DRAFT (18 September 2006)

MRC Environmental Risk Assessment Training Program

Chiang Rai/Bokeo Case Study
Workshop 2: Risk Analysis Stage 1

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Mentor: Professor Barry Hart

11-15 September 2006

1. Introduction

The report contains a summary of the activities and outputs from the Chiang Rai/Bokeo Case Study Workshop 2 undertaken 11-15 September in Chiang Khong, Thailand.

The full program is outlined in Appendix A.

The Environmental Risk Assessment process being followed is shown in Figure 1. Different stages being undertaken as follows:

- Workshop 1 — Problem formulation
- Workshop 2 — Introduction to risk analysis (both qualitative and quantitative) – including an introduction to Bayesian Network models
- Workshop 3 — Risk analysis for present and future scenarios

  Management and planning implications of the results
- Workshop 4 — Complete final report with conclusions and recommendations

  Final presentation of results by each team

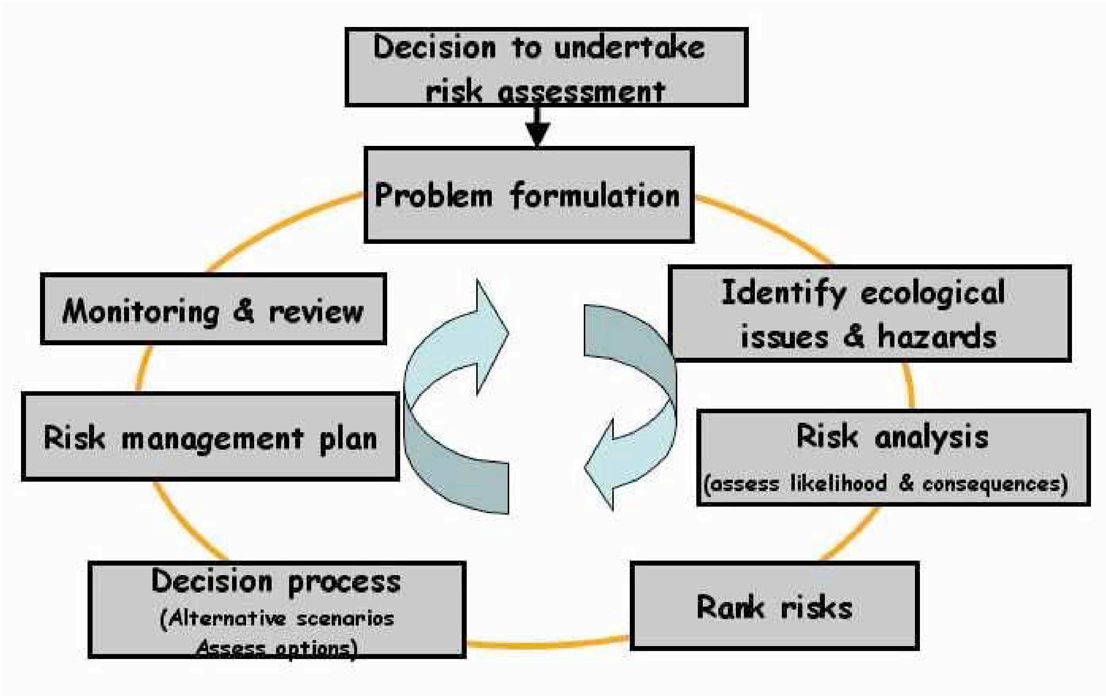

Figure 1: Environmental risk assessment process

2. Summary of problem formulation stage

2.1 Overall risk assessment objective

- To determine the potential risks to three important environmental values[1] due to human activities[2] in the study region now and over the next10 years.

2.2 Study region

- Figure 2 is the system (big picture) conceptual model developed by the participants during Workshop 1.
- During Workshop 1, participants undertook a field visit around the Chiang Rai, Chiang Saen and Chiang Khong regions in Thailand to familiarise themselves with the various activities in this region (see Chiang Rai/Bokeo Workshop 1 Report).
- During Workshop 2, participants undertook a field visit to the Bokeo Province. We visited Houay Xai and viewed the discharge of domestic sewage and wastewater from the market directly to the Mekong. We then travelled to Tone Pheung village and took a boat trip up the Mekong to view the extensive bank erosion that is occurring on the Lao side.

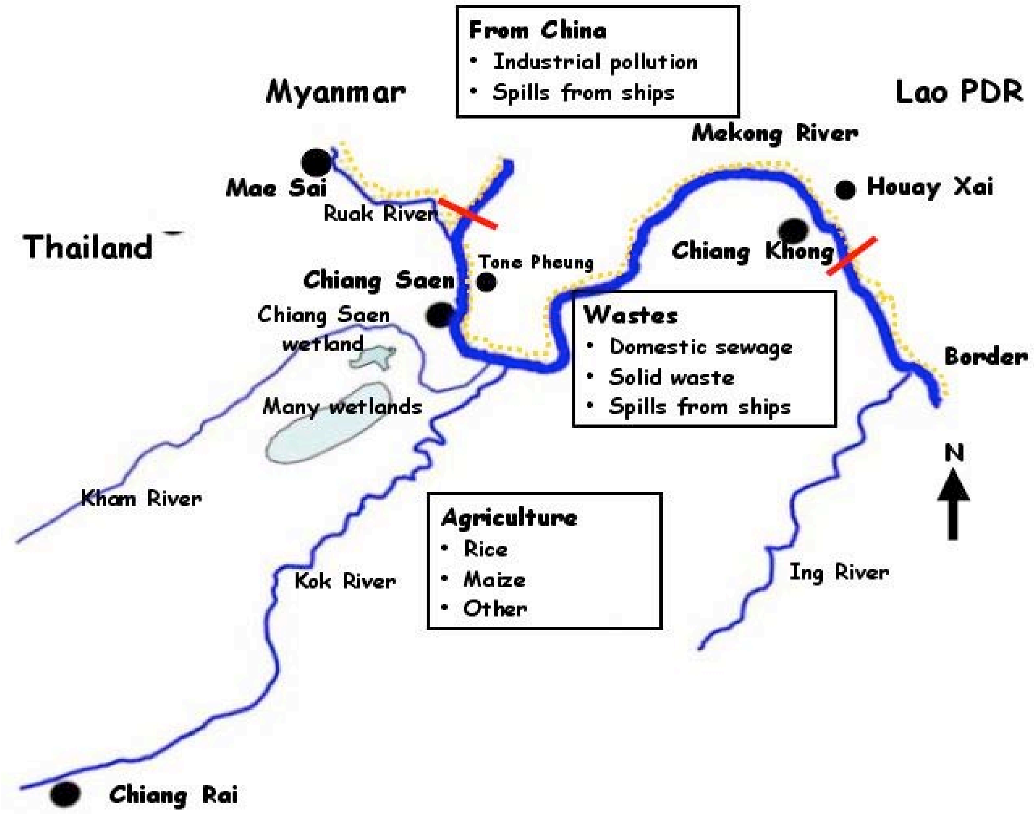

Figure 2: Big picture conceptual model for the Chian Rai/Bokeo case study

1 The health of the Mekong River in sustaining Giant Catfish and other fish populations: the health of the human population related to (a) domestic water for drinking and cooking, and (b) contaminated aquatic food resources.

2 Wastewater from humans, agriculture, water transportation; pollution from upstream Chinese industries; changed flow regimes (e.g. due to Chinese dams); climate change.

2.3 Scope of the project

Spatial

- See Figure 2 for project scope - broadly the Mekong River from the confluence of the Ruak River (border with Myanmar) to 10km south of Chiang Khong, the catchment of the Kok River in Thailand and Bokeo Province in Lao PDR.
- Subsequently, each team further considered the region of study to take account of the area of highest risk for their issue (see Team Workshop 2 Reports).

Temporal

Two time periods will be investigated:

- present
- medium term – 10 years.

Future scenarios

The future scenarios to be considered at Workshop 3 are listed in Section 5.

2.4 Issues for study

It was agreed that the environmental management goal for the study region was to maintain and protected the following environmental values:

- Improve the numbers of *Giant Catfish and other fish* in the Mekong River in the study region,
- Protect *human health* in the study region by maintaining *adequate quality water for drinking and cooking,*
- Protect *human health* in the study region by preventing *contamination of food* (particularly fish and other aquatic foods).

2.5 Hazard/threat analysis

The following major hazards (threats) were identified:

- *Domestic wastewater* discharged from Chiang Rai to the Kok River, and from Chiang Saen, Chiang Khong and Houay Xai to the Mekong River. These effluents include untreated sewage and stormwater. Possible adverse effects due to these wastewater discharges may occur in the vicinity of the city and further downstream. The risk assessment will determine the extent of possible downstream effects.
- *Agricultural* runoff to the Mekong River also occurs in the study region. This runoff may contain pesticides and herbicides, nutrients, suspended sediment and organic matter, and are a risk to the river and associated wetland ecosystems.
- *Industrial pollution* from China has also being identified as a possible risk the upper Mekong River in the vicinity of Chiang Saen. Currently, we have very little information on the types of industries that exist along the Chinese section of the Mekong River and of the composition of any waste discharges.
- *Water transport* – a large number of large boats transport goods from China to Thailand and Lao PDR through the Chiang Saen port. We will assess the risk to the river ecosystem and human health from possible spills of chemicals and oil from these ships.
- *Reservoirs* are being built upstream in the Chinese section of the Mekong River, and these have the potential to significantly alter the river flows in the study

region, and to increase the risks to the ecological health of the river and to the fisheries production.

3. Details of the issues to be assessed

3.1 Team 1 - The protection of fish populations with a focus on the Mekong giant catfish

Dr Santiwat Pithakool (Coordinator, and Modeller)

Dr Narumon Sanpgradub

Ms Souvany Phommakone

Statement of the issue

This part of the case study will assess the risk to the fish populations in the study region, with a particular focus on the Mekong giant catfish (*Pangasianodon gigas*).

The Mekong giant catfish is the largest catfish in the world. It is found specifically in the Mekong River and its tributaries, for example, Songkram river and Mae Mun River. Fishing of the giant catfish by local fishermen, particularly in Chiang Khong and Houay Xai area, has occurred for many years, and is still allowed despite the fact that this species is critically endangered. The numbers caught per year has been steadily decreasing.

Team 1 will investigate the factors causing this rapid decrease in giant catfish numbers (and also on the population of other major fish species), and assess the risk that population levels will decrease even further.

Assessment endpoints

Will be:

- Reduction in the giant catfish population, and
- Reduction in abundance and diversity of the general fish population.

Scope of the study

Spatial

Broadly the Mekong River from the confluence of the Ruak River to 10 km south of Chiang Khong/Houay Xai covering Chiang Saen and Chiang Khong areas in Thailand and Tone Pueng and Houay Xai in Laos PDR.

Temporal

Two time periods will be investigated - present and medium term (10 years)

Major hazards and threats relevant to the issue

- Loss of habitats and spawning grounds (Pi Long rapids in dry season),
- Changes in flow regime (particularly in the dry season),
- Bank erosion (Chiang Saen to Chiang Khong in flooded season),
- Poor water quality (Domestic wastewater from Chiang Saen and Chiang Khong municipalities, from Huai Sai area in dry season and toxicants from agricultural run off in rainy season),
- Possible pollution from China (this is being investigated).

Cause-effect conceptual model

This is shown in Figure 3.

There are three mains factors thought to cause the reduction of fish and giant catfish populations:

- domestic wastewater and agricultural runoff can cause an increasing in organic matter in the water which results in dissolved oxygen depletion. DO is necessary for the respiration of aquatic organisms, and a lack of oxygen causes mortality or fish and other aquatic animals.
- toxicants can enter the water body from many sources, such as domestic waste, agricultural runoff and wastes from water transportation. These can have two effects: they can be directly toxic to aquatic organisms or they can accumulate and magnify into higher trophic level through the food chain.
- habitat loss and habitat degradation. After a dam construction in China, the flow regime in the Mekong River may be changes and cause problems for the fish populations. Certainly the destruction of rapids in the main stream of the Mekong River, for improved navigation, will result in significant loss of fish habitat. Additionally, these changes are thought to cause additional bank erosion and increase turbidity. Such bank erosion can result in the loss of habitat for fish and Macroinvertebrate, and a deterioration of spawning grounds for fish. Also the increases in turbidity can reduce light penetration into the water, and reduce primary production. Phytoplankton, benthic diatoms and macroinvertebrates are important food source for fish, and a reduction in these food sources can result in a decline in the fish population.

In summary, the conceptual model shows that water quality, food availability, and the degradation and loss of habitat are the main factors thought to reduce catfish and fish population in the study region.

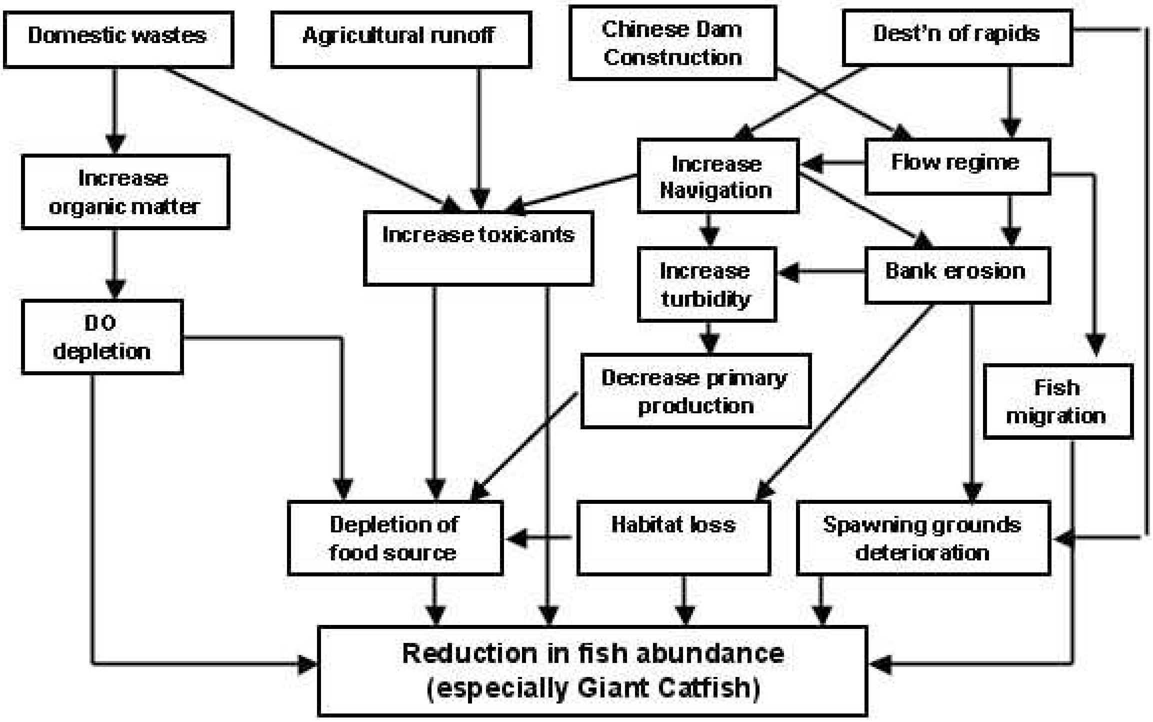

Figure 3: Team 1 conceptual model

Information obtained

See Team 1 Workshop 2 report.

3.2 Team 2 - Human health – drinking water

Dr Voranach Wangsupachart

Mr Porsak Jevasuwan (Coordinator)

Mr Bouakeo Suvanthong

Dr Chavalit Ratanathamskul (Modeller)

Statement of the issue

This part of the case study will assess the risk to human health of the local communities in the Chiang Rai/Bokeo areas from water-related factors.

There are communities of local people residing along the Lower Mekong River between Chiang Rai Province (Thailand) and Bokeo Province (Laos PDR) who use raw water from the Mekong River for drinking and cooking. Direct use of raw water as such might pose a potential health hazards to these people. This study will assess whether a high risk to human health exists or not.

Assessment endpoints

Team 2 will assess whether there is a serious risk to human health from using raw water from the Mekong River for drinking and cooking, and if so, what is the magnitude of the problem.

Scope of the assessment

Spatial

The Mekong River from the confluence of the Ruak River (Border with Myanmar) to 10km south of Chiang Koch, the catchment of the Kok River in Thailand and Bokeo Province in Lao PDR will be covered.

Temporal

Two time periods will be investigated: the present and the medium term (10 years).

Threats & Hazards

The major threats relevant to this study are:

- Biological pathogens (e.g. bacteria, helminths, protozoa, entero viruses),
- Chemical agents and toxicants (e.g. *Organic toxicants* such as organophosphate pesticides (OPs), other major group of pesticides used in the study sites (such as organochlorine, carbamate, paraquat) and key aromatic hydrocarbon from vessel fuel (e.g. BTEX), and *Inorganic toxicants* such as arsenic and nitrate.

Cause-effect conceptual model

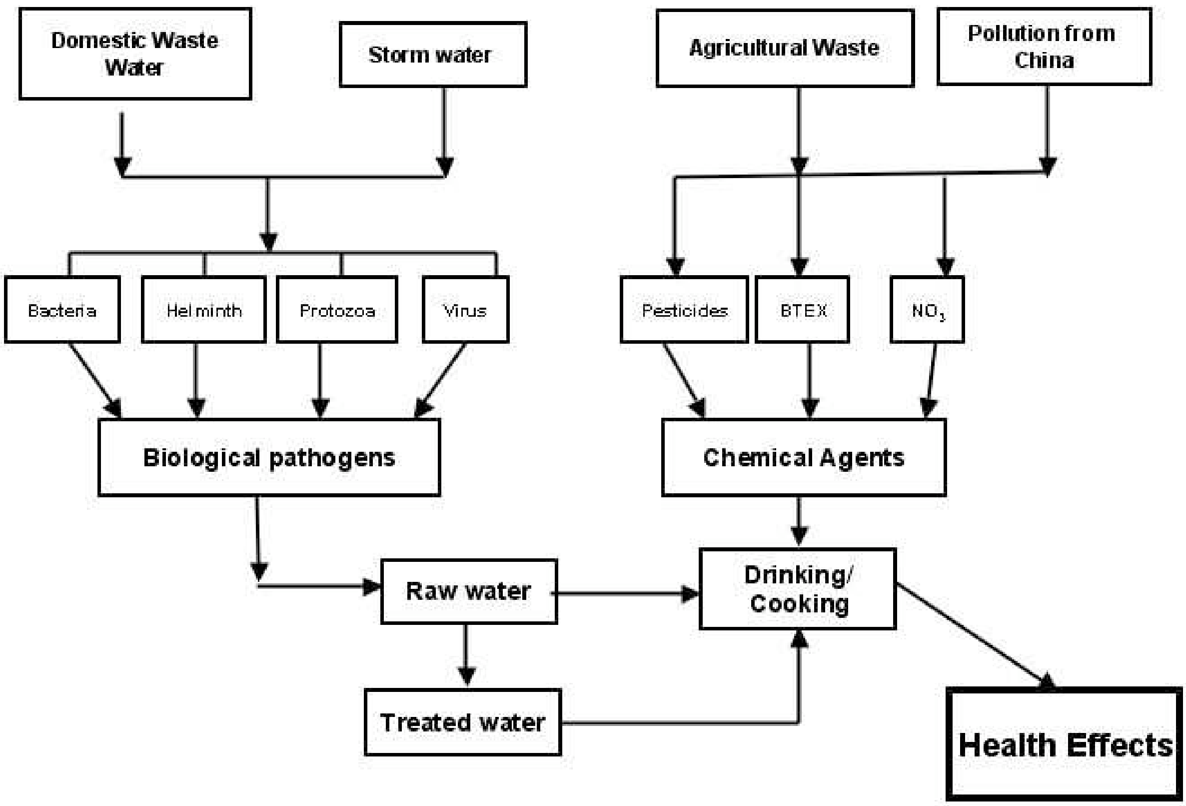

Figure 4: Team 2 conceptual model

Information obtained

See Team 2 Workshop 2 report.

3.3 Team 3 – Human health – contaminated aquatic food

Mr Chanthasack Bottaphanith

Mr Douangchan Lopaying

Dr Kannitha Krongthamchart (Coord)

Ms Amphone Vongvixay (Modeller)

Statement of the issue

This part of the case study will assess the risk to human health from eating contaminated aquatic food obtained from the Mekong River in the study area.

There is some concern that industrial pollution from upstream China will result in the contamination of aquatic food resources in the Mekong River in the study region. Additionally, there is also the possibility that more local pollution from domestic wastewater and agricultural runoff may also contribute to the contamination of these food resources.

This study will assess the potential that aquatic foods (fish, algae Kai) in the Mekong River will become contaminated because of both transboundary and local pollution sources and then a risk to human health.

Assessment endpoints

The main assessment endpoint for this study is the risk to human health from contaminated aquatic foods (fish and algae) due to toxicant substances resulting from pollution from shipping, industrial activities in the region and upstream, and pesticide from agricultural areas.

Scope of the assessment

The assumption is that the areas and the times of year when the risk is likely to be greatest are:

- The region around the Chiang Saen port, particularly during the dry season,
- Regions close to domestic wastewater discharge points throughout the year (Houay Xai, Chiang Saen, Chiang Khong municipality),
- The region around the Khon Pi Long rapids during the dry season.

Major threats

The main threats to be assessed are:

- Industrial operations, particularly those upstream in China,
- Leaking oils from ships (BTEX, PAH) in the study area and from upstream,
- Domestic waste (wastewater and solid waste) from the townships, and
- Pesticides from agricultural runoff, which may include organochlorins, organophosphates and carbamates.

Cause-effect conceptual models

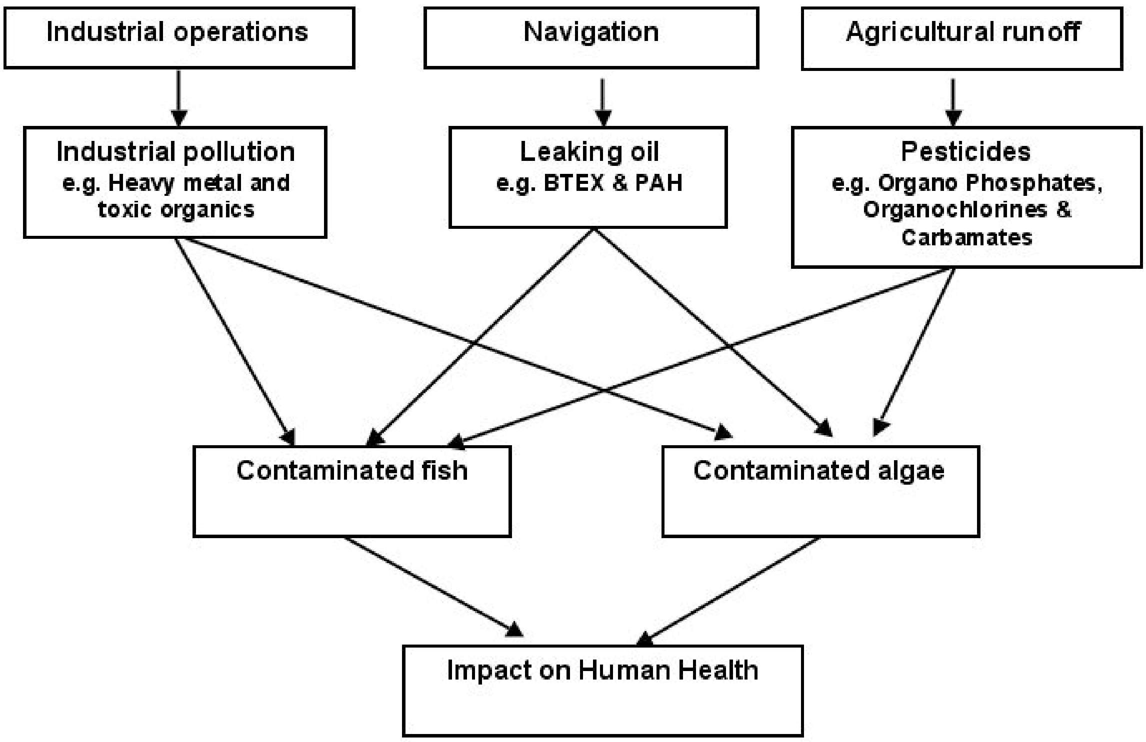

Figure 5: Team 3 conceptual model

Information obtained

See Team 3 Workshop 2 report.

4. Risk analysis stage

Participants undertook three exercises in this stage of the ERA process:

- Qualitative risk analysis,
- Introductions to quantitative risk analysis,

- Introduction to use of Bayesian Network models in risk assessment.

4.1 Quantitative risk analysis

For the qualitative risk analysis, each team was asked to rank the *consequences* and *likelihood* for each issue on a scale from 1 to 5, and then to estimate the relative risk.

Consequences - 1 = insignificant to 5 = serious

Likelihood - 1 = unlikely to 5 = almost certain

The results are shown in Table 1 below, and are interesting for a number of reasons.

- Three teams assessed fish aquaculture as being at highest risk – although interestingly the team who are assessing aquaculture did not rank this issue the highest.
- There was little agreement between the teams in their assessment of the five issues.
- The risk rankings ranged between 1 and 20, indicating huge differences between the groups in their assessment of risk
- A large number of the rankings for likelihood and consequences were in the range 2-3, suggesting that the teams were lacking in information and preferred the ‘middle ground’.

Participants discussed this process and decided the major problems with the approach were:

- difficulties in deciding on the ranking because of a lack of data or information,
- uncertainty in what was meant by the various terms (e.g. unlikely, almost certain, insignificant, serious),
- did not know what information the different teams used to make their assessments (lack of transparency),
- potential for the assessor to bias his/her assessments because no justification was required.

Table 1: Results of the qualitative risk assessment for the Chiang Rai/Bokeo case study

Issue	Team 1			Team 2			Team 3			Team 4			Team 5		
	C	Li	**R**	C	L	**R**	C	Li	**R**	C	Li	**R**	C	Li	**R**
Catfish health	4	2	**8**	4	4	**16**	3	3	**9**	4	3	**12**	5	2	**10**
General fish health	4	3	**12**	4	3	**12**	1	1	**1**	5	4	**20**	3	2	**6**
Human health – drinking water	4	5	**20**	4	3	**12**	3	3	**9**	5	3	**15**	4	3	**12**
Human health – contaminated food	4	5	**20**	4	1	**4**	4	2	**8**	5	2	**10**	4	2	**8**

C = consequences, Li = likelihood, R = risk

4.2 Introduction to quantitative risk analysis

Professor Hart presented the information ‘Quantitative risk assessment (see MRC ERA Presentation 4) demonstrating the advantages of more quantitative environmental risk assessments and showing a number of ways this can be achieved.

He indicated that the group would be using a new technique – Bayesian network modelling – for the first time to provide a quantitative assessment of the risks being assessed in each case study.

4.3 Introduction to use of Bayesian Network models in risk assessment

Professor Hart then presented the information 'An introduction to Bayesian Networks' (see MRC ERA Presentation 5a) in three stages:

- An introduction to BN and what they can do,
- Participants completed an exercise to define appropriate states (or categories) for the variables linked directly to the endpoint in their conceptual model,
- Completion of the presentation, showing how BNs can be used in different modes (e.g. prediction, inference, diagnostic, scenario testing).

The steps involved in building a Bayesian Network model are:

1. Construct the conceptual model,
2. Develop the BN *structure* from the conceptual model,
3. Define appropriate *states* for each variable,
4. Construct the *conditional probability tables* (CPT),
5. *Populate* the variable with information,
6. *Solve* the BN.

Participants focused mainly on steps 1, 2, 3 and 4. The results are provided in the three team reports.

The other steps will be covered in detail in Workshop 3.

5. Future scenarios

The future scenarios over the next 5-10 years that will be considered are listed in the Table below. Also shown is the consultant who will obtain the necessary information before the November 2006 workshop.

Table 2: Future scenarios to be considered in the final risk analysis

Possible Change	Who?
Agricultural changes • Increased rice production through increased irrigation infrastructure (in Kok and Ing River basins) • Possible increase in number of rubber plantations around Chiang Khong • Possible increase in rubber plantations in Bokeo Province • See Thai Govt National Social & Economic Development Plan 10 for information	Team 3
Flow changes due to upstream development of hydroelectricity dams (in China, Lao, etc) Two additional dams being built at present (one has 14 km3	Arounna with team modellers

volume – will be filled over several years) Effects of dams in the Study Region: • Little change in total annual flow (but some reduction in annual flow during filling) • Changes in seasonal flow pattern – higher flows in dry season and less in wet season • Possible less flooding (but flows in wet season will be little changed) • Possible less bank erosion (uncertain) • Less TSS in water coming from the dams, therefore more capacity to pick up sediment MRCS have lots of information.	
Climate change • Little change in next 10 years • In future - wet season commencement will be delayed by 1-2 months, wet more intense, dry season will be longer • Increase in extreme events – longer dry spells, more intense storms. MRCS have information Thailand – Dr Anond (Chula….. Univ)	Arounna Dr Chavalit
Increased ***urbanisation*** (**including tourism**) • Population increases (indigenous and immigrants) & potential tourist numbers in BDP report • Resulting in increased wastewater discharges • Possible increased tourists to visiting wetlands etc in the study region • Chiang Rai Tourist Authority	Pornsak plus Team 2 (for Lao PDR info)
Increased ***pollution from China*** Over the next 10 years	Already being considered by Team 1
Increases in ***water transportation*** • Possible increase between Chiang Saen and China • Agreement to transport 300,000 tonne petroleum Thailand to China – already started • Increased pollution around harbours from spills • Information from MRCS Navigation Program • Also info from Thai Department of Ports & Harbours	Team 1
Removal of ***Pi Luang rapids***	Already in Team 1 conceptual model
Increased ***industrial activity in Chiang Khong*** region More information required	Santiwat

6. Reporting

It was agreed that all reporting (reports, email contacts) between team members, coordinators and Professor Hart should go through the MRCS (Arounna), with a copy to the relevant EP coordinator.

7. Role of coordinator

A coordinator has been selected for each Team. The coordinator's tasks are:

- To ensure all work is completed on time.
- To report to Professor Hart and Arounna any problems being experienced (e.g. can't find data, can't access data). Important to report problems early and not wait until the final report is needed.
- To prepare regular short progress report (suggest fortnightly by email).
- To coordinate the preparation of the team report for presentation and discussion at the November 2006 Workshop.
- To be the main contact point for Arounna and Prof Hart.

8. Final report

Two reports will be prepared in February 2007:

- Report 1 will be full technical report.
- Report 2 will be small (2 page) summary report card setting out the main conclusions and recommendation in simple terms.

A broad outline of the structure and contents of the Final Report is provided below.

9. Team workshops & Mentor visits

The project has planned three additional workshops to coincide with important milestones, namely Completion of Phase 1 (and training of modeller in Bayesian modelling), completion of the risk assessment for the present and future scenarios, and preparation and presentation of final report.

- Workshop 1 & site visit (Planning, Problem formulation) Jun 2006
- Workshop 2 & site visit (Completion Phase 1) Sep 2006
- Workshop 3 (Quantitative risk assessment, develop models) Nov 2006
- Workshop 4 (Completion risk assessment, final report) Feb 2006

Prof Barry Hart

18 September 2006

Final ERA Report
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