Council Study: Inception Report

The Mekong River Commission

THE COUNCIL STUDY

STUDY ON THE SUSTAINABLE MANAGEMENT AND DEVELOPMENT OF THE MEKONG RIVER, INCLUDING IMPACTS OF MAINSTREAM HYDROPOWER PROJECTS

Inception Report

DRAFT FINAL

27 October 2014

Acronyms

ADB	Asian Development Bank
AIP	Agriculture and Irrigation Programme
AMRI	Australian Mekong Research Institute
BDP	Basin Development Plan Programme
BDS	Basin Development Strategy
CCAI	Climate Change Adaptation Initiative
CEO	Chief Executive Officer (Mekong River Commission Secretariat)
CPWF	Challenge Programme on Water and Food
DRIFT	Downstream Response to Imposed Flow Transformations
ECHD	Environmental Criteria for Hydropower Development
EIA	Environmental Impact Assessment
EOC	The GMS Environment Operations Centre
EP	Environment Programme
FP	Fisheries Programme
FMMP	Flood Management and Mitigation Programme
GDP	Gross Domestic Product
IBFM	Integrated Basin Flow Management
IKMP	Information and Knowledge Management Programme
ISH	Initiative for Sustainable Hydropower
IUCN	International Union for the Conservation of Nature
IWMI	International Water Management Institute
IWRM	Integrated Water Resource Management
LMB	Lower Mekong Basin
MRC	Mekong River Commission
MRCS	Mekong River Commission Secretariat
MWBP	Mekong Wetlands Biodiversity Project
NAP	Navigation Programme
NGO	Non-Governmental Organisation
NMC	National Mekong Committee
RTWG	Regional Technical Working Group
SIMVA or SIM/VA	Social Impact Monitoring and Vulnerability Assessment
TCU	Technical Coordination Unit (of the Mekong River Commission Secretariat)
TOR	Terms of Reference
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
WRM	Water Resource Management
WWF	World Wide Fund for Nature

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1. Introduction

1.1 Council Study Context

The fundamental objective of the 1995 Mekong Agreement is to achieve "the full potential of sustainable benefits to all riparian countries and the prevention of wasteful use of Mekong River Basin waters." This objective is complemented by the Shared Vision for "an economically prosperous, socially just and environmentally sound Mekong Basin." Achieving this objective towards the shared vision requires a detailed assessment of the positive and negative impacts of water resources development across sectors and borders.

At the First MRC Summit on 5 April 2010, MRC Member Countries' Prime Ministers reaffirmed their strong political commitment to implement the 1995 Mekong Agreement with the Hua-Hin Declaration. Subsequently, based on the outcome of the verbal discussion between the Member Countries' Prime Ministers at the 3rd Mekong-Japan Summit[1], the 18th Council Meeting of the MRC agreed in principle to implement a study on sustainable management and development of the Mekong River Basin including impacts of mainstream hydropower projects. The Council resolved to further consult with their respective governments and requested the MRCS to approach development partners to solicit support for the study[2].

In response to the Council's decision above, the MRCS developed a Concept Paper that was discussed and endorsed by the Regional Technical Working Group. The Concept Paper outlined the background and rationale, stated the goals and objectives, and set the thematic and geographic scope for the Study. It further discussed the impact areas and provided a general direction as to how the Study should be conducted and what the nature of the deliverables should be.

1.2 The Rationale and Added Value of the Council Study

The current understanding of how different water uses will impact the river basin can be improved and the confidence level of predictions made using models and other tools could be enhanced. The Basin Development Plan Programme (BDP)'s Assessment of Basin-wide Development Scenarios completed in 2011 assessed four future basin development scenarios against 42 economic, environment and social criteria that were selected to provide an overall picture of socio-economic development and environment protection parameters of importance for decision-making in the basin.

The BDP Assessment of Basin-wide Development Scenarios allows the Member Countries to identify the 'development space' available for the development of basin resources based on when unacceptable environmental and social repercussions set in. Based on expert opinion estimates, it assessed a number of scenarios over a 50-year timeframe including broad-based developments in the tributaries, the mainstream and the Upper Mekong (Lancang River) providing a useful tool for the four Member Countries to plan their development initiatives in the basin. However, considering the broad-based approach, it does not provide significant resolution on the impacts of large-scale projects planned or already underway in the mainstream of the Lower Mekong. Considering the urgency of understanding the sectoral, cross cutting and cumulative impacts of these impending developments, the Council Study was conceived as a strategy to close this gap.

In essence the Council Study will address the current uncertainties in assessing the impact of different development opportunities in the Mekong River Basin and provide a clear, strategic,

[1] Held in Bali, Indonesia, November 2011

[2] See paragraphs 21 and 22 in the minutes from the meeting of the Council

pragmatic and actionable set of recommendations to facilitate informed development planning in the mainstream of the Lower Mekong Basin.

Considering the importance of assessing the impacts of Climate Change, the Council Study will assess how a changing climate may exacerbate (increase) or mitigate (reduce) some of the impacts caused by changes in water use, in essence it will identify the risks and opportunities that Climate Change provides in the context of developments in the six thematic areas selected for the study.

Since its establishment in 1995, the Mekong River Commission has been involved in the collection of data and the development of models, both conceptual and mathematical, aimed at improving and demonstrating the understanding of the functioning of the Lower Mekong Basin ecosystem, the links between the people and the river. The result is an enormous body of data, understanding of life-histories and system functioning and resources such as mathematical models, including (see Section 3):

- Hydrological models (SWAT and IQQM) for the whole of the Lower Mekong Basin (LMB)
- Hydraulic, sediment and water quality models for the delta and parts of the mainstream
- Hydrodynamic models (MIKE 11; ISIS) for the Tonle Sap Great Lake
- Data on flooding patterns, and inundation depths and duration
- Life-history and distributional data on the fish and other biotic communities
- Data on the fisheries that are supported by the river
- Data on sediment transport through the system.

The MRC used these data and models to aid decision making in the region as it pertains to the sustainable management of the Lower Mekong Basin through the analysis of possible changes to river resources, and knock-on effects on the people that depend on them, in response to actual and proposed water-resource developments in the basin at large. Studies that have addressed this include

- A 2004 World Bank Study (MWRAS)[3],
- Integrated Basin Flow Management (IBFM; 2004-2006; MRCS 2006),
- Basin Development Plan (BDP; 2004-ongoing; reference),
- The Strategic Environmental Assessment (October, 2010).

Apart from IBFM, the abovementioned studies did not focus on detailed assessment of the positive and negative impacts of developments on the river ecosystem and on the value of ecosystem services to society through a systematic basin-wide comprehensive methodology. This lack was identified as a data gap in the recent revision of the Basin Development Plan and led to some of the uncertainties that motivated the Council Study. Therefore, it is expected that the Council Study will attempt to fill some of the significant knowledge gaps on the impact of water resources developments on the social, environmental and economic knowledge gaps towards supporting better-informed basin management.

[3] World Bank (2004) Modelled observations on development scenarios in the Lower Mekong Basin. In: Mekong regional water resources assistance strategy. Report prepared for the World Bank. Mekong River Commission, Vientiane Lao PDR

1.3 Objectives

As agreed to in the Concept Note, the main objective of the Council Study is to further enhance the ability of the MRC to advise Member Countries on the positive and negative impacts of water resources development on people, economies and the environment of the Mekong River Basin. This study will reduce the uncertainty in estimating these impacts, providing the Members Countries with higher confidence information towards informed decision-making.

The three objectives, also as agreed to in the Concept Note, provide a logical link between the overall objective of the Council Study and the outputs and activities. The first objective is for the generation of knowledge on the positive and negative impacts of water resource developments, the second objective is for the enhancement of long-term MRC processes using the new knowledge generated and processes tested and the third objective focuses on capacity development.

Objective 1: Further develop/establish a reliable scientific evidence base on the environment, social and economic consequences (positive and negative) of development in the Mekong River Basin.

Objective 2: Results of the study are integrated into the MRC knowledge base to enhance the BDP process providing support to the Member Countries in the sustainable management and development of the Mekong River Basin.

Objective 3: Promote capacity and ensure technology transfer to Member Countries in the process of designing and conducting of the study.

With these three objectives, the study will focus on the following thematic areas as agreed to in the Concept Note;

- Irrigation
- Agriculture and land use change
- Domestic and industrial water use
- Flood protection structures and floodplain infrastructure
- Hydropower development
- Transportation (including navigation and roads on major floodplains)

The study will result in the following[4];

a. A set of clear, strategic, pragmatic and actionable recommendations directly addressing potential uncertainties, risks and the information needs for development planning in the mainstream of the LMB including recommendations for impact avoidance and mitigation measures.

informed by;

b. Assessments for each thematic area summarising the transboundary impacts of developments in the selected thematic areas including cross-cutting impacts on the triple-bottom-line: the environmental, social and economic parameters of interest in the Mekong River Basin.

c. An assessment of the cumulative positive and negative impacts of water resource developments in all six selected thematic areas on the triple-bottom-line including clear indications of hotspots when/if relevant, and the thresholds of rapid transition—tipping points—in complex systems such as the Tonle Sap Lake in Cambodia and the Mekong Delta in Cambodia and Viet Nam.

[4] The need to clearly state the results of the Council Study was reiterated at the Regional Consultation on the Council Study held 28-29 May 2013 in Vientiane, Lao PDR

In addition, the MRC knowledge base will be enhanced by the knowledge, data and information produced by the Council Study further enhancing the effectiveness of the Basin Development Planning processes.

1.4 Main Outputs

The outputs included in this section are exactly as they were agreed to in the Council Study Concept Paper and Terms of Reference endorsed by the Regional Technical Working Group. Further clarification is included to define the objectives and outputs and indicate the expected outcomes. The activities and tasks presented in Section 5 show the steps that will be taken and the work that is required to achieve the expected outcomes via the outputs and objectives.

Objective 1: Further develop/establish a reliable scientific evidence base on the environment, social and economic consequences (positive and negative) of development in the Mekong River Basin.

Output 1.1: *Review the past scientific knowledge base and databases in terms of use as a basis and baseline for the study.*

This will result in an accessible database of existing relevant scientific information, publications and data through a literature review.

This output will include a review of the body of knowledge used to underpin the Basin Development Strategy 2011-2015, results from the Basin Development Scenario analysis and any other scientific literature that may be relevant from within MRC and from other relevant organizations. A detailed and systematic assessment of this literature will be conducted to determine whether the data, assumptions, and methodologies used and results of key related studies sufficiently meet the stated objectives of the Council Study. A scoping report will be produced to guide subsequent activities of the study.

Output 1.2: *Critical knowledge gaps in understanding of the Mekong River Basin system and the impacts of development of the main thematic topics of infrastructure and water use are closed.*

This will result in a series of key reports with clear policy recommendations with supporting information summarising the positive and negative impacts of water resource developments in the six thematic areas including cross-cutting impacts on the triple-bottom-line; the environmental, social, and economic conditions in the basin.

Building on the existing knowledge, this output will provide the improved understanding of positive and negative impacts of water resources developments/infrastructure to develop clear policy recommendations that will be included in the deliverables of the study; a series of reports summarising the positive and negative impact of developments in the selected thematic areas and sub areas including cross-cutting impacts on the triple-bottom-line, and an assessment of the cumulative impacts with requisite recommendations.

Output 1.3*: Climate change impacts are analysed in the context of the sector development impacts to assess opportunities and risks.*

This output will result in an enhanced, higher-confidence assessment of how climate change will change the positive and negative impacts of water resources developments and infrastructure within

the six selected thematic areas on the triple-bottom-line. The impacts of water resource development and infrastructure will be further analysed in the context of climate change to assess opportunities and risks.

Each thematic area assessment will include considerations of a changing climate (according to the best available knowledge of such changes) in order to better understand the impact of climate change may have on the social, environment and economic conditions of the basin, and assess whether changes in precipitation, temperature and extreme meteorological events and sea level rise will exacerbate or mitigate the impacts.

Objective 2: Results of the study integrated into the MRC knowledge base to enhance the BDP process providing support to the Member Countries in the sustainable development of the Mekong River Basin.

This objective is to enhance the on-going BDP processes using the information and knowledge generated from the Council Study.

Output 2.1: *Inclusion of information from the Study and other parallel initiatives into the MRC knowledge base.*

This will result in an enhanced MRC knowledge base and data to facilitate informed decision-making.

The information, knowledge and data generated by the Council Study in Outputs 1.1, 1.2 and 1.3 will be included into the MRC knowledge base. The products of the literature review in Output 1.1, the processes tested and information and knowledge generated in Outputs 1.2, and 1.3, and the decision support system used to manage the data will enhance the MRC knowledge base.

Output 2.2: *The Basin development scenario assessment for the Basin Development Strategy 2016-2020 uses the information and knowledge generated from the Study.*

This will result in an improved BDP process to support Member Countries in the sustainable development of the Mekong River Basin by testing and integrating the processes and results of the Council Study into the MRC knowledge base.

The Basin Development Scenario assessment process for the Basin Development Strategy 2016-2020 will be further improved through the use of information and knowledge generated and processes tested for the Council Study. Although the work to underpin the Basin Development Strategy 2016-2020 will begin before the Study is completed, interim results and improved understanding will directly support the work on the strategy in 2014 and 2015. In addition, results and conclusions from the Council Study will feed into the BDP process for the implementation of the Basin Development Strategy 2016-2020 and development of a new strategy for 2021-2025.

Objective 3: Promote capacity building and ensure technology transfer to Member Countries in the conduct of the Study.

Output 3.1: *Comprehensive capacity on scientific assessments, survey and analysis are strengthened among Member Country study team members*

This will result in enhanced capacity among Member Country study team members to conduct scientific assessments, survey and analyse impacts of water resources developments on the environment, economy and social parameters.

Output 3.2: *Member Countries' staff participating in the study is able to undertake major thematic studies and possible tools and guidelines are documented for future use of similar studies.*

This will result in a decentralized, targeted, incremental and accessible assessment methodology that incorporates emerging issues and supports new approaches to adaptive management for climatic variability and change available for use by riparian countries.

With the on-going efforts towards the decentralization of MRCS functions, the processes and approaches used in the Council Study will provide a working modality, a process and methodology for riparian countries to continue supporting the MRC through scientific analysis and collaborative and participatory processes. The working modality that will be used for the Council Study – thematic and discipline teams consisting of national and international personnel generating knowledge to be assessed through a common decision support system – can empower the decentralization process.

The three objectives and the corresponding outputs will work towards the overarching goal of developing a better understanding of the impacts of high priority developments on key socio-economic and environmental indicators. Furthermore, they will develop capacity within the MRC, NMCs and line agencies, and provide information, data and processes that can further strengthen the MRC goals and vision.

1.5 Deliverables

The main policy deliverables of the Council Study will be the following seven interrelated reports;

1. A Thematic Report on the Impacts and Benefits of Irrigation Development in the Lower Mekong River Basin Including Recommendations for Impact Avoidance and Mitigation Measures.

   The report will highlight the rate of irrigation expansion and the induced changes in flow parameters and the resulting changes in environmental, social and economic parameters including issues of food security, employment and transboundary benefits and costs. The report will also cover the impacts of irrigation on fisheries and the impacts of other developments on irrigation including dry season irrigation.

2. A Thematic Report on Impacts of Non-irrigated Agriculture Development and General Trends in Major Land-Use Categories in the Lower Mekong River Basin Including Recommendations for Impact Avoidance and Mitigation Measures.
   The report will indicate how land-use change including agricultural expansion can influence river flow in term of quantity, quality, timing and content (i.e. sediment, nutrients, etc.) and the resulting transboundary positive and negative impacts on environmental, social and economic parameters. The changes in sediment transport linked to land-use change and erosion will be a key section in this report.

3. A Thematic Report on Impacts and Benefits of Domestic and Industrial Water Use in the Lower Mekong River Basin including Recommendations for Impact Avoidance and Mitigation Measures.

This report will contain an updated map of large existing and planned and expanding urban and industrial centres within the basin, estimate water demand over the period covered by the Council Study, estimate general effluent and waste water discharge and highlight any possible risks of industrial spills or similar significant impacts. The report will further provide an estimate of the impact (positive or negative) of development in other sectors on domestic and industrial water use.

4. A Thematic Report on Impacts and Benefits of Flood Protection Structures and Floodplain Infrastructure and Impact of other Developments on Flood Risk Including Recommendations for Impact Avoidance and Mitigation Measures.
   The report will provide an assessment of the transboundary flood protection benefit and risks of existing and planned infrastructure. Furthermore it will describe how these structures can influence river flow in term of quantity, quality, timing and content and the resulting transboundary positive and negative impacts on environmental, social and economic parameters. The changes in sediment transport and ecosystem fragmentation will be a key section in this report as they are highly relevant for agriculture and fisheries, thus for food security.

5. A Thematic Report on Impacts and Benefits of Hydropower Development in the Lower Mekong River Basin Including Recommendations for Impact Avoidance and Mitigation Measures.
   The report will present an assessment of the cumulative positive and negative impacts of hydropower development in selected Lower Mekong River tributaries and the mainstream. The focus will be on how the dams can influence fisheries, river flow, sediment and nutrient flux in term of quantity, quality, timing and the resulting transboundary positive and negative impacts on environmental, social and economic parameters in the mainstream corridor, floodplains and Delta as well as coastal processes. Two key sections in this report will be an estimation of the disaggregated economic benefits and updated assessment of sediment transport and the effect of change on geomorphology, bank erosion and coastal processes and fisheries.

6. A Thematic Report on the Impacts and Benefits of Navigation Infrastructure Development in the Lower Mekong River Basin Including Recommendations for Impact Avoidance and Mitigation Measures.
   The report will include two main sections: an assessment of how existing and planned navigation infrastructure can influence river flow in term of quantity, quality, timing and content and the resulting transboundary positive and negative impacts on environmental, social and economic parameters and an assessment of the positive and negative impacts of water resources development in other thematic areas on navigation.

7. A Report on the Cumulative Impacts and Benefits of the Selected Water Resources Developments (Cumulative Report) Including Recommendations for Impact Avoidance and Mitigation Measures.
   This report will highlight the cumulative impact of the developments in the six thematic areas on the river flow in term of quantity, quality, timing and content and clearly indicate resulting transboundary positive and negative impacts on environmental, social and economic parameters. It will also show the economic benefits and costs of development including the

direct costs and benefits, positive and negative economic externalities from the developments assessed in the six thematic areas including ecosystem services and social impacts and multiplier effects of development including impact on regional macro-economic development, trade flows, replacement costs of lost benefits, etc.

These reports will present the positive and negative impacts of the selected water resources developments assessed in the Council Study[5], highlight key concerns and present clear recommendations for the sustainable management and development of the Mekong River Basin including Impacts of Mainstream Hydropower Projects.

1.6 Scope of the Study

The scope of the Study was established in the Council Study Concept Note endorsed by the Regional Technical Working Group (RTWG)[6]. The concept note outlines the major thematic areas as well as the geographic scope of the study.

1.6.1 Thematic Scope of the Study

Taking into account the basin-wide MRC context as well as the needs for a comprehensive and holistic sustainability study for the Mekong River Basin, the Study will cover the important thematic IWRM sectors and sub sectors that contribute to development in the basin:

1. Irrigation; including water use, return flows, water quality, and proposed diversions;
2. Agriculture and Land use; including watershed management, deforestation, livestock and aquaculture, and fisheries;
3. Domestic and Industrial use; including mining, sediment extraction, waste water disposal, urban development, and water quality;.
4. Flood protection structures and floodplain infrastructure;
5. Hydropower, including potential of alternative energy options;
6. Transportation; including navigation, infrastructure to aid navigation, and roads on major floodplains.

1.6.2 Geographical Scope

In order to focus the study and allow for more detailed and differentiated assessment of both positive and negative impacts, a set of geographic focal areas are selected.

The proposed geographic focus is on the positive and negative impacts on the mainstream. The main rationale for this is that direct causal impact of major development on the main stream as well as the aggregate of many developments on the tributaries are of importance in a transboundary context. In addition, the MRC Basin Development Planning through its various initiatives is addressing the basin-wide context of impacts through its support to the implementation of the BDS by the MRC Member Countries together with MRC Programmes. As part of the second objective, this Study will add a significant body of knowledge and understanding to BDS.

[5] Refers to the specific projects selected by the RTWG for analysis in the Council Study.

[6] Concept Note on the Follow-Up of the MRC Council Meeting decision of 8 December 2011 to Conduct a Study on Sustainable Management and Development of the Mekong River including Impacts by Mainstream Hydropower Projects - 15 January 2013

For the thematic topics identified as causing impact, listed in the previous section, the whole Mekong River Basin will be considered. A special focal area will be addressing the development on the Upper Mekong (Lancang) with respect to infrastructure and water use.

However, with respect to impacts (positive and negative) of a physical nature the focus would be on the following four areas.

1. A corridor on both sides of the mainstream from Chinese border to Kratie (Cambodia)
2. The Cambodia Floodplains including the Tonle Sap River and Great Lake
3. The Mekong Delta in Cambodia and Viet Nam
4. The coastal areas directly influenced by the Mekong estuary

The Mekong mainstream corridor is chosen based on the fact that along the mainstream, the cumulative impact of development and management in the basin is being directly felt, whereas in the tributaries the impact is mainly due to the activities in the specific tributary. An initial proposal of a 15 km corridor on both sides of the mainstream is based on the extent of direct impact on livelihoods dependent on the mainstream (as defined by the MRC Social Impact Monitoring and Vulnerability Assessment, or SIM/VA, of the Environment Programme).

Tonle Sap River and Great Lake and other floodplains in Cambodia is an important area as it forms a unique hydro-ecological system with a unique fishery within the Mekong River Basin which is directly impacted by changes in the flow of the Mekong mainstream with respect to the flood pulse, sediment replenishment, flood extent, etc.

The Mekong Delta in Cambodia and Viet Nam are proposed because being at the end of the river's course it will be affected by the cumulative impact of infrastructure and water use. The central importance of the delta in agriculture and fisheries/aquaculture productivity makes it important to assess potential impact, but also competing uses of water from high population and many urban centres needs to be considered.

The coastal areas in this context are to be delimited to the areas directly affected by changes in the Mekong River's discharge into the sea together with the significance of coastal fisheries and coastal processes (affecting issues such as coastal erosion and impacts of sea-level rise) makes this an important area to study.

1.6.3 Impact Areas

The six thematic areas will be assessed in terms of positive and negative impacts on a number of primary physical and biological (environmental) aspects, which include;

a. Fisheries and fish production including impacts of over-fishing and illegal fishing;
b. Environmental condition/health, the definition of which will be agreed upon for the study;
c. Biodiversity using internationally established indices;
d. Hydrology/water quantity which include ground water;
e. Water availability (drought);
f. Flood;
g. Food production;
h. Sediment transport including river bank stability, sand mining, delta sediment plume; and
i. Water quality including salinity intrusion.

There is also a need to assess how these changes result in positive and/or negative impacts on more complex social and economic aspects such as;

i. Food Security including impacts on food safety to the extent practicable;

ii. Quality of life based on either existing indices of United Nations (UN) organisations, or new indices developed specifically for the MRB;
iii. Flood risk;
iv. Drought risk;
v. Human health, focusing on standard parameters used to assess health and Millennium Development Goals such as water borne disease;
vi. Social development including changes in cultural and traditional aspects of life. Impacts of demographic change will also be considered.
vii. Economic development;
viii. Employment with a focus on income generation; and
ix. Distribution of economic benefits.

1.6.4 Impact of Climate Change

Climate change is an important factor in the Study and will be assessed in terms of how it may exacerbate (increase) or mitigate (reduce) some of the impacts caused by changes in water use, in essence the Study will identify the risks and opportunities that climate change provides in the context of basin development.

There are already a number of climate change initiatives in the region, including the Climate Change and Adaptation Initiative (CCAI) of MRC. The Study will be able to draw from the information of these initiatives and use the modelling outputs to provide insights into the impacts relevant to the Study.

1.7 Stakeholder Engagement

MRC as a regional institution explicitly committed to public participation in its activities will seek broad stakeholder support for the Study by adopting an inclusive stakeholders' engagement process from the inception to the end of the Study. Many stakeholder consultation workshops are planned as listed in the tasks in Section 4.

The objective of stakeholder engagement will be to manage expectations and develop a common understanding of the elements of the Council Study (objectives, values, scientific approach). This will be achieved through communication and discussion and will go beyond the simple dissemination and receipt of information.

The Council Study coordinator will work with the Regional Technical Group to identify key stakeholders and the issues of concern to them. As stakeholders are diverse, the engagement modalities may need to be catered to each group. This will require the mapping of key stakeholders and their stake in the Council Study and the development of targeted engagement modalities.

1.8 The Process of Implementing the Council Study

Terms of Reference (ToR) were developed expanding on the Concept Note describing a clear framework methodology, an overall work plan, implementation strategy including study coordination and an indicative budget for the Council Study. The ToR further refined the scope and developed consensus on the deliverables of the Study. It also clearly outlined a proposed overall approach for collecting and assessing data, developing conclusions and delivering the results. The ToR was approved by the MRC Joint Committee.

Preparatory activities including a literature review, technical assessment, consultations and a planning meeting were completed to define the needs in terms of data, information and expertise

and the input required of MRC programmes to successfully complete the Council Study. Annex III provides a summary of the discussions and decisions made during the First Planning Meeting for the Council Study on November 7-8, 2013.

This Inception Report is the first deliverable from the implementation phase of the Council Study and will be used by the MRC as a blue print for its implementation. During the 1st Regional Technical Working Group meeting held to discuss the Council Study Terms of Reference[7], the Inception Report was agreed to include the following information:

- Results of a review of existing data, information, models and knowledge and an assessment of additional resources needed. This will indicate whether the information within MRC is sufficient and how much update is required including the need for new data and models.
- A description of data/information/validation needs.
- A detailed (revised) Logical Framework linking Objectives, Outputs and Activities with a work plan including:
    - A detailed description of contributions from MRC programmes and a description and justification of the need for external support
    - A description and justification of contribution requested from Member Countries
- Detailed implementation/coordination arrangements including:
    - Budget
    - Team Compositions
    - Work packages for teams
    - ToR for individual external consultants
    - Detailed methodologies
- Assessment of potential risks in the implementation of the study and mitigation options
- Monitoring, evaluation and reporting framework

[7] 1st RTWG Meeting for the Council Study 26-27 September 2013 – MRC Secretariat, Vientiane, Lao PDR

2. Scoping of Existing Data, Information and Knowledge and MRCS Programmes

2.1 Introduction

The body of literature on Mekong Basin flow-related development impacts is extensive. At the time of writing, a search under google.com for "publication Mekong impacts of flow related water resources developments" revealed 10,600,000 hits. A google scholar search which normally results to more credible and peer-reviewed publications yielded 15,800 hits. When filtering out papers related to governance, institutional and political topics, the number of hits was reduced to 3,700 publications. This number does not include publications that are only accessible exclusively through subscription-only journal publications and therefore, are not searchable through google scholar.

More than 3,000 documents were initially selected for the literature review. These documents were further filtered on the basis of their scientific credibility and relevance to the Council Study which resulted to the following: 159 documents were determined to be of primary relevance, linking one or more development themes with one or more impacts areas in the Mekong Basin. Of these, 115 publications were produced by MRC. The rest of the publications were produced by other agencies mostly as journal articles, conference papers, and book chapters;.

- 76 publications related to Climate Change; and
- 272 publications representing international best practice and/or case studies from outside the basin that are highly relevant to the Council Study[8].

Two of these publications are considered to be very important as they have the most direct relevance to the Council Study. These two publications are the following:

- BDP Scenario Assessment (MRC, 2011)
- Water-Food-Energy Nexus in the Mekong Region (Smajgl and Ward, 2013) "The

In addition to the above primary publications, 1,766 publications that are considered of secondary relevance are also included in the database. These are documents that have some relevance to the Council Study but do not meet the stated criteria above to be considered a publication of primary relevance.

2.2 BDP Scenario Assessment

Building on previous work done under BDP phase 1, Integrated Basin Flow Management (IBFM) and The Strategic Environmental Assessment for Hydropower on the Mekong Mainstream (SEA HMM),

[8] These include 117 publications from the ISH knowledge base on benefit sharing mechanisms, reference papers from the Integrated Basin Flow Management (IBFM) project, case studies and other documents from the World Commission on Dams (WCD), publications from the Global Water Partnership (GWP) and numerous other scientific publications on environmental flows, ex post vs ex ante assessment, accounting for expert opinion in a scientific context, valuation methods for water resources management, recent publications on scientific method in a modern context and various other publications of relevance.

the BDP Scenario Assessment (MRC, 2011) is considered the single most significant reference to the Council Study because of the following reasons:

- It represents the most comprehensive assessment of potential impacts of water resources developments conducted to date in the LMB;
- It assessed potential impacts based on scenarios ranging from ongoing developments to planned developments within the next 50 years;
- It is based on well-established hydrological modelling approach using the MRC's Decision Support Framework; and
- It has been peer-reviewed and subjected to a thorough consultation process.

The BDP Scenario Assessment evaluated the environmental, social and economic impacts across the LMB based on national development plans of the Member Countries in the water supply, irrigation, hydropower and flood protection sectors. The scenario assessment is a major output of the second phase of MRC's Basin Development Plan Programme from 2007 to 2010.

A series of development scenarios were characterised as direct future scenarios, which will result from developments already underway in the basin, foreseeable future scenarios which are expected to result from developments planned for the next 20 years, long-term scenarios based on developments expected over a 50 year and climate change scenarios.

Impact assessment was based on hydrological modelling of the baseline and each of the above mentioned scenarios, followed by expert opinion to determine environmental, social and economic impacts.

The BDP scenario analysis was explicitly aimed at determining the cumulative impacts of developments in the LMB, the Chinese dams in the Upper Mekong Basin (UMB) and climate change on the hydrology of the mainstream Mekong along. Associated environmental, social and economic impacts of the hydrological changes were thereafter determined.

In summary, the major findings of the BDP scenario analysis were that, under the definite future scenarios, hydropower inter-seasonal storage developments in the UMB and on the tributaries will lead to a redistribution of flows from the wet season to the dry season. The flows in the river during the dry season will be sufficient to meet consumptive water use on the mainstream in the LMB. Economic benefits will be significant; however, substantial negative impacts will occur including loss of wetlands, reductions in the Tonle Sap flow reversal, reduced sediment loads, a seven percent decline in capture fisheries, and environmental hotspots and risks to the livelihoods of almost a million vulnerable people.

These trends will continue under the foreseeable future scenario. Impacts are particularly significant if all 11 of the mainstream run-of-the-river hydropower schemes are developed as 60% of the ecologically valuable river channel will be lost between Kratie and Houei Xay, two of the four flagship species may become extinct and the reduction in capture fisheries yield may reach 25% compared to the baseline conditions.

Under the long-term future scenario, the inter-seasonal transfer of water due to upper Mekong and tributary hydropower will be sufficient to ensure consumptive use of water through the dry season does not reduce the baseline dry season flow.

The major impact of climate change will be sea level rise in the delta which threatens both the Cambodian floodplain and the Delta in Viet Nam. Increased hydrological variability will also be experienced across the basin. In the face of climate change, measures to mitigate sea level rise, reduce flooding and reduce drought risk all need to be carefully considered.

2.2.1 Strengths and weaknesses of the BDP Scenario Assessment

As stated above, the fundamental strengths of the BDP Scenario Assessment are its comprehensiveness, the solid basis of the hydrological modelling undertaken and that it has been subjected to a thorough consultation process.

As hydropower and irrigation are the two development sectors that make the most use of water in the LMB, the BDP assessment primarily reflects the cumulative impacts of nationally planned irrigation and hydropower projects. However, the other development themes under the Council Study are not covered to the same level of detail including agriculture/land-use, domestic and industrial consumptive water use, flood protection structures, transport and navigation as their hydrological impact on the mainstream flows are much smaller than the impacts of hydropower and irrigation.

Regarding assessment of impacts of concern under the Council Study, the BDP scenario assessment generally covers the environmental and economic areas of concern of the Council Study except for the distributional impacts of economic benefits. Coverage of social impacts was limited to an assessment of the losses of livelihoods that would occur due to changes in the river's flow regime under each development scenario, and the compensating employment opportunities that would be created by the developments. Food security, quality of life (aside from income), flood risk, drought risk, human health, and social development impacts were beyond the scope of the BDP assessments.

2.3 The Water-Food-Energy Nexus in the Mekong Region

This volume includes sections that cover regional connectivity, water sector analysis, food security, energy system impacts, livelihoods/migration, land-use change and mining with a final section on cross-sectoral assessment. Critical findings include the following:

- Food security should improve if communities are able to gain benefits from developments, as long as global food prices remain stable;
- Mainstream hydropower will have pre-dominant impacts on the environment and local communities,;
- The extent of regional energy demand is such that hydropower will represent only a small portion of the overall demand;
- Water diversions, rubber plantations and mining will exacerbate the negative hydrological impacts of the mainstream dams;
- Significant upstream-downstream issues are foreseen with benefits predominantly going to upstream water users, while downstream users will face negative impacts;

- Timing of benefits and impacts are also problematic as negative impacts, especially on capture fisheries yields, will be triggered by the commencement of construction for the developments, yet the full accumulation of benefits will only be realised long into the working life of the developments. Developing appropriate adaptation options for negatively impacted water users is therefore seen as a high priority.

To address these issues, monitoring and governance of fisheries management and fish migration will be critical. Other recommendations included ensuring a diversity of land use, determining ways to improve the certainty of food prices/returns, creating stable income opportunities in rural communities and promoting energy savings initiatives.

2.4 Comments on other Documents

As described in the introduction above, a large number of additional publications that provide valuable information and insights of value to the Council Study are available from the MRC programmes, from other agencies and in the scientific literature.

2.4.1 Documents within MRC

As can be seen from the publications listing, numerous important publications of relevance to the Council Study have been produced by MRC across the development themes and impact areas under the Agriculture and Irrigation Programme (AIP), Climate Change Adaptation Initiative (CCAI), Environment Programme (EP), Fisheries Programme (FP), Flood Management and Mitigation Programme (FMMP), Integrated Knowledge Management Programme (IKMP), Initiative for Sustainable Hydropower (ISH), and the Navigation Programme (NAP). These publications include in particular the following:

- The Integrated Basin Flow Management (IBFM) suite of reports, under the Water Utilisation Programme (WUP), which led to the characterisation of flow zones on the Mekong mainstream and the characterisation of the annual flows seasons.
- The SEA for Hydropower on the Mekong Mainstream (SEAHMM MRC, 2010) report was a major undertaking at the time. It is now, however, largely superseded by the BDP Scenario Assessment and other subsequent publications under ISH. A further limitation of the SEAHMM report is that SEA is primarily concerned with policy rather than science.
- MRC (2014) *Regional Benefit Sharing in the Mekong Basin. Draft Scoping Report. Review of International Experience and Proposed Approach to the Regional Distribution Analysis.* Mekong River Commission, Vientiane,
- Studies on fish migration, barrier effects of dams and potential mitigation measures (produced between ISH and Fisheries programme);
- ISH Knowledge Base on benefit sharing, (MRC ISH, 2011);
- Improved environmental and socio-economic baseline information for hydropower planning (ISH 11) phase 1[9];
- ISH01, identification of ecologically sensitive tributaries;
- ISH02, Development of Guidelines on the Multi‐Purpose Evaluation of Hydropower Projects;

[9] *ISH 11 phase 2 documents were subject to consultations at the time of writing*

From this brief list it can be noted that significantly more attention is currently being given to environmental, social and economic impacts of hydropower, which is understandable given the scale of both positive and negative impacts that hydropower development may have.

2.4.2 Publications from External Organisations

To identify and obtain literature relevant to the Council Study, searches for relevant publications were done through the searches were done on the websites of partner organisations listed below as well as through online search engines including the following:

Development Partners
Asia Development Bank (ADB)
ADB Greater Mekong Subregion Environment Operations Centre (ADB GMS EOC)
The International Water Management Institute (IWMI)
United Nations (UN) Development Programme (UNDP)
UN Environment Programme (UNEP)
UN Educational, Scientific and Cultural Organisation (UNESCO)
UN Economic and Social Commission for Asia and the Pacific (UNESCAP)
UN Food and Agricultural Organisation (FAO)
World Bank
Australian Aid (AusAID)
Australian Centre for Irrigation and Agricultural Research (ACIAR)
The Global Water Partnership (GWP)
Danish Development Cooperation (DanIDA)
Swedish International Development Cooperation Agency (SIDA)
Japan International Cooperation Agency (JICA)
Government of Netherlands Development Cooperation
New Zealand Aid Programme (NZAID)
Foreign Affairs, Trade and Development Canada (CIDA)
United States Agency for International Development (USAID)

Academic Organisations
Asian Institute of Technology (AIT)
Australian Mekong River Centre (AMRC)
Cambodia Development Research Institute (CDRI)
Challenge Programme for Water and Food (CPWF)

NGO's
International Union for the Conservation of Nature (IUCN)
Mekong Program on Water Environment and Resilience (M-POWER)
Mekong Wetlands Biodiversity Programme (MWBP)
The Stimson Centre
Stockholm Environment Institute (SEI)
Thailand Development Research Institute
Thailand Environment Institute
World Wide Fund for Nature (WWF)

Online catalogues
The MRC portal and Library Catalogue
Wiley Online
Science Direct
Springer Online
Taylor and Francis
Plos One and Plos Biology and
Google Scholar

As described in the Introduction, a list of references from external organisations is contained in the Literature Review Report developed for the Council Study. Annex VI provides a breakdown of how these external publications relate to the development themes, impact areas and geographic scope of the Council Study.

2.5 Gaps

Environmental, social and economic impacts of agriculture-land use, consumptive use of water (domestic and industrial), transport and navigation were not considered critical aspects under the BDP scenario assessment so the understanding of these issues has not been well developed to this point. Furthermore, limited information is available on impacts of any of the development themes on food security, social aspects of flood risk, drought risk, human health, social development and distribution of benefits.

An extensive list of specific knowledge gaps was developed under BDP. The following are the knowledge gaps of primary significance to the Council Study:

- Develop a more detailed understanding of the social implications of a reduction in catches
- Biodiversity changes that will result from the changes in flow regime, including Identification of priority habitat, managing impacts on flagship species and environmental hotspots,
- More detailed modelling of changes to the Tonle sap flooded area, especially the flooded forest, and changes in the hydraulic gradient which drives reversals and sediment balances
- Social and livelihood impacts of developments in the mainstream corridor and Tonle Sap
- Fate and transport of water quality, parameters, especially sediments and nutrients
- Managing wetlands and flooded areas for development pressures
- Impacts of agriculture and irrigation on groundwater
- Erosion and sediment control including impacts of mechanical harvesting
- Irrigation return flows / water quality and impacts on sediment transport / downstream water quality,
- Assessment of cumulative downstream impacts in Viet Nam due to altered river flows and sediment reduction.
- Dam break risk for hydropower project flood impact
- Impacts of changing land use by way of resumption of floodplain lands for agricultural and irrigation developments.

3. Detailed Assessment Methodology and Framework

As indicated in the Council Study TOR, two impact pathways will be considered in the assessment;

1. Positive and negative impacts of water resource developments via changes in the hydrological regime. To illustrate, a dam or an irrigation project changes the timing, quantity, quality and/or content of the water which changes the biota which in turn has a socio-economic impact. This is similar to the process considered in the Integrated Basin Flow Management initiative.

2. Positive and negative impacts not transmitted via the hydrological regime. These include the primary and secondary economic costs and benefits of the selected water resources developments and infrastructure as well as other social benefits including access to services, employment opportunities, social displacement, migration, and gender impacts.

3.1 Assessment of Positive and Negative Impacts of Water Resource Development via Changes in the Hydrological Regime

Considering that many of the positive and negative impacts of water resources developments will be transmitted from the point of development to other countries and areas via changes in the hydrological regime, the Council Study will invest considerable time and effort in estimating those impacts.

These water resources developments to be analysed may be located on the mainstream Mekong River or in any of the tributaries in the LMB. The analysis of impacts of the water resources developments on the river ecosystem and people will be limited to the Mekong River and Tonle Sap River and Great Lake and the Mekong Delta.

The Council Study will assess water resources developments in six Thematic Areas via its impact on five Discipline Areas (Figure 3.1). A team representing each Thematic Area will be tasked with developing and analysing a series of water resources developments pertaining to their area. These developments may be located on the Mekong River or in any of the tributaries in the Lower Mekong River.

They will be assisted by the discipline teams who will be responsible for the analysis of the impacts in the mainstream Mekong River, Tonle Sap River and Great Lake and Mekong Delta of the water resources developments, including on the hydrological and sediment regimes, the riverine ecosystem and on the people with close links to the river and on the national economies.

The discipline teams will use information provided by the thematic teams to:

- Analyse and write up the impacts of the selected water resources developments on the hydrological regimes **(Climate, Hydrology and Hydrodynamics)**
- Analyse and write up the impacts on the sediment regimes and aquatic habitats **(Sediment Transport and Geomorphology)**
- Analyse and write up the impacts of the selected water resources developments on the aquatic ecosystems **(Biological Resources Assessment)**
- Analyse and write up the impacts of the selected water resources developments on river-linked livelihoods and ecosystem services **(Resource Economics)**

- Analyse and write up economic impacts of the selected water resources developments **(Economics)**
- Provide assistance with knock on hydrological effects of options in one Thematic Area on another **(Climate, Hydrology and Hydrodynamics)**
- Provide assistance with integrating the resource and macro-economic costs and benefits the selected water resources developments into each thematic description **(Economics).**

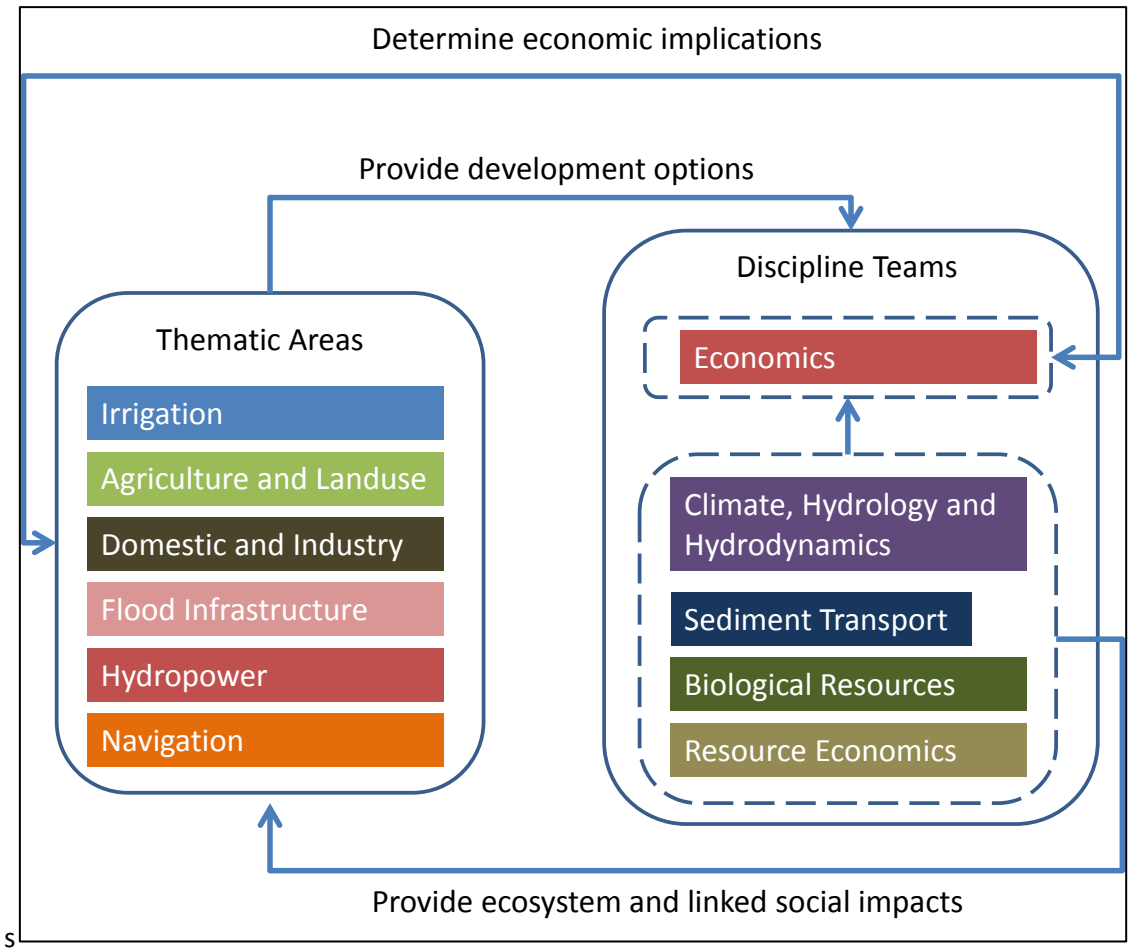

Figure 3-1: Organization and summary of information flow for the Council Study

3.2 Assessment of Positive and Negative Impacts of Water Resources Developments not Transmitted via the Hydrological Regime

A number of these impacts such as the primary and secondary economic costs and benefits of the selected water resources developments and infrastructure and social benefits including access to services, employment , social displacement, migration, and gender impacts will be captured in the social and economic assessments indicated above. However there will be sector specific impacts that will need to be assessed separately by the relevant thematic teams.

Most of these sector specific areas are described in the Council Study ToR T and in the specific Work Packages included as an annex to this report. These assessments will be the responsibility of the specific thematic teams with the support of consultants as needed and they range from evaluation of local impacts of water resource development projects to sector specific transboundary impacts.

Some of the direct impacts that need to be considered include:

Impacts of Sand Mining: There is considerable discussion on the various impacts of wide-scale sand mining. It was concluded in the Council Study planning meeting that the Environmental Programme would undertake this task with the support of consultants.

Navigation: It is likely that navigation infrastructure developments will not be of sufficient scale to cause significant transboundary environmental, social or economic impacts because of their limited impact on the flow regime.. The only impacts in this context may be some potential impacts via localized water pollution and bank erosion from increased navigation.

However, the need for risk assessments, especially of major events such as oil or a chemical spills have been indicated. Such a risk assessment would need to be carried out by the navigation thematic team with the support of specialised consultants as required and will include the following steps:

1. Data Gathering and Familiarisation
2. Hazard Identification
3. Risk Analysis
4. Risk Assessment
5. Recommendations for Risk Control

3.3 Assessment and Data Management Framework

This section pertains mostly to the assessment of positive and negative impacts of water resource development via changes in the hydrological regime. It describes the framework that will be used to:

- Estimate how the water resource developments in each thematic areas and cumulatively will change hydrological, sediment and water quality parameters along the river - changes in the key flow indicators;
- Estimate the ecological responses to these hydrological, sediment and water quality changes – changes in key biophysical indicators;
- Estimate positive and negative socio-economic impacts of these ecosystem and water quality changes – changes in key socio-economic indicators.

As described in detail below, this assessment will focus on selected study sites within river zones and will use response curves to assess how secondary (mostly biological and social) indicators respond to changes in primary (mostly hydrological, sediment and water quality) indicators. This section also describes how different configurations of water resources developments will be formulated for the assessment.

The subsequent sections describe the hydrological and sediment assessments, the biological resources assessment and the social assessments. It is important to note that these assessments are interconnected as described in the Council Study TOR with the hydrological modelling informing the biological resources and social assessments.

3.3.1 Study Sites and River Zones

When predicting the positive and negative impacts of water resources developments for the Council Study, all the data will be generated and analysed in the context of representative sites/areas, and all deliberations and predictions made in the Council Study will focus on study sites located within river zones. This will require the selection of representative sites in each of the river zones and representative areas in the Tonle Sap Great Lake and Delta. In addition, it may be necessary to select representative reaches in one or more tributaries in order to capture the effects of changes in the tributaries on the Mekong and Tonle Sap Systems.

When defining zones, the Council Study will adopt the same zones used by other MRC programmes[10] as this will allow the Council Study to capitalize on existing data and knowledge and on ongoing processes. These zones are:

ZONE 1: Mainstream Mekong River (from China border to Vientiane)

ZONE 2: Mainstream Mekong River (from Vientiane to Pakse)

ZONE 3: Mainstream Mekong River (from Pakse to Kratie)

ZONE 4: Kratie to Tonle Sap Great Lake.

ZONE 5: The Mekong Delta in Cambodia and Viet Nam

For the Council Study, Zone 4 is further divided into Zone 4a for the Tonle Sap River, and Zone 4b for the Tonle Sap Great Lake.

In addition, the **East Sea coastal areas** directly influenced by the Mekong estuary will also be included in the study.

The sites within the designated zones will be selected based on the ongoing initiative by the ISH 11 project[11] to define consolidated data collection sites along the river where hydrological, water quality, sediment, fisheries and social data collection initiatives coincide.

[10] Environment Programme SIM/VA project, Initiative for Sustainable Hydropower, Integrated Basin Flow Management Project etc.
[11] Improved Environmental and Socio-Economic Baseline Information for Hydropower Planning Project

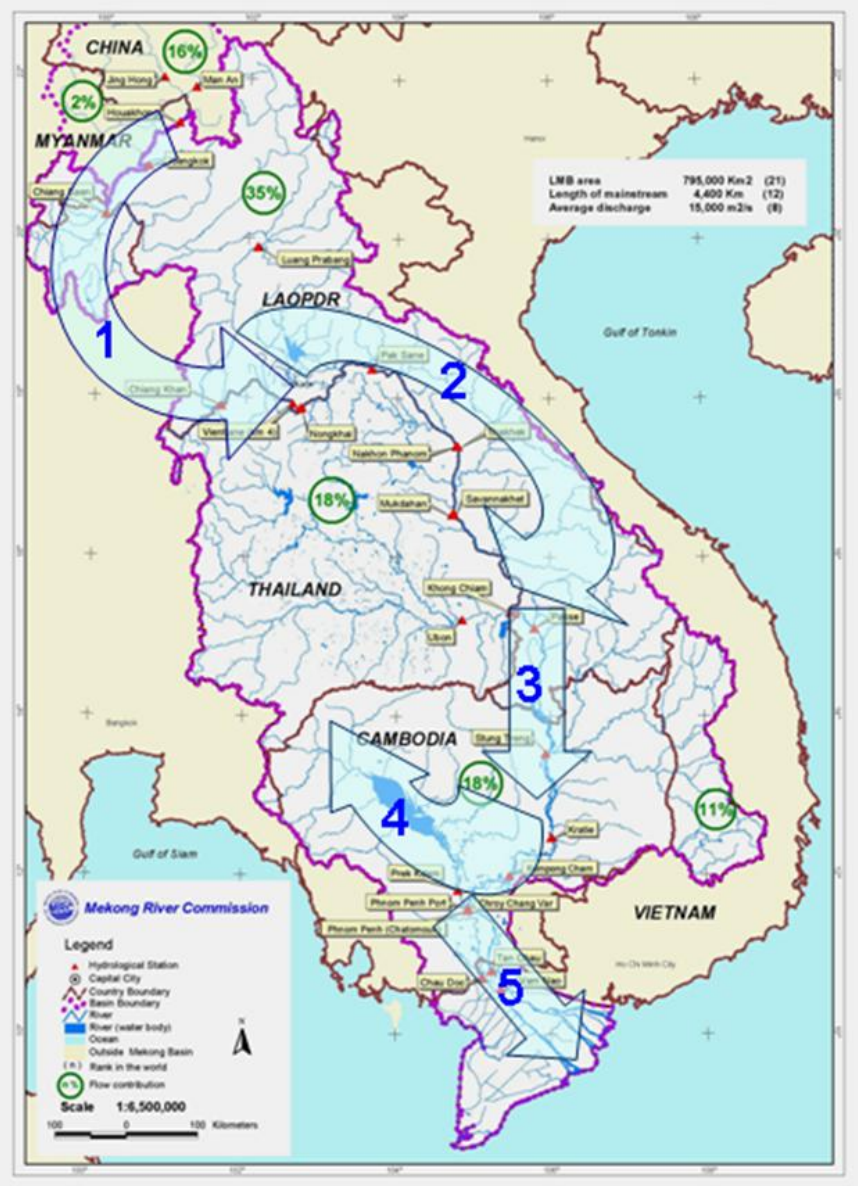

Figure 3-2: LMB zones used in IBFM3

3.3.2 Indicators

Indicators used in this section of the Council Study will be objects (e.g. sand bars) that are quantifiable rather than processes (e.g. nutrient cycling). The indicators will be described through changes in their abundance, concentrations (e.g., water quality), extent/area (e.g., sand bars), value or changes from a mean. Examples of indicators are provided in Table 3.1. A total of about 50 to70 biophysical indicators could be used for this project with an additional set of socio-economic indicators. The indicators should respond to imposed flow changes in a quantifiable manner in the context of a specific study site.

Table 3-1: Examples of indicators used in the Okavango study project to predict the biophysical and social impacts of development-driven flow changes

Discipline	Indicator
Geomorphology	Sand bars
Water quality	Conductivity
Vegetation – river	Upper Wet Bank (trees and shrubs)
Vegetation – delta	Lower Floodplain
Macroinvertebrates	Channel – submerged vegetation habitat
Fish	Large fish that migrate onto floodplains
Birds	Specialists – water lilies
Socio-economic	Household Income from floodplain agriculture
Socio-economic	Household Income from fish
Socio-economic	Household Income from livestock
Socio-economic	Potable water/water quality
Socio-economic	Household income from tourism
Socio-economic	Macro effects from changes in household income

The MRC is currently facilitating an in extensive process of developing an indicator framework. The purpose of this is described as:

"The MRC indicator framework is to provide a unified and integrated approach to assessing the impacts of current and proposed developments and the management actions needed within the Mekong River Basin to achieve the development aims of the 1995 Mekong Agreement." [12]

This framework, which is being developed for the assessment of basin-wide development scenarios and related assessments and to provide a structured approach for MRC data collection and monitoring programmes, provides a solid basis for Council Study indicators. When appropriate, the indicators from the MRC framework will be used directly in the Council Study with response curves developed for each indicator to establish how they respond to flow changes. In some cases a set of lower-level indicators may need to be developed to determine the impacts of developments on the MRC indicators.

3.3.3 Response Curves

Response curves depict the relationship between a biophysical (or socio-economic) indicator and a driving variable (e.g., flow). Response curves link an indicator to any other indicators deemed to be driving it to change. The aim is not to ensure that every conceivable link is captured but rather to capture the linkages that are most meaningful and can be used to predict the bulk of the likely responses to a change in the flow, sediment or water quality regimes of the river.

Response curves are constructed using severity ratings (Table 3-2). A Response curve is shown in Figure 3-4 where a much shorter or longer wet season would lead to decreased abundance.

The units on the x-axis depend on the driving variable under consideration. For instance, in the case of wet season duration (Figure 3.4), these are days.

The y-axis may refer to abundance as in Figure 3.4, but also to other measures such as concentration or area, depending on the indicator.

[12] MRC indicator framework for managing the Mekong Basin, Draft 21 April 2014 Basin Development Plan Programme

The number of response curves per indicator can range between 2 and 10 depending on the level of detail of the assessment. These are used to evaluate the water resource development configurations by taking the value of the flow indicator for any one configuration and reading off the resultant value for the biophysical indicators from their respective response curves. Once this had been done the database (further described below) combines these values to predict the overall change in each biophysical indicator and in the overall ecosystem under each configuration of water resources developments..

Table 3-2: Example of severity ratings and their associated abundances and losses – a negative score means a loss in abundance relative to baseline, a positive means a gain.

Severity rating	Severity	% abundance change
5	Critically severe	501% gain to ∞ up to pest proportions
4	Severe	251-500% gain
3	Moderate	68-250% gain
2	Low	26-67% gain
1	Negligible	1-25% gain
0	**None**	**no change**
-1	Negligible	80-100% retained
-2	Low	60-79% retained
-3	Moderate	40-59% retained
-4	Severe	20-39% retained
-5	Critically severe	0-19% retained includes local extinction

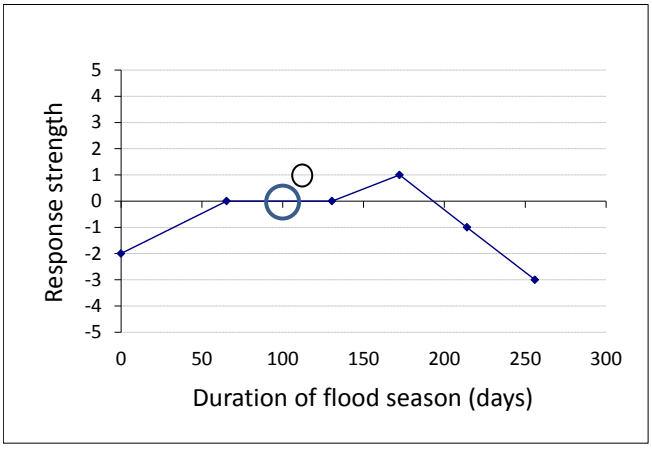

Figure 3-3: Example of a response curve

Example of a response curve showing the relationship between duration of the flood season and the abundance of fish in the river. The circle indicates median present day duration of the flood season and the line describes how fish abundance would increase or decrease in years with longer or shorter flood seasons. Fish abundances are shown (response strength) as comparisons to present day, with present day abundance always shown as zero or 100%.

The response curves will be developed by the Discipline Teams during two workshops based on existing MRC data, field studies, literature review and expert opinions. The workshops will allow the response curves to be formulated in a transparent and consultative process. Each response curve

will be supported by a robust set of scientific evidences based on credible and peer-reviewed publications. The DRIFT tool (described below) allows these citations and additional evidences to be recorded for each response curve. The response curves stored in the database can be queried and changed at any time to account for new or updated information and expert opinions. These updates in the response curves will automatically update the overall results of the assessment (i.e., environmental impacts of water resources developments based on the response of the environmental indicators to changes in flow).

3.3.4 Water Resources Development Configurations

The exact configurations of water resource developments[13] within the six thematic areas to be assessed by the Council Study will be defined by the MRC Regional Technical Working Group at an inception workshop. These thematic area and cumulative configurations are required to be sufficiently differentiated so that the analysis can show how these different configurations can affect the triple-bottom-line – social, economic and environmental conditions of the basin in different ways.

Configurations of Water Resources Developments

The Council Study will assess four main configurations of water resources developments:

1. Baseline
2. Baseline plus Chinese Dams
3. Baseline plus Chinese Dams plus individual Thematic Area development options in the LMB (referred to as the Individual Thematic options)
4. Baseline plus Chinese Dams plus one configuration that combined development options in the LMB from all the Thematic Area (referred to as the Cumulative Option).

Location

The water resources developments may be located anywhere on the mainstream Mekong River, or any of its tributaries.

Number of Configurations

At this stage it is not clear how many sets of development configurations will be provided for assessment by each of the six Thematic Areas. The original plan was to analyse one configuration for each Thematic Area, however, although the reporting may be confined to one configuration, it is likely that several configurations (possibly in several iterations) from each Thematic Area will be analysed before one can be selected for reporting.

Similarly, only one cumulative water resource development configuration is planned but it is likely that several will require analysis before one can be selected for reporting.

The time allocations provided in this document have assumed the following:

1. Baseline – analyse as one configuration
2. Baseline plus Chinese Dams – analyse as one configuration

[13] Water resources development configurations refer to the multiple possible combinations of hydropower dams, or irrigation projects, or land-use developments.

3. Baseline plus Chinese Dams plus individual Thematic Area development configurations (referred to as the Individual Thematic configurations) – analyse three configurations, no iterations
4. Baseline plus Chinese Dams plus one configuration that combined development configurations from all the Thematic Area (referred to as the Cumulative configuration) – analyse three configurations, no iterations.

3.3.5 Use of the DRIFT Flow Assessment and Data Management Tool

To assess the environmental impacts of water resources developments, the Council Study will use an established environmental flow assessment and data management tool, allowing data and knowledge to be used to their best advantage in a structured way. In the Council Study the DRIFT data management tool will be used, as it is one of the only methodologies that incorporate all of the areas of interest in the Council Study including environmental, social and resource economic parameters. Furthermore, using this data management tool promotes transparency as all assumptions and linkages are recorded within the data management tool and can be viewed and changed as required based on evidence.

Within DRIFT, each specialist uses discipline-specific methods to derive the links between river flow and river condition. The central rationale of DRIFT is that different aspects of the flow regime of a river elicit different responses from the riverine ecosystem. Thus, removal of part or all of a particular element of the flow regime will affect the riverine ecosystem differently than will removal of some other element. DRIFT will also be used to evaluate the impacts on people and resource economies of a changing river ecosystem.

The intention is to use DRIFT to organise existing MRC data, information in the international scientific literature and expert opinion to provide a clear, comprehensive and integrated picture for the Lower Mekong River, Tonle Sap River, Tonle Sap Great Lake and the Mekong Delta ecosystem of:

- The present condition in terms of the river ecosystem and its dependent social structures
- Reasons for this condition
- Possible future conditions, as described through the evaluation of the thematic area configurations for each representative zone/site/area.

The DRIFT data management tool is divided into three stages of the environmental flow assessment process. These are (see Figure 3.2):

- Set-up
- Knowledge Capture
- Analysis.

The first two stages deal with the population of the DRIFT database and the calibration of the flow-ecosystem relationships that will be used to predict the ecosystem response to changes in flows. The third stage is used to generate results once the first two stages have been completed, and to produce the reports detailing the predictions for the configurations under consideration.

DRIFT incorporates data from hydrological models already set up for the LMB. The present day, naturalised and expected future flow regimes associated with water resources developments need to be modelled / generated and the outputs required from the model are daily flow data since monthly data do not provide the resolution required. Where sites are influenced by hydroelectric power (HEP) schemes that generate power at peak times each day, he data are required at a sub-daily level. In the case of proposed HEP schemes where sub-daily hydrological data are not available, the sub-daily summary statistics required for the DSS will need to be developed from descriptions of the intended operation of the HEP.

The basic data requirement for DRIFT is daily (or, on occasion, sub-daily) hydrological flow sequences for a continuous time period – preferably 30 years or more. The first time-series produced is a continuous record of present day flows for each site over a given period. Thereafter, simulated time series are produced for the naturalised condition and for all chosen configurations, over the same period. For each time series, the water-resource conditions chosen are imposed over the full period.

As flow sequences are not easy to interpret ecologically, they are therefore transformed into a set of flow indicators and summary statistics chosen by the ecologists and resource economists.

In DRIFT, the hydrologist creates rules that help define when a season begins and ends, thus allowing for year-by-year information for each flow indicator: a 40-year hydrological record, for instance, will have 40 values for “dry season onset”. The flow indicators thus reflect the natural variations of the intra-annual and inter-annual hydrological cycle. They are summarised by mean, median, standard deviation and range.

In summary, daily (or sub-daily) time series form the hydrological input to the DRIFT tool, while it calculates the values for the flow indicators and summary statistics (Figure 3.2).

Furthermore, DRIFT can incorporate data via external models on hydraulics/hydrodynamics, sediments and water quality from models already set up and approved for the LMB.

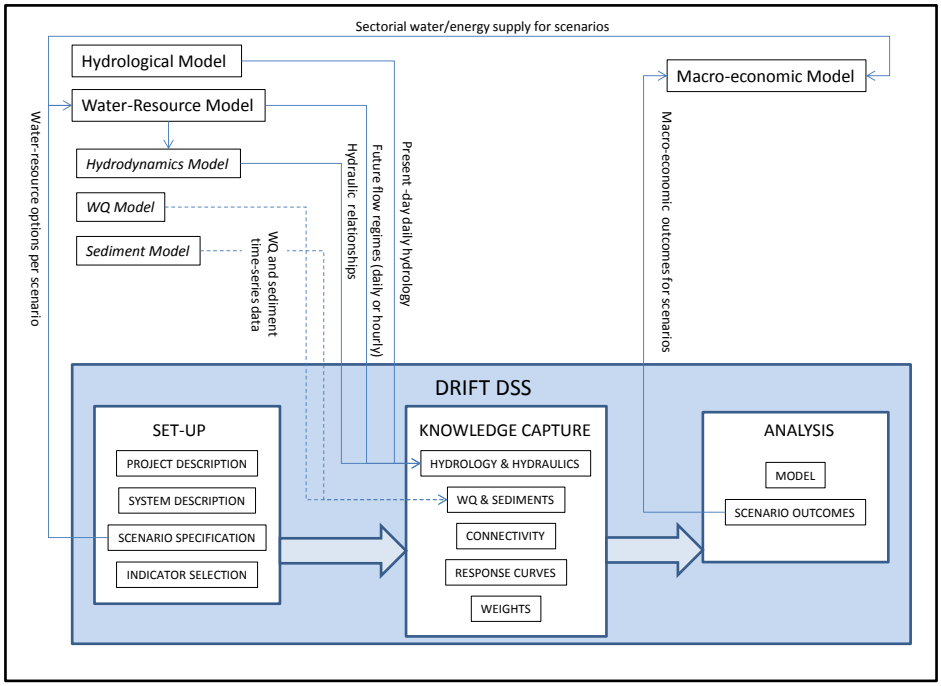

Figure 3-4: Arrangement of modules in the DRIFT and inputs from external models.

In the case of sediments and water quality, there are alternative coarse-level options available in DRIFT for incorporation of these disciplines if there are no flow-linked models available or the data available is insufficient to populate database.

The basic requirements with respect to these data are summarised in Table 3.4 including the DRIFT Phase for which the data are required.

3.4 Hydrological and Sediment Assessments

A number of hydrological and hydrodynamic models have been developed and applied to the Mekong Basin and that these are suitable for providing the data requirements for the Council Study (summarised in Table 3-3). Of the models listed, three (highlighted in blue in Table 3-3) form part of the MRC DSF (Decision Support Framework), *viz.* SWAT (Soil and Water Assessment Tool), IQQM (Integrated Quantity and Quality Model) and iSIS.

Discharge time-series

In terms of daily discharge time series required for the Council Study, the SWAT/IQQM hydrological/water balance models will be used to provide the input for the Council Study sites/areas, for historic/baseline conditions. These two models (particularly IQQM) are suitable for providing discharge time series for various thematic area development configurations.

iSIS extension to Chiang Saen is operational but cross sectional data is missing at 14 points. Empirical rating curves based on historical discharge monitoring can be used in lieu of cross-sectional data, however, they may not represent the current hydrologic conditions. Completing the cross-sectional survey represents a critical milestone in order for the DSF to be scientifically sound when applied up to Chiang Saen. The iSIS model include both water quality and sediment transport modules. The sediment transport has been included in the model applications for the Tonle Sap Great Lake and

Mekong Delta as shown in Table 3.3. Furthermore, the one-dimensional (1D) hydrodynamic model for the main-stem Mekong River will be extended in 2014 to include sediment transport.

One exception may be if hydro-peaking development configurations are considered, since rapid (sub-daily) changes in discharge are likely to require hydraulic rather than hydrological routing (as used in IQQM). Although recent refinement of the IQQM model for the Mekong (Mekong IQQM) includes domestic and industrial water use, irrigation and hydropower, it is likely that average daily flows are used. For hydraulic routing of hydro-peaking flows, the iSIS model that was previously setup for the Tonle Sap Lake and Mekong Delta (Table 3.3), and recently (2013) for the main-stem Mekong River from Chiang Saen to Kratie[14], is more appropriate. Existing setups of the model may, however, need further development/refinement to provide stable solutions for rapidly changing flow conditions[15].

Baseline period

For modelling simulations under WUP-A, BDP2 and other more recent studies, MRC adopted a baseline period from 1985 to 2000. The quality of the hydro-meteorological data set from 2001 to 2008 is also considered suitable for incorporating into the baseline and the BDP currently uses a baseline period that extends from 1985 to 2007. The baseline period for the Council Study will be discussed and established during an inception workshop. The choice will be based on the availability of data, resources and utility for the study.

Significant water resources related developments have taken place within the LMB from 2001 to 2008 and a number of studies have shown that these developments have significantly changed the hydrology of the river. An investigation of the validity of the hydro-meteorological records, hydrological records and infrastructure developments over the period 1985 to 2008 will be undertaken to establish a baseline for hydro-meteorology and hydrology. In establishing this baseline, it will be important to consider issues of long term temporal stationarity and representativeness of the baseline consistent with a low level of development in the basin.

Sediment transport and water quality modelling

Table 3.3 notes that the SWAT model has been applied to provide sediment yield and transport within the Mekong Basin. However although the software has the capability of simulating nutrient and sediment transport, the modelling of water quality and sedimentation was not completed during the DSF development term[16]. Furthermore when using IQQM to represent changes in loadings due to water resources developments configurations, significant effort would need to be invested in incorporating further data and recalibrating the model. The current IQQM implementation in the DSF did not incorporate this function, however IQQM was written for quality and quantity modelling therefore it is capable of providing the required information[17].

[14] 460 computational nodes covering 1480 km.
[15] It is assumed that iSIS is capable of modelling rapidly varying flow conditions associated with hydro-peaking. No specific references to sub-daily hydro-peaking have been found in the literature, but there applications for dam break studies.
[16] Due to limited water quality data
[17] from MRC, 2103 and personal communication between Dr. Dat Nguyen Dinh and Dr. Michael Waters

In the updated version of the model, *viz.* ARCSWAT 2012, the simulation period has been extended to 2007 and sediment and nutrient modelling is included (MRC, 2013).

Application of MRC-DSF Models for the Council Study

From the available literature describing the MRC-DSF hydrological/hydrodynamic model setups, the capabilities of the existing applications to simulate changes in water quality and sediment transport as a function of changes in discharge, are not entirely clear. What is clear, however, is that such capabilities do exist[18, 19], and may need to be developed (further) to provide the necessary information for the Council Study. The IKMP team has been responsible for more recent upgrades of the models, including extending and refining their spatial coverage, extending the simulation period, and improving calibrations. Therefore, with reference to this Study, it is envisaged that the Hydrologic Team will be responsible for the simulations (historic/baseline and development configurations) to provide the necessary model output. This (standard) model output will be post-processed for input to the Council Study assessments.

[18] Podger, G. and Beecham, R., 2003. IQQM User Guide. Department of Land and Water Conservation, NSW, Australia

[19] The water quality module add-on to iSIS 1D can model advection/diffusion, conservative and decaying pollutants, coliforms, salt, water temperature, pH, oxygen balance (BOD), organic nitrogen, ammonia oxidised nitrogen, water/sediment oxygen interactions, phytoplankton, solar radiation, macrophytes, benthic algae, absorbed phosphorous, silicate and cohesive sediments (http://www.halcrow.com/isis/wq.asp)

Table 3-3: Hydrological and water resource models and tools used in the Mekong since 2000, after Johnston and Kummu, 2010.

	Model	Application	Area	Source	Mekong application
Hydrological models	SWAT	Rainfall-runoff model in MRC DSF	LMB 700 sub-basins	MRC Technical Reports, described in Adamson (2006)	MRC DSF - input data for IQQM sediment yield and transport
	SLURP	Semi-distributed hydrological model	LMB	IWMI Kite (2001)	Hydrology of Mekong - fisheries impacts climate change
	VIC	Distributed hydrological model	Whole basin	Washington University Costa-Cabral *et al*. (2007); Thanapakpawin *et al*. (2007)	Hydrology, sediment transport; carbon cycle Climate change
	VMod	Distributed hydrological model	Whole basin	MRC WUP-FIN (2006, 2007)	Basin wise model developed by EIA Ltd. under IKMP programme of MRC. Several smaller scale applications exists, *e.g.* for Nam Singkram sub-basins
	YHyM	Distributed hydrological and water quality model	Whole basin	Yoshimura *et al*. (2009)	Hydrological model to simulate nutrient loads in the Mekong
Water balance models	Lancang model	Rainfall-runoff model	UMB	Chinese Academy of Surveying and Mapping Liu *et al*. (2007)	Lancang flows
	IQQM	Water balance, flow routing	LMB to Kratie	MRC Technical Reports, described in Adamson (2006)	MRC DSF - scenario assessment Assessment of flow regimes as input to negotiation of rules and procedures for water utilisation
	CSIRO water use account	Water accounting	LMB	CPWF/CSIRO Kirby *et al*. (2010a, b); Mainuddin *et al*. (2008)	Assess impact of climate change on water resource Water productivity assessment
	Mike Basin	Water balance, flow routing	LMB to Kratie	NORPLAN and EcoLao for ADB (ADB 2004)	CIA for Nam Theun 2
Hydrodynamic models	iSIS	Hydrodynamic model	Tonle Sap Lake and Delta	MRC - Halcrow MRC Technical Reports, described in Adamson (2006)	MRC DSF - scenario assessment Sediment transport
	VRSAP	Hydrodynamic model	Delta	Viet Nam Sub-Institute for Water Resources Planning Khue (1986); Hoanh *et al*. (2009)	Water allocation in the Mekong Delta; sluice gate operations
	EIA 3D model	Hydrological, hydrodynamic and WQ models	Sub-basins of LMB	MRC WUP-FIN (consortium of SKYE, EIA Ltd. and TKK) MRC WUP-FIN (2003, 2007)	Modelling of Tonle Sap River and Lake flood pulse Modelling of Songkhram Basin and Mekong Delta; sediment transport and erosion; nutrient transport
	Mike 21	Hydrodynamic model	Cambodian floodplain	MRC WUP-JICA MRC Technical Reports and Fuji *et al*. (2003)	Modelling of Cambodian Floodplain
	Mike 11	Hydrodynamic model	Tonle Sap and Delta Mekong Delta	NORPLAN and EcoLao for ADB (ADB 2004) Khem *et al*. (2006)	CIA for Nam Theun 2

ADB (Asian Development Bank); CIA (Cumulative Impact Assessment); DSF (Decision Support Framework); CPWF (Challenge Program on Water and Food); CSIRO Commonwealth Scientific and Industrial; Research Organisation; IKMP (Information and Knowledge Management Programme); IQQM - Integrated Quantity and Quality Model; IWMI (International Water Management Institute); LMB - Lower Mekong Basin; SKYE (Finnish Environment Institute); SWAT - Soil and Water Assessment Tool; TKK (Helsinki University of Technology, Finland); UMB - Upper Mekong Basin; WUP - Water Utilisation Programme; WUP-FIN (Finnish Environment Institute Consultancy Consortium); WQ - Water Quality

Data Outputs from the SWAT/IQQM and iSIS Models

The following data outputs can be expected from the existing MRC-DSF models

- SWAT/IQQM
    - Time-series of daily discharges at study sites/reaches along the main-stream Mekong River between the China border and Phnom Penh, for historic/baseline and development configurations. Baseline Simulation period: 1985 to 2008.
    - Time-series of daily discharges for nodes of interest for the Tonle Sap Lake and Mekong Delta, for baseline and development configurations. Baseline period: 1985 to 2008.
- iSIS
    - Tonle Sap Lake
        - Relationships between pertinent hydrological drivers (e.g.,flood peak, timing and duration) and inundated area and average depth.
    - Mekong Delta
        - Relationships between pertinent hydrological drivers (e.g., flood peak, timing and duration) and inundated area and average depth.
        - Salinity distribution (possibly as a time-series variable or function of river discharge).
    - Study sites/reaches along the main-stem Mekong River from China border to Phnom Penh
        - For hydro-peaking development configurations, time-series of daily discharges at EF sites/reaches. Hourly discharges are preferred if possible. Simulation period: 1985 to 2008.
        - Relationships between discharge and water level, water depth in the channel (maximum and average), average flow velocity, floodplain inundated area and average water depth.

As explained previously, there is uncertainty as to the existing capabilities of the MRC-DSF models in providing water quality and sediment information, although the capabilities do exist within these models (refer to Footnote 18). It is noted that the iSIS model has limited sediment transport capability.

It should be noted that the standard output from iSIS (and other models, if used) will not necessarily provide information in a suitable format for DRIFT. The outputs will most likely be post-processed to produce appropriate hydraulic indicators for DRIFT. In order to ensure that suitable (and agreed-to) hydraulic indicators are used and provided in an appropriate format for use in the DRIFT[20], the hydraulic modeller responsible for overseeing the various spatial components of the study (*viz.* the Mekong River sites/reaches, Tonle Sap Lake and Mekong Delta) will work closely with, *inter alia*, the Technical Coordinator, and the Hydrologic Assessment Team.

[20] Post-processing purpose-coded software may be required for this purpose, for converting standard output from the selected hydrodynamic/hydraulic models.

Other Relevant Models Developed and Applied in the Lower Mekong Basin

Two further modelling studies worth mentioning (that are not part of the MRC-DSF) are the Mike 11 modelling work carried out under the WUP-JICA (Japan International Cooperation Agency) and TSLVP (Tonle Sap Lake and Vicinities Project), and the WUP-FIN (Finnish Environment Institute Consultancy Consortium) modelling of the flow regime and water quality of the Tonle Sap Lake.

MRC (2005)[21] describes these two studies: The Mike 11 model consists of rainfall-runoff and river-lake-floodplain modules for the Tonle Sap System and Cambodian part of the Mekong Delta. The model has been setup for the period 1998 to 2003[22], using hourly and daily data.

The WUP-FIN modelling (Phase 1: 2001-2003) included the development of a three-dimensional (3D) Flow and Water Quality Model for the Tonle Sap Lake and the Floodplain. A 3D characterisation of the Great Lake was deemed necessary because of substantial gradients (horizontally and vertically) that lead to separation of aquatic habitats. Model parameters include hydrological (flood arrival time and duration), hydraulic (average and maximum water depth, velocity) and water quality (*e.g.* dissolved oxygen, nutrients, harmful substances, municipal wastes, coliforms, *etc*.). In Phase 2 (2004-2006), the models were extended to cover the Cambodian Floodplain, the Mekong Delta and 'hotspots' in Thailand and Lao PDR (Peoples Democratic Republic). MRC WUP-FIN (2007) provides the following description (edited): "In addition the LMB pilot model for the Cambodian Floodplains, Tonle Sap System and most of the Delta has been constructed. The purpose of the application was 2D/3D feasibility testing at a regional scale. The models compute the following main characteristics: overland flow from Cambodia, flood propagation in the floodplain as a 2D/3D process; control structures and their operation; tides; coastal flow; saline intrusion as a 3D density driven process; sediment transport, sedimentation and erosion; acidic water transport and dilution (at the moment no chemical reactions or modelling of the source term is included); other water quality variables as necessary, including sediment and nutrient transport."

iSIS Model for the Mainstream Mekong River from Chiang Saen to Kratie

The iSIS model for the Mekong River, upstream of Kratie, is based on the following topographical data (MRC 2013)

- Cross-sectional surveys extracted from the Hydrographic Atlas Survey Report (MRCS, 1998).
- An existing Digital Elevation Model (DEM) with a grid size of 100m covering the entire area. This is the DEM used to develop other models, and was used here as no more recent data seem to be available. The DEM for the Mekong Basin is based on various sources, but for the main-stem Mekong River is the GTOPO30 (30 arc-second (*c*. 1 km) from the China border to Chiang Saen), and the MRCS 50m grid (Chiang Saen to Kratie). The data sources for the latter (50 m) DEM are 1:50 000 American and 1:100 000 Russian topographical maps, and it was updated[23] in 2000.

[21] Mekong River Commission (MRC). 2005. Overview of the Hydrology of the Mekong Basin. Mekong River Commission, Vientiane, November 2005, 73pp.
[22] Which does not conform with the simulation period of the MRC-DSF models, which is from 1985 to 2000 (and apparently extended to 2006/7)
[23] No information is provided in MRC (2005) as to the 2000 updating

- NAP (Navigation Programme) produced datasets through digitising of the 1:20 000 Hydrographic Atlas of the Mekong River.

It could be that the iSIS river characterisation of the river topography is too coarse for this type of flow based assessment, that requires detailed, accurate and reasonably recent surveys of the river form and associated physical habitats. For this reason, it is envisaged that, firstly, the (in)adequacy of the topographical data in the iSIS modelling should to be confirmed. It is likely that selected ecologically critical and/or sensitive sites/reaches within each of the four river zones will need to be accurately surveyed. It is reasonable to expect that these surveys should be confined to the active portion of the channels, with the existing or refined[24] DEM used for any adjacent floodplain areas. Surveys are likely to involve the use of ADP (Acoustic Doppler Profiler) data collection techniques and provide multiple geo-referenced cross-sections within a selected river reach. Survey data must be on the same common elevation datum in the MRCS DEM[25]. Data collection may be best performed during high flow conditions, when large areas are inundated, allowing for more extensive surveys using a single data collection method.

Hydraulic conditions within these reaches would then need to be modelled using appropriate software, and integration into the existing iSIS model (between Chiang Saen to Kratie) is the obvious choice. Alternatively, separate iSIS models could be setup for each of these assessment reaches, with appropriate upstream and downstream boundary conditions. It is advisable that the hydraulic behaviour within these reaches[26] be 'calibrated' by collecting stage-discharge (or rating) data over a range of (low flows to high flows/flood) discharges.

3.5 The Biological Resources Assessment

Sequence of Activities for the Biological Resources Assessment

The basic sequence of activities for the Biological Resources Assessment will be:

1. Collect/collate relevant data for the study river.
2. Augment with expert knowledge for similar river systems and a global understanding of river functioning.
3. Obtain simulated baseline daily (or sub-daily where appropriate) hydrological data for each representative zone.
4. Obtain modelled baseline hydraulic, sediments and water quality data for each representative zone.
5. Calculate annual indicator time-series for flow, hydraulics, sediment and water quality for each representative zone.
6. Construct relationships for the expected response of individual ecosystem indicators to changes in aspects of the flow, sediment or water quality regimes (these are called Response Curves).

[24] The adequacy of the existing DEM or characterising any adjacent floodplain also needs to be established. For example, the SRTM (Shuttle Remote Topography Mission) DEM is listed in MRC (2013) under 'existing raster data', but no further reference is provided as to its use.
[25] Various references to 50m, but appears to be re-sampled to 100m for use in the iSIS modelling
[26] Specifically, the flow resistance

7. Calibrate the DRIFT Data Management Tool.
8. Use Response Curves to predict time series of abundance changes for baseline condition.
9. Obtain modelled future changes in catchment hydrology for individual and cumulative water resources development configurations (see Section 3.1.5). Obtain modelled knock-on hydraulic, sediment and water quality effects.
10. Calculate annual indicator time-series for flow, hydraulics, sediment and water quality.
11. Use Response curves to calculate severity scores and develop time-series of change in abundance for ecosystem indicators for development configurations.
12. Calculate average severity score for set of configurations for each indicator for entire hydrological time series.
13. Convert scores to provide a prediction of overall ecological condition.

The bulk of the work in the construction and calibration of the Response Curves will be done in a workshop setting at two workshops in Vientiane:

- Knowledge Capture Workshop
- Calibration Workshop.

Table 3-4: Abiotic information required for the Biological Resources Assessment

Discipline	Zones	Input data	Time-step	Appropriate MRC model (see table 3.3)	Data outputs	Data required for DRIFT at the start of:
Hydrology	Representative river sites in Zones 1, 2, 3, 4a	Hydrological time series	Daily	SWAT	Historic daily discharge Baseline daily discharge	SET-UP
			Daily	IQQM	Daily discharge associated with Thematic configurations	ANALYSIS
Site Hydraulics	Representative river sites in Zones 1, 2, 3, 4a	Hydrological time series	Same as input hydrology	iSIS (where available and subject to clarity on the spatial resolution of iSIS set up)	Water level Water depth in channel Velocity Lateral connectivity Longitudinal connectivity Inundated area of floodplain Water depth on floodplain	KNOWLEDGE CAPTURE
Hydrodynamics	1, 2, 3, 4	Hydrological time series	Same as input hydrology	iSIS (where available)* (Note: iSIS is not capable to provide sub-daily changes in discharge as a result of dam operation)	Sub-daily changes in discharge as a result of dam operations (	KNOWLEDGE CAPTURE and ANALYSIS
					Floodplain inundation patterns	
					Hydrological changes associated with channel change	
	4b (Tonle Sap Great Lake)	Hydrological time series	Same as input hydrology	iSIS	Inundation area	KNOWLEDGE CAPTURE and ANALYSIS
					Depth of inundation	
					Timing and duration of inundation	
	5 (Mekong Delta)	Hydrological time series	Same as input hydrology	iSIS	Salinity distribution in the delta	KNOWLEDGE CAPTURE and ANALYSIS
					Extent and timing flooding and inundation in the delta	

Discipline	Zones	Input data	Time-step	Appropriate MRC model (see table 3.3)	Data outputs	Data required for DRIFT at the start of:
Sediments/ Geomorphology	1 ,2, 3, 4, 5	Baseload and suspended sediment time series	Same as input hydrology	iSIS* (*Note: iSIS capability to produce these outputs range from none to limited)	Suspended sediment concentration	KNOWLEDGE CAPTURE and ANALYSIS
					Grain size of suspended sediment	
					Bedload supply	
					Grain size of bedload	
					Exposed extent of rocky and sandy islands	
					Bed elevation	
					Bank erosion and slumping	
					Effects of dredging and sand mining (particularly in Delta)	
					Depth of large pools	
Water Quality	1 ,2, 3, 4a	Water Quality time series	Same as input hydrology	iSIS* (*Note: iSIS capability to produce these outputs range from none to limited)	Conductivity	KNOWLEDGE CAPTURE and ANALYSIS
					Temperature	
					pH	
					Dissolved oxygen	
					Total suspended solids (from sediment modelling)	
					Organic content	
					Nutrient concentrations	
	4b Tonle Sap Great Lake	Water Quality distribution time series	As above	As above	As above	As above

Discipline	Zones	Input data	Time-step	Appropriate MRC model (see table 3.3)	Data outputs	Data required for DRIFT at the start of:
	5 (Delta)		Same as input hydrology	iSIS* (*other models with 2-D sediment transport modelling capability may be linked to iSIS if found necessary and appropriate)	Salinity Temperature pH Dissolved oxygen Water clarity DIN, DIP and silicate	KNOWLEDGE CAPTURE and ANALYSIS

3.6 Social Assessments

3.6.1 Framework for the Social Assessment

One of the most important components in the Council Study will be a socio-economic assessment of the benefits and impacts of water resources developments and infrastructure. This assessment will be based on published reports and census data and/or targeted socio-economic assessments conducted in the context of the Council Study. Particular attention will be given to the communities and their specific engagement with the natural resources of the LMB. Levels of consumptive and non-consumptive water use and levels of demand for the basin resources will be established and targeted social and economic assessments will be undertaken where no information exists.

The socio-economic assessment will cover all aspects relevant to the social dimensions of a triple-bottom-line assessment. This will include a measure of equity and access to social resources, health and well-being, quality of life, social capital and livelihoods to indicate impacts via composite socio-economic indicators. The sub-indicators used to compile the composite indicator, should at a minimum, include indicators linked to the changing status of peoples' livelihoods, income, access to resources, and health and nutrition.

Using the knowledge generated by the biological resources assessment on the impacts of water resource developments on hydrological, sediment transport, water quality as well as the environmental parameters, the socio-economic assessment will separately assess the impacts of water resources developments in each of the thematic areas as well as the cumulative impact of developments on the selected socio-economic parameters.

This information will be used by the thematic teams to compile the reports that are the principal deliverables of the project: six thematic reports pertaining to the six selected thematic areas describing the positive and negative impacts of water resources developments and infrastructure in the Lower Mekong River Basin including recommendations for impact avoidance and mitigation measures; and a report on the cumulative positive and negative impacts of the selected water resources developments.

3.6.2 Activities and Tasks for the Social Assessment

The team tasked with the social assessment will have the overall responsibility to further define the framework, coordinate, monitor, and integrate the components of the socio-economic analyses required to produce the deliverables of the Council Study.

In general, the work will fall within the following areas:

1. Define the framework and indicators for the Socio-Economic Assessment;
2. Develop ToRs for and/or coordinate the work of international and national consultants representing the following disciplines;
    a. Livelihoods and access to resources,
    b. Public Health, and
    c. Nutrition

3. Coordinate information exchange and activities between the Socio-economics Team and other teams; and
4. Develop the Technical Report on the Socio-Economic Assessment of the Positive and Negative Impacts of Selected Water Resources Developments and Infrastructure in the Lower Mekong River Basin.

Defining the Framework and Indicators for the Socio-economic Assessment

As indicated above the socio-economic assessment will cover all aspects relevant to the social dimensions of a triple-bottom-line assessment. Therefore, the assessment will include a measure of equity and access to social resources, health and wellbeing, quality of life, social capital and livelihoods to indicate impacts via a composite socio-economic indicator. The sub-indicators used to compile the composite indicator, should at a minimum, include indicators linked to the changing status of peoples' livelihoods, income, access to resources, and health and nutrition.

In this context, the Council Study Socio-economic Coordinator will use existing best practice to define a set of social indicators in discussion with the MRC programmes including the Basin Development Programme and the Social Impact Monitoring and Vulnerability Assessment (SIMVA) being undertaken by the Environment Programme.

Developing ToRs for and Coordinate the Work of Consultants

A team of consultants will support the Socio-Economic team as needed to conduct the Council Study Socio-Economic Assessment. This team could include:

a. A consultant who can link changes in hydrological and biophysical indicators to changes in access to resources and livelihood activities using SIMVA data and Fisheries Programme data;
b. A consultant who can link changes in the availability of resources and changes in biophysical indicators (i.e. disease vectors) to changes in public health conditions,; and
c. A consultant who (working with the Fisheries Programme) can link changes in resources availability and access to changes in nutritional indicators.

Information Exchange and Activities between the Socio-Economics Team and other Teams-

The social assessment will draw from the other teams to assessment positive and negative impacts of water resources developments and feed their information back to the thematic teams to enable them to develop their reports. These lines of communication will include:

a. Input from Thematic Teams on information related to the direct impacts of water resources developments and infrastructure on social indicators. These can include social displacement and resulting direct loss of livelihoods, employment benefits, loss of access to cultural practices, increased access to other economic activity, and increased mobility;
b. Information exchange with the Hydrologic Team and study coordinators on flow indicators that are directly relevant to social indicators;

c. Information exchange with the Biological Team and study coordinators on indicators that are relevant to social indicators;
d. Information exchange with the Macro-economic team on projected changes in household income, livelihood opportunities and employment;
e. Provide information to the Thematic Teams and to the Cumulative Team to inform the compilation of the Thematic and Cumulative Final Reports; and
f. Collaborate with the Coordination team on the reporting and liaising with the four MRC Member Countries.

3.7 Economic Assessments

Benefits of water resources developments are usually clear and well established ranging from primary benefits accruing from the sale of power, increased crop production, and employment to the secondary and tertiary benefits of increased economic development, higher government revenue and expenditure and regional economic integration.

On the other hand, direct costs of water resources development are accounted in the investment decisions, the indirect social and environmental costs are harder to assess and therefore may not be fully considered. Since water resources development and infrastructure result in changes to the flow regime downstream, this can lead to a change in ecosystem goods and services provided by the river and its derivative groundwater in the Lower Mekong River Basin. These foregone net ecosystem benefits would be the opportunity cost of taking action to develop the water resources of the basin. In a similar vein, any decision not to develop the water resource potential implies giving up the net economic benefits of hydropower, irrigation, land-use development and agriculture, urban and industrial water use, navigation and flood management including secondary and tertiary multiplier benefits in a national and regional context.

Furthermore, some of the indirect costs of water resources developments will be felt over time. A reduction in fisheries or ecosystem services for an example will be a gradual process and the full cost of that loss would likely be borne by people in 10, 20, 30 or more years in the future. Whereas in an economic analysis future benefits and costs are expressed in the context of Net Present Value (NPV) to facilitate informed decision-making at the current time, NPV does not fully capture the dynamism of an economy that results in changes in consumer preferences. In the context of the Lower Mekong River Basin, costs incurred due to the loss of fisheries based current consumption patterns may not fully reflect the social impact of that loss in a future where other alternatives to fish may be available and cost effective. Therefore, the economic analysis will compensate for the dynamism of the regional and national economies and changes in relative consumption preferences.

The main components of any economic analysis of future states of the system are future changes in net ecosystem benefits and water withdrawal benefits, each with its component changes in costs and benefits. In the Council Study alternative paths for developing the water resources will be examined and therefore the economic gains from water resources developments will contrasted with the losses in ecosystem goods and services.

Two streams of analyses will inform the Economic Assessment in the Council Study. They are the following:

1. Resource Economic Assessment, and
2. Macro-Economic Assessment.

3.7.1 The Resource Economic Assessment

The Resource Economic Assessment will capture the loss of downstream economic benefits from a baseline that exists today and will be presented in terms of changes in Net Present Value and via its impact on social indicators. The valuation of basin resources is required for the purpose of evaluating the impacts of gains and losses in economic welfare associated with decisions to develop or not develop the water resources of the Lower Mekong River Basin (and its tributaries). For this reason the analysis of basin resources is best circumscribed to include only those resources and sectors that will be affected by changes in the timing and amount of the flow regime – either in terms of impacts from changes in flow and timing downstream or in terms of the development benefits and impacts from the changes in development and land use patterns that accompany the water resource developments themselves.

In conducting the resource economics analysis, information will gathered from existing literature and field studies on the livelihood and economic values attributable to the river system in the basin. A number of studies conducted by the Fisheries Programme and the Environmental Programme SIMVA provide detailed data on the use of river resources by people and the corresponding values. However, if required brief surveys involving focus group and key informant interviews will be carried out at the study sites. This information will be used to develop natural resource use models, which will form the basis for the valuation.

The river and wetland values at the field sites, (i.e. those values that could be affected by flow change) include values for household use of river-based natural resources such as fish, reeds, floodplain grass, floodplain gardens and floodplain grazing, as well as commercial river- and floodplain-based tourism. The values of all natural resource uses will then be upscaled for the basin as a whole, including those making up the selected water resource developments.

The economic analyses will measure the private wellbeing of the basin inhabitants, as well as the national wellbeing of the basin countries as a change from the baseline. Private wellbeing will be measured as the net change in household livelihoods. This is the net gain in welfare, due to the resources of the river basin and its functions, experienced by households. It is the net profits earned by households in their income-earning activities. Private wellbeing as affected by intangible factors such as water quality will be assessed.

National wellbeing will be measured as the direct net change in national income. Measurement of the direct contribution to the national income will be extended to illustrate the total direct and indirect impact of resource use on national economies. This will be done using multipliers calculated from social

accounting matrix (SAM) models. National wellbeing as affected by indirect use values, or ecosystem services, will also be measured in terms of national income[27].

The Council Study will clearly define the present day and potential future uses of the water resource in the Lower Mekong River Basin. In the economic analysis, the losses in economic activity as a consequence of changes in the flow regime will be calculated in terms of the changes in ecosystem goods and services provided by the river system. In the subsequent analysis of configurations these annual values will be converted into streams of costs and benefits over defined time scenarios under defined discount rates. On a country-by-country basis these losses (and gains) will then be set off against the potential net benefits of the water resource developments that alter the flow regime.

This comparison will use the direct economic costs and benefits of the water supply, hydropower, and irrigation projects, as well as their impact on the ecosystem goods and services. For each water resources development, good and service, a reference case net present value will be calculated based on present day use of water in the basin; then net present values will be calculated for selected water resource development configurations. The change between each of the configurations and the reference case shows the net gains or losses to the economy for (a) the water resources developments and (b) ecosystem goods and services.

As successive configurations may incorporate the development projects of the former configurations, these configurations should not really be compared one with the other, but serve to illustrate the trend analysis. The results from the can show how increasing levels of water use will affect the national economies of each country. The tradeoffs between the distributions of these values between sectors highlight the issues of transboundary water allocation and management in the basin.

3.7.2 The Macro-Economic Assessment

This component of the economic assessment would capture the benefits and costs of water resources development to the national and regional economies. The assessment would use two categories of data

a. Aggregations of the data provided by the resource economic assessment, and
b. Data provided by the thematic teams as to the current or anticipated benefits from the water resources development (i.e. power generated, agricultural production etc).

These values will be used to assess the benefits and costs of development to the countries hosting the development as well as to other riparian countries.

The macro-economic assessment will seek to identify

[27] The inclusion of non-use values (existence, bequest and option value) has not been considered in this design of the resources economic assessment for the Council Study as it may not be relevant to the main objectives of the Council Study, which are to inform the lower Mekong Riparian countries with regards to the relative impact of water resources developments.

- Contribution of domestic and international hydropower sales to GDP, government revenue (taxes and dividends) and foreign exchange,
- Contribution from export of agriculture products, manufacturing and/or navigational services to GDP, government revenue (taxes and dividends) and foreign exchange,
- Multiplier effects of hydropower infrastructure development and the power sales in the national and regional economies including sustainability,
- Multiplier effects of other developments including agriculture and manufacturing, and
- Distribution of costs and benefits - incidence of benefits vs. costs amongst communities, livelihoods, countries and people of difference socio-economic strata.

In answering these and related questions, the following three-tiers of impacts will be assessed:

Direct Costs Benefits- Investment and other direct costs of development of infrastructure and direct revenue from the sale of power and other revenue sources.

Indirect Costs and Benefits - Positive and negative economic externalities from development including ecosystem services and social impacts valued and internalized.

Multiplier Impacts - Multiplier effects of developments including impact on regional macro-economic development, trade flows etc.

3.7.3 Components of the Valuation

The variable that changes in each configuration is how the water of the Lower Mekong River and its tributaries are used. Changes in flow lead to changes in economic welfare and, therefore, it is necessary to only examine those basin resources and sectors that are likely to respond to new water resources projects and the subsequent, downstream impacts of alterations in the timing and amounts of flows. On the water resources side, the changes will occur in hydropower production, irrigated lands and production, and water supply. On the ecosystem side, changes in flows are expected to alter the production of natural resources, tourism, ecosystem services and nature conservation.

A brief characterization of each sector and discussion of issues that may need to be addressed is provided below.

Fish, other aquatic animals and plants:

The surface water discharge of the River underpins the wetland ecosystems, the groundwater system, the productivity of the Tonle Sap lake system, and the functioning of the Mekong Delta processes. Thus abundance, distribution and the diversity of the biota in the river system are effectively reliant on the ecological function of the river, which in turn depends, in large part on the timing and availability of water. As a major source of income, food, cultural value and economic value, this one sector is separated out from the other natural resource sectors for special attention and prominence.

Natural Resources.

Natural Resources is a catch all sector that will be used here to capture the impacts of changes in river flows on the direct use values of resources like water, food, fibre, timber, wildlife etc that can be

categorized as components of local livelihoods for communities in the Basin. In the context "natural resources" are in effect ecosystem "goods." The emphasis here is on distinguishing between the primary goods provided by new water resource projects. Water resources development projects may increase water supply and food, for example, but the manner in which they do so oftentimes means that there are impacts on those communities previously relying on this water (or flow). New projects mean that these goods are provided through different economic production systems and, at times, to different groups of people. So, modern irrigated agriculture has often come at the expense of traditional, flood recession agriculture, for example. Thus, under the natural resources heading the impacts of changes in river flows and subsequent effects on the full variety of natural resources that enter into household production and consumption will be captured.

Ecosystem Services

Ecosystem Services refers to carbon sequestration, water supply, water purification, etc. In other words these are the natural hydrological and ecological functions that only indirectly enter into the economy. A key consideration with respect to natural resources and ecosystem services is to ensure that benefits, or the ensuing welfare changes, are not double-counted. Thus, the analysis needs to be clear as to whether the resource production based on groundwater extraction is classified under natural resources or ecosystem services (but not both). Priority is given to recording those services that lead to the production of direct use values as natural resources. Measuring the change in these direct use values under different flow regime could then be used to demonstrate the ecological value of the ecosystem services provided by the natural flow regime. However, these are not added back in to the analysis as that would be double counting.

Hydropower (HEP)

The hydropower sector is a subsector of the national energy sector and changes in hydropower production will need to be placed in the context of their expected benefits to the national energy sectors.

Irrigation

Irrigated agriculture provides direct and indirect benefits that should be captured in the macro-economic analysis.

Water supply

Water supply is used here to reflect large-scale infrastructure to provide water to households, commerce and industry. Domestic water supply is used to refer to water supplied to homes and communities for the purpose of household use.

4 Study Implementation

This section describes the sequence of activities and tasks that would be carried out to implement the Council Study including a work plan and the significant milestones.

The inception phase of the study commenced with the approval of the Council Study Terms of Reference. The activity indicated in the ToR was completed within this phase and a summary of the output is in Chapter 2 of this document. This activity was:

> **Activity 1.1.1**: Identification and collation of existing literature - Literature relevant to Objectives 1 of the Council Study will be collected and made accessible to the thematic and discipline teams. This will include publications including papers, scientific articles, project reports produced or commissioned by the MRC and any other scientific literature or grey literature that may be relevant from other organizations.

Furthermore, during this inception period, consultations were held with the MRC programmes and an internal planning meeting was held with the participation of MRC programmes specialists to achieve the following:

1. Develop a detailed description of the assessment methodology including how the thematic and cumulative assessments will be informed by the hydrologic, biological, social and economic assessments.

2. Describe detailed study implementation mechanisms including a detailed time-bound work-plan, a list of activities, milestone and a detailed budget.

3. Propose a detailed study management mechanism including the tasks and responsibilities for consultants and for MRC staff personnel. This should also include a risk management section highlighting the possible risks to study implementation and options for management.

4. Develop detailed ToRs for individual consultants in liaison with requisite MRC Programmes.

5. Further refine the work-packages for the Council Study teams in liaison with MRC Programmes.

This inception report is a product of these activities conducted within the inception period.

The subsequent sections of the document will elaborate on the Council Study TOR with detailed tasks to be carried out under the specific tasks and provide further narrative description of these tasks.

4.1 Detailed Work Plan

4.1.1. Study Implementation Phases

The Council Study will be implemented in three phases as illustrated below. The reader is referred to the Council Study ToR for the list of activities under each phase..

Phase 1 - Inception and Set-up:

In this phase, the activities preceding the production of the inception document will be carried out. Furthermore, the models and the data management tools will be set up and calibrated. The specific sites

within the zones will be identified and sites visits will be conducted. The thematic teams will identify the water resources developments and their parameters.

Phase 2 - Knowledge Capture

In this phase, the data management tools will be populated with existing and newly generated data. Site visits and new data collection activities will be conducted when required. Two key workshops will be held in this phase: the Knowledge Capture Workshop and the Calibration workshop. In the Knowledge Capture Workshop, the Response Curves will be created and entered into the data management tool. After this, there will be a period of calibration and refinement of these Response Curves.

Phase 3 – Assessment and write-up:

In phase 3, the data and information generated above will be used to assess the impacts of the water resource developments on the triple-bottom-line, the social, environmental and economic parameters of interest in the Lower Mekong Basin. The information produced by the discipline teams will be used by the thematic teams to develop the thematic reports and will be used by the process management team and BDP to develop the cumulative report[28].

4.1.2 Tasks

The work undertaken for the Council Study will fall under eight main tasks:

Task 1: Process Management

Task 2: Hydrological, hydraulic and sediment modelling

Task 3: Assessment for the corridor on both sides of the mainstream from Chinese border to Kratie

Task 4: Assessment for the Cambodia Flood plains including the Tonle Sap River and Great Lake

Task 5: Assessment for the Mekong Delta.

Task 6: Social and Economic Assessments

Task 7: Assessment of the East Sea coastal areas directly influenced by the Mekong estuary

Task 8: Report preparation, feedback and dissemination

The assessments for the mainstream, Tonle Sap Lake and the Mekong Delta are in separate tasks (Tasks 3, 4 and 5). The main reasons are the following:

- The hydrodynamic modelling requirements are quite different for the three ecosystems;

[28] In this phase the Council Study coordination team will work with a selected external group to assess the impacts of water resources developments on the East Sea coastal areas directly influenced by the Mekong estuary

- Most inland aquatic specialists tend to focus on one of rivers, lakes or estuaries, so it is unlikely that a specialist in any one discipline could cover all three ecosystems;
- The methods of ecoclassification differ somewhat between the areas;
- The manner in which the information is managed in the data management tool differs for the three ecosystems.

However, the name and order of the sub-tasks are the same for all three tasks (Task 3, 4 and 5) are described together.

Task 1: Process Management

The **objectives** of Task 1 are to manage the Council Study, including the organisation of meetings, helping teams organize and manage consultant input, facilitate and ensure coordination amongst the teams, ensure the timely and quality flow of information, organise and manage data entry and calibration of the DRIFT data management tool, manage the data and reports; run the Thematic Area development configurations to provide an indication of impacts on the aquatic ecosystems, and socio-economic parameters and write up the relevant sections for inclusion in the Thematic Area individual and cumulative reports.

As described in Section 1.7, the Process Management will also include stakeholder engagement as described below:

Task 1 comprises eighteen sub-tasks:

1.1	Inception Activities and Meeting
1.2	Preparation Meetings and Site Visit
1.3	DRIFT Data Management Tool Set-up and Updates
1.4	Social Assessment Set-up
1.5	Economic Assessment Set-up
1.6	Selection and Description of Water Resources Developments to be Assessed
1.7	Facilitation of Stakeholder Input for the Inception Report and Proposed Methodology
1.8	Workshop Facilitation (KCW and Configuration - Task 2)
1.9	Workshop Facilitation (KCW and Configuration - Task 3)
1.10	Workshop Facilitation (KCW and Configuration - Task 4)
1.11	Calibration of Scenarios
1.12	Quality Control
1.13	Stakeholder Engagement for Knowledge Capture, Study Progress and Intermediate Results
1.14	Combine Outputs of Tasks 2, 3 and 4 in Single DRIFT Data Management Tool
1.15	Provision of Information for the Coastal Zone Assessment
1.16	Individual Thematic Development Analyses and Reporting
1.17	Cumulative Thematic Development Analysis and Reporting
1.18	Presentation to Wider Stakeholders and Dissemination

The personnel needed for Task 1 are:

- Council Study Coordinator
- Council Study Technical Coordinator
- DRIFT data management tool manager
- Assistant workshop facilitators

Task 1. 1 Inception Activities and Meeting

This task will include all the activities required to initiate the Council Study including the consolidation of teams including national representatives, the lining up of consultants, and any other preparatory work that may be required. An inception meeting will also be held to provide an overview of the Council Study and the Thematic Areas and ensure that all teams are aware of the project goals, work plans and timelines, and their responsibilities within that.

Task 1.2 Preparation Meetings and Field Visits

A four-day preparation meeting will be held for all the discipline teams and supporting consultants to initiate the assessment of impacts via the hydrological regime. The aims of the meeting will be to:

- Discuss data and model selection
- Present a training programme on providing specialist input for DRIFT.
- Select focus areas within each zone
- Develop preliminary Indicator lists, and identify key linked Indicators

Following the preparation meeting, the field visits will be conducted during the low flow period (i.e., somewhere between February and early May) to provide the teams with an opportunity to familiarise themselves with the study area. Teams will only visit zones for which they will be responsible for providing information.

The aims of the site visits will be to:

- gain an understanding of the character of the study area and the challenges, if any, that it poses;
- gain an understanding of the locations of water resource and other activities and the implications for site selection;
- visit the location of the flow monitoring stations;
- identify the final locations for the focus sites or areas in each of the Mekong and Tonle Sap Rivers, Tonle Sap Great Lake and Delta zones and
- identify where the assessment of environmental impacts will be linked with the assessment of socio-economic impacts.

Task 1.3 DRIFT Data Management Tool Set-up and Updates

The set-up of the data management tool prior to capturing the specialists' knowledge as Response Curves involves mapping zone and site locations; mapping the locations of existing and proposed

developments; designating Indicators and their links to other Indicators; identifying river-length and floodplain connectivity and other issues related to the indicators; inputting the historic and baseline hydrological, sediment and water quality time-series and hydraulic relationships.

Updating the data management tool is a more-or-less continuous process as specialists initially work with their specific 'discipline' module of the data management tool and, from time-to-time, their inputs are transferred to a 'master' copy of the data management tool, and redistributed to the team for further work.

Task 1. 4 Social Assessment Set-up

The assessment will be set to capture information generated by the biological resources assessment on the impacts of water resource developments on hydrological, sediment transport, water quality as well as the environmental parameters. The socio-economic assessment will separately assess the impacts of water resources developments in each of the thematic areas as well as the cumulative impact of developments on the selected socio-economic parameters.

Task 1.5 Economic Assessment Set-up

The macro-economics consultant, working with the thematic teams, will develop the framework of the macro-economic model to capture information of direct and indirect benefits and costs of water resources developments.

Task 1. 6 Selection of Water Resources Developments to be Assessed

The selection of water resources development configurations for analysis is mainly the domain of the Thematic Areas, however, the Biological Resources Assessment team will need to ensure that the configuration of water resource developments selected have flow/water level/inundation implications that can be modelled, and will be likely to provide results that are distinguishable from one another.

Task 1.7 Facilitation of Stakeholder Input for the Inception Report and Proposed Methodology

This task will include all activities required to inform and solicit feedback from stakeholders including key Development Partners, NGOs, and CBOs at the inception phase. The Council Study Coordinator will package and disseminate information in an audience-appropriate manner via consultation meetings, workshops, emails and publications.

Task 1.8, 1.9 and 1.10 Workshop Facilitations

There will be two main workshops:

1 Knowledge Capture Workshop (KCW)
2 Calibration workshop.

In the Knowledge Capture Workshop, the Response Curves are created and entered into the data management tool. Following the KCW there is a period of calibration and refinement of these Response Curves using various 'calibration scenarios', during which time there is one-on-one interaction between the discipline teams and the study management team. Once this is complete, the team comes together again for the Calibration workshop, where the final adjustments to the data management tool are made before running the Individual and cumulative thematic configurations.

Separate workshops will be held for the assessment of the Mekong mainstream, Tonle Sap and the Delta.

Task 1.11 Calibration and Refinement

Once all Response Curves have been entered, the responses are calibrated to:

- Historical record: the hydrologic, biological resources and the climate change discipline teams will check whether decreases and increases in the abundance time-series relate to years in the hydrological record which are drier or wetter than usual, as appropriate. If there are data available for particular years (e.g. fish surveys, socio-economic surveys), these can also be checked against the values in the time-series.
- Calibration scenarios: these are often useful to allow the teams to calibrate their Response Curves for extreme minimum and maximum values.

Task 1.12 Quality Control

Quality control is an essential part of the assessment process because it uses data from disparate sources at different levels of detail and relies on some expert opinion. The data management tool inputs from the various specialists will be checked continuously to ensure that they are complete, logical, and that the reasoning behind each Response Curve is clearly explained and supported by references from the scientific literature.

The Council Study management team will also be responsible for reviewing and providing comment on the individual reports from the discipline teams.

Task 1.13 Stakeholder Engagement for Knowledge Capture, Study Progress and Intermediate Results

This task will include all activities required inform and solicit feedback from stakeholders in the knowledge capture phase. Similar to the earlier process of stakeholder consultations, the Study Coordinator will package information as to the current progress of the Council Study. However under this task the Discipline Teams can opt to have separate engagement processes to “ground-truth” response curves and other information used in the study.

Task 1.14 Combine Outputs of Tasks 2, 3 and 4 in a Single DRIFT Data Management Tool

Outputs of the three separate assessments: assessment for the Mekong and Tonle Sap Rivers, Assessment for the Tonle Sap Great Lake and the Assessment for the Mekong Delta will be entered into the DRIFT data management tool.

Task 1.15 Provision of information for the Coastal Zone Assessment

The Council Study coordinating group will use the results of the assessment of water resources developments on the bio-physical parameters to assessment its impact on the coastal areas. The

assessment will be based on existing information and will be conducted in liaison with an external group that has significant subject matter experience[29].

Task 1.16 Individual Thematic Development Analyses and Reporting

The hydrological, sediment and water quality time-series representing water resources developments to be assessed per thematic areas will be run through the DRIFT data management tool.

The current assumption is that there will be three sets of water resources developments from each Thematic Area, 18 sets requiring analysis (three sets for each of the six Thematic Areas).

The results will be:

- written up and supplied to the relevant Thematic Area for inclusion in their reports;
- provided to socio-economic team for further analysis.

Task 1.17 Cumulative Thematic Development Analysis and Reporting

Same as for the above task but three sets of cumulative water resources developments will be assessed and reports will be written.

Task 1.18 Presentation to Wider Stakeholders and Dissemination

This task will include a number of workshops and other activities to solicit inputs from a broader set of stakeholders including NGOs, CBOs, Development Partners, International Organisations, private sector and other interested individuals on the draft report. This task also includes activities to disseminate the final report and summary messages and policy briefs from report via a number of media and communication outlets.

Task 2: Hydrological, Hydraulic and Sediment Modelling

The objective of task 2 is to model and report the hydrological impacts of water resources developments. The Hydrologic team will obtain information from the thematic teams on the configurations and operational regimes of the water resources developments to model the hydrology of the river post water resource developments. The sub-tasks under this task include

2.1	Overview of hydrological data
2.2	Calibrate hydrological model
2.3	Naturalised and Present Day daily data
2.4	Calibrate a water-resources model able to predict changes in flow as a result of development configurations
2.5	Define of daily hydrological regimes for development configurations
2.6	DRIFT hydrological analyses
2.7	Input to Thematic Areas
2.8	Specialist reports

[29] This external group has not been identified at the timing of writing this report.

This task will be the responsibility of the Hydrologic Team with support from the Council Study Technical Coordinator and consultants as required

Task 3: Assessment for the Corridor on Both Sides of the Mainstream from Chinese Border to Kratie

Task 4: Assessment for the Cambodia Flood Plains Including the Tonle Sap River and Great Lake

Task 5: Assessment for the Mekong Delta.

The **objectives** of Tasks 3, 4 and 5 are to describe the relationship between flow and ecosystem resources and overall condition so that these can be used to assess the impact on the riverine ecosystem of future changes to the flow regimes.

Tasks 3, 4 and 5 comprise eleven sub-tasks:
NOTE: since the Sub-Tasks for Tasks 3, 4 and 5 are the same, they are denoted as 3,4,5.x. So Sub-Task 3,4,5.1 is the same as Sub-Task 3.1, Sub-Task 4.1 and Sub-Task 5.1

3,4,5.1 Literature/model review
3,4,5.2 Indicator and site selection
3,4,5.3 Site visit and familiarisation
3,4,5.4 Data collection/collation
3,4,5.5 Data analysis and modelling
3,4,5.6 Eco-classification
3,4,5.7 Knowledge Capture Workshops
3,4,5.8 Data management tool calibration
3,4,5.9 Configurations analyses
3,4,5.10 Calibration workshops
3,4,5.11 Specialist reports and internal review

The personnel requirements for each of the three tasks differ slightly and are shown in the table below

Table 4-1: Personnel requirements for Tasks 3, 4 and 5 and consultant support

Task 2 - Mainstem	Task 3- Tonle Sap Lake	Task 4- Delta
All Discipline Teams except socio-economic team		
Consultant support may include		
River Water Quality specialist	Water Quality specialist	Estuarine Water Quality specialist
Fluvial Geomorphologist	Lake Geomorphologist	Estuarine abiotic specilaist
River Botanist	Botanist	Estuarine microalgae specialist
River Invertebrates specialist	Invertebrate specialist	Estuarine macrophytes specialist
Herpetologist	Herpetologist	Estuarine invertebrate specialist
Fish	Fish Biologist (could be the same person as for Task 3).	Estuarine fish biologist
Ornithologist	Ornithologist and mammalogist (could be the same person as for Task 3).	
River mammals		

Task 3,4,5. 1 Literature/model review

The duration of the project is such that relationships between the riverine ecosystem and flow that will provide the basis for the assessment will for the most part be obtained from existing data, models and reports.

Each specialist will review all pertinent MRC data, reports and models relevant to their discipline. Based on the review, they will identify the data, reports and models that they will use, and identify additional data collection needed to complete their assignments.

The specialists will also review the international scientific literature for information on life histories and flow related change relevant for their discipline.

From a modelling perspective:

- if an MRC model is selected for use, then any necessary updating and calibration will be clearly specified
- if an MRC model is available but the recommendation is to use a non-MRC model, then the limitations of the existing models will be clearly outlined with an indication of how these limitations will compromise or limit the outcomes of the Council Study, and how the non-MRC model would enhance the assessment;
- if no MRC model is available, suitable models will be identified and the process of calibration clearly outlined.

Task 3,4,5.2 Indicator and site selection

The aims will be to:

- Generate a list of biophysical indicators that will be used to predict flow related changes in the Mekong River.
- Generate a list of socio-economic indicators that will be used to predict impact on social parameters
- Select focus areas (sites) in each of the Mekong zones

Task 3,4,5.3 Preparation meeting and site visits

See Task 1.2.

Task 3,4,5.4 Data collection/collation

The study will depend heavily on existing data, and the bulk of the effort will be directed at sourcing and collating these data. However, it is often useful to augment existing data with limited field data collection and it is vital that all relevant specialists visit each site. The extent of this will need to be determined in consultation with the team following their literature/model reviews and site visits.

Task 3,4,5.5 Data analysis and modelling

The extent of this will need to be determined in consultation with the team following their literature/model reviews and site visits.

Task 3,4,5.6 Ecoclassification

The condition of the riverine ecosystem will be described in terms of A-F Present Ecological State (PES) categories used to describe and classify the ecological condition of rivers (Kleynhans 1997), where A signifies a pristine ecosystem and E a critically modified one. Each discipline specialist will assess the current condition of each representative area/site in accordance with established methods.

Task 3,4,5. 7 Knowledge Capture Workshop

The Response Curves for each of the Indicators will be drafted and entered into the DRIFT data management tool database. This will take place in a workshop setting, which will allow for considerable discussion between the discipline teams before finalising their flow-response relationships. The KCW will require a minimum of one day per focus area, with two or three day start-up and a day for the scenario discussions for the sites.

The aim of the workshop is to:

- Finalise Indicator and Linked-indicator lists
- To generate at least a first draft of every Response Curve.

Separate KCW workshops will take place for Tasks 2, 3 and 4.

Task 3,4,5.8 Data management tool calibration

Once the Indicator and Linked-indicator lists have been finalised and a first draft of every Response Curve is available, the data management tool can then be run with the full suite of linked indicators (and associated knock-on effects). This usually requires some adjustment to the draft Response Curves. Once the data management tool has been run with full suite of linked indicators, the outputs will be sent to the specialists for checking and the technical coordinator and data management tool Manager will work with individual specialists (using email and Skype) to calibrate their Response Curves.

Task 3,4,5.9 Generation of Data

The hydrologic team will calibrate and run the MRC SWAT, IQQM and iSIS models to generate hydrology, hydraulics, hydrodynamics and sediments/geomorphology, water quality data for the Council Study. The hydrological data will be assessed via the data management tool. Other models will be run and the data

included in the data management tool as a time-series over the same period as the hydrological data. (See annex on "Abiotic information needs for the Biological Resources Discipline")

Task 3,4,5.10 Calibration Workshop

The calibration workshop is where the final adjustments to the data management tool are made before running the Individual and cumulative thematic configurations.

Separate Calibration workshops will take place for Tasks 2, 3 and 4.

Task 3,4,5.11 Specialist Reports and Internal Review

Reports will be provided for every specialist technical reports for every discipline.

For those disciplines where the response to flow was modelled outside of the data management tool, the reports will focus on the modelling. For those discipline where the Response Curves were provided, the report will focus on the synthesis of data and literature to support the assumptions made in the Response Curves.

Task 6: Social and Economic Assessments

The objective of this task is to use the information from tasks 2,3,4 and 5 to assess the positive and negative impacts of water resources developments on social and economic parameters. This includes the following tasks

6.1	Social Indicator workshop
6.2	Delineate socio economic areas within the basin
6.3	Assess livelihoods reliance on river and associated resources for household income and social wellbeing
6.4	Assess the economic value and economic impact of all river-related natural resource use for each IUA in the basin and its importance in terms of poverty alleviation, and development
6.5	Assess the impact of water use developments on the livelihoods and economic and social wellbeing in the basin and its countries.
6.6	Individual thematic development analyses and reporting
6.7	Cumulative thematic development analysis and reporting

This task will be the responsibility of the socio-economic team with consultant support.

Task 6.1 Social Indicator workshop

Working with SIMVA data and Fisheries Programme data in this workshop the socio-economic team will

a. link changes in hydrological and biophysical indicators to changes in access to resources and livelihood activities,
b. link changes in the availability of resources and changes in biophysical indicators (i.e. disease vectors) to changes in public health conditions, and
c. link changes in resources availability and access to changes in nutritional indicators.

Task 6.2 Delineate Socio-economic Areas within the Basin

Working with the zones formulated by the SIMVA process, the Socio-economic Team will demarcate areas that are homogenous in terms of relevant social and economic characteristics. These will then be reconciled with biophysical zones, which had been similarly defined by the biophysical working groups to create a map with integrated units of analysis (IUAs).

Task 6.3 Assess livelihoods reliance on river and associated resources for household income and social wellbeing

Using SIMVA data complemented by field surveys and existing literature, a framework of community reliance on natural resources will be established covering the multiple sectors described in the previous chapter. This will include, Livelihoods and access to resources, Public Health, and Nutrition. Using this framework and the information developed by the Hydrological and Biological Resources Teams (on the impacts of water resources development), the Socio-economic Team will be able to assess changes to social welfare resulting from changes biophysical indicators.

Task 6.4 Assess the Economic Value and Economic Impact of all River-Related Natural Resource Use for Each IUA in the Basin and its Importance in Terms of Poverty Alleviation, and Development

This task is for the resource economist to quantify the information gathered in task 6.3 in economic values. Emphasis will be placed on issues that are important in terms of continued poverty alleviation and economic development. The information derived in this task will be used to assess changes in private and national wellbeing due to water resources developments.

Task 6.5 Assess the Impact of Water Use Developments on Livelihoods and Economic and Social Wellbeing in the Basin and its Countries.

Using the information provided by the Thematic Teams, the Hydrological and Biological Resource Teams will assess changes in indicators relevant to them. This information will be used by the Socio-economic Team to assess changes in Social welfare resulting from these changes. These assessments will be the primary output of the socio-economic team.

Task 6.6 Individual thematic development analyses and reporting

The Social impact of water resources developments in each thematic sector will be separately assessed and the results will be:

- written up and supplied to the relevant Thematic Area for inclusion in their reports;
- provided to macro-economic team for further analysis.

Task 6.7 Cumulative thematic development analysis and reporting

Same as for the above task but three sets of cumulative water resources developments will be assessed and reports will be written.

Task 7: Assessment of the East Sea Coastal Areas Directly Influenced by the Mekong Estuary

The coastal areas assessed in the Council Study will be delimited to the areas directly affected by changes in the Mekong River's discharge into the sea together with the significance of coastal fisheries

and coastal processes (affecting issues such as coastal erosion and impacts of sea-level rise). However considering that the Mekong River Commission does not have the knowledge or the experience to assess coastal area impacts, this task will be conducted in liaison with an external organization that has significant experience in this field. The data pertaining to the impact of water resources developments on the hydrological, sediment, hydraulic and biological resources at the delta and the estuary will be the basis for this assessment. The assessment will be conducted using existing knowledge and information and no new research or data gathering will be conducted.

Task 8: Report preparation, feedback and dissemination

Task 8 and the subtasks will mainly be the responsibility of the thematic teams. Each thematic team will use the assessments provided by the discipline teams to craft the thematic reports that describes the impact of water resources developments on the triple-bottom-line. Each of the six thematic teams corresponding to the six thematic areas identified in the Council Study will formulate a report that describes the impact of water resources developments within that thematic area on triple-bottom-line using the information and analysis provided by the discipline teams as well as their own analysis of any direct impacts.

The Cumulative Impacts Team together with the coordination team will use the results of the three sets of cumulative water resources developments assessed by the discipline teams to formulate the cumulative report

Task 8.1 Development of the Thematic Report on Irrigation Development

The Thematic Team on Irrigation will develop a report that highlights the rate of irrigation expansion and the induced changes in flow parameters and the resulting changes in environmental, social and economic parameters including issues of food security, employment and transboundary benefits and costs. The report will also cover the impacts of irrigation on fisheries and the impacts of other developments on irrigation including dry season irrigation.

Task 8.2 Development of the Thematic Report on Non-irrigated Agriculture Development and General Trends in Major Land-Use Categories

The Agriculture Thematic Team will develop a report that indicates how land-use change including agricultural expansion can influence river flow in term of quantity, quality, timing and content (i.e. sediment, nutrients etc) and the resulting transboundary positive and negative impacts on environmental, social and economic parameters. The changes in sediment transport linked to land-use change and erosion will be a key section in this report.

Task 8.3 Development of the Thematic Report on Domestic and Industrial Water Use

The Thematic Team on Domestic and Industrial Water Use will develop a report that contains an updated map of large existing and planned and expanding urban and industrial centres within the basin, estimate water demand over the period covered by the Council Study, estimate general effluent and waste water discharge and highlight any possible risks of industrial spills or similar significant impacts. The report will further provide an estimate of the impact (positive or negative) of development in other sectors on domestic and industrial water use.

Task 8.4 Development of the Thematic Report on Flood Protection Structures and Floodplain Infrastructure

The Thematic Team on Flood Protection Structures and Floodplain Infrastructure will develop a report that provides an assessment of the transboundary flood protection benefit and risks of existing and planned infrastructure. Furthermore, it will describe how these structures can influence river flow in term of quantity, quality, timing and content and the resulting transboundary positive and negative impacts on environmental, social and economic parameters. The changes in sediment transport and ecosystem fragmentation will be a key section in this report as they are highly relevant for agriculture and fisheries, thus for food security.

Task 8.5 Development of the Thematic Report on Hydropower Development

The Thematic Team on Hydropower development will produce a report on the benefits and impacts of Hydropower Development that will present an assessment of the cumulative positive and negative impacts of hydropower development in selected Lower Mekong River tributaries and the mainstream. The focus will be on how the dams can influence fisheries, river flow, sediment and nutrient flux in term of quantity, quality, timing and the resulting transboundary positive and negative impacts on environmental, social and economic parameters in the mainstream corridor, floodplains and Delta as well as coastal processes. Two key sections in this report will be an estimation of the disaggregated economic benefits and updated assessment of sediment transport and the effect of change on geomorphology, bank erosion and coastal processes and fisheries.

Task 8.6 Development of the Thematic Report on Navigation Infrastructure Development

The Thematic Team on Navigation will develop a report that will include two main sections: an assessment of how existing and planned navigation infrastructure can influence river flow in term of quantity, quality, timing and content and the resulting transboundary positive and negative impacts on environmental, social and economic parameters and an assessment of the positive and negative impacts of water resources development in other thematic areas on navigation.

Task 8.7 Development of the Cumulative Positive and Negative Impacts of the Selected Water Resources Developments (the Cumulative Report)

The Cumulative Thematic Team, in close cooperation with the Council Study coordinating team, will produce a report that will highlight the cumulative impact of the developments in the six thematic areas on the river flow in term of quantity, quality, timing and content and clearly indicate resulting transboundary positive and negative impacts on environmental, social and economic parameters. It will also show the economic benefits and costs of development including the direct costs and benefits, positive and negative economic externalities from the developments assessed in the six thematic areas including ecosystem services and social impacts and multiplier effects of development including impact on regional macro-economic development, trade flows, replacement costs of lost benefits, etc.

Task 8.8 Dissemination of Draft Reports, Incorporation of Feedback and Finalization of reports

Once the draft reports have been produced they will be presented to the Regional Technical Working Group and other stakeholders[30] for comments and observations. These comments and observations will be incorporated and final reports will be disseminated.

4.2 Resources Requirements

Resource requirements are defined as

1. consultancy input
2. meetings and workshops
3. travel and field visits
4. Other

4.2.1 Consultancy Input

As indicated in the TOR the Council Study will be conducted by a number of teams drawn from MRC programmes. However, in areas where there is no expertise within MRC or when other constraints require, consultants will support the teams.

In accordance with this, the personnel for whom ToRs are provided in the annex include the full team required to undertake the Council Study. However, as the study gets underway it may be decided that some of the subject areas may not be of priority or that sufficient expertise and time is available within the MRC programmes. Also there may be a number of consultants who have expertise in a number of the indicated areas. For an example many sedimentologists also have expertise in geomorphology, and fluvial geomorphology.

It is envisaged that each discipline team would be linked with regional specialists, so that each discipline comprised one person who had experience with similar flow-linked assessments, and another who has experience in the basin. This arrangement was successful in IBFM3, and has also been used with success in several other similar assessments around the world, such as Lesotho Highlands Water Project, Pangani Basin EFlow Assessment and the Okavango Basin. Apart from the obvious advantages of pooling different types of expertise, it also ensures the development of capacity to understand and undertake flow-based assessments in the region. In the case of transboundary basins, it also offers individual countries confidence in the results, which comes from knowing that their experts were involved in the population and calibration of the tools used.

Consultants and expertise recommended are:

Task 1: Process Management:

1. Council Study Coordinator
2. Council Study Technical Coordinator

[30] As indicated by the Regional Technical Working Group

3. DRIFT Data management tool manager

Task 3: Assessment for the Mekong and Tonle Sap Rivers
Task 4: Assessment for the Tonle Sap Great Lake
Task 5: Assessment for the Mekong Delta.

4. Sediment Transport Expert/Sedimentologist
5. Geomorphologist
6. Water quality specialist
7. Fluvial geomorphologist
8. River botanist
9. River invertebrates specialist
10. Herpetologist
11. Fish biologist
12. River mammals (Dolphins)
13. Water birds
14. Estuarine microalgal specialist
15. Estuarine macrophyte specialist
16. Estuarine invertebrate specialist
17. Estuarine fish biologist
18. Estuarine bird specialist.

Task 6: Social and Economic Assessments

19. Socio-economics coordinator
20. Resource Economist
21. Nutritional Expert
22. Livelihood expert
23. Public health expert
24. Macro-economist

Task 7: Assessment of the East Sea coastal areas directly influenced by the Mekong estuary

25. A selected external agency with experience in the area

Task 8: Report preparation, feedback and dissemination

Note: these are optional allocations for consultants to support the Thematic Teams in the provision of information for the Council Study and for the development and editing of Thematic Reports. The lead programme for each Thematic Team will be required to define the TOR for the consultant supporting the team.

26. Support Consultant for the Irrigation Thematic Team

27. Support Consultant for the Agriculture and land use change thematic team
28. Support Consultant for the Domestic and industrial water use Thematic Team
29. Support Consultant for the Flood protection structures and floodplain infrastructure Thematic Team
30. Support Consultant for the Hydropower development Thematic Team
31. Support Consultant for the Transportation Thematic Team
32. Support Consultant for the Cumulative Thematic Team
33. Report Editors

Consultants when required can be recruited through the following arrangements:

1. Consultants can be directly hired by the MRCS Technical Coordination Unit or the Office of the CEO using funds designated for the Council Study
2. Consultants can be hired by the lead MRC Programme for the relevant Thematic or Discipline Team using funds designated for the Council Study
3. Consultants can be hired by the lead MRC Programme for the relevant Thematic or Discipline Team using programme funds designated for the Council Study

Based on the discussion carried out with the programmes, a table in the following section on study management shows suggested arrangements for the procurement of consultancy services.

4.2.2 Other Resource Inputs

Workshops

The following workshops will be held

1. Inception Meeting – 2 day meeting for all Thematic and Discipline Teams and process managers – approximately 36 MRCS staff, 12 National representatives and 10 consultants – 58 total
2. Preparation Meeting – for the assessment of impacts via changes in the hydrological regime – 24 MRCS staff, 12 National representatives and 20 consultants – 56 total
3. Knowledge Capture Workshop – same as above – 56 total
4. Calibration Workshop – same as above - 56 total
5. The Results Workshop – to present intermediate results – same participants as inception workshop with the addition of the full Regional Technical Working Group – 68 total
6. Four National Workshops – to present draft reports – 25 participants each
7. Final Workshop to present results – stakeholders from selected organisations – 50 participants

International Travel

International travel is required for any international consultancy services procured to support the teams

Regional Travel

Regional travel is required for the following;

1. RTWG and other riparian national representatives to participate in workshops and to accompany study teams to the assessment sites

2. For MRCS staff to travel for meetings and to travel to assessment sites
3. For consultants to travel within the region including to assessment sites
4. For national stakeholders to participate in national workshops

4.3 Budget

The following table indicates the main cost categories in the Council Study budget and the assumptions and information used to derive these costs.

Cost Category	
Coordination & Management	Team Coordination & Management, Data Integration Consultant, Study Coordinator, Technical Coordinator, Literature Review Consultant, Project evaluation
International Experts/Consultants	Based on inputs from the lead programme for each team [31]
Riparian Experts/Consultants	Based on inputs from the lead programme for each team [33]
National Experts/Consultants	Based on inputs from the lead programme for each team [33]
Travel	Based on an estimated number of regional and international airfares required
Meeting Costs	Based on the estimated number of meetings required
Operational Costs	Based on the estimation of Software Licenses, Equipment, Stationary and Document Production required
Payment of Coastal Assessment	An allocation of based on the reasonable estimate of effort required

In estimating the above costs, the following all inclusive rates were used

Consultant Category	Daily Rate (USD)
International Consultants	1000
Riparian Consultants	500
National Consultants	300
International Airfare	3,500
Regional Airfare	500
Per Diem in Vientiane	125
MRC Staff Technical Input	500

[31] Each team submitted their resource requirements in terms of international, national, and regional consultancy requirements, and other resource requirements to deliver the outputs indicated in the work packages they lead

Outline Budget

Description	2013	2014	2015	Total	MRC Funded	DP Funded
Coordination & Management	240,000	465,000	1,036,000	1,741,000	1,091,000	650,000
International Experts/Consultants	0	255,030	1,150,000	1,405,030	225,000	1,180,030
Riparian Experts/Consultants	0	45,025	164,000	209,025	50,000	159,025
National Experts/Consultants	0	39,020	546,000	585,020	105,000	480,020
Travel	0	0	368,500	368,500	35,000	333,500
Meeting Costs	0	250,000	560,000	810,000	37,000	773,000
Operational Costs	0	85,000	50,000	135,000	0	135,000
Payment of Coastal Assessment	0	0	250,000	250,000	0	250,000
Sub-Total	***240,000***	***1,139,075***	***4,124,500***	***5,503,575***	***1,543,000***	***3,960,575***
Contingency 5%						198,029
Management & Admin 11%	26,400	125,298	453,695	605,393	169,730	435,663
Total	***266,400***	***1,264,373***	***4,578,195***	***6,108,968***	***1,712,730***	***4,594,267***

5 Study Management

5.1 Composition of Thematic and Discipline Teams

The actual assessments and analyses will be carried out by two sets of teams constituted of MRC and national experts supported as required by consultants; six Thematic Teams representing each thematic area and a team tasked with developing the cumulative assessment and five Discipline Teams representing cross-cutting disciplines. These teams will be headed by relevant MRCS programmes (see Figure 5.1) and the team members will consist of the following as needed and available:

- RTWG and/or NMC representatives
- MRCS personnel
- External consultants
- Personnel from Member Country Line Agencies

Team members in each team will represent various disciplines as required to produce the outputs required[32]. The team approach could have a number of benefits including;

a. Close coordination with and incorporation of on-going MRC activities and programmes,
b. Synergies from a multi-disciplinary approach where experts from different relevant disciplines work towards common outputs,
c. Continuous and sustained national engagement at all levels leading to enhanced "ownership" of the study process and results,
d. Capacity building amongst national and MRCS personnel, and
e. An outcome through scientific discourse and collaboration instead of an individual perspective.

The seven Thematic Teams are:

- Thematic Team 1: Land use change, and Agriculture
    - Lead: Agriculture and Irrigation Programme
    - Basin Development Programme
    - Information and Knowledge Management Programme
    - National Planning agencies
    - Environmental Management Agencies
    - Cartographic Agencies (survey departments, geological survey etc)

- Thematic Team 2: Domestic and Industrial Water use
    - Lead: Environment Programme
    - Basin Development Programme
    - National Planning Agencies

[32] Exact outputs required from each team (work packages) will be detailed in the Inception Report

- Thematic Team 3: Flood protection structures and floodplain infrastructure including roads on major floodplains (note that this is moved from transportation)
    - Lead: Flood Management and Mitigation Programme
    - Information and Knowledge Management Programme
    - National Planning Agencies
    - National Environment Agencies

- Thematic Team 4: Hydropower development
    - Lead: Initiative for Sustainable Hydropower
    - Relevant National Agencies

- Thematic Team 5: Navigation (roads on floodplains moved above)
    - Lead: Navigation Programme
    - Relevant National Agencies

- Thematic Team 6: Irrigation
    - Lead: Agriculture and Irrigation Programme
    - Departments of Irrigation
    - Information and Knowledge Management Programme

- Thematic Team 7: Cumulative Assessment
    - Lead: Basin Development Programme
    - MRCS Coordinating Group
    - Climate Change and Adaptation Initiative
    - Information and Knowledge Management Programme

The Five Discipline Teams are:

- Discipline Team 1: Hydrologic modeling(cross cutting)
  The experts required for this team will include specialists on basin hydrology, fluvial geomorphology, hydraulic modeling (includes flood modeling) and aquatic chemistry
    - Lead: Information and Knowledge Management Programme
    - Flood Management and Mitigation Programme
    - National Academic/Research Institutions (as nominated by the RTWG and/or NMCs)

- Discipline Team 2: Biological Resources
  The experts required for this team will include specialists on fish and aquatic animals and plants
    - Lead: Fisheries Programme
    - Environment Programme
    - Line Agencies

- National Fisheries Research/academic organizations (as nominated by the RTWG and/or NMCs)

- Discipline Team 3: Socio-economics
  The experts required for this team will include specialists on nutrition, health, gender, and resource economics
  - Lead: Environment Programme (SIM/VA)
  - Fisheries Programme
  - Basin Development Programme
  - Research/Academic Organizations

- Discipline Team 4: Macro-economics
  - Lead: Technical Coordination Unit (interim)
  - Initiative for Sustainable Hydropower
  - Basin Development Programme

- Discipline Team 5: Climate Change
  - Lead: Climate Change and Adaptation Initiative
  - Flood Management and Mitigation Programme
  - Drought Management Programme
  - National Research Organizations

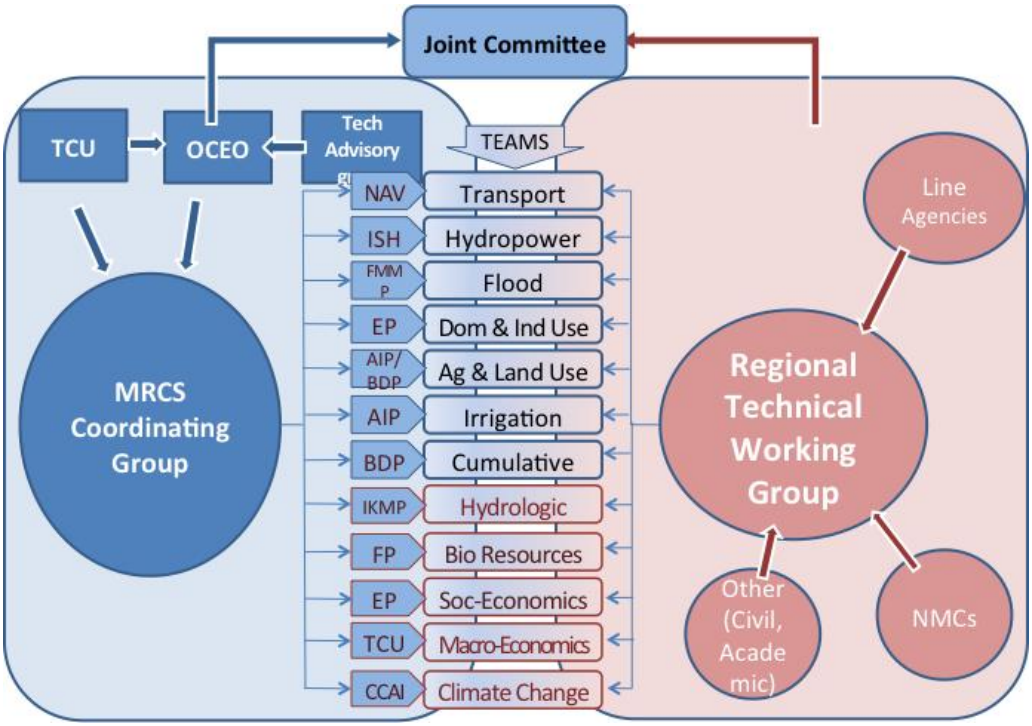

Figure 5-1: Coordination and Implementation

5.2 Roles and Responsibilities of MRCS Programmes

Consultants will support the teams as and when required especially in areas where in-house expertise is not available within the MRCS. The following table suggests how these consultancy services could be procured:

Table 5-1: Recruitment of Consultants

Consultant	By Programme or TCU/OCEO with Council Study Budget	By Programme with own budget
Council Study Coordinator	TCU/OCEO	
Council Study Technical Coordinator	TCU/OCEO	
DRIFT Data management tool manager	TCU/OCEO	
Sediment Transport Expert/Sedimentologist	IKMP	
Geomorphologist	IKMP	
Water quality specialist	IKMP	
Fluvial geomorphologist	IKMP	
River botanist		EP
River invertebrates specialist		EP
Herpetologist		EP
Fish biologist		FP/EP
River mammals (Dolphins)	TCU/OCEO	
Water birds	TCU/OCEO	
Estuarine microalgal specialist	TCU/OCEO	
Estuarine macrophyte specialist	TCU/OCEO	
Estuarine invertebrate specialist	TCU/OCEO	
Estuarine fish biologist	TCU/OCEO	
Estuarine bird specialist	TCU/OCEO	
Socio-economics coordinator	TCU/OCEO	
Resource Economist	TCU/OCEO	
Nutritional Expert		FP/EP
Livelihood expert	TCU/OCEO	
Public health expert	TCU/OCEO	
Macro-economist	TCU/OCEO	
Thematic Team support consultants	FMMP, NAV. EP, AIP	BDP, ISH

5.3 Study Monitoring and Evaluation

The Regional Technical Working Group will oversee and provide strategic direction to the Council Study and will also be responsible for the technical endorsement of the Study methodology and intermediate and final deliverables. Furthermore, the RTWG will lead the distillation of the policy recommendations based on the technical output of the Study and via the National Mekong Committees can brief the MRC Joint Committee on progress.

In addition it is proposed that representatives of relevant Development Partners participate as observers at RTWG meetings to provide input as requested.

The study will be managed and implemented by the office of the CEO with the support of the Technical Coordination Unit (TCU). A Technical Advisory group, comprising of senior MRCS technical personnel, and representatives from the Development Partners will advise the CEO and the formulation of principal policy recommendations.

An MRCS Coordinating Group will coordinate the work of the Council Study including input from MRCS programmes, external consultants and to liaise with National Line Agencies. This group will consist of MRCS programme coordinators, the Technical Coordination Unit and external consultants as needed. A Technical Coordinator with experience in management and technical assessments will support the MRCS Coordinating Group.

The Coordinating Group can solicit the services of external evaluators to assess the midterm and/or end term progress of the Council Study. The profile for such external evaluators should be somewhat different from that of a consultant recruited for general MRC programme evaluations due to the specialized nature of the Council Study. Instead, the possibility of working with either an academic or a research organization could be considered.

5.4 Risk Management

The following risk categories require management:

1. Administrative capacity to implement and coordinate the Council Study
2. Competing priorities especially for the MRC Programmes.
3. Dearth of available/affordable consultants with the requisite technical expertise
4. Capacity mismatches including personnel movements within MRC Programmes
5. Dearth of data and/or inadequate time to generate or collect new data

5.4.1 Administrative Capacity to Implement and Coordinate the Council Study

As is evident from the previous section, the Council Study will require extensive coordination amongst MRC programmes and a significantly large number of consultants to be recruited and managed. This requires dedicated support not only from the Human Resources Section and the Finance and Administration Section but also from other MRC programmes to assist in the identification and recruitment of consultants. However the strain on MRCS structures can be managed by recruiting either consulting firms or by working with academic and/or research organizations. Certain sections of the study such as hydrological modeling could be designated to such firms or organizations thereby reducing the burden on MRCS.

Likewise, a MRC Programme leads each Council Study Team and these lead programmes can coordinate the recruitment of requisite consultants.

5.4.2 Competing Priorities for MRC Programmes.

Each MRC programme has its own work-plan and budget developed in coordination with the national counterparts, the Technical Coordination Unit, and Development Partners funding the programmes. These work-plans and budgets have been finalized at the start of their year and the programme coordinators are held accountable for the delivery of outputs indicated in the work-plans. Likewise, the allocation of resources for the Council Study varies among programmes. Whereas some programmes have allocated significant funds and time for the Council Study, others have only allocated a token amount. Therefore some programmes may not be able to accommodate the significant additional time and funding commitments required to deliver outputs for the Council Study.

However, the Council Study objectives compliment on-going and/or planned activities within programmes such as the Initiative for Sustainable Hydropower and the Agriculture and Irrigation Programme thereby reducing the need for additional work and funds.

Furthermore, the office of the CEO, in consultation with the NMCs and the Development Partners, can revise the work plans and budgets to accommodate the Council Study for programmes where additional work is needed.

5.4.3 Dearth of Available/Affordable Consultants with the Requisite Technical Expertise

The Council Study will require highly specialized technical input in a number of areas and some of this expertise may not be readily available in the region. In some cases experts may be experienced with subject matter but may not have expertise to link their area of expertise to changes in flow regime, a component essential for this methodology to be used in the Council Study. Managing this risk will require innovative solutions including the possibility of holding small thematic workshops or technical sessions where experts are invited to address a specific uncertainty.

5.4.4 Capacity Mismatches Within MRC Programmes

MRC programmes are required to play a crucial role in the Council Study assessment. However, the primary objectives of the programmes have not been to assess links between their sectors to imposed flow changes due to water resources developments. For an example, the main role of the Navigation Programme is to facilitate the sustainable development of navigation amongst the lower Mekong countries, not the assessment of the impacts of navigation infrastructure development on environmental and social indicators. Likewise, the Flood Management and Mitigation Programme works to reduce the negative impacts of floods more than to assess the impact of flood management infrastructure. Therefore the expertise within the programmes may not be fully compatible with the requirements of the Council Study.

The way the Council Study is designed will partially address this risk. The Thematic Teams are only required to describe water resources developments in their respective sector in Phase 1 of the study. When developing the thematic reports in Phase 3, the Thematic Teams may need to recruit support consultants.

5.4.5 Dearth of Data and/or Inadequate Time to Generate or Collect New Data

The modeling and assessment methodologies for the Council Study are dependent on the timely acquisition and configuration of existing data and models. Considering that IKMP is responsible for maintaining and configuring MRC models, the Council Study will impose a significant burden on the programme.

Furthermore, new data and the quality checking and incorporation of existing data are required for the assessment of sediment impacts and significant amounts of new data may be required to assess the impacts of water resources developments in the tributaries. Information on the sensitivity of biota such as fisheries to imposed flow changes might require observation and data collection over several seasons in some contexts. However, such risks can be mitigated through expert opinion backed by rigorous recorded scientific observation. The method to be used in the Council Study assessment provides provisions for the inclusion of expert opinion in the estimation of response curves where the scientific evidence for the estimation is highlighted and recorded. Furthermore, considering that the population of the data management tool is conducted in a workshop setting, further safeguards can be introduced.

5.5 Conclusions and Recommendations for Study Implementation

The Council Study, as it is designed, is a study that will be led by the MRC, its programmes and Member Country representatives. Consultant support is included to support the MRC programmes where internal expertise or resources are inadequate. Therefore, study coordination will require significant resources and dedicated effort from the MRCS likely surpassing what is currently available.

If the Council Study is to succeed as a MRC driven and owned process, it will need to be considered a significant component of MRC programmes' work plans for the duration of the study. As indicated above the dedication of resources for the Council Study by MRC programmes is varied. However, now that the amount of effort required of programmes is clearly indicated in this inception report, this effort should be explicitly included in the programme budgets and work plans.

The current knowledge of the links between the impacts of water resources developments, the flow regime, ecosystem services and social impacts, especially in the Mekong, is incomplete. When subjected to changing flow conditions, ecosystems may exert non-linear and/or hysteretic behaviour. A change may cause cascading effects and lead to catastrophic and/or irreversible responses. On the other hand, some ecosystems may show strong resilience. Likewise communities not only adapt to changing environmental conditions but also may benefit from it. Therefore it is crucial to identify spatial/temporal thresholds, and extrapolations can only be used with great caution. While increased understanding of impacts may reduce uncertainties, such understanding can only confirm the existence of non-linearity if it is present, it cannot prove its absence.

Under conditions of uncertainty, irreversibility, and learning, there should be a clear preference for adaptive management. Adaptive management provides a mechanism for learning systematically about the links between flows, services and value. When establishing these links in the face of lacking knowledge and significant uncertainty, it is necessary to make qualified and systematic expert judgments. This suggests that in the Council Study Assessment process, there is a strong case to build in

and actively pursue a peer and stakeholder review process to provide inputs and incorporate some measure of quality assurance.

The strength of the Council Study, as designed in this Inception Report, is that it relies on time-tested, transparent methodologies that are scientifically robust. The process is owned by the MRC and is consultative, open and recorded for interrogation at every step and can provide a basis for informed and adaptive management of the Lower Mekong River Basin. This is a move forward from some previous studies that lacked ownership by MRC or were based on unsubstantiated and unsupported expert judgment.