Optimizing science-policy-practice interface for informed water policy in the transboundary Mekong River Basin

OPTIMIZING SCIENCE-POLICY-PRACTICE INTERFACE FOR INFORMED WATER POLICY IN THE TRANSBOUNDARY MEKONG RIVER BASIN

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ABSTRACT

Chapter 1: Introduction

The study focuses on the Mekong Region (MR) that is experiencing rapid changes from exponential increase in economic development activities potentially requiring that the development decision must be more knowledge-intensive and more participatory. The researchers, policy makers, basin managers and communities at large really need to know more and timely for ascertaining or convincing each other with plausible and accepted evidence about these complex relationships to build a consensus for action.

Interface is a key Concept of this study, and is generally referred to the point of interaction or communication between two entities such as information/knowledge producers, communicator and users. It covers how scientific knowledge and other validated knowledge are used to inform decision by the relevant decision-makers at different level and scale (from household, community, local, national, regional and global).

While the lack of high amount and high quality of knowledge for informed analysis and decision makings remains critical, the gap in the interface is considered by this study as the most critical one since it restricts the application of the available knowledge and tools and hence makes huge investment and efforts for knowledge management very ineffective.

The present study presents a first real systematic study for developing and trying the tools built around an appropriately standardized or custom-designed index to bridge science, policy and practice interface for sustainable development of the river basin's water and related resources in the Mekong Region, and potentially globally.

Chapter 2 provides a well-documented comprehensive analysis of the role of knowledge in designing and implementing activities and process contributing to effective transboundary environmental governance. The diagnostic analysis points to the required design principles and mechanism that have to rely on the intensive use of knowledge in the effective decision making and management.

The Mekong Region typology analysis demonstrates different ecological zones with prevailing difference in development potential and challenges, multiple scales and multi-stakeholders at regional, national, sub-national and local level, and diversity in social, political and cultural traditions and views. Diversity and harmony define the ranges of perspectives in Mekong Region's natural resource management and knowledge management. This diversity in harmony is taken into account in this study.

Secondly the review and analysis has found that the decision-makers perceived population growth and associated demand change associated with population and other fundamental social, economic, and political factors as the main justification for water and related resources rapid development. Appropriate assessment framework and usable knowledge, and assessment and monitoring tools are needed for considering at the earliest possible stage of planning, the impacts at a basin-wide level, predicting cumulative impacts over space and time, and supporting collaborative decision on mitigation and trade-off.

Chapter 3 provides qualitatively and quantitatively analyses the knowledge management practice and perception by selected three major groups of stakeholders that are considered

representative enough for this diverse group of key actors in the Mekong science-policy-practice nexus or interface. The results testify the complexity and multiple linkages of various scientific disciplines and topics called for providing knowledge and ascertaining facts for preventing and solving identified issues. It is worthy to note the uniformity of issues raised by researchers, policymakers and practitioners about poor permeability of knowledge into decision-making process are caused by multi factors – capacity and attitude, limited human resources and partnership, perception about relevance and salience, and prevailing political and cultural environment. The analysis concludes that an optimization of the interface and uptakes of knowledge for informed decision-making require a systematic approach towards improving readiness by relevant players and actors in the interface, capacity development, communication, engagement, and sustainable measures for instilling culture, political environment and behavior toward sharing, appreciating and applying knowledge in decision making.

CHAPTER 4 presents the process and outcomes of the development and trialing of the tool for evaluating and measuring improved interface for knowledge uptakes for decision making. This measurement tool proposed by this study is called "Best Knowledge Management Practices Index (BKMPI). The study applies a conceptual model of a multi-directional and multi-faceted interaction and connectivity among key actors in science-policy-practice interfaces in knowledge production (research design, planning and implementation), transmission and application, and other influencing factors, namely push and pull factors. **Table 4.2** presents the indicative dimensions, indicators, variables and means for verification, as well as the examples of evidence, defined, refined and fine-tuned through the development and trialing process during this study from August 2009 to May 2010.

The study attached careful thought on how numerical indicators of interface performance were to be used, and decided to use indicators as tin openers to aid judgements, and to facilitate comparison. The author of this dissertation and the group of invited specialists were able to use this method to specify the percentage of the variation that can be explained by indicator and variables values on the basis of documentary evidence, data-sets, surveys and interviews and in-depth case studies. For sensitivity analysis, the criteria weighting coefficients can be assigned both equal weight, and different priorities weighting scenarios, as well as triangulation analysis.

From its trialing, it is clear that BFKMPI has the potential to play an important role in enabling relevant stakeholders to monitor and redesign their knowledge management strategies and programs relying on factual, reproducible, objective and verifiable evidence to meet sustainable development objectives and for improving performance and promoting dialogue.

The assessment can be conducted either internally for self-assessment or externally as part of auditing process by the independent auditor(s) or assessor(s). As other scientific tools there are both potentials and limitations. The potential users and uses include the researchers, scientific groups, knowledge managers and users, governments, potential financiers, other decision-makers, private sectors, and civil society organizations involving in the knowledge production, communication and application. However, it is best to be used by individual who are a specialist of relevant knowledge management and scientifically informed policy process topic and also receive special training for applying BKMPI. In application of the tool, credibility of the assessment depends on how much information is disclosed by the assessed entity to the assessors.

To minimize diverse viewpoints with regards to attributes and aspects subjectively (personal preference, education and cultural background and institutional affiliation), the assessment results have to be challenged through rounds of additional peer-pressure and review process using evidence-based collaborative deliberation.

Key Recommendations

There is an urgent need to address enormous complexity of key actors in the science-policy-practice. Furthermore, physical and mechanical means for facilitating/ encouraging knowledge management and application through conducting regular performance review using BKMPI is highly recommended.

Key words: Science-Policy-Practice Interface, Mekong Region, Sustainable development, Best Knowledge Management Practice Index, scientifically informed decision making.

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DEFINITION OF KEY TERMS AND NOTIONS

At the first defense on April 23, 2012, the examination committee advised that some of the key concepts and terms are explained adequately from the start. A total of four questions were obtained during the presentation, and two additional questions were sent email.

The questions are summarized as follows:

1. Interface is a key concept in the dissertation, hence it is important to clearly define it from the beginning;
2. Define clearly scientifically informed decision-making and what is the difference between scientifically informed decision and democratic decision making?
3. Provide Typology of the studied river basin such as land forms and economic activities (land use and water demand etc.), social and ecological conditions, difference in perception and views.
4. State clearly who are intended users and what are the limitation of the BKMPI.
5. Show the originality and innovation in a more simplified way; and
6. Show one or two examples adapting loss of interests generated by different natural, population, industry, and cultural conditions using BKMPI in each basin.

This new section is to address the first two comments, and the remaining comments are addressed in relevant chapters of the dissertation.

1. Interface:

Interface: Interface is a key Concept of this study, as the study sets its objectives to understand what are the key factors influencing interface between science in broad sense, with policy and practice, and to develop a systematic tool/model for measuring its performance.

The science interface is generally referred to the point of interaction or communication between two entities such as information/knowledge producers, communicator and users (Lackey, Robert T. 2004, Sullivan, P. J., et al, 2006). The concept has been recently widely used in the western world, and started to spread in popularity among some research groups in the Mekong Region. Transmission model is one of dominating interface design representing both person-to-person, and media communication as means for facilitating interface or interaction (Fiske J, 1982). This model of communication has been a dominating way of interface between the knowledge producers and the end-users that has to ensure continual communication beyond dissemination, to constant feedback, resend and feed-back for improving relevance, effectiveness, receptivity of the knowledge quality. In short, the success of knowledge transfer from production to policy and/or practice requires effective and repetitive cycle of communication, feed-back and re-communication (resend), and quality of the addressors and addressees (See Figure 4.4 Interface through Dialogue – two-way flow of information, and Figure 0.1 Conceptual Model of Science-Policy-Practice Interface Potential Pathways in dissertation)

Science-Policy-Practice Interface: In this study, **science** is construed broadly to include the sciences, engineering and technology. **Policy** is best understood as the outcomes of a continuous, iterative and complex policy making process. The policy process is a process through which policy is made and implemented. **Practice** is understood as implementation process of a policy or program initiative, translating research outcomes into policy or action, and policy into action (Jacobs and Asokan, 2008). Not all examples of knowledge utilization go through a policy-making stage, and in some cases the policy comes after partial translation of the findings into practice. That explains the reason why practice is one of the key equations in this science-policy-practice interface assessment (Jacobs and Asokan, 2008).

2. Scientifically informed decision-making and scientifically informed decision and democratic decision making:

Scientifically informed decision-making: Science Informing Policy and democratizing science are two key aspects of how scientific knowledge and other validated knowledge are used to inform decision by the relevant decision-makers at different level and scale (from household, community, local, national, regional and global). How science gets implemented ultimately rests on how well it is interpreted and conveyed through policy process of the government that is either elected through democratic election and due process or other means (See Figure 0.2 Instrument Model representing more Linear Links between Policy-Makers and Knowledge Producers in the dissertation) a number of points of scientifically informed decision-makings can be made:

- Science can be used to identify existing and emerging problems (problem identification), and formulate clearer, less ambiguous policy, laws and regulations. For instance, scientific principles and information can be applied to climate change adaptation and mitigation planning make it more effective with fewer surprises and uncertainties;
- Information relevant to policy comes from multiple sources and varies in its objectivity.
- Science is only one part of a complex political process; there are other non-scientific aspects and factors of policy development (Sullivan, P. J., et al, 2006).

Democratic decision and informed decision-making*:* The world has become more globalized, but the political traditions and social norms (reasons of interest, ideology or intellect) continue to influence the mechanisms and institutions for integrating knowledge and expertise in the policy arenas (OECD, 2002, Science and Technology Committee, 2006, Pech S, 2009b). How far individual policy-makers would automatically attempt to use research findings on a regular basis will depend on multiple influences, such as motives, training, continuous education, and exposure to the media and to the demand of clients or constituency (OECD, 2002, Science and Technology Committee, 2006). The response of policy-makers to research varies not just with the type of issues and research being dealt with, but also with the differing attitudes they adopt towards the whole policy-making process and value of scientific and other form of knowledge. The adopted policy making styles in the country and organizations may affect the decision-makers' attitude towards mechanism for getting a wide range of advice from the best sources, particularly when there is uncertainty.

Facilitation an encouragement for using knowledge in policy process also depends on who can participate in the policy process (defining issues, developing agenda, making decision, undertaking implementation, and conducting evaluation and monitoring) and the forms of legitimacy and governance of associated with environment management policy processes.The characteristics of policy making styles (see **Table 4.3** in dissertation) also have a strong bearing on the recourse to and use of knowledge and scientific advice.

CHAPTER 1 INTRODUCTION AND STUDY DESIGN

1.0 INTRODUCTION

Some 100 years ago, science and society were two separated worlds hardly getting into direct contact. As the world enters the 21st century, the issues facing governments are increasingly complex and require decisions that have profound impacts on societies and economies. It has been empirically observed of "science evolving over a period of 100 years from a position of obscurity to a position at the centre of societal development" (Papponetti and Pinelli, 2004). The emergence of the knowledge-based society has underscored the importance of sound science advice as a key input to policy formulation both nationally and internationally. Fuelled by increased access to information, there is heightened public interest in science-based issues, and greater emphasis on public participation in decision making to deliver public policies that are robust, credible, and effective. A number of studies report methods and conceptual frameworks that have been applied, with varying degrees of success, to record utilization in policy-making.

The Mekong Region (MR) located in the mainland of South East Asia is the geographic scope of this study. The MR has the highest concentration of international rivers in Asia and contain the headwaters of major Asian rivers, including the Yangtze (over 6,300 km in length), Yellow (over 5,460 km), the Mekong River (over 4,900km) the Salween (Nu Jiang) (over 2,450 km) and the Red River (about 1,175 km) (MRC, 2006; Shaochuang, 2003). The Mekong region is changing rapidly. Economic, climate and population changes over the coming decades will have enormous implications for the challenge of reducing poverty or promoting sustainable growth (Pech S, 2010).

The Mekong River Basin (MRB) possesses the region's largest potential water and related resources. These resources have the ability to support ongoing economic development in terms of irrigation and agricultural production, fishery and aquaculture, energy and forest products, navigation and other modes of transport, domestic and industrial water supply, and tourism (MRC, 2010a, and 2010b).

The Mekong River Basin (MRB) is in the midst of rapid changes that are a testament to the regional peace and stability, and increased sub-regionalism and economic integration (ADB, 2002a). The MRB is a home to over 70 million people that is projected to increase rapidly (MRC, 2006). In the region, series of large scale development projects are at different stages of planning and implementation for both tributaries and mainstreams of the MRB (ADB, 2002b, World Bank and ADB, 2006). Development pressures are great in the region and level of dependency of people on the river's water and related resources are very high particularly among the rural poor (ADB, 2002b, MRC, 2010a), that requires an integrated and scientifically informed water policy for each Basin country and the MRB.

All Mekong Countries have adopted the integrated water resources management (IWRM) and political aspiration for common prosperity. However they face greatest challenge in translating these IWRM and common prosperity principles into practice.

The study is to contribute to the following five over-arching attributes that must be addressed if the water resources of river basins are to be managed in a sustainable way as required by the IWRM principles:

- Good knowledge management – making "best" available knowledge accessible to the right persons at the right time;
- Basin-wide policies, procedures, and strategies to guide effective water and natural resource planning, management and administration;
- Institutions, Regulations, Governance and Management;
- Communication, consultation, and participation for all basin stakeholders and partners; and
- Performance indicators, monitoring and reporting.

1.1 EARLY STUDIES ON SCIENCE, POLICY AND PRACTICE INTERFACE

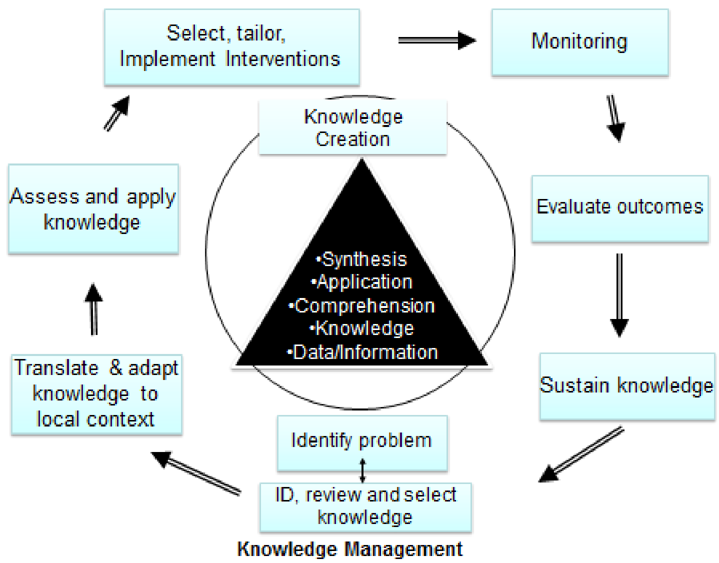
Many science and research initiatives emphasise the relevance of science to wealth creation, but the questions of how research can contribute to water policy and what incentives can be given to researchers, policy-makers and practitioners to encourage them to develop their activities in this way have not been considered well enough. The in-depth research commissioned by the European Union (EU) concluded that the use of knowledge for developing policy and practice at the national and EU levels would improve the quality and governance and produce substantial social and economic benefits (EU, 2007). The study also emphasized the need for creating appropriate enabling environment for fostering such interaction through introducing national and international initiatives, institutions policies to strengthen certain aspects of the knowledge management phases to ensure a holistic, coordinated approach across all these dimensions to evidence-based policy and practice (EU, 2007).

This study has observed a growing consensus on the importance of the engagement and openness in knowledge management for sustainable development. Some credible research works have been conducted elsewhere on transition from centred mode of knowledge development to more integrative and participatory knowledge management. In this *Mode 2*, knowledge is generated in a context of application and addresses problems identified through continual interaction among actors from a variety of settings (research, practice, policy and community) and disciplines (Gibbons M, *et al,* 1994).

In Europe, for example, over US $2 billion was spent annually on development-related research, but there was a widespread recognition that the research does not have impact as expected, since the results did not always inform and shape policies and programs, and were not adopted into practice (Young J, 2008). The UK Department for International Development (DFID) planned to double spending on development research from US $200 to $400 million per year, and to invest in generating new knowledge and working to ensure it is used in policy and practice (Young J, 2008).

Hanney R, *et al* (2003) underscored the growing attentions focusing on the interfaces and importance of research utilization in policy-making, and on understanding of the mechanisms and political and social settings especially in public health sector (Hanney R, *et al*, 2003). Recently similar attention has been paid to the utilization of research in the water and climate change management in the Mekong Region (Molle F, *et al* (edits), 2009, MRC, 2010b, Pech S, *et al*, 2010a).

Graham L. *et al* (2006) proposed the knowledge-to-action (KTA) process framework that could facilitate the use of research knowledge by several stakeholders, such as practitioners, policymakers, targeted community, and the public. The KTA framework also emphasizes the collaboration between the knowledge producers and knowledge users throughout the KTA process starting from problem identification stage to implementation, monitoring and sustaining knowledge as shown in **Figure 1.1**.



(Adapted from Graham L, *et al*, 2006)

Figure 1.1 Schematic drawing of knowledge-to-action process framework

There is a growing consensus on what constitutes good interface practice based on an extensive literature review of document from research institutes, academia, intermediary organizations, decision-making organizations and practitioners. At the Sunada CREST Tokyo Symposium on Science and Practice of Basin Scale Water Policy in Population Up-surging Asia on September 25-26, 2008, the study initiated a debate at the final session on the need for developing considerable resources and expertise in both the science, policy and practice camps for securing capacity and incentives to improve knowledge utilization in scientifically informed water policy. The debate most definitely gives a renewed sense of urgency of improving the science, policy and practice nexus or interface.

1.2 PROBLEM STATEMENTS

The rapid changes from exponential increase in economic development activities potentially pose serious threat to access to key ecosystem components in the MRB, affect migration patterns and possibly increase the chances of conflict. It requires that the development decision must be more knowledge-intensive and more participatory, since there are growing uncertainties and irreversible impacts associated with the development projects. More increasingly the Mekong political leaders proclaimed their adherence to their international commitments for exercising greater social and environmental accountability, and to sustainable development and equitable social and economic development (GMS Summit Declaration, 2005, MRC Summit, 2010). While sustainable development and equitable utilization as a general objective for policy-making is accepted, still there are a number of challenges when it comes to a practical application of that broad concept (MRC, 2010a).

The first challenge is the different viewpoints, needs, interests, information, and power of the different actors involved in the policy process. The researchers, policy makers, basin managers and communities at large really need to know enough for ascertaining or convincing each other enough with plausible and accepted evidence about these complex relationships to build a consensus for action. They consciously or sub-consciously have been searching for answers to fundamental sustainability and growth questions:

- How big are the effects of various economic development projects on the ecosystem and national interests of the riparian countries, and land use changes on stability of production eco-systems and livelihood at the local, national and regional level (multi-level cause and effect relationship)?
- What scientific evidence is available to answer these questions?
- Have all available sets of knowledge-base been accepted and used in the policy-making?

Moreover, in the context of sustainable development in the Mekong Region, there are a number of constraints facing policy making and implementation: lack of institutional capacity and access to information; lack of ecological, technological and administrative knowledge; lack of material or legal resources; weakness of institutions in relation to vested interests, etc. Decision concerning environmental and natural resources development and management are usually complex or even hyper-complex. Furthermore, there are various constraints in the policy environment itself, as in real life, effective and functional institutional and organizational framework for sustainable development requires the integration of political legitimacy, analytical competence and administrative capacity to translate policy objective into effective policy actions.

From the observation of this study, the main root-cause of the poor decision making quality is closely related to the lack of high amount and high quality of scientific information/knowledge for conducting informed analysis and decision makings, and the gap between those who generate knowledge, those who analyze and those who decide. However, the gap in the interface is considered by this study as the most critical one since it restricts the application of the available knowledge and tools and hence makes huge investment and efforts for knowledge management very ineffective.

1.3 RESEARCH HYPOTHESES AND OBJECTIVES

As shown in **Figure 1.2**, the interface is very complex and often requires dynamic flow and understanding of influencing factors typical for the natural and man-made environment. Numerous groups of actors – academia, researchers, policy makers, basin managers, and other interest groups - are involved in affecting the process/interface directly or indirectly.

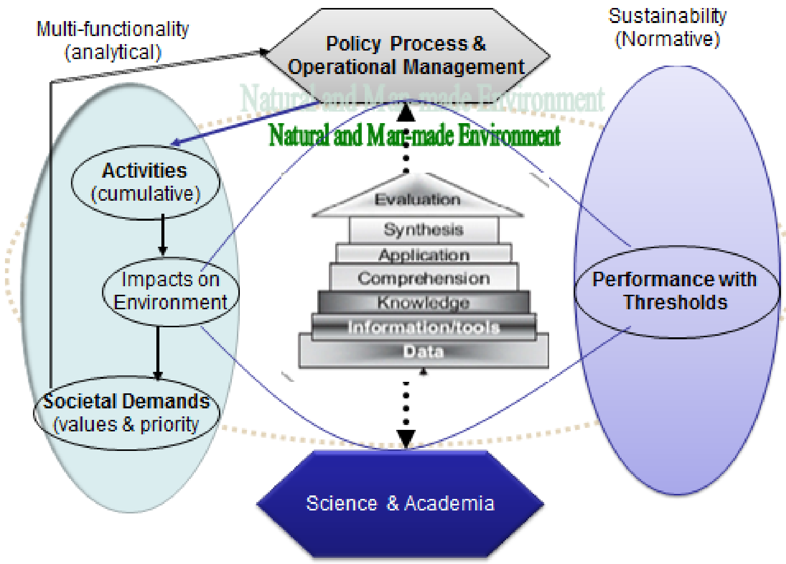


Figure 1.2 Complex Dynamism and Interface of Research, Policy and Practice

Figure 1.2 also depicts that the quality of interface dictates when, what and how knowledge is created, and if, how, when and what knowledge is used for analytical multi-functionality (assessing demands, determining values and priority, assessing impacts and linking them to environment and social implication), and for normative sustainability assessment and setting and monitoring threshold performance.

From this study's observation, the interface between knowledge production and application in decision making in the Mekong Region are very often following a non-linear and sometimes even illogical model. Countries, institutions, sectors and group of people view the interface and application of knowledge for informed decision making differently, depending on its social, political, economic position and their economic, political, social and cultural objectives. For example, the Laos Government deems that it has every right to consider large-scale hydropower development, forestry and mining operations as the engine of growth while the government of Myanmar given its current policy situation, considers integrative and participatory form of knowledge management for the river basin management as a low priority. Hence, diversity defines the ranges of perspectives in Mekong Region's natural resource management.

In spite of this diversity and priority issue, it has been recognized by many researchers, policy-makers and practitioners in the region that there is an urgent need for ensuring timely and better decision so that development can proceed smoothly and benefit and impacts are properly distributed and mitigated. Hence it is argued by this study that there is an urgent need to explore, understand, and communicate the components of successful knowledge management for sustainable water development. Science-policy-practice interface performance is considered to play a key role in improve knowledge uptakes and informed decision quality since it helps improve the effectiveness of the investment and effort for knowledge production and application. It is always a desire of the governments and funding organizations to make sure that their investment in improving informed decision and sustainable development has a stronger sustainable impact.

The author of this dissertation argues that a systematic approach to the assessment of the interface, built around an appropriately standardized or custom-designed index, will provide a valuable catalyst for finding answers and solutions to the emerging knowledge management transitions in the Mekong Region. Hence the overall research objective of this study is to develop and trial the tools for measuring the effective interface between science-policy and practice for sustainable water resources management in the Mekong Region. The following are the study's key hypothesis and objectives:

1. Goals and objectives (what to achieve) and measurable indicators for measuring potentials for improving interface can be developed based on the systematic understanding of the typology of the Basin's social, natural and geopolitical landscapes. This can be done through empirical evaluation and modeling of the situation and developing problem statements of relevance to the prevalent practices of knowledge management in the MRB;
2. The principles and mechanism for improving interface and resulted enhanced scientifically informed decisions can be then identified. The assessment and triangulation of the findings are conducted, and analytical results from the major functional category of research and organizations' performance and best practices are used as a logical basis for developing the assessment tools, indicators and criteria for measuring the sustainability and quality of the interface; and
3. A broadly trialed assessment tool to measure important dimensions of the science-policy-practice and guide its performance through validating and redefining the Best Knowledge Management Index (BKMI) is conducted.

1.4 SCOPE OF STUDY AND RESEARCH DESIGN

1.4.1 Multiple Approach and Multiple Scientific Disciplines

The dissertation applies both qualitative and quantitative research in validation and qualitative (inquiry) studies. A number of case-studies are conducted, and the techniques of data collection are adjusted to a relevant scale analysis, enabling the author of this dissertation to get to know the social and natural environment. In data collection, this study is not limited to one source or one technique only. Apart from the data acquired by interviews, and field observation, usually also different documentary sources and critical analysis using robust tools for publication mining are used.

The dissertation argues for a combination of multiple methodological practices, empirical materials, perspectives, and observers' insight and experience. This study also applies scientific discipline triangulation involving both **multi-disciplinary approach** by drawing from relevant academic disciplines or school of thoughts, and interdisciplinary studies to redefine problems outside of normal disciplinary boundaries to discover a new understanding of complex situations.

The dissertation also combines multiple triangulation forms, i.e. the triangulation of investigators and informants, theories data sources, methods and/or disciplines, to provide for the exhaustive data interpretation, for validating the scientific findings and a more thorough understanding of each researched phenomenon – interface of science-policy-practice. Triangulation of methods involves employing more than one method to gather data, such as interviews, observations, questionnaires, and documents to best understand and add rigor, breadth, complexity, richness, and depth to any inquiry. The end purpose is to generate and strengthen confidence with a result if different methods lead to the same result. Such approach is best in adding rigor, breadth, complexity, richness, and depth to any inquiry. Data sources triangulation involves cross-checking data from multiple sources to search for regularities and it involves also time, space, scale and persons.

By using pluralism of approach and methodologies to get at the answer to one question, the author of this dissertation finds that at majority of these, if not all, produce similar answers, or if clashing answers are produced, the author can discover that the question needs to be reframed, methods reconsidered, or both.

By combining multiple theories and methods for empirical observation and analysis, the study manages to overcome the weakness or intrinsic biases and the problems that come from single method, single-observer and single-theory studies. This design hypothesis applied in this study is supported and evidenced by numerous high profile peer reviewed publications with a view to double (or triple) checking results or "cross examination".

1.4.2 Scope and Flow of Research

The present study argues that proficient connection or interface between science, policy-making and water resources management practice lies on the ability to identify and connect appropriate nods and procedures for positive interaction (Dahm K, *et al*, 2009). For measuring the success of science-policy and practice requires both divergent and convergent thinking. The divergent and convergent steps are widely considered as two broad modes of thinking and analysis in the innovation process (Dym K, et al., 2009). Convergent thinking model is the process of asking and answering questions that reveal verifiable facts. When practicing divergent thinking, the study attempts to diverge from facts to the possibilities that can be created from them.

The investigation starts with step to establish and document facts. The facts learned in this step give rise to new ideas. Then an open-ended, exploratory and inquisitive mode of deploying non-traditional creative thinking and future visioning techniques is used. It includes ‘exploratory’ interface’s actors – researchers, decision makers and practitioners - insight research, qualitative exploration of knowledge management trends and discovering possible research-policy-practice interface qualities (Patcher R, 2009).

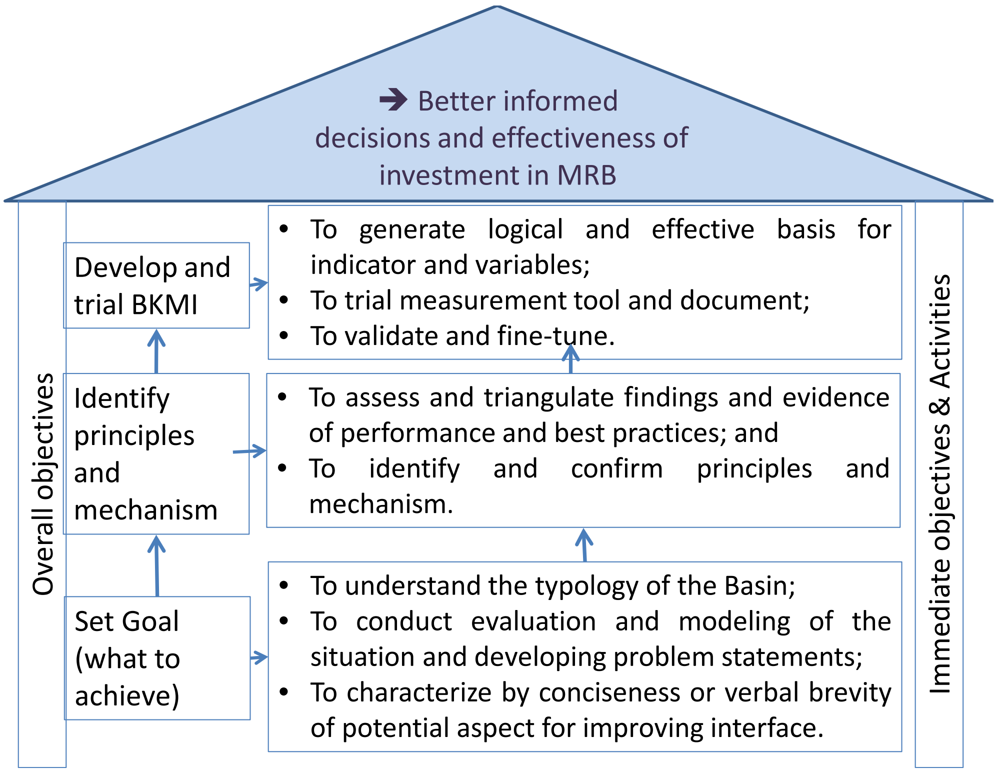


Figure 1.3 Schematic Analytical Framework

The step-wise approach starts from:

Step 1: **Setting goal and typology literature review** involves both an analysis of the ***situation*** in which the issue occurs, and identification of the ***problem.*** It provides an important foundation for problem and root-cause identification, demand-supply nod assessment, and risk characterization. The examination of the baseline conditions in which the issue occurs can provide insight into where challenges, and where opportunities exist – what do we have? What do we lack? And "what is inadequate? The baseline review is then followed by need assessment and problem identification. The problem identification and statement is to provide an appreciation of the magnitude of the problem (OECD, 2002, Pech S, *et al*, 2010b). The research questions for this step 1 include:

Where challenges and where opportunities may exist?

What are strengths and weaknesses, and opportunities and threats of the existing pattern of knowledge management (generation, transmission and use) in the Mekong Region?

Why a certain problem and gaps are occurring? And;

What is the broader environmental and socio-economic context supporting or discouraging an interface between research/science and water resources policy and practice?

Step 2: Based on the typology results (converging views on characteristics of existing interface through problem statement formulation) in step 1, divergent analysis in step 2 is performed to identify and propose principles and mechanism for improving interface and resulted enhanced scientifically informed decisions through using non-traditional creative thinking and future visioning techniques.

Relevant knowledge available in both formal and informal literature is critically reviewed for diagnosing the state of knowledge and its application. Then the study addressed more specific research questions to answer in the Situation Statement which include:

- What level of understanding exists in government and research/scientific groups about the critical drivers of the Mekong Region's water resources development?
- Which key stakeholders are involved in generating and using knowledge for supporting informed policy decision?
- What research topics have been undertaken by the identified researchers or research groups?
- What level of understanding exists in government and research/scientific groups about the science-policy-practice interface? and
- What related mechanism and tools exist for furthering that interface?

Within its general theme, the present study also searches for answers to the following questions relevant to the knowledge management within multi-level governance of natural resources in the Mekong Region such as which impact does quality of engagement, information flows and formats influence level of knowledge management? What roles do the policy instruments and participatory processes play in the interface performance? And which problems are encountered when implementing science-policy-practice interfaces in governance practice?

Further documentary and semi-structured analysis discovers issues such as what are the main pushing and pulling factors for successful knowledge management, and how when, what and why policy-makers drew on research findings in various stages of the policy process. The assessment is also focussing on the research and science groups for their efforts for developing mechanisms to enhance research utilisation. The list of critical questions requiring answers are:

a. Thematic or process 'focus' questions: what practices in what processes could or should be the target; how should actors in this interface best balance their responses to present day and futures challenges for better scientifically informed water/river basin management?

b. Implementation or strategy questions: how could change processes towards better science and policy interfaces be effectively supported by integrated water resources management (IWRM); how can they work together more effectively to respond to these challenges—and keep driving forward the necessary changes? and,

c. Organizational questions: depending on the decisions on focus and approach, what are the best working models of and instruments for measuring its success to create knowledge supply and demand patterns, and achieve basin sustainability?

<u>Step 3</u>: Validation and redefinition of Best Knowledge Management Index (BKMI): Creative exploration of possibilities for addressing identified issues through assessing variable facts obtained from Steps 1 and 2 is carried out. On the basis of these lessons and review of projects and other documents on the state and direction of science and policy interface in MRB, the study presents some ideas on possible knowledge generation, management and sharing monitoring strategies. Optimization process through trial and error is carried to fine tune and or adapt the proposed tools and options to produce a better outcomes (efficiency and effectiveness in meeting the agreed vision, and objectives). Convergent selection of the best possible solutions rooted in sound facts, is to be followed by divergent inquiry questioning assumption made to reveal if the "best" solution is still not sufficient to meet the interface improvement's goals.

In this step 3, the end product of this study - the assessment tools, indicators and criteria developed for measuring the sustainability and quality of the interface is finalized in a form of an assessment tool to measure important dimensions of the science-policy-practice and guide its performance.

This overall framework is developed and tested in an initial phase of study in the MRB countries through presentation and debate at the stakeholder meetings and international scientific conference, and the publication of related articles in a number of scientific journals and peer-review academic reports. The methodology proposed for assessing the interface consists of a two-part process:

- A **"macro"** assessment examining the overall interface from both producers and users perspectives, and the overall enabling environment in the Mekong Region and countries; and
- A **"micro"** analysis identifying the most effective specific aspects (indicators). Central to the micro assessment will result in confirmed index measuring the extent to which the overall or selected knowledge management activities/program meet necessary aspect and attributes considered to be successful.

1.5 CONTRIBUTION AND ORIGINALITY OF THE STUDY

There have been a number of theoretical approaches on measuring knowledge management, however, numerous groups of actors – academia, researchers, decision makers and practitioners/basin managers, and other interest groups find it difficult to design and collaboratively apply a systematic tool for evaluation their interface performance. Interface performance is found by this study to be a key to improvement in scientifically informed decision-making.

First of all, this study confidently argues that informed decision-making for sustainable river basin management and improved river basin governance can be enhanced with the improvement in the science-policy-practice interface. The study's originality is its development and trialing of a systematic tool for measuring and encouraging this complex interface building on dynamic flow and understanding of multi-faceted influencing factors typical for the natural and man-made environment. It is argued that such interface is influenced by not only the state of knowledge production (science and research), management (knowledge managers and brokers) and application (users –

decision-makers, practitioners, and researchers), but also by social/cultural, institutional and organizational environment in which the knowledge management and decision-making operate. The strategic emphasis of this study is on fostering academic, social, cultural and political factors of knowledge sharing and collaborative learning by the actors within the knowledge production, management and application continuum model (Figure 4.1 Knowledge Continuum Interface Model).

Secondly, it is for the first time, the study documents beyond any doubt that the key challenge to the informed decision making for sustainable development of the MRB is primarily from both limited availability of and accessibility to "credible" and usable knowledge and tools, and prevailing social, institutional and organizational factors affecting the interface. However, the access to available information is a key constraint.

There are a number of approaches to defining the effectiveness of linkage between scientific and technical knowledge production and its utilization in the policy-decision. The most for evaluating performance is the logical framework. However, to apply the commonly used conceptual framework of logical frameworks often presented difficulties in capturing 'network' aspects of interface or triadic inter-relationship among science/research, policy and practice. Alternative frameworks such as mapping of interface pathways were found to be more useful in monitoring the relationship between interface players, and mapping possible communication and interaction pathway, and relevant enabling environment (Perkins N, 2006). It is hypothesized by this study that the actual steps involved in utilization and achieving final outcomes are often multidirectional and convoluted. Hence, developing a conceptual assessment framework of the science-policy-practice interface for promoting knowledge application should place great emphasis on the importance of interaction and enabling environment conducive towards that interaction between researchers, policymakers and practitioners and application of knowledge. The key stakeholders in the MRB will benefit significantly from having a systematic performance evaluation and appraisal system contributed by this study's tool (BKMPI), since the monitoring and evaluation results can help detect areas for changes and improvements (MRC, 2010a).

Thirdly, the present study presents a first real systematic study for developing and trying the tools to bridge science, policy and practice interface for sustainable development of the river basin's water and related resources in the Mekong Region, and potentially globally. A range of strategies and approaches are explored, tested and redesigned to advance understanding of effective "Best Knowledge Management Practices" index (BKMPI). BKMPI is both main contribution and the originality of this study. The framework is built upon an understanding of both "push factor" and "pull factor" from both the knowledge producers, managers and users perspectives. The BKMPI's main goal is to provide pragmatic perspectives for assessment and improvement of management performance in addition to specific program level monitoring and evaluation framework. It is to make explicit the technical-scientific and social conditions necessary for enhancing performance and accountability through regular assessments using performance indicators and benchmarking for moving up the spiral to better integrated water resources management, and providing pragmatic perspectives for assessment and improvement of knowledge management performance.

Such an interface assessment model should also be able to meet the growing demands for accountability which could also be of benefit to the research community, decision-makers, practitioners and funding agencies. It should serve as one of the principle ways that the public and interested parties - donors, funding agencies, research groups, policy makers, civil society organizations etc., to determine whether their knowledge management efforts are providing a quality product or service and meet their objectives of improving informed decision-making. They should either jointly or individually be able to use that system for forming decision on appropriate actions for gearing toward enhancing interface performance and accountability.

The application of the BKMPI framework can be done using various entry points/lenses that can be used as guidepost for measuring the current sectoral, national and regional knowledge management programming and planning, and influencing their future directions of, helping them make strategic choices about where to concentrate its limited resources and how to leverage its comparative advantages to achieve the most positive and lasting change. The guiding principle of this BKMPI is to contribute to maximization and sustainability of the knowledge generated and applied in the informed decision for sustainable water resources development and management that will provide national, regional, and local benefits, and has the potential to play an important role in enabling countries to meet sustainable development objectives.

The innovative aspect of this study is the development and error/trialing of the tools for monitoring the interface level that potentially improve the application of knowledge for informed decision-making through **applying both scientific approaches and principles and social and multi-stakeholder participatory analytical and validation process and tools**. The BKMPI provides an interrogative and collaborative framework for measuring inter-related factors affecting performance in knowledge management.

1.6 OVERVIEW OF THE DESSERTATION

Logically, the present dissertation is divided into the following five Chapters and several sections and sub-sections. **Chapter 1** provides an overview on the problems statement, objectives and justification for this study. **Chapter 1** also describes the research frameworks and methodologies as well as the previous studies and the contribution and innovation of the present study.

Chapter 2 provides a literature review – typology of knowledge management in the Mekong Region by exploring strength, weakness, opportunity and threat of the existing body of knowledge and state of the interface.

Chapter 3 analyzes and summarises the challenge and perspectives for knowledge management from science-policy-practice interface's key actors such as the regional organizations and scientific research groups in Japan and Mekong countries, as well as interviews with decision-makers and practitioners to allow further development of relevant dimensions, performance indicators for the interface. In this Chapter, the study presents preliminary triangulation results on key interface efficiency and effectiveness questions derived from a critical empirical review and analysis of the knowledge management. **Chapter 4** describes the development of the Best Knowledge Management Practice Index (BKMPI) and provides the results of optimization of BKMPI following the trialing sessions conducted by this study with the involvement from invited water and policy specialists in the Mekong countries. **Chapter 5** provides for a conclusion, recommendations, and future research needs.

CHAPTER 2 LITERATURE REVIEW

The key findings from Chapter 1 confirms that in spite of this diversity and priority issue by countries and institutions, it has been recognized by many researchers, policy-makers and practitioners in the region that there is an urgent need for ensuring timely and better decision so that development can proceed smoothly and benefit and impacts are properly distributed and mitigated.

It also confirms that the main root-cause of the poor decision making quality is closely related to the lack of high amount and high quality of scientific information/knowledge for conducting informed analysis and decision makings, and the gap between those who generate knowledge, those who analyze and those who decide. However, the gap in the interface is considered by this study as the most critical one since it restricts the application of the available knowledge and tools and hence makes huge investment and efforts for knowledge management very ineffective. Therefore there is an urgent need to explore, understand, and communicate the components of successful knowledge management for sustainable water development. Hence this study sets as its overall research objective to develop and trial the tools for measuring the effective interface between science-policy and practice for sustainable water resources management in the Mekong Region.

Chapter 2 presents the results of the literature review – typology of the state of knowledge in the Mekong Region by exploring strength, weakness, opportunity and threat of the existing body of knowledge and influencing factors.

2.0 REVIEW METHODOLOGY AND PROCESS

The literature review in **Chapter 1** and subsequent analysis in **Chapters 3- 4** are for extracting critical and variable facts and information on the state of knowledge in key critical areas such as the population growth and environmental pressure, correlation between improved knowledge application and good water governance and triangulating candidate criteria for realistically measuring the quality of interface and knowledge management in the Mekong Region. The findings and analytical results based on the literature review were then presented in the peer reviewed articles and scientific peer-reviewed book chapters, as well as consultancy reports and presentations in academic and programme meetings and workshops with relevant stakeholders – water and river basin decision-makers, researchers and practitioners.

As depicted in **Figure 2.1**, the proposed phased but integrated scoping and assessment approach is designed to provide a credible study and indicative plan development process that is based on systematic data collection and consultation, extensive collaborative planning and knowledge transfer activities, validation meeting and workshop with relevant government agencies, academic groups and civil society organizations.

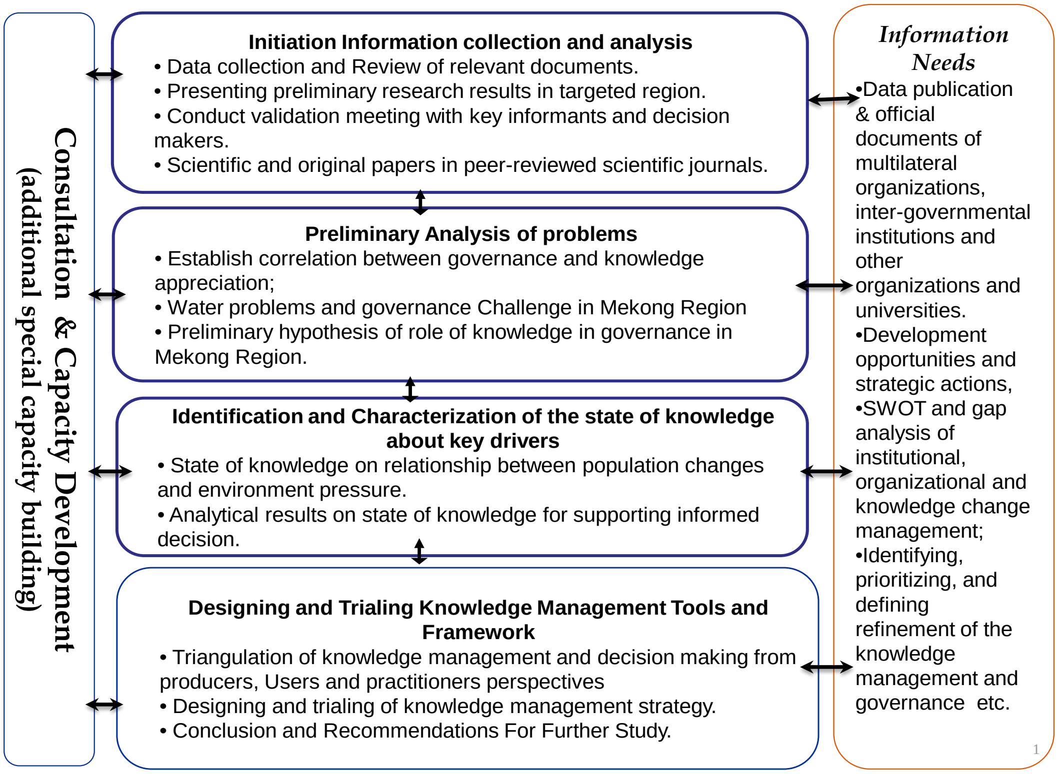


Figure 2.1 Conceptualized Approach to Scoping and Assessment

As shown in **Figure 2.1**, all tasks listed were implemented in inter-related phases. Information requirements and proposed timelines of key activities and segments are shown on the right side of the figure. This phased and integrated approach is designed to provide: (i) a well-planned and organized literature review, presentation and validation of initial findings; and, (ii) credible studies based on careful information gathering and rigorous analysis.

The process of preparing this dissertation went on from April 2004 to June 2011. The data collection and analysis process has involved:

- Several travels through the region for data collection and presentation of preliminary research results;
- A range of informal consultations with researchers, government officials, and international organizations for improving the results;
- Participation and presentation of key papers at the international scientific conferences and dialogues; and
- Submission and publication of scientific and original papers in the peer-reviewed scientific journals.

The information and data have been obtained through the application of methodological triangulation, essentially through:

- In-depth interviews and dialogue with key institutional actors – decision-makers, practitioners and academia. Documentary analysis and in-depth interviews are used techniques and are often combined; and
- Data analysis and intensive observation of research and policy interfaces in Mekong Region and other parts of the world through both action research activities, and consultancy services to various regional and national organizations and funding institutions in the Mekong Region.

Its starting point is to observe the interplay of science/research communities, governmental or administrative actors, corporate actors and actors from civil society at large. In this framework, the exhaustive analysis of definitions and practices of institutional roles become essential for characterizing in depth science and policy interfacing processes in a specific spatial and temporal environment.

Data and information were gathered from various key sources - observed data and key statistics, indicators and indices, collated and developed through intensive data collection, surveys and questionnaires carried out by those multilateral organizations, such as World Bank, World Health Organizations, UNICEF, Asian Development Bank (ADB), UNESCO, and Mekong River Commission (MRC). The selected Mekong related research consortiums both in Japan and Mekong Region, and three inter-governmental institutions or initiatives such as Mekong River Commission, Greater Mekong Sub-region (GMS), and the Upper Mekong Navigation Agreement were scrutinized closely. Other useful data sets are also obtained from other organizations, such as World Resources Institute Earth Trend Information Portal, and the US Bureau of the Census International Data base, and National Institutes in Mekong countries.

The study conducted several evidence sessions to validate the results in conjunction with the over-arching inquiry at the following fora:

1. The 1st Mekong Forum on "Future Opportunities for Knowledge Generation and Utilization in Mekong River Basin Integrated Management", Vientiane, Lao PDR, 27 October 2004 – the author was the chairperson of the forum to lead the discussion on knowledge generation and utilization in the Mekong River Basin (MRB);
2. The 2nd Mekong Stakeholder Forum "Mekong Research for Mekong People" – searching for linear relationship between Research, Policy and Management, Chiang Rai, Thailand, 19 October 2006. The author was a co-chairperson of the forum to present the research results and lead the discussion on knowledge generation and utilization for people in the MRB;
3. The Modern Mekong Myth Workshop conducted by National University of Laos (NUoL), Vientiane, and Water Resources Laboratory, Helsinki University of Technology (TKK) on February 3-4, 2006;
4. The Stakeholders Consultation conducted at the Mekong Region Water Dialogue which took place in Vientiane on July 6 – 7, 2006. The author was a presenter in a parallel sessions on fisheries, knowledge and policy issues to lead the discussion on root-causes of limited application of social and fisheries knowledge in policy-making in the MRB;

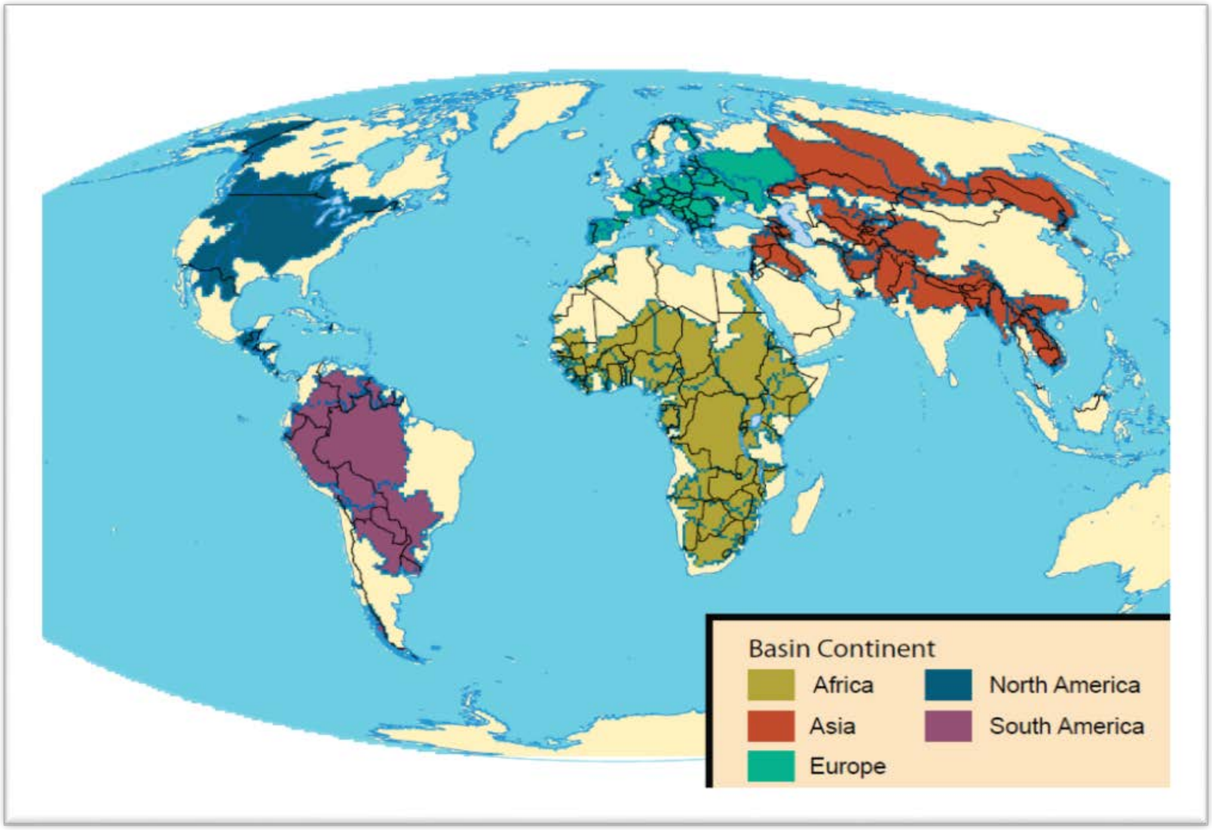
5. The Symposium on Science and Practice of Basin-Scale Water Policy organized by Sunada Crest/JST in Tokyo from 25-26 September 2008. The author was one of three lead discussants at the closing session to discuss the challenge and perspectives for science-policy-practice interface;
6. The Workshop on "Transboundary Governance for South East Asian Environment", University of Tokyo, March 8, 2009. The author was one of lead discussants on the issues of knowledge management and water governance in the MRB from Cambodia's Perspectives;
7. The Technical Seminar and Consultation on "Hydropower Sustainability Assessment Protocol", Mekong Program of Water, Environment and Resilience (M-POWER), Phnom Penh February 11 and 12, 2010. The author was a facilitator of the trialing of the sustainability assessment tools and designing of the index for measuring the sustainability and interface performance;
8. The Consultation on "Rapid Assessment of Mekong Water and Energy Planning (Case of Cambodia), Mekong Program of Water, Environment and Resilience (M-POWER), Phnom Penh April 8, 2010. The author was a team leader of independent assessors conducting a rapid assessment and trialing of the sustainability assessment tools and interface performance assessment tools; and
9. The Regional Informal Stakeholder Consultation organized by M-POWER and Challenge Program on Water and Food (CPWF) in Vientiane on May 2, 2010 on the eve of the Hydropower Sustainability Assessment Forum (HSAF) meeting. The author presented the results of the rapid assessment and trialing to representatives from key government and non-government organizations and developers from Cambodia, China, Lao PDR, Thailand and Viet Nam.

The original research papers, scientific papers, and peer reviewed reports were submitted to and published in the peer-reviewed journal and academic book series, and discussed at the multi-stakeholder and focused group meetings.

2.1 TRANSBOUNDARY RIVER BASINS

There are over 260 international river basins sharing between two or more Nations. They cover nearly half of the earth's surface, provide an estimated 60 percent of global freshwater surface flows and are home to some 40 percent of the world's population (Sadoff C, *et al*, 2008). With population growth and growing economic development activities, these shared resources are increasingly drawn upon to meet the competing needs of billions of people for drinking water, food, energy, and industrial production – leaving less water, often of much lesser quality, for other in-stream use and ecosystems (Pech S, 2008).

Transboundary water resources as source of potential tensions among competing users are found at all scales (Sadoff C, *et al*, 2008). The sub-national entities such as states, regions, provinces, and municipalities need to share and cooperatively manage the waters that flow between them. However, different users generally find it challenging to share water in a manner that is considered by all to be fair and reasonable. In the Mekong Region, from the international to the local level, such tensions and opportunities arise wherever users share a holistic water resource whose quality and quantity affects, and is affected by, all of its users.



(Source: Sadoff C, *et al*, 2008).

Figure 2.2 Map of Transboundary River and Lake Basins in the World

There are opportunities and mechanisms - commonly known as "river basin management" and means for achieving it "water governance" for benefit sharing that can be adapted to each social, political, economic, and environmental context. As shown in **Table 2.1**, knowledge is required for supporting all key steps and aspects of the cooperation, collaboration, and benefit sharing processes. They can be structured through knowledge sharing, project design, revenue allocation, and institutional and policy development.

Table 2.1 Examples of Mechanisms for Benefit Sharing

Knowledge sharing

- **Data and information sharing** among river basin countries/communities and sharing costs; and
- **Cooperative assessments** on the hydrological opportunities and dynamics of the basin, jointly generating knowledge, and enhancing trust and building human capacity.

Project design

- **Core project design and location** largely determines the physical benefits and the populations affected – both positively and negatively;
- **Ancillary investments -- a broadened bundle of benefits -** compensating or supplementary investments that (re)distribute costs and benefits more equitably.

Revenue allocations & financial arrangements

Allocating revenue streams – e.g. royalties, rents, carbon credits:

- **Providing direct payment for water use –** e.g., municipal or irrigation supplies (where rights are already assigned);
- **Providing direct payment for benefits** – e.g., fisheries, watershed management services, beneficial changes in river flow regimes;
- **Providing compensation for costs** – e.g., inundated land, pollution, loss of ecosystem services, harmful changes in river flow regimes;
- **Undertaking purchase agreements** – e.g., for power, agriculture products (where terms of the agreement can be used to transfer benefits); and
- **Financing & ownership arrangements** – e.g., joint infrastructure ownership and management.

Institutional and policy development:

- **Operating procedures –** e.g., dam operations to sustain flood recession agriculture or the productivity of fisheries;
- **Policy alignment and enabling environment** – institutions and incentives to ensure benefits, e.g., legal, regulatory, land tenure, taxes and pricing, consumer protection; and
- **Public-private partnerships** – e.g., potential to leverage funds, expertise, integration.

(Source: Sadoff C, *et al*, 2008)

2.1.1 Knowledge Appreciation and Good Water Governance Co-relation

Based on a comprehensive analysis, it is generally accepted that if the water resources of river basins are to be managed in a sustainable way, its governance has to be supported by increasing integrated water resources management (IWRM) functionality and performance across the basin (World Bank, 2006). It is important to vision the future of the Mekong Region and countries, from a perspective or understanding of "governance" dynamics. Scholars, policymakers, aid donors, and aid recipients acknowledge the importance of good governance for sustained economic development (World Bank, 2006, Pech S, 2011). The changes in the governance quality will certainly change in the way the decision on major water infrastructures are made, monitored based on credible and accessible knowledge and how sustainable development and pro-poor development are actually achieved.

As transboundary water resources governance is based on cooperative agreement, understanding by and capacity of all member countries, it is not possible to achieve effective basin-wide IWRM unless all member countries and stakeholders achieve a reasonable level of IWRM capability, and are supported by the appropriate action and support programs. The role of knowledge in designing and implementation of activities and process for achieving benefit sharing –hence good water governance and management is beyond doubt. This section provides a broad overview of how the knowledge components of the integrated trans-boundary water management are brought together to contribute to effective transboundary environmental governance.

Part one of this Section lays the foundation for this work by providing an overview of the knowledge appreciation for the overall good governance for the transboundary water resources governance. Part two basing on an extensive empirical analysis of the actual transboundary river basins around the world, provides a detailed overview of key attributes and goals of IWRM capabilities in supporting the effective and efficient implementation of the transboundary basin management. It illustrates with case studies showing progression from identification of co-relation between knowledge appreciation and good water governance in selected international river/lake basins around the world.

2.1.2 Knowledge as Catalysis for IWRM Based International Cooperation

River Basin States have to invest considerable efforts to negotiate, conclude and implement agreements related to the management of their transboundary waters. It requires more than just real political commitment, sufficient technical and financial support, but also the availability of credible data, information and knowledge and, the right attitude and commitment to apply them for making informed decision.

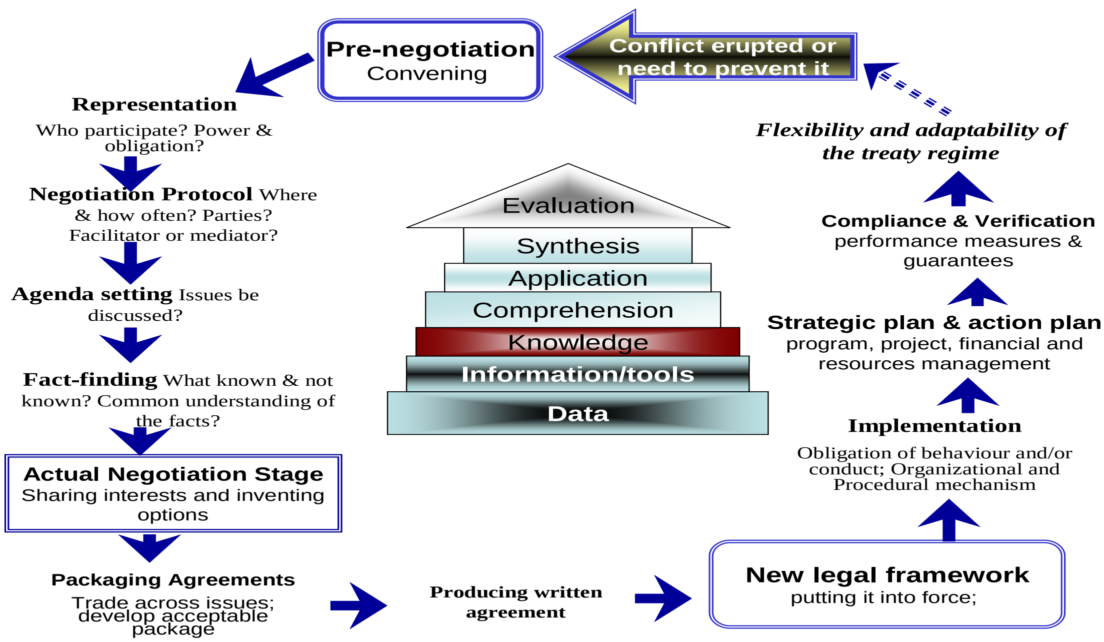


Figure 2.3 Cycle of Transboundary Governance Process

As shown in Figure 2.3, in all phases of transboundary water resources management (initiation, negotiation, implementation and monitoring) knowledge (scientific and other form) has a crucial role to play in addressing factual certainty and supporting scientifically informed decision-making. As knowledge and information are valuable, and costly, cooperative activities must cover sharing and applying knowledge and information, or jointly generating system-wide knowledge and decision support tools to allow best possible use of the knowledge. For instance hydrological information can help river basin countries and communities better manage water resources within their territories, it can help them better understand the impact of their actions on one another, and it can also help to identify cooperative opportunities for enhanced basin-wide management (Sadoff C, *et al*, 2008). Moreover, as water management models become more sophisticated, data are increasingly vital. Information itself can be used as a form of negotiating capital and data-sharing can lead to breakthroughs in negotiations. For example, an engineering study allowed circumvention of an impasse in the negotiations through clarifying the actual water demand and supply (water balance) allowing for more room in the bargaining mix.

The lack of agreed criteria for data in negotiations on the Ganges has hampered progress over the years (Sadoff C, *et al*, 2008). Perhaps the best example of this is the Mekong Committee's first five-year plan, which consisted almost entirely of data-gathering projects, effectively precluding future data disputes and providing an opportunity for the Lower Mekong Countries to develop cooperation and trust (Mekong Committee Secretariat, 1987). Another converse example was the Israeli-Arab Working Group on Water Resources. It was unsuccessful in developing a single water data bank, given the strong suspicions between countries and the political sensitivity of the data.

An extensive empirical analysis of the actual transboundary river basins around the world, through case studies show progression and co-relation between knowledge appreciation and good water governance in selected international river/lake basins around the world.

Integrated Water Resources Management (IWRM) emerged around the 1980s in response to increasing pressures on water resources, the recognition of ecosystem requirements, pollution and the risk of declining water availability due to climate change (UNESCO, 2008). IWRM is defined by the Global Water Partnership (GWP) as 'a process which promotes the coordinated development and the management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems' (UNESCO, 2008). The integrated water resources management (IWRM) is a step-by-step process of managing water resources in a harmonious and environmentally sustainable way by gradually uniting stakeholders and involving them in planning and decision-making processes, while accounting for evolving social demands due to such changes as population growth, rising demand for environmental conservation, improvement in technology and knowledge, changes in perspectives of the cultural and economic value of water, and climate change. It is an open-ended process that evolves in a spiral manner over time as one moves towards more coordinated water resources management (UNESCO, 2008)

IWRM at the river basin level seeks improvements in existing and conventional approaches to water resources management that should lead towards the ultimate goal of sustainable development, and efficiency and equity of basin-wide water resources management. To achieve this requires states to coordinate and implement the planning, development, management and conservation of their shared water related resources in a participatory and integrated way, consistent with relevant international conventions and national laws, policies, objectives and goals. What can be seen from this definition is that transboundary governance across a large basin is enormously complex. Words such as 'coordinate', 'facilitate', 'implement', 'water related', 'participatory', 'integrated' and 'consistent with' are all open to interpretation. There is no universal guidance for their interpretation. When it comes to creating a functional framework for effective water resources management at the basin scale, it is therefore essential to build trust and create a shared vision of states' goals (Lusthau C, *et al*, 2002).

From basin to basin there will be different scopes and scales for operationalizing transboundary basin management. But there are several key elements that must be addressed in order to sustainably manage the water resources in any river basin. The first overarching attribute is governance – the political, social, economic and administrative systems that develop and manage water resources and deliver water services. Governance arrangements are most clearly manifest through institutional arrangements such as well-defined treaties, organizations, management procedures and regulations – but, importantly, governance also relates to effective implementation of these arrangements.

One good example of transboundary governance is the development of mutually beneficial cooperation on more than 150 rivers and lakes along the 8,900 kilometer border between Canada and the United States (Chayes A, *et al*, 1995). The 1909 Boundary Waters Treaty is a framework agreement that sets out the basic principles and procedures governing the use of all boundary waters shared between two countries, especially with respect to water quality and quantity, navigation, and dispute settlement.

The International Joint Commission (IJC) set up within the framework of the Boundary Waters Treaty has proven highly adaptable. Through many decades of successful operation, it has effectively expanded its mandate from monitoring water levels along the boundary, to managing the implementation of complex water-sharing and water-quality arrangements, and boundary water resources development and management (Chayes A, *et al,* 1995).

A similarly longstanding legal regime has evolved with respect to the International Commission for the Protection of the Rhine (ICPR), which has experienced a growth in the scope of its traditional water quality management/pollution control mandate towards broader 'ecological protection' and flood defense mandate (Vinogradov S, *et al*, 2003). These are also numerous examples of river basin commissions that are endowed with ambitious basin wide governance mandates, but are facing serious challenges in implementation and genuine multi-state political commitment and availability of knowledge and tools for effective and informed decision.

Case 1 The Tigris-Euphrates Joint Technical Committee – deadlocked

The Tigris-Euphrates river valley is often referred to as the cradle of civilization. The two rivers, shared by Iran, Iraq, Syria and Turkey, flow most of their journey to the sea in two separate streams but are generally regarded as one system. This apparently simple distinction has proved an impediment to transboundary cooperation in the basin.

There is no basin-wide agreement on the Tigris-Euphrates, although the idea of a Joint Technical Committee (JTC) was discussed by Iraq, Syria and Turkey as early as 1965. A Protocol between Turkey and Iraq set up a JTC on Regional Waters in 1980; Syria joined in 1983. The JTC was a committee of experts with a mandate to determine methods and definitions of reasonable water use for each country. After sixteen meetings they were not able to reach consensus on basic principles and definitions, and the work of the JTC essentially deadlocked in 1992.

One of the key reasons for the impasse was the inability of the three countries to reach an agreement as to whether the Euphrates and Tigris rivers should be considered one system, in which case the water to be allocated would be that of the entire basin, or whether discussions could be limited to the Euphrates River alone.

Some consider tri-lateral cooperation under this Committee a failure, blaming the countries' differing views regarding the basic function of the JTC. Turkey, a hydrologic and economic hegemon in the system, considered the JTC a consultative body, whereas Syria and Iraq hoped it would develop a water *sharing agreement. Others argue that the JTC was a successful forum, which despite its irregular meetings provided at least for some level of consultation and cooperation among the riparian countries.*

In the absence of a basin wide agreement, a number of bilateral accords have emerged. For example, in 1990 Syria and Iraq entered into a bilateral agreement according to which the two countries share the waters received from Turkey on a 58% (Iraq) and 42% (Syria) basis. Those who follow the history and politics of cooperation in the basin are skeptical, however, as to whether these occasional agreements have been honoured (Source: Pech S, 2008).

A robust and trusted knowledge base is a key to implementing cooperative transboundary water management. Knowledge should inform riparian perceptions of the costs and benefits of cooperation, and is therefore a crucial element in motivating transboundary management. A shared understanding of the river system among key stakeholders as well as river basin planners is crucial for diminishing information asymmetries that engender mistrust, and for generating evidence-based options for cooperative management. Usable knowledge comes in many forms, from specialized data in the western scientific tradition to the informal knowledge of indigenous peoples.

Chapter 40 of Agenda 21 underlines the importance of information and knowledge for sustainable development: "In sustainable development, everyone is a user and provider of information considered in the broad sense. That includes data, information, appropriately packaged experience, and knowledge. The need for information arises at all levels, from that of senior decision makers at the national and international levels, to the grass-roots and individual levels (UNCED, 2002).

Table 2.2 Knowledge related IWRM Capabilities Attribute and its Goals/outputs

Key IWRM Attributes	Goals/Objectives

Good Basin related data, information, systems and models, and on-going skills to operate and interpret the models.	• Appropriate knowledge management (conscious strategy and action of getting the right knowledge to the right people at the right time and helping people share and put information into action) is in place:
	  • Data and information sharing agreements in place and effectively implemented, and all are prepared to share all relevant data that will allow levels of trust to increase, in line with agreed and constantly reviewed information management rules and disclosure policy;
	  • Data collection networks and processing protocols established,
	  • Overarching decision support system with suite of models and knowledge base allowing development scenarios and new policy concepts to be evaluated at the basin scale,
	  • Improved linear relationship between knowledge generation and its application in decision-making;
	  • On-going and training for decision makers, planners and key stakeholders to make the most of these tools;
	  • Provision of access to the pool of information / knowledge to users, researchers, civil society representatives, institutional developers and capacity builders for meaningful debate on the sustainable development and equity.

An appropriate form of communication and participation for all basin stakeholders and partners – not just information exchange	• To establish an effective participation/consultation process with the basin community through a number of different and separate approaches. • Transparent program for obtaining external stakeholder input and participation for all of its projects and follows this program at all times. • Existence of a robust and on-going, participative strategic planning process and dialogue platforms for state, non-state and business actors to inform, and be

but true consultation and participation	informed, to assess national and regional water resources development strategies, and to enable the articulation of different perspectives about Basin water-related development to be considered in decision-making.
Management approach /system & performance indicators for both organization performance & basin sustainability	• Strategic performance of the impact of all the rules, procedures, guidelines, protocols. • State of the Basin' reports and score cards are regularly prepared covering key economic, social and environmental factors, resource 'health' trend analyses, and indicators of resource condition and monitoring/reacting to these. • A set of 'basin sustainability indicators' (with some form of priority rating) developed and data collected to assess the impacts of various development and conservation programs on these indicators. • To ensure that social, economic and environmental concerns are incorporated into basin-wide water resources development strategies and impact assessments. • Long term financial sustainability addressed and proper analyses of what constitutes the 'essential' functions of an RBO carried out, funding options considered. • All management systems (budgeting, financial, human resource, performance indicators, targets and monitoring, management accountability) in place and operational.

An effective knowledge management plan needs to focus on appropriate level technology, and reflect a conscious strategy to deliver pertinent knowledge to the right people at the right time. Furthermore it should emphasize gathering and sharing knowledge in a cooperative manner that builds confidence in the knowledge base, diminishes duplicative (and expensive) data gathering and analysis, and fills strategic knowledge gaps.

Collection and application of data, information and knowledge for monitoring and reporting are important to ensure that programmatic activities are achieving their objectives, to determine if the programs are having any unanticipated physical or socio-economic impacts, and to provide guidance for adaptive management responses. Various methods are used to monitor change in the environment—from simple measures of water quality, to more complex ratings of quality, to indicators of sustainable development. The Great Lakes Water Quality Agreement between the United States and Canada includes specific objectives to restore and maintain the chemical, physical, and biological balance of the Great Lakes ecosystem. It is periodically updated and reviewed (1972, 1978, 1987 and 2006) to strengthen its programs, practices, and technology and to increase accountability for implementation in light of scientific advances. The International Joint Commission monitors and assesses the progress of implementation and advises the two governments.

The EU Water Framework Directive introduced a control mechanism for ensuring the continuous adaptation of standards (Reichert G, 2005). Member states are committed to achieving 'good' chemical and ecological status of surface water within 15 years. Criteria for achieving 'good' ecological status are defined, and 'good' chemical status is achieved if concentration of pollutants in the surface water does not exceed specified environmental quality standards. Detailed baseline information is regularly reviewed and updated to monitor subsequent improvements.

In some areas, monitoring is used to compile a more sophisticated set of 'basin sustainability indicators' and data are collected to assess the impacts of various development and conservation programs on these indicators. In its 2003 and 2010 State of the Basin reports, the Mekong River Commission gave an overview of developments and their cumulative impacts on basic hydrological, environmental, and economic characteristics of the basin with plans to update these reports on a regular cycle and to extend them to include trend analyses.

As part of its work on the Mekong transboundary issues and governance challenge, the study was conducted and the result was published in two scientific journals (Pech S and Sunada S, 2006a, Pech S, Sunada K and Oishi S, 2007) and two peer-reviewed book chapters (Pech S and Sunada K, 2008, Pech S, 2010). The contents of these publications are presented in the following Sections of this Chapter 2.

2.2 MEKONG TRANSBOUNDARY RIVER BASINS AND GOVERNANCE CHALLENGE DISCOURSE IN MEKONG REGION

The Mekong Region has come to symbolize many of the environment-development dilemmas of the mainland Southeast Asia region. The Mekong Region - or "Greater Mekong Sub-region (GMS) in Asian Development Bank's term – incorporates the land and people within six riparian countries – covering the whole of Yunnan province, Guangxi Zhuang Autonomous Region of China (since 2004), Myanmar, Laos, Thailand, Cambodia, and Vietnam (ADB, 2005). The region encompasses a land-area of about 2.6 million km^2 and is home to a combined population of over 300 million; a population that is projected to increase rapidly annually (ADB, 2005).

The Mekong Region is endowed with a rich natural resource base including an extensive agricultural base, notable timber and fisheries resources, considerable mineral potential, and vast energy resources in the form of hydropower and large coal and petroleum reserves (MRC, 2010a, ADB, 2002). A number of development initiatives are in place in the Mekong Region including transportation (road transport, rail transport, water transport and air transport), energy (hydropower, natural gas), tourism, and trade (ADB, 2002). There are many important rivers in the Mekong Region, but the iconic Mekong River Basin (MRB) is the epicenter of large-scale development projects and their resultant impacts.

The Mekong Region has a high density of major river basins. The five major rivers in the Mekong region include: Mekong (countries), Red, Hong or Yuan Jiang (China, Laos and Vietnam); Chao Phraya (Thailand), Dulong or Irrawaddy (China, Myanmar and India), and Salween or Nu (China, Myanmar and Thailand). All of these rivers, except Chao Phraya and Irrawaddy, are shared by more than two countries and have headwaters at high elevation in mountainous terrain in Tibet, China (ADB, 2002). In addition to the Mekong and those listed above, the countries in the Mekong Region share many other international rivers, namely Saigon (Cambodia and Vietnam); Song Vam Co Dong (Cambodia and Vietnam); Pakchan (Thailand and Myanmar); Bei Jianh or Hsi (China and Vietnam); Beilun (China and Vietnam), Ma (Laos and Vietnam); Ca or Song Koi (Laos and Vietnam); and Golok (Thailand and Malaysia). The largest of all these rivers, and the one that dominates the area, is the Mekong River.

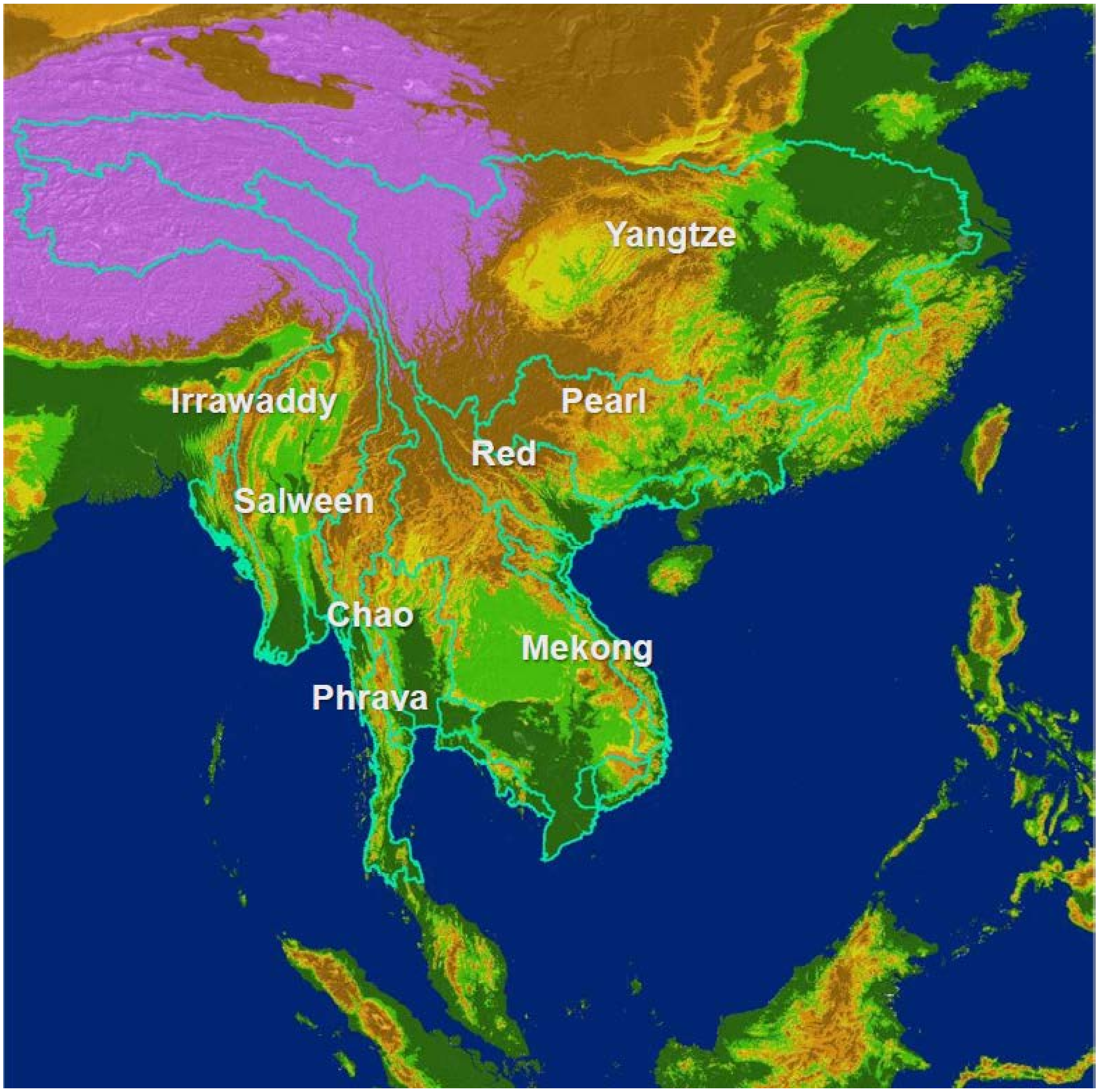


Figure 2.4 Map of Mekong Region

Table 2.3 Major River Systems in the Mekong Region

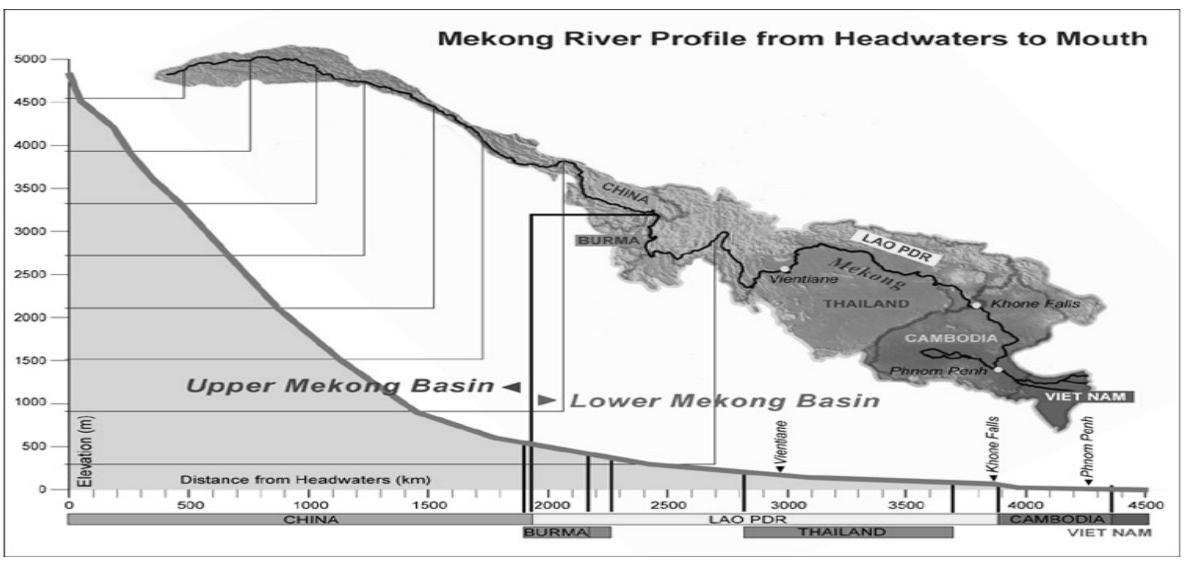
Characteristic	*Mekong*	*Red or Hong (Yuan Jiang)*	*Chao Phraya*	*Irrawaddy*	*Salween (Nu)*
Countries in basin	All	PRC, Vietnam	Thailand	Myanmar, PRC, India	*PRC, Thailand, Myanmar*
Basin (catchment) area (km^2)	777,000 + 73,000 in Tibet & Qinghai	226,000 (40% in Vietnam)	160,000	411,000	*325,000*
Area above 3000 m altitude, km^2	62,000 (7%)	Negligible	Zero	8,000 (<2%)	*90,000 (28%)*
Mean annual Runoff, mm	560	782	188	1000	*466*
Water yield per	475,000	177,000	29,800	410,000	*151,000*

annum, Mm3					
Major dependent cities	Phnom Penh, Vientiane, Ho Chi Minh City, Can Tho, Khon Kaen	Hanoi, Hai Phong	Bangkok	Rangoon	*Moulmein*
Extent of lands Under irrigation	Large	Large	Large	Large	*Small*
Level of water quality pollutants from human activities	Low (high at certain localities during low flow)	Medium	High	Low	Very low

(ADB, 2002)

2.2.1 Typology of Basin Biophysical Conditions & Geopolitics

The southwest provinces of China - Yunnan and Tibet - have the highest concentration of international rivers in Asia and contain the headwaters of major Asian rivers, including the Yangtze (over 6,300 km), Yellow (over 5,460 km), The Mekong River (over 4,900km) the Salween (Nu Jiang) (over 2,450 km) and the Red River (about 1,175 km) (MRC, 2005; Shaochuang, 2003). Those rivers are indeed a vital source of resources, whether for subsistence farmers and fishermen or national development agendas.

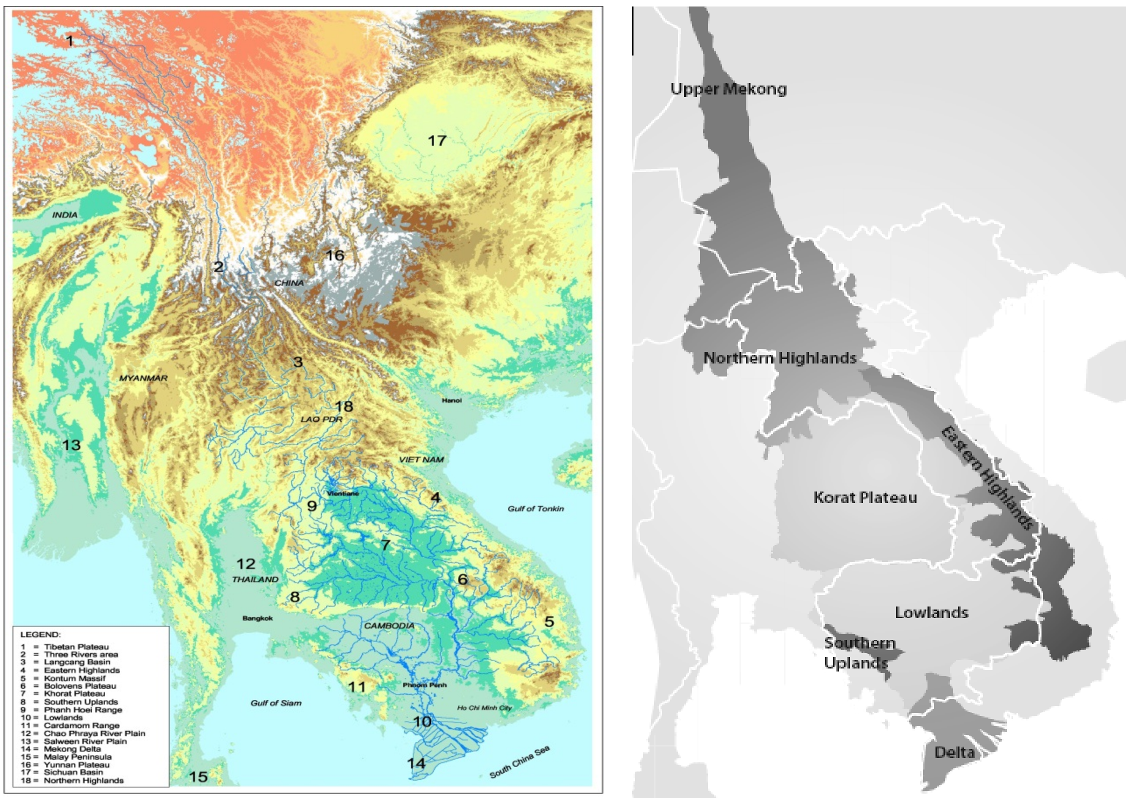


(Source: MRC, River Awareness Kit, 2003)

Figure 2.5 Mekong Longitudinal profile from headwaters to river mouths

The MRB is one of the world's largest river basins. Its length of 4,800 km makes it the twelfth longest in the world, while its area of 795,000 km^2 makes it the twenty-first in terms of size. The Upper Mekong Basin (Lancang) makes up 24 per cent of the total area and contributes 15 to 20 per cent of the water that flows into the Mekong River. The upper catchment is steep and narrow. Soil erosion has been a major problem and approximately 50 per cent of the sediment in the river comes from the Upper Basin (MRC, 2006). Snow-melt controlled floods from May to July dominate the upper Mekong (Lancang), and rain-induced floods from the summer monsoon (July to October) control floods on tributaries, especially within Lao PDR and Central Highland, Viet Nam, to the lower Mekong River.

The Mekong River flows from its source at the Tibet plateau in China (33°45′48″N, 94°40′52″E) (Shaochuang, 2003). Starting at an elevation of over 5,200 meters above mean sea level the Mekong River flows from its source to the South China Sea through six countries. The MRB is highly controlled by the geological units through which its flows. The Basin is divided into 06 major landforms.



(Source: MRC 2003)

Figure 2.6 Topography Map and bio-geographical zones of Mekong Basin

Table 2.4 Key characteristics of MRB landforms

Landforms	**Rainfall (mm/year)**	**Population Person/km^2**	**Vegetation**	**Topographic attributes**
Lancang Basin (1 - 3)	600-2,700	Low to moderate 7 – 145	Mountain brush, meadow, pine forest, mixed evergreen and broad-leaved,	From an altitude of around 5,000 m on the Tibetan Plateau, and drops to 310 m at the port at Simao. The topography is steep and the river falls 6.5 m per kilometre, with limited arable land
Northern	2,000-	Low: 8 - 15	Grassland, hill	Elevations up to 2,800 m running from Southern

Highlands (3, 4, 9 and 18)	2,800		evergreen and mountain forest	Yunnan Province, through Myanmar, Lao PDR and North Thailand, and eastwards into the northern end of the Annamite Cordillera in Viet Nam. Relief is sharp with slopes exceeding more than 30% and forest cover has been reduced considerably (high rates of erosion). Several of the peaks rise to over 2,000 m, and typical crest heights are more than 600 m above valley floors.
Korat Plateau (6, 7 and 8)	1,000-1,600	Moderate 80 – 160	Scrub, grassland, arable land	Most of the plateau lies in Thailand. Parts of the plateau are underlain by saline evaporates which are mined for salt. During the dry season, saline water seeps through the topsoil resulting in soil salinity.
Eastern Highlands (5)	2,000-3,200	Low: 6 - 33	Upland savannah, rain forest	Covering western slopes of the Truong Son range (Annamite Chain), which show complex and often sharp relief features but slope less abruptly than the eastern side of the range in Vietnam. These mountains extend about 700 km from Lao PDR through Viet Nam, with altitudes as high as 2,800 m.
Lowlands (6, 10 and 14)	1,100-2,400	Moderate to dense in Lowlands: 10 -570;	Arable land	Two subcomponents: the Cambodian floodplains and the delta. Both are formed from the deposition of recent sediments over older bedrock. The floodplain shows evidence of numerous recent changes in river course, and, because of the flat terrain, large areas are submerged during the high flow period. The delta area extends across some 65,000 km² (1/3 in Cambodia, rest in Vietnam). In the upper delta, the river channels are lined by natural levees formed through silt deposition. Lower down within the Vietnamese section of the delta, there is an elaborate network of canals and dikes.
Southern Uplands (11)	1,600	Very low in upland: < 8	Dense forest	An extension of the Northern Highlands, and include the Cardamom and Elephant ranges (in South East Cambodia), and consist of granite ridges with a maximum altitude of just over 1,800 m. Both these ranges are still densely forested.

(Sources: MRC, 2003, MRC & UNEP, 1997, UNEP/GIWA, 2006)

Different ecological zones have different potential and challenges, and their difference in scales (regional, national, sub-national and local level), and in social, political and cultural traditions and views. Countries, institutions, sectors and group of people view the interface and application of knowledge for informed decision making differently. It is depending on their respective social, political, economic position and their economic, political, social and cultural objectives. For example, the Laos Government deems that it has every right to consider large-scale hydropower development, forestry and mining operations as the engine of growth while the government of Myanmar given its current policy situation, considers integrative and participatory form of knowledge management for the river basin management as a low priority. Hence, diversity defines the ranges of perspectives in Mekong

Region's natural resource management. This diversity in harmony is taken into account in this study.

2.2.2 Mekong River Basin Water Resources Potential and Challenge

Different sub-basins of the MRB dominate the Mekong hydrology in different seasons. As shown in Table 2.5, the dry season low flow regime is dominated by the flow from China known as the "Yunnan Component", while in the flood season the hydrology is dominated by inflows from the large left bank tributaries of the Lower Basin itself (MRC, 2006). The water flow from China contributes about 51 per cent of the total flow at Vientiane, Laos, and 16 per cent of the flow at Kratie, Cambodia (MRC, 2006b).

Table 2.5. Key Hydrological Characteristics of MRB

	Yunnan	Myanmar	Laos	Thailand	Cambodia	Vietnam	Total
Catchments (Km^2)	165,000	24,000	202,000	184,000	155,000	65,000	795,000
% of MRB total	22	3	25	23	19	8	100
% of total country's area	38	4	97	36	86	20	
Average rainfall (mm/yr.)	1,561		2,400	1,400	1,600	1,500	1,750
Average runoff (m^3/s)	2,414	300	5,270	2,560	2,860	1,660	15,060
Average runoff (MCM/yr)	76,128	9,461	166,195	80,732	90,193	52,350	474,932
In dry season	19,032	1,419	24,929	12,110	13,529	7,852	78,871
Average runoff as % of total	16	2	35	17	19	11	100
Dry season average runoff %	24.1	1.8	31.6	15.4	17.2	9.9	
Population (million)	10	0.5	4.9	24.6	10.8	21	71.8

(Source: MRC, 2005, UNEP/GIWA, 2006)

Water issues in the Mekong Region are closely related to the unequal spatial and temporal distribution of flow, and the lack of well-informed decision making for water resources development and management, and mitigation of vulnerability. Historically observed natural year-to-year variability is very significant in terms of river discharges, flooded areas, and the beginning and end of the wet and dry seasons. For example, depending on the year, between 1 and 4 million hectares of the floodplain is submerged during the wet season (MRC, 2006b).

In the Mekong Region the structure and functions of wetlands are also closely linked to the seasonal flow pattern of the river, involving a wet season flow up to 10 meters higher than the dry season, especially in the MRB. Fluctuations in the Mekong flow and consequent flooding change the wetlands and their productivity.[1] The river channel and wetland habitats are crucial for the ecological functioning of the river system.

The Mekong is a large fluvial system which changes from upstream to downstream due to changes in water discharge and sediment transport (sediment flows, that are moved either on the bottom (bed load), in suspension, or nutrients attached to the suspended matters, and/or in solution of the flows), and due to changes in the nature of its bed (bedrock, substratum, or geological base) (see e.g. Bravard and Goichot M, 2010). The lifecycles of many Mekong fish species and adjacent coastal zones have evolved to take benefit from the river's hydrological

1 An important feature is the Mekong Basin is its rich riverine ecology, fuelled by the annual "flood pulse" especially in the Tonle Sap Great Lake where the seasonal cycle of changing water levels at Phnom Penh results in a very large flow reversal of water into and out of the lake via the Tonle Sap River.

and sediment/nutrient regime. Fishes migrate to deep pools in the mainstream to take refuge during the dry season, and migrate back to spawning and feeding grounds on floodplains during the flood season.

2.2.2.1 Existing and Potential Uses

About 325 million people live within the GMS, which has a land area of 2.6 million km² (ADB, 2002, ADB, 2010). The GMS encompasses the entire Yunnan province of China, Myanmar, Laos, Thailand, Cambodia and Viet Nam. Over 70 million people living in the MRB (MRC, 2010a). About 90 percent of the population of Cambodia (13 million) and 98 percent of Lao PDR (5.2 million), 39 percent of the population of Thailand (23 million), and 20 percent of the population of Viet Nam (17 million in the Delta and 3 million in the Central Highlands) living within the basin.

Among the six riparian states of the MRB, China and Myanmar have only a small percentage of their populations located in the Basin (1 and 2 per cent respectively). China's Yunnan province, however, has one quarter of its population (10 million) residing in the Basin. China has the strongest geo-politic position - over 15 major hydropower projects on mainstream, capital and technological resources for investing mega-projects in water and mining sectors in LMB, largest markets for bilateral trades, and its political and military superpower status in Asia.

The numbers of Vietnamese and Thai inhabitants in the MRB is, however, far higher than the number of Laotians or Cambodians (MRC, 2003). Population growth in the basin is 1-2 percent in Thailand and Viet Nam and 2 percent in Cambodia and Lao PDR. Despite impressive economic growth over the past decade within the basin countries, much of the Mekong Basin itself remains among the world's poorest areas. It is currently witnessing a major demographic transition that is creating both opportunities and challenges. Population, together with other major drivers, such as institutions, markets, and technology, will have a very strong bearing on the way in which the rich resources of the Mekong Region are developed and distributed in the present and future.

Governments of Mekong countries have targeted "poverty reduction strategies" within national socio-economic and sector development plans, all of which include the development of water resources (MRC, 2010b). These plans have the common aims to:

- Considerably increase agricultural production, for food security, the growth of high value crops, and to increase in food export.
- Significantly increase hydropower and energy production to meet increasing demand for affordable electricity and/or generate foreign exchange.
- Considerably decrease the damages of floods and drought to prevent or minimize people's suffering and economic losses due to floods and droughts.

A series of large scale economic activities in the Mekong Sub-region are at various stages of planning and development. Fluctuating oil and gas prices, an emphasis on renewable and non-fossil fuel generation and the availability of private finance, are making hydropower increasingly attractive and accelerating its development in the LMB. Global food demand and rising prices can make irrigation more profitable in the LMB and grow interest for investments from foreign entities. Numerous dams and water diversions are on the agendas of the private and quasi-public-sector developers, transnational capital providers, and the six governments of the region. A recent count found 82 existing and 179 potential hydropower projects in the wider region (King P, *et al*, 2007), and those existing and planned dams and diversions will transform the waterscapes of the region (Molle F, *et al*, 2009).

China is developing a cascade of 8 projects on the upper Mekong stretch in Yunnan with a total installed capacity of 15,450MW and a series of over 15 dams on the stretch below the headwaters of the Mekong River.

LMB tributaries have a very large tributary potential (some 70 projects under various levels of exploration representing a capacity of 9,364MW) and 12 dams are being studied and planned in the LMB mainstream. There are plans to increase the irrigated area by 50% (from 1.2 to 1.8 million ha) in the next 20 years, with Lao PDR planning to expand dry-season irrigation from about 100,000 ha to over 300,000 ha.

Agriculture remains the biggest water user as 78-94 percent of fresh water withdrawal goes to irrigated agriculture (MRC, 2010a). In 2000, irrigated agricultural use accounted for around 15 per cent (72,837.66 MCM) of the annual average discharge (475,014 MCM), or 80 – 90 per cent of the total water abstraction from the MRB in the form of both blue water - receding flood water storage, diversion of water from stream and from ground water sources - and water from precipitation (soil moisture) (MRC, 2010a). More than half of this water use takes place in the Mekong Delta (MRC, 2010b).

At the same time, countries' uncoordinated economic activities are being challenged by the need to balance development of water resources to achieve benefits with the needs of other communities and riparian countries.

2.2.2.2 Existing and Emerging Problem and Issues

The Mekong is defined as a river with a medium level of modification due to the number of dams, reservoirs on the mainstream and tributaries, water diversions, irrigation consumption, and level of flow regulation. Even though the MRB eco-system is in relatively good shape, it is under increasing strain from a growth in development, population pressures, and other climate induced changes. At the same time, transboundary problems - latent and manifest - have emerged in the MRB in higher frequency and magnitude. The problems cover the entire spectrum of possible situations where the interests of the MRB states related to the use of water resources may collide, ranging from minor differences in opinion to rather tense situations.

The issues include: i) blasting and dredging of river bed in the Upper Mekong for improving commercial navigation (*upper Mekong Navigatio*n); ii) large scale dam projects on the Mekong mainstream in Yunnan (*Yunnan Dams*); iii) bank erosion of the boundary Cambodia, v) Cambodia's concern over "flood-water back-up" from flood control along Vietnam-Cambodia border (*Flood control*); vi) Cambodia-Vietnam navigation barriers (*Navigation barrier*), and vi) Vietnam's grave concern over severe flow fluctuation in the Mekong Delta (*Flow fluctuation*). **Table 2.6** summarizes those identified key problems.

Table 2.6 Key Water related Problems

Key Concerns	**Impacts**

1.	Severe Flow level fluctuation	Impact of dam storage/release operations, or inter-basin water transfers on: Dry season's water availability. Reduced flooding in important habitats - Great Lake, floodplain forests and freshwater and estuarine wetlands.
2.	River bank /bed erosion and sedimentation	Shifting of political boundaries and loss of valuable land and infrastructure by accelerated river bank/bed erosion. Sediment trapping in reservoirs and downstream erosion. Reduction in rich natural fertilizers and food chain in flood plains. Impacts on delta region and coastal zone erosion.
3.	Obstruction to Navigation	Physical barrier to navigation by dams, weirs and bridges, and channel siltation. Reduced navigation opportunities by rapidly fluctuating river levels. Non-physical barrier to navigation due to national conflicting policies and regulations.
4.	Water Quality Deterioration	Elevated levels of microbial pollution from urban wastewater discharges at certain urban hotspots in dry season and early wet season. Pesticide pollution of surface and ground water. Elevated salinity and sea water intrusion.
5.	Fisheries Productivity and Ecosystem Functioning	Impacts on fisheries productivity by reduced, delayed or otherwise altered, wet season flood flows, sediment discharge and flooded area. Impact of increased fishing pressure – overfishing and sustainable fishing practices. Obstruction of fish migration/dispersal (upstream, laterally and downstream), and destruction of fish habitats.
6.	Deforestation	Commercial logging and clearing of land for agriculture and reservoir clearance. Forest-fire, loss of coastal mangrove. Degradation of forest ecosystem in watershed area.
7.	No harmonization of policy targets, and impact assessment	Lack of agreed assessment yardsticks and policy responses minimize chance for optimizing the resources development, joint development and equitable sharing of benefits, and mitigating impact. Lack of collaborative research and knowledge generation that would be accepted and respected by all Mekong countries.

On the mainstreams and tributaries of the Mekong, disputes exist, as a result of interventions to natural flow regimes and overt or default management decisions. The first challenge is the different viewpoints, needs, interests, information, and power of the different actors involved in the policy process. There are different assessments of the positive and negative impacts of the Chinese dams on the Lancang/Mekong. These can be divided into at least two different schools of thought. The first group - proponents of dam development in China and some Mekong countries - holds a wide range of views from highly "optimistic" to cautiously optimistic about the "social, economic and ecological benefits" to the downstream countries including increased dry-season flow and flood control benefit (Chapman E and Daming He, 2002). Another group that mainly consists of downstream communities, as well as regional and local NGOs, are concerned with the serious negative impacts in all of the Mekong countries, including China itself, such as impact on fishery, river bank farming, and on the Tonle Sap Great Lake, Asia's biggest fresh water natural reservoir and the Mekong's most important fish habitat. However, both sides admitted that the assessment of the impacts and suggested measures for mitigation were often based on limited quality of knowledge and inappropriate scope and assumptions.

2.2.3 Mekong River Basin Governance and Knowledge Management Initial Baseline Condition

The existing Mekong regional organizations have resulted in considerable progress in improving regional confidence and trust building by providing important regional platforms for dialogues. During the last decades, a development focus in the Mekong has expanded from the irrigation, hydropower, flood control and navigation to a more holistic basin development planning and economic integration.

2.2.3.1 Mekong Basin Sub-regional Governance

Over the last 50 years, dramatic changes have occurred in the Mekong Region, and also in the ways the relationship between development, resource use and the environment are viewed. Recent changes in the region have thus affected the opportunities and constraints for resource management at different levels. The geopolitical perspectives that set the parameters for MRB resource management are basically divided into three main periods, namely the 1st Indochina war (1940-1954), the 2nd Indochina war (1965-1975), and Post-Cold War era (1989-present) (Mekong Committee Secretariat, 1989; Pech, 1995; Browder and Ortolano, 2000).

In the present-day Mekong Region there are many actors with very different interests and powers, exhibiting contrasting modes of behaviour, and with varying degrees of influence. First of all there are the six Mekong Region countries – China, Myanmar, Lao PDR, Thailand, Cambodia and Vietnam. They have different economic, political, social and cultural objectives that define the range of perspectives in the natural resources management. Moreover, perspectives are differentiated by country, by resource sector, by socio-political actor and by scale of orientation. From the social-economic point of view, all six countries are at different level of development. The difference in level of income is also there between those living within the Mekong Basin area and their peers living in other areas.

The sudden groundswell of hydropower development by private power producers and private financing, along with the revitalization of the once-abandoned hydropower dam projects along the Mekong Mainstream in the Lower Mekong Basin starting from 2008, took many observers—including major regional organizations such as the MRC, and international financing institutions—by surprise.

Those private project developers are mainly from Thailand, Vietnam, China, Malaysia, and Russia – with limited commitment to international social and environmental performance standards[2]. Massive inflows of bilateral and private funds from Thailand, Korea, Kuwait, Qatar, China, and India for irrigation and water diversion are a reality in Cambodia and Lao PDR (John D, personal communication, 2010). It is happening as there are significant vested bureaucratic, political and business interests behind the hydropower industry and large-scale water diversion. These interests work to promote large dam and water diversion projects even where better energy and farming options exist.

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2 A report prepared by the World Bank and Asian Development Bank (ADB) in 2006 did not foresee that such aggressive development of hydropower dams on the mainstream in parts of the Mekong Basin (other than in China) was feasible from environmental, financial and political standpoints (World Bank and ADB, 2006). Rather, the 2006 report predicted that the countries' rapidly growing needs for power would alternatively be met through cooperation in cross-border hydropower sharing on tributaries, and through other alternatives.

Flush with nearly a trillion dollars in hard currency reserves, and eager for stable friends and influence in Southeast Asia, China makes big loans for big projects to countries that used to be the sole preserve of Western donors - the World Bank, the Asian Development Bank, the United States and Japan. The multi-bilateral trade and investment between China and Vietnam, and China and Thailand makes it imperative for these more developed Mekong countries (Thailand and Viet Nam) to not openly challenge China.

Recently, United States of America (USA) announced its return to the Lower Mekong Region after decades of absence from the region since the end of Viet Nam war (Yun, 2010)[3]. USA advised some Mekong countries not to place all their "eggs" in a single Chinese basket. Similar questions were raised when World Bank decided to return to the Mekong Region in late 2000s – would they be capable to make any difference? It is important to monitor and assess further the change in geopolitics and changes in decision-making quality and benefit and risk distribution mechanism in term of:

- How the on-going territorial claims in the South-China Sea between China and other South East Asian Countries, especially with Viet Nam will evolve further?,
- How territorial conflict between Cambodia and Thailand in which China and USA are suspected of supporting each of these disputing nations will be resolved, and
- How successful USA, World Bank and other western countries will be in changing the Chinese domination in the Mekong Region and in restoring the balance of powers in the region?

There are numerous international agreements and institutions dealing with sustainable management of the MRB. Each of them has its own membership, focus, principles or norms that determine how it cooperates and defines its strategic direction and priority. It is regrettable that the coordination and integration.

The challenge is how to manage and coordinate the 'congestion' of the Mekong related regional initiatives and frameworks, as well as the access and trust among users of the knowledge generated by each institutions and entities. Among them, GMS and ASEAN Mekong programmes etc. have strong impacts positively and negatively on the basin's ecology and its community's livelihood. While MRC is mandated by an international treaty to manage the Mekong Basin within its hydrological boundaries among its member-countries, GMS is the only regional forum in which all six Mekong riparian countries participate, and its geographical scope encompasses the whole of Yunnan, Myanmar, Laos, Thailand, Cambodia and Vietnam. The proliferation of the Mekong-related regional initiatives and institutions continues.

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3 To help strengthen U.S. engagement in Southeast Asia, Secretary Clinton announced the Lower Mekong Initiative (LMI) in July, 2009 on the margins of the ASEAN Post-Ministerial Meeting. The LMI aims to engage Cambodia, Laos, Thailand, and Vietnam by helping build regional capacity in the areas of environment, health, education, and infrastructure in order to facilitate multilateral cooperation among the four countries on issues of mutual concern, such as the common challenge of effective water resource management

2.2.3.2 Mekong Knowledge Management Challenge

Close examination of the geopolitical landscape of the Mekong River Basin reveals that it is exceedingly complex, with multiple transboundary issues. Development banks also projected a rather gloomy future for regional cooperation through the Mekong River Commission (MRC), one of the oldest Mekong regional bodies (World Bank and ADB, 2006). They cautioned that the MRC was at a crossroads and—if over the next 3 - 5 years this cooperation framework were not consolidated and seen by the member countries to have a visible impact and improved performance—the system may begin to unravel, in turn threatening broader achievements in the MRB.

Many Mekong commentators have begun to wonder whether the current regional institutions and organizations are not well enough equipped to solve or ameliorate transboundary problems. Some commentators also complain that the regional organizations have even been notoriously absent in addressing critical transboundary problems, or have hid them under the rug, displacing them spatially into the future or onto other issue-dimensions. Failure of the MRC and donor communities to address the Yali Falls Dam issue between Cambodia and Viet Nam and current controversy surrounding Xayabury Dam on the Mekong Mainstream in Lao PDR are two of many examples of this failure (MRC, 2011a, Pech S, 2011).

Some independent commentators observe an increasing dissatisfaction with the non-transparency of decision making, approvals and compliance processes, and have expressed concerns about the interests and types of knowledge being privileged and the process limitations which hinder presentation of alternative viewpoints, even within China. For example, the recent independent panels of experts found that the Basin Development Plan Impact Assessment and Strategy were not satisfactory as far as the tools and data for assessing the mean water flows were concerned, and were not sufficient for physical and environmental impact assessment and, for selecting alternatives and mitigation options. The inadequacy is likely to lead to unrealistic economic valuation and an underestimation of the negative impacts on livelihoods of the poor and vulnerable, biodiversity, inland and offshore fisheries, erosion of river banks and coastal shores. It has become increasingly obvious in the past few years that there is the need for greater cooperation in the Mekong Region, and greater interface between science policy and practice.

First of all, an effective mechanism for such cooperation and interface need to be established or substantially consolidated. Ideally, the unification or harmonization of the currently dispersed regional institutions and organizations would be the preferable option. Figure 2.7 sketches the authors' suggestion for future Mekong regional governance that would consist of three inter-related levels and the relevant institutional design principles. The horizontal boxes B, C and D in Figure 2.7, represent the existing regional regimes at government, semi-official (government, academia and non-state), and at community levels, respectively. The dotted lines depict the currently weak line of communication between official, and semi-official and community levels. The vertical Box on the right-hand side contains those key designing principles and determinants for assessing performance of the said regional regimes. Some of these principles and determinants are tested and discussed in more detailed later on in Chapters 3 and 4.

In horizontal Box A, this study proposes a gradual evolution of the current inter-governmental organization and programmes - MRC, ASEAN Mekong and GMS - into the Mekong Development Authority (MDA) or Programme to be the apex body as required by IWRM principles, which are composed of all 6 countries with a clear development mandate and a strong technical and financial basis. Such an MDA would have to establish a close two-way communication with the community, either through semi-official multi-stakeholder track or directly with relevant NGOs and basin communities. The MDA must also be well placed in order to ensure a significant impact on the development of policies, strategies and legislation. If it is well designed and active, it can influence the regional debate on, and direction of, water management activities.

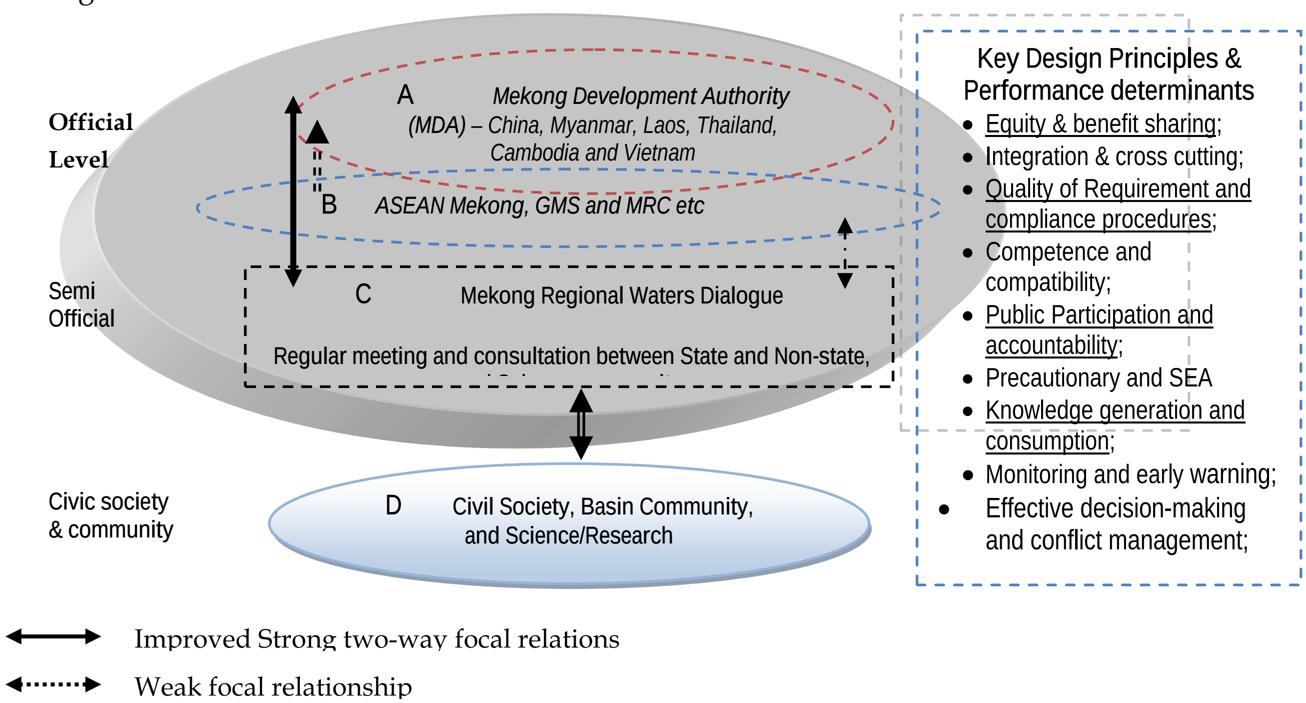


Figure 2.7 Recommended overhaul of the Mekong Governance Structures

It is true that one cannot expect such a body to be established and functioning in the immediate term scenario. The success of such change depends very much on how the other Mekong countries can convince China of the logic of consequences and appropriateness of the changes made and of the broader benefits of cooperation beyond the river. The cost of failure must also be considered. Some commentators ponder whether or not cooperation in the Mekong Basin will simply institutionalize the present asymmetry of power and capacity in obtaining and applying appropriate knowledge and considerations in the MRB. This, the critics claim, would still render that new mechanism ineffective (Dosch J and Hensengerth O, 2005). From this study's observations, it can go either way, depending on the willingness of state actors to develop a wider set of integrative formal and informal institutions (e.g. agreements, codes of conduct, commissions, regular high-level meetings) using the existing and politically promising institutions built within MRC and GMS frameworks as a nucleus, adjusted and improved to meet those designing principles listed in right vertical box of Figure 2.7.

In order for the new scheme of cooperative mechanism to work, the following key institutional interplay and design principles have to be properly addressed:

1. <u>Mutual self-interest and benefit sharing:</u> To realize this challenging vision, the Mekong countries need to replace an age-old perception of water use as a zero-sum game by a win-win approach and a concept of benefit beyond river. They have to put in place a proper and

functional institution that can operationalize the basic precept and principles to achieve equitable sharing of the benefits from any cooperative undertakings and taking into account both cross-sectoral and social implications of development intervention. It has to be supported by an agreed upon analytical framework, the harmonization of policy targets, evaluation tools and benefit distribution/impact mitigation and compensation;

2. Quality of Institutional Requirement and Compliance procedures - The Mekong needs mechanisms that will increase the benefits of compliance or raise the costs of non-compliance. Linking institutional arrangements together can raise the price of non-compliance by increasing the probability that the consequences of violations in one issue area will spill over in such a way as to degrade cooperation in other areas of importance to individual actors. The monitoring mechanisms and strategy and framework for compliance review in encouraging implementation and compliance, which normally encompass those state and non-state activities aimed at achieving the goals and objectives of the treaty regime, are necessary. It would require an agreed baseline and method for verification, established in a transparent and participatory manner. The quality of requirement is very crucial since compliance with dysfunctional regime rules will not improve outcomes.

3. Improved Linear Relationship between Knowledge Generation and its Application in Decision-making: The efforts to match institutional arrangements governing human actions to the properties of bio geophysical systems cannot succeed in the absence of usable knowledge regarding the ecosystem and a proper understanding of the causal mechanisms at work within such a large and dynamic system. It requires the development of usable knowledge in one form or another (western scientific tradition and the informal knowledge by indigenous peoples. It also requires circumstances to be overcome where the available knowledge is simply ignored or questioned, especially when it is combined with an attitude of dominance that licenses, or even encourages, human exploitation of natural resources unless the consequences become demonstrably destructive. The knowledge needs and hierarchy should place an emphasis on generating information and analysis which will help to promote a better understanding of key issues, including the multi-functionality of resources, societal demands and sustainability monitoring threshold.

2.3 STATE OF KNOWLEDGE ABOUT KEY DRIVERS IN MEKONG REGION

The main purpose of this literature review on the state of knowledge about the key river basin development drivers and impact (individual, incremental and cumulative) is to investigate and analyze the state of scientific debate over the population growth and environmental challenges facing the MR and MRB. The section provides the context, empirical evidence, and an analysis of the demands and environmental changes associated with population trends, and provides an initial contextualization and conceptualization of interface optimization in the Mekong Region. This characterization leads to the search for root-cause of success and/or failure in the Mekong knowledge management and interface to be discussed in **Chapter 3**.

As part of its work for this dissertation, the review and critical analysis was conducted and the result was published in a scientific journal (Pech S and Sunada K, 2008b), in a peer-reviewed book chapter (Pech S, 2011) and in two international scientific conference papers (Pech S and Sunada K. 2006c, and Pech S, Sunada K, Oishi S, and Miyazawa N, 2005). The detailed results from these publications are discussed in the following sections.

2.3.1 Relationship between Population Changes and Environment Pressure

A rapid population growth and environmental change are two topics that have caused substantial debate over the past decades in the world and in the Mekong Region. Both population and environmental concerns are often subsumed within the dialogue on "sustainable development," aimed at addressing the needs and aspirations of today's population without compromising the well-being of future generations (WCED, 1987).

Population growth, and associated food and water demands and their impacts on water resources in the MRB was considered by planners and policy-makers as the main drive of the Mekong River Basin "exploitation and development".

The Mekong Region has an undoubtedly long history of human occupation – far longer than most river basins outside of Africa. Nonetheless, population densities in most of the basin were quite low until recently. Since then, the MRB has experienced relatively rapid increases in population and extensive conversion of forest to agricultural land to meet the demand associated with the population growth and for export. This was particularly true in Northeast Thailand and the Vietnam's Mekong Delta where now have little forest cover remaining.

A number of studies discussed at a very general level the population growth, food and water demands and their impacts on water resources in the other parts of the world and the MRB (Borberg J, 2005; Molden D, *et al,* 2001; Rosegrant M. *et a*l, 2002; Hoanh C, *et al,* 2003; Davis T (*ed.*), 2003, MRC, 2010a and b).

The opponents of "optimistic" theory maintained that during the last 30 years during which the population of the MR has doubled, there was some isolated famine that was caused largely by poverty and lack of funds within certain section of the population to purchase food rather than by an absolute shortage of food. The optimists admitted a multiplicity of other factors such as policies and institutions that influence the socio-economic growth more than the population growth alone.

The proponents of theory "population neutralism" argue that population growth can generate "demographic dividend"- labour supply; saving, and human capital. They further argued that to derive a meaningful conclusion from the analysis of the population, economic growth and natural resources exploitation relationship, one has to focus not only on the population size and growth, their age structure dynamics, but also on the policy and institution.

2.3.1.1 Population Changes and Environment Pressure in the Mekong Region

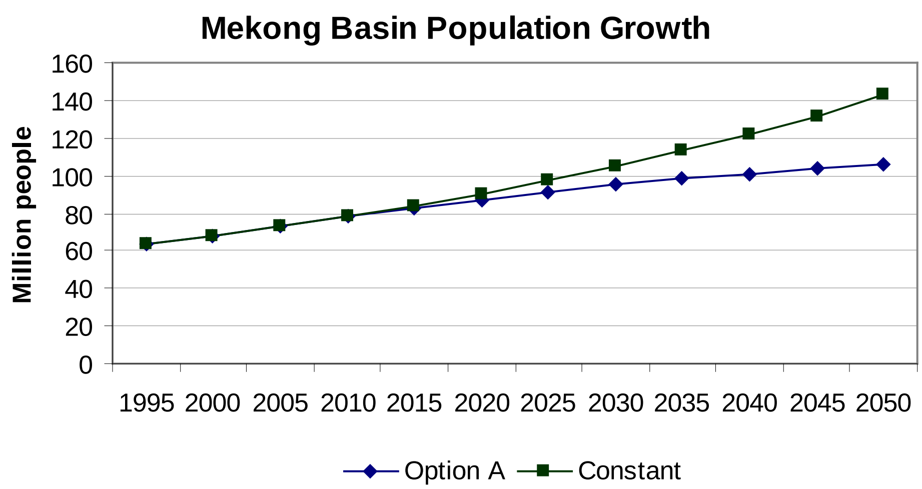
The Mekong countries have a complex, but interesting, mosaic of demographic attributes and trends. The population of the Mekong Region - whole Yunnan province of China, Myanmar, Laos, Thailand, Cambodia and Viet Nam - is nearly 300 million, with over 70 million people living in the Mekong River Basin (MRB) (MRC, 2010b, ADB, 2005).

Table 2.7 Year 2000 Population in Mekong River Basin

Mekong River Basin	*Yunnan*	*Myanmar*	*Laos*	*Thailand*	*Cambodia*	*Vietnam*	*Total*
Population (million)	10.l	0.5	4.9	24.6	10.8	21	71.8
% of total population	25	2	92		83	30	

(Source: MRC, 2010b; ADB, 2004)

There are different population growth projection rates for the MRB. The projections of population growth in the MRB differ widely as a result of both different methods of enumeration and poor reporting (MRC, 2006, Rosegrant M, *et al*, 2002, Davis, T. (*ed*) 2003).



(Data source: MRC 2006)

Figure 2.8 Projection of Mekong Basin Population Growth (1995-2050)

As shown in **Figure 2.8** , the MRB population was modeled to grow from 63 million in 1995 to over 72 million in 2005. This was in good agreement with the observed/estimated data (MRC, 2006). However, the MRC's projection based a constant growth, argued that the MRB population would double its 2005 values by 2050, while other studies predicted less than 60%increase (United Nations, 2005).

The patterns of the demographic transitions in the region – changes in population age structures – vary from country to country, but they also share many common features - as the birth rate goes down, the proportion of population in the working and productive age (15 – 59) grow rapidly. Laos and Cambodia are in early stage of demographic transitions and the proportion of their population groups reaching productive ages (15-59 years old) will grow over 54% in next few years (US Census Bureau, 2006). Thailand and Vietnam have reached a stage where over 60% of their populations are between 15-59 years old and their population age groups of 60 years old and older will be increasing remarkably in the coming decades. Whole of China and Myanmar would soon reach a negative population growth, and their population age groups of 60 years old and older are increasing remarkably in the coming decades (US Census Bureau, 2006).

While these population growth figures are only indicative, but they do point to the complexity associated with academic and policy debate around population growth and natural resources exploitation – hydropower and energy, and irrigation and agriculture, urban and infrastructure development, and deforestation and reforestation - in MRB. Most Mekong countries have argued that to fulfill the resource requirements (perceived or real) of a growing population, some form of water and/or land-use change are required to support increasing human numbers (World Bank and ADB. 2006, MRC, 2010a and b).

The decision-makers and practitioners perceived population growth and associated demand change as the main justification for water and related resources, without seriously exploring other sustainable and cost-effective options in addressing water, energy and food nexus. Certainly, scientific research and tools are required for generating proper projection of the population, searching alternatives/options, and modelling the growing environmental pressure to meet the growing demands associated with population changes.

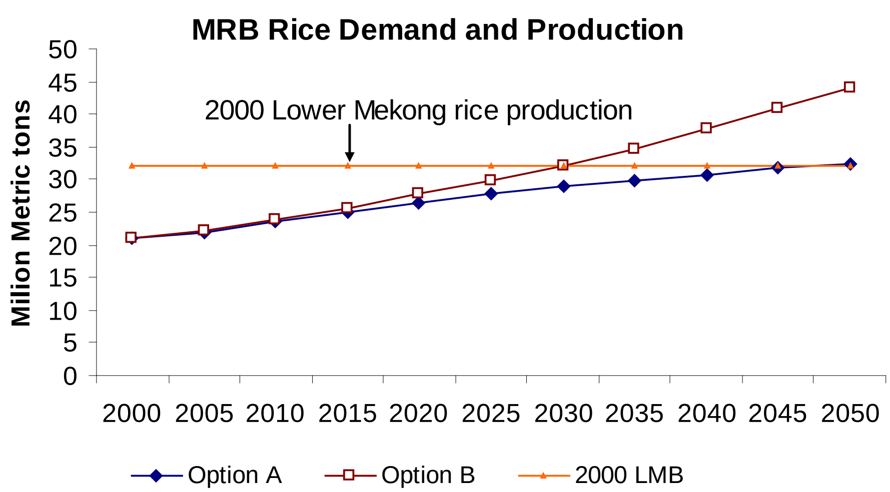
2.3.2 Population Growth, Food Demand Growth and Land Use Change

Demand for food, energy and development associated with rapid population growth is expected to have impacts on the MRB water and natural resources. Fulfilling the resource requirements of a growing population ultimately requires some form of land-use change and increase productivity of crop, and development of infra-structure necessary to support increasing human numbers (Davis T (*ed*), 2003). The increase in agricultural production (expansion of agricultural areas and/or increase of land and water productivity) along with urbanization and industrialization potentially put increasing on key terrestrial and aquatic ecosystem components.

2.3.2.1 Population and Food Demand Growth in Mekong Region

Some earlier studies applied a very simplified method for calculating food demand (Hoanh C, *et al* 2003). They were built on an assumption of a per capita food demand of 300 kg/year of paddy or equivalent for all Mekong countries. The results of that method were over-generalized as from countries to countries the food composition, and diet are different.

In the absence of household-level food consumption survey data, the food balance sheet on country's average per capita food supply provides information for measuring long-term trends in national food demand and diet composition. In all six Mekong countries, more than 65% of the daily calorie supply was provided by cereals (rice and wheat), both directly as cereal products and indirectly through animal products (FAO, 2006).

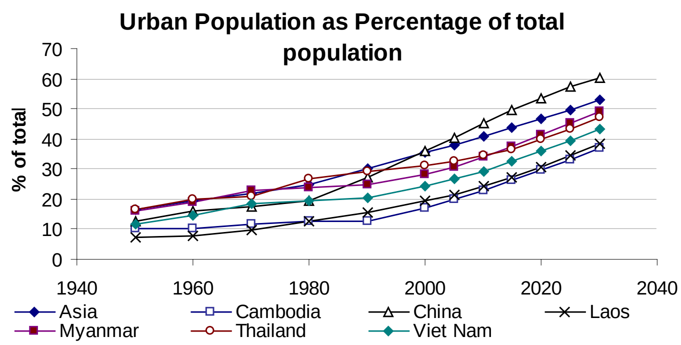


(Option A: population growth rate declining; Option B: population growth constant)

Figure 2.9 Mekong Basin cereal demand projections and 2000 cereal production

Figure 2.9 shows that in the scenario where the population growth rate is declining as the total fertility rate in the MRB declines shows that in 2050 the cereal demand increases by nearly 60% (roughly 11 million tons more than 2000 values). Comparing it with the 2000 paddy rice production of 30.64 million tons (BDP, 2002), it found that with same paddy production level and farming practices, the MRB is likely to produce enough rice to feed its basin community until 2030 or 2040. Thailand Northeast and Vietnam's Delta – major rice producers and exporters, are likely to produce rice surplus even after 2050. Cambodia and Laos have potential to increase their production to meet the self-sufficiency level well beyond 2040, but that will require a huge investment and improved management.

It is true the existing approach to food demand projections did not take into account other factors for example the basic caloric requirements vary according to an individual's age and gender, with daily demands for infants and adult man. Urbanization, too, can be related to food demand and people demand larger quantities of meat and more dietary variety as incomes rise.



(Data source: WRI Earth Trend, 2004)

Figure 2.10 Urban Growth Projection for Mekong countries

Figure 2.10 depicts that urbanization and relatively larger proportion of working age population (15 – 60 years of age), as well as the present growth trend in the economic development relying on natural resources exploitation, and regional integration characterizing many Mekong countries, there is an increase in uncertainty about the impact on and changes in the natural and social systems in the Mekong region.

The level of urbanization in most of the Mekong River Basin lags nearly half a century behind those of industrialized countries where urbanized population was 55% in 1950, and 76% in 2000) (ADB, 2002a). But, nearly half of Chinese population of 1,350 million will live in the urban areas by 2010 (United Nations, 2005). Thailand and Myanmar will have about 50% of their population living in the urban areas after the year 2025, Vietnam in 2035, while Laos and Cambodia with much smaller populations will reach that level after 2045 (United Nations, 2005). The challenge is the current urbanization process in MRB is taking place in a different context, namely it happens at the time when regional integration and globalization are intensified and the level of economic development is comparatively lower.

One of the greatest challenges which the Mekong countries face is to prepare for a smooth transition from being fundamentally rural societies to urban ones. Urban growth is both opportunity and challenge. This growth will come at a cost, such as:

1. Urban waste is increased beyond that readily absorbed by the surrounding environment, resulting in high concentrations of pollutants;
2. Rapid pace of urban growth occurring in developing regions outpaces the development of adequate infrastructure or regulatory mechanisms to handle the environmental impacts of human concentration;
3. Further turning the immediate surrounding areas including flood plains into urban areas. This would result in the loss of valuable farm land, and further encroachment on the flood plains and disaster-prone areas in some cases, and therefore increase risks and cost associated with flooding and natural disaster; and
4. Rapid urbanization may influence agricultural water demand through food demand and diet change, as well as domestic and industrial water demands.

Further improvement in scientific knowledge and options for meeting future demand and supply balance and support appropriate planning and impact mitigations is required.

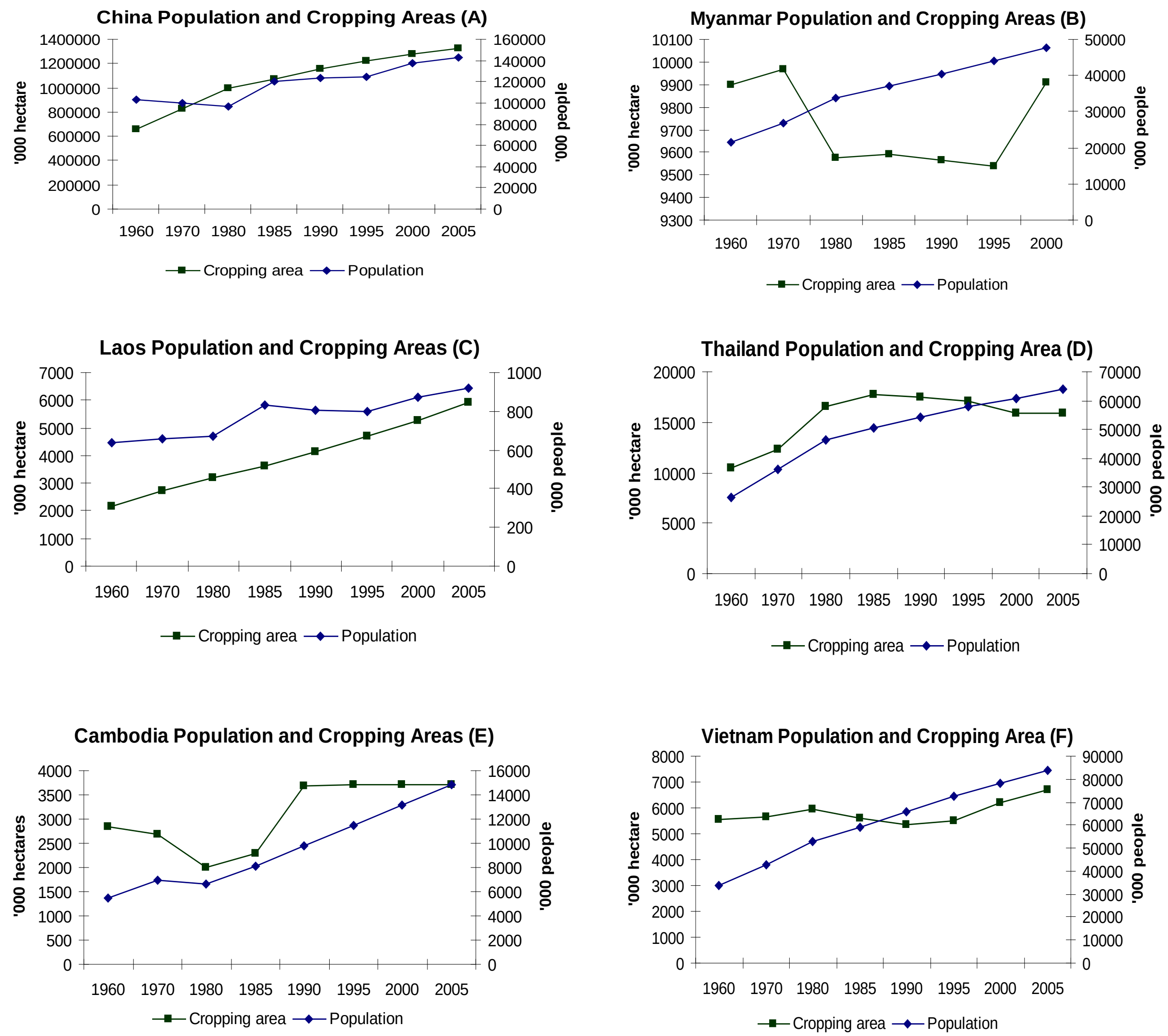
2.3.3 Population and Land Use Change in Mekong Region

The relationship between demographic factors, mediating forces, and deforestation is complex and is not fully understood. However, the analysis of long-term population (United Nations, 2005) and cropping-area changes in all countries in the Mekong region during the past four decades (1960–2004) does not produce a uniform relationship between population growth and land-use change. There are general indications that the extent of agricultural land has been increasing at the expense of forest land over the 1990s in the Mekong Basin.

As shown in **Figure 2.11** all Mekong countries except for Myanmar experienced cropping land area increases in proportion to the increase of population until 1995 when-after agricultural land expansion has been much slower than population growth. This result suggests that although population size is an important determinant of agricultural land-use change, its form and the intensity of change in the Mekong River Basin in a particular locale are influenced by other factors, including land-tenure policies, international markets for forest and agricultural products, land resource availability and the level of competition for it, technological factors, and development.

Agricultural expansion to meet the growing number of population is judged to be just one of the key causes of deforestation. Other factors include logging (illegal and legal), domestic and international market demand, agricultural expansion, infrastructure development and fuel-wood collection and human settlement (ADB, 2000). There are other underlying factors of deforestation including institutional and policy changes (ban on logging and poor state of enforcement), lack of other alternative energy supply, poverty, small land holding, demographic changes and migration, and parts of arable land infested by land-mine and unexploded ordinances. Lack of reliable data on intra-regional forest products trade, on quantity and quality of forest, and on actual rate of deforestation - different definition of forest/vegetation type - make it is extremely challenging to quantitatively assess the future trends and likely impacts on the forest cover and its ecological and economic values (Lang Ch, 2001; ADB, 2000; MRC, 2003). Some land classified as "forest' is, in some cases, shrub land with little economic or ecological value.

This study's findings confirm that population size is only of many important determinants of food demand, the type of agricultural land-use change and the implications of that change are determined by fundamental social, economic, and political factors, and resources availability. The recent changes can be of a result of competition for land use by urbanization, industrial development, watershed management, and increase in crop productivity, or land suitability issues.



(Data source: FAO, 2006 - Cropping land refers to land under temporary and permanent crops, temporary meadows, market and kitchen gardens, and temporarily fallow land)

Figure 2.11 Comparative analysis of population growth and Agricultural land expansion

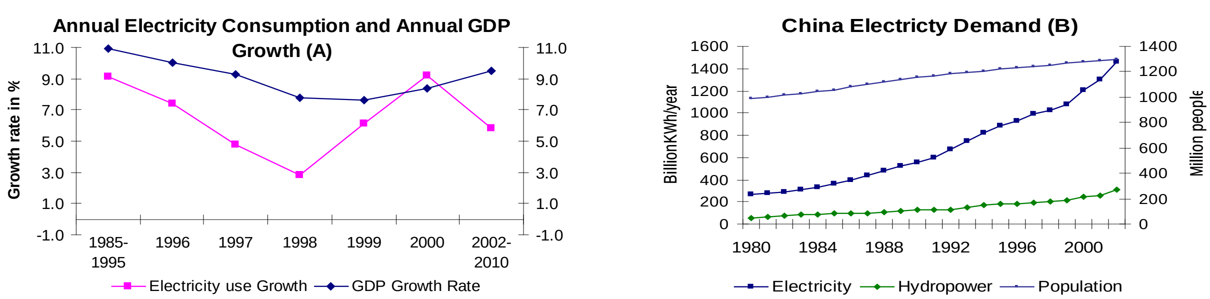
2.3.4 Population Growth and Energy/Hydropower Development in MRB

Globally, net electricity consumption is expected nearly double to over the next two decades, according to the International Energy Outlook 2010 (IEO, 2010). Reference cases predict world marketed energy consumption grows by 49 percent from 2007 to 2035. Total demand for energy was 495 quadrillion British thermal units (Btu) in 2007, and projected to increase to 590 quadrillion Btu in 2020, and 739 quadrillion Btu in 2035. Even though fossil fuels (liquid fuels and other petroleum, natural gas, and coal) are expected to continue supplying much of the energy used worldwide, the share of the hydropower is growing remarkably (IEO, 2010). Developing nations in Asia especially China, and India are expected to lead the increase in world electricity use (IEO, 2010).

It is quite obvious that electricity supply continue to grow in the Mekong Region to support economic growth, demographic change (population growth and urbanization) and improved electrification. But there is no consensus on how much it will grow in the coming years. Demand is one of the critical elements in the analysis of future hydropower development in the Mekong Region, since demand drives the requirement to install new generation and level of operation of generating unit.

As stated earlier, the electricity demand grows rapidly in China and the Mekong Sub-region. But there are different projections on the demand growth rates (World Bank, 1999; GMS, 2001, IEO, 2010). It has been a concern that the conservative growth forecast might affect proper planning and investment and end up with a power shortage (Lin B, 2003). It is equally important to clarify whether demand estimates are unnecessarily 'high' and being used as justification to permit headlong expansion of hydropower production without exploring appropriate technology and all other alternatives (Dore J and Xiaogang Y, 2004; MRC, 2010a).

The analysis by the present study on the actual power use shows that the demand growth rates are not constant. The demand tend to go up and down in respond to market/tariff and economic conditions, countries' financial and technical capacity (generation and transmission line limits), increase in energy efficiency and conditions of industry.

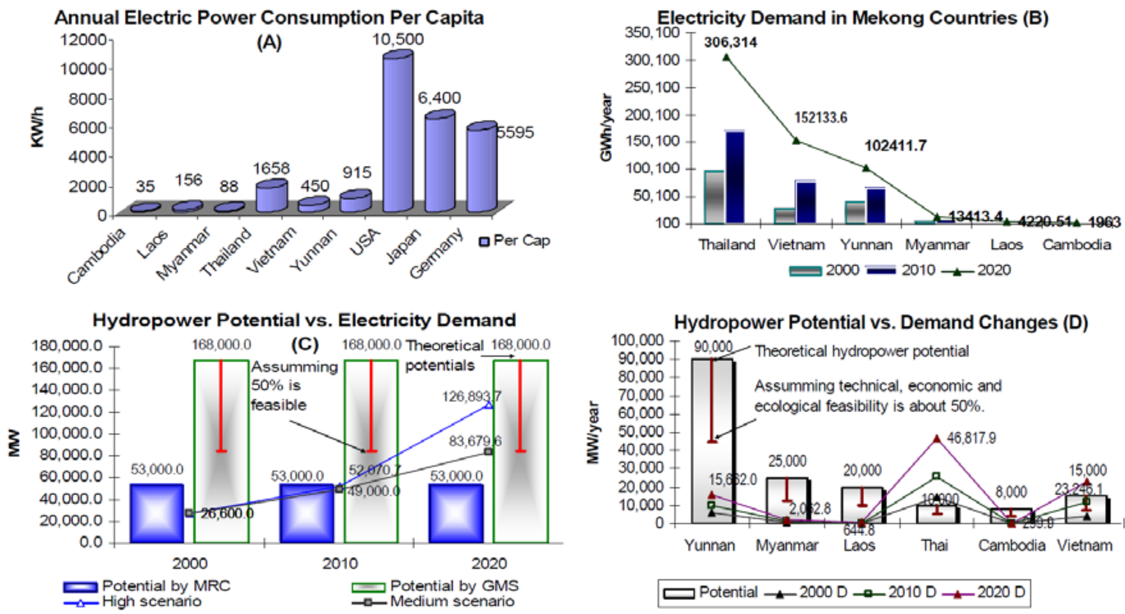


(Data source: Energy Information Administration, 2005 & 2006)

Figure 2.12 China annual electricity & GDP growth rates; Graph (B) electricity generation, hydropower production, and population growth in China

As shown in Figure 2.12 **Graph A** and **B**, the electricity consumption in China does not correlate well with the GDP and population growth rates. This explains the complex nature of factors driving electricity demand that include not only the population and GDP growth, tariff changes and electricity prices, but also availability of other energy sources, consumer preference, accessibility, structural changes in the economy, efficiency improvement, and demand-side management. So the population should not be the single most important driver of the hydropower development in the Mekong Region.

Yunnan, with population of over 40 million, used to account for over 22% of the regional power consumption, will be over-taken by Vietnam as second largest power user in the region by 2020. Power demand growth in the China and other Yunnan neighbouring provinces - Guangdong, and in the Guangxi Zhuang Autonomous Region, is expected to be high also (Dore J and Xiaogang Y, 2004). All these demand increase perceptions will certainly drive the push for hydropower development in the MR.



(Data source: various)

Figure 2.13 Key Electricity and Hydropower Indicators in Mekong Region

Graph A of the **Figure 2.13** shows per capita electricity consumption in Mekong Region comparing to selected industrialized nations, **Graph B** presents electricity demand in each Mekong country (based on ADB and World Bank estimated growth rates). **Graph C** depicts the Mekong hydropower potentials estimated by ADB and the World Bank vs. projected electricity demands by them; and its **Graph D** introduces the estimated hydropower potentials and demands by countries.

Based on those projections by ADB and World Bank, the regional power consumption is likely to grow from 174,000GWh (26,600MW) in 2000, to around 321,000GWh (49,100MW) in 2010 (increase by 45%) and to between 550,000GWh (84,000MW) (by 68%) and 830,000 GWh (127,100MW) (79%) in year 2020 (Pech S, and Sunada K, 2008b). Although, the future electricity demand in many countries is likely to follow a lower growth rate (last column of Graph B), the electricity production has to be increased to meet the expected growth in demand. To date, about 3,200 MW or 10% out of an estimated/theoretical potential of 30,000 MW has been put into operation in the LMB. The situation is now changing rapidly with a further 3,200 MW under construction and more than 50 memoranda of understanding signed with private developers to study the feasibility of implementing other projects over the next decade (Bird J., *et al.* 2008). This rapid hydropower development is causing serious concern for development banks (e.g. ADB and World Bank), and regional river basin organizations (e.g. MRC), and civil society organizations (CSOs).

It is true that the demand projections include substantial system losses (currently 11% in Thailand, 14% in Vietnam, 18% in Myanmar and 29% in Laos and Cambodia (GMS, 2001). But the decrease through saving will cope only with some percentage of expected increase in demand associated the with the increased use of additional offices and household electric applicants, improved access to electricity, increased level of income, and limitation/restriction of the use of fire-woods as cooking and heating energy sources

Gr**aph B** of the **Figure 2.13** shows a break-down of electricity demand as projected by the Asian Development Bank (GMS, 2001). Thailand, Vietnam and Yunnan are expected to lead the increase in GMS electricity usage. Thailand used over 60% of the total electricity consumption in Mekong Region in 2002 and Thailand continues to be the principal market in the region, though its share was expected to fall to about 52% by 2010 and 40% by 2020 as power use in Vietnam and Yunnan increase (MRC, 2010b).

2.3.4.1 Issue of Knowledge Application in Hydropower Development in MRB

The Mekong Region is well endowed with both hydro and thermal resources. The Sub-region holds nearly 25 billion tons of coal, of which most can be found in Yunnan (23.6 billion tons), and significant reserves are in Thailand, Laos and Vietnam. Vietnam also holds abundant oil and gas reserves: five billion tons of oil and more than four trillion cubic feet of gas. Thailand and Myanmar have significant oil and gas reserves as well. These petroleum reserves are many times the present consumption levels (MRC, 2001; World Bank, 1999). However most of the exploitable resources are not evenly distributed and accessible.

The total hydropower potential of the Mekong River Basin (MRB) is estimated to be 53,000 MW, with about 30,000 MW technically available in the four lower Mekong countries of Cambodia, Lao PDR, Thailand and Viet Nam (MRC, 2010b). At present, only about 19.7% of the total estimated hydropower potential in the Sub-region (10% for Lower Mekong) has been developed (Pech S, *et al*, 2010a). By all estimates, Yunnan Province accounts for the largest share of the hydropower potential, followed by Myanmar, Lao and Viet Nam (MRC, 2010b). Investment in hydropower over the last two decades has been expanding rapidly. Thailand, Viet Nam and China's electricity demand and their geo-politic position also drive the hydropower development and energy trade in other parts of the Mekong Region. But it is safe to assume that the pushing factors may become stronger that make some of those hydropower projects become less feasible if not completely infeasible from technical (expected increase flow may not actually take place), economic and financial (increased internality vs. externality on end users and communities).

As demonstrated in the previous **sub-section** that demographic dynamic is only one many factors driving hydropower development in the MRB. There are other driving and underlying factors that either push for or prevent any aggressive exploitation of the Mekong hydropower potentials. It is obvious that the perception on the exponential increase of the regional electricity demand drives the hydropower development and energy trade in the MR. Other key drivers for hydropower expansion include the on-going push for and direction of economic growth and structural changes in the economy, energy security concerns, and a political environment in which energy entrepreneurs have strong incentives to push ahead with expansion plans (Dore J and Xiaogang Y, 2004; Magee D, 2005).

Table 2.8 Factors Influencing Hydropower Development in Mekong Countries

Pushing Factors	Negating Factors
Agenda for an integrated approach to energy development and regional energy trade is being put in motion by regional players, such as GMS, ASEAN and State and Private Power Producers	Rethinking on hydropower development strategy in most of the Mekong countries and funding agencies following the World Commission on Dams Report combined with regional economic downturn (1997 Asian Financial crisis).
Hydropower proliferation: Rise in oil and gas price, hydropower is thought as a "cheaper and reliable" source of energy. China begins providing financial supports, and exporting the state-of-the-art hydropower development World Bank now returns to Mekong sub-region to support mega infrastructure projects (World Bank & ADB, 2006)	Public awareness and anti-dam movement is growing, even in countries with one party-political system. Donor countries and funding agencies are under pressure from their own constituencies and internationally not to fund projects with high environmental and social risks. Lao, Yunnan and Vietnam's reliance on hydropower face with high seasonality problem of water level and severe drought.
Corporatization of the electricity industry, A move towards private financing Private power producers and investment groups	MR Countries' Lack of investment requirement for power generation and transmission (US$ 10 – 14 billion annually from now until 2020 (see e.g., World Bank, 1999).
	Lack of enabling conditions, such as the existence of utilities with sound financial structures, profitable operations and good billing and collection performance, features of predictability and stability.
Major electricity buyers - Thailand and perhaps Vietnam trying to diversify external supplier (Laos, Yunnan, Myanmar, etc.) and develop options for domestic power generation.	Significant improvements in the fuel efficiency of combined cycle gas turbine (CCGT) generating plant reduce the price per unit of electricity production

(Source: MRC, 2001; Ryder, 2003).

There have been debates on performance, benefits and negative impacts of the large dams culminating in the World Commission on Dam (WCD) Report released in 2000. The WCD findings show a mixed success of most of the studied large dams.

Table 2.9 Positive and Negative Impacts of Dams in Mekong

Positive Impacts	***Negative Impacts***	***Comments***
Flood control downstream	▪ False sense of security in face of historical flood (100 – 500 year flood) ▪ Impact of abrupt release of flood water. ▪ Potential dam breaks due to earthquakes, landslides, storm, reservoir mismanagement…	▪ Need regional dam operation rules, and advanced flood and storm forecasting to support proper dams operations, ▪ Need regional mechanism for early notification and impact mitigation.
Navigability improved with less requirement for channel improvement	▪ Bank erosion and pollution from increased navigation and its accidents. ▪ Asymmetry in fleets and trade imbalance.	▪ Need navigation rules and models (oil spill, mitigation plans); Bank erosion prevention. ▪ Regional environment and trade policy.

▪ Increase dry season flow for irrigation use & preventing sea-water intrusion. ▪ Make possible for inter-sub-basin and basin diversion.	▪ Hamper seasonal river bank farming/gardening; ▪ Impact on natural pulse system (fish spawning, migration and rearing). ▪ Impact on fish habitat and migration route. ▪ Deforestation.	▪ Lack of basin model & data to assess & quantify impacts on other sectors ▪ Need regional regimes for integrated impacts assessment and mitigation.
Sediment reduction	▪ Loss of storage and dam productivity ▪ Affect sedimentation/erosion in downstream areas; ▪ Impact on fish food chain and soil fertility.	As above
Hydropower sale to generate revenue.	▪ Lack of equitable distribution of incomes. ▪ Inadequate compensation and mitigation measures. ▪ Variability of economic performance. ▪ Impacts on downstream livelihoods.	Need regional institutions and governance
▪ Cheap source of energy; ▪ Carbon allowance trading	▪ Maintenance costs rise and climate change possibly alters the hydrological regime. ▪ Possible source of greenhouse gas emission.	▪ Study of other alternatives and technology; ▪ Study on dam related emissions levels.

Dams are constructed to fulfil a variety of human needs, such as power generation, irrigation, flood control and water supply. Flood control, surplus flow for navigation and water diversion for irrigation, and power generation (Chapman E and Daming H, 2000) are widely considered as the benefits of hydropower dams. Other benefits such as stimulation of economic prosperity of a region due to multiple cropping, rural electrification and the expansion of physical and social infrastructure are often cited as well. The dam opponents point to the adverse impacts of dams, such as debt burden, cost overruns, displacement and impoverishment of affected people, impacts on water quality, division and destruction of important ecosystems, impacts on fishery resources, and inequitable sharing of benefits.

According to the World Bank report assessing the development scenarios in the Mekong, the existing and planned dams in this basin will change in-stream conditions, regardless of whether they are regulating storage reservoirs, or run-of-river types (World Bank, 2004). However, all these understandings are not widely shared by many hydropower promoters and Mekong Region decision-makers. The concern is compounded by many factors as follows:

- The lack and poor quality of data leads to a failure to fully understand and correctly evaluate sustainability tests to quantify impacts, the causal mechanisms at work in large, dynamic systems, and to consider and integrate multiple risks and degree of vulnerabilities. Both "pro-dam" and "anti-dam" groups admitted that there are no reliable and independent assessments of the potential costs and benefits of proposed projects, and full exchange of information between governments and between governments and the public, dialogue and cooperative decision-making would go a long way to solving problems, and preventing problems from happening in the future.
- Lack of a truly Mekong-wide institution for negotiating cooperative development, and commonly accepted knowledge base and tools for impact assessment and monitoring. As the number of development projects in an area increases, the incidence and importance of cumulative impacts also increases, sometimes dramatically. Failure to properly assess cumulative impacts can potentially lead to severe negative environmental alterations and events. Better approaches, guidelines and conventions

for carrying out cumulative and cross sectoral impact assessment and monitoring are needed.

- So far, the regional organizations, for example GMS and MRC, are predominantly centred on the rather small political elites of the Mekong riparian states.

2.4 INCREMENTAL AND CUMULATIVE IMPACTS FROM KEY WATER PROJECTS IN MRB

It has been widely recognized that the resources provided by the river, its ecosystems, human populations, cultures and economies that these resources support, do not respect national borders (ADB, 2002a; GMS Summit Declaration, 2005). Similarly, the local and transboundary environmental and socio-economic impacts, benefits and opportunities caused by development activities such as hydropower production, navigation channel improvements, flood management and irrigation schemes in the river basin are poorly understood (World Bank, 2004; UNEP/GIWA, 2006).

2.4.1 Critical Analysis of Existing Assessment Impact of Water Related Development Projects

The current planning and assessment of the hydropower projects in all Mekong countries have been strongly criticized for inadequacy in their methodology, limited data and information, and limited in their scope and methodology. The impact of any qualified development project on the environment and community has been mainly studied using sectoral environmental impact assessment instrument (EIA) and sectoral decision-making (ADB, 2002b, World Bank 2004). As shown in **Figure 2.14**, each hydropower, irrigation, navigation, transport or infrastructure development project proponent undertakes their own environmental or social impact assessment individually of discrete elements such as noise, air, soil, surface water, ground water etc., and in a format preferred by them.

The practice proved to be fragmented and could not deal with subjects that cut cross sectors and theme of the river basin management; normally led to incomplete and inaccurate assessment of the impacts. As shown in the lowest bar of **Figure 2.14**, the sectoral assessment often results in sectoral decision-making, mitigation measures, management and monitoring plan.

Two key regional assessments of various hydropower development scenarios were released most recently:

1. Mekong River Commission (MRC) Basin Development Plan (phase 2), 2010. Assessment of the Basin-wide Development Scenario; and
2. ICEM, 2010. MRC Strategic Environmental Assessment for Hydropower on the Mekong Mainstream Impacts Assessment (Opportunities and Risks), , MRC initiative on Sustainable Hydropower (ISH), Mekong River Commission Secretariat, Vientiane, Lao PDR.

In the above-mentioned reports, the development scenarios were assessed on a range of hydrological indicators to evaluate water availability and use, and the flow changes caused by different levels of water use (hydropower and irrigation), taking into account the existing and planned developments in the Upper Mekong Basin. The hydrological results were then fed into the assessment of the transboundary economic, social and environmental impacts.

Both these assessments were commissioned by the MRC, but they reached at different conclusion on some key issues on potential environmental, social and economic impacts (MRC, 2010a and b). The Strategic Environmental Assessment (SEA) of the 12 Lower Mekong mainstream dams was implemented in parallel with the MRC Basin Development Plan Phase 2 (BDP2) process and included a number of consultations with internal and external stakeholders.

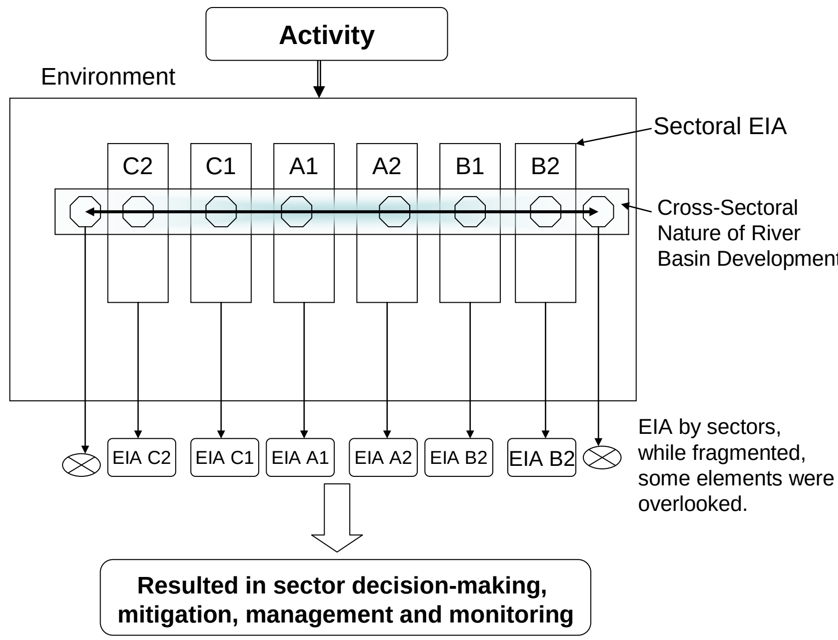


Figure 2.14 Sectoral Impact Assessment and Cross-Sectoral Nature of River Basin

The Strategic Environmental Assessment (SEA) and Basin Development Project phase 2 (BDP2) cover the 12 and 11 mainstreams dams respectively in their Foreseeable Future scenario in addition to numerous other dam projects on the tributaries and substantial increase in irrigation abstraction. Whilst the SEA draws on the BDP2 scenarios to inform their analysis, there are obvious discrepancies in the analysis, assessment and conclusions in the BDP2 and SEA reports. Some main differences and contradictions include:

- Fishery assessments of BDP2 and SEA contradict each other in some aspects such as replace value of aquaculture and reservoir fisheries for the loss of capture fisheries.
- There are different considerations of sediment and nutrient issues, and associated environment consequences from increased use of chemical fertilizers and pesticides to replace loss natural nutrients.
- The two reports have widely varying assessments of the energy scenario, especially in comparison with 'other river benefits' (Pech S, *et al*, 2010c).

These weaknesses are seen in the development of the scenarios by this regional river basin organization. The flaw included the narrow scope of the overall plan by severely limiting its constricting of IWRM to only hydropower and irrigation, and lack of consideration of trade-offs to offset livelihood losses or between countries within sectors of loss (e.g. fisheries, social consequences of resettlement) or gain (hydroelectricity or expanded irrigation).

In spite of some attempts to create a framework for assessing the impact of various development projects in the MRB, there is so far no actual 'cumulative assessment" study has been carried out yet on those major water development projects and programmes. The absence of a comprehensive impact assessment and monitoring system from broader and strategic perspectives in the Mekong Region further compounds the concern for severe cumulative impacts on resources sustainability and livelihood.

The study also observes that several impact assessment frameworks and methodologies providing possibilities to look at impacts at different levels and phases already exist in the Mekong Region, however, the use of different impact assessment methods has so far been rather non-systematic - weak linkages between different assessments components especially those of social aspect and livelihood, weak sensitivity analysis, and misunderstandings related to impact assessment methodology and terminology.

2.4.2 Testing Cumulative Assessment Impact of Water Related Development Projects

The traditional approach implied a strong hydrological focus in the analysis; practices to control quantity, quality, and timing of water flows. It has frequently been criticized for its short-coming. Consideration and integration of multiple stresses and magnitude and multiple risk/degree of vulnerabilities can serve as one of examples of an integrated analytical approach towards regional planning and development of the Mekong Basin water and other key resources.

Since water is a key strategic resource, vital for sustaining life, promoting development and maintaining the environment, the water sector assessment approach applied in this study is concerned both with water issues and other closely associated water resources/ elements and people that depend on it or intimately linked thereto. In this study, the assessments of water focuses not only on the availability of water for human use at particular time and space, but also the quality and quantity of water required by an aquatic ecosystem for the protection and maintenance of its structure, functioning, and dependent species (Vladimir S *et al*, 2003, Pech S, 2011).

A fundamental point of departure is the changes/impacts and what will they affect other water elements and people's livelihood whose dependency of on the river's water and related resources are so strong. They are particularly important and critical among the rural poor who heavily depend on subsistence livelihood, and morale economy. Based on that, the following key indicators and variables are selected for assessing the potential water sector changes – hydrological changes, and changes in other water elements - geo-morphological changes that have implication on ecosystem sustainability and sustainable livelihood.

All projects and plans for developing hydropower, intensifying water abstraction for irrigation and large scale mining activities are the most likely major impact drivers. The building of roads and similar structures in the watershed and floodplains, and large scale rubber plantation potentially cause further hydrological and morphological changes but mostly locally.

The hydropower and diversion of water for agriculture across the Mekong Basin are presently the most important economic activities of interest/concerns. It is not possible to assess the impacts of each and every dam and irrigation project due to the fact that they are so numerous in numbers and data availability is the biggest challenge. It is true that the magnitude of the impacts changes with the change in number and locations of dams and other major water related uses and infrastructures that will be actually built and operated. The magnitude of the impacts also depends on the way on how these projects are designed, built and operated, as well as types of technology to be applied.

One thing is clear that these major development projects in both incremental and accumulative manner will change hydrological and other water element regime. Changes in the hydrological regime will change the wetlands and their functions. The changes in the Mekong flood pulse are expected to have transboundary impacts, particularly for the floodplains in Cambodia, including the Tonle Sap Lake and the Mekong Delta (MRC, 2010c). Large dams in particular may also reduce sediment transport and associated nutrients, and disconnect wetlands from the river system.

2.4.3 Expert Opinion on Combined Impacts

Based on the expert opinion and the evidence provided in the previous sections, this section aims to provide an assessment of the combined impact on water sectors assuming all these changes realised in the near future.

All projects and plans for developing hydropower, intensifying water abstraction for irrigation and large scale mining activities are likely to create impacts. The construction of roads and similar structures in the watershed and floodplains, and large scale rubber plantation potentially cause further hydrological and morphological changes but mostly with local implications. The hydropower and diversion of water for agriculture across the Mekong Basin are presently the most important economic activities of interest/concerns.

It is not possible to assess the impacts of each and every dam and irrigation project due to the fact that they are so numerous in numbers and data availability is the biggest challenge. One thing is clear that these major development projects in both incremental and accumulative manner will change hydrological and other water element regime (World Bank and ADB, 2006).

Table 2.10 Summary of Potential Cumulative Impacts

Aspects	Indicators/ Variables	Foreseeable 20 years 2030 with LMB dams
Hydrological changes	Development sector totally alter hydrological regime of the entire basin.	
	Water level	Mainstream flow fluctuation relatively slow - +/-0.16m/day at Luang Prabang, +/-0.11m/day at Pakse and 0.09m/day at Stung Treng. But further changes depend on dam operation and regulation (peaking vs. continuous). Areas immediately (40-50 km) below reservoirs can experience up to 3-6 meters of daily flow fluctuations from peak operations and abrupt release. Potential flood hazard due to storage reservoir operation in the receiving basin.
	Flow level in dry season at specific	Mainstream flow change due to mainstream dams has the least positive effect to support any major water diversions from Tributaries. Tributaries from where water is abstracted will be more severely

Aspects	Indicators/ Variables	Foreseeable 20 years 2030 with LMB dams
	locations;	impacted. Intra-basin diversions can cause significant reductions in dry season flows in the mainstream reaches by-passed by the diversion. 25 - 50 or 70% increase in dry season in Northern Laos and Thailand (higher than annual deviation), but only 10% in Delta. Increase in irrigation water use coupling with sea water rising will further exacerbate water shortage in extreme drought period in Delta. Large quantities of water will be extracted either from the river or as groundwater for the extraction and production of minerals ➔ local and transboundary low flow issues can be escalated during the dry season and during drier years for downstream communities in Lao PDR and Cambodia
	Flood timing	More even hydrograph in stretch above Vientiane Transition from dry to flood: 2-4 weeks shorter above Pakse, and by 1 week in Cambodian Floodplains. Spates and first flushes of transition to flood no longer occur. Further reduction the length of transition period to flood season (disappearance totally above Vientiane). Emergency release due to flooding to avoid dam break will cause flooding in the immediate downstream stretches.
	Flood duration	Shorter flood peak - Mostly at uppermost reaches Lower and shorter flood peak
	Flood area	Reduction of 300,000ha in flooded area (15% in Thailand and Laos, 5% in Cambodia and Viet Nam 9000 – 150,000 ha of garden and agricultural land inundated in dam reservoir sites (54%) in Chiang Saen to Pakse. Disappearance of floodplains and channels due to impoundment of river stretches into reservoirs. Downstream: reduction in wetland by 34% in Laos, 18% in Thailand, 2.4% in Cambodia
	Reverse flow/water level in Tonle Sap;	Reduce flooded area by 500-600km2 (- 5 to 10%) – affect reverse flow in and out. Increase in dry season inundated area +5 – 8% Some 82% of the total flooded area was subject to shorter flood durations under the worst case Average annual flow into TLS will be reduced by 13% or over 430 MCM.
	Inundated area, duration and timing	Significant reduction in flooded areas and wetlands in LMB floodplains and Tonle Sap. Sea-water intrusion prevention in VN Delta causes flooding in a wider area and longer flooding duration. Duration of the ending flood drainage for the entire delta would be longer.
	Storage	700% increase in active to store 14% of the mean annual flow (9.9 -> 68.8km3). Series of 300 new large and medium-sized reservoirs and 25,000 community reservoirs in North-east Thailand as result of water diversion schemes.
	Change in water quality (turbidity and relevant quality	Reduced turbidity by 75% Overall nutrient loading from irrigated areas increases with 85% (N) and 100% (P) Overall nutrient loading from wastewater discharges increases with 33%

Aspects	Indicators/ Variables	Foreseeable 20 years 2030 with LMB dams
	parameters -	(N and P) Considerable basin-wide increase in herbicide and pesticide/fungicide use (75% and 59%) Point-source and non-point source pollutants are expected to substantially increase for irrigation expansion and human activities in Vientiane Plain and from return flow from Mun Chi (Thailand). Increases are largest in the Mun – Chi Basin, the 3Ss Basin (agricultural run-off and mining operations) and the Tonle Sap Basin Large-scale mining in Bolevan will cause serious water quality issue locally, but there will be long-term transboundary water quality issues in 3Ss region. Investment in water infrastructure for salinity intrusion prevention will reduce flushing capacity that lead to further deterioration of water quality in the delta areas of Viet Nam.
	Change in salinity intrusion	Increase in dry season flow from dam operations will be offset by sea level rise by 0.3m or 1m by 2100.
Geomorphological changes	Barrier effects and dis connectivity	▪ 55 - 66 % of the total LMR 1760 km river distance (Sambor to Pak Beng) and 81.3% of the watershed will be obstructed. ▪ Major changes to sediment transport of all sizes ▪ Local alteration of surface hydrology crossed by roads, resulting in increased sediment and increased soil erosion. ▪ Changes in the level of the water table ▪ Sea Water Intrusion and flood control infrastructures will cause further ecological and habitat dis-connectivity in Mekong Delta
	From UMB	75 to 80% reduction (90Mt to 20Mt/year) Half the amount of nutrients. ▪ Medium size sediment to Kratie-PP –TLS decrease to 0 by 2050. ▪ Fine-sized sediments reduced by another half at all locations. ▪ Nutrient reduced by another 50%.
	Within reservoir area	• Formation of deltaic type deposits at the head of each of the reservoirs. • Middle and lower parts of each reservoir will sediment during flood events, associated with reduced velocities/gradients. • Sedimentation and deltalic formation at head of reservoirs. • Sedimentation in reservoirs.
	Downstream and critical deep pool and habitat	• Erosion starts from Chiang Sean and progressively downstream but slowdown by deep-pool. • Increased down cutting and bed and bank erosion in Vientiane-Pakse reaches. • Riverbed and bank erosion Vientiane-Pakse reaches, and Pakse-Kratie. Changes in Thalweg border lines between Laos and Thailand • Bank and bed erosion starts to be felt at Kratie to PP reaches. • No more supply of sand sized sediment to Mekong Delta (not enough stream power for suspension) • 335 deep-pools continue to function, but their long-term functioning may affect. • 48% of them are lost. (About 70% on Chiang Saen- Vientiane reaches. -

Aspects	Indicators/ Variables	Foreseeable 20 years 2030 with LMB dams
	Mekong Delta	• Reduce in floodplain sedimentation • §165 million tonnes per year down to 36% in 20 years. • Stability of the delta shaping processes due to loss in sediment deposition, which are potentially further exacerbated by sea level rise • Greater instability and erosion of channel; • Some sections of the dykes would have to be even relocated to further land due to the seashore erosion; • Rises in sea water levels combining with increased water consumption within the Mekong Delta and upstream will push saline and saltwater further inland. • Higher embankments and strengthening of dikes and roads, sluice gates for salinity intrusion will lead to hydrological and morphological changes and variation (obstructions to flood drainage, increasing flood peaks, and increase sedimentation and erosion) on both sides of the border.

2.4.4 Hydrological changes

2.4.4.1 Water Level

As shown in Table 2.10, in hydrological term, it will be for the very first time since records began in 1915 that the development sector alters the hydrological regime of the entire MRB – most of these impacts are from the hydropower development. The active storage will potentially increase by 700% from 9.9 to 69 km^3 and about 23.7 km^3 or 36% will be within Yunnan province, mainly from its two largest hydropower dams with active storage about 22.2 km^3 (Xiawan and Nuozhadu) (MRC, 2010b). With the 11 LMB mainstream projects, 55% of the total length of the mainstream stretch between Chiang Saen (Thailand) and Kratie (Cambodia) will be converted to reservoir and the change transforms the river from a free running river to a series of impoundments with slow water movement and rapidly changing flow in response to dam operations (MRC, 2010b)[4].

2.4.4.2 Flow level in dry season at specific locations

The increase in dry season flow will theoretically be able to meet a planned increase in irrigation abstractions over current levels depending on location along the mainstream. However, China and other LMB dams will cause an increase in lowest and mean minimum annual dry season flows at all stations, except for Kratie where the increase is only around 2% and 10% respectively (MRC, 2010b, Halcrow Group, 2003, Halcrow Group, 2004). The flow increase is the least in the Mekong Delta where the dry season irrigation demand is the highest. Hence, dams have strongest impact in the areas nearest to the dam sites only not in the Mekong Delta where water is needed the most.

The operation of the mainstream dams can cause significant downstream fluctuations during any one day if they are operated as peaking projects. In this case, water level fluctuations

4 Ward P, 2010. Power Point Presentation at Regional Consultation Workshop of June 2010: About 66 % of the total 1760 km river distance, Sambor dam (Kratie) site to the upper end of Pak Beng reservoir, will be affected.

locally may amount to typically 2-4 m or more in extreme cases (MRC, 2010b)[5]. This may have severe implication for local navigation and river bank gardening. About 54% of the riverbank gardens along the mainstream stretches from Chiang Sean to Kratie will be inundated due to higher low flows and reservoirs inundation (Ward P, 2010). The increase in dry season flows between Chiang Saen and Luang Prabang will have positive impact on the navigation and water diversion, but would adversely affect those underprivileged farmers relying on the riverbank gardening and fisheries.

Water abstraction from the River is limited during the wet season when flow levels are high and rain water is available, however, there are many constraints on water utilization during the dry season, especially in the drier years. The drier years pose the most severe water constraints.

The increase in mean monthly flows will be expected for at least the three months of February to April. But in early dry season (December) most downstream stations starting from Vientiane expects reduction in flow due to dam operation and high demand for irrigations. If the planned large scale diversions in Thailand are materialized, further reduction in base flow is expected. The dry season flow change would be more remarkable, with the projected increase of the dry season irrigation in the area further downstream of Kratie, but may be compensated slightly by the hydropower reservoirs operation in Vietnam Central Highlands.

Areas immediately (40-50 km) below reservoirs can experience up to 3-6 meters of daily flow fluctuations from peak operations and abrupt release, and emergency release due to flooding to avoid dam break will cause flooding in the immediate downstream stretches.

Moreover, this projected increase in dry season flow from upper mainstream stretches will not directly benefit any planned diversions from the tributaries. For instance, intra-basin diversions will cause significant reductions in dry season flows in Nam Ngum/Nam Lik tributaries from where water is abstracted. It can cause positive and negative transboundary impacts mostly in relation between Lao PDR and Thailand that share this stretch of Mekong River as their political boundary (Thalweg channel). Positive impact will be for Thailand for additional irrigation water; however, there will be a potential flood hazard for the reservoir operation in wet season. It will cause more severe impact and at the mainstream reaches by-passed by the diversion, especially in drier years. A diversion of a constant rate for the whole year potentially cause water shortage during critical dry season months (February to May), and will cause water shortage for other uses and reduction contribution flow for maintaining minimum flow in the Mekong Mainstream.

It is expected that large quantities of water will be extracted either from the river or as groundwater for the extraction and production of minerals, e.g. for washing of ores and in the production processes. The local and transboundary low flow issues can be escalated during the dry season and during drier years for downstream communities in Lao PDR and Cambodia (ADB - RETA 40082, 2011).

5 Ward P. 2010. Personal communication: The time elapse for a rapid fluctuation from opening the turbines - planned and unplanned circumstances, and breakdowns of plant and electrical transmission systems at the proposed LuangPrabang dam site, will be about 1 to 1 ½ hours to the city of LuangPrabang, very little warning time for bank-side residents to prepare for inundation.

2.4.4.3 Expected Changes in Flooding Conditions

The onset of transition from dry to flood season will be significantly reduced - 7-8 weeks earlier in Chiang. Saen6, and 2-4 weeks earlier at upstream of Pakse and 1 week at Kratie. This change will see a reduction in the important freshwater '*spates*' which drive many ecosystem functions such as fish spawning, lave dripping and fish migration.

The water diversion during flood season is limited due to limited irrigation needs and limited water storage capacity. The impact of dam and irrigation developments on flood conditions will vary at different key points of the Mekong River. The mainstream dams in the LMB will provide limited flood protection to the location immediately downstream (MRC, 2010b, 2010c, 2010d). The flood reduction functions of the dams may cause false sense of security in face of historical flood (100 – 500 year recurrence flood) and dam failure due to earthquakes that may lead to dam break and unplanned abrupt release of flooding waters from the reservoirs. Records from around the world indicate that flood protection (which does not bring in revenue) tends to be neglected in multipurpose projects (Pech S et al, 2010c, Pech S, 2011)[7].

The reduced flood season peak flows would reduce the extent and duration of the inundation of the floodplains and contribute to bank erosion on the critical stretches and infilling of deep pools (MRC, 2009). There will be an overall 7% reduction in flooded area (309,000 ha) in average year. The reduction areas are expected to be smaller in wet years and larger in dry years. The greatest area of reduction occurs in Cambodia (142,000ha), Lao and Thailand (17% and 19% reduction respectively) (MRC, 2010b).

2.4.4.4 Reverse Flow in Tonle Sap and Impact on Water Level and Inundated Area, Duration and Timing

The changes in the Mekong flood pulse are expected to have transboundary impacts, particularly for the floodplains, the Tonle Sap Lake and the Mekong Delta (MRC, 2010c). For 2030, the dam-development scenarios will result in significant changes in the ecology of the Tonle Sap Lake and Mekong Delta. The inundation of the Tonle Sap Lake will reduce by 5-10% (500 – 600km^2). However, sea-water intrusion prevention measures in VN Delta will cause flooding in a wider area in both Cambodia and Viet Nam parts of Mekong Delta and longer flooding duration. Duration of the ending flood drainage for the entire delta will be

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6 MRC, 2010b: At Chiang Sean, peak daily flows will be reduced by 18% (1,100m3/s), and dry season flow volume will be increased by about 61% (12,093 MCM), and peak daily flows at Kratie will be reduced by 7%, and dry season volume will be increased by 23%.

7 Most of the dams have not been designed to take into consideration major natural disasters such as earthquakes or floods. Lessons from the typhoon Ketsana (end of September 2009) show that mismanagement can cause misery to vulnerable communities. Even where they have been considered, the imperatives of maximizing revenue obliged the dam operators to keep a reservoir as full as possible (and thus maximize hydropower generation as well as irrigation water availability). In recent years a number of earthquakes have taken place across Asia resulting in impacts to numerous dams (Mongabay.com, 2008; Brewer, 2008; Vijay and Ramesh, 2005; Hough and Martin, 2001). For example, the 12 May 2008 earthquake in Sichuan province of China (7.9 magnitudes) seriously damaged hydroelectric dams and caused serious social and economic losses. Sixty-nine dams were in danger of collapse, 310 were at "high risk," and 1,424 posed a "moderate risk" (Brewer, 2008). China said it would spend more than $1.3 billion per year fixing vulnerable dams, many of which were poorly constructed (Mongabay.com, 2008; Brewer, 2008). USGS Earth Quake Hazards Project reported two major quake measuring 4.7 on the Richter scale in late February 2011 and 6.1-magnitude quake in 2007at the proposed mainstream dams near Xayaboury, Lao PDR.

longer and the flow stagnation will also bring about more water quality issues in the Mekong Delta.

The reverse flow in Tonle Sap will start at least a week sooner, and the average day of reverse flow will be shorter (for about 8 days). Dry season inundated area increase by 5 to 8% turning seasonal terrestrial ecosystem into permanent aquatic. These changes will affect ecosystem and farming productivity, fish migration and sediment flushing capacity. The decrease in reverse flow volume in flood season to the Tonle Sap Lake will result in a reduction of flooded area, flood depth and duration; and a reduction in sediment inflow into the lake (MRC, 2010b, Pech S, 2011).

2.4.4.5 Change in water quality (turbidity and relevant quality parameters

These dam development and operation will reduce turbidity by 75% (sediment transport) due to dam sediment trapping. The increase in dry season flow means more water for irrigation, water supply and other uses, but expansion and consolidation of agriculture and irrigation will also lead to an increase in use of chemical fertilizer to offset losses in sediments. The expansion of the production cost (water fee, inputs and labour) will be potentially much higher.

It will see considerable basin-wide increase in herbicide and pesticide/fungicide use (75% and 59%), and overall nutrient loading from irrigated areas increases with 85% (N) and 100% (P). The increases will be largest in the Mun – Chi Basin, the 3Ss Basin (agricultural run-off and mining operations) and the Tonle Sap Basin.

There will be an increase in overall nutrient loading from wastewater discharges increases with 33% (N and P), as increase in urbanization along the mainstream and key tributaries. It is expected that the impacts of large-scale mining in Bolevan Plateau on water sector will be substantial water quality issue (from a local and a transboundary perspective) within some critical transboundary catchment. Pollution affects mainly surface water and potentially groundwater from highly alkaline red mud, with its associated contaminants from bauxite mining, and leach out of toxic compounds, metal salts etc., into the water and hence discharged into streams and rivers and in the sediments.

In the scenario where the Vietnamese government will invest in water infrastructure (higher embankments and strengthening of dikes and roads, sluice gates), this structural measure will cause not hydrological and morphological changes and variation on both sides of the border, but will also cause stagnation of flow and reduce flushing capacity that lead to further deterioration of water quality in the delta areas of Viet Nam (Pech S, 2011).

2.4.4.6 Change in salinity intrusion – extent, duration, and concentration

While water availability in the critical period of the dry season is problematic, more irrigated water is needed most during that period of April and May, especially, in the Vietnam's Mekong Delta (MRC, 2002). In the Mekong Delta where the water abstraction for irrigation is extremely high use coupling with sea water rising will further exacerbate water shortage in extreme drought period. Hence, the reduction of dry season flow without compensation from other flow coupling with climate changes may potentially deteriorate salinity intrusion in Mekong Delta.

A larger flow contribution is from the return flow from the Tonle Sap during the early stage of dry season (Dec – February) to the downstream of Chaktomuk and eventually to Mekong Delta in Viet Nam. It confirms the important role of the Tonle Sap Great Lake in the early phase of the dry season flow regulation in the Delta. A drastic change to the flow level at the Mekong Delta will be expected if the flow into and from Tonle Sap is tempered with or drastically reduced or delayed by upstream dams operations and diversion.

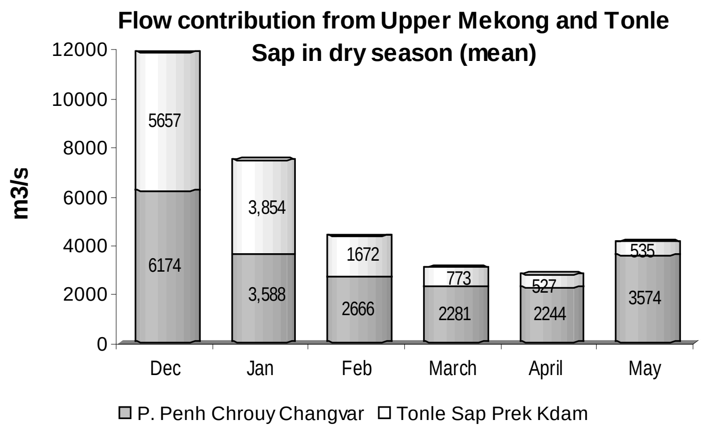


Figure 2.15 Chaktomuk Average monthly minimum flow from upper Mekong and Tonle Sap Rivers

Comparing the irrigation volumes of 2000 with flow volume of April and May shows that the irrigation demand constitute 81 - 76% of the flow availability. This is confirmed by the report of incidence of sea water intrusion in the Mekong Delta area of Vietnam. With a projected growth in irrigation water use, the critical dry season months - April and May - will face serious water shortage and tough competition among water uses, as irrigation demand alone already surpasses flow availability (World Bank, 2004).

Earlier studies by the consultant teams commissioned by the Mekong River Commission (MRC), and by Chinese expert estimated that during low flow period the Mekong Delta flow needs at least 1500 m^3/s for preventing any severe sea water intrusion (Daming, 1997; SMEC, 1998). The MRC and Vietnamese Sub Institute for Water Resources Planning estimated the water requirements for crops in the Vietnam's Mekong Delta (2000) was at around 1528 - 1018.7 m^3 per second during critical dry period, namely February until May, when the observed mean discharge at Phnom Penh, Cambodia (starting point of the Mekong Delta) was measured between 1984 – 2769 cubic meters/second during that same period of time (MRC data). Besides meeting the irrigation and other farming water demands, that flow is needed also for preventing sea water intrusion and other ecological functions. In order to satisfy the requirement for further irrigation expansion and to prevent sea water intrusion in the Delta area, the additional dry season flow need to be generated in March, April and May either from the points above Kratie and from Tonle Sap Great Lake, if the dry season irrigation in Cambodia and Vietnam is to increase to the maximum.

Furthermore the rises in sea water levels combining with increased water consumption within the Mekong Delta and upstream in the dry season and droughts, will push saline and saltwater further inland. The Vietnamese government will invest in water infrastructure (higher embankments and strengthening of dikes and roads, sluice gates). This structural measure will cause hydrological and morphological changes and variation (obstructions to flood drainage, increasing flood peaks, and increase sedimentation and erosion) on both sides of the border.

2.4.4.7 Geomorphological changes

Large dams (even though being claimed by its proponent as run-off the river) in particular may also reduce sediment transport and associated nutrients, and disconnect wetlands from the river system.

The study by WWF (Jean-Paul Bravard and Marc Goichot, 2010) referred to four dimensions of a River System as far as the geomorphological changes are concerned such as the longitudinal, lateral, vertical and time. The downstream impacts on the longitudinal profile will trigger localized riverbank erosion and indirect effect of a higher level process that will influence the lateral dimension of the river geomorphology. The key downstream impact often associate with the loss of the River downstream due changes in bed load and part of its suspended load through the dissipation of the energy by eroding the river bed to reconstitute bed-load, then reducing the slope of the river bed. Consequences for the populations living on the river banks (downstream in the area around Vientiane and immediately downstream, and to a greater extend on the stretch downstream from Kratie), until the Vietnamese border will be much more critical than anticipated in the current scenario assessment (Jean-Paul Bravard and Marc Goichot, 2010).

Incision of the river bed in alluvial stretches from Vientiane to Paske, and downstream from Kratie from sediment hungry river are also another potential impact and will result in water table and riparian vegetation changes. Dam directly upstream those areas will cut bed load and very rapidly lead to significant loss of habitats diversity that will translate into loss of biodiversity and fisheries productions.

2.4.4.8 Barrier effects and dis connectivity

With the 11 LMB mainstream projects, 55 - 66 % of the total LMR 1760 km river distance between Chiang Saen (Thailand) and Kratie (Cambodia) will be converted to reservoir and the change transforms the river from a free running river to a series of impoundments with slow water movement and rapidly changing flow in response to dam operations (ICEM, 2010). From 9000 – 150,000 ha of garden and agricultural land will be inundated in dam reservoir sites (54%) in Chiang Saen to Pakse, and significant reduction in wetland by 34% in Laos, 18% in Thailand, 2.4% in Cambodia. This change is expected to cause further changes in the key ecological habitats and productivity

With mainstream hydropower power projects operating, there will be much less velocity to suspend particles and keep them moving, and the result of this will be enhanced sedimentation, with the formation of deltaic type deposits at the head of each of the reservoirs, and middle and lower parts of each reservoir associated with reduced velocities/gradients (MRC, 2010d, ICEM, 2010). Only load of suspended (fine sized) particles has been measured at several stations on the Mekong mainstream since the 1960s.

The built infrastructures in the floodplains and across the rivers contribute to changing a natural system as they locally oppose water outflow, and prevent water and its elements (fish and sediment, nutrients) inflow or outflow. The key impact will be alteration of surface hydrology crossed by roads, resulting in increased sediment and increased soil erosion, and modification of water flood patterns mostly locally. Furthermore, the sea water Intrusion and flood control infrastructures in the Mekong Delta will cause further ecological and habitat dis-connectivity in Mekong Delta.

2.4.4.9 Critical deep pool and habitat

The development will also potentially reduce fined sized sediment transport from 70 to 80%. (75-81% reduction in sediment load from Upper Mekong Basin (UMB) (from 90Mt/year to 20Mt/year at Chiang Sean, and from 165Mt/year to 88Mt/year at Kratie) (Ward P, 2010 in Pech S, 2011). The reduction will result in a significant loss of nutrients in floodplains and coastal offshore, making deep pool fish habitat at most stretches become less productive and will have impacts on farming and fisheries within and beyond Mekong as well as in long-term changes to river bed and bank erosion, including threat to stability of the delta shaping processes, which are potentially exacerbated by sea level rise[8] Some sections of the sea water prevention dykes would have to be even relocated to further land due to the seashore erosion.

Limitation of this work: It is not possible to assess the impacts of each and every dam and irrigation project due to the fact that they are so numerous in numbers and data availability is the biggest challenge. It is important to note that current modelled hydrological changes by MRC used in deriving these conclusions are built on a number of rough assumptions. Furthermore, in spite of some attempts to create a framework for assessing the impact of various development projects in the MRB, there has been so far no "cumulative assessment" carried out in the Mekong river basin. The absence of such a comprehensive impact assessment and an underpinning monitoring system in the Mekong Region highlights the concern for severe cumulative impacts on resources sustainability and livelihood. However, one thing is clear that these major development projects in both incremental and accumulative manner will change hydrological and other water element regime.

2.5 CURRENT STATE OF KNOWLEDGE ABOUT FISH RESOURCES AND THEIR CORRELATION WITH HYDROLOGICAL CONDITIONS OF MRB

With mainstream hydropower power projects being constructed and operated, there will be much changed hydrological and morphological conditions. These changes will affect ecosystem and farming productivity fish migration and sediment flushing capacity. The decrease in reverse flow volume to the Tonle Sap Lake will result in a reduction of flooded area, flood depth and duration; and a reduction in sediment inflow into the lake and blockage of fish migration paths by mainstream dams (MRC, 2010a).

8 Loss of sand-sized sediments to Mekong Delta and marine environment result in loss of nutrients (phosphates) to agriculture = 3,400 tonnes/year = US$ 24 million in replace value/year, and reduction in nutrient loads to over 18,000 km² of Cambodia flood plain and 5,000-10,000 km² of Mekong Delta floodplain and Mekong marine sediment plume

Fisheries are one of the main social, economic and health mainstays and concerns. The study was conducted and the result was published in a scientific journal (Pech S, Sunada K, Oishi S, Miyazawa N and Tanaka, 2008), and in an international conference paper (Pech S and Sunada K. 2006d). The following sections are based on these publication findings.

2.5.1 Role of fishery and Key fisheries Issues in MRB

Fish together with rice are essential elements in food security for the region. Currently, the level of understanding of the role of natural resources in livelihoods and the likely impact of the forces of change on these components is limited and often fragmentary.

The Mekong River ranks third in the world in terms of having the highest number of freshwater fish species and fourth in terms of tonnage caught. More than 1,200 different fish species have been identified in the Mekong basin, with new species being discovered almost on a monthly basis. Freshwater capture fisheries form one of the single most important economic activities in the basin. Socially, Mekong fisheries range from individuals fishing part-time for subsistence, to medium and large-scale industrial operations.

From the literature reviewed and interviews undertaken by this study, there is little doubt about the importance of these aquatic resources in providing a significant source of nutrition, income and employment for the large majority of rural dwellers in the basin. Rural families commonly harvest fish and other aquatic animals such as crabs, shrimps, snails, frogs, insects and plants from nearby fields, canals, ponds, rivers, streams and lakes (CEMARE, 2002). Fish make up the primary source of animal protein in the Mekong River basin and comprise between 40 per cent and 80 per cent of the total animal protein intake within these communities. The fisheries sector, and particularly subsistence fisheries, is therefore crucial to the dietary requirements of people living in the Mekong River basin.

The MRB also has one of the highest rates of freshwater fish consumption in the world and the most intensive fisheries in terms of catch per person. The average consumption of freshwater fish is 56 kg/person/year. This varies from 10 kg/person/year in mountainous areas of the basin to 89 kg/person and 60 kg/person in the flood plain in Cambodia and Viet Nam, respectively. It has been assumed by some quarters that everyone is convinced of the importance of these resources in the livelihoods of communities in the basin. Nonetheless, its true value has often been ignored or given lower priority in the face of "economically and socially higher priorities" (for example, hydropower production or other water uses).

2.5.2 Previous Study

The Tonle Sap supports one of the most productive freshwater fisheries in the world, with annual yields of 230,000 metric tons (1995-1996), equivalent to about 60% of the country's total annual fish catches. Over 500 fish species have been described for the Mekong system in Cambodia, and about 200 species are reported to be found in the TSB. But for any particular fishery, most of the catches usually comprises of 10 dominant species (Hortle K, *et al* 2004). Some of the species found in the Tonle Sap Great Lake remains there permanently, while many other species use the Great Lake and its floodplains only temporarily and migrate back to the Mekong River at the end of the rainy season. Hence, the Great Lake's ecosystem is not only the main source of animal protein for much of the population of Cambodia, but also provides the last refuge for some of the globally most significant biodiversity(see e.g. MRCS/UNDP, 1997).

Recently, the annual fish catches of some key species have been reducing remarkably. It becomes a main cause of great concern among the concerned citizen groups, because in the MRB and TSB, the rich fish species are not only an indicator of the ecological health of the Basin system, but also serve as a main source for the incomes and livelihood of millions of people. In the TSB, the annual fish production is thought to depend on a combination of hydrological, biological and physical parameters as well as the fishing practices. However, to assess the role of each influencing factor is usually made difficult because of their diversity, and by the absence or poor quality of data. The most recent studies confirm that the area of flooding is the most influential parameter driving the fish production (Koponen J, *et al,* 2003).

Most (if not all) of the Mekong countries do not derive their statistics based upon direct and systematic observation, report verification, sampling of catch or landing, or any other form of objective and systematic monitoring (Baran E, *et al* 2003). To overcome that gap of knowledge, few studies were carried out to model the environmental factors that drive fish production in the MRB (see e.g. Baran E, *et al* 2003). Recently Tanji H, *et al* (2004) has proposed an empirical method for estimating fish catches in the whole of Cambodia. But that method is not for estimating the total inland fish resources. The project on modelling of the flow regime and water quality in the Tonle Sap by a consortium led by the Finnish Environmental Institute (SYKE) provides useful information to assess and evaluate the impacts of physical and environmental changes in the Tonle Sap Great Lake in relation to the whole MRB (Sarkkula J and Koponen J, 2003). A preliminary study to detect the shorelines of the Lake during different water levels (from 1 metre to 10 metres) for the planning and flood management purpose by using the remote sensing data – JERS-1 and available topographic data, was carried out by Seang T *et al,* 1998. Van Zalinge, 2002 assessed the relationship between the bag nets (*Dai*) fishery catches during 1995–2002, and the River flood levels. They maintained that higher the flood the more sediment is brought into the TSB, that led to improved survival and growth of fish and hence of fishery yields.

The present study grasps the relationship between the change of inundated areas (water level and flood extend change), and the level of fish production in the Tonle Sap Basin. The term “fish production” and/or “fishery resources” in this study is referred to the total fish biomass produced in a given year, not only fish catches resulting from the fishing efforts.

A simple ecosystem model is used for this study (to be described in more detail in the following section). It critically assesses the physical and environmental influence of the sensitive level, and the changes in the parameters of the fish habit quantity and fish species. Hydrological data in the Mekong River Commission’s "LOWER MEKONG HYDOROLOGIC YEARBOOK" is analyzed. Hydrological data of the TSB at Prek Kdam station is available only from 1960-1968, and from 1998 - 2001. The Pakse hydrological station, Southwest of Laos, has a reliable hydrological dataset from 1924-2001. The Prek Kdam station discharge curve is derived from the available level data, and to file the water level data gap, the flow data of the Pakse station is used to assess its relation with the Tonle Sap water level and its flood extend.

Figure 2.16 shows the best possible approximation between discharge at Pakse and water level at Prek Kdam in Tonle Sap River. Hence, Pakse flow is used to approximate monthly water level at Prek Kdam which will serve for estimating flood extent inundated area in the Tonle Sap Basin. The flood extend information is then used for assessing its co-relation with fish catch. The estimated water level deriving from correlation with Pakse flow is then compared with the available observed water level of 1962 (hydrologically average year), 1998 (drier year), and 2000 (wetter year) as shown in Figure 2.17 **Graphs A – C**.

Figure 2.17 shows a good agreement between the simulated result and the available observed data at Prek Kdam in average year (1962) (R2=0.9629) and wet year (2000) (*R2=0.9727*). The correlative relation is found and the modelled result agrees well with the observed data.

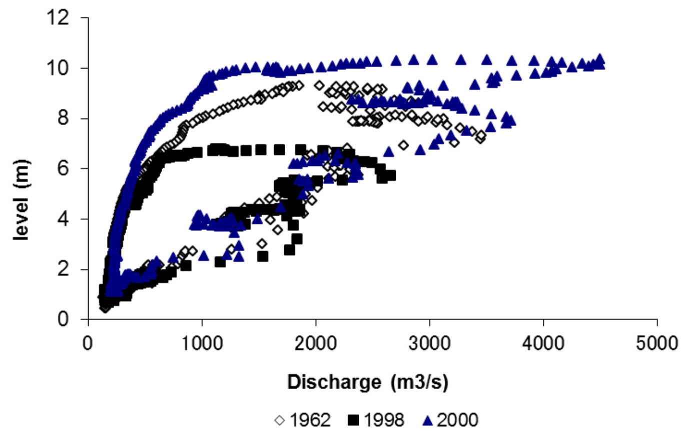


Figure 2.16 Relationship of Discharge at Pakse with water level at Preak Kdam in 1962 (average year), 1998 (drier year) and 2000 (wet year).

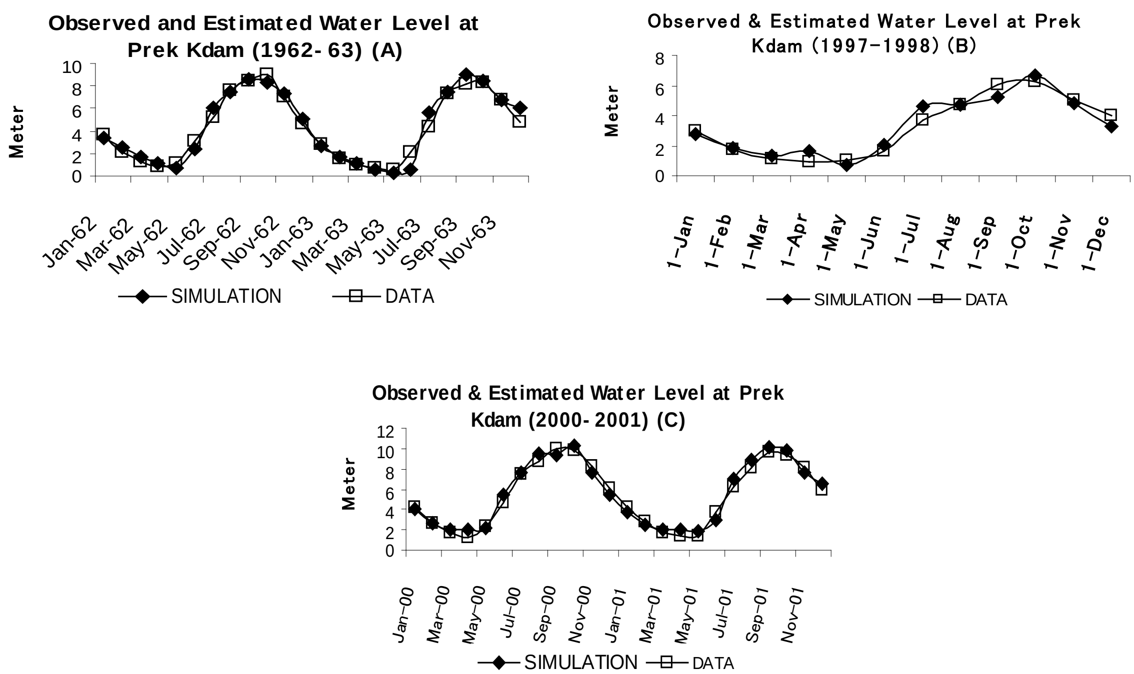


Figure 2.17 Confidence level of estimated against observed data of Prek Kdam water levels

Some slight disagreement between the simulated and observed values for the drier year (1998) is observed (*R2=0.8291*), because either of the model error or the data quality (**Figure**

2.18 Graph B). The study then estimated the inundated area of the Lake Basin from 1925 – 2000 using the estimated water level data. To improve the relation between the water level and the actual inundated area in the Tonle Sap Basin, the satellite JERS-1 data was used. The result improved by the satellite data shows a good agreement between the water level at Prek Kdam and Tonle Sap surface area changes.

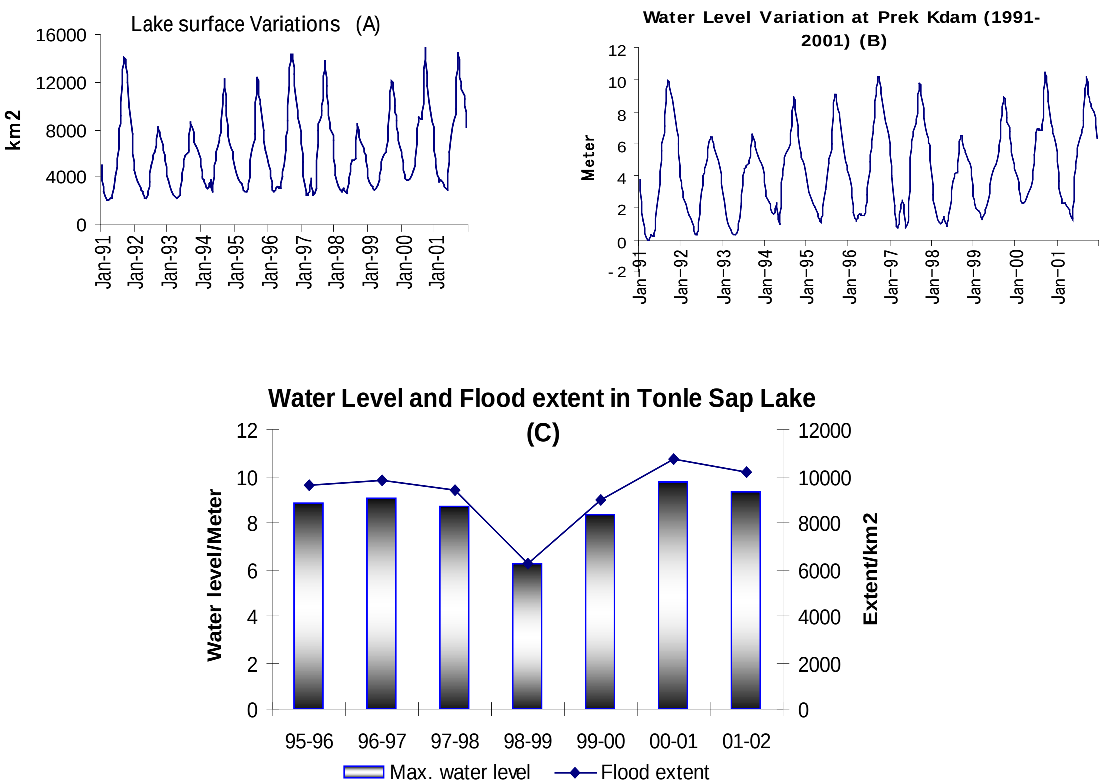


Figure 2.18 Estimated Tonle Sap surface area change (Graph A); Estimated water level at Prek Kdam (Graph B), and water Level and inundated areas (Graph C)

Figure 2.18 Graph C shows a close co-relation between simulated 1991-2000 water levels and inundated areas. There is an obvious annual variation and the lowest water level occurred in 1998 and the highest in 2000.

2.5.3 Correlation between Fish Production and Hydrological Changes

From over 200 fish species in the TSB, only about 10 of them dominate the annual fish catches (Van Zalinge, 2002). To simplify the study, those dominating species are grouped into two groups:

1. Black fish species that undertake only short distance lateral migration from the seasonal water-bodies on the floodplain to permanent water bodies when the water recedes. They can breathe air and survive in anoxic conditions as water recedes and stagnates. They constitute less than 40% of the Tonle Sap total fish catch.

2. White fish species that normally undertake longer (longitudinal) migration from the TSB mainly to the upper Mekong River and staying in deep pools there for the dry seasons. They tend to be more fragile, and vulnerable to the hydrological and morphological

change and less tolerant to the poor water conditions. They constitute over 60% of the TSB annual total catches. This group are sub-divided into:

a. Opportunists – small fish species of short life span and are able to reproduce within one year. They are dominant in the catches in TSB and MRB. They are called "opportunists" because each year their abundance in the catch appears to follow the level of the floods. They constitute 76% of the total annual fish catch.

b. Non-opportunist – larger white fish tend to spawn later in life. They constitute about 24% of the total annual fish catch (Van Zalinge, 2002).

There is still a huge gap in the fishery data. There is some data on fish catches, but it needs to be treated with caution since they were obtained mostly from the estimations or guestimation of the annual catches by the national agencies concerned (Baran E, *et al*, 2003).

Figure 2.19 Photo 1 (from left): snake head representing "black fish spicy; # 2 Trey Real dominant migratory fish spicy also known as opportunists, and # 3: representing non-opportunist – larger white fish

It is not possible to assess the extent to which these figures approach the actual annual catches, and real fishery productivity level in the basin. Nonetheless, the drag-nets (Dais) fish catch data is more reliable since they are small in numbers - the official number of Dais units in operation was between 60 and 63 - and located closer that make it easy for the Department of Fisheries to monitor. The "Dais" or drag nets operate from the end of October till about the middle of March in the single-channel part of the Tonle Sap River before it joins the Mekong River (Figure 2.20). The Dais targets migratory white fish (both opportunist and non-opportunists). Nine-year data (1995 – 2004) are available for the Dais fishery, which can be regarded as an indicator of the state of the migratory fish stocks. The catch data is relatively accurate and ranged from 8,000 – 16,000 tons annually (Catch and Culture, 2005). The peak catches are usually in January, when most fish migrate down the Tonle Sap. During the 2004-2005 season, however, the peak about two thirds of the total catch – was in December. Hydrographs did not show any features which might explain the earlier migration (Catch and Culture, 2005).

As shown in Figure 2.21, the study found a strong correlation between, the Dais fish catches, the water level and Lake inundated area from 1995 to 2002. The correlation is less obvious when opportunist and non-opportunist are considered separately. It also shows that in 2003 to 2004, that nice correlation was disrupted. It may point to the extreme increase in fishery activities and timing and duration of the flood peak of the year in question).

From analysing the daily discharge data (Kratie station) by the Mekong River Commission (MRC) (Figure 2.22), the study found out that the 2003 flood rise started late, and the flood peak duration was shorter. This factor combined with the fishing pressure might be a main cause of the 2003 and 2004 fish catch decline plunged to barely 6,000 metric tons, the lowest since systematic monitoring began in 1994-1995 (Catch and Culture, 2005).

Arial view of row of dai fish units in Tonle Sap River

Hauling in a fish catch from a dai fish unit during peak

(Sources: Catch and Culture, May 2005)

Figure 2.20 Dai Fishery along Tonle Sap River

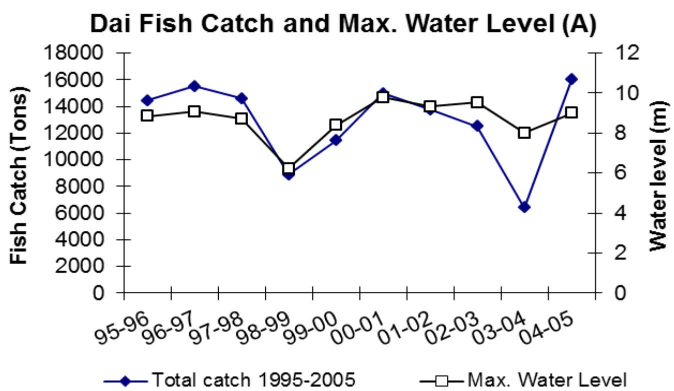
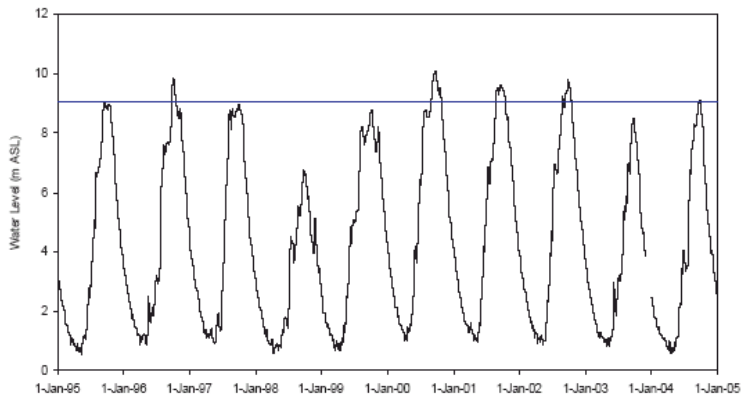


Figure 2.21 Correlation between total Dai fish catch and maximum water level

As also shown in Figure 2.21, the Dai fishing catches 2004-2005 soared to more than 16,000 metric tons - almost 10,000 tons more than the previous season's haul and the highest over the past 10 years.). The record catch may have been resulted from the above average flood levels and longer flood peak duration of 2004 and the reduction in illegal fishing. It, however, can be clearly stated that elevation and duration of flood plays a key role in the general ecology driving the fish production, as most of the impacts are related to time, height and duration of flood. It thus confirms the concern over the potential impact of flow regulations by reservoirs on the timing and extent of flooding.



(Source: Catch and Culture, 2005)

Figure 2.22 Daily Water Levels at Phnom Penh Port (Tonle Sap River) 1995-2005

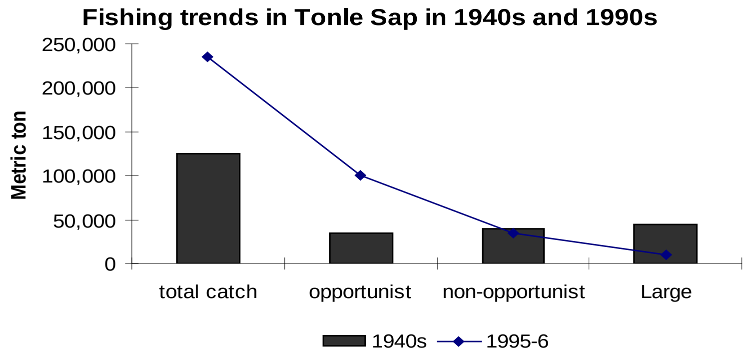
The study reproduced the variation of the fishery productivity based on changes in water level and inundation and the observed fish catches trend - total catch, catch of opportunist, non-opportunist, and large size fish - in the Tonle Sap. Next, the study examines whether this simple ecosystem model can reproduce the variation of fish relative area density corresponding to these change of fish catch or not.

Considering the data constraint, a simple model is used in this study to quantify the possible future trends in the TSB fishery resources by making a specific focus on the hydrological changes. Only a few dominant fish species out over 200 species were selected and express them by a simple differential equation as follows:

$$\frac{dF_i}{dt} = \alpha_i \frac{dA}{dt} - \beta_i F_i + \mu_i F_i \frac{K_i - F_i}{K_i} \quad \text{.........} \ (1)$$

Whereas, F represents virtual fish density (ton/km^2); t is the computing time, A as Tonle Sap inundated relative area; and α, β, μ, and K represent parameters relating to the components of fish density variation described below, and subscript i of each variable and parameter means group(s) of selected fish species. Fish density expresses an average fish quantity per km^2. By using that average value per km^2 a best parameter can be selected that would allow us to grasp and reflect the change of the relative fish density. The first term in right hand of the equation (1) represents the temporal variation of the fish relative area density due to the temporal variation of the surface area of the Tonle Sap Lake. The second term represents the fish catch corresponding to the fish relative area density. The third term represents the logistic equation using the innate capacity of grown μ and the capacity K as a maximum limit of fish density.

The equation (1) was applied to the two representative kinds of species – i=1, 2, those are for "Black and non-opportunist" and "opportunist" fish groups. The parameters are determined as follows. At first, initial value of K is determined from fish catch per area and whereby F – fish production - is determined. Moreover, a range of each parameter is set from its importance and annual fish productivity referring to the standard values at the selected sample points of the TSB and other rivers, see e.g. Hand, 2003; Ouch, 2003. Those are $\alpha_i=10^{-3} \sim 10^{-1}$ ton/km^2, $\beta_i=10^{-6} \sim 10^{-3}$month^{-1}, $\mu_i=10^{-8} \sim 10^{-3}$month^{-1} and $K_i=10^3 \sim 10^6$ton/km^2. After a series of the preliminary calculation, the optimal sets of order of the parameters were estimated by trial and error. The fish productivity change is simulated by using the optimal parameters compared against the temporal changes of the long-term observed Dai fish catches in Tonle Sap River (Figure 2.23**)**.



(Data sources: Fishery Department, 2004)

Figure 2.23 Observed Fishery catches in Tonle Sap Great Lake in 1940s and 1990s

The simulation results of temporal variations of fish relative area density of both white and black species groups are shown in Figure 2.24. Its Graphs indicate that simulation reproduces a tendency of variation of fish productivity corresponding to the fish catch as shown in Figure 2.23. The temporal variation of the absolute fish catch in Figure 2.24 **Graph "A"** is compared with data of Tonle Sap fish catch.

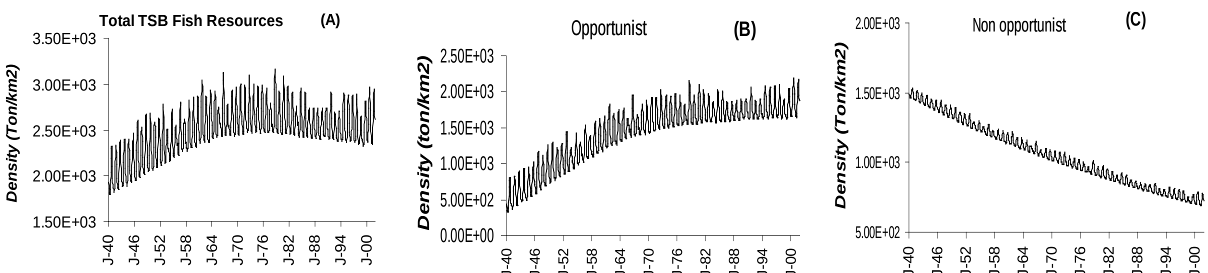


Figure 2.24 Graph A: Simulated Total Fish Production Trends per km^2, B: Projected Opportunist Productivity; and C: Projected Non-opportunist Productivity

Figure 2.24 **Graph A** shows the overall trends in the fish production, due to the changes in the inundated areas that affected the fish relative area density. Figure 2.24 **Graph C** shows the substantial decreases in large and medium fish - "non-opportunists" in response to the likely "over-fishing", as these species require longer time to reach a mature and reproduction stages. For example the famous Giant Mekong catfish (*Pangasianodon gigas*) is reported to spawn for the first time when it is about 20 years old and 160 kg or more (Mekong Development Series, 2004). The result shows with confidence that the model can reasonably detect the changing trends by fine-tuning the parameter to reflect the changes in the estimated fish productivity per km^2 and variation in inundation areas.

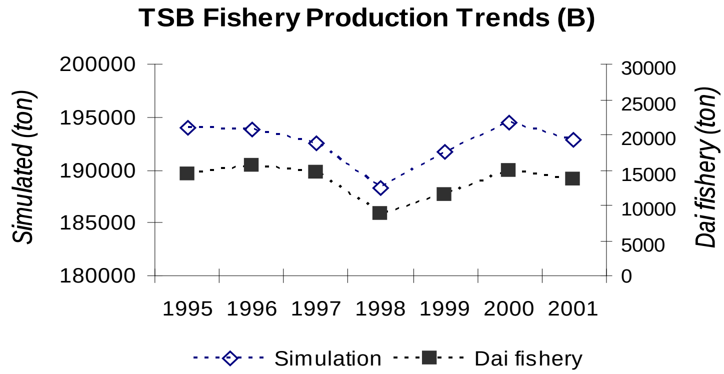


Figure 2.25 Simulated fish production trends and fish catch data (white species from 1995 to 2001)

Figure 2.25 shows the comparison between the simulated opportunist + non-opportunist fish catches with the 1995 to 2001 Dais fish catch data. The simulated fish production in the study area follows similar trends as observed in the Dais fish catch data. The simulated result is higher the Dai catch data, and the main reasons are: 1) Dais fishery data covers only the migratory white fish species that normally represent only over 61% of the reported Tonle Sap Basin (TSB) annual fish catches; and 2) even the whole TSB fish catch data does not reflect all TSB fish biomass. Nonetheless, the result strongly reaffirms the study's hypothesis that as the inundated area of the Tonle Sap Lake becomes timelier, larger and longer, the chance of survival by the fish fries is higher, the fish relative area density increases, and as a result the fish catches go up.

2.5.4 Conclusion on Knowledge about Fish Production and Hydrological Changes

Multiple impacts and indicators are highly correlating with each other in the TSB. It, however, can be clearly stated that flood elevation and duration of flood peak plays a key role in the general ecology driving the fish production. Most of the impacts are related to time, height and duration of flood.

The primary reason for the enormous quantity of fish in Cambodia is the monsoon which annually swells the river and flood waters inundate the highly productive flood plains. Thus, in a dry year (e.g.1998/99) fish production is much less than in a wet year (e.g. 2000/01), because much less land is inundated. White fish have evolved to synchronize their time of spawning with the onset of the monsoon, so that fry and juveniles are ready to enter the plains when they are flooded. Black fish spawn and feed in the inundated flood plains. Without the floods and the flood plains the fish catch would be only a small fraction of what it is now.

The model result confirms the continued dominance of the highly migratory fish species, especially the opportunist, in the fish composition of the TSB. Many species, so-called "white" fish, will then undertake longer (longitudinal) migrations from the lake or tributary to the Mekong River, probably moving mainly upstream and staying in deep pools for the dry season. Longitudinal migrants constitute about 63% of the total catch taken by the fisheries in the Tonle Sap area. They begin to spawn in the Mekong River at the onset of the rainy season

(May-July), when the first floodwaters are coming in and water levels start rising again. Important spawning areas are located upstream of the floodplains in the Mekong river in Kratie and Stung Treng provinces. Migratory species are prolific spawners (MRC, 2002). Large numbers of fish eggs and fry are carried downstream by the currents and swept into the floodplain areas that are being inundated.

The modelling results and the observed catches data show that quality of the Dai fish catch has declined steadily in recent years and will continue, with the valuable bigger fish becoming scarcer, amid concern that a combination of fishing pressure and environmental change threatens the productivity of the Mekong fishery. Dams on the upstream Mekong and its tributaries, conversion of wetland habitats around the lake's perimeter, and pollution from agricultural runoff threaten the productivity of this remarkable ecosystem. Despite the lack of clear evidence of a decline in the overall production of past Mekong fish catches there are actual reasons why one should fear such a decline in the future. These threats are multiple, and they affect to varying degrees, the Mekong basin as a whole. However, as confirmed by numerous studies, the hydrological cycle has the greatest influence on fish ecology and productivity. These evidences underline the importance of a cross-sectoral and cross-boundary management of the fishery and other sectors both in Cambodia and other riparian countries. Any river basin development measures that would substantially lower or even delay annual flood will have negative impact on the TSB and MRB fish production.

Another key problem facing fisheries is that the value of the fisheries resource is usually ill-defined and poorly represented from an economic and social perspective. This is borne out by the paucity of information on the economic value of fisheries and institutional constraints such as the lack of appropriate capacities to collate and analyse relevant data and information. There are some contradictory figures about the freshwater fish catch and its economic values that appear in different publication and reports as there is very limited direct observation, report verification, sampling of catch or landing, or independent monitoring.

From this preliminary analysis, some aspects in fisheries have not been covered by all quoted studies including:

- impact of sediment retention and barrier impacts by dams on water productivity, fish habitat, fish migration and fish production;
- changes in quality of fisheries products in the case of change in species composition, in particular the nutritional value of the newly dominant species;
- changing value of fisheries products, depending on changes in catch composition and on market demand for a scarcer product;
- Socio-economic issues and shifts of benefits between social groups following losses and changes in species composition (MRC, 2010a, MRC, 2010b).

2.6 ANALYTICAL RESULTS AND CONCLUSION ON STATE OF KNOWLEDGE ON IMPACT AND OPPORTUNITIES IN MEKONG REGION

From this literature review, *the following key conclusions on strength, weakness, opportunity and threat* can be made:

Series of large scale economic activities in the Mekong Sub-region are at various stages of planning and development. Rapid demographic and economic changes, combined with relatively weak institutions and knowledge base constitute a serious constraint. Appropriate assessment framework and usable knowledge and prediction and monitoring tools are needed as a means of supporting the process of economic growth by making it socially and environmentally sustainable by considering at the earliest possible stage of planning, the impacts at a basin-wide level, and to predict cumulative impacts over space and time, and support decision on mitigation and trade-off.

The literature review shows that there are opportunities and mechanisms`- commonly known as "river basin management" and means for achieving it "water governance" for benefit sharing, and the knowledge is required for supporting all key steps and aspects of the benefit sharing mechanisms. Scholars, policymakers, aid donors, and aid recipients acknowledge the importance of good governance and role of credible and accessible knowledge for achieving sustainable and pro-poor development. Role of knowledge including data, information, appropriately packaged experience, and knowledge, in designing and implementation of activities and process for achieving benefit sharing is recognized by many literatures under the review. The need for information arises at all levels, from that of senior decision makers at the national and international levels, to the grass-roots and individual levels.

The Governments of Mekong countries have targeted "poverty reduction strategies" within national socio-economic and sector development plans, all of which include the development of water resources. A series of large scale economic activities in the Mekong Sub-region are at various stages of planning and development under the justification for economic development and meeting the needs of the growing population.

The review also shows that it has become increasingly obvious in the past few years that there is the need for greater cooperation in the Mekong Region, and effective knowledge management will definitely contribute to improve better cooperation and governance. The literature review on the state of knowledge about the key river basin development drivers and impact (individual, incremental and cumulative) provides not only the context, empirical evidence, and an analysis of the demands and environmental changes associated with population trends, but also an initial contextualization and conceptualization of the strength, weakness and opportunity and threat to the Mekong knowledge management.

A number of studies discussed at a very general level the population growth, food and water demands and their impacts on water resources in the other parts of the world and the MRB. There are different population growth projection rates for the MRB as a result of both different methods of enumeration and poor reporting. These widely different population growth figures do point to the complexity associated with academic and policy debate around natural resources exploitation – hydropower and energy, and irrigation and agriculture, urban and infrastructure development, and deforestation and reforestation - in MRB. Most Mekong countries have argued that to fulfill the resource requirements (perceived or real) of a growing population, some form of water and/or land-use change are required to support increasing human numbers.

The decision-makers and practitioners perceived population growth and associated demand change as the main justification for water and related resources, and while the most needed scientific knowledge and tools for generating proper projection of the population, searching alternatives/options, and modelling the growing environmental pressure to meet the growing demands associated with population and other policy/social changes remain a challenge.

With the recent revitalization of large scale hydropower and large scale irrigation projects in the MRB, the demand to meet the needs associated with the economic growth and demographic change (population growth and urbanization) is often used as meta-justification for the expansion. But there is no consensus in the existing literature on how much it will grow in the coming years and how best to meet the demands.

It is clear that the improvement in knowledge of the causal mechanisms at work within such a large and dynamic system of the MRB and tools for assessing demand and supply options for supporting appropriate planning and impact mitigations is required. The literature review also points to the need for overcoming the practices and circumstances where available knowledge is simply kept away, ignored or questioned.

The literature review also points to a number of progress and issues in the knowledge application in the planning, impact assessment and mitigation, and design and implementation of the hydropower projects in the MRB. The lack and poor quality of data leads to a failure to fully understand and correctly evaluate sustainability tests to quantify impacts, the causal mechanisms at work in large, dynamic systems, and to consider and integrate multiple risks and degree of vulnerabilities. The existing practices by key regional and national institutions fell short in providing reliable and independent assessments of the potential costs and benefits of proposed projects, and failed to cover key social and livelihood aspects as well as other cross-sectoral implications. The impact of the qualified development project on the environment and community has been mainly studied using sectoral environmental impact assessment instrument (EIA) and sectoral decision-making. Sectoral assessment often results in sectoral decision-making, mitigation measures, management and monitoring plan.

Recently, some efforts have been made to initiate strategic impact assessment and cumulative assessment. Several impact assessment frameworks and methodologies providing possibilities to look at impacts at different levels and phases already exist in the Mekong Region. However, the use of different impact assessment methods has so far been rather non-systematic due to weak linkages between different assessments components especially those of social aspect and livelihood, weak sensitivity analysis, and misunderstandings related to impact assessment methodology and terminology.

For example, the positive and negative impacts from selected hydropower plans and projects were studied and documented to some extent. However, uncertainties remain relating to the nature, extent and distribution of benefits and impacts on vulnerable group of people. Those studies often failed to give social, cultural and economic values of the loss to paddy production, livelihood, fishery and other wetland services. The social and environmental transformation to be resulted in these values such as fisheries, agriculture, navigation and environmental services is poorly understood in the Mekong Region.

The literature review also confirms that fisheries are one of the main social, economic and health mainstays and concerns. There were some studies on the change in hydrological and morphological conditions and their effects on the ecosystem productivity of many important parts of the Basin, including the Tonle Sap Great Lake. The annual fish production is thought to depend on a combination of hydrological, biological and physical parameters such as decrease in reverse flow volume to the Lake and resulted reduction of flooded area, flood depth and duration and a reduction in sediment inflow, and the blockage of fish migration paths as well as the fishing practices. The most recent studies confirm that the area of flooding is the most influential parameter driving the fish production.

Dams on the upstream Mekong and its tributaries, conversion of wetland habitats around the lake's perimeter, and pollution from agricultural runoff threaten the productivity of this remarkable ecosystem. These evidences underline the importance of a cross-sectoral and cross-boundary management of the fishery and other sectors both in Cambodia and other riparian countries. Another key problem facing fisheries is that the value of the fisheries resource is usually ill-defined and poorly represented from an economic and social perspective. There are some contradictory figures about the freshwater fish catch and its economic values that appear in different publication and reports

In conclusion, the literature review manages to gain a better understanding of the strength, weakness, threat and opportunity of the existing knowledge and prevailing practices in knowledge development and application in the MRB. It confirms that even though, there is knowledge gap but the main concern is the practices that inhibit the knowledge application for informed decision-making. The following Chapter will investigate the potential factors and conditions that influence effective knowledge management in the MRB.

CHAPTER 3 ASSESSING AND CONTRASTING KNOWLEDGE MANAGEMENT PRACTICES

3.0 TRIANGULATION OF PERCEPTION AND PRACTICE IN SEARCH OF INTERFACE OPTIMIZATION MEASUREMENTS

This Chapter 3 qualitatively and quantitatively analyses the knowledge management practice and perception in search of possible interface optimization measures by specifically focussing on the potential push and pull factors that influence interface and knowledge management effectiveness in the MRB. To grasp these factors, the study closely scrutinized the whole process of knowledge management - conscious strategy and action of getting the right knowledge to the right people at the right time and helping people share and put information into action. The analysis focuses on range of knowledge management dimensions such as data collection and collation, processing and analysis, packaging and communication, and accessibility and application of generated knowledge for beneficial purpose.

The study was conducted and the result was published in a scientific journal (Pech S, Sunada K and Oishi S, 2007), in two peer-reviewed book chapters (Pech S and Sunada K, 2008a, Pech S, 2011) and in international conference papers (Pech S and Sunada K 2006b, Pech S and Sunada K, 2006e, Pech S and Ito, 2006). The following presentation is based on those peer-reviewed and conference materials.

3.1 DEFINING KNOWLEDGE MANAGEMENT AND ITS KEY ACTORS

The study defines the knowledge management as conscious strategy and action aimed at producing and getting the right knowledge to the right people at the right time, and helping people share and put information into action in ways that strive to improve performance to achieve set goals and objectives. The quality interface between science-policy and practice is a key toward building up best practices for knowledge management (Carlos R., 2005).

The science, policy and practice are possibly understood in fundamentally different ways, that's why it is important to set the stage with defining what the present study means by these terms.

The present study takes into account the social and interactive aspects of knowledge. The act of "knowing" is a socially constructed sense-making endeavor that requires ongoing dialogue, coordination, and collaboration among various actors - policymakers, practitioners, and researchers. This definition recognizes not only the practical aspect of management but also its social aspect of supplying knowledge to find out how existing knowledge can best be applied to produce results.

For the management and administration purpose, knowledge is understood as a combination of: i) explicit' coded (e.g., documented, identified, and articulated) and readily available knowledge or information; and ii) 'implicit' or tacit experiences, skills and attitudes or knowledge of individual person (Davenport T and Prusak L, 1998). It is resulted from an interactive and dynamic process of a never-ending spiral of tacit and explicit knowledge conversion through socialization, externalization (translation of tacit knowledge into explicit knowledge), combination, and internalization (translation of explicit knowledge into tacit knowledge).

From technical point of view and from knowledge management, the knowledge is distinctively defined between its ascending and descending levels or grades as shown in the central part (pyramid of knowledge) of **Figure 1.2**. In the ascending phase raw data is distilled into information and ideas. Raw, unprocessed physical facts or data is the lowest grade and these facts get categorized and organized as information. At a higher level, organized facts are processed and distilled into ideas, concepts, and theoretical propositions that provide a perspective which reveals their significance and interrelationships (Jacobs and Asokan, 2008**)**. In the descending phase that leads from knowledge to action, ideas and theoretical concepts are applied to generate plans, organizational patterns, technological processes and physical skills that express in action.

The main source of knowledge is derived from data collected/recorded usually as numbers, codes or lists. They are then transformed into **information** by making up data: combining, and interpreting data to form reports and other texts and graphics. Information is the result of human interpretation of data (**Figure 1.2**). **Scientific Knowledge** is acquired information which has been substantiated and submitted to severe validation axioms and institutionalized in the sciences, and must be well-founded and able to meet with approval in any competently and rationally conducted debate (Blackerler F, 1995).

The knowledge management is also divided into related phases. <u>Knowledge production</u> refers to different means of creating and organizing evidence, and experience through: i) collection of existing knowledge; ii) generation of new understandings; iii) synthesis of research findings, experiences and tacit knowledge; and; iv) knowledge organization - knowledge description; knowledge storage in repositories; knowledge packaging and delivery modalities; and coordination of intellectual resources (Blackerler F, 1995).

As shown in knowledge hierarchy in **Figure 1.2**, the next phase of the knowledge management is "comprehension" and "application", since knowledge users should be able to not only recall or have access to, but also comprehends information so that information becomes useful in problem solving or decision making and makes creativity more probable. <u>Comprehension</u> and <u>Application</u> are referred to a state where users are able to understand the abstraction well enough that he/she can correctly use it. The next phase of knowledge management is the <u>analysis, synthesis and evaluation</u> that normally require certain level of expertise and qualifications. The analysis is intended to clarify the communication/information through categorization, organization or re-organization of the transmitted knowledge (Jacobs and Asokan, 2008).

From the initial assessment of the knowledge management, it is clear that there are at least three major groups involving in these interface relationship in the Mekong River Basin, namely:

- Hundreds of MRB related researchers, research groups or consortium based both inside and outside of the region;
- Many international, regional, and national government institutions, non-government organizations involving the decision-making related to sustainable

development, social and economic development, and well-being, as well as funding institutions and donor community; and

- Thousands of practitioners and communities of practices in the Mekong Region at both regional, national, and local level as well as the local communities.

Hence, the Mekong policy-science interfaces issues cannot be considered in isolation from the busy web of multi-level interaction and institutional arrangements among these actors. The science-policy-practice interface in the Mekong Region has to be investigated and modeled from integrated perspectives of various players of this interface and the institutional and organizational challenges that may inhibit or prohibit more open involvement of public inputs into decision and intakes of appropriate knowledge in the informed decision making.

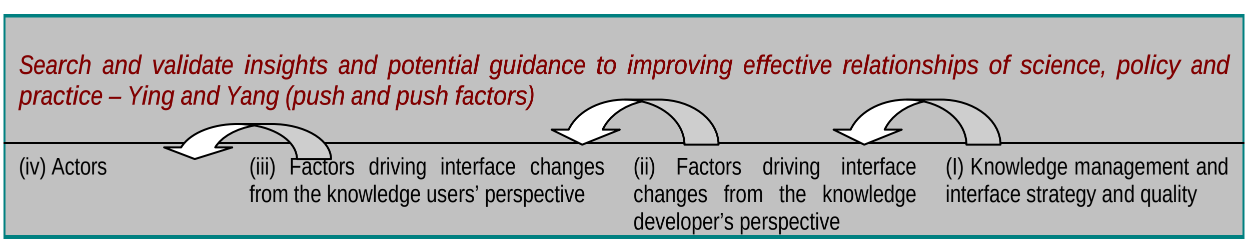
This study selected three major groups of stakeholders that are considered representative enough for this diverse group of key actors in the science-policy-practice nexus or interface. The study closely scrutinized the whole process of knowledge management by (**Figure 3.1**):

i) Applying rapid assessment framework evaluating three major Mekong Regional Organizations/Programs - Mekong River Commission (MRC), Greater Mekong Sub-region (GMS), and Navigation Channel Improvement Agreement; and

ii) Applying advanced data mining and information visualization techniques profiling Mekong publication of selected Mekong Research Groups; and

iii) Applying semi-structured techniques to survey national and local decision-makers and practitioners users' perspectives on the interface.

As illustrated in **Figure 3.1**, to achieve the expected research impacts and accuracy, this research applying multiple-analytical and participatory learning research approach by focusing on the knowledge management for sustainable water resources development analyses, identifying key challenges and opportunities for improving the current management issues, and capacity building. The result of these analyses contributes to the improved interface. For this research - searching and validating insights and potential guidance to improving effective relationships of science, policy and practice – Ying and Yang (push and pull factors) , the following impact pathways assessment framework as shown in **Figure 3.1** is set toward the achievement of the project outcome – investigating Knowledge management and interface strategy and quality by three main regional intergovernmental organizations and programmes, then moving on to assessing key factors driving interface from the knowledge developers and users' perspectives and practices.



Major Mekong Regional Organizations/ Programs - Mekong River Commission (MRC), Greater Mekong Sub-region (GMS), and Navigation Channel Improvement Agreement; Selected Mekong Research Groups; and National and local decision-makers and practitioners users' perspectives on the interface.	Understanding of the complex social, political and cultural factors and perceptions influencing the interface and knowledge management from the policymakers and practitioners' perspectives (consumers): • personal and professional experiences and views on science-policy-practice interface in various stages of policy process and research program cycles; • Current practice in disseminating and uptake data and information, barriers and opportunity, and suggested strategies for improved interface. • Types of research and policy environments, perception on social relevance and scientific credibility, and prevailing social, political and environmental condition, etc. • Analysis of collected information and multi-stakeholder consultation for further validation and triangulation of data and findings	The analysis specifically focuses on the following areas: • Geographic scope of studies; • Level of interaction between researchers and potential users: involvement of other researchers and users; and • Assessing overall research trends and key research areas: Extent of their coverage over those key problems, water related scientific and academic fields, and key attributes of Integrated Water Resources Management (IWRM).9	Participatory learning and action research by focusing on Knowledge production, communication, and application: • Efforts for data collection & core datasets coverage; Capacity in mobilizing, using knowledge; • Linkage with to Academic Institutions and Research Communities; • Efforts in promoting Actual application in informed decision-making

Figure 3.1 Pathways Framework of the Knowledge Management Practices

3.2 KNOWLEDGE MANAGEMENT FROM PRACTICE OF THREE MAJOR MEKONG REGIONAL ORGANIZATIONS

In the present-day MRB there are many actors (Table 3.1) with very different interests and powers, exhibiting contrasting modes of behaviour, and with varying degrees of influence (ADB, 2002). First of all there are the six Mekong Region countries – China, Myanmar, Lao PDR, Thailand, Cambodia and Vietnam with very complex governmental and non-governmental organizations and communities. There are also numerous international and regional organizations and funding agencies. Since 2008, the private power producers and private financing have become more and more prominent in with the revitalization of the once abandoned hydropower dam projects, large-scale water diversion, and major mining and transportation projects along the Mekong Mainstream and in the Lower Mekong Basin. Those private project developers are mainly from Thailand, Vietnam, China, Malaysia, and Russia – with limited commitment to international social and environmental performance standards. Massive inflows of bilateral and private funds from Thailand, Korea, Kuwait, Qatar, China, and India for irrigation and water diversion are a reality in Cambodia and Lao PDR (John D, personal communication). Each country

9 It was not intended to validate the quality and credibility of the publications at this stage. With a more in-depth review by subject matter experts, the study should manage to validate the quality and credibility of the research works and their social relevance.

and their governmental and social organizations have different economic, political, social and cultural objectives that define the range of perspectives in the natural resources management. Moreover, perspectives are differentiated by country, by resource sector, by socio-political actor and by scale of orientation.

The selected inter-governmental bodies for this assessment were the Mekong River Commission (MRC), Greater Mekong Sub-Region (GMS), and Upper Mekong Commercial Navigation Agreement whose mandates, memberships and geographical scopes are defined in **Figure 3.2**. The assessment of their efforts and success in knowledge management was carried out applying a model for mapping research to policy flows based on qualitative and quantitative approach (Pech S, 2011). Their performance and capacities are assessed by four clusters of indicators that are commonly used for measuring the knowledge management including data collection and datasets coverage; capacity in mobilizing, using and upgrading knowledge; efforts in promoting informed decision-making; and interface with research communities.

The researchable research questions are carefully developed by taking into account the subjects and variables that would allow this study to derive practice and impact actors for supporting tool to address the research problem – improvement of knowledge management and interface quality. The four key groups of questions are supported by other relevant variables as shown in **Table 3.2**. Based on the research problems and research questions, the study decided to employ the most appropriate research method design, namely the mixed quantitative and qualitative methods. By using qualitative research, the initial inductive, constructivist and interpretative exploratory approach focuses on words rather than quantification in gathering and analyzing the data.

The exploration is to view the performance and practices in knowledge management by the studied inter-governmental organizations by emphasizing both the process and results. Therefore the techniques of data collection were adjusted to a regional and national scale analysis, and data collection source and technique was multiple. Apart from the data acquired by interviews and observation, the study also used other documentary sources; different records produced in the process of data collecting, and relevant scientific publication on the studied topics. Altogether 20,540 pages of research reports and articles were reviewed, and 65 interviewees were interviewed in three years. The majority of the interviewees (No = 56 or 86 percent) were Mekong national and international researchers working in the Universities in the Mekong River Basin or attending the Mekong Forums (2004 and 2006 in Vientiane and Chiang Mai respectively). Only 12 percent of the interviewees (No = 8) were female, due to limited number of female participants at these events.

Table 3.1 Box 1 - Major Mekong Regional Initiatives and Forum

Mekong River Commission (MRC) was established by the four countries of the Lower Mekong Basin – Laos, Thailand, Cambodia and Vietnam in 1995 to replaces Mekong Committee (1957-1975) and Interim Mekong Committee (1977-1992). These Mekong Committees were "infamous" for their large scale plans for "harnessing the mighty Mekong". MRC (at least from 2000-2006) attempted to move away from its earlier image of being sectoral, closed, and hydropower-focused, to become an organization supporting integrated river basin management. China and Myanmar are currently observers to MRC.

Greater Mekong Sub-Region (GMS) established in 1992 is the largest program to promote trade, investment and infrastructure development in the GMS. The GMS is the only regional forum in which all six Mekong riparian countries participate. Whereas MRC operates only within the MRB hydrological boundary the GMS program extends beyond this boundary to cover the whole of Yunnan province, Guangxi Zhuang Autonomous Region of China, Myanmar, Laos, Thailand, Cambodia, and Vietnam.

Upper Mekong Commercial Navigation Channel Improvement Project (UMNCIP) under the Quadripartite Agreement on Commercial Navigation Lancang-Mekong is so far the only treaty directly related to the Mekong River resources that China is a party to. According to it, the river stretch of over 886 km from Samoa port in Jinghong, China, to Luang Prabang in Laos, is open to navigate freely by the state parties' commercial vessels - China, Myanmar, Laos and Thailand. There are more than 100 shoals, rapids and reefs in that section, of which 11 major rapids and 10 reefs pose a serious threat to navigation and, have to be removed. Works in Thailand and some sections in Laos were halted due to growing public protest.

Association of Southeast Asian Nations (ASEAN) is another regional body set up in 1967 to promote free-market principles and regional security. ASEAN now includes all 10 countries in Southeast Asia. In 1996, ASEAN inaugurated the Basic Framework of the ASEAN-Mekong Basin Development Cooperation (AMBDC). In 2000, ASEAN launched Initiatives for ASEAN Integration (IAI) to help its four new member countries along the Mekong River - Cambodia, Laos, Myanmar, and Vietnam (CLMV) - narrow the development gaps and fully integrate into ASEAN. At the fifth ASEAN + China Summit in November 2001, Chinese Premier Zhu Rong Ji declared his support and commitment to strengthening the cooperation in the Mekong Basin, free trade and the navigation channel improvement project. ASEAN-China Free Trade is being finalized.

World Bank and ADB Mekong Water Resources Partnership Programme (MWARP): In 2004, the World Bank initiated an effort to redefine the Bank's approach to the Mekong Region. The output of this effort will be the Mekong Water Resources Assistance Programme (MWARP). From the perspective of the WB and ADB, it is a five- to seven-year engagement providing the mechanism to implement and further develop this cooperation framework under four strategic results areas: balanced Development and investment; environmental and social safeguards; integrated water resources management; and governance. Initially, it focuses on the four LMB countries focusing on three transboundary sub-basins between Thailand-Laos, Cambodia-Laos-Vietnam, and Vietnam and Cambodia and on hydropower, infrastructure, irrigation and agriculture, navigation and transport, flood and wetland nexus, and capacity building (World Bank & ADB, 2006).

UNESCAP is a UN Regional Body whose longest history of promoting economic development in the Mekong region dates back to 1949. In 2000, ESCAP declared the years of 2000 – 2009 as the Decade of the Greater Mekong Sub-region Development Cooperation. It is especially active in promoting transport and navigation.

Ayeyawady-Chao Phraya-Mekong Economic Cooperation (ACMECS) was formalized at the 12 November 2003 Summit of the heads of the governments from Cambodia, Laos, Myanmar and Thailand, took place in which Bagan, Myanmar. At the 2005 Summit where Vietnam joined it, ACMECS adopted a vision of "five countries, one economy".

Donor community and international funding institutions: There are host of multilateral and bilateral donors and funding agencies, and private investment groups. They support & fund various projects and programs through various Mekong initiatives/organizations or bilateral channels covering different parts of the Mekong Region.

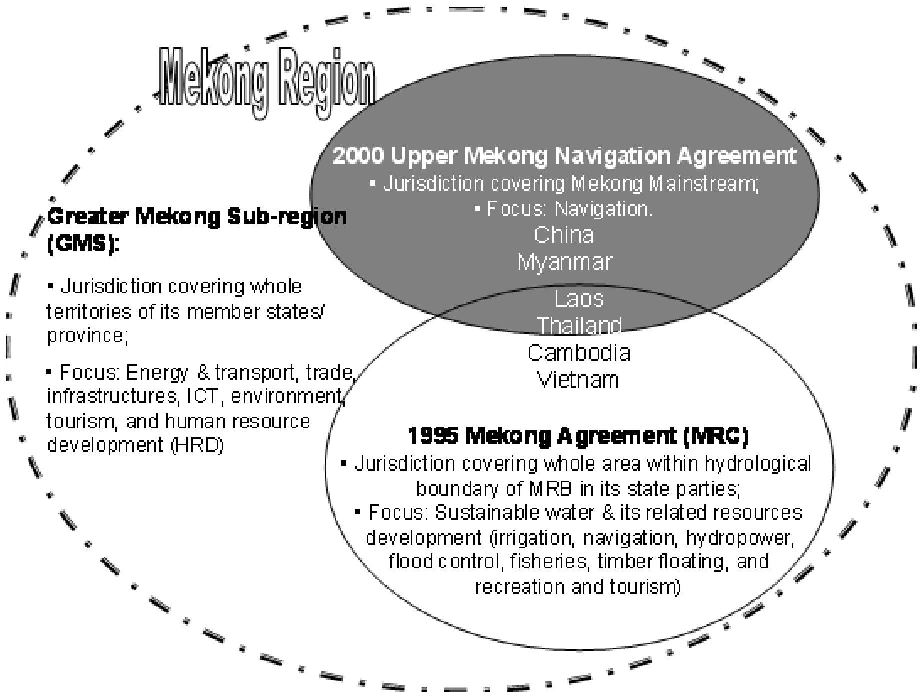


Figure 3.2 Membership and Strategic Focuses of MRC, GMS and UMNCIP

This number of the female participants (researchers and practitioners) of these two events cannot present the whole pictures about the gender representation within the research community in the MRB. But from the personal observation by the author of this study from participating in over 200 regional and international conferences and meetings in the MRB for the last 20 years (1991-2011), the Mekong research community is still highly male dominated.

Table 3.2 Key indicators, variables and code numberings

Indicators	*Variables*	*Coding*
A. Constant efforts for data collection & core datasets coverage	Investigation and data collection/collation and achievements	A.1
	Coverage of core datasets in their disposal	A.2
	Data quality and gaps	A.3
	Availability of improvement plans (quality and gap filling)	A.4
B. Capacity in mobilizing, using knowledge	Capacity of relevant staff at the regional office	B.1
	Capacity of relevant staff at the national office	B.2
	Efforts in knowledge transfer to national/riparian	B.3
C. Efforts in promoting Actual application in informed decision-making	Efforts in transforming data into information products	C.1
	Development & application decision making support tools	C.2
	Making information production available to the public	C.3
	Success & effectiveness in using knowledge in decision-making	C.4
D. Linkage with to Academic Institutions and	Availability of its own research facilities	D.1
	Partnership with research and academic communities	D.2

Research Communities	Effectiveness in linking scientific knowledge into action	D.3
	Existing plans for improvement of interaction and effectiveness	D.4

The derived codes were divided into categories according to the qualitative research approaches (e.g. interview, observation, document analysis). The agreement on the statement of facts or evidence identified from the information sources - published papers and interviews (calculated at 96 %) was counted, and frequencies and percentages were used to present the results. Each variable received a score that was then aggregated with the score of other relevant variables to determine the indicator score. All relevant indicators and variables were scored from level 0 to 1 with equal weighting: 0 = absence, 1 = presence/excellence. **Figure 3.3** shows the global and relative scores/result of the analysis. As shown in **Figure 3.3**, from the analysis of the statement of facts or evidence, all three international organizations/initiatives, in spite of the success in some aspects/variables, still have a lot of rooms for improvement in the areas of: a) data generation and coverage; b) capacity and skill in knowledge management; c) facility for knowledge and information access; d) linkage and collaboration research groups and academia. The findings of each indicator are discussed below:

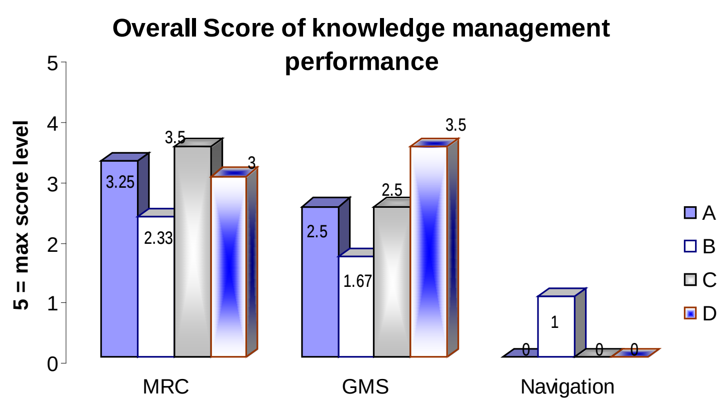


Figure 3.3 Global and Relative Scores of Knowledge Management

3.2.1 Data collection and extent of datasets coverage

The MRC (and its predecessors) has a better score in history and achievement in data and information collection and use, as it has had the longest history of data collection (**Figure 3.4**), mainly related to hydro-technical information such as rainfalls and flow dated back to 1894 (Mekong Secretariat, 1989). Its systematic measurements along the Mekong mainstream and key tributaries were initiated later in 1959 with major field investigations on hydrology surveys for planning and investigations of other related resources (Mekong Secretariat, 1989, Pech S, 2011).

Asian Development Bank (ADB) initiated the GMS Economic Cooperation Programme in 1992, and data and information gathering. It relied mainly on the networks of collaborating partners in member-countries, partner-institutions such as MRC, UNEP, and outsourcing to third parties (UNEP/Regional Resource Centre for Asia and Pacific, 2002).

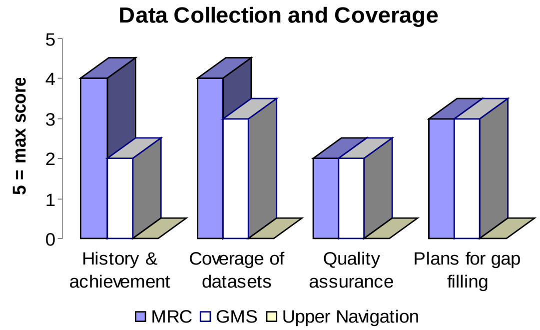


Figure 3.4 Data Collection and Coverage

As far as the coverage of core datasets in their disposal is concerned (**Figure 3.4**), the MRC and GMS have some remarkable coverage of core dataset types/thematic layers that fairly represent certain physical (e.g. hydrology), environmental (e.g. land/water use) and biological (e.g. fish stocks) characteristics of the Mekong Basin (Watershed Management Project, 2005; Starbuck, 2001). The biggest gaps, however, remain in the areas of economic, social, institutional, policy and political knowledge (CERAME, 2002). Both the need for, and data gaps have been increasing together with the expansion of the initial development focus from irrigation, hydropower, flood control and navigation to progressively integrate more holistic basin development planning and economic integration (MRC, 2010a). In spite of some success on the part of the MRC in getting some hydrological data from China since 2003, the data and information gaps from the upper Mekong Basin remain tremendously huge (MRC, 2010b). The gaps are due to communication problems and other artificial barriers (Magee, 2005).

The quality assurance and quality control score remains low for all of these organizations. Tools and data for assessing the environmental changes and impacts were limited to support rigorous and credible physical and environmental impacts. This inadequacy likely leads to huge underestimation of the negative impacts on livelihoods of the poor and vulnerable, biodiversity, inland and offshore fisheries, erosion of river banks and coastal shores (Pech S, *et al*, 2010). There are on-going plan for filling the gaps as all three organizations need good science, careful analysis and modeling that would help them understand these substantial variability, change and uncertainty in water flow regimes better. It is important to understand fundamental dynamics, to make the most informed decisions in non-stationary river basin and region including information on the factors that control the variance in the water regimes from droughts to floods, from water for agriculture and fisheries to water for hydropower etc., and to understand the impacts of that change on the social condition and livelihood of the dependent community for supporting appropriate prevention and mitigation measures.

3.2.2 Capacity in mobilizing, using and contributing to knowledge management

The analysis points to a massive need for capacity building and funding at both the regional and national levels, if the data and information management was to be sustained and strengthened in a long run (World Bank and ADB, 2006). The capacity is different in all six Mekong countries. As shown in **Figure 3.5**, the capacity is the biggest challenge for Cambodia, Laos and Myanmar. Their national capacity in knowledge management is severely constrained by lack of financial and qualified human resources, and or institutional limitations (GMS, 2006). The regional congestion of Mekong institutions/activities unfortunately left its marks in the national institutional set-up and spreads thinner the limited resources and capacity. For instance, Sarkkula J, *et al* (2006) documented that at least hundreds of academic modelling studies in Vietnam, China and Thailand. However, their development is mainly driven by separated projects and research institutes in isolation from each other.

Many of the Mekong-related models and knowledge management tools were realised through the development co-operation projects or programmes through contract arrangements with the companies dominantly from the North (UNEP/Regional Resource Centre for Asia and Pacific, 2002; Sarkkula J, *et al*, 2006); Watershed Management Project, 2005, Pech S, 2010). Bringing "North" data management and modelling approach brought several new things into the picture of knowledge management and use that sometime was considered as culturally sensitive and unfamiliar with.

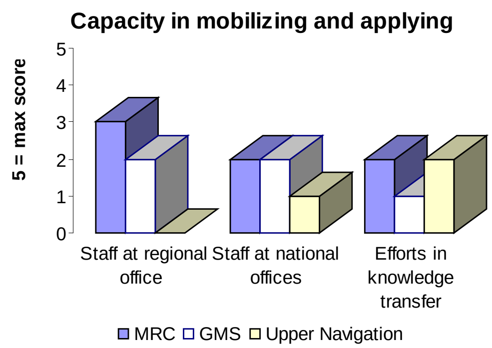


Figure 3.5 National and Regional Capacity

The review also shows that the greatest challenge remains in how to provide appropriate transfer of knowledge to guarantee sustainable use and benefit of the developed knowledge base, modelling and assessment tools for the beneficiaries in future. As obvious from **Figure 3.5**, the problems lie not only in the attitudes and capabilities of those who are supposed to transfer the knowledge but also due to limited absorbing capacities – technical skills/experience and language barrier - and other institutional constraints that lead to high staff turn-over rates or assignment of less qualified persons (Sarkkula J, *et al*, 2006).

The issues of data sharing remained an issue for many years within the national and cross-border contexts and should basically be resolved within the national context through the cooperation of data and knowledge producers and users. There have been limited efforts within the country to establish a national level data centre, which could have acted as data clearing/ware house and platform for data and information exchange.

3.2.3 Efforts in promoting actual application in informed decision-making

Most evidence points to the need to intensify all efforts to make model and knowledge base into a useful outcome in the planning and decision making (Sarkkula J, *et al*, 2006; GMS, 2006). As shown in **Figure 3.6**, both MRC and GMS have worked on data and information sharing platforms, and development of modelling and decision support tools. As shown in Table 3.3, MRC and GMS have developed a number of modelling tools and decision support systems. However, the challenges are: i) how to increase trust and confidence by the decision-makers in the quality of data and assumptions, information products, tools and the results of their simulation or assessment; ii) how to integrate and translate this information so that it is seen useful for decision-making; and iii) how to improve the knowledge base and decision support systems.

The independent evaluation of the Upper Navigation EIA as an indication of application of knowledge, stated that far too much of the content was based on patently inadequate data, and longer-term impacts were almost entirely overlooked, and the cumulative impacts both social and environment, were essentially ignored. Similar characterisation on the limited application/mainstreaming of the acquired knowledge into decision-making process can be related to most of the institutions under evaluation.

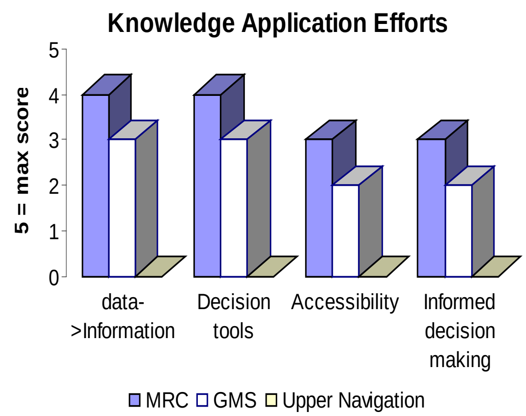


Figure 3.6 Efforts for Promoting Informed Decision Making

Table 3.3 Major Information products and knowledge dissemination tools by MRC and GMS

MRC	***GMS***	***Upper Navigation***
1. State of the Basin Report (2003) 1. Mekong River Basin Diagnostic Study Final Report (1997)	1. GMS Atlas of environment (2004)	Unknown
2. Decision Support Framework (DSF) (2004)	1. Strategic Environmental Framework (SEF) (2002) (Phase II on going)	
3. 1D lumped HBV model, 2D distributed watershed model (VMod), and 3D EIA Model (WUP-FIN, 2003) 4. 1D hydrological model, 2D hydraulic model, and Mike 11 for Cambodia floodplains (WUP-JICA & TSLV Project, 2004). 5. DHI Mike21 2D for Chaktomuk area (2002)	2. Sub-regional Environmental Monitoring and Information System (SEMIS) (2001 - on going. 3. Early Warning and Information System (EWIS) (2002)	
6. MRC-IS and Information sharing and Exchange (2000 – present)	4. Sub-regional Environmental Training and Institutional Strengthening (SETIS) (1999)	
7. Mekong River Awareness Kit, (2003) interactive CD-ROM & 8. Environment Training Kit, (2005)	5. Regional Indicative Master Plan on Power Interconnection in the GMS	

interactive CD-Rom 9. Various Interactive fisheries Database and publications 10. People and Environmental Atlas (2003) 11. Social Atlas (2003) 12. Information product catalogue and online purchase facilities	(2003) interactive CD-ROM

3.2.4 Linkage with Academic Institutions and Research communities

GMS and MRC have been involved in the research activities in at least three different levels, namely, i) through its affiliated research institutes or programmes; ii) coordinating research programmes; and iii) partnership arrangement with major research groups.

As shown in Table 3.4, both GMS and MRC have signed partnership arrangements with a number of research institutions and universities in the region and other parts of the world. However, the partnership has been restricted to jointly conduct short-term activities or remains mainly on the paper.

The GMS established its Environmental Operations Centre (EOC) in Bangkok to support knowledge generation and management under its Core Environmental Programme (CEP) (GMS, 2005). In 2006, the Mekong Institute established its Research Advisory Committee (MIRAC) to coordinate and facilitate policy research programs, and publish and use such research as a reference for GMS policy makers (Mekong Institute, 2006). However, as shown in **Figure 3.7**, there is still a lot of room for improving the knowledge generation effort in the MRB, and narrowing the gap between knowledge developers and users i.e. basin planners, managers, decision-makers and basin communities (World Bank and ADB, 2006; Magee, 2005).

Table 3.4 List of Partners and Research Institutions Associated with MRC and GMS

MRC	*GMS*
Asian Institute of Technology, Bangkok	GMS Academic and Research Network (GMSARN)
Australian Centre for International Agricultural Research	Asian Institute of Technology, Bangkok
Consultative Group on International Agriculture Research	Institute of Technology of Cambodia
Canadian Space Agency & Canada Centre for Remote Sensing	Yangon Technological University, Myanmar
Development and Environment; University of Berne	Kunming University of Science and Technology,
Institute for Sciences and Techniques of the Equipment and the Environment for Development	National University of Laos
International Network for Water & Ecosystems in Paddy Fields	Khon Kaen University, Thailand
International Water Management Institute (IWMI)	Thammasat University, Thailand
National Centre of Competence in Research North-South, Centre for Development and Environment; University of Berne	Hanoi University of Technology, Vietnam
National Institute of Rural Engineering, Japan	Ho Chi Minh City University of Technology
Public Works Research Institute, Japan	Royal University of Phnom Penh, Cambodia
RR2002 The Revolutionary Research Project	Yunnan University, China
Network of Aquaculture Centres in Asia-Pacific	GMS Tertiary Education Consortium (GMSTEC)
Southeast Asian Fisheries Development Centre	Mekong Institute (MI)
UNESCO/IHE Institute for Water Education	Asian Institute of Management (AIM)

Cooperation	
University of New South Wales and University of Sydney	Asian Development Bank Institute (ADB I)
WorldFish Centre	GMS Environment Operations Centre (EOC)
CIGAR Water and Food Challenge Programme	Institute for Global Environmental Strategies
	Mae Fah Luang University, Thailand
	Stockholm Environment Institute

(Source: MRC website, 2006 & ADB GMS website, 2006; and ADBI, 2006)

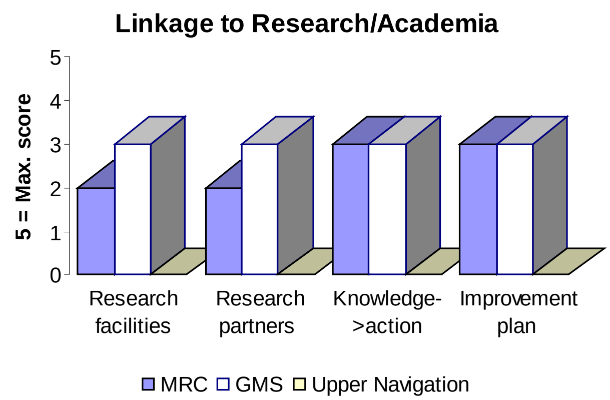


Figure 3.7 Level of Interface with Research Institutions

The review shows that the relationship between science-policy-practice was constrained by numerous factors. One major constraint facing these regional/international institutions responsible for the MRB's development is the limited research facility and unsustainable relationship/partnership with relevant research partners. Even though, GMS and MRC score above average for their efforts, there is some critical success in promoting knowledge application and plan for improving knowledge management (See **Figure 3.7**).

The study finding agrees with some commentators who argued that the flow of the Mekong related research and knowledge from Yunnan and China was severely restricted by the communication and language problems and other artificial barriers (poor interface) rather than by the absolute lack of such knowledge (Magee, 2005)

3.2.5 Conclusion on State of Knowledge Management from Key Inter-Governmental Organizations Perspective

The analysis of the studied inter-governmental bodies - Mekong River Commission (MRC), Greater Mekong Sub-Region (GMS), and Upper Mekong Commercial Navigation Agreement shows both opportunities and threat to the knowledge management. The findings can be used to support development of model for improving the interface from key Mekong regional organizations' perspectives.

Their performance and capacities are assessed by four clusters of indicators that are commonly used for measuring the knowledge management. From the analysis of the statement of facts or evidence, all three international organizations/initiatives, in spite of the success in some aspects/variables, still have a lot of rooms for improvement in the areas of: a) data generation and coverage; b) capacity and skill in knowledge management; c) facility for knowledge and information access; d) linkage and collaboration research groups and academia.

Even though, the MRC (and its predecessors) and GMS have had the longest history of data collection, with some remarkable coverage of core dataset types/thematic layers that fairly represent certain physical (e.g. hydrology), environmental (e.g. land/water use) and biological (e.g. fish stocks) characteristics of the Mekong Basin, the biggest gaps, however, remain in the areas of economic, social, institutional, policy and political knowledge.

The quality assurance and quality control score remains low for all of these organizations. This inadequacy likely leads to huge underestimation of the negative impacts on livelihoods of the poor and vulnerable, biodiversity, inland and offshore fisheries. All three organizations need good science, careful analysis and modeling that can help them understand these substantial variability, change and uncertainty in water flow regimes better based on improved understanding of fundamental dynamics.

The analysis points to a massive need for capacity building and funding at both the regional and national levels, if the data and information management was to be sustained and strengthened in a long run. The capacity is different in all six Mekong countries and it is the biggest challenge for Cambodia, Laos and Myanmar.

The review also shows that the greatest challenge remains in how to provide appropriate transfer of knowledge to guarantee sustainable use and benefit of the developed knowledge base, modelling and assessment tools for the beneficiaries in future. The issues of data sharing remain an issue for many years within the national and cross-border contexts. Most evidence points to the need to intensify all efforts to make model and knowledge base into a useful outcome in the planning and decision making. The challenges remain how to integrate and communicate them for decision-making. The flow of the Mekong related research and knowledge has been restricted by the communication and language problems and other artificial barriers. Many of the subject areas are deemed for right or wrong reason as sensitive and difficult to research.

The gap between them and knowledge developers and users remains huge. Relationship between science-policy-practice was constrained by numerous factors. One major constraint is the limited research facility and unsustainable relationship/partnership with relevant research partners and limited success in promoting knowledge application and plan for improving knowledge management.

In conclusion, there are a large number of research and development projects operating in the region, both national and international, but the size and complexity of the science knowledge gaps within the MRB are considerable as a result of a rapid growth in numbers, magnitude and complexity of the economic development in the MRB. Finally, there is a limited local research capacity which will need to be addressed.

3.3 KNOWLEDGE MANAGEMENT FROM MEKONG RESEARCHERS PRACTICE

It is true that the Mekong region (MR) and Mekong River Basin (MRB) have been the main focus of the research by research communities both from within and outside the region for many years. Various types and forms of knowledge have been generated. This sub-section assesses the factors driving interface (relationship between the research knowledge generation and its application in decision-makings) from the knowledge developer's perspective (Push Factor).

The analysis of the research papers published in selected major Mekong related science research groups. This study hypothesizes that the research scope, paradigm and thematic focus evidenced in their published papers provide insight into the past and current research focus and knowledge transmission patterns of the international, regional and national research laboratories and programmes.

The study searched and profiled publication and research papers published by the key Mekong related knowledge centres and research consortiums. The following seven key Mekong related knowledge centers and research consortiums located both in and outside of the Mekong Basin are selected:

1. Mekong River Commission (MRC) www.mrcmekong.org;
2. Asian International Rivers Center (AIRC), Yunnan University, www.lancang-mekong.org;
3. Mekong Research database (M-info) www.mekonginfo.org;
4. Asian Development Bank & ADB Institute www.adb.org, www.adbi.org;
5. Mekong Program on Water, Environment, and Resilience (M-POWER) www.mpowernet.org;
6. University of Yamanashi (UY) - Sunada Core Research for Evolutional Science and Technology (CREST) and Centre of Excellence (COE) programs, www.yamanashi.ac.jp, and
7. National Institute of Rural Engineering (NIRE) - Tanji CREST & Global Scale change in water cycles and food production programs, http://mekong.job.affrc.go.jp.

The flow of the inquiry included the identification, text mining, coding and validation (triangulation of findings), documentation and presentation of results. In the first step of analysis, the selected knowledge and research centres' websites and proceedings/annual reports (RR 2002 and MRC, 2004; 2nd APHW, 2004; JST and SIWRR, 2005; COE Annual reports, 2004 and 2005; and Sunada CREST Annual Reports, 2005) were screened for their respective Mekong relevant research papers. Combining search results, with duplicates removed yielded 178 articles and papers belonging to or commissioned by the selected knowledge centres and research consortiums. The time frame of the research was dated back from early 2000 to 2006. Even though they represent only a portion of those Mekong related information have generated and made available in the publication; and they did provide a good overview of the research patterns and trends.

In the step 2 of analysis, the review was carried out using the text mining techniques - analyzing the text and coding the data by using the designed coding sheet (Börner, *et al*, 2003). The summary section and conclusion were read by the author of this dissertation. In step 2 of the analysis, after weeding out duplicates (e.g., very similar paper with different orders of authors and/or slightly changed titles, or the same papers appeared more than once in various search engines), the review scanned through the selected papers in their abstracts and conclusion, or scanned the full papers to identify dataset types/themes, affiliations of authors and co-authors, date of publication, publishers, scientific topics, title, geographic focus, and key words. The analysis specifically focuses on the following areas:

A) Geographic scope: covering whole Mekong Region (MR); Mekong River Basin (MRB); Upper Mekong Basin (UMB); Lower Mekong Basin (LMB); single country (SC); or site specific (SS);

B) Level of involvement of Mekong nationals as first authors and/or co-authors; and

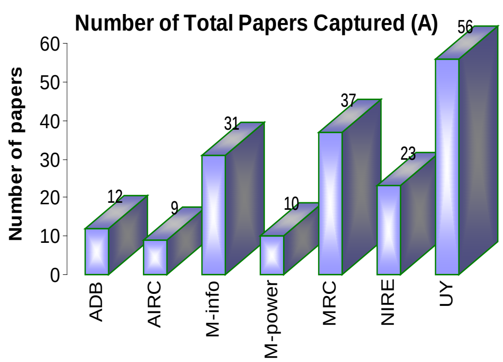
C). Extent of their coverage over those key problems, water related scientific and academic fields, and key attributes of Integrated Water Resources Management (IWRM).

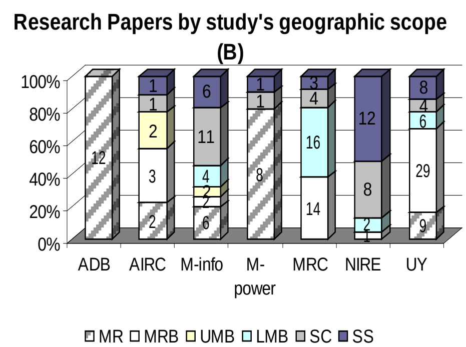
Then author and invited external reviewers cross-examined the derived codes, and a coding and scoring sheet was developed (Step 3). The data obtained by the document analysis were then entered into the excel file and additionally coded and added into the coding sheet. The publication review results were then entered into the Mekong Research Database (**MRD**) created by this study (Step 4).

This step-wise analysis permits the study to capture the overall research trends, key research areas, and level of interaction between researchers and potential users. With a more in-depth review by subject matter experts, the study managed to validate the quality and credibility of the research works and their social relevance.

3.3.1 Geographic Preference and Local Researchers/Practitioners Involvement

The analysis of the research fields shows the distribution of the reviewed publication (total number of publication) from each selected research group or entity (**Figure 3.8 Graph A)**.





Legend: MR = Mekong Sub-region; MRB = Mekong River Basin; UMB = Upper Mekong Basin, LMB = Lower Mekong Basin, SC = specific country, SS = site specific (highly localized)

Figure 3.8 Graph A: Total Number of Publication found; Graph B: Geographic focus of those research/studies

As far as the geographic focus is concerned, **Figure 3.8 Graph B** shows that over 27% of the total publication focussed over the MRB as a whole, while only 2% of them focused on the Upper Mekong Basin (UMB). This finding is in good agreement with the same assessment from the major Mekong Inter-governmental organizations presented in Section 3.2 above, where the limited availability of knowledge from the Upper Mekong Basin reaches is not from an absolute lack of such information alone, but also from lack of the access, and language and other artificial barrier.

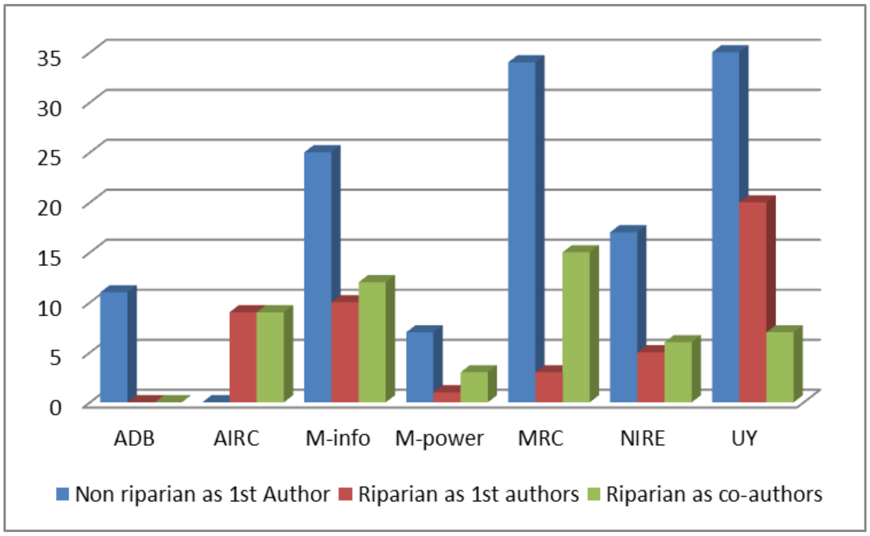


Figure 3.9 Riparian and Non-Riparian Authors of those research/studies

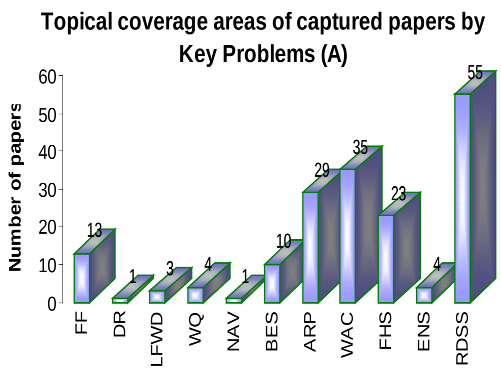
The analysis also finds that the majority of papers were written mainly by the non-Mekong as first authors (constituted over 77% of the 178 papers) (see Figure 3.9)

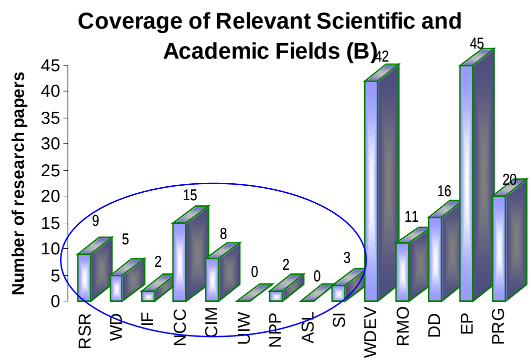
3.3.2 Research Problematic and Thematic Focus

The analysis of the scientific research fields and Mekong key issues to which those papers have dedicated, shows the majority of the selected papers were devoted to generating mathematical models and parts of the decision support framework (RDSS), watershed mapping and study (WAC) such as land use change, upper watershed forest and land use, and soil erosion, flood (FF) and the aquatic resources productivity (ARP). Other key problems, such as drought (DR), critical low flow and water demand (LFWD), navigation (NAV), and energy and hydropower issues (ENS), have been studied the least (**Figure 3.10** Graph A).

As shown in Figure 3.10 **Graph B**, about 45 papers (total =178) focus on water and related resources use efficiency and productivity (EP). Another 43 papers (about 30%) are on different aspects of integrated watershed management (WDEV) such as monitoring changes in rainfall and snow cover, forest cover, land use changes in the upper watershed and key lowland ecosystems such as Tonle Sap and the Mekong Delta. The reservoirs storage and release (RSR), large scale irrigation water diversion (WD), development of mega-infrastructure (IF), and the cumulative impacts – are covered the least by the reviewed papers.

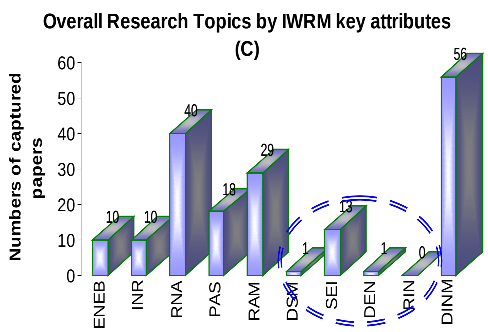
As far as their coverage of key IWRM attributes is concerned, the analytical results in Figure 3.10 **Graph C** shows that 56 papers (46% of total = 178) of the papers focus on developing technical data and information, and mathematical modelling (DINM). Another 29% focused on the assessment of resources availability and demand (RNA) by applying various tools such mathematical model, GIS and remote sensing for mapping, and monitoring, and to assess water and related resources such as fishery, and irrigated areas. A few papers focused on those issues such as the dispute engagement (DEN), the demand-side management (DSM), regulatory instruments for water allocation (RIN), and other key social, political and economic aspects





FF = Flood, **DR** = Drought, **LFWD** = **Low flow & water demand**, **WQ** = Water quality, **NAV** = Navigation, **BES** = Bank erosion/sedimentation; **ARP** = Aquatic resources productivity, **WAC** = Watershed changes; **FHS** = Food Security, **ENS** = Energy security, **RDSS** = Mathematical models and Decision support system, = Regulatory instruments**.**

RSR = Reservoirs storage & release; **WD** = Water diversion; **IF** = Infrastructure, **NCC** = Nature & climate change; **CIM** = Cumulative Impacts; **UIW** = Urban & industrial waste; **NPP** = Non-point source pollution; **ASL** = Acid & salt leaching; **SI** = Salinity intrusion; **WDEV** = Integrated watershed management; **RMO** = River morphology; **DD** = Demography & demand; **EP** = Efficiency & Productivity; **PRG** = Regional governance



ENEB = Enabling Environment**;** **INR** = Institutional roles **RNA** = Resources/need assessment**;** **PAS** = Planning & Scenarios; **RAM** = Risk assessment and management**;** **DSM** = Demand side management**;** **SEI** = Social & economic instrument; **DEN** = Dispute engagement**;** **RIN** = Regulatory instruments; **DINM** = Data/Info/models/tools.

Figure 3.10 Coverage of the Research on key Mekong Problems, academic fields and Key IWRM Attributes

3.3.3 Conclusion on Analysis of Knowledge Management from Science and Research Perspectives

It is true that the current analysis is limited only to the overall trends and classification of the selected research papers. But the refined analysis of the topical area, geographical scope and key words provides a good overview of the emerging interest by the leading research organizations and individuals. The analysis of the coverage areas, research themes, authorship etc. of the research publication provides a useful indication as to the current status and trends of the research, as well as nature of the involvement or interface in the Mekong research.

The findings provide insights and potential guidance to improving effective relationships of science, policy and practice. The findings do point to the need for encouraging more active participation of the Mekong experts and professionals in the research and knowledge generation activities as part of improving relevance, local capacity and confidence in the research quality and utilities of the generated information and tools in practice and decision making.

The analysis demonstrates also the level of complexity and demand for contribution of a number of scientific disciplines and topics to address problems and support improved IWRM functionality. It further reinforce the suggestion for a better integration and coordination of efforts and results among all major research and knowledge producing entities that are normally constrained by limited human and financial resources, shorter project life and limited scope and narrow disciplinary functioning, and under-representation of social science.

The findings are similar in many aspects to the findings from the analysis of the knowledge management performance of the key regional inter-governmental bodies and programmes in Section 3.2. They point to the need for a more cooperative and collaborative research works and partnership for reinforcing the research quality and a more free flow of the results.

Further careful review by subject matter experts would be necessary to fully validate the quality and credibility of each paper and its social relevance. The database developed by this study with further improvement and constant update would be useful for those interested in identify key research areas, sub-topics and detailed research questions of special interests.

3.4 NATIONAL AND LOCAL DECISION-MAKERS AND PRACTITIONERS' PERSPECTIVES ON THE INTERFACE

The section presents an elaborated search for improved understanding of the complex social, political and cultural factors and perceptions that influence the interface and knowledge management from the water policymakers and practitioners' perspectives (consumers). The concept of including "consumer" opinion in the formation of knowledge development research and policy, even at the level of individual research projects is no longer considered radical (Galvin R, 1998).

As part of its scientific and social validation, the study was conducted and the result was published in three peer reviewed book chapters (Pech S, 2008, Pech S and Sunada K, 2008a, and Pech S, 2011), and three consultative meeting reports and analysis (Pech S, et al, 2010a, b and c). The "consumer self-evaluation" analysis was conducted in four Mekong countries: Cambodia, Lao PDR, Viet Nam and Thailand, to facilitate cross-national comparisons of the issues under investigation. The main research problem is the success and failure factors of the science-policy-practice interface from knowledge users' (decision-makers, practitioners and other users) perspective.

Data was collected using a semi-structured discussion guide and interview/questionnaire form. The use of semi-structured interviews allowed the collection of reliable comparable data from respondents, as they were allowed to express beliefs and opinions in their own terms around the set of questions listed in the questionnaires.

As shown in **Figure 3.11**, the government affiliated researchers, river basin managers and policymakers dealing with water resources development and policy at the national and Mekong Regional level in each of the targeted countries are identified as key informants. The first round of interview was for informants randomly selected, and the interview was then snow-balled to include a wider group of interviewees recommended from the first round of the interview. A total of 148 semi-structured interviews were conducted from 2008-2010.

Over 77 percent were male and less than 33 percent were female. The participants were from the government departments and research institutes, the Non-governmental Organizations (NGO), International Organizations (IO), Universities and independent consultants (**Figure 3.11**).

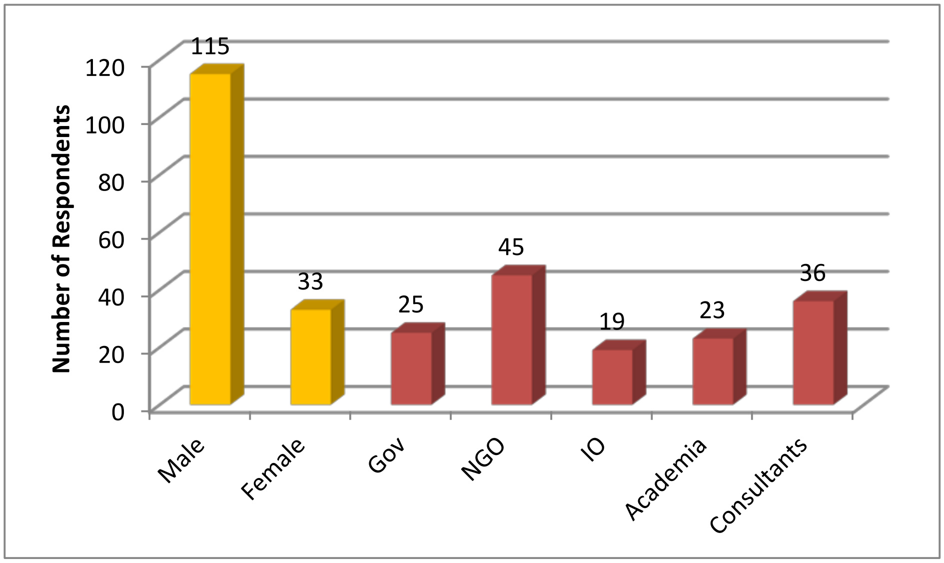
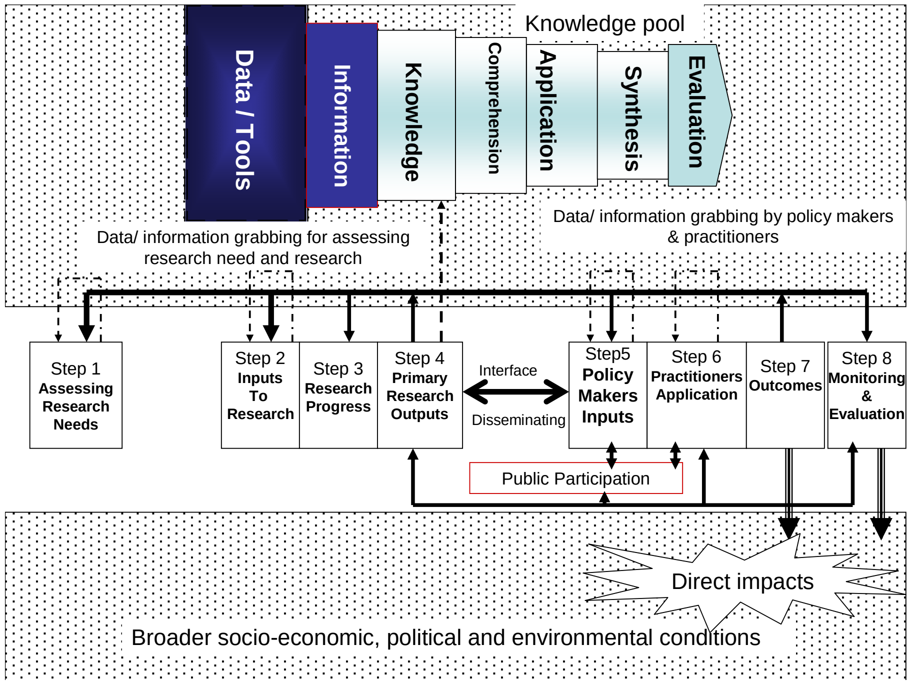


Figure 3.11 Participant Property in Semi-Structured Survey

The information collection was structured around the respondents' personal and professional experiences and views on science-policy-practice interface in various stages of policy process and research program cycles as shown in **Figure 3.12**. The informants were asked to describe their current practice in disseminating and uptake data and information, barriers and opportunity, and suggested strategies for improved interface from knowledge user perspectives.

As shown in **Figure 3.12**, the process was designed to grasp into an extremely important factors for enhancing understanding of the issues, including the differential scope for utilization associated with types of research and policy environments, perception on social relevance and scientific credibility, and prevailing social, political and environmental condition, etc. The collected information was analyzed and input into a conceptual framework that includes relevant stages of the policy process and knowledge management stages.

The results of the assessment are presented at multi-stakeholder consultations for further validation and triangulation of data and findings. The analysis shows that there is no significant difference between male and female respondents' perception on knowledge management in general. However, there are some significant views between respondents from different sectors and affiliations on certain aspects of knowledge permeability and social relevance of knowledge management. The detailed discussion is presented in the following sub-sections



(Adapted from Meyer, et al, 2006)

Figure 3.12 Conceptual Model of Science-Policy-Practice Interface Potential Pathways

3.4.1 Permeability Issues in Current Knowledge Management

Most of the respondents (No = 131/148) agreed that in a perfect world, research and policymaking should go hand in hand, yet, in practice, their interface has been limited by some known factors. Many of them concurred that policymakers tend to be busy with immediate problems and may not be well acquainted with research and science, and the way they function. 48% (N=67/148) of the respondents argued that most researchers were focused primarily on academic studies for purely academic purpose, and publication of their results in scientific journals, and might not understand the policy process and how it works and what and when data and information are needed. The survey findings are in agreement with an assessment carried by Myer J, *at al* (2006) in the United States of America, Africa and Asia. They argued that to put new and innovative research to work in the policymaking process took tenacity, commitment and understanding each other worlds – academic and political - on the part of both researchers and policymakers (Myer J, *at al*, 2006).

Most of the respondents (No =132/148) stated that the partnerships between researchers and policymakers were not effective due to the lack of sustainable relationships and mutual trust between them. Many respondents (No =98/148) argued that there was no agreed formula or mechanism to guide the interface that would fit for all circumstances, but real commitment and tools for measuring and encouraging such commitment toward that improvement, must be put in place. This argument for tool for measuring effective interface is well aligned with the study key hypothesis. This study found a total agreement among various actors in the knowledge management on the need for commitment and tools for encouraging and monitoring the science-policy-practice interface.

3.4.2 Current Practices of Recourses to Knowledge for Decision Making

As far as when and how practitioners and policy-makers recourse to knowledge is concerned, Most respondents (No= 124/148) said that they turned to researchers for answer after certain critical events, crisis (disastrous flood or drought) or pressing policy issue have emerged (reactively rather than proactively). Once they were aware of the problem, policy-makers, managers and their staff scanned existing research to learn about the issues, scope and extent of the problem, and explain its root-causes. This reactive attitude toward knowledge for solving problem often resulted in less-informed decision making with severe consequences. The findings on the need for a more proactive approach in the MRB were confirmed by the most recent studies by other researchers (Myer J, *at al,* 2006, Pech S, *et al*, 2010b and c, MRC, 2010a). These studies recommended that policymakers should cultivate relationships with researchers so that they are able to proactively plan for mobilizing for needed information and knowledge in anticipation of the emerging issues and reach out to knowledge producers and custodians to anticipate the issues and respond quickly when pressing policy issues arise. Likewise, researchers should develop either formal or informal relationships with government officials to keep abreast of what issues are of greatest concern to policymakers such as the climate changes, drought, flood, storms, and impact assessments and mitigation.

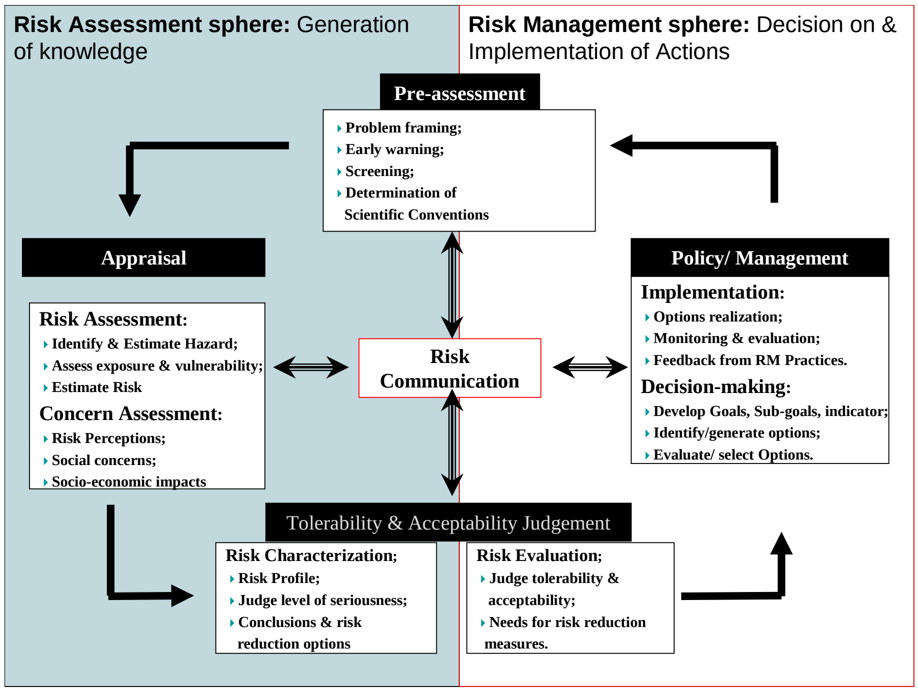
About 50% of respondents (N =73/148) observed growing number of cases of direct collaboration or partnership between policy-maker and managers, and researcher/knowledge producers on some key contemporary issues emerging in the MRB on such as climate change, and sustainable hydropower development issues etc. For example, M-POWER (Mekong Program on Water, Environment, and Resilience) involved the policy-makers, hydropower developers, researchers and Non-Governmental Organizations (NGOs) in identifying the problems and improving decision-making around energy and water resources development in the Mekong region (Molle F, *et al*, 2009, Pech S, *et al*, 2010a, b and c).

The study has conducted four rapid assessment consultations with decision-makers, practitioners, and researchers from relevant government agencies, and Civil Societies Organizations (NGOs, Academia and community based organizations), in 2010 and 2011 to assist them in applying available tools for assessing sustainability of water and energy planning in the MRB.

3.4.3 Perception on Trustworthiness and Relevance of Knowledge in Each Policy Process Stage

As shown in **Figure 3.13**, the questionnaire and analysis of how knowledge is captured for decision making if any at all, were focused on each step of the policy process – pre-assessment (problem identification and formulation), appraisal (risk assessment), acceptability/tolerability assessment (risk and policy option evaluation, goals and objective setting), and management (decision, implementation and evaluation). Many respondents (No= 98/148) said that at the problem identification and policy options development stage (setting goals and objectives), the relationship between policymakers/managers and researchers and the exchange of information, typically became more formalized through concrete contractual arrangement.

Policy-maker and managers often commissioned consultants or research group/organizations they knew to help design policy options and risk management and mitigation. At this particular stage, the task of the researcher was to provide a strategic and conceptual framework, as well as information, within which policymakers could determine which option was best aligned with their intended policy goals. The researchers or consultants need to be able to work rapidly within allocated time frame to provide policymakers with viable options for program improvements and assemble credible data that can be used to predict the potential impact of these options (Myer, *at al* 2006).



(Source: Pech S, 2009 at http://www.popstoolkit.com/riskmanagement/module/intro.aspx)

Figure 3.13 Conceptualized model of science-policy-practice interface in risk management process

As shown in **Figure 3.13**, while the problem formulation and option development stage involves defining the problem, risk and level of acceptability (modeling potential outcomes), the implementation stage involves the trial and error of testing policy options and determining their robustness under a wide variety of real circumstances (Myer F, *at al* 2006, Pech S, 2009). Some respondents argued that during this stage, researchers or consultants work closely with government officials to work through the technical issues.

The response from most interviewees somehow matched with the observation in the literature (Meyer F, *et al*, 2006). They said that at this implementation stage – policy management, the traditional role of researchers was limited. In order for a researcher to have input at this stage, he or she often must win a competitive bidding process or have an existing strong relationship with concerned national agencies/department leaders. Most respondents argued that the researchers need to have a different set of skills for the implementation stage as they become more like consultants, with state policymakers as their clients who decide the fate of the final outputs linking to the final payment and acceptance for informing policy decision.

Many respondents (N =135/148) confirmed that at the program and policy evaluation stage, the evaluation are mainly decided by concerned government institutions, especially when such evaluation was required by the program, enabling legislation or a requirement imposed by the funding institutions. An evaluation could also be initiated and funded by an outside party, such as a civil society organizations or regional organization.

In either case, the internal and external evaluators need access to qualitative and quantitative data necessary for a comprehensive and accurate evaluation. Many respondents (N=99/148) said that the government agencies sometime gained access to data maintained by the researchers, but very often they preferred to use data (baseline and monitoring) generated or collated by the projects/program they associated with. The unawareness and lack of trust seem to be a main reason behind this practice.

The respondents (N=78/148) confirmed that the role of program evaluator sometimes fell to an institution, such as a university or a think tank, with which the government agencies concerned developed or maintained relationship. For example, Sunada CREST research team member was commissioned by the Mekong River Commission's donors to conduct an institutional, organizational and financial performance of the Mekong River Commission and its programs/project in 2004-2005. In this case, the researchers interact mainly with staff in MRC Secretariat and concerned government agencies in MRC member countries.

3.4.4 Policymakers and Practitioners Perception on Quality of Knowledge Dissemination

Many respondents (N=110/148) said that they would more likely to use the research outputs for the policy and program development if:

- They were involved in the research process;
- They had commissioned the research, or
- Research was in direct response to a policy need.

Respondents (N=89/148) believed that carefully designed involvement of decision-makers in the research process led to a more effective consideration of policy issues, political limitations and practical realities in up-taking the research findings into decision making. They (N=92/148) recommended that collaboration between researchers and policymakers should be at all relevant stages in the research process: defining research; designing research questions, conducting research and developing policy recommendations and communication.

Some decision-makers and practitioners (N=55/148) – many of them have limited exposure to research works - reported difficulties with the academic style using technical language, and complex statistics. They suggested that in addition to a long and detailed academic style report, a concise, well-structured report with an executive summary of the key findings, policy implications and options would be more useful to the policy development purpose (packaging and communication). Some respondents (N=68/148) felt that a range of policy recommendations should be provided such as short, medium and long-term strategies and that options should be given for various resource scenarios (Pech S, *et al*, 2010c).

Most of the respondents (N=125/148) from the governments and non-governmental agencies identified the lack of a central depository for research outputs. Some of them expressed frustration at trying to locate research reports without a central clearing-house or database where they could easily access water resources related research or knowledge for use with confidence about its quality. Many respondents thought that a depository of research outputs would be particularly useful and suggested that such clearing-house - depository or knowledge mining web-based tool to be coordinated by a public institution to enable greatest access and should be publicized widely among the research, policy and practice community.

Some respondents (N= 89/148) reported that there seemed to be no structured mechanisms through which dissemination of research/scientific information and knowledge would take place effectively for all circumstances. The respondents (N=120/148) pointed to two different dissemination processes – the research commissioned by a donor or a government agency, and the non-commissioned research. From their experience, these respondents found that the commissioned research usually has a direct channel of communication between the researcher and the commissioning agency, facilitating dissemination of the final research outputs and their uptake in decision making. The governmental agencies commissioning research are typically involved in the research process and demonstrate interest in the research outputs (research report). The commissioned research is often disseminated via workshops, or the donor agency initiates the distribution of the research outputs to a wider audience.

The respondents (N=112/148) confirmed that the non-commissioned or independent research tends to have less clear and more varied channels of dissemination to the decision-makers and practitioners. Many researchers were found to have to limit dissemination to academic channels (e.g. papers in peer-reviewed journals or presentations at the scientific conferences). The respondents (N= 97) also observed some kind of direct dissemination of non-commissioned research to the policymakers and practitioners either through the distribution of research reports and papers, involving some government agencies officials in the research project activities (knowledge facilitator or champion), or inviting some of them and other stakeholders to a dissemination workshops or conference.

Many respondents (N=94/148) emphasized the need for diversification of means and forms for transmitting/disseminating the research outputs in additional to presenting at international conferences or published in international journals) - in a way and format that should be more easily accessible to local decision-makers and government ministries. They also (N=98/148) thought that the lack of communication skills and resources by the researchers was a key barrier to the successful dissemination of their research outputs. This finding is in agreement with the previous analysis of the three intergovernmental organizations, and other key Mekong related water research groups. They all pointed to the need for skill development for researchers in communication of research findings outside academic circles and identifying/building links with their targeted audiences.

Some local researchers (N=45) found that frequent changes in government portfolios and frequent staff movement (resignation, promotion or transfer to other positions) made the development and maintenance of networks with and access to decision-makers and practitioners challenging.

3.4.5 Perception on Social and Political Environment as Influencing Factor

The respondents (N=65/148) complained that the policy environment in some studied countries was not encouraging the incorporation of research in policy formation and program development. Many respondents (N=98/148) recognized that even well-developed research findings may not be acted upon if the political climate was not conducive to change. Some local researchers said that the lack of a strong evidence-based culture in policy development in some Mekong countries was a significant bottleneck in disseminating research outputs to decision-makers. Respondents (N=96/148) observed that capacity and ability to evaluate the quality of a research study or to interpret complicated research findings, tends to make it difficult in translating research findings into informed policy action.

Many respondents (N=94/148) stressed the importance of understanding of the cultural and contextual issues surrounding the research, and ensuring research findings and recommendations reflect realities. They stressed the need for allocating adequate time and resource for consultation in identifying priority research issues and packaging the research products.

Some respondents (N=64/148) said that the quality and accessibility of in-country research was an issue that prevented them from using local research outputs. This was a particular issue in Cambodia and Lao PDR, where limited skill and resource base amongst local researchers made it difficult to conduct high quality research. It is well in an agreement with the result of the review of three inter-governmental organizations' knowledge management in section 3.2.2.

Some respondents (N=64/148) said lack of government investment in the research was to be blamed for since local researchers did not have the advantage of expert training and technical competence afforded to those in international agencies from more developed world to undertake research to meet an international standard.

3.5 CONCLUSION AND TRIANGULATION

The triangulation analysis in this chapter permits the author of this dissertation to address more specific research questions underlined in the research methodology section as follows:

3.5.1 Complex Key stakeholders' Mapping

From the initial assessment, it is clear that there are at least three major groups involving in these interface relationship, including hundreds of Mekong Region related researchers, research groups or consortium based both inside and outside of the region; numerous international, regional, and national government institutions, non-government organizations; and thousands of practitioners and communities of practices in the Mekong Region at both regional, national, and local level. Each of them has its own membership, focus, principles or norms that determine how it cooperates and defines its strategic direction and priority. It is regrettable that the coordination and integration remains a great challenge.

3.5.2 Understanding by government and research/scientific groups about the science-policy-practice interface

The analysis of the inter-governmental bodies are the MRC, GMS, and Upper Mekong Commercial Navigation Agreement for their efforts and success in knowledge management were focused on data collection and datasets coverage; capacity in mobilizing, using and upgrading knowledge; efforts in promoting informed decision-making; and interface with research communities.

From the analysis of the statement of facts or evidence, all three international organizations/initiatives, are conscious and sub-conscious about the importance of knowledge management for supporting growingly complex water and related resources development decision. The MRC (and its predecessors) and GMS have had history and achievement in data and information collection and use covering wide ranges of core dataset types/thematic layers that fairly represent certain physical (e.g. hydrology), environmental (e.g. land/water use) and biological (e.g. fish stocks) characteristics of the Mekong Basin. The quality assurance and quality control score remains low for all of these organizations. This inadequacy likely leads to huge underestimation of the negative impacts on livelihoods of the poor and vulnerable, biodiversity, inland and offshore fisheries.

There are on-going plan for filling the gaps, as all three organizations need "good science", careful analysis and modeling that can help them understand these substantial variability, dynamic change and uncertainty about factors that control the variance in the water regimes from droughts to floods, from water for agriculture and fisheries to water for hydropower etc.

The analysis points to a massive need for capacity building and funding at both the regional and national levels, if the data and information management was to be sustained and strengthened in a long run. The review also shows that the greatest challenge remains in how to provide appropriate transfer of knowledge to guarantee sustainable use and benefit of the developed knowledge base, modelling and assessment tools for the beneficiaries in future.

The problems lied not only in the attitudes and capabilities of those who are supposed to transfer the knowledge but also due to limited absorbing capacities – technical skills/experience and language barrier - and other institutional constraints that lead to high staff turn-over rates or assignment of less qualified persons.

Most evidence points to the need to intensify all efforts to make model and knowledge base into a useful outcome in the planning and decision making. In spite of the efforts by relevant organizations and research groups, the challenges remain: i) how to integrate and translate this information so that it is seen useful for decision-making; and ii) how to improve the knowledge base and outreach and interaction.

Analysis of the scientific fields and Mekong key problems shows the majority of the selected papers were devoted to generating mathematical models and decision support framework, watershed management issues, and the aquatic resources productivity. Other equally important topics and problems, such as drought and flood, critical low flow and water demand etc. have been studied the least. This fact suggests for a need for developing and employing tools for mapping demand driven research program or projects.

As far as the coverage of key IWRM attributes is concerned, the analytical results shows that research papers focus on developing technical data and information, and mathematical modelling, applying various tools such mathematical model, GIS and remote sensing for mapping,. A few papers focused on those issues such as the dispute engagement, the demand-side management and alternative options, regulatory instruments for water allocation, and other key social, political and economic aspects.

The analysis also found that the majority of papers were written mainly by the non-Mekong nationals as first authors. The results confirmed the most critical needs for encouraging more active participation or empowerment of the Mekong experts and professionals in the research and knowledge generation activities as part of improving relevance, local capacity and confidence in the research quality and usefulness. This fact also points to the need for a more cooperative work and a truly regional collaborative research works and partnership for reinforcing the research quality and a more free flow of the results.

The analysis of the thematic and problematic focus of those publications allows this study to grasp not only the trend of the research, but also potential gaps of the knowledge to address the entire spectrum of possible functionalities of the IWRM and associated problems. The problems identified in this sub-section and those problems in **Table 2.6** are then framed into the water issues, and land use changes concept – and their linkage to sustainable livelihood approach and governance. The findings are then framed into relationship causality or linkage to the key attributes of IWRM as shown in Figure 3.14).

Figure 3.14 depicts key water resources problems in the Mekong River Basin (see problem analysis presented in **Table 2.6**) and ideal thematic flow and focus for addressing key knowledge and decision-making requirement for supporting IWRM. This Figure also introduces the analytical samples of the linkage of one of the identified problems with possible cause(s) and effect(s) and IWRM and knowledge based problem management. Each identified key problem is seen to have multiple cause- effect relationship and is closely related to many key IWRM knowledge and institutional attributes.

This analytical result confirms the previous hypothesis in Chapter 2 about the correlation between IWRM based governance and knowledge management. For example, drought and flood issues are closely related flow, water storage, and hydro-meteorological conditions, and upstream-downstream water allocation and withdrawal. All of these problems and cause-effects are closely to other cause-effect relations and require specific IWRM knowledge and institutional measures. The result implies knowledge need for problem solving that has to be multiple disciplinary and cross-cutting and must meet not only scientific rigor, but also the social relevance.

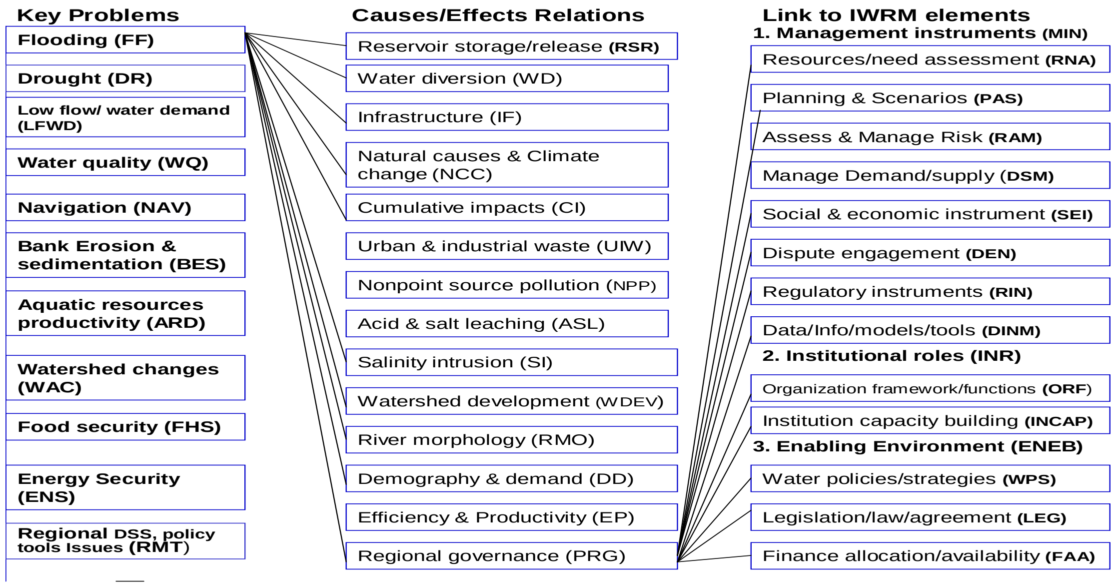


Figure 3.14 MRB problems, their causes-effect relationship, and linkage to key IWRM attributes

The results of the analysis testify the complexity and multiple linkages of various scientific disciplines and topics called for providing knowledge and ascertaining facts for preventing and solving identified issues. The scientific disciplines that are required to provide solution to the issues range from those of natural sciences – hydrology, climatology, physical geography – political sciences, to social sciences – demography, humanity, and environment economics etc.. They explain the need for selecting the research topics or fields based on the multi-disciplinary angles, rather than from individual scientific disciplines.

Table 3.5 presents an example of potential knowledge areas and science topics required for supporting improved IWRM functionality in MRB derived from literature review and consultation with the researchers and policy-makers in the MRB. The future research should be built upon the two premises – IWRM key elements and key problems, as there is an obvious need for responding to the need for increased IWRM functionality in the MRB, and preventing or solving problems proactively and efficiently. The analytical result clearly demonstrates the level of complexity and high demand for contribution of a number of scientific disciplines and topics to address major knowledge area to support improved IWRM functionality. It further reinforce previous suggestion for a better integration and coordination of efforts and results among all major research and knowledge producing entities that are normally constrained by limited human and financial resources, shorter project life and limited scope, and narrow disciplinary functioning of many research entities and weak representation of social science community.

Table 3.5 Example of IWRM functionality research needs road-mapping

	Major Knowledge Areas	Related Science Topics
1. IWRM Planning &	Understanding resources availability/demand: Resources needs, supply-side and demand-	**Water resources and hydrological processes -** ground water and surface

monitoring functionality	side analysis and monitoring Tools for balancing supply and demand (efficiency and productivity technology) Advanced scientific framework/methodologies for demand forecasting Water management indicators, performance threshold and monitoring, basin sustainability monitoring Valuation of resources (resources economics) River/lake basin planning tools (knowledge and models), and capacity Improving system efficiency and productivity & changing user behaviours Social change instruments - public participations/multi-stakeholders forum, water education… Building trust and cooperation over the validity and usefulness of information and tools Methods for improving effectiveness of data and modelling framework Management and mitigation of man-made and natural hazards	water flow, water properties, water quality, water supply and demand, water use, flow and sediment transport. **Hydrometeorology & climate –**, precipitation, evatranspiration, runoff, climate change, and global change. **Ecology & environment**: biodiversity, ecosystems, habitats, floodplains, environmental flow. **Geologic processes**: erosion, land subsidence, sedimentation, tectonic processes. **Natural resources:** Agriculture, forestry, land resources, biodiversity, fishery & aquaculture. **Catchment management:** Watershed & floodplain dynamics + estuarine & coastal zones. **Natural hazards & risk (NHR)**: droughts, floods, storms, earthquakes, land/mudslides
2. Institutional Roles & Enabling Environment	Tools supporting cross-sectoral policy/strategy framework (trade off and planning scenarios) Hydrologic, socio-economic, resources allocation models and framework Assessment and improvement of forms and functions of transboundary organizations & agreements Management methodologies and systems for monitoring, compliance and verification Regional good governance functions and supports - sound legal basis, resource management policy and trade-off negotiations... Proactively managing disputes, ensuring equitable sharing of benefits Institutional capacity building/ upgrading skills and understanding of decision-makers, managers, professionals and other stakeholders Improving capacity for coordination and integrations, management accountability, Effective mechanism for basin stakeholders and partners communication and participation	**Demography & humanity:** Water supply & sanitation, food & energy security, demographic scenarios, life style and demand growth, and demand forecasting and response. **Natural Resource economics:** Resources valuation & pricing, resources distribution and redistribution efficiency, and equity and sustainability. **Knowledge and management tools:** tools to support decision-making, modelling, communication, assessment, planning and monitoring tools, **Regional Politics and governance**: Collective relationship – special incentive, side benefit, form of coercion/compliance - , conflict management, Diplomacy and international relations, law, governance and participation, and science-policy-management interaction.

3.5.3 Quality of existing mechanism and tools for furthering interface

The findings showed that there are some structured mechanisms through which dissemination of research/scientific information and knowledge potentially take place effectively for all circumstances. There are at least two different dissemination processes – the research commissioned by a donor or a government agency, and the non-commissioned research. The commissioned research usually has a direct channel of communication between the researcher and the commissioning agency, facilitating dissemination of the final research outputs and their uptake in decision making. The commissioned research is often disseminated via workshops, or the donor agency initiates the distribution of the research outputs to a wider audience.

The non-commissioned or independent research tends to have less clear and more varied channels of dissemination to the decision-makers and practitioners. Many researchers were found to have to limit dissemination to academic channels (e.g. papers in peer-reviewed journals or presentations at research conferences). Gradually some kind of direct dissemination of non-commissioned research to the policymakers and practitioners take place either through the distribution of research reports and papers, involving some government agencies officials in the research project activities, or inviting some of them and other stakeholders to a dissemination workshops or conference. It is also confirmed that the knowledge users initially seek for information internally or through commissioned research outputs, and then consult a range of sources including other ministries and government departments and documents from international research organizations (using search engine and open access). The findings also confirm the need for diversification of means and forms for transmitting/disseminating the research outputs in additional to presenting at international conferences or published in international journals) - in a way and format that should be more easily accessible to local decision-makers and government ministries.

Most of the respondents identified the need for an operational depository or a central clearing-house for research outputs for easily accessing related research or knowledge for use with confidence about its quality by users.

3.5.4 Key Bottlenecks

In the MRB, the gap between knowledge developers and users i.e. basin planners, managers, decision-makers and basin communities, remains constrained by numerous factors. One major constraint facing these regional/international institutions responsible for the MRB's development is the limited research facility and unsustainable relationship/partnership with relevant research partners, even though, GMS and MRC score above average for their efforts, though with some limited success, in promoting knowledge application and plan for improving knowledge management.

In some circumstances, the flow of the Mekong related research and knowledge was severely restricted by the communication and language problems and other artificial barriers rather than by the absolute lack of such knowledge. The analysis of the research fields by key research groups shows that over 27% of the total publication focussed over the MRB as a whole, while only 2% of them focused on the Upper Mekong Basin (UMB). This finding is in good agreement with the same assessment from the major Mekong Inter-governmental organizations, where the limited availability of knowledge from the Upper Mekong reaches is not from an absolute lack of such information, but also from lack of the access, and language and other artificial barrier

There are a large number of research and development projects operating in the region, both national and international, but the size and complexity of the science knowledge gaps within the MRB are considerable. Many of the subject areas are also sensitive and difficult to research. Finally, there is a limited local research capacity which will need to be addressed.

The findings also confirm that policymakers tend to be busy with immediate problems and may not be well acquainted with research and science, and the way they function, and researchers may tend to focus primarily on academic studies for purely academic purpose, and may not understand the policy process and how it works and what and when it needs.

The policy-makers turned to researchers for answer after certain critical events, crisis (disastrous flood or drought) or pressing policy issue have emerged (reactive vs. proactive). This reactive attitude toward knowledge for solving problem often results in less-informed decision making with potentially severe or irreversible consequences. The findings on the need for a more proactive approach in the Mekong Region were confirmed by the most recent studies by other researchers. These studies recommended that policymakers should cultivate relationships with researchers so that they are able to reach out to them to anticipate the issues and respond quickly when pressing policy issues arise. Likewise, researchers should develop either formal or informal relationships with government officials to keep abreast of what issues are of greatest concern to policymakers such as the climate changes, drought, flood and storms.

Most decision-makers and practitioners reported difficulties with the academic style using technical language, and complex statistics. They suggested that in addition to a long and detailed academic style report, a concise, well-structured report with an executive summary of the key findings, policy implications and options would be more useful to the policy development purpose (packaging and communication).

They findings also pointed to the need for skill development for researchers in communication of research findings outside academic circles and identifying/building links with their targeted audiences. Frequent changes in government portfolios and frequent staff movement (resignation, promotion or transfer to other positions) made the development and maintenance of networks with and access to decision-makers and practitioners challenging. It is a fact of life that the players in the science-policy-practice interface have to live with and adapt to.

3.5.5 Uniformity of Evaluated Issues

It is worthy to note the uniformity of issues raised by researchers, policymakers and practitioners about poor permeability of knowledge into decision-making process. The gaps between the water resources knowledge generation and its utilization in the decision making and practice were found in both the knowledge producers and knowledge users' perspectives.

The findings indicate common challenging experiences with dissemination and communication, lack of capacities and incentives and motives from the parts of all sub-set of players. A number of issues were more prominent in the least developed countries like Cambodia and Lao PDR, due to the lack of capacity and experiences in appreciation and application of knowledge in the decision makings by both governmental and non-governmental policy-makers and practitioners. The resource and infrastructure limitations and the smaller pool of skilled professionals lead to the greater prominence of issues such as the lack of communication networks, the need for central depositories of research information and the lack of in-country expertise for policy research in these countries.

The lack of a strong evidence-based culture in policy development and policy making styles in some Mekong countries was a significant bottleneck in up-taking research outputs in the decision-making process. The capacity and inclination of the decision-makers to appreciate scientific knowledge or to interpret complicated research findings, would enhance translation of research findings into policy decision and action.

The analytical result shows that the current research interests not always coincide with the actual needs of the targeted users and communities to address its current and emerging problems. They are also related to poor absorbing capacity, poor communication, lack of proper understanding of actual social needs, domination of traditional scientific approach and narrow disciplinary functions etc. (Stephenson, *et al* 2002).

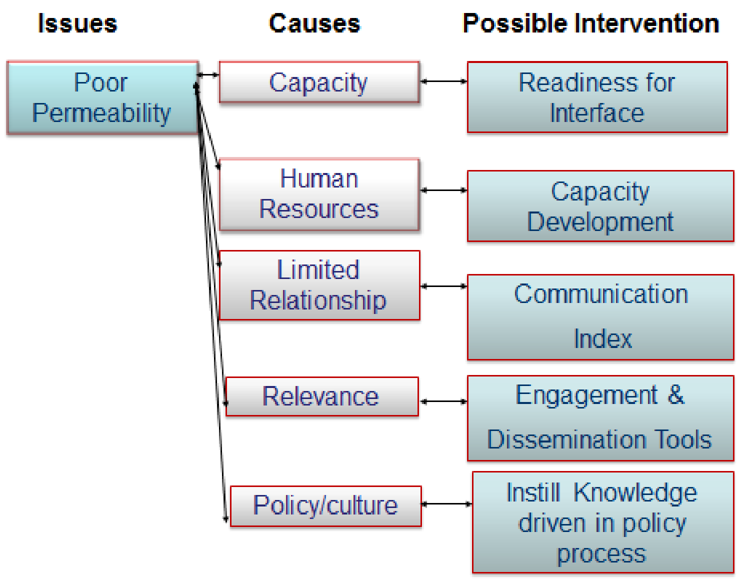


Figure 3.15 Triangulation of Players Perspectives and Possibilities for Optimization of Interface

Figure 3.15 summarizes root-causes of that gap, and suggests ways for measuring optimization of the interface by using proper index, appropriate dimensions and indicators and variables. It shows for example the need for stronger coordination among the institutions that generate knowledge and active, iterative and inclusive communication between the producers and users should be enhanced to avoid duplication of efforts and increase social and policy relevance (balancing scientific and social relevance).

The analysis also concludes that an optimization of the interface and uptakes of knowledge for informed decision-making require a systematic approach towards improving readiness by relevant players/actors in the interface, capacity development, communication, engagement, and sustainable measures for instilling culture and behavior toward sharing, appreciating and applying knowledge in decision making.

CHAPTER 4 DESIGNING AND TRIALING KNOWLEDGE MANAGEMENT TOOLS AND FRAMEWORK

4.0 THEORETICAL BASIS OF INTERFACE OPTIMIZATION MEANSUREMENTS

The analytical results from the previous CHAPTER 3 show that proper tool and process should be adopted and applied systematically for encouraging and measuring science-policy-practice interface. It is generally believed that measuring improvement in science-policy-interface, and knowledge management is a difficult undertaking; however, without credible approach to show evidence about its value and encourage its improvement, knowledge management initiatives might not be sustainable (Zack M, 1999; DeLone and McLean, 1992).

There have been a number of theoretical approaches on measuring knowledge management, so far research groups, decision makers and practitioners find it difficult to design an evaluation effort (DeLone and McLean, 1992).

The strategic emphasis of this study is on fostering a culture of knowledge sharing and collaborative learning by the actors in the science-policy-practice interface within the knowledge production, management and application continuum model. From empirical evidence discussed in the CHAPTER 2 and CHAPTER 3, the key challenge to the informed decision making for sustainable development of the MRB is primarily from both limited availability of and accessibility to “credible” and usable knowledge and tools, and prevailing social, institutional and organizational factors affecting the interface. The main hypothesis of this study is the informed decision-making for sustainable river basin management and improved river basin governance can be enhanced with the improvement in the science-policy-practice interface. Such interface is influenced by not only the state of knowledge production (science and research), management (knowledge managers and brokers) and application (users – decision-makers, practitioners, and researchers), but also by social/cultural, institutional and organizational environment in which the knowledge management and decision-making operate.

This CHAPTER 4 presents the process and outcomes of the development and trialing of the tool for evaluating and measuring improved interface for knowledge uptakes for decision making by providing an interrogative framework for designing evaluation initiatives. The development and error/trialing of the tools for monitoring the interface level that potentially improve the application of knowledge for informed decision-making was explored through applying scientific and participatory analytical and validation process and tools. The analytical results were documented in relevant consultancy reports and analytical work-papers built on the basis of the lessons and scientific evidence on the state and direction of science and policy interface in MRB and widely shared with the key stakeholders from the Governmental Organizations (local, national and transnational) and civil society organizations (academia, researchers, community based organizations).

The process includes analysis for establishing and documenting fact, and applying open-ended, exploratory and inquisitive non-traditional creative thinking and future visioning techniques to explore and try interface factors to get insight for possible research-policy-practice interface optimization. Then, the study conducts a creative exploration of possibilities, and selection of the "best" solution, rooted in sound facts, by calling into question the assumptions made, or reveal if the "best" solution or indices for monitoring interface can be supported by available best practices.

Then the interface assessment framework was developed through the optimization process of trial and error for fine-tuning and adapting the proposed tools and options to produce better outcomes (efficiency and effectiveness) in meeting the set objective for measuring and improving interface. Finally, the CHAPTER 4 feeds the findings for validating and redefining the assessment tools, indicators and criteria developed for measuring the sustainability and quality of the interface. The assessment is aimed at supporting a potentially broadly endorsed assessment tool to measure important dimensions of the science-policy-practice and guide its performance.

4.1 ASSESSING THEORETICAL BACKGBONES FOR MEASURING SCIENCE-POLICY-PRACTICE INTERFACE

There are a number of approaches to defining the effectiveness of linkage between scientific and technical knowledge production and its utilization in the policy-decision. The most commonly used conceptual framework for evaluating performance is the logical framework. However, the use of logical frameworks often presented difficulties in capturing 'network' aspects of interface or triadic inter-relationship among science/research, policy and practice. Alternative frameworks such as mapping of interface pathways were found to be more useful in monitoring the relationship between interface players, and mapping possible communication and interaction pathway, and relevant enabling environment (Perkins N, 2006).

Delone W and McLean E (1992) argued that to assess success of knowledge production and application, the study should use independent variables in appropriate assessment tools by building upon factors that influence effective continuums from knowledge production to its application (**Figure 4.1**). Hanney S, *et al* (2003) placed great importance on assessing the research utilisation in policy-making by trying to better understand about the importance of interfaces and quality of the policy makers, practitioners and other users as receptors (their ability, attitude and capacity to access, absorb and understand).

The emphasis on assessing knowledge management as continuum process, and quality process of research design and process, and knowledge grabbing for decision making by Hanney S, *et al* (2003) and Delone, W and McLean E (1992) was also reiterated in the Process Classification Framework developed in 1992 by the Global Best Practices (http://www.apqc.org/portal/apqc/site). It documented the process and sub-process for effectively marketing and selling out the research and other products to the targeted users through promoting more active two-way communication and interaction in various stages. Those stages are: i) defining research agenda and activities, ii) capacity building for players in the interface; and, iii) translation scientific results into socially acceptable form and assimilating it with local knowledge to make it relevant to local conditions.

Westberg L (2008) stressed the importance of measuring the interactive process in the knowledge management – to create, and consciously make knowledge available for decision making – through co-management, adaptive management etc. to strengthen the research product's relevance and trust and credibility of the results (Cash, et al., 2003).

Hanney S *et al* (1999) argued that even though it was sometimes possible to identify how research findings have informed policy-making, but it remained extremely difficult to assess quantitatively the direct social and economic impacts of the knowledge utilisation. It could take longer time and intensive data gathering and analysis to reliably evaluate this kind of impact. In some studies, a combination of tracking forwards and tracking backwards was proposed for evaluating the impact of research on policy and practice (Davies H, *et al*, 2005).

Tracking forwards was generally used for evaluating from completed research to see where and how knowledge was transferred, and to what effects, while tracking backwards examined the policy choices, organisational management and professional practice to explore how research was sought out and used in these areas, and to what effects (Nonaka I, Takeuchi H, Umemoto K, 1996, Nonaka Ikujiro, 1991). A study by Davies H, *et al* (2005) proposed five categories of indicators for "tracking forwards" to capture the multi-dimensional nature of research output and impact: i) knowledge production; ii) research capacity building; iii) policy or product development (e.g. research input into official guidelines or protocols); iv) sector benefits (e.g. impacts on specific client groups); and v) wider societal benefits (e.g. economic benefits from increased productivity) (Davies H, *et al*, 2005).

All these works also highlighted the prevalence of different norms and expectations in the players in the interface – research and scientific communities and policy-makers and community of practices - regarding such crucial concepts as what constitutes reliable evidence, convincing argument, procedural fairness, and appropriate characterization of uncertainty.

Other studies suggested that the "effectiveness" of scientific inputs needs to be gauged in terms of impacts of science, technology and ideas on issue evolution - on how issues were defined and framed, and on which options for dealing with issues were considered (Cash, *et al*., 2003). This approach focused more on the process rather than the outcomes such as policy or product development, or social and economic benefits from increased productivity etc., since the outcomes depended on not only the knowledge availability and use, but also on other social, economic, political and other factors locally and internationally. Westberg L (2008) argued for an approach that placed greater emphasis on quality and frequency of the interfaces between communities of researchers/experts, decision makers and practitioners. Westberg L (2008) further argued that the element of influence included the direct engagement by researchers with the policy and practice community not only through communication of end results of the research, but also through continual relationships with them at relevant stage of the knowledge continuums. Hence, he argued that permeability of the knowledge depended on the following key indicators: quality of knowledge (vigour, trust, relevance etc.), communication, dialogue and or involvement at various stages of research such as setting research questions and priority, commissioning of research, and validating and communication of the findings. Westberg L (2008) demonstrated that the assessments of these categories could be derived from multiple data sources, including documentary evidence, data-sets, surveys and interviews and in-depth case studies. The data and information gathered could be then scored in each category, using Delphi-type methods (Westberg L, 2008; Davies H, *et al*, 2005).

It is hypothesized by this study that the actual steps involved in utilisation and achieving final outcomes are often multidirectional and convoluted. Hence, developing a conceptual assessment framework of the science-policy-practice interface for promoting knowledge application should place great emphasis on the importance of interaction and enabling environment conducive towards that interaction between researchers, policymakers and practitioners. This sequence of interaction is useful and potentially encouraging more widespread use of research products in policy-making and practice.

4.2 SCIENTIFIC AND SOCIAL RELEVANCE OF BEST KNOWLEDGE MANAGEMENT PRACTICES INDEX

As found in the conclusion of CHAPTER 3, the MRB needs to improve the informed decision through applying credible knowledge by improving the science-policy-practice interface. The findings also point out to the need for user-friendly, practical and credible tool for assessing the interface and agreeing on area and strategic action for its improvement. The key stakeholders in the MRB will benefit significantly from having a systematic performance evaluation and appraisal system, since the monitoring and evaluation results can help detect areas for changes and improvements (MRC, 2010a).

Such an interface assessment model should also be able to meet the growing demands for accountability which could also be of benefit to the research community, decision-makers, practitioners and funding agencies. It should serve as one of the principle ways that the public and interested parties - donors, funding agencies, research groups, policy makers, civil society organizations etc., to determine whether their knowledge management efforts are providing a quality product or service and meet their objectives of improving informed decision-making. They should either jointly or individually be able to use that system for forming decision on appropriate actions for gearing toward enhancing interface performance and accountability.

This measurement model proposed by this study is called "Best Knowledge Management Practices Index (BKMPI). The main goal of this model is to provide pragmatic perspectives for assessment and improvement of management performance in addition to specific program level monitoring and evaluation framework. It is to make explicit the technical-scientific and social conditions necessary for enhancing performance and accountability through regular assessments using performance indicators and benchmarking for moving up the spiral to better integrated water resources management, and providing pragmatic perspectives for assessment and improvement of knowledge management performance (Conner R, 1980, Sudsawad P, 2007).

The application of the BKMPI framework can be done using various entry points/lenses that can be used as guidepost for measuring the current national and regional knowledge management programming and planning, and influencing their future directions of, helping them make strategic choices about where to concentrate its limited resources and how to leverage its comparative advantages to achieve the most positive and lasting change. The guiding principle of this BKMPI is to contribute to maximization and sustainability of the knowledge generated and applied in the informed decision for sustainable water resources development and management that will provide national, regional, and local benefits, and has the potential to play an important role in enabling communities to meet sustainable development objectives.

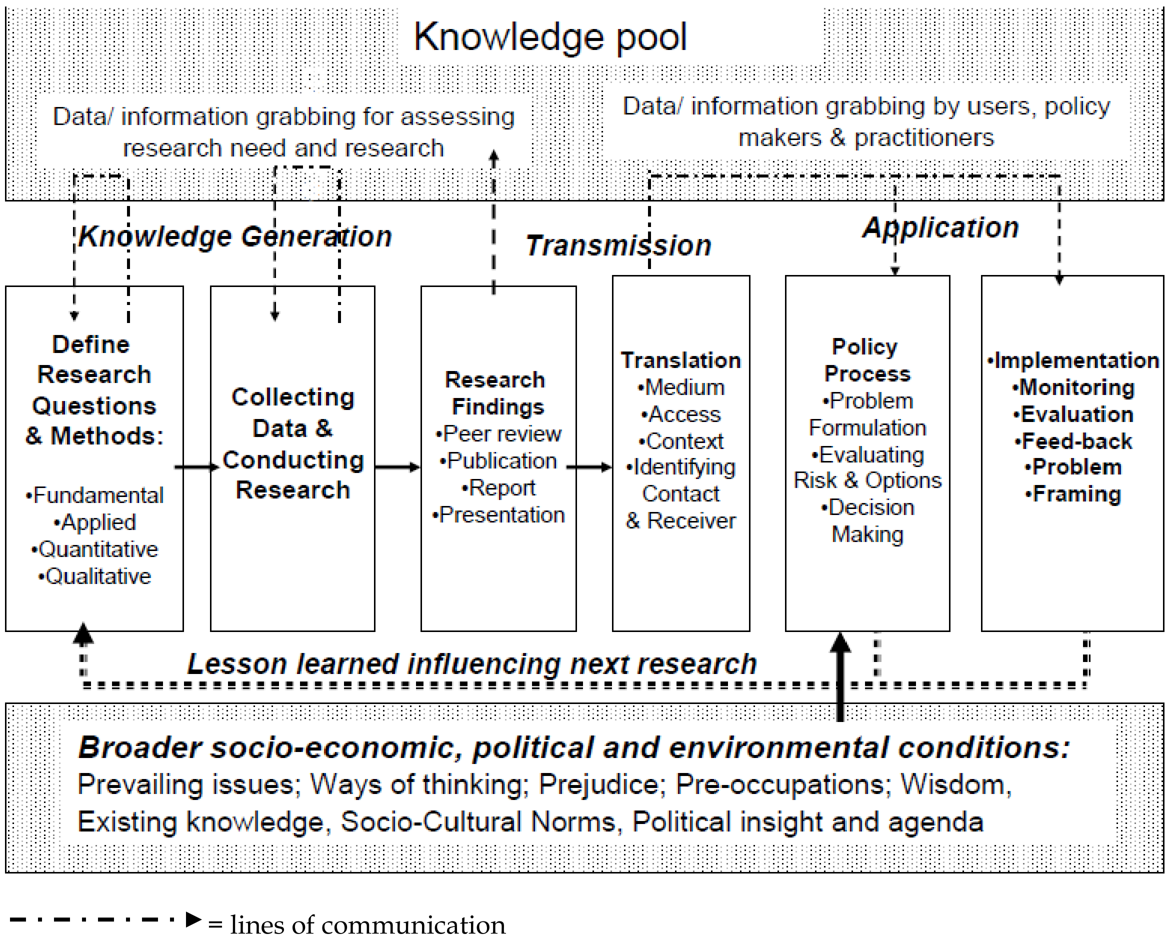
Sustainable development calls for considering synergies and trade-offs amongst economic, social and environmental values based on best available scientific and other knowledge (United Nations, 1987). This balance should be achieved and ensured in a transparent and accountable manner, taking advantage of expanding knowledge, multiple perspectives, and innovation, and also requires a stronger manifest of scientific value, social responsibility, transparency, and accountability by all actors in the science-policy-practice interface. This sustainability indicators and factors can be translated into BKMPI for measuring efforts toward sustainable interface.

The BKMPI framework has been designed by this study to be used for a wide range of purposes, including self-assessments for research and knowledge management project continuous improvement. The BKMPI assessment relies on factual, reproducible, objective and verifiable evidence to support a score. The potential users and uses include, but are not limited to the researchers, scientific groups, knowledge managers and users, governments, potential financiers, other decision-makers, private sectors, and civil society organizations. The concerned parties may use it or its adapted version to assess the sustainability of existing research or knowledge program for improvement at different stages, to form their own views on the sustainability performance of concerned actors in the science-policy-practice interface, and to form a basis for dialogue on these projects.

4.3 FUNDAMENTAL ASSUMPTIONS FOR BUILDING FRAMEWORK FOR MEASURING INTERFACE EFFECTIVENESS

The interface performance-based theory, like all theories, adopts several assumptions. The evaluation of the performances that is always strongly influenced by the human choices represents one of the most complex undertakings. From the resource-based view, it is assumed that the performance differences amongst the organisations or the different groups can be credited to the resources (financial, technological, human resources and time) that are available to each group (Barney and Arikan, 2001). Hence, these resources variables can greatly influence the fate of an organization and interface. However, institutions that those key players represent make knowledge management choice based not only on their human, capital and technological resources, but also prevailing quality of leadership and political and cultural condition.

Figure 4.1 depicts a conceptual model of a multi-directional and multi-faceted interaction and connectivity among key actors in science-policy-practice interfaces in knowledge production (research design, planning and implementation), transmission and application. A series of stages in research and policy process and points of potential interfaces – grabbing data, information and knowledge for application purposes are featured in this interface model. It also incorporates the concept of the stock, or pool, of knowledge and the idea for potential interfaces between research and the wider political, professional and social environments. Both researchers and decision-makers uptake necessary data and information from available knowledge pool to meet their needs within their specific economic, social, political and cultural settings either for research program and policy formulation, their implementation, or monitoring and evaluating, as well as for validating their works (Hanney S, *et al*, 2003).



(Source: adapted from Hanney, *et al*, 2003)

Figure 4.1 Knowledge Continuum Interface Model

As shown in **Figure 4.1**, understanding of the interface pathways and their dynamism are found to be useful when examining how a research products and existing knowledge could be utilised in research, policy-making and practice, in a way that would result in final outcomes such as sustainability gains and social-economic benefits.

The present study conceptualizes 'linking continuum' in two dimensions: i) interface as part of a scale of communications from monologue to dialogue, and from passiveness to inter-activeness; and ii) as a spectrum of institutional or societal engagement from:

a. Independent research and information dissemination (through monologue distribution of the research products;

b. Research through consultation on specific topics through conference, workshop, joint planning, and sharing results using of mass media and information technology etc..); and

c. Collaborative research through direct/active 'involvement'.

All modes of communication reinforce each other and play a role in supporting quality interface. In the light of the current emphasis on scientific evidence based policy making in MRB, the study places a stronger emphasis on dialogue as an interactive *two-way communication* rather than monologue mood of interface.

4.3.1 Propositions for Framing of Best Knowledge Management Practices Index

To assess the knowledge management through looking at the quality and process of interface required to adopt several strategies. First of all the assessment studies should be structured around an interface and their actors' framework and the enabling or constraining environment within which they operate. Secondly, the framework should be sufficiently broad to allow it to be applied to many situations focusing on both how research findings are communicated across the interfaces, and the degree of their receptivity by uses (Hanney S, *et al*, 2003).

While numerous propositions have been developed, four are particularly important.

i. Accordingly, there are two fundamental groups of factors influencing interface, namely i) push factors; and ii) pull factors;

ii. Understanding by researchers and policymakers and practitioners, of the issues, including the differential scope for utilization associated with different types of research and policy environments;

iii. If the scientific information or tools are perceived by the users (potential users) to be credible (reliable evidence and convincing argument); salient (relevance), legitimate and fair (procedural fairness); and properly characterizing certainty and uncertainty; and

iv. There is a wide range of science-policy-practice interactions that manifest at national or possibly sub-national (e.g. state) and transnational policy making process.

The push and pull factors were found to be the key suggestive propositions. The ability of the science-policy-practice interface to structure and restructure itself to adapt to and enhance level of application of scientific knowledge in informed decision making depended on both internal (strength and weakness) and external (opportunities and threat) conditions prevailing for all actors within the knowledge continuum model presented in Figure 4.1.

The research consortium, institution, or policy organization's actual functionality is normally determined, by the level of capability, resources, qualification and appropriate division of labour and coordination, by the patterns of communication, networks of influence and leadership, patterns of decision-making, and by the structure of norms (Cullivan D, *et al*, 1998). These formal and informal resources, enabling environment and qualification define the availability, and quality and frequency of grabbing of data, information and knowledge, work routines and knowledge flows that are primary determinants of an interface's functionality.

Consequently, in proposing factors for improving interface in the "knowledge continuum model", this study has to recognize the distinct role of the push and pull factors and formal and informal organization and work routines in facilitating interface and functionality.

The antitheses or mutual correlations in inter-institutional and inter-personal relationship functionality is contributed by a unity of opposites - ***"Yang"*** - the masculine: being hard and formal institution and organizations, hot, energetic, moving, and sometimes aggressive and "***Yin***" representing aspects of the feminine: being soft, cool, calm, introspective, and healing qualities of informal organization. For the purpose of this study, these two groups of influencing factors are considered to be "push factor as a capacity or quality to appeal or attract the users" and "pull factor as a capacity or quality to obtain and absorb".

4.3.2 Parametization of Key propositions and dimensions

In many cases, the terminology of performance measurement is often associated with terms such as inputs, outputs, outcomes, targets, effectiveness, efficiency, and economy. All of these terms described measures of performance, but each measures different aspects of performance. In the choice of each indicator, the study kept in mind the following criteria for selection.

- Relevant and observable – does it actually exist? Can evidence be collected about it? Is it applicable to interface of science-policy/practice in the context of IWRM?
- Controllable – is it able to be managed as a discrete, identifiable item? Can we change its value through progressive actions?; and
- Realistic - does it address important IWRM functions in study river basin - MRB?
- Understandable - can it be interpreted by internal staff of the research projects, targeted users – policy-makers, and internal staff of the targeted river basin organization, and key water management agencies of their member-states (usually government agencies)?

The BKMPI Index has been designed and trialed into a rating system capable of coherently evaluating the interface performance both from the push and pull factors by different projects and/or countries.

Parameterization of push factors: This factor is mainly relevant to scientific and researcher groups, intermediary groups and other purveyors of research (such as communications staff) aim to increase awareness of research evidence among their users (policy makers, practitioners and civil society organizations (academia, NGOs and community based organizations). The push factors are strongly associated with group or individual performance, such as human resources choices, researchers, communicators, decision-makers' and organizational capacity and attitude, quality of human resource management for finding, selecting, developing and maintaining individuals with the best potential. They are also associated with availability and appropriate use/deploy of resources (financial, technological, human resources and time) (Barney J and Arikan A, 2001). Hence, these resources variables can greatly influence the fate of an organization and interface. The ability of the team and organization to implement or perform, such as their capabilities, trustworthiness, being seen as valuable, rare, costly-to-imitate, and non-substitutable resources controlled variables) also play a critical part in the exchange, interaction and recognition.

Parameterization of pull factors: The pull factors manifest through the willingness and desire (conscious and/or sub-conscious, formal or informal) for uptake of the research evidence. It occurs when policy and decision makers identify an information gap and request evidence or commission research to fill this gap. The attributes of knowledge users - tangible or intangible, are strategically relevant if they enable that individual or entity (organizations) to efficiently and effectively to obtain, analyze, and apply knowledge in decision-making or practice, and in turn, generates superior performance (meeting sustainable development objective etc.).

There are several different ways that the strategic value of knowledge users' attributes can be evaluated. For example, to the extent that their attributes enable them to obtain, analyze, and apply knowledge in decision-making or practice that have the effect of reducing a social, environmental and economic costs or increasing its sustainability and social well-being. Individual and organizations resources to conceive the objective of improved knowledge uptake constitute strategically valuable variables or attributes. The creativity and innovativeness can be understood as resources and a source of superior performance for both the producers and users of the knowledge in the science-policy and practice interface through generating knowledge product and uptake differentiation opportunities.

The "access" variables - knowledge, funds, and process, as well as the quality of institution in order to meet their need for knowledge is also important variables for both users and producers of knowledge (Nicol, 2000). While access to knowledge and resources are critical, the institution and process have a profound influence on access, since they affect level of investment and allocation of financial resources, determine access (ownership rights, institutions regulating access to knowledge and other resources.

It is also possible to describe the policy, social and cultural structure within which individual and organizations operates. They are kinds of attributes (variables) that are likely to be sources of superior performance in science-policy-practice interface. In general, the extent to which the knowledge users and producers are capable to develop and implement strategies that lead to superior performance cannot be evaluated independently of the social, economic, and political context within which they are operating.

4.3.3 Indexing and Clustering Indicators for Assessing Effectiveness of the Research Communication

An index is a mathematical aggregation of variables or indicators, often across different measurement units so that the result is dimensionless (Esty D, *et al*, 2005). An index aims to provide compact and targeted information for management and policy development. The problem of combining the individual components is overcome by scaling and weighting processes, which will reflect societal preferences (Esty D, *et al*, 2005). A number of hierarchies have been developed to classify or categorize indicators according to either the type of indicator or their use.

A set of dimension and indicators important to forming a view on the overall attempt for ensuring effectiveness of the interface at each point in the knowledge management life cycle, when taken together, provide the list of issues that must be considered to confidently form a view. Hierarchy of BKMPI is presented as follows:

1. Dimension or perspective representing broader function categories of knowledge management or science-policy-practice interface, such as push factor dimension, and knowledge production function etc.
2. Indicator or also known as measurable or objectively verifiable indicators, is a quantitative and qualitative way of measuring performance, and whether project/program outputs, purpose and goal have been achieved.
3. Variable or means of verification is information, data, facts required to assess performance against indicators and their sources. They serve basis for understanding the scoring/ranking approach.

   They should provide facts for assessing the needs at hand.

Example of evidence in science-policy-practice interface are those sets of processes and activities that are consistent with knowledge production transmission and application values/goals/ethics, theories/beliefs, evidence, and understanding of the social, political and natural environment, and that are most likely to achieve informed decision making promotion goals in a given situation. They may include management plans, change management process, monitoring and management, reviews, stakeholder maps and consultation plan / program including engagement strategies, records of meetings, surveys, web information, written materials, media information and various forms of engagement, etc.

Table 4.2 presents the indicative dimensions, indicators, variables and means for verification, as well as the examples of evidence, defined, refined and fine-tuned through the development and trialing process during this study from August 2009 to May 2010. The list of indicators for each dimension – push factor dimension or pull factor dimension, including an explanation of what each indicator addresses and the indicator intent, is provided in later part of this CHAPTER 4.

4.3.4 Trialing of Best Knowledge Management Practices Index (BKMPI)

The Best Knowledge Management Practices Index (BKMPI) development has gone through relevant steps in its inception, validation through trial and error) and revision. It has been developed on the basis of field tests conducted by analyzing factors of success or excellence in the interface performance as actually practiced by water research and river basin management institutions in MRB. Its development has benefited from the extremely rich experience of such interface performance evaluation using both statistical and Delphi analysis system in order to offer a completely objective result.

The first stage was the collection of known best practices in knowledge management for integrated water resources management (IWRM) from a number of sources:

a. A review of the literature and analytical experiences in the development of science-policy-practice performance indicators in the context of the IWRM. The majority of the literature was concerned with performance indicators of the river basin organizations and addressing gaps between research-policy and action in climate change adaptation in South East Asia; and
b. A review of experiences of researchers, water resources and social/political scientists, practitioners, consultants, basin managers and water resources

managers in the MRB. These practitioners published material in a variety of forms, including web-based documentation/reports, agency reports and professional journals. This material review was triangulated by discussions with selected researcher, decision-makers and practitioners from Cambodia, China, Lao PDR, Viet Nam and Thailand who were involved in water and related resources knowledge generation and management projects.

The second stage involved the synthesis of best practices to create a suite of interface performance indicators. 'Best Practice' was used as an embracing term referring to as what was considered by basin practitioners and relevant literature as the range of management practices with list of potential evidence which would most likely result in the implementation of effective and proficiency interface of science-policy-practice.

Stage 3 involves a series of trialing of the assessment framework. For testing the BKMPI and refining the performance standard or best practices for supporting the bench-marking and scoring the indicator performance, a series of four trialing meetings were conducted in Mekong countries. In Cambodia, the multi-stakeholder trialing consultations with key government ministries, academic institutions and with civil society organizations were conducted in February 9-10, 2010, and April 8, 2010 and in Regional Workshop in Vientiane, Lao PDR on 31 May 2010 (Pech, 2010, Pech S *et al*, 2010b and c).

The primary objective of the trialing was to validate the BKMPI by providing feedback on how well the BKMPI measured interface performance and sustainability, and to inform the final revision. Trials assessed and provided recommendations for improvement on replicability and objectivity **-** to understand how robust the BKMPI is in terms of assessors or auditor arriving at consistent and objective results; and to obtain views on the appropriateness of the set of indicators and criteria and variable, as well as set of the evidence.

The trials used the BKMPI) decision tree that comprised of four inter-related phase, namely, i) setting goals; ii) nomination phase; iii) analysis phase; and iv) action phase. In goal setting phase, the goals and scale that the trailing wanted to achieve was set. In the nomination phase, this study and group of assessors selected the relevant regional research consortiums and organizations involved in knowledge management in the Mekong Region. They were reviewed and entered into the database, and additional information was gathered ready for analysis.

In the analysis phase the selected projects was analyzed to determine whether available data was sufficient to determine the existence or extent of a current or potential problem, and if the projects or organizations selected possessed all relevant attributes or resources for encouraging stronger interface or at-risk of failing to support application research evidence in policy and practice. The author of this dissertation applied key characteristics of the Delphi method that helped the participants to focus on the issues at hand:

i) <u>Structuring of information flow</u>: The initial contributions from the experts were collected in the form of answers to questionnaires and their comments to these answers. The author controlled the interactions among the participants by processing the information and filtering out irrelevant content to avoid the usual problems of group dynamics; and

ii) Regular feedback: Participants comment on their own assessment, the responses of others and on the progress of the panel as a whole to allow them to reflect and refine their assessment. The author of this dissertation facilitated the responses and feed-back rounds. The responses were collected and analyzed, and then common and conflicting viewpoints were identified. The process continues through thesis and antithesis, to gradually work towards synthesis, and building consensus.

The participants/experts were asked to answer questionnaires in two or more rounds. After each round, a facilitator provides summary of the experts' assessment or forecasts from the previous round as well as the reasons they provide for their judgments. Thus, experts are encouraged to refine their earlier answers in light of the disclosed facts. During that process the range of the answers would narrow down and the group would converge towards the "correct" answer either by achieving consensus (stability of results) or mean or median scores of the final rounds determining the results (Davies H, *et al*, 2005, Rescher N, 2006).

In this study, the last phase –Action Phase – was not undertaken since it was beyond the scope of this study. In the future if the project or organization owners are interested, the Action Phase can be applied for prioritizing aspect or areas for action, identifying and proposing mitigation and remediation actions; and proposing measures for continued monitoring.

4.3.5 Scoring and Presenting the Results

The study attached careful thought on how numerical indicators of interface performance were to be used. "Where indicators were involved, they were used as either 'dials' to measure process and quality accurately, or as 'tin openers' to identify issues needing further examination or to aid judgement. The use of numerical indicators as dials in an area such as the assessment of research and its utilisation in policy making, was difficult to make measurements (Hanney S, *et al*, 2003). Hence, the study decided to use indicators as tin openers to aid judgements, and to facilitate comparison.

In trialing, the author of this dissertation and the group of invited specialists were able to use this method to specify the percentage of the variation that can be explained by indicator and variables values on the basis of observations and measurements. It was primarily based on scoring stakeholder perceptions using a coding system which can then be quantitatively analyzed. Each indicator receives a score from level 1 to 5. For some indicators, there are multiple variables' (means for verification) scores which were aggregated to determine the indicator score. As explained in **Table 4.1**, level 1 is understood to be the absence of or very poor practice. Level 3 is understood to be basic good practice (average level). Level 5 is understood to be proven best practice. The indicator scoring required identification and comparing against the benchmarking or evidence/body of evidence that had to be met to receive a particular score as shown in the last column of the **Table 4.1**.

Table 4.1 Scoring Instructions

Score level	Criteria	Example of Means for Verifications and Scoring
5	• Most suitable, adequate, and effective with no gaps. • Thorough/comprehensive.	• Quality of process leading to understanding of knowledge

<table>
<tr><td></td><td>• Very intensive and meaningful involvement of potential user
• High level of effectiveness in arranging, planning, monitoring and mitigation of issues.</td><td rowspan="5">needs of targeted users;
• Quality of research program document and plan.
• Research capacities
• Fund & financial resources.
• Quality, reliability and accessibility of research products;
• Scientific and social relevance;
• Quality of dissemination means
• commitment to capacity building for knowledge transfer
• Effective organization for knowledge uptakes;
• Organization's capabilities and resources etc.</td></tr>
<tr><td>4</td><td>• Suitable, adequate, and effective with very few non-critical gaps.
• Good, and in-depth in some aspects
• Intensive and meaningful involvement of potential user
• High level of effectiveness in arranging, planning, monitoring and mitigation of issues with minor gaps.</td></tr>
<tr><td>3</td><td>• Suitable, adequate, and effective with a number of non-critical gaps in components.
• Basically Good analysis of all components.
• Basically Good involvement of potential user
• Basically good level of effectiveness in arranging, planning, monitoring and mitigation of issues.</td></tr>
<tr><td>2</td><td>• A number of critical gaps making the process significantly less than suitable, adequate, and/or effective.
• Limited involvement of potential user
• Low level of effectiveness in arranging, planning, monitoring and mitigation of issues.</td></tr>
<tr><td>1</td><td>• A large number of critical gaps in the assessment process.
• Absence of intensive and meaningful involvement of potential user
• Lack of effectiveness.</td></tr>
</table>

These scores is assigned by the auditor or reviewer (independent and specially trained or internally) based on observations, results of interviews with relevant stakeholders (panel of experts), and review of objective evidences. The term objective evidence refers to evidence brought to the attention of the assessors by relevant documentation and interviewees. The objective evidence can then be used by them to verify whether and to what degree a variable or means for verification has been met, and to judge relevance and replicability of each indicator and its means of verification (variables), as well as to document example of evidence. The evidence was either qualitative or quantitative information, records or statements of fact, either verbal or documented. It is important that it is retrievable or reproducible, is not influenced by emotion or prejudice, and is based on facts obtained through observation, measurements, documentation, tests or other means. The personal observation and assessment can be then validated through facilitated Delphi method.

The study uses spread-sheets as medium for information management. By arraying the data in a pre-determined matrix, this spread-sheet allows data inputs to be converted to an interactive graphic representation and sharing. As the analysis grows it may be necessary to conduct expert "reality checks", and then use an iterative process of brainstorming and redefining score and assessment with emerging knowledge and information.

Each indicator comprises of a number of means for verification (variable). For scoring and ranking exercise, all indicators and their respective variables are scored in the sample spreadsheet, the weighting coefficients (expressed as percentage so that the weightings add up to 100%) are entered into the spreadsheet. It allows present both each individual variable's score, and an overall score of the indicator. For sensitivity analysis, the criteria weighting coefficients can be assigned both equal weight, and different priorities weighting scenarios. The users may change the set of variables and indicator, and their weights (weighting coefficients) as they consider appropriate. In this study, for ranking of overall score, the study applied "weighted summation" technique where the performance measures are multiplied by the weights, and then summed for each option to obtain an overall or global intensity index of each related issue.

4.3.6 Presenting the Results

The overall outcome of the assessment could be presented in a summary table and as a standard figure presenting the high and low variable scores for each indicator. **Figure 4.2** provides an example of the assessment spreadsheet for documenting and scoring relevant indicators and variables against available evidence/means for verification. The indicator scoring bars also show an asterisk indicating where the level of effectiveness, efficiency, reliability and quality score (lowest and highest of all variables) is, as well as the predominance of the scoring level. For example, for "research need and resources" performance indicator – the highest score is 3, and lowest is 1.50. Predominance of most of the scores is between 2 and 1.50. It shows that the result is well below the average, and most of its variables require a lot of improvement.

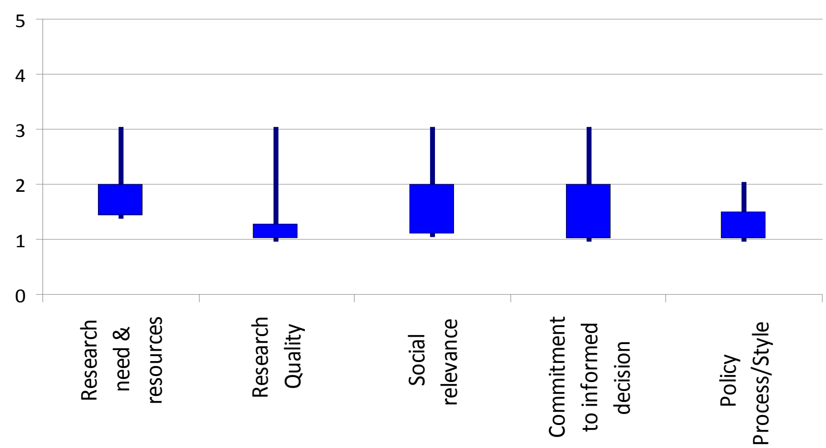
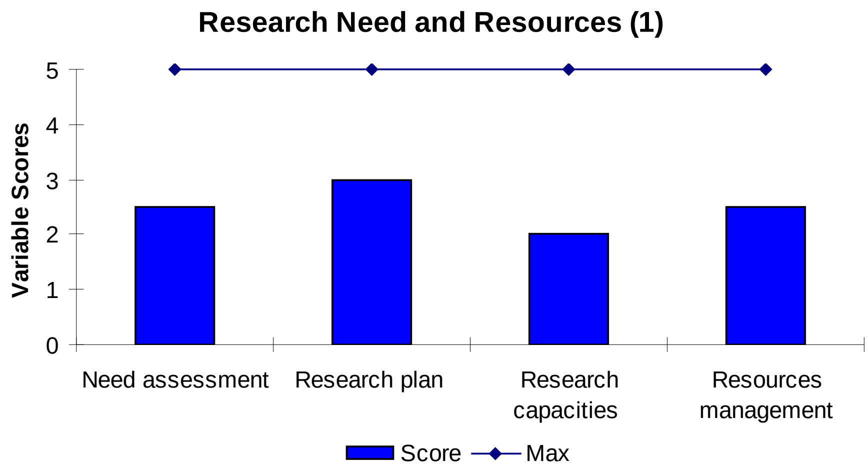
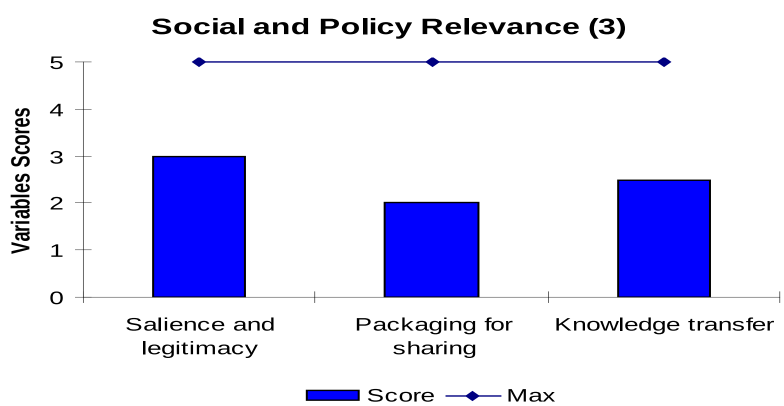


Figure 4.2 Samples of Overall BKMPI Scoring

The following graphs in **Figure 4.3** provide options for graphic presentation of the assessment results of all key indicators and their variables. The results can also presented in a spider graph to easy identification of aspect/indicators required needs for further improvement if the interface performance is to be achieved.


Research Need and Resources (1)
Variable Scores
0
1
2
3
4
5
Need assessment
Research plan
Research capacities
Resources management
Score
Max


Research Quality (2)
Variable Scores
0
1
2
3
4
5
Method soundness
Quality
Reliability
Accessibility
Score
Max


Social and Policy Relevance (3)
Variables Scores
0
1
2
3
4
5
Salience and legitimacy
Packaging for sharing
Knowledge transfer
Score
Max

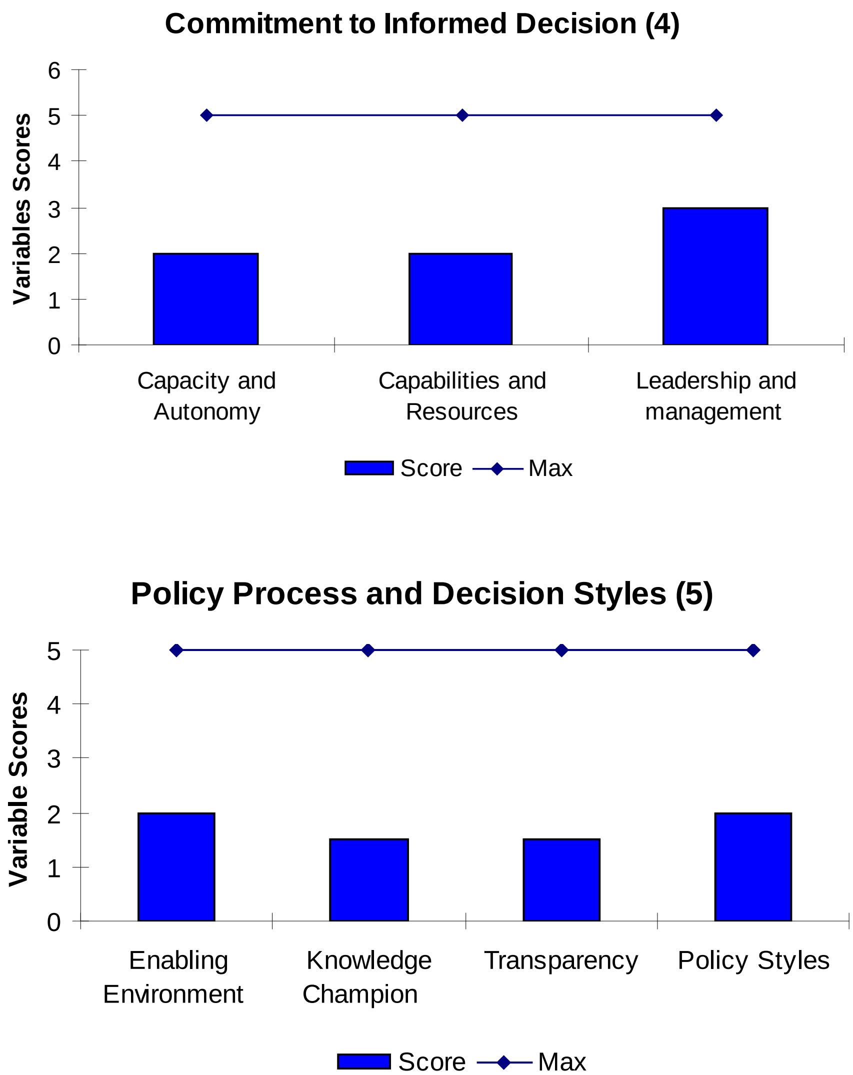


Figure 4.3 Samples of Scoring Presentation of Each Performance Indicator

Throughout the trailing process, numerous critical comments and feedbacks were obtained for further refinement of the present BKMPI (**Table 4.2**). The list of indicators for each dimension – push factor dimension or pull factor dimension, including an explanation of what each indicator addresses and the indicator intent, were documented.

Table 4.2 Suggested Index for Assessing Science-Policy-Practice Interface Performance

Dimension/Functions +	Performance Indicators++	Variables or Mean of Verification+++	Example of Evidence ++++
I. Push Factor Dimension			
Knowledge production and transmission aspect	1. Research need and resources capacity planning	1.1. Availability and quality of demonstrated need assessment prior to and during research design;	Quality of process leading to understanding of knowledge needs of targeted users: • Analytical reports; • Stakeholder analysis; • Stock-taking reports on status and needs.
		1.2. Quality of research program document and plan (suitable, adequate and effective).	• Appropriate for a desired purpose, or condition; • Adequacy to satisfy identified need, and capability of producing an intended, effect. • Clear description of study and scientific approach(s) and areas of impacts. • Clear description of knowledge dissemination and management plan.
		1.3. Research organizational capacities	• Ability to decide budget, human resource management, planning and implementing projects, and organizational goals and strategies; • Adequacy of professional and technical skills and disciplines to address all required study areas; • Appropriateness of personnel (not too senior or junior) for specified tasks; • Team and leader's attitude and understanding of the analytical and policy making process; • Skill level and attitude for interacting and communicating.
		1.4. Fund and financial resources management	• Proportionality of research fund size and scope; • % for outreach, communication and engagement (resources for interaction); and • Cost-effectiveness of fund used.
	2. Research Quality	2.1. Appropriateness and soundness of the methods.	• Methods and technique fit nature of the project and the availability and quality of data. • Appropriate sampling and analytical methods used

Dimension/Functions +	Performance Indicators++	Variables or Mean of Verification+++	Example of Evidence ++++
		.	to gather information. Quality, reliability, timeliness, & comprehensiveness of knowledge used. • Analysis is transparent, explicit and easy to replicate. • Proper combination of models and methods used for establishing cause-effect networks. • Proper reporting and QA/QC procedures followed.
		2.2. Quality, reliability and accessibility of research products.	• Scientific adequacy, and reliable technical evidence (credibility); • Quality of peer-reviewed papers scientific/ conference papers, policy brief and other. • Comprehensiveness of information products (scopes and, findings - direct, indirect, interactive, cumulative, spatial, temporary, permanent, long-term, and short-term variables.). • Organization of data/knowledge-base, and research products (format, visualization (tables, figures, maps, graphics, footnotes, and reference citations) • How uncertainties treated and implications on impact forecasting reported. • How recommendations are developed and presented.
	3. Social and Policy Relevance	3.1. Salience and legitimacy	• Level of relevance of knowledge products to the actual needs of targeted users. • Adaptation of knowledge to suit targeted areas and circumstances for application. • Collaborative process: continual interaction and feedback with targeted users.
		3.2. Packaging Information products for sharing	• Appropriate mix of research products - peer-reviewed papers, scientific/ conference papers, policy brief and others applicable media. • Level of accessibility to targeted users; • Effective means and technological process for

Dimension/Functions +	Performance Indicators++	Variables or Mean of Verification+++	Example of Evidence ++++
			sharing. • Volume of information made available through selected transmission means or knowledge management system. • Information presented clear, understandable, and relevant for users • Information presented in a logical manner • The results easy to read (non-technical summary to enhance readability and understanding).
		3.5. level of commitment to capacity building for knowledge transfer	• Attention and success in capacity building and collaboration; • Involvement of local specialists and staff; • Number and quality of forums, meetings, workshops or conference to facilitate exchange; • Mechanism for on-going exchange (such research priority setting committees); • Secondment of trusted researchers in policy-making institutions.
II. Pull Factor Dimension			
Knowledge Management and Application	4. Commitment to informed decision-making	4.1. Effective organizational autonomy for knowledge uptakes	• Power to make decisions about important matters: budget, revenues, staff/human resources management, setting and implementing policies, plans, projects, and organizational goals. • Conformity and compliance with policy and plans on how and what knowledge to be sought and applied, and plans to address gaps, and complexities.
		4.2. Organization's capabilities and resources	• Its ability to conduct knowledge need and gap scanning; • Technical capacity (internal staff and external experts); • Capacity to recruit and sustain qualified human resources and technological systems.

Dimension/Functions +	Performance Indicators++	Variables or Mean of Verification+++	Example of Evidence ++++
			• Quality of in-house knowledge and research management; • Financial resources allocated for knowledge gathering and application (sum and percentage of total budget); • Technological resources available for knowledge generation, dissemination/ retrieval, and application. • Information is routinely shared among planning, design, and construction units to ensure smooth technical coordination.
		4.3. Leadership and Management	• Ability at many different levels to inspire understanding and commitment to mission, • Availability of mechanism and functionality dealing with how scientific advice is provided, • Designation of responsibility, the processes to be employed and the sources of advice; and • Quality assurance and evaluation.
	5, Policy Process and Decision-Making Style	5.1. Enabling Environment	• Policies and practices in place to enable interface and uptake of knowledge in the policy process. • Investment for knowledge management in place to enable decision-makers and practitioner to help solve relevant water problems. • The effective co-ordination mechanism within relevant organizations and across different organizations/agencies to ensure smooth flow of information.
		5.2. Knowledge Champion	• Influential Individuals and institutions are strategically placed to initiate /define the specific responses and changes. • Knowledge champion's position within the policy-making for them to serve as an internal honest knowledge brokers. • Commission of research to search for solution to

Dimension/Functions +	Performance Indicators++	Variables or Mean of Verification+++	Example of Evidence ++++
			identified policy problem. • Intellectual endeavours by public opinion makers (journalists, public figures, famous academia, etc.) to raise the quality of public debate about public policy issues. • Capacity and willingness of officials to undertake research and analysis.
		5.3. Openness in Political Process	• Priorities in political and development terms, and resources for facilitating or encouraging uptakes of appropriate knowledge in policy process. • Broad-base participation in the policy process and transparency in policy making: i) An open and honest policy on the publication of research (evidenced by the role of public consultations in the development of policy); ii) Publication of all evidence (knowledge, scientific advise) used in policy making; iii) Explanation on the process by which knowledge, scientific advice is obtained; and, iv) Plans and action to address gaps and deficiency.
		5.4. Decision-Making Styles	• Level of openness to professional and academic inputs and public scrutiny into the policy making, • Presence and level of elaborated procedures oriented towards contesting and agreeing on set of knowledge for informed decision. • Strong reliance on impartiality of information and evaluation; • Level of fair representation of major societal interests in decision-making.

4.4 EVIDENCE FOR BENCHMARKING KNOWLEDGE MANAGEMENT PERFORMANCE STANDARDS OR BEST PRACTICES

The Section documents reflects and assesses key indicators, variables, as well as those bodies of evidence ranging from knowledge creation to knowledge intakes validated through trialing process of both pushing and pulling dimensions.

The trialing was conducted with a group of Cambodian assessors from March 2010 to May 2011. A multi-stakeholder consultation and trialing with broader participation of officials, lecturer and researchers from relevant Cambodian Ministries, Universities and Non-Governmental Organizations was conducted in Phnom Penh on April 8, 2010. Preliminary results and experiences were also presented at a Regional Informal Dialogue organized by M-POWER and the Challenge Program on Water and Food (CPWF) in Vientiane, Lao PDR, on May 2, 2010. Similar trialing was conducted in Viet Nam in late 2010 and in Lao PDR in February 2012. The following documents key findings on objective evidences of relevant variables and indicators.

4.4.1 Key Measures of Verification for Push Factor Dimension

This push factor dimension covers both Knowledge production and knowledge transmission aspects. *The knowledge production* is an activity that embraces a set of concepts, methodologies and objectives dealing with (i) acquisition of knowledge, (ii) analysis and synthesis of data and information (quantities), (iii) integration and interpretation of knowledge (quantities and qualities), and (iv) packaging and making them readily available for uptake in the application.

For investigating key mechanism operating at the interfaces to enhance the responsiveness of the targeted users from the production perspective (push factor), it is important to consider dynamism and scientific principles regulating the scientific and research works, and mechanism for collaborative priority setting, research commissioning mechanisms; the creation of research centers and facilitating links with policy-makers; encouraging and funding research brokerage/translator/promoter activities. The end result of knowledge management is its application and the application is closely associated with a process covering several aspects of collaboration/engagement in knowledge production, dissemination, communication, technology transfer, knowledge utilization, and the synthesis, and organization and presentation of results with the global and local context.

Accordingly, the knowledge production dimension covers the following performance indicators and means of verification (MOV):

1. Research need and resources capacity:

    1.1. Availability and quality of demonstrated need assessment prior to and during research design;

    1.2. Quality of research program document and plan (suitable, adequate and effective).

    1.3. Research capacities

    1.4. Fund and financial resources management

2. Research Quality

2.1. Appropriateness and soundness of methods

2.2. Quality,

2.3. Reliability and

2.4. Accessibility of research products

3. Social relevance

3.1. Salience and legitimacy

3.2. Packaging Information products for sharing

3.5. Level of commitment to capacity building for knowledge transfer.

The following sections provide justification and characterizations of key indicators, variables and example of evidence for the "push factor" perspectives.

4.4.2 Research Need and Resource Planning Performance Indicator

4.4.2.1 Availability and quality of demonstrated need assessment prior to and during research design

The demonstrated research need and resource planning indicator addresses the needs that justify investments and conducting research to generate or upgrade existing knowledge. This aspect is important for supporting sustainable development objectives at local, regional, national and transboundary levels and avoid over-or under-investment in important disciplines or aspects of knowledge production, management and application needs.

If there is a particular research project or system of projects being considered, the capability for it to contribute to established needs for knowledge or tools for improving informed decision-making for promoting sustainable development of water and related resources should be demonstrated. The trialing participants underlined the needs of potential knowledge users to be incorporated into each phase of knowledge creation, such as tailoring the research questions to address the problems identified by the users, customizing the message for different intended users, and customizing the method of dissemination to better reach them (See indicator 1, MOV 1.1 in **Table 4.2**). The potential key evidences for assessing this variable include:

- How are organizational/research policies, goals and programs set - by the research group/organization alone, by others, or jointly with local partners or targeted users?; and, ii) how are they communicated to their stakeholders?
- Availability of the analysis of knowledge requirements (horizon scanning), the analysis of development objectives of the targeted basin or sub-basins, and analysis of likely project fit with development needs and objectives.
- Allocation of resources to the interface process (qualifications/expertise of those involved, utilization of local knowledge as appropriate, scale of resource commitment, and continuity).

4.4.2.2 Quality of research program document and plan

The participants perceived that knowledge production depends as well on the participation of relevant players in the research design, use of appropriate methodology, technical and other tools, and data and information to meet the need and produce intended effects (See indicator 1, MOV 1.2 in **Table 4.2**).

The evidence of effective consultation is a fundamental requirement for ensuring positive and sustainable outcomes for both the project and the targeted users. Considerations relevant to this attribute include:

- Stakeholder mapping and engagement;
- Formulation of the consultation plan (objectives and targets over an appropriate time period).
- Appropriateness and transparency of the engagement processes (participation, assistance to stakeholders, timing, location, accessibility of information, and feedback procedures,
- Allocation of resources for consultation (appropriateness, scale, continuity and capability).
- Integration of the consultation plan, processes and outcomes with other relevant plans and arrangements.
- Monitoring, evaluation, review, and continual improvement.

4.4.2.3 Research Capacities

The trialing participants also stressed the importance of capacities, team skill set and competency, fund and resources availability and accountability in improving the potential for better knowledge being accepted and applied. This best practice has been recognized as such in numerous scientific studies. The organizational capacities (research and/or knowledge users' organizations) are characterized by their ability to make decisions about the following important matters: budget, human resources management, policies, planning and implementation of projects, and organizational goals.

Key research evidence for assessing capacity variable may include:

- **S**et and change own organizational policies and goals, as well as strategies to provide guidance and direction in achieving the objectives;
- Establish and maintain staffing levels sufficient to meet needs;
- Determine own organizational structure including roles and responsibilities of major groups or divisions;
- Team skill set and competency covering all required disciplines and meeting level of technical and professional complexity; and
- Have source of information (statistics, surveys, forecasts, etc.) for planning and implementing? See indicator 1, MOV 1.4 in **Table 4.2**).

4.4.2.4 Fund and financial resources management

The fund and resources management variables, especially those made available for facilitating interfaces (MOV 1.4) were considered to be one of the key means for verification of the capacity and commitment to promoting interface. It is important to qualitative and quantitatively evaluating the fund size and scope, and percentage of the fund allocated for capacity building for own staff and those of targeted users, and engagement of primary targeted users, as well as the cost-effectiveness of the fund use (See indicator 1, MOV 1.4 in **Table 4.2**) Key research evidence for assessing financial resources variables may include: how are budgets prepared? Are they adequate, reasonable and consonant with needs and available resources - proportionality of research fund size and scope? Percentage of those funds are for outreach, communication and engagement (resources for interaction); and the level of cost-effectiveness of fund used?

4.4.3 Research Quality Performance Indicator

The participants stressed the importance of the research quality performance indicator (Indicator 2) in influencing the knowledge products to be accepted and applied by the users. Based on its extensive analysis of a number of case studies related to knowledge systems for sustainability, the scientific information is likely to be accepted and be effective in influencing the policy process and social response, if the scientific information or tools are perceived by the users (potential users) to be:

- Credibility and meeting scientific and research principles of reliable evidence & convincing argument, andsoundness and appropriateness of methods applied;
- Properly characterizing certainty and uncertainty;
- Quality and reliability of the research products; and
- Functional knowledge bases and management system.

4.4.3.1 Credibility, appropriateness and soundness

Key research evidence for assessing their appropriateness and soundness may include: i) how specific project objectives or systematic evaluation of the problem of interest are defined ii) if suitable and adequate techniques for data and information collation are used; and iii) how data and information that form the knowledge base for a particular problem are evaluated/treated (QA/QC and gap filling) (UNEP, 2007).

The trialing results stressed the quality and scope of knowledge creation in term of the quality of the analysis of data and information nature, proportion, function, or relationship and synthesis or antithesis of analysis through simulation, optimization, visualization and organization and presentation of the results (MRC, 2010a). Evidence may include application of integrative systems for blending quantitative as well as quantitative information, expert systems, intelligent geographic information systems, computer-based tools, intelligent database management systems, object-oriented simulation, and knowledge-based systems.

4.4.3.2 Quality, reliability and accessibility of research products

In Indicator 2, MOV 2.2, the evidence of sufficiently high rigor, validity and reliability, were considered importance for both scientific and social relevance. The key areas for assessment derived from four scientific guiding principles and relevant appraisal questions may include:

i) **Contributory** in advancing wider knowledge or understanding:
    a. How has knowledge or understanding been extended by the research?

ii) **Defensible in design** by providing a research strategy which can address the evaluation questions posed:
    a. How defensible is the research design?

iii) **Rigor in conduct** through the systematic and transparent collection, analysis and interpretation of qualitative data:
    a. How well does the evaluation address its original aims and purpose?
    b. How well is the scope for drawing wider inference explained?
    c. How well defended are the sample design/target selection of cases/documents?
    d. How well is the eventual sample composition and coverage described?
    e. How well was the data collection carried out?
    f. How well has detail, depth and complexity (i.e. richness) of the data been conveyed?
    g. How adequately has the research process been documented?
    h. To what extent do others review and approve these studies (peer-review, review by partners, or other forms of independent reviews etc.) before they can be released or acted upon? (Commonwealth of Australia 2006).

iv) **Credible in claim** through providing well-founded and plausible arguments about the significance of the data and information generated (Spencer, et al, 2003).
    a. How credible are the findings?
    b. How clear is the basis of evaluative appraisal?
    c. How well has the approach to, and formulation of, analysis been conveyed?
    d. How well are the contexts of data sources retained and portrayed?
    e. How well has diversity of perspective and content been explored?
    f. How clear are the assumptions/ theoretical perspectives/values that have shaped the form and output of the evaluation?
    g. How clear are the links between data, interpretation and conclusions – i.e. how well can the routes to any conclusions be seen?

4.4.4 Social and Policy Relevance

Performance indicator 3 – Social relevance – was found to be strongly related to "knowledge transmission for application purpose" to be discussed in the following sub-section. Indicator 3 related closely to aspects, mechanisms, methods, and measurements of the interface - in knowledge production, dissemination, communication, technology transfer, knowledge utilization, and the synthesis, and organization and presentation of results.

4.4.4.1 Salience and legitimacy

The trailing results show that social relevance or salience of the knowledge/research is considered one of the key elements leading to uptakes of research and knowledge in decision making. According to trialing and literature review, the social and policy relevance consists of several factors, such as the availability of research results, their applicability to a given social and policy problem, their acceptability and how reliable they are perceived. Relevance as an evaluation criterion does not guarantee that the research results will be used, given the complexity and other factors influencing knowledge transfer from science to policy, but still it is a facilitating element for knowledge acceptability and applicability. The hypothesis associated with the knowledge relevance is that if a particular piece of research is seen to be of high quality, relevant and readily accessible, it could potentially help reinforce a decision-maker and practitioner's inclination to use it.

The political and social relevance indicator was considered as an important nod in the Continuum Knowledge Management or science-policy-practice interface model potentially linking the knowledge production to the knowledge application (**Figure 4.1**). From empirical analysis, the participation of relevant stakeholders in defining the objectives and research questions of data and knowledge program is important from the point of view of acceptability.

The questions for assessing evidence of efforts toward creating social relevance may include: what studies and long-term plans have been prepared in the past five years? Are these studies and plans adequate to meet the needs of the institution and targeted users? What are form and format selected for presenting and refining the results? Other key questions could be asked to obtain additional information to assess relevance:

- Is there research available that is either relevant to policy issues, or could help bring new issues onto the agenda?
- Is such research being effectively brought to the attention of policy-makers in diverse positions within the water governance system?
- Is the policy-making system capable of absorbing the research findings?
- Are there situations where the policy-makers are willing, and able, to use it?

User engagement is the key to taking communication beyond mere dissemination. It is frequently referred to in the literature as a good strategy for increasing the responsiveness of development research projects, making research agendas more relevant and useful to end users, facilitating trust and ownership, and thereby increasing the chances for uptake of the research results into policy and practice (Ingie, 2003). User engagement can operate at different levels:

i) Considering users' realities and preferences into account in development research and communication (mapping research demand, information deficit areas, information-use environment and existing communication patterns in the targeted countries in order to make design and communication of research more responsive to these realities);

ii) Strengthening user's capacity to generate research and to grab available knowledge for application;

iii) Providing identifiable mechanisms for knowledge producers and users to interact in key stages of the knowledge continuum model over important matters (e.g., research design, planning, implementation, knowledge transfer, and cost-effective ways for informing and educating the public;

iv) Availability of research staff oriented toward serving their identified clients (Indicator 3, MOV 3.1 and 3.2).

Transmission model was one of dominating interface design representing both person-to-person, and mass media communication. The proponents of the transmission model argued that sorting out the technical problems (technical accuracy and academic rigor) would lead to improvements in how precisely was the meaning conveyed and how effectively the received meaning would affect behaviour (Fiske J, 1982). This model of communication has been a dominating way of interface between the knowledge producers and the end-users in the Mekong Region whereby the producers (researchers/academia) conducted the research and reporting their findings and generated information in the scientific or specialized journals, and project reports, expecting that the end users would grab them from the knowledge pool for their use.

As shown in **Figure 4.4**, the participants in the trialing organized by this study emphasized the need for re-assessing the following key aspects for efforts for ensuring continual communication beyond dissemination for increasing social and policy relevance:

1. Ability of addressers (knowledge producers and managers) to minimize interference and distortion of the message during the transmission and ensure quality of transmission medium. It depends on the form, means and frequency of the interface between addressers and the targeted users. The addressers package their knowledge in a form that the intended users are capable to digest and send them the knowledge they need.

2. Level of support to build receiver's capacity to grab, and interpret knowledge that actually determines the interface success.

3. Efforts for addressing the attitude and capacity of the addressers to address social and cultural misconceptions and negative attitude that directly or indirectly distort understanding and affect acceptability of the message (Jakobson R, 1960).

4. Addresser's ability and capacity for packaging and presenting the message in a manner that offers the best chance of reaching and influencing the addressees, keeping in mind the listener's ability to understand the message (targeted audience or users).

5. Addressees' capabilities to interpret or decode to grasps the message meaningful or relevant to them.

6. Feedback loop' for *feedback* (reaction from the receiver) and for more frequent communication between the knowledge producers and users at various stage of the research/knowledge generation and consumption.

7. Ability and willingness of addressers to resend the addressees an updated/validated information and knowledge.

Feedback, resend and feed-back can help improve the accuracy of the message transmission – effectiveness, receptivity of the knowledge quality. In short, the success of knowledge transfer from production to policy and/or practice requires effective and repetitive cycle of communication, feed-back and re-communication (resend), and quality of the addressors and addressees.

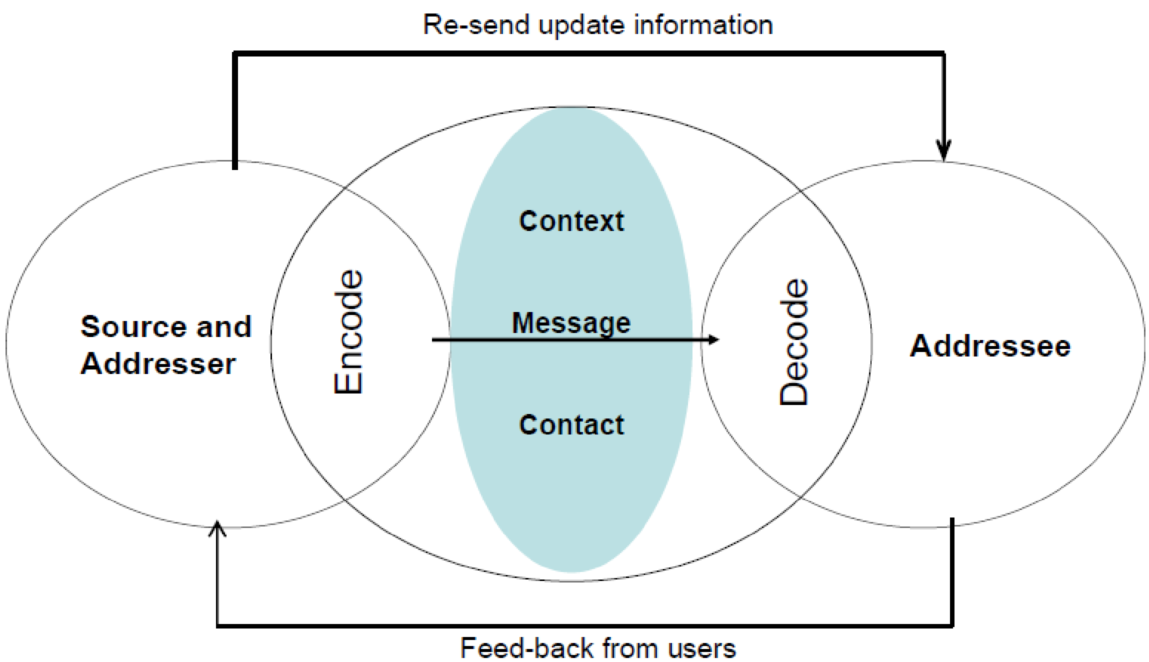


Figure 4.4 Interface through Dialogue – two-way flow of information

From the empirical observation in the Mekong Region, it was evident that the concerns about linkages and communication pertain not only to relations between researcher groups, policy maker, and practitioner groups, but also among the members of each of these overlapping and heterogeneous groups (MRC, 2010a).

4.4.4.2 Packaging and Adaptation of Information Products for Sharing

The reviewed literature also shows the importance of packaging and adaptation to suite targeted users. It includes the format of a message, the linguistic codes and timing, the implicit associations and layers of potential interpretations. They are prominent stages of an interactive process underpinning the effective exchanges among players in the interface – those who create new knowledge and those who use it.

As shown in **Figure 4.4**, the research staff at all levels should be capable to package and present the message in a manner that offers the best chance of reaching and influencing the addressees by:

- Keeping in mind the listener's ability to understand the message; and

- Putting the message into some kind of coded system or into words, written and spoken format, or graphical presentation for the benefit of the addressee (targeted audience or users).

The key evidences may include:

1. appropriate mix of research products - peer-reviewed papers, scientific/ conference papers, policy brief and others;
2. effective means and technological process for sharing, level of accessibility; volume of information made available; and
3. information presented clear, understandable, and relevant for users - easy to read (non-technical summary to enhance readability and understanding).

Other key best practice evidence or assessment questions may include i) what types of public information activities do they carry out? ii) how are they defined? iii) to what extent have their public information programs created or supported knowledge outreach/dissemination? and iv) what is the type of public image that they are trying to create?

4.4.4.3 Commitment to Sustainable Knowledge Transfer

MOV 3.5, Indicator 3 – Level of commitment to capacity building for knowledge transfer and engagement is closely linked to MOV 1.4 – Fund and resources management (percentage of fund allocated for interface), and MOV 1.3 (Human resources and skill), and MOV 3.2 (packaging information products).

MOV 3.5 can be potentially measured by level of attention and success in capacity building and collaboration both for the research team and targeted users, and involvement of local specialists and staff; number and quality of forums, meetings, workshops or conference to facilitate exchange; and secondment of trusted researchers in policy-making institutions etc.

The research staff at all levels should be capable:

- to communicate and interact with targeted users in a manner that offers the best chance of reaching and influencing the addressees; and
- to help develop receiver's capacity to grab and interpret the research based-knowledge.

The capacity building and human resources management efforts should focus also on addressing social and cultural conceptions and attitude of both addresser and receptor of the message. For international research or knowledge management related projects, it is also important to assess the level of involvement and communication between northern-based (developed countries) and southern-based (less-developed countries) researchers; how to the access and engagement of Southern-based researchers to Northern or international research circle is promoted.

The evidences may be found from the quality and frequency of interaction with other researchers and users through journal articles, books, peer reviews, university seminars, conferences, academic associations, email lists, personal contacts, policy briefs, or collaborative researches, etc. The reviewed literature tends to see different types of research networks as one (potential) solution – especially electronic networks and regional research networks (range from email discussion lists, electronic research networks and regional research networks, policy networks and advocacy coalitions, and dispersed organisational teams or inter-organisational partnerships.

4.4.5 Key Evidence for measuring Pull Factor Dimension in knowledge management

For the push factor dimension of knowledge management, the proposed performance indicator and include the followings:

4. Demonstrated commitment to informed decision-making;
    4.1. Effective Organizational Capacity and Autonomy
    4.2. Organizational Capabilities and Resources; and,
    4.3. Leadership and management conducive to knowledge uptakes.
5. Policy Process and Decision-Making Style Performance Indicator
    5.1. Enabling Environment
    5.2. Presence of Knowledge Champion
    5.3. Transparency
    5.4. Decision-Making Styles

4.4.6 Commitment to Informed Decision-Making Performance Indicator

The performance indicator of demonstrated commitment to informed decision-making can be comprised of 4 key MOV.

4.4.6.1 Effective Organizational Capacity and Autonomy

Similar to the case of the knowledge producers, the capacities and competency, resources availability and accountability are key performance indicators for organizations and institutions to uptake, understand and apply the knowledge products effectively The organizational capacities of knowledge users' organizations are often characterized by their ability to make decisions about the following important matters: budget, human resources management, policies, planning and implementation of projects, and organizational goals (UNEP, 2007).

Key research evidence for assessing capacity variable may include: i) **s**et and change own organizational policies and goals, as well as strategies to provide guidance and direction in achieving the objectives; ii) establish and maintain staffing levels sufficient to meet needs; and iii) determine own organizational structure including roles and responsibilities of major groups or divisions. See and compare Indicator 1, MOV 1.4 in Table 4.2.)

4.4.6.2 Organization's Capabilities and Resources

This MOV 4.2 – Organization (user) capabilities and resources - is focusing on technical capabilities as they are the measure of the organization's competence in conducting technical and operational work. The key evidences of the technical capabilities include:

i) Availability and performance of skilled, qualified employees, as well as outside specialists, and capacity to recruit and sustain qualified human resources and technological systems;

ii) Regular provision of both formal training programs and the informal training(on-the-job training, apprenticeships, secondment, staff exchange and job rotation);

iii) Provision of sufficient incentives to staff to apply knowledge and skill; and

iv) Technical and scientific information is routinely shared among planning, design, and construction units to ensure smooth technical coordination; and

v) Quality of in-house knowledge and research management, and financial resources allocated for knowledge gathering and application (sum and percentage of total budget) (FAO 2006).

The emphasis is placed on the sustainable institutional capacity building and means for enhancing performance, through a sum of efforts to nurture, enhance and utilize the skills and capabilities of people and institutions at all levels so that they can make better use of knowledge to progress towards a broader goal (Global Water Partnership, 2000).

This human resources development normally achieved through training, education, and the provision of knowledge and tools. Its key evidence may include empowering and equipping staff and organizations with appropriate tools and knowledge-base and sustainable resources to solve their problems. When capacity building is successful, the result of informed decision making is more effective and individuals and institutions are better able to provide products and services on a sustainable basis. Other key evidence of capacity building is new skills or ideas are actually to be used by institutions and individuals to change practices and approaches and the ability of an institution to adapt its human potential – the knowledge, perspectives and skills of its staff (FAO 2006).

The development and maintenance of a functional water and related resources knowledge base is another evidence of commitment (FAO 2006). The key evidence is if technical and scientific information is routinely shared among planning, design, and construction units to ensure smooth technical coordination.

It is equally important to assess how knowledge is considered by administrations at different levels- e.g. how if at all are investments in knowledge management accommodated by regional and national programs? This may include consideration of the resources available to knowledge management programs, the political commitment at various levels of government, and the opportunities for stakeholder involvement in decision-making processes.

The key assessment questions for collecting evidence for scoring this MOV may include:

- Are the technical staffs sufficiently capable? What is the balance between services contracted out (outside specialists/consultants) and in-house work?
- What types of technology are used and to what extent are the systems operable and economical?
- Is the technology suitable given the level of skills, funds for spare parts, levels of manpower?

- What types of research and experimentation are conducted? Are they useful or practical? Why?
- What are the annual budget and manpower allocations devoted to research or uptakes of the research products?
- Is there a functional library? To what extent do staffs have access to and read research or academic papers and thesis etc.?
- How often do they attend conferences, training or workshop?
- Mechanical and social means for data, information and knowledge dissemination and access?
- How often are new skills or ideas used by institutions and individuals to change practices and approaches? (FAO 2006).

4.4.6.3 Leadership and Management

This MOV 4.3 – Leadership and Management – is critical since the organization in many instances depends on the leadership to perform its functions in a competent manner, and it needs to have effective leadership at many different levels to inspire understanding and commitment to mission and improved application of scientific knowledge for informed decision making. It can also be measured through availability of mechanism and functionality dealing with how scientific advice and need are identified and obtained and applied in time of need or crisis.

The key assessment questions for collecting evidence for scoring this MOV may include:

- What is the level of scientific and technical knowledge that top management (or unit leaders) have?
- Do leaders get out in the field/offices and interact with knowledge production, management and application? How often?
- What is management's attitude toward problems and need for scientific information?
- What role does the leadership of the organization play in selecting the technology and knowledge use in supporting of decision-making? (FAO 2006).

4.4.7 Policy Process and Decision-Making Style Performance Indicator

Another key aspect is the understanding of the relationship between knowledge application performance and social, political and culture environment. They influence the way the users' attitude toward recourse to knowledge and scientific advice in decision making. There are evidence to support the theory of correlation between a society, political system and culture and the knowledge application performance (Maureen H, 1996).

4.4.7.1 Enabling Environment

An enabling environment is a critical means of verification, since in the Mekong Region and other developing world, barrier to the use of knowledge in decision-making is not always due to an absolute lack of it or poor dissemination, but is sometime due to lack of a favorable political environment. The recent trials of this assessment model in Cambodia examining why science research was not used as effectively as it could be in the development of Cambodia's water and energy policy and why public policies were frequently not put into practice the way they were intended. The study confirmed that the problem was due to lack of an enabling political/economic environment that would allow the practitioners and decision-makers to take up and use the information.

Enabling environment was considered as one of the important elements of an effective water resources management system (Global Water Partnership, 2000). The enabling environment is basically national, local or organizational policies and regulations that constitutes the "rules of the game" and enable all stakeholders to play their respective roles in the development and management of water resources and in knowledge management and application, and capacity building. Apart from assessing the state or trends in knowledge management and application by the targeted users, it is important to identify and assess policies and practices in place to enable interface and uptake of knowledge in the policy process. For this reason it will not be sufficient to simply check for the existence of positive policies and legislation, but it is also important to assess changes in policies that will encourage application of knowledge for a long-term sustainable development. It will be necessary to assess:

- Existence and adequacy of policy relating to knowledge management and informed decision making for sustainable development of water and environment, including comprehensiveness of strategies; and
- Existence and adequacy of sectoral policies in terms of their support for knowledge management and informed decision making for sustainable development considerations.

Assessment of knowledge availability and demand (horizon scanning): informed decision on water resources management requires an understanding of the nature and scope of the problem to be managed and what we know and don't know, and what we need to know for ascertaining with plausible and accepted evidence about the changes and how to mitigate them.

Investment plan for knowledge management is in place or not for reducing the spatial and temporal gaps in knowledge availability and application for informed decision-making for sustainable water resources development. Such investment enables decision-makers and practitioner to help solve relevant water problems falls within the realm of personal responsibility.

The effective co-ordination mechanism within relevant organizations and across different organizations/agencies to ensure smooth flow of information for designing, planning, implementing and evaluating policy, program and projects is one of important mean of verifications of the enabling environment. The key criteria of sustainable knowledge management efforts and information flow may include:

- Accessibility: level of data, information, knowledge of appropriate quality and coverage are easily available;
- Availability: long-term continuity of supply as well as the short-term quality of service;

- Acceptability: public attitudes and the environment, covering relevant issues; and
- Less effort and time required to locate required knowledge/information (EU, 2007, Weiss, Carol, 1977).

4.4.7.2 Presence of Knowledge Champion

This array of policy influences reflect the general conditions of society and operate continuously, but there needs to be channels through which they are translated into specific policy responses. This to some extents depends on the presence of and meaningful influence by the ***agents of change*** who are either individuals or institutions that are strategically placed and that will define the specific responses to these general influences at any one time. These will include key figures in the administration and the political system, but may also include people and institutions that 'have their ear', that are influential in determining whether a momentum for change builds up or is resisted.

There are at least three models for assessing the presence of such knowledge champion for promoting knowledge use. As shown in Figure 4.5, the instrumental model represents the process in terms of knowledge being acquired for using directly in making specific decisions either through commissioning research to search for solution to identified policy problem.

The second model represents a more complex (see Figure 4.6), indirect, and diffuse process intellectual or research-oriented process, in which research, together with other intellectual endeavours by public opinion makers (journalists, public figures, famous academia, etc.) raises the quality of public debate about public policy issues (EU, 2007).

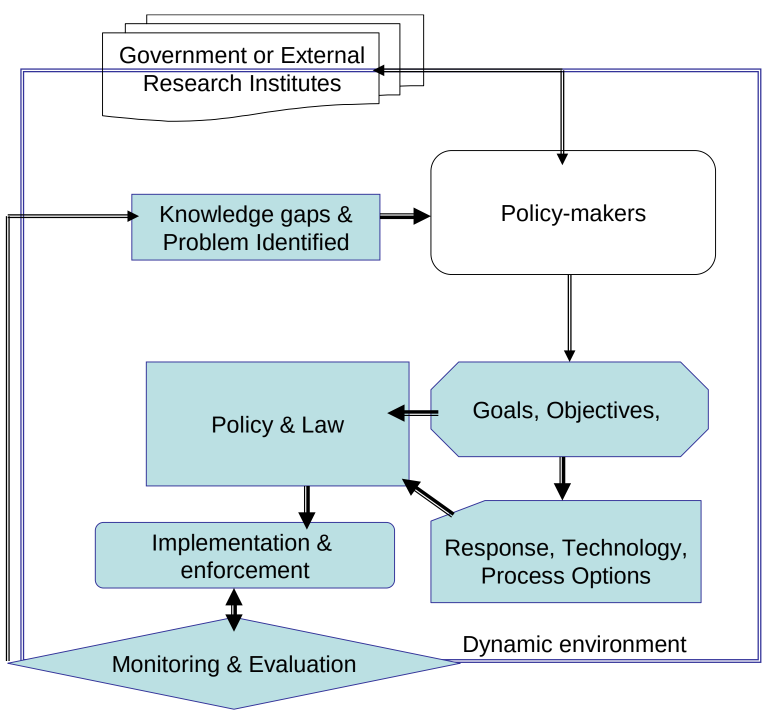


Figure 4.5 Instrument Model representing more Linear Links between Policy-Makers and Knowledge Producers

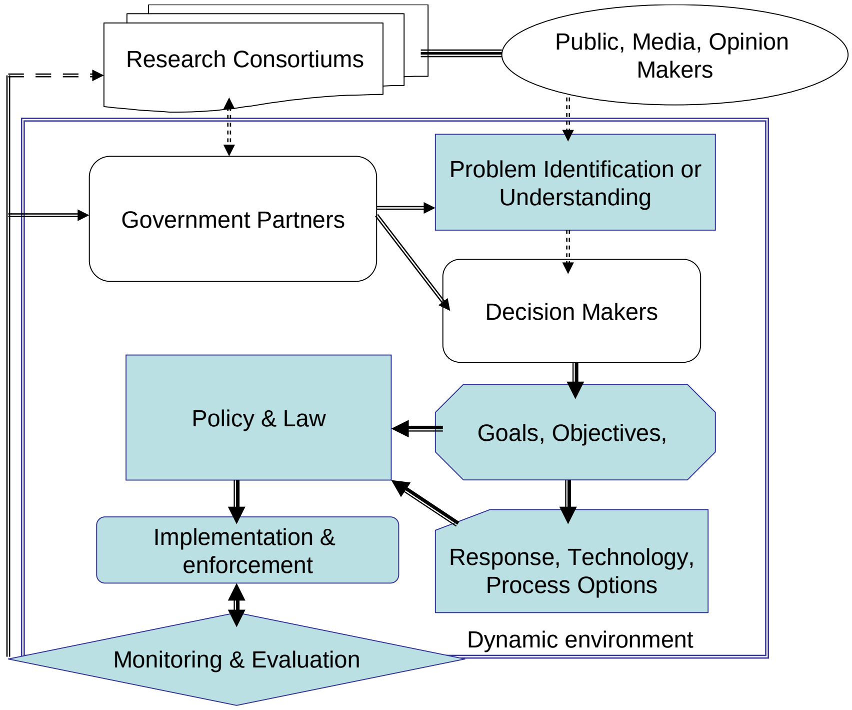


Figure 4.6 Conceptual model of Knowledge Use through a more complex, indirect, and diffuse process – *interactive or enlightenment*

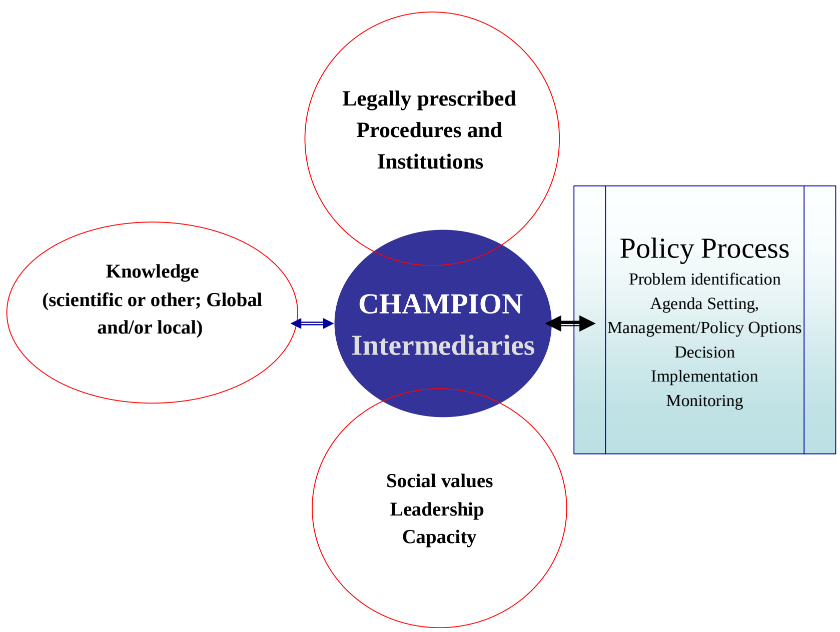


Figure 4.7 Science and Policy Interface through National Facilitators

Thirdly, the capacity and willingness of officials to undertake research and analysis is seen as important as depicted in Figure 4.7. Whatever their provenance, they may be able to assume the skills and value-set of boundary-crossers and research enablers (Kogan M and Henkel M, 1983 in Hanney S, *et al*, 2003). In the countries such as Viet Nam and

Thailand where the research and policy connections are strongest, the relationship has been enhanced by the fact that some of the senior administrators have had research experience or interests as part of their prior education (Pech S, 2010). Some have become influential and known for their ability to empathise with the needs, problems and potentials of researchers whilst enabling policy-makers to secure otherwise inaccessible skills and knowledge (Hanney S, *et al*, 2003). So an important determinant of their success will be their position within the policy-making organisation for them to serve as an internal honest knowledge brokers.

4.4.7.3 Political Process

The world has become more globalised and the water resources management perceptions are similar throughout the world, but the political traditions and social norms (reasons of interest, ideology or intellect) continue to influence the mechanisms and institutions for integrating knowledge and expertise in the policy arenas (OECD, 2002, Science and Technology Committee, 2006, Pech S, 2009b). How far individual policy-makers would automatically attempt to use research findings on a regular basis will depend on multiple influences, such as motives, training, continuous education, and exposure to the media and to the demand of clients or constituency (OECD, 2002, Science and Technology Committee, 2006). Knowledge management is often dictated by short-term motives, whereby senior decision-makers and politicians are primarily concerned about winning the next election and their reign of power. The response of policy-makers to research varies not just with the type of issues and research being dealt with, but also with the differing attitudes they adopt towards the whole policy-making process. The adopted policy making styles in the country and organizations may affect the decision-makers' attitude towards mechanism for getting a wide range of advice from the best sources, particularly when there is uncertainty. The Policy Process is influenced by many factors including:

The priorities in political and development terms, and resources likely to be available to policy makers have a strong bearing on the country or organization's attitude and capabilities to recourse to and use appropriate knowledge and scientific advice. Facilitation an encouragement for using knowledge in policy process also depends on who can participate in the policy process (defining issues, developing agenda, making decision, undertaking implementation, and conducting evaluation and monitoring) and the forms of legitimacy and governance of associated with environment management policy processes.

Transparency in policy making: The commitment to evidence based policy making is a key mean of verification that likely to encourage recourse to and application of knowledge. It requires instilling transparency into the policy making process, such as:

v) An open and honest policy on the publication of research (evidenced by the role of public consultations in the development of policy);

vi) Publication of all evidence (knowledge, scientific advise) used in policy making;

vii) Explanation on the process by which knowledge, scientific advice is obtained; and,

viii) Plans and action to address gaps and deficiency (Pech *et al*, 2010a and b).

4.4.7.4 Decision-Making Styles

The characteristics of policy making styles (see **Table 4.3**) also have a strong bearing on the recourse to and use of knowledge and scientific advice. For example in the western world (industrialized nations), the adversarial approach to policy making is usually characterized by openness to professional and public scrutiny into the policy making, and more elaborated procedures oriented towards contesting and agreeing on set of knowledge for informed decision. In the Mekong Region, some progress has been made in transition from fiduciary approach (hardly any procedural rules oriented towards producing informed decision making) toward either corporative or consensual policy making styles OECD, 2004). Key evidences that should be looked into include:

- Level of openness to professional and academic inputs and public scrutiny into the policy making,
- Presence and level of elaborated procedures oriented towards contesting and agreeing on set of knowledge for informed decision.
- Strong reliance on impartiality of information and evaluation;
- Level of fair representation of major societal interests in decision-making.

Table 4.3 Characteristics of policy making styles

Style	Characteristics	Inclination toward knowledge
Adversarial approach	▪ Open for professional and public scrutiny; ▪ Debate and scientific justification of policy selection; ▪ Precise procedural rules oriented towards producing informed decisions by plural actors	▪ Emphasis on mutual agreements on scientific evidence and pragmatic knowledge. ▪ Integration of adversarial positions through formal rules (due process); ▪ Essential for reaching communication objectives
Consensual approach	▪ Open to members of the “club” ▪ Negotiations behind closed doors ▪ Flexible procedural rules oriented towards producing solidarity with the club.	▪ Personal and professional reputation and strong reliance on key social actors and scientific experts. ▪ Emphasis on demonstrating social consensus. ▪ Focus on communication and support by key actors.

Fiduciary approach (patronage)	▪ Closed circle of "patrons" ▪ No public control, but public input is allowed; ▪ Lack of procedural rules oriented towards producing faith in the policy process and system.	▪ Limited enlightenment and background knowledge from its own experts; ▪ Strong reliance on institutional in-house and "trusted "expertise"
Corporative approach	▪ open to interest groups and experts ▪ Public control, and high visibility of public inputs; ▪ Oriented towards sustaining trust to the decision making body.	▪ Emphasis on expert judgement & demonstrating political prudence; ▪ Strong reliance on impartiality of information and evaluation; ▪ Communication focused on fair representation of major societal interests

4.5 CONCLUSION OF BKMPI TRIALINGS

From its trialing, it is clear that BFKMPI has the potential to play an important role in enabling relevant stakeholders – donors, research communities, governments to monitor and redesign their knowledge management strategies and programs to meet sustainable development objectives. The assessment can be conducted either internally for self-assessment or externally as part of auditing process by the independent auditor(s) or assessor(s).

The push and pull factors were found to be the key suggestive propositions. The ability of the science-policy-practice interface to structure and restructure itself to adapt to and enhance level of application of scientific knowledge in informed decision making depended on both internal (strength and weakness) and external (opportunities and threat) conditions prevailing for all actors within the knowledge continuum model. The trialing also proves dynamism and flexibility of BKMPI, as the users could select or prioritize the most relevant dimensions and performance indicators, and adjust the weighting factors to focus on the areas or aspects that they wanted to assess for future improvement in their knowledge management project or activities.

The information derived from the assessment lad to a range of possible improvement projects and activities. These could range from very specific short-range improvements to an integrated multi-year institutional development and research project. The assessment using BKMPI would provide a profile of the strengths and weaknesses of the assessed project and/or organizations, and external factors such as opportunities and threats affecting the interface for informed decision-making.

Trials assessed and provided recommendations for improvement on replicability and objectivity - to understand how robust the BKMPI is in terms of assessors or auditor arriving at consistent and objective results; and to obtain views on the appropriateness of the set of indicators and criteria and variable, as well as set of the evidence. The trailing demonstrated beyond doubt that the standardized measure method was possible to help form descriptive scales of the degree of interface effectiveness. As other scientific tools there are both potentials and limitations.

4.5.1 Targeted Users and limitation of the BKMPI

The BKMPI framework has been designed by this study to be used for a wide range of purposes, including self-assessments for research and knowledge management. The BKMPI assessment relies on factual, reproducible, objective and verifiable evidence to support a score. The potential users and uses include the researchers, scientific groups, knowledge managers and users, governments, potential financiers, other decision-makers, private sectors, and civil society organizations involving in the knowledge production, communication and application.

The trialing was conducted in Cambodia, Viet Nam and Lao PDR from March 2010 to February 2012. From this series of trialing, it is clear that the tool has both its potential and limitation. The trialing proves dynamism and flexibility of BKMPI, as the users could select or prioritize the most relevant dimensions and performance indicators, and adjust the weighting factors to focus on the areas or aspects that they wanted to assess for future improvement in their knowledge management project or activities.

Its limitation is it cannot be used by individual without adequate understanding of the tools through short familiarization training. Moreover, it is not designed for using by the local communities for the following two reasons – 1) local communities are more interested in tools for helping them to improve their livelihood directly; and 2) they do not involve directly in the knowledge management activities per se, and may not have adequate background in knowledge management and monitoring and evaluation using BKMPI.

The following are two cases to support this finding:

A multi-stakeholder consultation and trialing with broader participation of officials, lecturer and researchers from relevant Cambodian Ministries, Universities and Non-Governmental Organizations (from national, sub-national and local levels) was conducted in Phnom Penh on April 8, 2010. Similar trialing was conducted in Viet Nam in late December 2010 –January 2011 and in Lao PDR in February 2012 (Pech S, et al, 2010a and 2010b).

From the first trialing in Cambodia, it is clear that BKMPI has the potential to play an important role in enabling relevant stakeholders – donors, research communities, governments to monitor and redesign their knowledge management strategies and programs. See for example, Cambodian Ministry of Water Resources and Meteorology (MOWRAM, 2011) multi-million dollar - Project Proposal for Strengthening of Hydrological and Meteorological Network Improvement for Cambodia, Department of Hydrology and River Works and Department of Meteorology, Ministry of Water Resources and Meteorology, Phnom Penh. It was developed based on the findings on the gaps in their hydrological and meteorological information management.

The trialing also shows that there were initial discrepancies between the preliminary assessment results by the assessment team selected from various government agencies and civil society organizations (CSOs) including research and academic institutions. The study observed differences among the group members in scoring the same attributes/variables depending on personal preference, education background and especially their institutional affiliation. However, through application of Delphi method by this study helped the participants in the trialing focus and narrow down their subjectivity.

The trialing shows that the participants from the local communities North-east region (Stung Treng Province, Cambodia) where have been facing with concern over the impacts from the hydropower development, are not interested in the tool for improving science-policy-practice interface directly as their priority lies in a higher priority for addressing their daily life and livelihood (Pech S., et al, 2010b).

The most recent trialing was conducted in Lao PDR from February 22-25, 2012 with the participants from many government Ministries, Universities and Non-Governmental Organizations (from national, sub-national and hydropower project site local levels). They used this tool to assess and validate all relevant evidence (visual, verbal and written) to derive at scoring after completing site-assessment and visiting the local communities. They confirmed that the lead assessor (properly trained) were capable to conduct an objective assessment and provide written explanation and justification for supporting the score, as skill and reputation risk are key factor for success in using this BKMPI (Pech S., et al, 2012).

The trialing in Lao PDR also confirms that even through there is always subjectivity in the assessment using this tool, the systematic processes (including expert reviews, stakeholder consultations, round of comments and validation of evidence etc.) help ensure the result is as objective and credible as possible.

It further discovers that in application of the tool, credibility of the assessment depends on how much information is disclosed by the assessed entity to the assessors. The assessment is a snapshot gained by the assessor based on evidence obtained before and during an on-site assessment - visual (obtained through a site visit), oral (obtained through interviews), or documentary (obtained through review of written materials). The assessor group highlight challenges in providing objective scoring due to lack of adequate information (evidence) and chance for validating their findings with relevant stakeholders. They find that it would be useful to have reliable baseline data and monitoring data for assessing changes and improvements in key knowledge management and application aspects (Pech S, et al, 2012).

The key conclusion is in order to be an assessor, one need to be a specialist of relevant knowledge management and scientifically informed policy process topic and also receive special training. More in-depth learning and understanding of BKMPI should be provided so that it can be adapted, applied and included in university curriculum and short-term training for human resources development (Dr. Souphap, Professor of National University of Laos in Pech S, et al, 2012).

4.5.2 BKMPI Applicability Perspectives in different natural, population, industry, and cultural conditions

A trialing was undertaken from March 4 to May 1, 2010 in Cambodia, by a group of four Cambodian Independent Assessors and author of this study (International Team Leader). **As part of this trialing, a** multi-stakeholder consultation was conducted in Phnom Penh on April 8, 2010. The participants were asked to reflect and score relevant aspects of the BKMPI, by providing evidence against and for their scoring etc., and suggesting recommendations. Most of the participants from key Government Ministries and Agencies, Universities and NGOs, took part.

The multi-stakeholder assessment was focusing on the following: I) objectivity and replicability; ii) understandability; iii) scope and comprehensiveness; IV) ease of use; v) impact and effectiveness; VI) adequacy of implementation guidance; and, vii) presentation of Results.

The trialing observed discrepancies between the preliminary assessment results by the assessment team and by the trialing participants with diverse social, educational and cultural backgrounds. The team observed differences among the group members in scoring the same attributes and using the same evidence. Different discussion groups and members tended to have diverse viewpoints with regards to attributes and aspects depending on personal preference, education background and institutional affiliation. This lack of consistency may be explained by:

- The fact that the existing BKMPI still allows an aptitude for subjective judgment and personal/professional bias, and that bias has to be challenged through additional peer-pressure and review process using evidence-based collaborative deliberation; and
- The BKMPI requires a specially trained assessor to be able to conduct the assessment objectively and consistently.

Scoring is one of the most discussion points during the trialing. The participants from the government agencies and regulatory agencies provided the scores for most of Cambodia's institutional capacity for up-taking available knowledge energy planning - most of the aspects between 3 and 5, even though it was clear that level 4 and 5 "best practice" is far from achievable in countries with minimal resources or capacities and experience like Cambodia. Other participants from Non-governmental organizations scored most of the aspects between 2 and 3. More guidance on scoring was later provided based on more understandable levels of practices (poor to best practices).

Most of the trialing participants and assessment team found that to be able to provide assessment of each aspect, the users need to have not only the required expertise, but also have a good knowledge of English language and guidelines/instructions very well (translation into local languages is needed).

The trailing participants regarded initiatives such as the BKMPI as important practices, when implemented in a participatory evidence-based deliberation process, could improve decision-making around scientifically informed decision-making.

In the country where data and knowledge management are poorly developed, it is extremely challenging to get information required to apply. The trialing participants and the assessment team understood that it would even more challenging to collect information for assessing other given the high number of aspects involved. A score from 1-5 is assigned to each assessment topic, based on evidence, which helps to reduce bias, and to ensure that the assessment is not subjective (Dr. Nattawuth, Vice-President, Italian Thai Company, in Pech S, et al, 2012).

The trial also found that BKMPI can be applicable only in relation to project scale, key organizations involving in different aspects of knowledge management (production, dissemination and application). Nonetheless, the most difficult issue is in its application for assessing informed-decision-making for hydropower development in Cambodia and Lao PDR; as they have to deal with personal vested interest, perspectives, cultures and traditions, and the fact that the development projects often touch upon individual requirements, preferences and problems. As far as the industry is concerned, the most important output of the BKMPI assessment is scoring and how the result is communicated (sensitivity of commercial secret and security). As long as this concern is addressed, BKMPI acceptance by the hydropower developers and financiers will be increased.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.0 CONCLUSION

This final chapter provides for key conclusion, recommendations, summary and directions for future research and development.

5.1 MAIN CONCLUSIONS OF THE STUDY

In the Mekong Region (MR), from the literature review, field survey, critical analysis and validation conducted by the present study, over the past 60 years numerous efforts have been undertaken by the Mekong countries and other Mekong related research groups aiming at producing and applying scientific and other knowledge related to water and related resources in various river basins in the Mekong Region. But in spite of that, the availability and permeability level of usable knowledge and tools in decision making remains one of major constraints facing the national and regional institutions in charge of sustainable development of this great international river basin.

Both the needs for, and gaps in data and information have been increasing together with the expansion of the economic development activities within the MR focusing on major infrastructures, mega energy and water projects. As in many parts of the world, the relationship between science-policy- practice does not always conform to the linear model, where research plays role of information providers for policy-makers, who make policy decisions based on it and then hand decisions down to administrators (managers) for implementation. The Region has to address quickly and systematically the challenges to uptakes of research knowledge/information in the decision-making.

The following concrete conclusions are drawn from the study:

Conclusion 1: Even though the main root-cause of the poor decision making quality is closely related to the lack of high amount and high quality of scientific information/knowledge, the gap between those who generate knowledge, those who analyze and those who decide is found to be the most critical one since it restricts the application of the available knowledge and tools and hence makes huge investment and efforts for knowledge management very ineffective.

Conclusion 2: There is an urgent need to explore, understand, and communicate the components of successful knowledge management for sustainable water development. In spite of non-linear and sometimes even illogical model of knowledge management, and diversity and priority issue, it has been recognized by many researchers, policy-makers and practitioners in the region that there is an urgent need for ensuring timely and better decision so that development can proceed smoothly and benefit and impacts are properly distributed and mitigated.

Conclusion 3: Knowledge is a catalyst for the IWRM based river basin cooperation for sustainable development and equitable utilization**.** Scholars, policymakers, aid donors, and aid recipients acknowledge the importance of good governance supported by increasing integrated water resources management (IWRM) functionality and performance across the basin, and role of credible and accessible knowledge for achieving sustainable and pro-poor development. The need for information arises at all levels, from that of senior decision makers at the national and international levels, to the grass-roots and individual levels.

Conclusion 4: The Mekong researchers, policy-makers, practitioners, and concerned public consciously or sub-consciously have been searching for answers to basic sustainability and growth questions**.** Water issues in the Mekong Region are closely related to the unequal spatial and temporal natures of flow and other water elements such as sediment and fishes, and the lack of well-informed decision making for water resources development and management, and mitigation of vulnerability. While the principles of sustainable development and equitable utilization, as general objectives for policy-making, are accepted at the political level, there are still a number of challenges when it comes to the practical application of these broad concepts.

Conclusion 5: A rapid population growth and environmental change are two topics that have caused substantial debate over the past decades in the world and in the Mekong Region. Population growth, and associated food and water demands and their impacts on water resources in the MRB was considered by planners and policy-makers as the main drive of the MRB "exploitation and development". The decision-makers and practitioners perceived population growth and associated demand change as the main justification for water and related resources, and exploring other sustainable and cost-effective options in addressing water, energy and food nexus.

Conclusion 6: This study confirms that population size is only one of many important determinants of food demand, the type of agricultural land-use change and the implications of that change are determined by fundamental social, economic, and political factors, and resources availability**.** Lack of reliable data on intra-regional forest products trade, on quantity and quality of forest, and on actual rate of deforestation - different definition of forest/vegetation type - make it is extremely challenging to quantitatively assess the future trends and likely impacts of population growth and other formal and informal economic activities on the forest cover and its ecological and economic values.

Conclusion 7: Electricity supply continue to grow in the Mekong Region to support economic growth, demographic change (population growth and urbanization) and improved electrification, but there is no consensus on how much it will grow in the coming years**.** The analysis by the present study shows that the electricity consumption does not correlate well with the GDP and population growth rates. This explains the complex nature of factors driving electricity demand that include not only the population and GDP growth, tariff changes and electricity prices, but also availability of other energy sources, consumer preference, accessibility, structural changes in the economy, efficiency improvement, and demand-side management.

Conclusion 8: The understandings about the performance, benefits and negative impacts of the large dams (hydropower and irrigation purpose) are not widely shared by many hydropower promoters and Mekong Region decision-makers**.** The concern is compounded by many factors. But poor quality of data and information leads to a failure to fully understand and correctly evaluate sustainability tests to quantify impacts, the causal mechanisms at work in large, dynamic systems, and to consider and integrate multiple risks and degree of vulnerabilities.

Conclusion 9: Current planning and assessment of the hydropower and other major water related projects in all Mekong countries have been strongly criticized for inadequacy in their methodology, limited data and information, and limited in their scope and methodology. Appropriate assessment framework and usable knowledge and prediction and monitoring tools are needed as a means of supporting the process of economic growth by making it socially and environmentally sustainable by considering at the earliest possible stage of planning, the impacts at a basin-wide level, and to predict cumulative impacts over space and time, and support decision on mitigation and trade-off.

Conclusion 10: This study confirms that fisheries are one of the main social, economic and health mainstays and concerns and there have been some studies on the change in hydrological and morphological conditions and their effects on the ecosystem productivity of many important parts of the Basin, including the Tonle Sap Great Lake. The annual fish production is depend on a combination of hydrological, biological and physical parameters such as decrease in reverse flow volume to the Lake and resulted reduction of flooded area, flood depth and duration and a reduction in sediment inflow, and the blockage of fish migration paths as well as the fishing practices. The area of flooding is the most influential parameter driving the fish production.

Conclusion 11: There are both strengths and weaknesses, and opportunities and threats in the existing pattern of knowledge management in the Mekong Region that can be built upon and considered for strengthening best practices in knowledge management for supporting sustainable and responsible water policy and practice**.** The findings of this study confirm the possibility for building up and sustaining best practices in knowledge management.

Conclusion 12: The quality interface between science-policy and practice is a key toward building up best practices for knowledge management. There is a growing consensus on what constitutes good interface practice based on an extensive literature review of document from research institutes, academia, intermediary organizations, decision-making organizations and practitioners. There is all clear reason to assume that the success of the knowledge management and interface is conditional to favorable social and political conditions in which science, policy and practice are conducted. It will contribute to an even more relevant and credible knowledge production, effective transmission and acceptance of the generated knowledge products into decision and practice.

Conclusion 13: Even though it is challenging to assess qualitatively and quantitatively the direct social and economic impacts of the knowledge utilisation, the permeability of the knowledge depended on a number of key indicators. To measure enabling condition, it would require employing behavioral study approaches (neuroscience) using systematically measured variables, and statistical techniques. To qualitatively and quantitatively assess the interface and capacity (enabling environment) to affect behavior change for informed decision-making, at least four basic parameters: 1) attitude of all key players toward knowledge management; 2) communication/transmission quality, 3) institutional and regime effectiveness where policy makers and communities are able to appreciate knowledge to address existing and emerging problem; and 4) users' capacity and attitude to appreciate and apply them - are deciphered from the collated data and information. Quality of knowledge (vigour, trust, relevance etc.), communication, dialogue and or involvement at various stages of research such as setting research questions and priority, commissioning of research, and validating and communication of the findings. Such assessments can be derived from multiple data sources, including documentary evidence, data-sets, surveys and interviews and in-depth case studies.

Conclusion 14: For measuring and encouraging interface improvement management, an assessment model "Best Knowledge Management Practices Index: (BKMPI) is needed. The main goal of this measuring tool is to provide pragmatic perspectives for assessment and improvement of management performance in addition to specific program level monitoring and evaluation framework. The regular assessments using performance indicators and benchmarking is confirmed by a series of trailing as a useful tool for moving up the spiral to better interface, and providing pragmatic perspectives for assessment and improvement of knowledge management performance.

Conclusion 15: BKMPI Index of the push and pull factors was designed and trialed into a rating system capable of coherently evaluating the interface performance. The trialing was considered to have met its set objectives of validating the BKMPI by providing feedback on how well the BKMPI measured interface performance and sustainability, and to inform the final revision. The trailing demonstrated beyond doubt that the standardized measure method was possible to help form descriptive scales of the degree of interface effectiveness. The documentary analysis, semi-structured interviews, application of scale reporting; and overall analysis appear to be appropriate methods to use in a retrospective study of science-policy-practice interface.

5.2 RECOMMENDATIONS

These recommendations therefore take into consideration the progress that has been made with regard to interface and sustainable knowledge management in the Mekong Region.

Recommendation 1: It has become increasingly obvious that there is an urgent need for greater cooperation in the Mekong Region, and greater interface between science policy and practice. The effective mechanisms for such cooperation and interface need to be further strengthened or established.

A new scheme of cooperative mechanism must be built on key institutional and functional design principles such as mutual self-interest, benefit sharing (harmonization of policy targets, evaluation tools and benefit distribution/impact mitigation and compensation), quality of institutional requirement and compliance procedures; and improved linear relationship between knowledge generation and its application in decision-making. Another equally critical issue is the need for linkage between knowledge generation and its consumption. Especially it requires circumstances to be overcome where the available knowledge is simply ignored or questioned. The knowledge needs and priority should place an emphasis on generating information and analysis by the knowledge producers which will help to promote a better understanding of key issues, including the multi-functionality of resources, societal demands and sustainability monitoring threshold.

Recommendation 2: Scientific knowledge and tools are required for generating proper projection of the population, searching alternatives/options, and modelling the growing environmental pressure to meet the growing demands associated with population changes. Existing approach to population growth project, food demand projections, and factors causing environmental pressure need to be improved and applied systematically based on credible information. Further improvement in scientific knowledge and options for meeting future demand and supply balance and support appropriate planning and impact mitigations should be researched and provided to the planners and policy-makers.

Recommendation 3: Since the planners and policy-makers in the Mekong Region believe that electricity supply must continue to grow in the Mekong Region to support economic growth, demographic change (population growth and urbanization) and improved electrification, it is important to investment more in developing tools and approach for projecting the demand and supply, and generating and selecting most appropriate supply and demand management options.

Reliable and independent assessments of the actual demand and factors driving growth, and potential costs and benefits of relevant technical and management options, and full exchange of information and application of proper knowledge for informed decision would go a long way to solving problems, and preventing problems from happening in the future.

Recommendation 4: Appropriate assessment framework and usable knowledge and prediction and monitoring tools are needed to support and enable decision-makers and practitioners in mapping actions and working toward achieving the broad concept of sustainable development and equitable utilization. As the number of development projects in an area increases, the incidence and importance of cumulative impacts also increases, sometimes dramatically. Failure to properly assess cumulative impacts can potentially lead to severe negative environmental alterations and events.

The development decision must be more knowledge-intensive and more participatory. Appropriate assessment framework and usable knowledge and prediction and monitoring tools are needed as a means of supporting the process of economic growth by considering at the earliest possible stage of planning, the impacts at a basin-wide level, and to predict cumulative impacts over space and time, and support decision on mitigation and trade-off.

Better approaches, guidelines and conventions for carrying out cumulative and cross sectoral impact assessment and monitoring are needed. A fundamental point of departure should be the changes/impacts and what will they affect other water elements and people’s livelihood whose dependency of on the river's water and related resources are so strong.

Recommendation 5: Need to generate an enabling condition for building upon and considering strengths and weaknesses, and opportunities and threats for strengthening best practices in knowledge management for supporting sustainable and responsible water policy and practice. There is an opportunity for defining and measuring science – policy- practice interface within a broadly understood knowledge management concept. In order to define science – policy- practice interface within a broadly understood knowledge management concept, firstly it is necessary to determine the social (political and cultural), economic and environmental factors prohibiting or influencing the interface that warrant for focusing on demand-led knowledge generation and research for optimal way for bridging gaps between the producers and users of knowledge.

Secondly, it requires the development of usable knowledge in one form or another (western scientific tradition and the informal knowledge by indigenous peoples) to promote a better understanding of key issues, including the multi-functionality of resources, societal demands and sustainability monitoring threshold. The dominant social paradigm underlying decision making supporting a *'business-as-usual-with-a few-minor-changes'* approach with regard to application of knowledge and cooperation approach to natural resources may not support closer interface. While this approach may still be practical in the short term, it may not be conducive to long-term prevention of conflicts over water, food and energy nexus. Hence the quality interface between science-policy and practice is a key toward building up best practices for knowledge management.

Recommendation 6: There is an urgent need to address enormous complexity of key actors in the science-policy-practice. It is even more complex with the emergence of powerful private developers and investors in the Mekong Region. It is clear that there are at least three major groups involving in these interface relationship. Each of them has its own membership, focus, principles or norms that determine how it cooperates and defines its strategic direction and priority.

A shared understanding among key stakeholders as well as river basin planners is crucial for diminishing information asymmetries that engender mistrust, and for generating evidence-based options for cooperative management. The capacity and inclination of the decision-makers to appreciate scientific knowledge or to interpret complicated research findings must be strengthened to enhance translation of research findings into policy decision and action.

It is important to raise further the level of understanding about the science-policy-practice interface among the government and research/scientific groups, and those involved in applying and making decision. It is important to broaden and intensify the research focus to cover all equally important topics and problems through developing and employing tools for mapping socially and scientifically demand driven knowledge generation research program and projects.

Recommendation 7: The key players and funding agencies operating in the Mekong River Basin have to consider seriously a sustainable programme for supporting and facilitating the conduct of in-depth study collaboratively by the knowledge developers and users i.e. basin planners, managers, decision-makers and basin communities, on the interface constraining factors and ways and means for overcoming them.

The optimization of the interface and uptakes of knowledge for informed decision making requires a systematic approach towards improving readiness by relevant players/actors in the interface including capacity development, communication, engagement, and sustainable measures for instilling culture and behaviour toward sharing, appreciating and applying knowledge in decision making. It is important to improve the practice where the research interests will strongly coincide with the actual needs of the targeted users and communities to address their current and emerging problems. The focus of such joint endeavour should also be on improving the communicating and absorbing capacity, increasing understanding of actual social needs in addition to scientific rigor, and strengthening the scientific approach and broadening the disciplinary focus etc.

Recommendation 8: The key players and funding agencies operating in the Mekong River Basin have to consider and secure programme for promoting this systematic assessment tool – BKMPI - to generate and widely share with the donor community, research community, policy makers, and broader community for monitoring the interface and improving uptake of knowledge for decision making and practice. To measure the success or failure of the knowledge production, management and application for informed decision-making primarily, one can start from assessing the state of the science-policy-practice interface, and prevailing social and political environment. The informed decision-making for sustainable river basin management can be enhanced with the improvement in the science-policy-practice interface. **The role of mechanical and social means for communication and interaction for data, information and knowledge sharing and exchange and the skill and capacity for communicating and absorb required knowledge should be the key focus for any future knowledge management programme.**

5.3 DIRECTIONS OF FUTURE RESEARCH

This study has informally tested and trialed this BKMPI in an academic and informal setting leading to the finalization of this dissertation. It is important that a more concerted effort should be made to conduct trialing and familiarizing the tools in a more formal and semi-official setting. This undertaking will need a functional program and regional center to lead and coordinate the trialing process and document the outcomes.

The trailing demonstrated beyond doubt that the standardized measure method was possible to help form descriptive scales of the degree of interface effectiveness. The documentary analysis, semi-structured interviews, application of scale reporting; and overall analysis appear to be appropriate methods to use in a retrospective study of science-policy-practice interface.

More research is required to explore best modality and options for improving the characteristics of policy making styles that would support a strong recourse to and use of knowledge and scientific advice within the social and political context of the Mekong countries.

It is important for increasing and making available investment plan for knowledge management for reducing the spatial and temporal gaps in knowledge availability and application for informed decision-making for sustainable water resources development. Such investment enables decision-makers and practitioner to help solve relevant water problems falls within the realm of personal responsibility.

Concerted efforts are needed for improving effective co-ordination mechanism within relevant organizations and across different organizations/agencies to ensure smooth flow of information for designing, planning, implementing and evaluating policy, program and projects is one of important mean of verifications of the enabling environment.

An operational depository or a central clearing-house for research outputs for easily accessing related research or knowledge for use with confidence about its quality by users will be able to address this need. This knowledge hub or center should also lead the familiarization and improvement of BKMPI as part of its overall campaign for improving knowledge application for informed decision. The research publication database developed by this study should be constantly improved and updated. It would be useful for those interested in identify key research areas, sub-topics and detailed research questions of special interests.

The present study was limited only to the overall analysis of the overall trends and classification of the selected research papers to gain a good overview of the emerging interest by the leading research organizations and individuals. Further careful review by subject matter experts would be necessary to fully validate the quality and credibility of each paper and its social relevance. Further analysis should also be conducted to grasp not only the trend of the research, but also potential gaps of the knowledge to address the entire spectrum of possible functionalities of the IWRM and associated problems. It is important to map the knowledge generation needs, through a full grasping of the linkage of the identified problems with possible cause(s) and effect(s) and IWRM and knowledge based problem management. Each identified key problem is seen to have multiple cause- effect relationship and is closely related to many key IWRM knowledge and institutional attributes. It will support addressing complexity and high demand for contribution of a number of scientific disciplines and topics to address major knowledge area to support improved IWRM functionality.

Last but not least, presence of knowledge champions is to be strengthened. This array of policy influences reflect the general conditions of society and operate continuously and this to some extents depends on the presence of and meaningful influence by the ***agents of change*** who are either individuals or institutions that are strategically placed and that will define the specific responses to these general influences at any one time. These will include key figures in the administration and the political system, but may also include people and institutions that 'have their ear', that are influential in determining whether a momentum for change builds up or is resisted.

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