the Mekong River Basin, which was discussed at length and in much detail. The discussions provided comments and suggestions to improve the presented methodologies, disseminate the results for a broad group of users and a final panel discussion provided recommendations for future developments in the context of the MRC Climate Change and Adaptation Initiative.

1 Introduction

1.1 Background

National governments and international organisations working in the region are increasingly expressing their concern over climate change. There is a high demand for a better understanding of the potential impacts of climate change and variability, and in particular the options for adaptation to these changes.

The fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC) from 2007 and the IPCC Technical Paper on Climate and Water outlines the current understanding of the climate change impacts on water resources. This includes changes in weather patterns affecting temperature, rainfall and wind in terms of intensity, duration and frequency. The mega-deltas of the big river basins in Asia are considered particularly vulnerable because of the combination of flooding, sea level rise and large populations living there. Many of the impacts envisaged by IPCC can be expected to affect the Lower Mekong River Basin. The projected weather pattern changes point to increase in variability e.g. less rain during the dry season and more rain during the wet season and more frequent extreme weather events (though with regional differences within the Basin). Seasonal water shortages and floods may become worse, as may saltwater intrusion into the Mekong Delta due to storm surges and sea level rise. Impacts of such changes are expected to affect natural ecosystems as well as agriculture and food production, and exacerbate the challenges of satisfying increasing food demands for growing populations. This will increase the pressures on the socio-economic conditions of the various man-made systems and sectors and in the Mekong Delta increasing the competition between land use interests. Communities whose well-being depends on natural resources and ecosystem services will be affected with particular concerns for the Mekong Delta where a large population may be threatened.

For the time being, detailed understanding of climate change and how climate change may threaten the key environmental and social systems in the Mekong River riparian countries vary, but is in general limited. Viet Nam and Thailand have developed climate change scenarios and projections and have accomplished some studies on impact assessment and potentials for adaptation. The climate change information for Cambodia and Lao PDR is less developed, but expected to increase in the coming years following from the efforts to develop the Second National Communication to the UNFCCC.

Most past studies on climate change in the Mekong region used a single or limited number of global climate models (GCM-General Circulation Model), and simulation results to represent the future climate and did not quantify the uncertainty around the climate projections. The climate change projections are associated with a range of uncertainties related to the underlying assumptions of the global climate change drivers (expressed in the global IPCC scenarios), the selection of scenarios for the projection, the uncertainties of the GCMs and uncertainties of regional downscaling of the global modelling results. A recent study, undertaken by the CSIRO, attempts to quantify some of these uncertainties. The study predicted climate change parameters for 2030 based on the IPCC's Scenario A1B using the models that best simulated past climate conditions in the Mekong River Basin (using 11 models out of 24 available model simulations). The scenario A1B was selected as it represents a mid-range emission scenario. The study came up with the following average climate effects for the Mekong River Basin:

- A basin wide temperature increase of 0.79˚C, with greater increases for colder catchments in the north of the basin with ranges from 0.68-0.81˚C.
- An annual precipitation increase of 200mm, equivalent to 15.3%, predominantly from increased wet season precipitation with ranges from -3-360mm.

- An increase in dry season precipitation in northern catchments and a decrease in dry season precipitation in southern catchments, including most of the LMB.
- An increase in total annual runoff of 21% which will maintain or improve annual water availability in all catchments, however with pockets of high levels of water stress remaining during the dry season in some areas such as north-eastern Thailand and Tonle Sap.
- An increase in flooding in all parts of the basin, with the greatest impact in downstream catchments on the mainstream of the Mekong River.

The study also looked at impacts on food security through agricultural productivity and capture fisheries and found a possible 3.6% increase in agricultural productivity but with overall increases in food scarcity as food production in excess of demand reduces with population growth and changes to the productivity of capture fisheries and aquaculture. This requires further investigation, in particular with respect to the responsiveness of these sectors.

1.2 The Regional Technical Workshop on Climate Change Modelling

The Regional Technical Workshop on Application of Modelling Tools for Climate Change Impact and Vulnerability Assessment of Mekong River Basin provided an opportunity for the study team (CSIRO, MRCS, SEA START RC, IWMI) behind the project: "Climate Change Impact and Vulnerability Assessment for Food Security for the Lower Mekong River Basin" to share and discuss their results, obtain comments and discuss climate change modelling and application of modelling tools in a wider context.

The objectives of the Regional Workshop were to:

- disseminate the outputs of the collaborative study to national and international experts for further discussion with an aim to finalise the study and report;
- create a regional platform for climate-related modellers in the Lower Mekong Basin for updating, sharing and exchanging data and knowhow on applications of modelling tools for climate change studies; and
- ensure that the outputs of the collaborative study would further support the development and application of modelling tools for the MRC Climate Change and Adaptation Initiative.

The Regional Workshop was held 8-9 September 2009 in Bangkok in accordance with the programme attached in Annex 1.

About 55 participants attended. They included delegations of experts from the four LMB riparian countries, universities and research institutions, international and regional experts, MRC representatives from the four National Mekong Committees (NMCs) and MRCS. The list of participants is provided in Annex 2.

The Regional Workshop was structured into four sessions with 16 presentations in total by national and international experts. There was a strong focus on regional perspectives. Panel discussions were used to facilitate the dialogue and response to the topics of the sessions.

1.3 The Regional Technical Workshop Report

This report provides a brief background for the event, briefs summaries of the presentations made, as well as the main points raised in the panel discussions at the end of the sessions. The concluding chapter provides a brief summary of the conclusions and recommendations emerging from the meeting. All speeches and presentations made at the Regional Technical Workshop are on the MRC website (*www.mrcmekong.org*).

2 Workshop presentations and discussions

2.1 Opening Session: Climate Change and Adaptation Challenges

The opening session included a short welcome by Ms. Pornsook Chongprasith, Director of Environment Divison, MRC, an opening address by Dr. Siripong Hungspreug the Alternate Member of the MRC Joint Committee for Thailand, followed by keynote addresses by two International Experts on climate change impact assessment.

Ms Pornsook Chongprasith welcomed all participants to the Regional Technical Workshop and invited Dr Siripong Hungspreug, Director General, Department of Water Resources, Ministry of Natural Resources and Environment to make the welcome address.

Dr Siripong introduced his viewpoints of the challenges of climate change for the Mekong River basin and mentioned that in order to overcome the complexity of the climate change and its impacts in all aspects, the modelling and related tools are prerequisite. Since February 2008, the Mekong River Commission Secretariat; in collaboration with Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia and Southeast Asia SysTem for Analysis, Research and Training Regional Center (SEA START RC), Bangkok, have begun a collaborative study on climate change impact and vulnerability assessment for the Lower Mekong River Basin. It will be completed by January 2010. In June 2008, another project called the "Climate Change and Adaptation Initiative" for the Mekong was established by the Mekong River Commission with financial support from AusAID. The Climate Change and Adaptation Initiative will provide knowledge, tools and capacity building to assist the Member Countries to better prepare for climate change. Dr. Siripong explained that this workshop has been organized to support these two MRC climate change projects and stressed that the workshop is needed to be open and transparent, in order to generate constructive feedback on the outputs.

Prof. Tony Jakeman in the 1st keynote address presented an overview of "Modelling and decision support for integrated climate change impact and vulnerability assessment". He presented a range of frameworks for integrated assessment and compared their strengths and weaknesses in a Mekong context. He talked about integrated modelling approaches and suggested that Bayesian networks is a very useful tool to link complex issues and problems in decision making, including such issues as analysing the combined impacts of and vulnerability to climate change and non-climatic factors (economic development, hydropower development, population growth and displacement, risk and uncertainty management, adaptation policies and activities etc.) in a large basin such as the Mekong. He then linked this further to decision support systems. He emphasized lessons from two Australian case studies highlighting the importance of the participation of stakeholders and the process of design and implementation of the methodologies for decision support systems. He concluded by stating that the approaches need to be developed through an adaptive but systematic process involving explicit frameworks, selective modelling and decision support in a learning setting.

The second keynote presenter, Professor Raghavan Srinivasan made a presentation called *"Climate change impact on agriculture, water and environment".* This keynote address

started off with a general overview of climate change, greenhouse gas (GHG) emissions, the atmospheric processes and then focused on impacts on agriculture, water resources and adaptation options for agriculture. The presentation provided illustrations of impact and assessment methodologies from various case studies from different areas around the world (e.g. India, USA). The assessment methodologies included agricultural modelling as well as water resources modelling using the same or similar tools as those being used in the Mekong River Basin. The presentation concluded that an increase in temperature over the next decades would likely reduce yields of important crops such as maize, wheat, cotton, sorghum, and peanut. On the other hand the increase of atmospheric CO_2 concentration in the next decades could favor the yields of some species due to the so-called CO_2-fertilization effect (i.e. increased photosynthesis and water use efficiency). All crops will be subject to increased recurrence of extreme climatic conditions (e.g. droughts, extreme temperatures) and for fields close to the rivers also to risks of floods.

Question	Answer
Opening session	
How can the integrated modelling framework presented be applied for climate change analysis in MRC Member Countries such as Cambodia? How to implement the integrated modelling for the current work in Cambodia on vulnerability and adaptation assessment?	Models are not just put together but need to work in hierarchical order and linked to address the problem. Different models will not show exactly the same results. However, models may reveal the costs and benefits and can support the discussion on trade-offs. By using an integrated system you can combine the strength of different models.
In Tonle Sap, Cambodia – how to define where is the most vulnerable areas and the most vulnerable species of these areas?	A bottom-up approach is needed. In an integrated system, some parts can be more effective and sensitive, some are less sensitive but more reliable, some can be very costly require a lot of money and resources, other can be less expensive
In the presentation it was not clear how to deal with Methane and Nitrogen related GHG emission in relation to mitigation of agricultural GHG emissions	Prof. Srinivasan explained by two examples: reduction of fertilizer use in agriculture and preliminary processing of the manure before adding to the fields hence reducing nitrogen related emissions.

2.2 Session 1 – Application of modelling tools for climate impact and vulnerability assessment of Mekong River Basin: Outcomes of MRC-CSIRO Project

This session provides the workshop participants with the key achievements and results of the project. The set of modelling results to be presented includes climate change modelling and downscaling of General Circulation Models (GCM), hydrological modelling and agricultural modelling for the Mekong River Basin.

As a background for the discussions on global emission scenarios, global modelling and regional downscaling Dr Anond Snidvongs made a presentation entitled: "Next Generation Climate Projection for the Mekong Region". Dr. Anond focused on the recent developments of the global modelling and how this in the future may affect the downscaling and more detailed assessment of climate threats. This reflects the scientific developments in the IPPC lead work towards the Assessment Report 5. The new generation models will move away from the emission scenarios (SRES) to Representative Concentration Pathways (RCP) and focus on Earth System Modelling approaches to try to integrate e.g. feedbacks from land use. The RCPs are based on the target level of CO_2. How to reach these levels through mitigation and socio-economic development is not prescribed by the Global Modelling but must be negotiated at global scale. The Climate and Earth

System Model will use the RCPs to generate outputs to be used for vulnerability and adaptation analysis and integrated assessment models will have to be developed to match the RCPs with socio-economic costs and benefits. The new models will give more reliable support to be brought into the national and sub-national climate change agenda.

Dr. Guillaume Lacombe presented a detailed: "*Analysis of possible rainfall and temperature change in the greater Mekong sub-region over the period 1960-2049"*.
Dr. Lacombe has analysed climate trends using statistical analytical techniques and use the trend analysis to discuss future changes. The objective of the study was to detect impacts of climate change on rainfall and temperature in the Greater Mekong Sub-region, using output from the PRECIS regional climate model data (for emission scenarios A2 and B2). The study looked at a range of indicators for example change in rainfall: annual mean, number of rainy days, dry and wet season rainfall and heavy and light rainfall. The conclusion was that compared to temperature changes the rainfall changes are minor. The most significant prediction for rainfall is that light rainfall and number of rainy days during the dry season will decrease in the southern part of the LMB. Dr. Lacombe has also compared 8 studies of climate change predictions (including his own study). In general the studies provide consistent results; some discrepancies occur for rainfall due to natural variability and significance level of detected changes.

Dr. Chu Thai Hoanh in his presentation entitled: "*Overview on assessment of climate change impacts on Mekong hydrological regime"* explained the downscaling process from the General Circulation Models through to the Regional Circulation Models and to the hydrological modelling by the MRC Decision Support System (DSF). The presentation described the steps and assumptions made and how the climate change modelling scenarios and the MRC Basin Development Plan scenarios were coupled to provide the combined picture. The project has worked with the scenarios A2 and B2 using the GCM model ECHAM4 and the downscaling model PRECIS. The PRECIS model results were checked with observed data (1985-2000) and necessary adjustments made. Systematic adjustments were also used to correct the PRECIS results for the climate change scenarios. Dr. Hoanh presented the hydrological modelling system (the MRC DSF) and outlined its strengths and weaknesses in relation to climate change and development modelling. The climate change scenarios were combined with future development scenarios identified by the MRC Basin Development Plan and a combination of model runs used to present the results:

- With climate change vs. without climate change
- 1985-2000 vs 2010-2050
- Development vs baseline
- With adaptation vs without adaptation

In total six simulations and five comparisons of simulations were identified. The results were presented by the next speaker.

Dr. Kittipong Jirayoot continued the presentation of Dr. Hoanh discussin *"Impacts of climate change on Mekong hydrologic regimes of baseline and development scenarios"*. The presentation explained the approach used to adjust the PRECIS climate data by comparison between modelled results for the baseline period 1985-2000 with observed data for the same period, and then used this comparison to modify the projected data from PRECIS. The modeling results for the various points along the river and for various time periods were presented. The results presented the mean annual as well as wet season and dry season situation. The impacts on snow melt was also addressed as well as salinity intrusion for the Mekong delta though reminding that sea level rise was not taken into account. The combined effects of climate change and basin development were presented. The results showed – among many other things – that the basin development to some extent will compensate some of the expected effects of climate change both in the wet and the dry season.

The final presentation of this session was made by Dr. Mohammed Mainuddin talking about the *"Potential impact of climate change impacts on agriculture, fish and food security and*

adaptations strategies". Based on the data on climate change effects as presented by Dr. Kittipong, Dr. Mainuddin and the CSIRO team were modelling the impacts on agriculture, focusing on rainfed rice cultivation - as this represents 80% of the agricultural activities of the LMB measured by area. The study has used the AQUACROP model recently developed by FAO and setting up the model for a number of sub-catchments in the basin (3-4 in each country). Various data from the period 1985-2000 was used to establish the baseline of the model including adjustment of parameters to match e.g. yield data. The model results presented were only preliminary as more investigation into various aspects is needed such as sensitivity analysis of planting date, effects of fertilizer, increased concentration of carbon dioxide and supplementary irrigation. Furthermore, the team will try to model effects on other types of crops (e.g. irrigated rice, maize, sugarcane) and make an overall food security assessment.

Question	**Answer**
Session 1	
Do you use only one formula to adjust PRECIS data? This may be acceptable for temperature, but for rainfall it will not be acceptable as the differences between rainy and dry season are large so at least 2 different formulas are needed.	The adjustment uses one formula but specific parameters are derived for each month, which is a finer resolution than only considering the seasonal differences.
It seems that PRECIS has some difficulty calculating the changes of peak rainfall. What is the cause of this?	It is most probably related to aggregation. In the past there were no incidents of daily rainfall > 1000 mm, so when the modelling results showed such values they had to be adjusted. It was commented that there is almost no change in the annual rainfall due to the adjustment but some changes in the seasonality. Also, the findings on changes in rainfall patterns by Dr. Lacombe and Dr. Kittipong differ partly because of aggregation aspects but also because the methodologies used are different.
In case the results exceeded the set threshold level, how did you adjust rainfall?	The RCM outputs were compared with observed data monthly and adjusted by using coefficients until a fit to a certain extend was achieved. The future projections by PRECIS are adjusted using the same coefficients on a monthly basis.
How come some of the results for hydrology downstream of Kratie do not show positive change for the wet season (more water) and negative in dry season (less water)?	The model shows that without future development the flow will increase in both seasons. With development the dry season flow will increase whereas the pattern for the wet season flow depends on the combination of factors: increased rainfall, increased irrigation demand because of higher temperatures and finally storage in dams. It is necessary to use model simulations and sensitivity analysis to quantify the future flow situation.
Are the development scenarios used in combination with climate change exactly the same as the BDP development scenarios? Are the results published and if not when will this happen? The audience urged the authors to consider to document and present the results so that it can be used by other scientist working in other fields. The results are not only beneficial for climate change studies but also for	The team used exactly the same scenarios as the BDP with regards to development but the climate data are a little bit different because the climate change simulations use the RCM climate data as input, not the observed climate data. The difference in climate data is less than 5 %. The report is under preparation and one of the purposes of this workshop is to get feedback that can be taken into account in the report. The expressed concern will be considered.

Question	Answer
assessment of other changes in the basin. For example fish biologist would need separate results for the two seasons: dry and wet seasons as the species respond differently to the seasons. And it is better to publish also results on baseline options, not only climate change because many people are not only working with climate change, but impacts of other types of change and can use the results.	
Does the climate modeling assume any future development with regards to changing water usage and crop pattern or only weather and water flow?	The GCM focus is on emission scenarios and do not include as many feedbacks as we could wish. This will hopefully be improved with the presented future developments.
How did you determine the parameters used in the AQUACROP model?	For a large part of the parameters, the model suggests a value and recommends not changing them. For the other parameters a range of for the values are suggested. Some parameters were determined through calibration.
What are the main drivers of the crop model and did you perform sensitivity analysis for those?	Fertiliser stress and planting date are very important and can affect the results very much. These main drivers were not changed so far. As part of the finalization of the study the team will do sensitivity analysis of the fertiliser effect and planting date.
The MRC Fisheries Programme has very good time series on fish yield in Cambodia, which may be helpful for the further analysis on capture and aquaculture.	The team will use this information for future work

A panel discussion followed Session 1 where all speakers of the Opening Session and Session 1 were invited to form the panel. A few comments were made followed by a very lively Question and Answer session. The comments conveyed the following messages:

To complement the detailed discussion on modelling of climate change there is a need to discuss aspects of adaptation and how the climate change will affect the water regime and crop and socio-economic parameters. From the results shown today some of the expected negative effects of climate change are compensated by development e.g. the construction of dams, but the uncertainties mean that it is still premature to make definite conclusions. It is also clear the some areas are relatively more vulnerable to the future changes such as the Mekong delta, Lao PDR and North East Thailand. There is a need to focus the efforts on the vulnerable sectors and/or locations. In addition to the talk about impacts, it is also necessary to highlight the possible opportunities of developments such as dams and to consider opportunities not just look for the adverse impacts.

Question	Answer
Panel discussion, Session 1	
The climate data used to establish the crop model was based on a 20-30 years baseline and the model was relatively stable. But for crop model it self, the baseline period was 1996-2000. What would happen if this period was changed e.g. to 2000-2004?	The climate data is available only until 2000 so it is not possible to make the base line later than that. There is yield data for the area up to 2006, but with no climate data for this period it cannot be used. The baseline period is meaningfull because it is not possible to consider very long periods for crop

Question	Answer
Probably the results would be different. If that is the case, is the is the baseline then still meaningful?	modelling. The baseline period was selected to reduce the uncertainty.
How is it possible to extrapolate the crop modelling to regional model and scale, will the results it still be reliable?	Up to now the crop model is still at a national scale. More investigations will be made to upscale to a regional level in the near future.
The presentations have shown that the water flow will increase in the future. However for the Delta there is a need t o consider sea level rise. The observations have so far shown sea level rise at 3mm per year. Vietnamese experts have just finished a proposal for the official scenario including a sea level rise at 0.75 m by 2070. Could this be included into this model?	So far most of models on sea level rise for the Mekong delta are based on global trends. A study by the WB assumed sea level rise could be 1.5 m, and predicted 40 million people would be affected and estimated the costs. Sea level rise is however a long-term process, not a Tsunami. Ecosystems and society will adapt, and this long-term process needs to be incorporated in the modelling to provide meaningful results. Furthermore, the sea level rise in the delta is not just an average, but because of the north east monsoon, it may create problems during the dry season. Which on the other hand will experience more water in the future. For this complex system there is a need for more integrated long term modelling using as much knowledge as possible to reduce uncertainty.
How can we use the crop model for the Mekong delta. The crop modelling should not only use temperature/ rainfall and water but include effects of salinity intrusion and soil conditions. With sea level rise, floods would be more frequent.	The crop model did not include sea level rise and nobody can probably do it now. However the hydrological model includes estimates of how climate change will affect flood inundation. The prediction of inundated areas includes 100 thousand ha of crop.
The Climate Change estimates cover the next 50-100 years, with a gradual increase. Are our current hydrological models capable enough predicting the future 50-100 years? If not enough, what can we do?	The models are capable of modelling this. The IQQM for 2100 is still reliable/stable. The weakest points still lie in the limitation and consistency of data particularly for the Upper Mekong Basin.
How is the data availability for the modeling work? Experience from a study in China showed that it took 3 years to get data from the government for the model. And how is the accessability of the data for other groups than MRC?	MRC holds a wealth of data and the Information and Knowledge Management Programme (IKMP) manage the data especially on hydrology and flow. There are gaps in the data for China, so any organization with access to data from China that is willing to share it will be most welcome. The University of Oregon holds data from the Chinese Academy of Science. They can share the processed data but not the original/raw data. The MRC has an agreement to share data between countries based on the Mekong 1995 Agreement. IKMP is developing a data portal with all quality assured data that will be accessible via the Internet from next year. Some data may have restrictions on it use that will have to be observed.
Many data at provincial level, how to get long time series data will be expensive for study. In other countries it's very difficult to find,	The MRC data sharing procedure should make it possible to acquire such data if it is of basin wide nature. Of course when data does not exist, the MRC cannot provide it.
Listening to the ideas about creating a	The DSS is needed, and there is sufficient

Question	Answer
Decision Support System, is this something that can readily be done or does it require a lot of additional studies?	knowledge about the issue and sufficient time to create the DSS. But it must be done in a very inclusive way.
What are the main uncertainties of climate change modeling? What are the most difficult part of each step from global to regional, hydrological and crop model.	Global modelling is uncertain as discussed, but there is very little we can do about that. At the regional and country level other uncertainties such as land-use change are important. The most difficult part is probably the feedback or link to economic, political and land-use management. At present it's still impossible to include all those factors but we need to develop this aspect further.

2.3 Session 2 - Learning from international experiences on climate change study related modelling applications

The session 2 focused on learning from international experiences on studies of relevance to the Mekong context. The relevance could either relate to similar climatic and socio-economic conditions or the use of modelling tools and techniques that would be relevant for the Mekong River Basin context.

Dr. Yoichi Fujihara initiated the session by talking about the use of downscaled climate data: *"Hydrologic simulations of global warming impact using dynamically downscaled data: Case study of the Seyhan River Basin in Turkey"*. A dynamic downscaling method, referred to as the pseudo global warming method (PGWM), was used to connect the outputs of general circulation models (GCMs) and river basin hydrologic models. Two GCMs were used in this study (MRI-CGCM2 and CCSR/NIES/FRCGC-MIROC) under the SRES A2 scenario, and the downscaled data covered two 10-year time slices corresponding to the present (1990s) and future (2070s). The hydrologic models along with a reservoir model were driven using the downscaled data for the present period. As a result, the temperature and precipitation, which were dynamically downscaled through bias-correction, were in good agreement with the observed data. The average annual temperature changes in the future relative to the present were projected to be +2.0-2.7 °C. According to the model, annual precipitation decreases by 157 -182 mm (25-29%) in the future, and the annual evapotranspiration decreases by 36-39 mm (9-10%); the annual runoff decreases by 118-139mm (52-61%). The analysis of water resource systems was conducted by using a simple scenario approach to take into account changes in water use. This analysis indicated that despite the impacts of climate change, water scarcity will not occur in the future if water demand does not increase. However, if the irrigated area is expanded in the future, water scarcity will occur due to the combination of decreased inflow and increased water demand. The analysis also showed that snow melt is a key factor for the hydrology of the river. Presently, snow melt sometimes leads to floods in early spring and this may increase in the future. If the snow amount is monitored in winter, it is possible to forecast the inflow in spring, and relatively easy to operate reservoirs for flood control and water resources. However, precipitation observation systems have not been established yet.

Dr. Peter McCornick continued the session by talking about: *"Water Resources and Adaptation to Climate Change with a Focus on the Ganges"*. The presentation outlined a case study of the Ganges River covering the countries, India, Bangladesh and Nepal looking at the existing challenges, climate threats and risks including temperature rise, glacier retreat, flooding, drought and sea-level rise. The main sectors where water resources and climate change intersect were agriculture/food security and energy. Broad strategies for enhancing adaption were identified and the barriers for their implementation described to provide policy advice. The barriers for implementation included lack of data and information, limitations in capacity both technical, financial and human as well as physical, socio-political and institutional. Mr. McCornick concluded that water resources are affected by a range of drivers beyond the water sector, and

adaptation is entwined with broader development processes and models and decision frameworks increasingly need to capture relationships between livelihoods and water management under changing conditions and circumstances.

Dr. Krirk Pannangpetch presented a national study on the potential impacts of climate change on agriculture: "*Impacts of climate change on rice, sugarcane, cassava, and maize production in Thailand"*. The overall consequences of climate change for the yield of crops relate to increases in CO_2 concentration and temperature and the effects of increased climate variability. A spatial and temporal model was used to simulate the growth and yield of irrigated and rainfed rice, maize, sugarcane and cassava. The climate data used was results from the ECHAM4-PRECIS model complex. Simulations until 2100 showed in average small increases (about 10-15%) in yield except for cassava where a 43% decrease was predicted. The spatial variability was larger than the temporal due to weather extremes. Analyses were presented identifying areas were yield was less than 70% of average for the country. The next steps of the study are to investigate more closely why these areas are hit harder and what adaptation options can be identified.

Prof. Dr. Srikantha Herath from the UN University shared experiences through the presentation: *"Some experiences on regional climate change and variability modelling, rainfall downscaling & flood inundation in Southeast Asia"*. The UN University is hosting a Mekong Basin Research Network including a range of universities, research institutes and the World Bank Institute. UNU is undertaking arrange of research studies relevant to the Mekong context e.g. a study of climate change impact on rice production. A case study for North East Thailand found a decrease in yield as a result of climate change at about 25%. UNU uses a large range of modelling approaches for the studies and research. It was noted in this respect that it is almost impossible to clearly understand the water cycle of large basins. Assessment of ground water flow, storage and transport remain a major challenge. Evaporation and water use, especially return flow characteristics may complement each other and using stream flows alone is not sufficient for verification. Independent estimates of evaporation could be the key to clarifying groundwater and water utilization patterns in large catchments. For basin-wide decision making, consensus on the state of the basin water cycle and its potential changes are required. Prof. Herath concluded in this context that model based predictions are indispensable to assess climate change impacts on resources, production and extremes. Dealing with model prediction uncertainties is the greatest challenge facing designing adaptation strategies and require further research and ground observations. New design approaches may be necessary to cope up with uncertainties.

Question	**Answer**
Session 2	
Comparing Ganges and the Mekong, what are in your opinion the key issues for the future in relation to conflicts in a transboundary context, if any?	Conflicts will express themselves on a smaller scale rather than at the transboundary scale between countries
What can we do to transfer the scientific knowledge including modeling tools to the decision making level? Is the answer capacity building or are there other possibilities to facilitate the transfer?	The key is capacity building but also a more flexible use of existing capacities e.g. between countries. In the Ganges area, modelling capacities exist in Bangladesh but not in Nepal. A closer collaboration using the capacities in each of the countries would benefit all the involved parties.
Concerning the impacts on crops, how did you integrate the irrigation pattern into the analysis?	The land-use maps distinguish between rainfed and irrigated rice cultivation.
Are you sure the effects you have discovered are not due to climate variability rather than climate change? And how do you explain the results for cassava?	It is very difficult to distinguish as climate change is also expected to increase climate variability. The results for cassava are difficult to understand and will need to be further investigated.

Question	Answer
Are the increase in spatial climate variability verified or could it be a model artefact?	This is hard to answer, but needs to be further investigated.
Is the 20 by 20 km grid suitable to do this type of crop modelling e.g. for the soil map and weather grid?	This is the best we can do now. However, in some areas a suitable grid size would be a 5 by 5 km grid, but this varies by location depending on the variability of the determining parameters such as soil characteristics and rainfall patterns.
Inspired by the presentation of the UNU a comment was made: There is a large number of relevant networks that need to work together. Besides the large network presented by the UNU, examples include the initiative at the Can Tho University under the Dragon programme, Vietnam; the climate and adaptation initiative at AIT; the regional knowledge platform on climate change adaptation supported by Sida and lead by SEI and UNEP and the global adaptation network with a regional component hosted at the UNEP GRID center at AIT.	

2.4 Session 3 – Member Countries' climate modelling study and research on the Mekong River Basin; up-to-date modelling capacity and knowledge

Mr. Heng Chan Thoeun, Cambodia, presented the: "*Cambodian capacity and experiences on climate modeling"*. He described the climate models used for climate assessment in Cambodia e.g. for the Cambodian NAPA, past trend analysis and future projections by GCMs, the potential impact of climate change on sectors in Cambodia and the modeling efforts undertaken so far (dynamic and stochastic models) and the climate change adaptation strategies and linkages with sectoral programmes. The GCM models used give a mixed picture for Cambodia though they point to increased rainfall in the wet season and slightly decreased or unchanged rainfall in the dry season. Cambodia has performed a vulnerability assessment for the provinces and fund that the agricultural sector is the most vulnerable to climate hazards. The Cambodian NAPA has identified priority adaptation projects.

Mr. Chanseng Phongpachith presented *:" Lao PDR capacity and experiences on climate modeling"*. The presentation started by providing some background information about Lao PDR and the Mekong River in particular. The expectations in relation to climate change for Lao PDR are that drought affected areas will experience more drought and that heavy rainfall will increase leading to more flooding.. The NAPA for Lao PDR has nominated four major areas of concern: agriculture, forestry, water resources, and public health. To date there has been limited assessment, analysis or prediction through modelling efforts of the potential impacts of climate change on physical and social environment and long term climatic data do not exist in Lao PDR. The MRC DSF presented in session 1 was transferred to LNMC and the National modelling Centre established in the Water Resources and Environment Administration (WREA) and set-up for five sub-catchments. Further developing this approach would enable Lao PDR to model changes in water resources in the important tributaries in a similar fashion as presented for the Mekong River mainstream in Session 1. This is the strategy followed by Lao PDR, but their modelling capacity is still too weak and the linkage with the climate predictions not yet established.

Dr. Kampanad Bhaktikul presented some new approaches to: *"Iirrigation and agriculture modelling compared against rea- time climate extreme data"*. Dr. Kampapnad introduced some of the aspects of foreseen effects of climate change in Thailand and also presented the recent experiences (past 20 years) of floods, numbers of deaths by flooding, wind and waves. He presented a methodology to model future evapotranspiration under climate change, which is very useful for crop modelling. He then focused on demonstrating the use of generic modelling

algorithms for opimisation for cases relevant to the climate change situation namely root zone soil moisture balance, water scheduling in complex systems and equitable water allocation.

Mr. Tran Dinh Trong, presented the status in Viet Nam*: "Viet Nam capacity and experiences on climate modelling".* Mr Trang started by presenting an analysis of the weather patterns during the past 50-100 years in Viet Nam including trend analysis of temperature, rainfall and sea level. On average the temperature has increase slightly (0.1 C), a sea level rise of about 0.2 m was observed, whereas the precipitation trends are very mixed across the country with increase as well as decreases. Mr. Tranh then outlined the climate change modelling efforts in Viet Nam and a range of studies undertaken to assess impacts of climate change as well as to identify adaptation strategies. He finally presented the recent publication: "Climate change scenarios, Sea level rise for Viet Nam" which was developed in order to guide the work on adaptation at national and provincial level. It has been presented to the National Assembly for consideration and approval.

Mr. Suppakorn Chivanno concluded Session 3 by talking about: *"Strengthening and networking of regional capacity and experiences on climate modelling for the Lower Mekong Basin"*.Mr. Suppakorn argued that there is a need for developing the regional capacity on climate modelling to provide the necessary localized – high resolution climate scenarios which requires local expertise. There is a lot of work but limited resources and expertise. He presented some of the groups undertaking climate modelling work most of which is in Thailand. He promoted sharing of data and information to fully utilize the results of the on-going work and at the same time support capacity building. He also emphasized capacity strengthening on the use of climate simulations including proper understanding on climate scenarios, use of multiple climate scenarios for risk assessment and interpretation of key climate change concerns in a local context. Mr. Suppakorn's proposal for the way forward included networking for verification and post-processing of climate simulations, regional collaboration on interpretation of key climate change concerns in various hotspot throughout the region, awareness raising among the potential users of the results for risk assessment, continuity in further development of existing and new generation models for the region and seeking for other tools and method to project future climate change.

Question	**Answer**
Session 3	
Have you used any data from the GCM or RCM for Lao PDR or did you assume constant changes all over the sub-basins?	We did not have the capacity to use the RCM data.
Can the modeling case studies in Lao be used for decision making or is it only for capacity building?	Only capacity building so far. But it was clarified from MRCS, that the modelling case studies can be used to simulate more realistic climate simulations using the PRECIS data.
Is Lao planning to expand the modeling their modeling effort to use RCM data?	Yes hopefully with support from MRCS. It was commented that MRCS is willing to provide such support for the case study areas.
Is there any connection between the modeling efforts presented for Lao and the students at Lao National University that work with modeling?	There are some students studying abroad on this, but the connection seems not so strong. It was commented that it is important to build capacity at line agency as well as university level and to coordinate the various modelling capacity building activities.
The presented methodology from Thailand is statistical rather than physical based. What are the perspectives to use this for decision support for the Mekong River?	The method will be used for climate specific studies in the future. It is a new method, but it may have potential for working on aspects not able to describe by deterministic models such as health related issues and social aspects.

Question	Answer
When do you expect that the climate scenario for Vietnam will be approved?	The proposed scenario has been submitted to the parliament but when it can be approved is not known at this time. The scenario modelling work has not been stopped by this. It will be further improved and revised in 2010 and again in 2015.
If you have the Japanese MRI/AGCM model at 20 by 20 km grid for Vietnam, when do you have to use the PRECIS data, which does not provide a more detailed spatial scale?	The Japanese model data is only one result and we need to use more model results to make the decision robust. It was commented that the University of Cape Town has made data available for 19 stations in Vietnam as well as downscaling of 9 GCM models for Vietnam which can be downloaded from the web site.
Te presentation recommend working together and combining efforts but at the same time you present 6-7 groups working on downscaling at the same time in Thailand. Do you think we should join forces and use one model or continue to work in parallel like today?	The groups in Thailand use very different techniques and the value of this is a more robust understanding of the range of possible developments. It is not possible or useful to only work on one model or one technique within an area of such uncertainty.
Given the increasing difficulties of short-term climate prediction is the climate change modelling not predictions of the unpredictable?	The aim of climate modelling is not predictions as such but to understand the future directions of change.

3 Conclusions and recommendations

The final panel discussion engaged all the speakers of session 2 and 3. It aimed at drawing recommendations for the way forward by posing the question: How can MRC support the Member Countries improving their climate change modelling capacity? The response from the panel and comments from the participants can be summarized as follows:

- Summarize the climate modelling results using an IPPC approach. More work is needed at local scale in order not to base the decision making only on the RCM.
- Highlight the positive aspects of climate change and adaption: e.g. the hydropower planning (operational rules etc) could be assessed under a future climate and perhaps demonstrate benefits of climate change. Similarly for the agricultural sector results would show increase in yield as a result of climate change.
- To the extent the uncertainty of the predictions cannot be further reduced it would be useful to assess worst case scenarios to set a kind of boundary.
- The MRC should base their scenario work on regional and international expertise to transfer such knowledge and results to the Member Countries. Technical workshops like the one today are very useful.
- Capacity building on climate modelling. Special technical training should be organized to transfer the knowledge to the national level. If possible this should be integrated with the national activities. Training should be focused on promoting the skills of young people of e.g. the climate change office of Ministry of Environment (Cambodia). It should start now according to Lao PDR.
- Do we really need super precise models? Perhaps what we have is good enough for many applications. Perhaps the knowledge is sufficient to make risk and vulnerability assessments and find solutions in the local context.
- Need to integrate the work of the MRC-CSIRO climate modelling into the modelling work and expertise in the Member Countries.
- It is recommended to distinguish between climate change impacts and vulnerability assessments.
- It is also recommended to discuss other tools than mathematical models which are needed for the impact and vulnerability assessment and as part of this to define indicators of vulnerability.
- As also mentioned in the very first key note address it is important to engage in careful stakeholder participation.
- Make sure to look into quality information not only quantity. This is relevant for a range of aspects: agriculture, pesticides, water quality etc.
- Develop downscaling to a level of 1 by 1 km grid. Tools for developing high quality, high resolution long-term climate information. Don’t stop doing the high quality work or you will loose credibility.
- A data sharing web site to provide relevant climate change data. This is already planned by the Mekong Portal.

Annex 1. Programme

Regional Technical Workshop on Application of Modelling Tools for Climate Change Impact and Vulnerability Assessment

MRC-CSIRO Climate Change Project on Reducing Vulnerability of Water Resources, People and the Environment in the Mekong Basin to Climate Change Impacts

8 – 9 September 2009, Landmark Hotel, Bangkok, Thailand

AGENDA

Day 1 : 8 September 2009	
08:30 – 08:45 AM	Registration for the Workshop
Opening Session and Keynote Address (Chair: Dr. Siripong Hungspreug Director General, Department of Water Resources, Thailand)	
08:45 – 09:00 AM	Welcome address Objectives and expectation Workshop Agenda *By Dr. Siripong Hungspreug* *Director General, Department of Water Resources, Thailand*
09:00 – 09:45 AM	Modelling and decision support for Integrated Climate Change Impact and Vulnerability Assessment *By Prof. Tony Jakeman,* *Director of Integrated Catchment Assessment and Management Centre (ICAM), Australian National University, Australia*
09:45 – 10:30 AM	Climate Change Impact on Agriculture, Water and Environment *By Prof. Raghavan Srinivasan,* *Director of Spatial Sciences Laboratory,* *Texas A&M University, USA*
10:30 – 10:45 AM	Coffee break
Session 1 : Application of modelling tools for climate impact and vulnerability assessment of Mekong River Basin : Outcomes of MRC-CSIRO Project (Chair: Dr Anond Snidvongs, SEA START RC, Bangkok, Thailand)	
10:45 – 11:15 AM	Climate change data downscaled by PRECIS regional climate model for Mekong River Basin *By Dr. Anond Snidvongs,* *SEA START RC, Bangkok, Thailand*
11:15 – 11:45 AM	Analysis of possible rainfall and temperature change in the greater Mekong sub-region over the period 1960-2049 *By Dr. Guillaume Lacombe*

	International Water Management Institute – Southeast Asia (IWMI-SEA), Vientiane, Lao PDR
11:45 – 12:00 AM	Questions and comments
12:00 – 01:15 PM	Lunch
Session 1 : 'continued'	
01:15 – 01:45 PM	Overview on assessment of climate change impacts on Mekong hydrological regime *By Dr. Chu Thai Hoanh* *International Water Management Institute – Southeast Asia (IWMI-SEA), Vientiane, Lao PDR*
01:45 – 02:45 PM	Impacts of climate change on Mekong hydrologic regimes of baseline and development scenarios *By Dr. Kittipong Jirayoot, MRCS*
02:45 – 03:30 PM	Mekong climate change project - agricultural impacts and adaptation *By Dr. Mohammed Mainuddin* *CSIRO Land and Water* *Canberra, Australia*
03:30 – 03:45 PM	Coffee break
03:45 – 04:30 PM	Panel discussions on the modelling outputs from MRC – CSIRO Climate Change Project and recommendation for the next step of MRC Climate Change and Adaptation Initiative
Day 2 : 9 September 2009	
Session 2 : Learning from international experiences on climate change study -related modelling applications (Chair: Dr Sucharit Koontanakulvong, Department of Water Resources Engineering, Faculty of Engineering, Chulalongkorn University, Bangkok, Thailand)	
09:00 – 09:30 AM	Hydrologic simulations of global warming impact using dynamically downscaled data: Case study of the Seyhan River Basin in Turkey *By Dr. Yoichi Fujihara* *Japan International Research Center for Agricultural Sciences, Japan*
09:30 – 10:00 AM	Water Resources and Adaptation to Climate Change with a Focus on the Ganges *By Dr. Peter McCornick* *Nicholas Institute, Duke University, USA*
10:00 – 10:30 AM	Impacts of climate change on rice, sugarcane, cassava, and maize production in Thailand *By Dr. Krirk Pannangpetch* *Department of Plant Science and Agricultural Resources* *Faculty of Agriculture, Khon Kaen University, Thailand*
10:30 – 10:45 AM	Coffee Break

10:45 – 11:15 AM	Some experiences on regional climate change and variability modeling, rainfall downscaling & flood inundation in Southeast Asia *By Prof. Dr. Srikantha Herath* *Environment and Sustainable Development Programme* *United Nation University, Tokyo, Japan*
Session 3 : Member Countries' climate modelling study and research on Mekong River Basin; up-to-date modelling capacity and knowledge (Chair: Representative from NMCs)	
11:15 – 11:45 AM	Cambodian capacity and experiences on climate modeling *By Cambodian expert - Mr. Heng Chan Thoeun* *Team Leader of the Vulnerability and Adaptation Thematic Working Group of the Second National Communication*
11:45 – 12:15 AM	Lao PDR capacity and experiences on climate modeling *By Lao expert – Mr. Chanseng Phongpachith* *Chief of Water Resources Research Center, Water Resources and Environment Research Institute (WERI), WREA*
12:15 – 01:00 PM	Lunch
01:00 - 01:30 PM	Thailand capacity and experiences on climate modeling *By Thai expert – Dr. Kampanad Bhaktikul* *Mahidol University*
01:30 – 02:00 PM	Viet Nam capacity and experiences on climate modeling *By Vietnamese expert – Mr. Tran Dinh Trong,* *National Institute of Meteorology, Hydrology and Environment*
02:00 – 02:30 PM	Strengthening and networking of regional capacity and experiences on climate modelling for the Lower Mekong Basin *By Dr. Anond Snidvongs* *SEA START RC, Bangkok*
02:30 – 02:45 PM	Coffee break
02:45 - 03:45 PM	Panel Discussions on recommendation for MRC Climate and Adaptation Initiative to apply and support climate modelling tool for Member Countries of Lower Mekong River Basin *By National Experts*
Closing Session	
03:45 – 04:00 PM	Workshop Conclusion *By Representative from MRCS*
04:00 – 04:10 PM	Workshop Closing *By Representative from TNMC* *Department of Water Resources, Thailand*

Annex 2. List of Participants

Dr. Yoichi FUJIHARA	Japan Int. Research Centre for Agricultural Sciences
Dr. Peter McCORNICK	Nicolas Institute, Duke University, USA
Prof. Srikantha HERATH	Senior Academic Programme Officer, United Nation University, Japan
Dr. Chu Thai HOANH	IWMI-SEA, Vientiane, Lao PDR
Prof. Anthony JAKEMAN	Director of Integrated Catchment Assessment and Management Centre, The Australian National University
Dr. Sucharit KOONTANAKULVONG	Faculty of Engineering, Chulalongkorn University
Dr. Guillaume LACOMBE	IWMI-SEA, Vientiane, Lao PDR
Dr. Mohammed MAINUDDIN	CSIRO, Canberra, Australia
Dr. Krirk PANNANGPETCH	Faculty of Agriculture, Khon Khaen University
Dr. Anond SNIDVONGS	Director, SEA START RC
Prof. Raghavan SRINIVASAN	Director, Spatial Science Laboratory, Texas A& M University
Dr. Bounthanh BOUNVILAY	Assistant to Director General, WERI, WREA
Mr. Chanseng PHONGPACHITH	Chief of Water Resources Centre, WREA
Mr. Phetsamone KHANOPHET	Technical Officer, WREA
Dr. Siripong HUNGSPREUG	Director General, Department of Water Resources
Dr. Vichien KERDSUK	Research and Development Institute, Khon Kaen University
Dr. Khampanad BHAKTIKUL	Nat. Expert, Mahidol University
Mr. Nirat PHURIPHANPHINYO	Civil Engineer, TNMC
Ms. Thitima PHUAVONG	Assistant to Nat. EP Coordinator
Dr. Nguyen Anh DUC	Programme Officer
Mr. Tran Dinh TRONG	Inst. Of Meteorology, Hydrology and Environment
Mr. To Quang TOAN	Senior Researcher, Southern Institute for Water Resources
Mr. Heng CHANTHOEUN	Deputy Director of Int. Convention and Biodiversity Department, Ministry of Environment
Mr. Chea CHANTHOU	Deputy Director of Int. Convention and Biodiversity Department, Ministry of Environment
Mr. Peou VUTHYRAK	National EP Coordinator
Mr. Eric BARAN	World Fish Centre
Mr. Winai CHAOWIWAT	Chulalongkorn University
Dr. Kai Kim CHIANG	SEI
Mr. Supakorn CHINVANNO	SEA STAR RC
Mr. Alan COOPER	
Mr. David HANNAWAY	CropScience, Oregon State University
Mr. Ville HOKKA	GMS, EOC
Mr. Wichayan JALERNKUL	Chulalongkorn University

Mr. Tarek KETELSEN	ICEM
Mr. Mac KIRBY	CSIRO, Australia
Ms. Elizabeth KISTEN	Nicolas Institute, Duke University, USA
Mr. Jorma KOPONEN	EIA Ltd., Finnland
Dr. Phouphet KYOPHILAVONG	National University of Laos
Mr. Lothar LINDE	GMS, EOC
Mr. Tetsuro MIYAZATO	Japan Institute for Irrigation and Drainage (JIID)
Ms. Petra Pailin Mueller	GTZ, Bangkok
Mr. Sacha SETHAPUTRA	Srinakarinviroth University
Ms. Amphavanh SISOUVANH	AusAID, Vientiane, Lao PDR
Mr. Chaiyuth SUKHRI	Chulalongkorn University
Mr. Apichai SUNCHINDAH	GTZ, Bangkok
Mr. Sokchai SUTHIDHUMJIT	Chulalongkorn University
Dr. Jongdee TO-IM	Faculty of Environment and Resource Studies, Mahidol University
Mr. Pornsak WISETSOPA	Civil Engineer
Dr. Pornsook CHONGPRASITH	Director, ENV
Dr. Vithetr SRINETR	EP Coordinator
Dr. Hanne Clausen BACH	Chief Technical Advisor
Dr. Tran Mai KIEN	Programme Officer, ENV
Mr. Kaviphone PHOUTHAVONG	Programme Officer, FP
Dr. Kittipong JIRAYOOT	Modeller, ENV
Dr. Tanapon PIMAN	BDP
Ms. Ornanong VONNARATH	TSD
Ms. Navida MANOTHAM	Secretary, ENV