CGIAR Challenge Program on WATER & FOOD

Revised Submission Document – Mekong Project 3

On optimizing the management of cascades or systems of reservoirs at catchment level

Basin Development Challenges of the CPWF

To reduce poverty and foster development through management of water for multiple uses in large and small reservoirs

March 2010

1. Basin Development Challenge:

Mekong: *To reduce poverty and foster development through management of water for multiple uses in large and small reservoirs*[i]

2. Project:

MK 3: *On optimizing the management of cascades or systems of reservoirs at catchment level*

3. Project Data

Duration:	*2 YEARS*
Target start date:	*April 2010*
Finish date:	*December 2012*
Maximum budget requested from CPWF:	*USD $800,000*

4. Project Deliverable

- Develop and evaluate strategies for management of cascades or systems of reservoirs at catchment level

5. BDC Goals to which the Project will contribute

New WSI are being built in various tributaries of the Mekong, including (but not restricted to) the common border area between Lao PDR, Cambodia and Vietnam. If this BDC is successfully addressed, these reservoirs will be managed in ways that are more fair and equitable for all water users. WSI management will take account of fisheries and agricultural potential as well as hydropower generation, and riparian communities will be able to utilize these water sources for multiple purposes. Catchments will be managed in ways that reduce erosion and the siltation of WSI, while benefiting riparian communities by opening up farming and other opportunities. Of importance will be the ability to manage WSI sequentially, along the length of rivers, so as to optimize benefits for all. In order to achieve this, water governance – the capacity to negotiate amongst water users (including dam operators) – must be improved, paving the way for policy and administrative changes that enable the sharing of benefits among riparian communities, among water users and between nations.

6. Links with other projects in the Basin Development Challenge[ii]:

MK3 is seen as an integral part of the Mekong BDC, coordinated through MK5 and the BDC leader. There are a number of critical inputs into the work of MK3 and outputs from it that contribute to the other Mekong projects. These are outlined below:

MK5

- **will maintain** the overall direction and coherence of all five projects and provide the coordination linkages, establish the institutional home for the BDC in each of the three countries through appropriate agreements on behalf of the BDC as a whole and facilitate the political support necessary to ensure the projects' success. MK5 will facilitate the provision of data on the characteristics and operation of the dams/reservoirs from the operators/developers, and other catchment data from the government water resource and environment agencies, and the Mekong River Commission

- **will receive and use** the results and products of MK3 in the multi-stakeholder platforms that are organised to showcase and discuss the work of the BDC. MK3 will provide text and pictures for articles on the BDC website.

MK1

- **will provide** recommendations for alternative land and water management strategies for improved livelihoods around each of the chosen reservoirs after the first year, together with their agro-ecological requirements, water demand, and sediment loading. These will then by scaled-up to the catchment level by MK3 and used in developing the hydrological and sediment models
- **will receive** feedback from MK3 on the applicability and impacts of these alternative strategies at a catchment level, so that these strategies may be modified appropriately. MK3 will also provide information on the geographic boundaries and water balances of each of the reservoirs being considered and downstream ecological flow requirements.
- The modelling results of MK3 will be linked with the DSS developed by MK1, so that catchment level implications of their strategies can be incorporated and simulated for other reservoirs in the catchment.

MK2

- **will provide** information on the economic valuation of the different strategies and impacts as applied to the three chosen reservoirs, to allow scaling up of economic benefits and costs at the catchment level, and to highlight trade-offs between the different sectors. MK2 will provide valuations of the different environmental flow analyses
- **will receive** feedback from MK3 on the catchment level economic analysis of these strategies, highlighting cost and benefit sensitivities that arise from such scale-up. MK3 could run the hydrological models to focus on such sensitivity analysis of the trade-offs between electricity production and changes in agricultural and ecosystem productivity.

MK4

- **will provide** information on the various water governance institutions in each of the catchments and at national and regional levels, working closely with the MK3 institutional and management specialist. The analysis of MK4 will help MK3 to identify the "gatekeepers" in both government and communities. They will provide guidance on the development and orientation of policy briefs arising out of MK3 recommendations.
- **will receive** the empirical observations of the impacts of multiple uses of water, and the implications for water governance, both at the conceptual phase and after the models have been run for the different scenarios.

It is anticipated that at reflection workshops, there would be opportunities to develop the agro-ecological profiles of the catchments, the ecological flow criteria and sustainability criteria that will allow MK3 to assess the catchment scale impacts of the different options being tested. It is envisaged that this will involve a facilitated discussion with participants from all the teams. MK3 will be collecting GIS data and developing maps for each of the catchments, and could respond to requests for specific GIS mapping and data analysis from any of the MK BDC projects at cost.

7. Project Summary

This project is about scaling up to the catchment level the results obtained from optimizing the management of individual reservoirs. As such, it draws on results from MKs 1 and 2. It seeks to understand at the catchment scale the cumulative upstream and downstream consequences of management decisions taken for multiple reservoirs. It includes the study of land degradation and reservoir siltation processes.

8. Links to previous and ongoing work

8.1 Previous and on-going work

Collectively, the project partners and team members have more than 7 decades of field experience in the target catchments including the following recent projects:

ICEM:

- A Strategic Environmental Assessment (SEA) of the Mekong mainstream dams for Mekong River Commission (2009 - 2010), the first assessment of its kind in the region.
- ICEM experts led the Mekong Wetlands Biodiversity Programme (2003 - 2007) aimed at conservation and sustainable livelihoods development in the LMB as a whole, with demonstration sites in Attapeu, Laos (on the Sekong) and at Stung Treng, Cambodia. Baseline surveys of biodiversity and socio-economic status were carried out, livelihood and conservation initiatives were developed.
- EIAs of three hydropower dams on the Sekong undertaken on behalf of the Russian developers, Region Hydropower Stations Laos - Sekong 4, Sekong 5 and Nam Kong 1 (2007-2008).
- Review of the impacts of hydropower dams on fish and fisheries for the MRC, with a component considering EIAs and fisheries monitoring in the LMB, especially Nam Theun 2, Theun Hinboun and the proposed dams on the Sekong (2009)
- A Cumulative Impact Assessment (CIA) of hydropower development on the 3S rivers basin, covering developments in Vietnam (Sesan and Srepok), Cambodia (Sesan and Srepok) and Lao PDR (Sekong). This project for ADB also includes a testing of the International Hydropower Associations Sustainability Assessment Protocol and development of the ECSHD initiative between ADB, MRC and WWF in the application of the protocol in a basin-wide context (2009).
- Scoping (IEE) for the Thakho hydropower run-of-river diversion for WWF and CNR (2009)
- Aquatic ecosystem monitoring, especially fish, in the Nam Ngum River Basin as part of monitoring for the Nam Ngum 3 Cumulative Impact Assessment (2007 - 2009) for ADB

Helsinki University (TKK):

- LMB Modelling Project (WUP-FIN) (2003-2007). WUP-FIN was an applied research project for the MRC Water Utilization Programme (MRC/WUP) to understand physical, chemical, biological and socio-economic processes of the lake-floodplain system under estimated changes caused by water resources development in upstream Mekong; and an assessment of environmental and socio-economic impacts of water resource development in four specific areas in Cambodia, Vietnam, Thailand and Laos.
- Sediment transport and trapping by the reservoirs in the Mekong region. The most relevant, is the study on the sediment trapping efficiency of the planned dam cascade in Lancang,

Upper Mekong. Other studies focused on the sedimentation of Tonle Sap Lake, river bank erosion in Vientiane-Nong Khai area and the human impacts on the hydrology and sediment transport in Angkor.

World Fish has been instrumental in advancing research and understanding of fisheries issues in particular and water resource management generally in the Mekong Basin. Within the CWPF group, WF has undertaken programs on stakeholder perceptions of water dynamics and collective learning at the catchment scale, as well as programs aimed at: enhancing Mekong Region water governance; Improving Mekong water allocation: searching for success with scenarios, environmental flows, multi-stakeholder dialogues, and consensus-building negotiations; amongst others (Sect14)

The other consortium Partners: ITC, WASI, NUoL are all based in the LMB and have undertaken a broad spectrum of projects covering IWRM, environmental flows, monitoring programs, teaching courses, livelihoods assessments in the region.

8.2 Lessons learned

The following lessons are drawn from the work of the project partners in the Lower Mekong Basin (LMB):

1. **Changes in flow affect sediments which impact directly and indirectly on local livelihoods:** Flow alteration has significant impacts on sediment transport which has knock-on effects like decreased nutrient transport, increased river channel erosion and decreased reservoir operation life time. Information on nutrient transport is important as many of the ecosystems supporting food production are dependent on the nutrients brought by the annual floods. Understanding of sediment trapping and its impacts provides essential information for the assessment of reservoir development and operations in the project's study area.
2. **Water balance modeling for catchments is often absent from WSI planning and when conducted fails to consider multiple uses.**
3. **WSI planning in the LMB is project based:** Development planning for rivers, especially those crossing national borders, occurs on project by project basis with little assessment of the cumulative or cross sector implications. Most projects, especially those for hydro and irrigation are not designed for multiple-use or benefit sharing.
4. **Benefits of WSI projects are national while risks and negative effects are often concentrated on local communities.**
5. **Spatial planning and the definition of safeguards for catchments as a backdrop for WSI development is neglected**
6. **Planning and development within the energy sector continues outside IWRM frameworks** with energy projects overriding other development and water use priorities.
7. **Coordinated inter-ministry planning within countries is improving** with increasing application of integrating tools such as strategic environmental assessment.
8. **Regional coordination remains underdeveloped**. It is evident that the MRC has not been given the authority or accumulated the credibility to drive basin planning or to act as a regular for development.

9. Research questions

The following are the research questions that this project should address:

- What are the cumulative consequences of alternative management strategies for individual and cascades of reservoirs on water use, livelihoods, land degradation and reservoir siltation, ecosystem services and other factors?
- What happens when water and land management strategies go to scale, and are adopted in a number of reservoirs in a catchment.
- To what extent will adoption of resource-conserving practices in catchments affect the rate of siltation in WSI?

How will your research address these research questions?

The project aims to develop a systems approach to coordinated and equitable management of cascades of reservoirs through a suite of hydrological and hydraulic modeling designed to focus on multi-use, optimization and benefit sharing at the catchment level.

The project elevates planning and management to catchment level and models all water uses and options as part of a comprehensive assessment of opportunities and risks posed by the operation of many WSI projects in one catchment.

At the core of the method is an assessment of the features of catchment hydrology which drive ecosystem functions and support a large proportion of LMB livelihoods. These features, such as dry/wet season flows, the flood pulse, intra-annual floods, droughts, inter-annual floods and sediment load and transport are the hydrological characteristics responsible for the high levels of biodiversity and productivity of the LMB. The hydrological and hydraulic modeling in this project is centred on the identification and quantification of those hydrological characteristics for the target catchments.

Three open-access models will be applied:

(i) VMod used to describe overall catchment hydrology. It has been applied by TKK to catchments in the LMB (e.g. Nam Songkhram catchment) with good results. It is a license-free program and can be distributed to the end users with the outcome of this project. However, normally the model is released only with sufficient training. VMod contains an open-source GIS application called RLGIS. The team is also currently exploring other open source GIS options (GIS Mapwindow)

(ii) HEC-ResSim, a reservoir model which emphases on water allocation, regulation and extraction which can be freely downloaded from the internet.

(iii) Generalized Dynamic Programming Package (CSUDP) which simulates operation rules and guides from historical flow data and reservoir characteristics. It is an open source program which can also be freely downloaded from the internet.

This suite of models quantifies the impacts of flow regulation and multiple water uses at catchment scale, and helps define catchment-wide management responses and the optimal design for cascade and systems of reservoirs and their operating rules and guides.

The project provides an efficient framework for the assessment of future management options through the translation of hydrological analysis into water and land use implications and a combination of stakeholder consultation and expertise. The relationship between hydrology and

agro-ecological systems are extended to identify the implications for the project's three focal sectors (power, agriculture and fisheries). Each management strategy is linked to hydrology which can be used to evaluate the potential livelihood implications. A set of ecological sustainability principles will be derived from consultations, expertise and the outputs of MKs 1 and 2 and used to gauge the effectiveness of the management strategies and resource conservation practices.

The project addresses the research questions in stages:

1. **Reservoir livelihood assessments:** First, the project simulates the sets of livelihood strategies identified in MK1 at the reservoir level for each land/water management strategy. This expresses the change to livelihoods for each reservoir or set of reservoirs in terms of water use, availability, sediment transport, (addressing the first research question). These results can then be evaluated against the sustainability principles and compared to the performance anticipated in MK1 and MK2.
2. **Effectiveness of resource conservation measures:** Second, the model simulates the effects of resource conservation measures at the reservoir level to determine their hydrology, water availability and sediment transport consequences. This will verify the effectiveness of these measures for the reservoir in question, involving estimates for the rates of sedimentation (addressing the first research question).
3. **Catchment livelihood assessments:** Focus then shifts to the catchment level as the modelling simulates the cumulative effects of livelihood options, based on the land/water management strategies, for all reservoirs in the catchment as well as up and downstream users (addressing the second research question). The expected insight from this set of activities is an understanding of the specific water use and sediment implications of the land/water management strategies. The analysis builds on a comprehensive water use and management profile of each of the target catchments.
4. **Effectiveness of catchment conservation measures:** Also, the analysis of resource conservation measures will be upscaled to the catchment level, so that their cumulative effects on the fate and transport of sediment is understood along with their relationships with WSI design and management.
5. **Catchment synthesis:** The final layer in the modeling component is to combine the two catchment-scale layers which explore the cumulative effects on livelihoods of various management strategies and the fate and transport of sediment with and without conservation practices.

There will be two categories of management outputs: (i) specific approaches for the three catchments under study (cf Sect12) and (ii) generic lessons, safeguards and standards of wider application. The project will document the challenges and benefits of a model approach to integrated water management at catchment level and package the models in a toolkit with interpretive manuals. Those insights and materials address the second research questions and are valuable to basin planning. The package of outputs allows planners to explore, use and adapt the methodology developed in this study for other catchments in the region and worldwide.

Consultations and capacity building: In order to influence the behaviour of the key stakeholders (dam designers and operators and catchment mangers), it is envisaged that there will 3 rounds of stakeholder consultation and training in each catchment designed to ground truth the model

and resulting conclusions, provide an opportunity for building the institutional and personal capacity of stakeholders, and to introduce the toolkit and method to them.

Sector analysis: The sector analysis throughout the project focuses on fisheries, hydropower and agriculture. Specialists will translate the modeling effects into implications for the performance of each sector for each scenario. Socio-economic assessments will act as cross-cutting conduits tying the four main elements under investigation together, namely: hydrology, ecosystem functions, sector water use and livelihoods.

10. Research Outputs, Methods and Uptake Pathways

10.1 Project research outputs

- Information on the cumulative consequences of alternative water and land management strategies for sets of reservoirs in three selected catchments.

What additional research outputs should the project produce, if any? What does the output(s) add to the BDC?

OUTPUT 1: Information on cumulative effects of alternative water and land management strategies for cascades or sets of reservoirs

This output aims to understand the livelihood implications of alternative land and water management strategies for WSI. It expresses their impacts as changes to the hydrological signatures of the river and evaluates their feasibility. It identifies the implications of the changes for ecosystem functions, and the fisheries, agriculture and power sectors. Finally, it analyses the changes through cross-cutting socio economic evaluation of costs and benefits for effected communities and their livelihoods. In a region where 80% of the population is directly dependent on the productive capacity of natural systems for their livelihood[1], a better understanding of flow-agro-ecosystem relationships is critical to any management strategy attempting to improve benefit sharing or to reduce poverty.

The output is designed to build on and test the outputs of MKs 1 and 2.

The output is expected to generate a suite of communications products (cf Sect12) targeted for the policy/decision making level, as well lay the foundation for Output 3 and begin to develop the toolkit for Output 4. It will also contribute to MK5 by providing information for the multi-stakeholder platforms.

OUTPUT 2: Information on cumulative effects of resource conservation practices on sedimentation in cascades or sets of reservoirs and evaluation of their catchment maintenance effectiveness

While Output 1 focused on quantifying the hydrological implications and subsequent effects of alternative land and water management strategies, Output 2 explores the hydrological implications and subsequent effects of resource conservation practices, especially erosion management in the catchment. It is expected that the fate and transport of sediment will be the key systems feature linked to changes in flow. Sediment dynamics are fundamental to all uses of

[1] ICEM, 2003. *Regional Report on Protected Areas and Development*: *Review of Protected Areas and Development in the Lower Mekong River Region*, Indooroopilly, Queensland, Australia. 197 pp.

WSI, affecting system efficiencies (eg power generation, irrigation) as well as nutrient transport. By improving understanding of this issue Output 2 is expected to improve WSI performance as well evaluate the effectiveness of various resource conservation practices to improve catchment management.

Output 2 will complete the substantive framework required for Output 3, as well as embed a sediment-balance methodology into Output 4. It will also incorporate and build on the expected outputs of MKs 1 & 2 bringing greater cohesion between the projects.

OUTPUT 3: Catchment level management strategies for target cascades and systems of reservoirs and generic lessons and strategies for wider application to other catchments

The central aim of Output 3 is to scale up the cumulative effects of different livelihood strategies (Output 1) and resource conservation practices (Output 2) to the catchment level. There is significant hydropower potential in the Lower Mekong Basin (LMB) and decisions made at the project level invariably affect the livelihoods of communities both up and downstream of the reservoir. The benefit of Output 3 is that elevating the cumulative effects to the catchment level allows for better integration and a more holistic, multi-use approach to management, with increased sensitivity to fairness and equity. It is expected to enhance the inclusiveness of decision making related to WSI and to consider the key sectors related to livelihoods (fisheries, agriculture) together with power development.

Output 3 will provide policy and management recommendations for each of the three catchments under study, and develop a set of generic materials, such as WSI guidelines, sustainability principles and safeguards and standards which will be useful for other catchments in the LMB and throughout the world.

Output3 will help to identify the trade-offs between different water management options for dams and reservoirs, and for the livelihood options within the catchments. Linkage between the modeling systems and the MK1 Decision Support System would be developed.

This Output will also contribute to the CPWF core value of building both institutional and local capacity, by embedding a two-way consultation process into its methodology.

OUTPUT 4: An integrated suite of models to simulate changes in hydrology and sediment transport to guide catchment level management of cascades or systems of reservoirs

This output aims to develop, test and package a modelling toolkit with the capacity to quantify the implications of management decisions on the hydrology and sediment dynamics at the catchment level. It is designed to use freeware and open access software, as well as be supported by a manual, case studies from the three project catchments and a program of training and consultations in all basins and at the national level.

The toolkit will be used to generate the technical understanding required for the management recommendations, approaches and policy guidelines arising from Output3. Additionally, it will ensure the longevity of the project findings, as the toolkit can be used and inform IWRM long after the Challenge project is finished and in catchments outside the scope of this particular study. In this light, Output 4 is directed at an institutional weakness ubiquitous in the LMB – the capacity for coordinated and integrated planning across sectors and across governmental departments and for geographic areas. The modelling toolkit will be linked with the Decision Support System developed under MK1.

10.2 Project partners

The project team comprises eight research and development organizations, half are national bodies, and all firmly embedded as key players in the LMB livelihood improvement and sustainable development fields (Section14). The consortium was designed to bring together the leading innovators in study fields. The project is designed such that all partners are intimately involved in all project activities, with each focusing on their particular area of expertise.

Output 1 & Output 2

- **ICEM/ WorldFish/IWMI** – consolidation of background information and MK1&2 outputs
- **TKK/ICEM** – set up, validation and simulation of model toolkit
- **ITC/WASI/NUoL** - stakeholder consultation and preparation of catchment profiles
- **ALL** – quantify the sector impacts and cumulative effects for livelihoods (Output 1) and effectiveness of conservation measures (Output 2) at the reservoir level

Output 3

- **ICEM/ WorldFish/IWMI** – consolidation of Output 1 & 2 and elevate to the catchment level
- **TKK/ICEM** – set up, validation, simulation & review of model toolkit
- **ITC/WASI/NUoL** - stakeholder consultation, catchment profile, impact assessments
- **ALL –** quantify the sector impacts and cumulative effects for livelihoods and effectiveness of conservation measures at catchment level

Output4

- **ICEM/NUoL/ITC/WASI –** develop, package and promote model tool kit and supporting documentation

10.3 Next users

The project outputs are targeted at the (i) WSI developers and operators working in the three catchments under study, (ii) government line agencies and (iii) research institutes. Line agencies include decision-makers and planners working on integrated water management strategies in catchments where there are multiple and sometimes conflicting water users. During the early stages of the work, an institutional analysis of the different stakeholders in each catchment at provincial, national and river basin levels will be carried out in conjunction with MK4.

Output 1 & Output 2: Focused on stakeholders directly involved in planning and development of the three study catchments: ie hydropower developers and operators, water resource and catchment management agencies and power development departments (national and provincial), and the development community supporting water management and power development projects (e.g. the MRC BDP program, GTZ,

AusAID, Finida, ADB, World Bank) and research institutes such as the project partners and those in the CGIAR network

Output 3: Stakeholders directly involved in planning and development within the three study catchments: ie hydropower developers, government socio-economic planning agencies (national and provincial), line agencies concerned with agriculture and fisheries extension and infrastructure, as well as the development community (e.g. the MRC BDP program, GTZ, AusAID, Finida, ADB, World Bank).

Output 4: Will have the widest audience of all project outputs, because it will be an open source tool packaged and disseminated over the internet. It will be used by the same stakeholders as Output 3, but in addition, will be picked up by development NGOs and INGOs, research institutes and students working in the Mekong region and around the world.

Finally it is expected that the power developers, investors and governmental energy departments would form a unique group of stakeholders because of their proximity to the decision making process. With regard to the outputs these users will be recipients for all four outputs. In particular with reference to Output 3 and 4 which the culmination of the entire project and the expression of the principle for integrated, fair and rapid management of WSI.

10.4 Learning required by next users

The learning required for the four outputs is similar and best expressed in terms of KAS (Knowledge, Attitudes and Skills).

The change in **Knowledge** required is likely to involve:

- Enhanced understanding of the hydrological and sediment dynamics in the three catchments
- Improved understanding of basic ecological functions (eg hydrological characteristics, and the relationship with ecosystem functions) and the linkage with changes in water resource management
- Improved understanding of water resource management implications of the three focal sectors. The approaches to IWRM are well known but enhanced knowledge and experience of their practical expression in the three catchments will be developed in all stakeholders.

The change in **Attitude** can be the most difficult to achieve for users of action-research work. It is also the most important for effecting long-term systemic change. In terms of the hydropower dam developers, attitude change will require recognition that other water uses have rights to use of that water, and that multiple-use of reservoirs needs to be incorporated into their operations for greater sustainability. Amongst catchment managers and the agriculture and fisheries sectors, an attitude change would see

hydropower dam operators being seen as partners for optimizing multiple use of the water. An attitude change amongst the policy makers would be the willingness to consider trade-offs highlighted by the project, e.g. electricity generation for increased agricultural production in a catchment.

It is expected that the change in **skills** will largely revolve around the ability to use and apply the model toolkit in action research programs and in practical planning situations, as well as improved consultation techniques to involve stakeholders. Skills will be developed amongst stakeholders to interpret and undertake numerical modeling (already advanced in Vietnam).

10.5 Research methods

The methodology employed in the study is presented in brief below. Section 11 provides a detailed itemized list of activities together with timing. Across the project the methodology employed can be divided by the type of activity:

Modeling: Three numerical models and one conceptual impact severity rating matrix. The model architecture comprises three main components (cf Section 9). First is a generalized dynamic programming package (CSDUP) designed to mimic the operation rules of hydropower reservoirs. Second a distributed physically based/conceptual hydrological model (VMOD), which has been used in several river sub-basins in South-East-Asia (Tonle Sap, Nam Songkhram, Mae Cham and Khuwae Noi) - it is already adjusted to fit the South-East-Asian monsoon weather conditions. Last, a reservoir operation model (HEC-ResSim) is designed to study behavior of reservoirs and to help reservoir operators plan releases in real-time at a daily time-step. HEC-ResSim represents a system of reservoirs as a network composed of four types of physical elements - junctions, routing reaches, diversions, and reservoirs.

The modeling activities include building the toolkit architecture, setup, simulation, and generation of outputs as follows:

1. Optimization procedure: Data on stream flow, reservoir characteristics (active storage volume, active storage height, dead storage volume, storage volume-water level relationship) and power station characteristics (installed capacity, peaking capacity, annual and firm energy, maximum and minimum head and maximum discharge) are used to set up the CSUDP model. Then constraints are added to reflect different management options for example, reservoir water level demands, release demands, water demands for irrigation, reservoir storage demands for flood protection.

An objective function is then used to find the optimal solution (e.g. maximum energy production of the whole cascade) that satisfies all the constraints. CSUDP uses discrete dynamic programming for optimization, which finds the optimal decisions e.g. releases from each reservoir so that the objective function gets its minimum or

maximum value. Objective function can be formulated so that it considers the energy production of each individual reservoir simultaneously with the total energy production of the whole cascade. The objective function will be formulated to consider multiple use, optimizing for one or more of the target sectors - energy, agriculture and fisheries – based upon the management strategies developed under MK1 and 2.

The output from the optimization procedure will be releases and reservoir storage levels from each reservoir.

Currently the modeling team has used the CSUDP model to estimate the hydrological impacts of reservoir cascade in the Chinese part of the Mekong, Lancang. Prior to Lancang cascade the CSUDP in Nam Ngum basin was tested by the team with rather good results.

2. Hydrological modeling: CSUDP outputs are put into the distributed hydrological model – VMod, in which each dam will be treated individually. The operation rules from the optimization guide the reservoirs in VMod so that the reservoirs function as a part of a cascade. This method enables the assessment of catchment-wide hydrological implications of reservoir cascades. Water extraction from the streams, e.g. for irrigation, can also be directly considered in VMod. VMod has also been used in China and the Mekong basin.

3. Sediment modeling: Sediment modelling has not been done and will require development. V-mod also has an inbuilt sediment transport module, which is currently being tested at the basin-wide scale by MRC. MRC is currently undertaking a review of sediments monitoring data to date, quality proofing them, and preparing proposals for collection of additional data. Initial information from MRC sources indicate that about 37% of the sediments from the central Highlands of Vietnam are likely to be trapped by dams. Sediments arising in the Central Highlands make up about 50% of the total sediments in the Mekong.

5. Water allocation modeling: MODSIM or HEC-ResSim will be used to study the water allocations between various users within the study river basins, as well as to predict the amount of sediments trapped behind individual dams. The MRC has not yet developed an integrated suite of models to simulate changes in hydrology and sediment transport in the tributaries of the Mekong, and has no model capable of dealing with cascades, though this is being considered in collaboration with the ADB at the moment for the 3S rivers. The model to be applied in MK3 – ResSim – can accommodate cascades. The allocation between different water users in each catchment will be based upon an inventory of water users, developed at the beginning of the project. These different demands and projections will be fed into the model as part of the overall water balance. The modeling integrates allocations for different water users throughout the catchment as part the overall water balance and allows the definition of trade-offs based on quantifying the availability of resources.

6. Analytical qualifications: The modelling outputs will be fed into and supplement a number of well-established analytical methods: 1) Brune method, 2) Brandt method, 3) Grant method. The Brune method will be used to estimate trapping efficiencies. The Brandt and Grant methods will be used to qualify the downstream geomorphological changes to the river channel in response to management decisions. The Grant method contains a method of visualising the direction of change that could be expected from a management initiative, which would be very useful from a planning and stakeholder participation point of view.

7. Data acquisition: Most of the data needed for these assessments is available through the Mekong River Commission such as flow and meteorological data and reservoir characteristics. Additional data, such as land use data and digital elevation maps, can be acquired from free global databases.

Additional data on the reservoir operation policies; the land and water management strategies and the resource conservation practices will be obtained from MK1 and MK2. The field collection of large volumes of primary data is not anticipated. There will be a reliance on primary data already being collected by others, for example, as part of the hydropower schemes being developed and operated. Data sharing will require direct interaction with the dam operators and agreements to use their data, especially on sediments.

Catchment and institutional profiles: Profiles of each of the catchments will be described to provide the context. These profiles will provide information on the environmental situation, land and water uses, key economic developments and socio-economic trends occurring in the catchments. An institutional analysis will be carried out both to identify the key stakeholders in each catchment, and the current status of their knowledge, attitudes and skills. This will form the basis for the M & E for the project, identifying the indicators of change.

Socio-economic analysis: Socio-economic analysis, linked the results from MK1 and 2, would scale up the livelihood implications to a catchment level to define a baseline. All modeling outputs are processed through sector and socio-economic analysis by the research team. This component ensures that all findings are consistently brought back to a livelihood assessment framework in keeping with the goal of the study to foster fair, feasible and coordinated management. The process will involve a definition of ecosystem-flow relationships, establishing sustainability criteria for the different agro-ecological zones and then testing the hydrological and sediment predictions of the models against these criteria. These would then be used to assess the implications compared to the baseline for the different sectors – agriculture, fisheries and hydropower – and for livelihoods of the communities living in the catchment.

Consultation: There will be three rounds of consultation for each of the catchments. They will be multi-purpose events designed to: build partnerships with key stakeholders, extract local information relevant to that stage of the project, build capacity and train stakeholders on the use and capabilities of the toolkit, ground truth predicted impacts directly with stakeholder to assess whether they are realistic, finally for the project team to report back and review their work with stakeholders. It is anticipated that such consultation meetings may be arranged with the other BDC projects.

Dissemination: The conclusions and lessons learnt from all outputs will be disseminated in a series of communication products (cf Section12), which express the cumulative effects of alternative water and land management strategies for each catchment and the livelihoods of its communities.

10.6 Participatory research approaches

The skills and knowledge challenges of KAS transfer (cf Section10.4) are easily addressed through conventional stakeholder consultations. However, the attitudinal shift requires a more innovative approach. ICEM and the consortium partners, through their wealth of experience in the LMB, have found that only continued and consistent involvement throughout the project will allow stakeholders to feel a sense of ownership of the work and its outcomes. And it is this ownership of the project which has the capacity to shift attitudes.

Also, given that the tool uptake is closely linked with the capacity of individuals and institutions to absorb it, the project team will undertake a review of the KAS (Knowledge, Attitudes and Skills) institutional and transfer analysis within the consultative activities. This will contribute further to the understanding of the challenges facing an integrated modeling approach to decision making in the LMB, as well as provide some guidance on how to overcome them

10.7 Change in user practice

Change in user practice	***Related Output***	***Research institutes***	***Government line agencies***	***WSI developers***
		Indicator of success		
Users will bring in multi-sector implications and trade-offs earlier into the planning process	1 & 2		Improved cooperation between government ministries	Increased consideration of multi-use reservoirs for planned and future reservoirs
			Regulations developed for multiple use in dam operation	Optimization of dam operational rules between the dams in the cascade
			Catchments managed for multiple use of water resources and reduction of erosion	Dam operators working closely with each other and government agencies for improved

Change in user practice	*Related Output*	*Research institutes*	*Government line agencies*	*WSI developers*
		Indicator of success		
				catchment management
User's will explore options for retro-fitting or upgrading existing WSI to multi-use systems	3		Increased consideration of benefit sharing options	Increased cooperation between local communities and WSI operators
Users will consult modeling as a useful tool to explore the implications of management decisions	4	Further research is undertaken by local and international institutes	Increased use of modelling in government institutes	Improved quality of EIAs WSI development plans showing a higher level of integration with other users
Users will be aware of the strengths and weaknesses of modeling as a tool to explore the implication of management decisions	4	Further research is undertaken by local and international institutes	Government will begin to produce guidelines for the use of flow model approaches to cumulative impact assessments	Dam operators use models for managing flows
Users will utilize multi-stakeholder consultation forums sooner in the planning/approval process	4		Increased support for consultation activities	Increased and sustained cooperation between developers and other stakeholders
Users will be able to gauge the impacts and evaluate the livelihood implications of possible management scenarios sooner in the planning/approval process	4		Increased involvement of agriculture, fisheries and water resource sectors in the WSI planning process	Increased cooperation and dialogue between developers and affected communities
Users will have the technological capacity to consider the implications of management at different scales	4	Development of model framework Continued use of the Mekong BDC website	Improved ability for spatial planning	

10.8 Suggested sites

The project will focus on the Nam Theun catchment (Lao PDR), the Sesan catchment (both Cambodia & Vietnam) and the Sesan/Srepok catchment (Cambodia).

In the Nam Theun catchment there are two existing (Nam Theun II and Theun-Hinboun) and two planned (Theun-Hinboun Expansion and Nam Theun I) dams.

On the Vietnamese reaches of the Sesan River there are five existing dams (Plei Krong, Yali, Sesan 3, Sesan 3a, Sesan 4). However in Cambodia there are no existing dams on the Sesan. Furthermore, the selection of the Sesan incorporates a transboundary challenge to the research, providing an opportunity to further test the methodology in a more complex and increasingly common water management challenge in the region.

There are no existing dams on the Sesan/Srepok, although approval has recently been granted for the development of Lower Sesan 2/Lower Srepok 2 dam at the confluence of the two rivers. This catchment was chosen because it offers the opportunity to enter the decision-making at the beginning of the development cycle not at the mid-point (NamTheun) or the advanced stage (Sesan Vietnam).

The first two of these catchments have been selected for other projects because of the presence of high profile reservoirs (eg Nam Theun II and Yali) and also because of the high number of proposed reservoirs for these catchments. MK1 and MK2 have also selected to work on the proposed dam and reservoir of Lower Sesan 2/Lower Srepok 2 in Cambodia, offering MK3 a unique opportunity to test the transferability of its outcomes in catchments where hydropower dams are at an early stage of planning and design.

11. Activities and Implementation Plan

The flow of activities relating to each output is summarized below. The scheduling of these activities is detailed in the attached Gantt chart.

Output 1: Information on cumulative effects of alternative water and land management strategies for cascades or sets of reservoirs

Output 1 addresses the first research question of the project and is driven by a modeling approach exploring various management options. Therefore it is crucial that a framework of criteria is established against which the results of assessments can be measured. In this project we propose to use a set of ecological sustainability principles. These will be built on the work of Projects 1 & 2 and supplemented with multi-stakeholder consultations and a literature review.

The next step is to draw together the required inputs for the model toolkit (see data acquisition above). Then the team will define the hydrological signatures of the river system**.** After which the natural systems specialists will establish the ecosystem-flow relationships based on the hydrological signatures and the sector specialists will establish flow-fisheries-agro-ecological links.

The models would be run for each of the existing and proposed reservoirs or systems of reservoirs based on the water use estimates for the alternative water and land management strategies from MK1 to quantify their overall effects on the systems hydrological signatures.

The results would be translated into effects on the systems hydrological signatures and subsequently into impacts on the ecosystem functions to determine the ecological and

biodiversity implications. The implications of these effects would then be translated to the three focus sectors (fisheries, agriculture, power) in order to assess the cumulative effects on: water availability; linked implications for management; design of reservoir systems; and trade-offs between different users.

The impacts of the management strategy would be assessed against the sustainability criteria in order to provide an understanding of the strategy's effectiveness at the reservoir-level.

Output 2: Information on cumulative effects of resource conservation practices on sedimentation in cascades or sets of reservoirs and evaluation of their catchment maintenance effectiveness

Consolidate the outputs of MK1 and MK2 relating to sediment for each identified conservation practices of alternative water and land management strategies for up-scaling to catchment level (MK1) and their associated cost-benefits (MK2)

Quantify the fate and transport of sediment loads and develop indicative sediment-flow relationships which link sediment dynamics to the hydrological signatures of the natural system and then extend to the alternative land and water management strategies with and without the resource conservation practices.

Undertake a sediment-balance, using a combination of analytical[2] and numerical modeling techniques, for each cascade or system of reservoirs based on water use requirements for each sector and environmental flows.

Using the results of the sediment balance quantify the sediment transport and catchment maintenance implications of differing hydrological signatures emerging from each resource conservation strategy and determine the ecological and biodiversity implications, then extend to express these implications in terms of the three focus sectors and determine the cross cutting socio-economic and reservoir maintenance implications.

Define and analyse the combined and cumulative effects on: water availability; linked implications for management; design of reservoir systems; and trade-offs between different users against the ecological sustainability principles. Then make the adjustments required in the original sets of livelihood options to ensure effective application of the ecological sustainability principles.

[2] For example empirical trapping efficiencies derived for similar WSI structures studied in the region. See for example: Kummu, M. and Varis, O., 2007. *Sediment-related impacts due to upstream reservoir trapping in the lower Mekong River*. Geomorphology, 85: 275–293

Output 3: Catchment level management strategies for target cascades and systems of reservoirs and generic lessons and strategies for wider application to other catchments

Output 3 combines the approach defined in Output 1 and 2 replicating them at the catchment level. Because the scope is now aimed at the catchment level the first step will be to develop detailed profiles for the three catchments under study, including analysis of: the institutional context (what are the decision making processes, the institutional structure, capacity to absorb integrated planning approaches?); the condition of the biophysical environment as well as catchment-wide profiles for water users at the catchment level.

Then through analysis, the first round of stakeholder consultations and the reservoir-specific findings of Output 1 and 2 identify a number of catchment-wide management strategies and resource conservation practices for each catchment so that the cumulative effects on livelihood options for each land and water management strategy can be understood and their effects on the systems hydrological signatures quantified.

Undertake a sediment balance for each catchment, using a combination of analytical[3] and numerical modeling techniques and then translate these effects on the systems hydrological signatures and sediment dynamics into impacts on the ecosystem functions and determine the ecological and biodiversity implications for the catchment

Critically review and fine-tune the catchment-level and MK 1 and 2 alternative land and water management strategies and associated resource conservation processes based on their catchment wide implications.

Develop predictions on the general nature and direction, and when possible the timing and extent, of change to ecosystem functions and livelihoods based on the associated changes to the systems hydrology. Using a severity ratings approach quantify the severity of the consolidated predictions on a 5-point scale and organize in a matrix.

Explore issues of scalability associated with hydrological and hydraulic modeling and draw implications for the integrity of the MK 3 findings.

Draw both general and target catchment specific conclusions of the 'scalability' of a modeling approach based on the translation of hydrological signatures into ecosystem and sectoral effects.

Output 4: An integrated suite of models to simulate changes in hydrology and sediment transport to guide catchment level management of cascades or systems of

[3] For example empirical trapping efficiencies derived for similar WSI structures studied in the region

reservoirs

The model will be built and tested in Outputs 1-3. The purpose of Output 4 is to package it and develop a library of supporting materials which will make it easier to use and increase its longevity as a decision support tool.

Package the suite of models including the severity matrix as a toolkit available for download or on DVD, including a user-friendly interface for the severity matrix

Develop a library of case study materials selected from the cascades or systems of reservoirs, and a manual in English.

Finally, to promote the use and future development of the toolkit the team will undertake a rapid desktop assessment to identify other catchments in the MRB and other BDC catchments which could benefit from the model toolkit, and also to undertake a program of workshops in each country.

12. Communications and alignment with CPWF Culture

12.1 Communications

The project is expected to contribute to the following communications products:

- A series of innovatively-designed products that communicate research findings to a range of stakeholders with a diversity of interests
- Working papers, journal articles and book chapters, particularly in Mekong-based journals and edited volumes, that describe the cumulative impacts of dam operations on downstream resources (particularly fisheries) and livelihoods; that reveal both the positive and negative impacts of hydropower and irrigation at livelihoods levels; that describe the costs and benefits of altering dam operations to the benefit of alternative, non-hydroelectric uses; and that analyze the utility and effectiveness of negotiation techniques across borders and between stakeholder power asymmetries.
- An open access website with contributions from CPWF partners and stakeholders

Briefly describe your communications plan

The MK 3 communications plan will be elaborated following a stakeholder analysis in each country and focus catchment. The main stakeholder targets for the plan will be defined and the most appropriate media and approaches for reaching those targets identified. Key ingredients of the plan will include:

A guide and manual for use of the suite of models including detailed methodological description

Three catchment case studies illustrating the application of the suite of models in the 3 target catchments – published in English

A set of GIS maps for each catchment and demonstration of GIS analysis as part of the modeling results analysis and communication

An interactive DVD including software for the three models, the manual, three case studies, the GIS maps and 3D flyovers of the catchments.

Four policy briefs – one for each catchment on challenges and strategies of IWMR and fair and coordinated water management and one communicating the generic strategies and approaches to senior planners – published in English, Khmer, Lao and Vietnamese.

Academic articles: At least three articles in academic journals authored with the researchers from the three national partners institutions

A technical report bringing together the methodology, findings, conclusions and recommendations of MK3. It would target national governments, the MRC and donor organizations. The technical report would aim to integrate the results of MK3 with those of MK 1 and 2 and facilitate the linkages with MK4 and MK5 analysis. It is anticipated that this will provide the information on which the policy briefs, posters and other products are based and may highlight the use of modeling and impact analysis in EIA/SEA procedures, hydropower and irrigation guidance, river basin management and specific guidance for optimising design and operation for dam developers/operators.

Consultative and capacity building workshops

Three consultative workshops at will be held in three stages in each of the three catchments:

1. To review the results of MKs 1 and 2, the three catchment profiles and the sustainability criteria.
2. To analyse the modeling of cumulative effects and interpret them in terms of catchment strategies and generic safeguards, standards and procedures
3. To build capacity in the modeling package and related interpretative materials

Project website

It is anticipated that MK5 will develop a website for the Mekong BDC as a whole. A dedicated page in this website will contain information on the project, its objectives, outputs, details of the partners, available reports and workshop power point presentations, photographs, and other materials, all free for download. It will also contain an interactive timeline of the project activities. Contributions to the project page will be provided by ICEM, in collaboration with its project partners.

Information sheets and posters

Taking advantage of the partnerships with regional universities, the project plans to produce a number of posters and information which will be available for the university partners to disseminate amongst their workplaces. The products are designed to provide information to students and researchers – and for use in university teaching courses. It will be also aid in the university's publishing of its research work and provide motivation to the students studying at these faculties.

University seminars

Scheduled throughout the project will be 2-3 talks on the project and its objectives and outputs at the partner universities. These will be open to all students at the universities to highlight the

project and the university partners' work. It is expected that these sessions will provide an opportunity to share experiences and encourage cooperation and student interest. The project team members will attend and speak to the students, encouraging knowledge sharing at both a local and international level.

Monitoring and evaluation
M&E will be a regular part of the communications plan, through feedback surveys, questionnaires and website numbers. This will be relevant in establishing what stakeholders find relevant, useful, educational, or difficult to understand. A record will be kept of the project's media coverage, and working relationships established with local and regional media outlets to ensure the project's successful communications.

12.2 Evaluative culture

Briefly describe how you will support an evaluative culture in the project

The M&E framework will include two components: (i) indicators and milestones for assessing progress in project implementation and (ii) impact indicators to assess the influence and uptake of the project.

Project progress M&E: A set of indicators of progress will be prepared for each project output in the form of a logframe. The project is implemented in five main stages and the indicators will be applied for each stage involving stakeholders.

Impact M&E framework: Section 10.7 set out initial indicators of success – ie reflecting up-take by stakeholders of project products and its overall influence on their research, planning and management activities. Many of the indicators would demonstrate changes over the medium to long term and so arrangements would be made with the MRC and national partner research organizations to build them into ongoing programs.

The M&E plan will be synchronized with the communications plan so that key communications events (deadlines for publications, upload dates for the website, reporting targets) are preceded with an internal project tracking review to ensure the desired outputs will be available as needed.

Each team member will have a work plan and progress reporting requirement to be brought together in a project (i) inception report, (ii) mid-term report and (iii) final progress report. The full team will come together for at least three progress review and planning sessions.

12.3 Alignment with CPWF core values

Capacity building: The project targets key staff in the local research institutes who are the partners in the research activities, local government line agencies, the hydropower developers, and the national agencies responsible for catchment planning and management. It has a strong on-the-job capacity building component and a series of

special training events bringing stakeholders together with planners and local research staff.

Interdisciplinary research: The project team includes 8 disciplines to help use hydrological modeling results to build an integrated planning and management framework of strategies for each catchment – and then to make IWRM strategies for generic application.

Partnerships: the project includes seven applied research organizations working in teams in all activities – four from the target countries and three with decades of local experience and commitment to the region.

Gender and diversity: The project team includes 12 nationalities. One of the proposed team is a women. Further gender balance will be sought in field activities and through the involvement of post graduate students, government staff and representatives of developers.

13. Assumptions and Risks

Assumptions:

- MK 1 and 2 would produce outputs useful for MK 3, including alternative land and water management strategies for cascades or sets of reservoirs and associated resource conservation practices.
- MK 1 and 2 outputs can be readily expressed in terms of water use, flow regimes and sediment effects
- MK 1 and 2 inputs are available in a timely manner and in a suitable form to feed into the modeling process
- The team will be able to access the critical climate and hydrological information from MRC
- The suite of models can be readily integrated into the programs and planning systems of national research organizations and line agency practitioners

Responses:

- MK 3 will start slowly during the implementation of MKs 1 and 2 so the teams can work closely together on common language and approaches to maximize effective integration.
- The three international partners (ICEM, WF and TKK) are all working with MRC in a range of projects and have special agreements to access the MRC databases. Those agreements will be extended to cover MK 3 activities and requirements.
- The project will conduct and institutional analysis in all three catchments to help shape the products to meet the needs and gaps identified. Regular training events will be conducted to help build capacities to pick up and use project outputs.

14. Project Team[iii]

Names of team members	Professional discipline	Institutional affiliation and address	Area of expertise important to this project.	Brief description of research responsibilities with respect to the outputs and activities listed in the Gantt chart.	Commitments[4]
Peter-John Meynell	Aquatic biologist	ICEM – Hanoi Vietnam	Integrated assessment tools for hydropower projects (EIAs, SEAs, CIAs), Water resources and wetlands biodiversity; Ecosystem management, River basin management; Fisheries management and monitoring.	• Project management, M&E • Sector & natural systems analysis • IWRM	
Jeremy Carew-Reid	Ecologist	ICEM – Hanoi Vietnam	Institutional assessment and capacity building	• Institutional Assessment • Design and M&E of capacity building activities • Design & facilitation of consultation events • IWRM	
Peter Ward	Hydrologist/hydropower engineer	ICEM – Hanoi Vietnam	Hydropower engineering, hydrology, hydraulic modeling, dam design and maintenance planning, sediment management, drafting of environmental and water quality guidelines	• Assessment of the cumulative impacts on the power sector • Sediment dynamics	
John Sawdon	Socio-economist	ICEM – Hanoi Vietnam	Distributional and poverty analysis, rural livelihoods, climate change impact assessment, project monitoring and evaluation, socio-economic survey design and conduct	• Project coordination • Communications • Sector and socio-economic analysis	
Tarek Ketelsen	Water engineer/modeler	ICEM – Hanoi	infrastructure design, hydrology,	• Project coordination	

[4] Note: Given the relatively slow start up of MK 3, it is not possible to project all commitments forward. There would be ample time for all team members to manage their respective project commitments

Names of team members	Professional discipline	Institutional affiliation and address	Area of expertise important to this project.	Brief description of research responsibilities with respect to the outputs and activities listed in the Gantt chart.	Commitments[4]
		Vietnam	modeling, IWRM, Fluid mechanics,	• Intra-team knowledge sharing • Modeling • IWRM • Hydrological signature definition	
Matti Kummu	Modeller	TKK Water Research Group – Helsinki Finland	Water resources, Hydrological impact assessment, Sediment transport, Hydrological modelling, GIS applications in water resources, Spatio-temporal scales in impact assessment	• Modeling • Sediment fate and transport •	
Marko Keskinen	IWRM and Social assessment specialist	TKK Water Research Group – Helsinki Finland	Socio-economic analyses & participatory research methods, Impact assessment processes, Multi- and interdisciplinary research on water resources,	• Participatory research • Socioeconomic impact analysis • Multi-disciplinary research coordination • erosion	
Timo Rasanen	Water engineer/modeler	TKK Water Research Group – Helsinki Finland	Water resources, hydrology, River basin modelling, Soil water and solute transport modelling, Hydrological impact assessment	• Modeling • Hydrological signature definition	
Robyn Johnston	Agro-ecologist	IWMI	Agro-ecology, IWRM, land rehabilitation	• IWRM • Definition of agro-ecological zones • Agricultural sector and natural systems analysis	
Eric Baran	Aquatic biologist	World Fish Centre – Phnom Penh Cambodia	Fish ecology, hydrology-fisheries interactions, Bayesian network and decision-support tools, impact of dams on fisheries	• Aquatic habitat analysis • Fisheries sector and natural systems analysis	

Names of team members	Professional discipline	Institutional affiliation and address	Area of expertise important to this project.	Brief description of research responsibilities with respect to the outputs and activities listed in the Gantt chart.	Commitments[4]
Paradis Someth	Water Resource Engineer	ITC – Phnom Penh Cambodia	IWRM, irrigation, water supply systems	• Preparation of catchment profiles • Modeling • Sediment fate and transport • Water supply infrastructure • Impact assessment • Promotion and training of modelling	
Phaknakhone Rattanna	Environmental Engineer	NUoL – Vientiane Lao PDR	Hydropower and irrigation infrastructure planning Environmental assessments and catchment profile building	• Preparation of catchment profiles • Assessment of existing and proposed infrastructure • Critical review of feasibility of strategies • Impact assessment • Promotion and training of modelling	
Truong Hong	Agronomist	WASI – Dak Lak Province Vietnam	Agro-ecology, soil science, Soil and fertilizer management; Agro-forestry management, water management for crops; Soil and water impacts assessment	• Preparation of catchment profiles • Soil erosion • Groundwater infiltration • Cropping cycles • Sector analysis • Impact assessment • Promotion and training of modelling	

Provide a brief text statement on why the lead institution is well-placed to lead the group.

ICEM - The International Centre for Environmental Management *is an independent public interest centre that helps governments, private sector and communities define and implement policies for ecologically sustainable development. It was established in 1999 to help governments and communities in building capacity to use natural resources sustainably and to maintain environmental quality. ICEM operates from offices in Brisbane and Hanoi and has specialists in environmental institution building and strategic planning, environmental economics, environmental assessment, protected areas, biodiversity conservation, GIS and modeling.*

ICEM has recently been commissioned by the Mekong River Commission to undertake a Strategic Environmental Assessment (SEA) of 11 planned hydropower dams along the mainstream Mekong River, in Cambodia, Laos, Thailand and Viet Nam. The SEA aims to assess the wider economic, social and environmental implications of the proposed developments. The SEA process has involved wide consultation with government, NGOs, civil society and the private sector, to facilitate information exchange and stakeholder participation. The country-level consultation has been facilitated by the National Mekong Committees (NMCs). The SEA has been building on the work undertaken by various MRC programs, including the fisheries, navigation and agricultural programs as well the Basin Development Planning process. The result will be an advisory study to guide and inform MRC member countries. In addition, ICEM has also contributed to a number of SEAs for hydropower sector plans and conducted climate change impact and adaptation studies in Vietnam.

Relevant Projects:

- *2009 – 2010: MRC Strategic Environmental Assessment (SEA) of Hydropower dams on the mainstream Mekong River, implemented in collaboration with the WorldFish Center*
- *Mekong Wetlands Biodiversity Programme (2003 - 2007).*
- *EIAs of three hydropower dams (Sekong 4, Sekong 5 and Nam Kong 1)on the Sekong River (2007-2008)*
- *MRC Review of the impacts of hydropower dams on fish and fisheries (2009)*
- *Scoping for a CIA of hydropower development on the 3S rivers basin, covering developments in Vietnam, Cambodia and Lao PDR ADB (2009)*
- *Testing of the International Hydropower Associations Sustainability Assessment Protocol and development of the ECSHD initiative in a basin-wide context ADB, MRC and WWF (2008 - 2009)*
- *Scoping (IEE) for the Thakho hydropower run-of-river diversion for WWF and CNR (2009)*
- *Aquatic ecosystem monitoring, in the Nam Ngum River Basin ADB Nam Ngum CIA (2007 - 2009)*

Provide brief text statements on why the proposed institutions are qualified to carry out the proposed research.

Helsinki University (TKK): *Water & Development Research Group is a cross-disciplinary research group operating at the Water Resources Laboratory of the Helsinki University of Technology (TKK), Finland. The laboratory has a long research tradition in water and development issues as well as in integrated management of water resources.*

Water & Development Research Group seeks to look at the interconnections between water and development with a comprehensive view. The group's research builds on multi- and cross-disciplinarity and on close cooperation with other universities and research institutes both in Finland and abroad.

The aims of TKK are to: (i) conduct multi- and interdisciplinary water research aiming for sustainable and balanced development, (ii) offer educational activities focusing on the links between water and social, economic and environmental development at local, regional and global level, and provide expert services in innovating and implementing technologies, strategies, policies and plans for enhancing integrated water resources development and management. In response to this mandate TKK have been involved numerous development research activities, most notably in the LMB. Over the past decade TKK has become one of the most innovative modeling teams globally.

The WorldFish Center *(WorldFish, formerly known as ICLARM) is one of the 15 centers of the Consultative Group on International Agricultural Research (CGIAR), with a mission to reduce poverty and hunger by improving fisheries and aquaculture. The Center has implemented grant projects in the region since the early 1990s, established permanent staff presence in 2003, and then a Mekong Regional Office in Phnom Penh, Cambodia, since 2005. WorldFish has a Memorandum of Understanding with the Fisheries Administration of the Ministry of Agriculture, Forestry and Fisheries to work collaboratively in fisheries research development in the country. The Center also has a high-level Country Agreement with the Royal Government of Cambodia represented by the Ministry of Foreign Affairs, with extended privileges that also cover IWMI.*

WorldFish has implemented a number of research projects in the Mekong region, on hydrology-fisheries interactions, impacts of dams on fisheries, valuation of wetlands and aquatic natural resources, and fisheries-dependent rural livelihoods, jointly with local government and non-government partners, and also collaborated with key regional intergovernmental bodies such as FAO and MRC, on various joint projects. WorldFish has lead and contributed to a number of CPWF Phase I projects, including CP/PN71 - Water allocation in Tonle Sap, CP/PN 35 - Community-Based Fish Culture, and CP/PN 10 - Coastal resource management for improving livelihoods and contributed to expert meetings and stakeholder consultation processes organized by the MRC Fisheries Program, the Basin Development Plan, and the Hydropower Program. In recent years WorldFish have been involved in the following CPWF programs:

- *PN 25 - Companion modelling for resilient water management: Stakeholders' perceptions of water dynamics and collective learning at the catchment scale*
- *PN 50 - Enhancing Mekong Region Water Governance*
- *PN 67 - Improving Mekong water allocation: searching for success with scenarios, environmental flows, multi-stakeholder Dialogues, and consensus-building negotiations*
- *PN 71 – Integrating Fisheries in Agro-Ecosystem Analysis (AEA) to support water allocation in the Tonle Sap wetland system*
- *CP-PN 35 -- Community-Based Fish Culture in Irrigation Systems and Seasonal Floodplains*
- *CP-PN 10 --- Managing Water and Land Resources for Sustainable Livelihoods at the Interface between Fresh and Saline Water Environments in Vietnam and Bangladesh*
- *CP-PN 35 -- Community-Based Fish Culture in Irrigation Systems and Seasonal Floodplains*
- *CP-PN69 --- Valuing the Role of Living Aquatic Resources in Rural Livelihoods in Multiple-use seasonally inundated wetlands in China for improved governance*

Institute of Technology Cambodia (ITC): *is a Cambodian Higher Education Institution which was founded in 1964 and supported by cooperation between the Cambodia and the former Soviet Union. More than 4000 executive members have been graduated from ITC. They are currently working intensely on the economic and social infrastructure development of Cambodia. In the current context of globalization and fast transformations of new technologies, ITC's main concerns are to play an efficient role in the Cambodian society and to be at the cutting edge of development to improve our educational system. Our goal is to provide students with a high quality education in the fields of engineering sciences and technologies. Students are provided with technical know-how and skills of analysis which allow integration and evolution in the labor market.*

ITC has implemented several research activities with international, regional and local partners, on Food Technology and Chemical Engineering, Civil Engineering, Electrical and Energy Engineering, Information and Communication Engineering, Industrial and Mechanical Engineering and Rural Engineering.

National University of Lao PDR (NUoL*): Founded in 1996 NUoL is a university is a partner of the Greater Mekong Sub-region Academic and Research Network (GMSARN) and ASEAN University Network (AUN)) and has developed into one of the leading universities in the Lao PDR. The establishment of NUOL, aiming at the consolidation and reform of higher education in the Lao PDR. NUOL has established extensive academic exchanges and cooperation with over sixty overseas institutions focusing mostly on student/scholar exchanges, staff development, joint research, join seminars, and exchange of academic publications. More specifically NUoL researches have worked with leading international universities such as Helsinki University modelling the fate and transport of sediments and hydrological modelling within the Mekong River Basin.*

Western Highlands Agro-forestry Scientific Technology Institute (WASI): *WASI was established in 1997 with the function to: (i) Study and transfer advanced technology in agriculture, forestry and water resource to Central Highlands regions , (ii) Participate in training, consulting and transferring scientific and advanced techniques to organizations, individuals and farmers and (iii) Collaborate with local and international organizations to carry out scientific studies on agriculture, forestry, environment protection to support the development in agriculture and forestry of Central Highlands regions. In this regard, WASI is well suited to work with international consultants, using their training and capcity building expertise with local farmers to improve the penetration of the challenge project into the local community. WASI has a total of 169 staff and has a research wing dedicated to the improvement of seeding, grafting technique protocols and other agricultural products. The institute is based in Dak Lak province and staff command excellent working knowledge of the Sesan and other catchments in the Western Highlands.*

WASI has collaborated on the following international projects:

- *Collaborate with International Phosphorus and Potassium Research Institute to implement the project of study on mineral fertilizer for corn in Central Highlands.*
- *Collaborate with E.D.E (Embden, Drishaus & Epping Consulting, GmbH & Co) to implement the project of "Sustainable coffee development".*
- *Collaborate with GTZ to implement the project of "Avocado value chain", "Cashew value chain", "Coffee value chain" and 4C coffee production.*

[i] This project is one of several that together constitute a research program to tackle the basin development challenge (BDC). Please read the description of the BDC that can be found in the Medium Term plan. If you are successful you will be expected to work as part of a coherent research program, led by the Basin Leader responsible for program coordination and coherence.

[ii] Project linkages and project contribution are shown in the BDC impact logic model in the Medium Term Plan

[iii] The quality and experience of your project team will help ensure the delivery of quality outputs.