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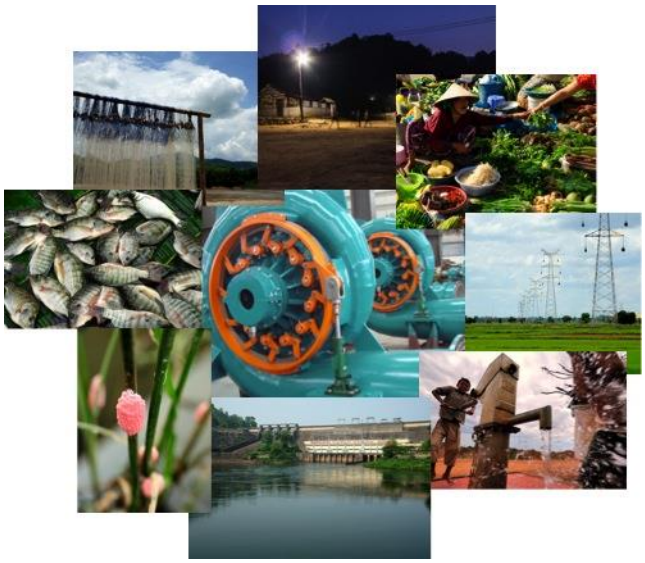
MRC Initiative on Sustainable Hydropower (ISH)

IMPROVED ENVIRONMENTAL AND SOCIO-ECONOMIC BASELINE INFORMATION FOR HYDROPOWER PLANNING

ISH11 PHASE 2 REPORT:

- **Executive Summary**
- **Extracted Tables**
- **Matrices**

TO ACCOMPANY EXTERNAL DRAFT 1.0 ISH11 PHASE 2 MAIN REPORT AND ANNEXES – for Member Country review



20th December 2013

NOTE: This Paper is an extract from the External Draft 1.0 of the ISH11 Study Phase 2 Report which is for review by MRC Member Countries. It should be read in conjunction with the full Phase 2 Report.

Executive Summary

The MRC 'ISH11' study "Improved Environmental and Socio-Economic Baseline Information for Hydropower Planning" addresses a fundamental aspect of the MRCS Basin Development Strategic Priority #3 to **"Improve the Sustainability of Hydropower Development".** Good information underpins all aspects of hydropower development and management, and is vital to maximise opportunities and reduce risks across economic, social and environmental dimensions for all stakeholders.

The MRC has for many years taken up the role of gathering, storing and disseminating information important for basin planning for the benefit of all Member Countries. However, with the increased scrutiny of infrastructure development, particularly hydropower on the mainstream, gaps in some important information types have emerged.

The lack of critical information to inform current debates on hydropower developments in the Mekong mainstream has been raised in a number of previous studies including the Basin Development Strategy, the SEA process, the PNPCA analysis for Xayaburi, and most recently on the discussions on the Don Sahong HPP. Member Countries have agreed on the importance of these issues, reflected in the Basin Development Strategy strategic priority #4 "to acquire essential knowledge to address uncertainty and minimize risks of identified development opportunities". Twelve Mekong mainstream dams are at various stages of development ranging from early concept to feasibility studies to construction, heightening the timeliness for actions to improve information relevant to hydropower planning and management.

The ISH11 Phase 2 Report is provided to MRC Member Countries to progress dialogue on important Mekong mainstream hydropower information needs, gaps and improvements, pertinent to the basin-scale role of the MRC.

The ISH11 study commenced in November 2012 with a multi-disciplinary team of experts, to review existing monitoring and information management systems at the MRC to assess how well they provide information to Member Countries for hydropower planning and management information needs. At this stage of the study, the team has:

- reviewed information needs relevant to hydropower planning and management based on Mekong-specific issues and experiences elsewhere;
- established a Guiding Framework for hydropower information needs relevant to the MRC;
- completed a review of existing and presently-collected information for the Mekong;
- identified gaps and opportunities with respect to the Guiding Framework; and
- proposed improvements to address key gaps.

Basin-Scale Hydropower Planning and Management Information Needs

There are many types of information "needs", including basin development, institutional, scientific, and those of other stakeholders. These have been explored by the ISH11 team, focussing on information that is most appropriately collected in a consistent and coordinated manner by the Member Countries and centralised and shared amongst them through the MRCS information management systems. The study focus is not on project-specific information needs that would be pertinent to a development site, but rather on the **whole-of-river and long-term information** that can complement hydropower project- and site-specific information. This whole-of-river information provides contextual and big picture information to supplement and help interpret project- and site-specific information, allows evaluation of transboundary considerations, and enables comparisons and trend evaluation throughout the Mekong mainstream.

Some examples of basin-scale management questions arising in relation to the Mekong mainstream hydropower developments relate to:

- socio-economic implications of mainstream developments;
- the significance of incremental flow changes due to run-of-river operations;
- the biodiversity-richness of the Mekong River, and changes that might follow hydropower developments;
- implications of hydropower developments for capture fisheries; and
- changes and consequences arising from trapping of sediments and nutrients by dams.

Status and Gaps against the Guiding Framework

The ISH11 study team developed a 'Guiding Framework for MRC Basin-Scale Information for Hydropower Planning and Management' to help structure a status and gap analysis and target improvement proposals. The Guiding Framework has five main components: Locations, Parameters, Timing, Information Management and Information Use. Within each component, key criteria have been succinctly defined.

The team has identified the status, gaps and opportunities for improvement against the Guiding Framework on a discipline-by-discipline basis. Within and across these disciplines, the gaps range in priority from **significant gaps requiring immediate action** to those that should be addressed in the longer-term to provide a more complete and better quality information management system. The following provides a summary of findings, ordered to first draw attention to those issues considered of highest priority for immediate action. Those proposals given highest priority address information needs essential for the appropriate design and implementation of hydropower projects, and which will in the long-term contribute to reduced impacts and costs associated with mitigation measures.

Hydropower Project Information: The MRC ISH has a database of hydropower projects in the LMB. At present this is not up-to-date, and so does not provide an accurate reflection of the development status nor enable any analysis of trends. A **comprehensive update of the hydropower project database** is required, and is considered an immediate need for action so that inflow modelling and operations planning of any hydropower project is based on accurate information about existing developments. Ideally systems would be set up for sustainability in data collection and maintenance, and content would be broadened to cover dams.

Fisheries: The MRC FP provides a centralised approach to fisheries monitoring and information sharing. Whilst several current gaps and opportunities for improvement are recognised by FP and built into their workplan, from a hydropower information perspective the most critical of these is the absence of **standardised fish sampling methods**. FP is addressing this need, given the importance of this resource in the region this gap needs to be addressed immediately, as conclusions relating to hydropower developments cannot be confidently stated at present and decisions need to be made on mitigation measures. All standard methods should be supported by SOPs and WIs to ensure data quality and consistency. Further areas of attention important from a hydropower-information perspective relate to timing; systems need to be improved to enable faster processing and reporting so that fisheries information is available to fully support hydropower information needs. Standard habitat assessment and fish biological analysis methods would be beneficial to add once standard fish sampling is developed, to increase the level of understanding of fisheries status, trends and influences.

Sediments: The MRC IKMP manages Mekong River sediment monitoring through the Discharge and Sediment Monitoring Programme (DSMP), which goes a long way towards addressing hydropower-information needs but with some significant gaps. The most critical gaps to address regarding sediment monitoring relate to: (1) the **timeliness and continuity of the sediment data collection** and availability of results, as presently the systems in place are leading to gaps in the sediment record at

critical times of sediment movement in the river and there is a long lag period between sediment sampling and data availability; and (2) comprehensive **bedload data and grain size analyses** of bedload and suspended sediment to support analysis of what will be retained in versus be transported past hydropower impoundments. Other gaps against the Guiding Framework relate to some monitoring locations and parameters, and shortfalls in the ability to generate and use indicators relevant to hydropower information needs that are derived from the sediment data.

Water Quality: The MRC EP's Water Quality Monitoring Network (WQMN) provides water quality information relevant to human and ecological health through monthly monitoring of the mainstream and some tributaries. This monitoring successfully documents large-scale water quality trends in the LMB, but there are gaps from a hydropower-information perspective relating most critically to the **lack of integration of sediment and water quality monitoring, and the absence of some parameters relevant to hydropower.** These gaps could be addressed by supplementing the existing WQMN with the collection and analysis of additional water samples concurrently with the DSMP sampling, and the addition of relevant water clarity, nutrient and organic carbon parameters. Integration of the water quality and sediment monitoring would also help increase the frequency of water quality sampling to make it more meaningful for hydropower information needs. Filling location and parameter gaps for better hydropower information, and work on indicators and analytical methods relevant to hydropower would also be necessary from a hydropower information perspective.

Socio-Economics: Many of the hydropower-relevant information needs are currently being addressed through the establishment of a socio-economic database for MRC, led by BDP, which will centralise socio-economic information collected by the Member Countries and promote sharing and accessibility. The MRC EP coordinates a field-based socio-economic data collection programme, SIMVA, which is responsive to the specific information needs for hydropower and other sectors, and has been continuously improving the methodology for the survey. Some parameter gaps identified by the ISH11 study relate to **macroeconomic and energy statistics indicators, and cultural values**. ISH11 has also identified an opportunity to increase SIMVA's relevance for hydropower by targeting communities at the 33 ISH11 priority monitoring locations for the qualitative study of the 2014 SIMVA.

Aquatic Ecology: The MRC EP's Ecological Health Monitoring (EHM) collects aquatic ecology information at twelve Mekong mainstream locations and a number of tributaries on a bi-annual basis, focussing on macroinvertebrates, diatoms and zooplankton. These instream biota are important to the riverine food chain and the ecological processes that support fish communities, and are in turn influenced by changes in flow, sediments, water quality and channel morphology that can arise due to hydropower developments. From a hydropower-information perspective, there are a number of gaps identified against the Guiding Framework that could be addressed over time. Improvement efforts would best be directed to strengthening data through **capacity-building in taxonomic identification and improvement to the biomonitoring database** for information management. Quality assurance mechanisms and quality control in the lab should be initiated. Further improvements from a hydropower perspective relate to locations and timing of sample collection, trialling phytoplankton monitoring because of its fisheries information links, and development of indicators.

Hydrology: The Mekong-HYCOS network managed by the MRC IKMP can be considered "state-of-the-art", but opportunities for improvements remain from a hydropower information perspective. Potential improvements include the **integration of hydrological data with information from other disciplines**, both in the field (e.g. collection of flow, sediment and water quality information at the same time) and through indicators and analytical methods, to get improved information and methods relevant to hydropower. Filling key location gaps would also be of importance if it is determined that hydrologic modelling is unable to accurately determine flows and flow changes associated with hydropower developments. Further opportunities arise with respect to expanding the HYCOS transmission system to include additional parameters.

Across these disciplines, there are gaps identified relating to information management and accessibility by users. Having data available in timely manner and in easily usable and integrated formats would help considerably in addressing hydropower information needs.

Improvement Proposals

The status and gap analysis against the Guiding Framework has enabled identification of opportunities for improvement. The study team has focussed on those it considers would add most value, and has formulated **proposals for action** for the consideration of MRC Programmes and Member Countries.

Nineteen proposals have been identified by the ISH11 team, addressing all of the ISH11 disciplines and all aspects of the Guiding Framework. The proposals are listed below, with colouring reflecting priority levels:

1. Orange colouring is for those considered of highest priority for immediate action;
2. Tan colouring is for emerging needs of second highest priority for action; and
3. White colouring is for longer-term needs.

Hydropower Project Information

- H1: Hydropower Project Database

Socio-Economics

- SE1: Macro-economic and Energy Indicators for Hydropower Information
- SE2: SIMVA Enhancements for Hydropower Information
- SE3: Mekong River Cultural and Religious Sites

Fisheries

- F1: Fisheries Indicators for Hydropower Information
- F2: Fisheries Fish Sampling Standard Methods
- F3: Habitat Assessment Standard Methods
- F4: Biological Analysis Standard Methods

Aquatic Ecology

- AE1: Aquatic Ecology Indicators for Hydropower Information
- AE2: Phytoplankton Monitoring for Hydropower Information
- AE3: Strengthening the Bio-Monitoring Database for Hydropower Information

Sediments, Water Quality & Hydrology

- SWH1: Integrating Sediments, Water Quality and Hydrology for Hydropower Indicators
- SWH2: Water Quality Monitoring Enhancements for Hydropower Information
- SWH3: Sediment Monitoring Enhancements for Hydropower Information
- SWH4: Geomorphic Methods for Hydropower Information

Information Use

- IU1: Improving Accessibility of Datasets for Hydropower Information
- IU2: Facilitating Application of Hydropower-Relevant Indicators
- IU3: Web-based Presentation to Communicate Hydropower-Relevant Information
- IU4: Technical Guidelines on Monitoring in Support of the Preliminary Design Guidance

= highest priority, need for immediate action

= second priority, need for emerging action

Considerations for Decision-Making

The simultaneous implementation of multiple proposals would maximise the benefits, as many are related (e.g. IU1 builds on F1 and AE3; IU2 build on SE1, F1, AE1 and SWH1; IU1 and IU2 could be maximised through IU3). Funding commitments are required for many of the proposals, including decisions on magnitude and timing (e.g. funding small first steps versus full implementation). Responsibilities for the monitoring areas addressed by these programmes are spread amongst BDP, EP, FP, IKMP and ISH. Some proposals are already strongly endorsed by their responsible programmes, whereas others are new ideas for the programmes to consider incorporating into their

work plans. Most of the proposals can play an important role in building capacities alongside the process of decentralising monitoring programme responsibilities.

Dialogue on this Phase 2 Report is intended to lead to commitments to implement actions for improvement. These commitments could be delivered fully through the responsible MRC programmes, with various scenarios available for support to implementation from the MRC ISH (through ISH11 Phase 3) and/or the MRC Council Study.

Recommendations

The ISH11 team recommends that:

1. The MRC Member Countries note the needs for hydropower-relevant information, the Guiding Framework, and the status and gap analysis against this framework.
2. The MRC Member Countries note that there is ongoing and planned work being undertaken by MRC Programmes and the Member Countries towards addressing some of these gaps important to hydropower information needs.
3. The MRCS work with Member Countries to **address the highest priority actions** highlighted in this report **in the immediate term** through the relevant MRC Programmes and the Council Study, and that funding be allocated as a matter of priority to facilitate these activities. These highest priority improvement actions include:
    - Proposal H1 to update the hydropower project database
    - Proposal F2 to finalise and establish standardized fish sampling methods
    - Proposal AE3 to strengthen the bio-monitoring database
    - Proposal SHW3 to enhance sediment monitoring
    - Proposal SWH2 to enhance water quality monitoring
4. Current and planned work be accelerated, and funding made available where needed, to **address the second priority actions** highlighted as **emerging needs** in this report. These activities Include:
    - Proposal SE1 on macroeconomic and energy analysis methods and indicators
    - Proposal F1 to develop fisheries analysis methods and indicators for hydropower
    - Proposal AE1 to develop aquatic ecology analysis methods and indicators for hydropower
    - Proposal SWH1 to develop integrated sediment, water quality and hydrology analysis methods and indicators for hydropower
    - Proposal IU1 to improve the accessibility of hydropower-relevant datasets
    - Proposal IU4 to provide technical guidelines for monitoring to supplement the PDG
5. During the Consultation on this Phase 2 Report, the **preferred approach for implementation** of these proposals be decided.
6. Improvements to address **information management** be prioritised within the MRC, to enable ready access to information for the large number of important studies now and in the future.
7. Remaining ISH11 proposals be acknowledged by the MRCS and NMCs, and embedded in respective MRC Programme work plans.

Next Steps

Following review of this report by MRC Programmes and Member Countries, through MRC, national and regional consultations, the ISH11 team is ready to provide more details on scope, time and cost

for those improvement proposals that may be agreed and supported for advancement during ISH11 Phase 3.

Conclusion

The ISH11 study team intends for this report to provide a pathway that can help **Member Countries obtain a clear and scientifically-sound understanding of conditions, changes and trends in the LMB to inform hydropower planning and management**. Many of the proposed actions also have direct benefits with respect to capacity building, supporting the decentralisation process, and are consistent with the information needs of other studies currently being conducted in the region.

The MRC ISH and the ISH11 team welcome the views and advice of MRC Member Countries and other stakeholders on the needs, gaps and improvement proposals presented in this report, and look forward to a constructive process of ISH11 project Phase 3 and 4 formulation that builds on and enhances the existing work in the LMB.

Enclosed Information and Key Matrices

1 Context of the Phase 2 Report within the Suite of ISH11 Study Reports

Inception Report. *Jan 2013.*

Major Report. Mixture of technical content (for preliminary discussion with Member Countries) and non-technical (study logistics to be agreed by ISH). Confirmation of understanding of ToR, initial review of existing monitoring and data availability, preliminary findings and ideas. The **purpose** of the Inception Report is **to ensure all stakeholders are clear on the scope and timing of the study**.

Phase 1 Report. *Mar 2013.*

Major Report. Main Report plus 7 separate discipline-specific Annexes (Socio-Economics; Fisheries; Aquatic Ecology; Sediments & Geomorphology; Water Quality; Hydrology; Data Management). The Main Report provides study overview information, relationships to other key MRC Programme initiatives, a proposed long-term monitoring framework for basin-scale information for hydropower planning and management, and summary information about the improvement proposals. Each Annex provides an outline of best practice monitoring, Mekong information sources (past and present), a brief overview of the state of knowledge, evaluation of hydropower information needs, forward MRCS monitoring programmes, and initial ideas on improvement proposals for consideration. The **purpose** of the Phase 1 Report is **to stimulate and inform discussions during Phase 2** to help clarify background information, prioritise and refine improvement proposals, and detail resource requirements for trial implementation of selected improvement proposals in Phase 3.

Discussion Points. *Aug 2013.*

Minor Report. Non-technical. Power point slides and hand-outs covering study objective and scope, basin scale information needs for hydropower planning and management, guiding framework and gap analysis of present monitoring, ISH11 Phase 3 design and implementation approach, and further Phase 2 timetable. The **purpose** of the Discussion Points is to assist discussions within Member Countries relating to the ISH11 study, so feedback can inform the Phase 2 Report.

Phase 2 Report. ***Nov 2013. (accompanying this Extract)***

Volume 1: Main Report plus Volume 2: Six discipline-specific Annexes (Socio-Economics; Fisheries; Aquatic Ecology; Sediment & Geomorphology; Water Quality; Hydrology). The **Main Report** contains information on hydropower information needs; a guiding framework for basin-scale monitoring information; present status, gaps and opportunities for improvement; and specific improvement proposals for ISH11 Phase 3 activities. The **Annexes** provide an update of the Phase 1 Report Annexes to include further information accessed, a more complete summary of information sources, discipline-specific comments and responses, and accompanying information to explain the context for the improvement proposals for Phase 3 activities. **The purpose of the Phase 2 report is to get agreement on the recommended ISH11 improvement proposals.**

NOTE: Approach to the following Phases 3 and 4 to be determined during the National and Regional Consultations on the above Reports. The following ideas on the Phase 3 and Phase 4 deliverables may be revised based on outcomes of these consultations.

Phase 3 Progress Report. *(target date – month 7 of the 12-month ISH11 Phase 3).*

Minor Report. One document with attachments as needed. Describes progress against the work plan outlined in the Phase 2 Report. May include examples of results, or proposed methods of analysis, reporting and outputs. The **purpose** of the Phase 3 Progress Report is to provide information for noting to Member Countries and MRC Programmes on the progress to date.

Phase 3 Report. *(target date – 3 months after end of ISH11 Phase 3, to allow all data to be processed)*.

Major Report. Main Report plus 5 separate discipline-specific Annexes (tentatively would be Economics; Social; Fisheries; Aquatic Ecology; Sediments, Water Quality & Hydrology). The Main Report describes the activities undertaken in Phase 3, presents integrated findings and data management information not specific to a discipline, and shows progress with respect to the guiding framework and gap analysis presented in the Phase 2 Report. The Annexes describe activities undertaken during the ISH11 Phase 3, and present information in forms suitable for hydropower information needs for planning and ongoing management. The **purpose** of the Phase 3 Report is to provide a complete summary of the Phase 3 activities, to evaluate their achievements against their objectives, and to reconsider the status of the gap analysis against the Guiding Framework.

Phase 4 Report. *(target date – 3 months after start of ISH11 Phase 3).*

Major Report. Non-Technical. Contains long-term recommendations based on a guiding framework for basin-scale hydropower information needs, with full costs and resource requirements elaborated. More detailed structure to be discussed with Member Countries during Phase 3. The **purpose** of the Phase 4 Report is to present long term recommendations.

Completion Report. *(target date – 5 months after start of Phase 4).*

Minor Report. Non-Technical. Essentially a project management document referenced against the study's Terms of Reference, and clarifying what was done and what was delivered through the project. The **purpose** of the Completion Report is to provide a complete summary of the undertakings of the ISH11 study so that those following this study can have a ready reference, to verify that all data and resources collected are catalogued and archived on MRC systems for future use, and to enable commercial close out of ISH11.

2 Guiding Framework for Basin-Scale Information for Hydropower Planning and Management

1. **Locations of Data Collection:**
   a) Cover all Mekong River hydro ecological zones
   b) Near proposed or operational hydropower project or group of projects
   c) Enable understanding of mainstream processes
   d) Facilitate understanding of changes occurring across national boundaries

2. **Parameters Monitored:**
   a) Provide inputs to indicators related to hydropower planning and management
   b) Able to be replicated across the basin
   c) Able to be measured and analysed at a low cost
   d) Able to help predict as well as explain cause and effect of changes

3. **Timing of Data Collection:**
   a) Length of record covers the cycles of natural variability (seasonal, annual, decadal)
   b) Frequency captures natural or operational system changes and migratory cycles

4. **Information Management**
   a) Quality management systems are in place to ensure consistency across countries
   b) Systems allow information to be centrally archived and shared

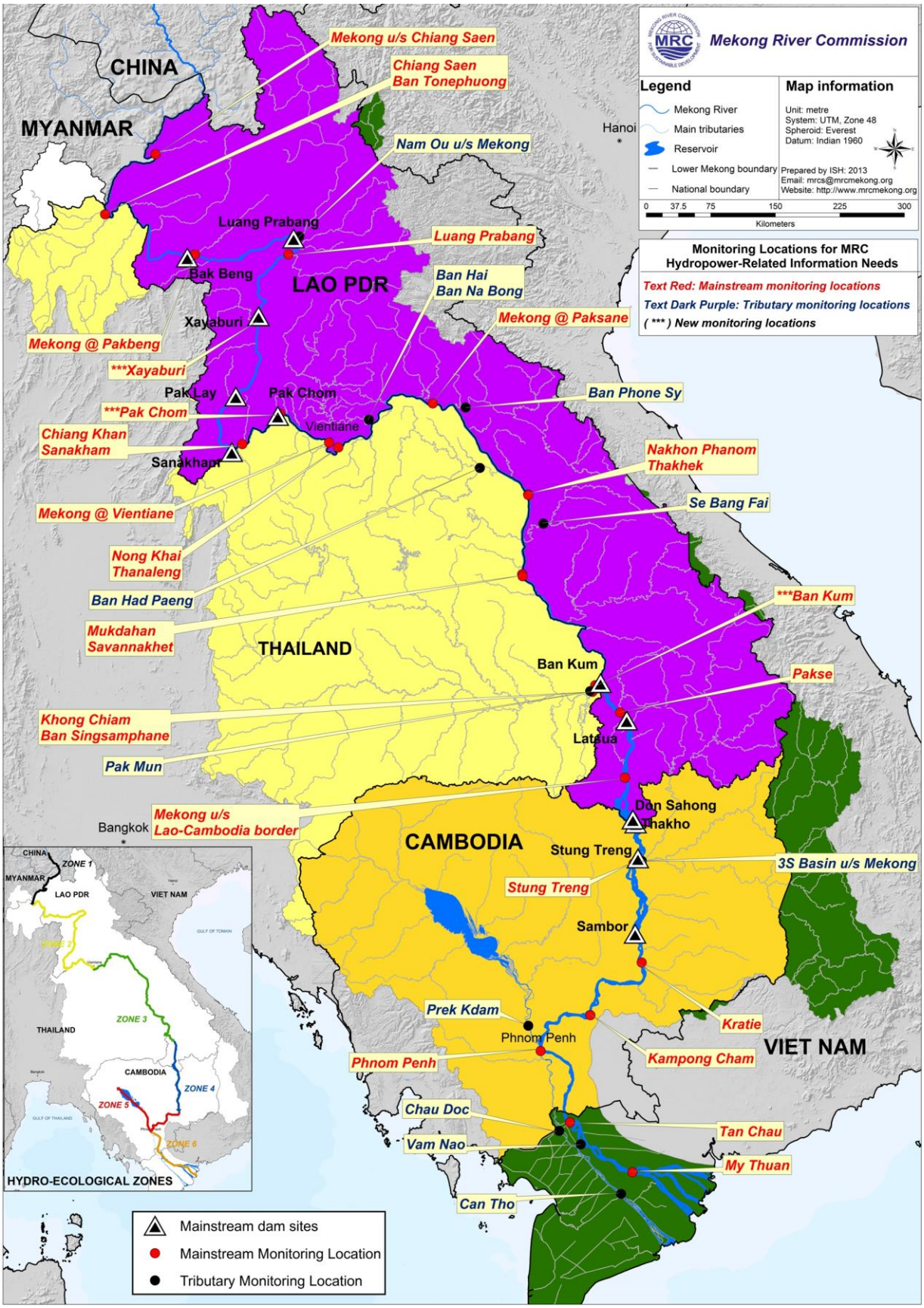
5. **Information Use**
   a) Information is readily available for users (e.g. Member Countries, developers, NMCs, Line Agencies)
   b) Links to tools are available for decision-support and analysis

Box 3.1 – Guiding Framework for Basin-Scale Information for Hydropower Planning and Management[1]

[1] Box 3.1 is extracted from ISH11 External Draft 1.0 Phase 2 Main Report Section 2.7

3 Monitoring Locations for MRC Hydropower-Relevant Information Needs

Figure 4.1 – Monitoring Locations for MRC Hydropower-Relevant Information Needs[2]



[2] Figure 4.1 is extracted from ISH11 External Draft 1.0 Phase 2 Main Report Section 2.2.2

4 Parameters for Hydropower Information Needs[3]

Table 5.1 – Parameter Needs for MRC Hydropower Project Information

MRC-Centralised Parameter Groups	Hydropower Relevance	Example Basin-Scale Indicators
General Data location and Characteristics: commissioning year, condition, status, owner, purpose, lay-out, dam type, specifications, spillway features, outlets, fishpass, re-regulation storage	➢ Planners must consider different geographic and development options ➢ Costs, Risks and Economics must be assessed. ➢ Electrical system planning	✓ rate of development, ✓ Capital requirements ✓ Storage volume basin wide
Hydropower Operations: rated head, plant design discharge, installed capacity, peaking capacity, mean annual energy, firm annual energy, full supply level (FSL), low supply level, live storage, reservoir area at FSL, tailrace flow	➢ Assess multi-purpose opportunities ➢ Operational of cascades can be planned ➢ Flood management rules assessed	✓ Degree of regulation in sub-basins ✓ installed capacity peak, off-peak ✓ mean & firm annual energy, ✓ Reserve capacity
Project-related Hydrology: catchment area, production hydrology, project design flood, sediment load	➢ Hydrological parameters serving for hydropower design and production assessment and operation	✓ mean inflow, ✓ flood/spill frequency ✓ Energy in storage ✓ sedimentation
Construction, Resettlement, Migration: construction period, construction cost, reference year for budget, reference project budget, grid expansion, destination country for power, number of people resettled	➢ Understand commissioning date ➢ Assess costs and viability ➢ RAP design and risk assessment ➢ Planning at high level	✓ Construction cost, ✓ mitigation cost, ✓ number people resettled

[3] Tables 5.1 – 5.7 are extracted from ISH11 External Draft 1.0 Phase 2 Main Report Section 2.3.2

Table 5.2 – Parameter Needs for MRC Hydropower-Relevant Socio-Economic Information

MRC-Centralised Parameter Groups	Hydropower Relevance	Example Basin-Scale Indicators
Population and Demographics: population, dependency ratio, household size, number and % of ethnic minorities	➢ Test for vulnerability hydro development pressures, ➢ isolate gender/minority issues ➢ Develop of RAP ➢ Measure increased in/out-migration within or across countries	✓ Rural Population density movements ✓ Number vulnerable social groups
Income / Employment / Poverty : gross domestic product (GDP), power purchasing parity exchange rate (PPP)	➢ Monitor success of RAP ➢ Monitor for benefits of HP improvements at local and/or national scale	✓ GDP/capita, ✓ Unemployment (%) ✓ Rate of rural poverty
Health: occurrence HIV/AIDS, liver fluke, malaria; household average distance and travel time to health facilities; Nos and % of HHs with clean drinking water or access to sanitation; malnutrition rate; No. employed in health sector, $ in PPP	➢ Hydropower development is expected to improve health and education, at local and/or national scale.	✓ Life expectancy at birth ✓ Disease occurrence, access to health care, clean water, sanitation ✓ Human development index ✓ Millennium development goals
Education: Education achievement, literacy rate, No. employed in education sector, $ in PPP		✓ Access to education ✓ Education achievement level
Culture and Religion: Number and locations of sites, funding for sites, number of cultural events	➢ Hydropower projects may endanger cultural and religious sites and disrupt local cultures	✓ Retention/maintenance of established religious and cultural sites of importance
Macro-economics: sectoral accounts, National accounts, CPI or PPI, traded vs non-tradable, exports, imports, balance of trade (BoT), factor income, cash accounts, foreign direct investment (FDI), other portfolio/ investment	Monitor the benefits/impacts of HP to the macro economy: ➢ assist economic growth, ➢ decrease inequality of income distribution ➢ increase foreign direct Investment, industrialization, Forex income ➢ lead to Exchange Rate Appreciation	✓ GDP ✓ Export and import of power ✓ GINI coefficient of income distribution ✓ Public debt ✓ Real exchange rate

Table 5.3 – Parameter Needs for MRC Hydropower-Relevant Fisheries Information

MRC-Centralised Parameter Groups, Parameters	Hydropower Relevance	Example Basin-Scale Indicators
Participation in fisheries and fishing effort: Number of fishers full-time, part-time, occasional, fishing effort by fisher, time and gear type.	Participation in fisheries changes under hydropower development, which requires planning, management and mitigation.	✓ Current status and changes in fish stocks and species diversity ✓ Total biomass that may need to be passed through dams at locations and change over time ✓ Reliance of the river communities on the fish resource ✓ Reservoir fisheries as proportion of total consumption ✓ Aquaculture as proportion of total
Abundance and diversity of fish in catches or samples: CPUE (numbers and biomass) by species can be used directly and to generate various indicators.	Fisheries are affected in many ways by hydropower development, which should be planned and managed and mitigate impacts.	
Habitat: River width, depth, current speed, substrata, in-stream and riparian vegetation.	Hydropower development will change habitats, leading to a range of flow-on effects which require management and mitigation.	
Biological characteristics of fish: Fish health, diet, reproduction, condition, and value as food.	Fish biology may change as a result of hydropower development; monitoring allows adjustments to mitigate and manage impacts.	
Aquaculture and Reservoir Fisheries: Species, production quantity and value, inputs and costs, profitability.	Aquaculture may be favoured in reservoirs and downstream of HP plants if flows are stabilized.	

Table 5.4 – Parameter Needs for MRC Hydropower-Relevant Aquatic Ecology Information

MRC-Centralised Parameter Groups, Parameters	Hydropower Relevance	Example Basin-Scale Indicators
Benthic and littoral macroinvertebrates: abundance and diversity per sample and per sampling site	➢ Support understanding of effects of hydropower relating to impoundment, hydro-peaking and channel dewatering. ➢ Can be closely linked to key fisheries and sediment parameters.	✓ Changes in biological health of the river concerned at a location over time ✓ Changes in biodiversity at locations over time and longitudinal along Mekong mainstream
Plankton	➢ Important component of fish diet in the Mekong River ➢ Particularly relevant for impoundments / reservoirs with low flow velocities and high transparency	

Table 5.5 – Parameter Needs for MRC Hydropower-Relevant Sediments Information

MRC-Centralised Parameter Groups	Hydropower Relevance	Example Basin-Scale Indicators
Sediment characteristics: suspended and bedload concentrations and fluxes, seasonality, grain-size distribution, organic content, mineralogy, lithology	➢ Influx of sediments to impoundments is critical for siting and design of hydro schemes ➢ Need to understand sediment and geomorphic processes to design appropriate mitigation measures ➢ Changes to sediment fluxes downstream of power stations can affect geomorphological and ecological processes and have social impacts ➢ Separating changes due to hydropower from the effects of other basin developments/actions at transboundary locations.	✓ Changes in sediment Flux and size grading at locations over time ✓ Changes in river morphology, habitat ✓ Coastal erosion rates
Geomorphic characteristics and habitat quantity & quality: channel cross-sections, channel characteristics (depth, roughness, hydraulic radius, etc) longitudinal channel profiles, planform features (e.g.width, number of channels, sinuosity, braiding), composition of channel (bedrock controlled, alluvial, combination, presence of woody debris)		
Geomorphic rates: rate of channel migration, rates of channel infilling or incision, bank stability		
River dynamics: coefficient in variability of depth, heterogeneity of current velocities floodplain connectivity, Tonle Sap reversal		
Tidal sediment dynamics: rates of change and locations for transport, deposition, erosion		

Table 5.6 – Parameter Needs for MRC Hydropower-Relevant Water Quality Information

MRC-Centralised Parameter Groups	Hydropower Relevance	Example Basin-Scale Indicators
Suspended sediment characteristics: size and composition of material	➢ Water quality can affect hydropower infrastructure ➢ Need to understand influent water quality to predict and manage potential changes during storage, and to assess whether inflowing water is changing over time ➢ Need to understand changes to water quality during storage so can differentiate between hydropower development impacts and other impacts (such as aquaculture or land run-off) ➢ Need to understand any downstream impact on water quality due to hydropower operations, and to distinguish between hydropower impacts and other land use impacts	✓ Water quality standards for human health, drinking water, water for aquatic ecosystems, water for domestic uses, water for agricultural and industrial uses ✓ Aquatic biota indicators
Physico-chemical water quality characteristics: temperature, pH, electrical conductivity, acidity, clarity, alkalinity, dissolved oxygen in surface and sub-surface water		
Metals: total and dissolved iron, manganese, zinc, mercury, arsenic		
Nutrients & carbon: concentration, speciation, seasonal variability, changes during storage		

Table 5.7 – Parameter Needs for MRC Hydropower-Relevant Hydrology Information

MRC-Centralised Parameter Groups	Hydropower Relevance	Example Basin-Scale Indicators
Rainfall: hourly, daily, monthly annual total, intensity, seasonality	➢ Required for the siting, design and optimising generation from hydro power developments; ➢ Planning of hydropower operations to manage alterations to d/s flow and the effect on ecological processes and to minimise social impacts; ➢ Maintaining flows on mainstream (per PMFM).	✓ Changes in hourly, daily and seasonal river flows ✓ Tidal variation and sea level change ✓ Groundwater levels
River Flow: Magnitude, duration, seasonality, rate of change, minimum, maximum		
Groundwater: Level		
Tidal dynamics: flow direction, flow magnitude, inland extent		

5 MRC Currently-Held Information Relevant to Hydropower Needs[4]

Table 6.1 – MRC Currently-Held Information on Hydropower Projects

MRC-Held Historical Information	*Not applicable*
MRC Monitoring Programme Name	Hydropower Dams Database, managed by ISH.
Locations	Currently holds over 100 hydropower projects throughout the LMB.
Timing/Frequency	Compiled in 2009 by BDP, occasional updates by ISH.
Parameters	Dam Characteristics; Hydropower Operations; Project-Specific Hydrology; Construction, Resettlement, and Mitigation.
Analyses	For use as input to other efforts including BDP Scenarios and Basin Atlas, and for ISH projects and studies including guidelines on multi-purpose evaluation, ecologically sensitive areas, etc.
Information Management	Managed by ISH.
Information End-Uses	MRC Technical Papers.

[4] Tables 6.1 – 6.7 are extracted from ISH11 External Draft 1.0 Phase 2 Main Report Sections 3.2 – 3.8

Table 6.2 – MRC Currently-Held Socio-Economics Information

MRC-Held Historical Information	Earliest is the Social Atlas of the LMB (2003), containing data collected in 1998 for Cambodia, 1995 for Lao PDR, 2000 for Thailand, and 1999 for Viet Nam. Differing definitions and methodologies were used, making it difficult to compare indicators across the four countries. Latest are national census data being provided for the BDP socio-economics database.
MRC Monitoring Programme Name	Social Impact Monitoring & Vulnerability Assessment (SIMVA), managed by EP. BDP Socio Economic Database 2013 (in progress) sourced from National Statistics agencies and other national sample surveys.
Locations	SIMVA: 2011 survey covered 135 villages and 2,720 households within 15 km on each side of the Lower Mekong River, increasing to 40 km at the floodplains. 2014 SIMVA to increase sample size to ~5,000 households, and reduce included area around flooded areas to 15 km. Other: National census data is country-wide, and sometimes commune or district level.
Timing/Frequency	SIMVA: Pilot survey in 2010, follow up survey in 2011 and next survey planned for 2014. Planned to be recurrent bi-yearly, depending on budget and scope. Other: National census data is collected 5 yearly and other sample surveys more frequent.
Parameters	SIMVA: Quantitative household survey; for 2014 planned qualitative data collection from key informants and focus groups; secondary data collection; GIS mapping of corridor. Other: National census and survey data collection covers a very broad range.
Analyses	SIMVA: 63 indicators covering baseline vulnerability; dependence on fish, OAAs, and irrigation and riverbank cultivation; resilience; shocks and trends; and climate change. 2014 survey planned to apply a sample that is representative of zones and sub-zones, which will enhance analytical power.
Information Management	SIMVA: Collected data are quality checked and entered at the national level. A dedicated specialist in EP manages SIMVA. Consultants carry out the analysis and report. Other: BDP Socio Economic database currently under design and development, working through national statistical officers from the Member Countries.
Information End-Uses	MRC Technical Papers.

Table 6.3 – MRC Currently-Held Fisheries Information

MRC-Held Historical Information	Earliest is 1994, to present, with changes over time. Extensive measurement is done by MCs outside of MRCS records, dating back to 1950s.
MRC Monitoring Programme Name	Fisheries Monitoring, managed by FP.
Locations	39 sites for fisher catch monitoring: 22 MS, 17 tributary. Tonle Sap dai fishery & larvae sampling in Cambodia and Viet Nam.
Timing/Frequency	Daily all year for most fishers. Larvae daily but seasonal. Dais sub-sampled over 6-month period.
Parameters	Catch-per-unit effort as biomass and numbers by species.
Analyses	CPUE, diversity, composition, proportion of various guilds, proportion exotic.
Information Management	Currently in FP managed by one specialist, plan to move to IKMP.
Information End-Uses	MRC Technical Papers; Catch & Culture summaries; Development Series syntheses. Agencies translate for their uses.

Table 6.4 – MRC Currently-Held Aquatic Ecology Information

MRC-Held Historical Information	Scattered data from early studies (1960's to 1980's) as hard copies; data from 2003-Present, with ongoing improvement
MRC Monitoring Programme Name	Ecological Health Monitoring, managed by EP.
Locations	Total: 68 Sites (12 Mekong Mainstream & 56 Tributaries / mainstream junctions); Currently monitored: 12 Mekong Mainstream, 29 Tributaries / mainstream junctions.
Timing/Frequency	Early studies on single biota groups; EHM Pilot study 2003; and method development: 2004-2008. Present EHM monitoring is 2 yearly (2011, 2013).
Parameters	Macroinvertebrates (benthic and littoral); Benthic diatoms, Zooplankton.
Analyses	Taxonomic identification and number of specimen per taxon and sample; 3 indicators per parameter; Ecological Health Class; Environmental variables.
Information Management	Reported to EP by NMCs; 2004 – 2008 results are in the EHM database on the Master Catalogue; 2011 and 2013 results are in excel, to be incorporated in database
Information End-Uses	MRC Technical Reports; Report Card on Ecological Health; State of the Basin Reporting.

Table 6.5 – MRC Currently-Held Sediments Information

MRC-Held Historical Information	Sporadic measurements between 1960-2000 with large gaps and a small number of measurements per year at some sites. DSMP (2009-2013) has provided significant improvements.
MRC Monitoring Programme Name	Discharge Sediment Monitoring Programme (DSMP), managed by IKMP.
Locations	17 Sites (in 2012-13): 13 in Mekong River; 1 in Tonle Sap; 2 in Bassac River; 1 Tributary site
Timing/Frequency	Suspended sediment & bedload: Monthly during dry season; Fortnightly / weekly during the transition and wet season. Bed material: Annually
Parameters	Discharge, Channel cross-section, Suspended sediment, Bedload sediment, Bed materials
Analyses	Total suspended sediments (all); Grain size distribution (8 sites); Bedload (3 sites); Bedload Grain size (3 sites); Bed material grain size analysis (GSA).
Information Management	Reported to IKMP; QA/QC – IKMP; Results to be available on Master Catalogue.
Information End-Uses	QA/QC being completed on 2009- 2012 results which will be available on Master Catalogue; Preliminary analysis of results used to derive sediment budgets for 2011.

Table 6.6 – MRC Currently-Held Water Quality Information

MRC-Held Historical Information	1985-present, with various improvements and changes to parameters during this period.
MRC Monitoring Programme Name	Water Quality Monitoring Network (WQMN), managed by EP.
Locations	22 Mainstream & 26 Tributary/Tonle Sap/Bassac/Canal sites (in 2012).
Timing/Frequency	Monthly surface grab samples.
Parameters	Physico chemical, Ecosystem, Human health & Agriculture indicators.
Analyses	pH, EC, DO, T, TSS, Ca, Mg, Na, K, Alkalinity, Cl, SO_4, TN, TP NO_{2+3},NH_4, COD, FC
Information Management	Reported to EP; QA/QC- EP; WQ database on Master Catalogue
Information End-Uses	Annual Report; Bi-annual WQ Report Card; State of Basin Reporting, Diagnostic water quality studies.

Table 6.7 – MRC Currently-Held Hydrology Information

MRC-Held Historical Information	HYCOS data from 2000-present. Earlier records started in 1900 with discontinuous measurements since that time.
MRC Monitoring Programme Name	HYCOS supplemented by DSMP data, managed by IKMP.
Locations	HYCOS: 49 sites on mainstream and tributaries (17 included in DSMP).
Timing/Frequency	HYCOS: continuous recording; Discharge measurements as per DSMP monitoring schedule.
Parameters	River level, Rainfall, Temperature, River discharge.
Analyses	River discharge; Rating curves; Flow duration Annual/seasonal minimum/maximum Timing of wet/dry seasons Rainfall totals/ distribution /intensity
Information Management	Reported to IKMP; QA/QC – IKMP; Data storage - Master Catalogue; Real time results on MRC website.
Information End-Uses	Flood forecasting, Modelling, Hydrologic analysis, Hydrologic Year Book.

6 Present State of Environmental Monitoring at Hydropower-Relevant Monitoring Locations *(2 pages)*[5]

	Location Name	River Name	River km u/s Mekong mouth or Mekong confluence	National Location *(Lead country in blue font)*	Existing / Proposed New	Fisheries Data	Aquatic Ecology Data	Sediments Data	Water Quality Data	Hydrological Data	Hydro-Ecological Zone	Comments about Location from Phase 1 Report
1	Mekong u/s Chiang Saen	Mekong	To be determined	Myanmar-**Lao PDR**	Existing	Not currently monitored	LMX, Ban Xiengkok Luangnamtha; 2005,2008,2011,2013	Not currently included in DSMP	W (WQMN) at Houa Khong	H (HYCOS) 2 in China. Xieng Kok	1	IKMP is interested to have a site upstream of Chiang Saen for transboundary purposes, and suggests at the new Lao-Myanmar Friendship Bridge. There is an existing biodiversity site at the Nam Ma confluence. It could be anywhere upstream Chiang Saen but propose in river reach shared between Lao PDR and Myanmar
2	Mekong @ Chiang Saen / Ban Tonephuong	Mekong	2364.1	**Thailand**-Lao PDR	Existing	Fisher catch monitoring, LARREC, Houai Tab Site is ~50 km downstream	TCS, Chiang Saen; site is downstream of WQ/Sed site; 2008,2011,2013	S (DSMP)	W (WQMN)	H (HYCOS)	2	upper end Pak Beng HPP reservoir, long-term monitoring site
3	Mekong @ Pakbeng	Mekong	2181.0	Lao PDR	Existing	Catch monitoring, LARREC at Pak Ngeuy, a few km downstream	Not currently included in EHM	Not currently included in DSMP	Not currently included in WQMN	H (Lao PDR site - need info); no data on Master Catalogue (MC)	2	It is possible to include an existing hydrological site downstream of the Pakbeng HPP dam as one of the priority monitoring locations; however there may be sufficient coverage without this
4	Mekong @ Luang Prabang	Mekong	2010.2	Lao PDR	Existing	Catch monitoring, LARREC	LPB, Mekong at Done Chor, Luang Prabang; 2008, 2011, 2013; LPB above Luang Prabang, upstream of Pak Nam Karn, 2004, 2005 (site shifted between years?)	S (DSMP)	W (WQMN)	H (HYCOS)	2	downstream Luang Prabang HPP, upstream Nam Ou tributary and Xayaburi HPP reservoir, long-term existing site
5	Nam Ou u/s Mekong	Nam Ou	To be determined	Lao PDR	Existing	Catch monitoring, LARREC	LNO, Nam Ou about 5 km from river mouth, 2004; LOU, Nam Ou between Ban Pak Ou and Ban Hat Mat,2005	Not currently included in DSMP	W (WQMN) at Ban Hatkham	H (Lao PDR site - need info); no data on MC	2	There are two options with existing sites: Ban Hatkham located downstream of the proposed Nam Ou 1 HPP but possibly subject to backwater effects, or Ban Fay upstream of Nam Ou 1 HPP. Note Nam Ou 1 HPP may not be constructed for 5+ years
6	Mekong @ Xayaburi	Mekong	1904.0	Lao PDR	New	Catch monitoring, LARREC, at Thadeua, about 30 km upstream	Not currently included in EHM	Not currently included in DSMP	Not currently included in WQMN	Monitored upstream by Lao PDR at Ban Pakkhone	2	Important hydropower location. Downstream Xayaburi HPP, upper end Paksay HPP reservoir. Would provide an approximately halfway point between the existing sites of Laungprabang and Chiang Khan. Note that Ban Pakkhone (MRC site 011304) is nearby
7	Mekong @ Chiang Khan / Sanakhan	Mekong	1715.3	**Thailand**-Lao PDR	Existing	Catch monitoring, Thai DOF, Ban Noy site	Not currently included in EHM	S (DSMP)	Not currently included in WQMN	H (HYCOS)	2	Downstream Sanakham HPP, upper end of Pak Chom HPP reservoir. Note that Chiang Khan (011903) and Sanakhan (170109) are in this location but not the same site. It may be possible to drop this site in the future in favour of Pak Chom, as downstream of full cascade is the best long-term location.
8	Mekong @ Pak Chom	Mekong	1655.0	***Lao PDR*** *- Thailand?*	New	Not currently monitored	Not currently included in EHM	Not currently included in DSMP	Not currently included in WQMN	Not currently included in HYCOS	2	Downstream Pak Chom HPP. Important hydropower location because it would be bottom end of cascade. There are a number of tributaries between this location and the Vientiane site so this station would provide increased understanding of cause-effects relating to hydropower
9	Mekong @ Vientiane	Mekong	1580.1	**Lao PDR**-Thailand	Existing	Catch monitoring, LARREC, Tha Mouang Site	LVT, Upstream of Vientiane, 2004,2007; LVT Ban Huayhome 2008,2011,2013	DSMP monitoring at Nong Khai satisfies this	W (WQMN)	H (HYCOS)	3	Vientiane is a HYCOS and WQ site, but not a sediment site. It is close to Nong Khai and so both do not need to be monitored. Nong Khai is preferred as it has the benefit of more existing parameters
10	Mekong @ Nong Khai / Thanaleng	Mekong	1549.3	**Thailand**-Lao PDR	Existing	Catch monitoring, Thai DOF	Not currently included in EHM	S (DSMP)	Not currently included in WQMN; Vientiane satisfies this	H (HYCOS)	3	
11	Nam Ngum @ Ban Hai/Ban Na Bong	Nam Ngum	~7	Lao PDR	Existing	Not currently monitored	No site at confluence with Mekong; site upstream at confluence with Nam Lik	Not currently included in DSMP	W (WQMN)	H (Lao PDR site at Ban Pak Ngum need info) no data on MC	3	As outlet of Nam Ngum river basin, MRC monitors WQ here. Ban Na Bong is an existing hydrological station belong to Lao PDR
12	Mekong @ Paksane	Mekong	1394.0	**Lao PDR**-Thailand	Existing	Catch monitoring, LARREC	Not currently monitored	Not currently included in DSMP	Not currently included in WQMN	Not currently included in HYCOS		Of interest to CCAI, IKMP, FMMP and ISH, as it would provide important information about water and sediment inflow from 'left-bank' tributaries
13	Nam Kading @ Ban Phone Sy	Nam Kading	25.0	Lao PDR	Existing	Not currently monitored	Not currently monitored	Not currently included in DSMP	Not currently included in WQMN	H (Lao PDR site - need info); historic data on MC	3	There is an existing hydrological station belonging to Lao PDR, downstream Nam Theun 1 HPP
14	Nam Songkhram @ Ban Had Paeng	Nam Songkhram	36.0	Thailand	Existing	Catch monitoring, Thai DOF	TSK, Nam Songkhram, about 8 km from river mouth 2004,2007; TSM Mekong junction 2008,2011,2013 (no mainstream site, Nam Songkhram sampled)	Not currently included in DSMP	W (WQMN) (d/stream)	H (HYCOS)	3	Ban Had Paeng is existing HYCOS site; downstream there are B,F,W monitoring listed as Ban Chai Buri
15	Mekong @ Nakhon Phanom / Thakhek	Mekong	1220.8	**Thailand**-Lao PDR	Existing	Catch monitoring, Thai DOF	TNP, Nakron Phanom (spelling?) 2008,2011,2013	S (DSMP)	W (WQMN)	H (HYCOS)	3	The site shows incremental increase from 'left-bank' tributaries relative to Paksane
16	Se Bangfai u/s Mekong	Se Bangfai	To be determined	Lao PDR	Existing	Not currently monitored	LBF, Sebang Fai (exact location Khammouan?, not same loc. in all years) , 2007,2008,2011,2013	Not currently included in DSMP	W (WQMN)	H (HYCOS)	3	Large tributary
17	Mekong @ Mukdahan / Savannakhet	Mekong	1127.0	**Thailand**-Lao PDR	Existing	Catch monitoring, Thai DOF at Lad Charoen	Not currently included in EHM	S (DSMP)	W (WQMN)	H (HYCOS)	3	upper end Ban Kum HPP reservoir

[5] This matrix is extracted from ISH11 External Draft 1.0 Phase 2 Main Report Section 3.9

Present State of Environmental Monitoring at Hydropower-Relevant Monitoring Locations *(page 2 of 2)*

	Location Name	River Name	River km u/s Mekong mouth or Mekong confluence	National Location *(Lead country in blue font)*	Existing / Proposed New	Fisheries Data	Aquatic Ecology Data	Sediments Data	Water Quality Data	Hydrological Data	Hydro-Ecological Zone	Comments about Location from Phase 1 Report
18	Mekong @ Ban Kum	Mekong	924.0	***Thailand*** *- Lao PDR?*	New	Not currently monitored	Not currently included in EHM	Not currently included in DSMP	Not currently included in WQMN	Not currently included in HYCOS	3	Important hydropower and transboundary location. Downstream Ban Kum HPP. Important transboundary site in shared Lao-Thai river reach upstream Pak Mun tributary which is also controlled by hydropower-regulated flows. Importance increases if locations downstream Pak Mun are to be inundated by Latsua reservoir
19	Pak Mun u/s Mekong	Pak Mun	To be determined	Thailand	Existing	Not currently monitored	TMU, Kong Chiam, Mun River, 2008,2011,2013	Not currently included in DSMP	W (WQMN)	H (Thai site need info); historic data on MC	3	Important tributary location. Downstream Pak Mun HPP. Would assist distinction of cause-effect with respect to Ban Kum HPP and Pak Mun HPP.
20	Mekong @ Khong Chiam / Ban Singsamphane	Mekong	909.3	**Thailand**- Lao PDR	Existing	Not needed; Pakse site (LARREC) is adequate for this, also Lad Charoen site upstream by Thai DOF	TKC, Kong Chiam at Mun Mekong junction, 2008,2011,2013	S (DSMP)	W (WQMN)	H (HYCOS)	3	Downstream Pak Mun tributary, important transboundary site. Long-term need for this site could be revisited as details of potential HPP developments are better understood. Need to check if this would be inundated by the Latsua reservoir.
21	Mekong @ Pakse	Mekong	866.6	Lao PDR	Existing	Gill net fishers at Ban Hat, LARREC	Not currently included in EHM	S (DSMP)	W (WQMN)	H (HYCOS)	4	upper end Latsua HPP reservoir. Need to check if this location will be inundated by the Latsua reservoir. If to be inundated some or all of the time, the Mekong @ Khong Chiam location woud be important to retain.
22	Mekong u/s Lao-Cambodia border	Mekong	To be determined	Lao PDR	Existing	Ban Hat, gill net fishers and Khone Falls lee traps, LARREC, Tha Khon, Ou Run, downstream of border, IFREDI	LDN, Ban Muang Pathumphone (Done Ngiew or Dom Noi, diff. spelling), downstream Pakse, 2007, 2008, 2011,2013	Not currently included in DSMP	Not currently included in WQMN	Not currently monitored on mainstream	4	Important transboundary and hydropower location. Downstream Latsua HPP. Also need to consider Don Sahong HPP. A possible location is one of the existing country sites: Ban Mouang (H,S), Ban Chan Noi (H), Ban Hat Sai Khoune (H), Veunkham (H)
23	3S Basin u/s Mekong	Se Kong or Se San-Sre Pok	To be determined	Cambodia	Existing	3 sites fisher catch monitoring, IFREDI	some sites in 3S basin; CKM at Kbal Koh village, Se Kong River (=river mouth), 2005,2006,2007,2008,2011, 2013	S (DSMP) since 2012	Sites in upper catchment but not in lower catchment	H (HYCOS) on each river upstream from confluence	4	A possible location is one of the existing country sites: 3S (W), Chantangoy (H), Ban Kam Phun (H)
24	Mekong @ Stung Treng	Mekong	683.0	Cambodia	Existing	Koh Kne catch monitoring, IFREDI	CMR, Ramsar Site at Stung Treng (upstream 3S), 2005,2006,2007,2008,2011	S (DSMP)	W (WQMN)	H (HYCOS)	4	downstream Stung Treng HPP, downstream 3S trib
25	Mekong @ Kratie	Mekong	560.2	Cambodia	Existing	Not currently monitored	CKT, Kampi Pool upstream Kratie, 2004,2006,2008,2011,2013	S (DSMP)	W (WQMN)	H (HYCOS)	5	downstream Sambor HPP
26	Mekong @ Kampong Cham	Mekong	448.1	Cambodia	Existing	Not currently monitored	Not currently included in EHM	Not currently included in DSMP	W (WQMN)	H (Cambodian site - need info); historic data on MC	5	Fills a long-distance river reach between Mekong @ Kratie and Mekong @ Phnom Penh
27	Tonle Sap @ Prek Kdam	Tonle Sap	~32	Cambodia	Existing	Sang Var, fisher catch monitoring, TSMA. Ichthyoplankton, IFREDI	CTU, Prek Dam ferry, Tonle Sap River, 2011,2013	S (DSMP)	W (WQMN)	H (HYCOS)	5	Long-term goal is to have sufficient monitoring sites to capture the mainstream Mekong upstream and downstream of Chaktomuk, the Tonle Sap and the Bassac.
28	Mekong @ Phnom Penh (Chaktomuk)	Mekong	348.0	Cambodia	Existing	Ichthyoplankton, IFREDI	CPP, Phnom Penh port, but site at Tonle Sap, not at Mekong; CNL Neak Loeung at Mekong is some km downstream Phnom Penh; 2011,2013	Not currently included in DSMP	W (WQMN)	H (HYCOS)	6	Needs some closer scrutiny to ensure that flow/sediment/water quality balances can be calculated through the bifurcation of the Mekong, Bassac and Tonle Sap. Unclear at this stage about exact sites used by different disciplines with different names and references.
29	Mekong @ Tan Chau	Mekong	236.2	Vietnam	Existing	Ichthyoplankton, fisher catch monitoring, RIA2	2 Mekong sites at border; VTP Thuong Phuoc, Dong Thap (coordinates wrong?) and VTT Thuong Thoi, Dong Thap; 2008, 2011,2013; VCL between Tan Chau and My Thuan	S (DSMP)	W (WQMN)	H (HYCOS)	6	upper delta, transboundary
30	Bassac @ Chau Doc	Bassac	221.0	Vietnam	Existing	Ichthyoplankton, fisher catch monitoring, RIA2	VDP (?) Da Phuoc, An Giang, Bassac River; 2008,2011,2013	S (DSMP)	W (WQMN)	H (HYCOS)	6	upper delta, transboundary
31	Mekong @ Vam Nao	Mekong	195.0	Vietnam	Existing	Fisher catch monitoring, RIA2	not sure, near VCT?	Not currently included in DSMP	Not currently included in WQMN	H (HYCOS)	6	Relevant to Viet Nam Delta Study
32	Mekong @ My Thuan	Mekong	123.7	Vietnam	Existing	Fisher catch monitoring, RIA2	VVL, My Thuan, Vinh Long, Mekong River, 2008, 2011,2013	Not currently included in DSMP	W (WQMN)	H (HYCOS)	6	lower delta
33	Bassac @ Can Tho	Bassac	126.0	Vietnam	Existing	Fisher catch monitoring, RIA2	VCT, Phu An, Can Tho, Bassac River, 2006,2008,2011,2013	Not currently included in DSMP	W (WQMN)	H (HYCOS)	6	lower delta

7 Summary Gap Analysis for Hydropower-Relevant Information *(3 pages)*[6]

Guiding Principles for MRC Basin-Scale HP Planning & Mgmt Info	Socio-Economics	Fisheries
1. LOCATIONS OF DATA COLLECTION		
1a) Cover all Mekong River hydro ecological zones	↗ SIMVA sampling is representative of all defined socio-ecological zones. Data for socio-economics database sourced from national statistical offices	✓
1b) Near proposed or operational hydropower project or group of projects	↗ SIMVA locations for in-depth study are proposed to be aligned with priority HP locations **(SE2)**	✓
1c) Enable understanding of mainstream processes	✓ SIMVA focus on a 30 km corridor along the mainstream, Tonle Sap and flooded areas	✓
1d) Facilitate understanding of changes occurring across national boundaries	↗ Socio-economic data is being sourced at the lowest meaningful administrative level. SIMVA socio-ecological zones are sub-zones according to national boundaries	✓
2. PARAMETERS MONITORED		
2a) Provide inputs to indicators related to hydropower planning and management	◐ Most parameters identified as HP-relevant are included in the list for the Socio-economic Database, although macro-economic and energy indicators and info on cultural and religious sites require development **(SE1)**	↗ Missing biological parameters for targeted individual fish species, and better habitat assessment data **(F3, F4)**
2b) Able to be replicated across the basin	↗ The socio-economic database project, involving the four Member Countries, is developing principles and processes for data harmonisation.	↗ Standard methods are being developed by FP **(F2, F3, F4)**
2c) Able to be measured and analysed at a low cost	↗ Cost of official socio-economic statistical data is low; SIMVA data collection costs can be potentially lowered by collaborating with national statistical agencies.	↗ There are potential efficiencies and cost-savings through less frequent sampling, but need to avoid loss of information or gaps in data **(F1)**
2d) Able to help predict as well as explain cause and effect of changes	◐ Over time the socio-economic database will enable trend and regression analysis and projections, and greater exploration of causes and effects **(IU2)**	↗ Can be improved with better understanding of stressors and collection of biological and habitat parameters **(F1, F2, F3, F4)**
3. TIMING OF DATA COLLECTION		
3a) Length of record covers the cycles of natural variability (seasonal, annnual, decadal)	↗ Will be improved with the gradual inclusion of time series data in the socio-economic database	✓
3b) Frequency captures natural or operational system changes and migratory cycle	↗ Proposed SIMVA qualitative study focuses on trends over 10 years in mainstream communities **(SE2)**	↗ Frequency is excessive – daily - for most monitoring and could be reduced
4. INFORMATION MANAGEMENT		
4a) Quality management systems are in place to ensure consistency across countries	↗ QA/QC systems are being developed for the Socio-economic database	✗ SOPs/WIs for fisheries monitoring are in development but not presently available **(F2, F3, F4)**
4b) Systems allow information to be centrally archived and shared	↗ The socio-economic database will have national level and central level installations, and be on the web.	↗ FP data is being cleaned for harmonisation and centralisation with IKMP **(F1, IU1)**
5. INFORMATION USE		
5a) Information is readily available for users (e.g. Member Countries, developers, NMCs, Line Agencies)	◐ This will be delivered with the SE database on a DevInfo or simiar web based platform. The HP project database is not up-to-date **(H1)**	↗ Delayed fisheries technical reports are in process of being published. Data accessibiity could be improved **(IU1)**
5b) Links to tools are available for decision-support and analysis	◐ The SE database will include a web-interface for data download and analysis **(IU1);**	? Not presently clear what tools are needed for HP decision-support and analysis relating to fisheries **(F1, IU1, IU2)**

KEY:		
	✓ = Fully met	◐ = Partially met
	↗ = Not fully met, but action in progress	? = Unsure if met
	✗ = Not met	

[6] This matrix is extracted from ISH11 External Draft 1.0 Phase 2 Main Report Section 3.10

Summary Gap Analysis for Hydropower-Relevant Information *(page 2 of 3)*

Guiding Principles for MRC Basin-Scale HP Planning & Mgmt Info	Aquatic Ecology	Sediments
1. LOCATIONS OF DATA COLLECTION		
1a) Cover all Mekong River hydro ecological zones	✓ Zones are covered, number of sites per zone to increase for sound longitudinal overview and basis for evaluation of longitudinal changes	✓
1b) Near proposed or operational hydropower project or group of projects	◐ Missing some Upper Lao locations near HPPs	◐ Missing some Upper Lao locations near HPPs
1c) Enable understanding of mainstream processes	◐ Present number of sites do not adequately reflect biota distributions; some sites at confluences not clear if representing mainstream or tributary	◐ Missing some priority tributary locations required for understanding mainstream processes
1d) Facilitate understanding of changes occurring across national boundaries	◐ Missing some priority transboundary locations	◐ Missing some priority transboundary locations
2. PARAMETERS MONITORED		
2a) Provide inputs to indicators related to hydropower planning and management	◐ Missing phytoplankton **(AE2)**. EHM indicators need supporting environmental and pressure data **(AE1)**	◐ Gaps in spatial coverage of bedload and grain-size data collection **(SWH3)**; missing geomorphic parameters **(SWH4)**
2b) Able to be replicated across the basin	✓ Methods for EHM parameter groups are defined in Biomonitoring handbook. Work Instructions for phytoplankton suggested **(AE2)**	✓
2c) Able to be measured and analysed at a low cost	↗ Monitoring and equipment not cost-intensive. Present capacity-building efforts could be enhanced	✗ Sediment work is labour intensive, potential for alternative emerging technologies **(SWH3)**
2d) Able to help predict as well as explain cause and effect of changes	✗ Requires better understanding of stressors, further data analysis, and linkages with other disciplines for "diagnostic capability" **(AE1, AE3)**	✗ Missing parameters at key locations **(SW3)** limits interpretative abilities; requires further data analysis, and linkages with other disciplines **(SWH1)**
3. TIMING OF DATA COLLECTION		
3a) Length of record covers the cycles of natural variability (seasonal, annnual, decadal)	↗ Will be improved with increasing length of data record	↗ Will be improved with increasing length of data record
3b) Frequency captures natural or operational system changes and migratory cycle	✗ Annual monitoring at priority locations would better meet HP-info needs **(AE1)**	◐ Monitoring frequency good, but gaps in record during onset of wet season due to contracting delays **(SWH3);** no monitoring of geomorphic processes at time-scale of years to decades **(SWH4)**
4. INFORMATION MANAGEMENT		
4a) Quality management systems are in place to ensure consistency across countries	✗ Systems do not appear consistent across countries. Taxa catalogues are not up-to-date; quality assurance system needed **(AE1, AE2, AE3)**	↗ 2009-2012 DSMP results in process of being completed
4b) Systems allow information to be centrally archived and shared	◐ The biomonitoring database would benefit from a number of improvements **(AE3, IU1)**	✗ 2009-2012 DSMP results not yet available on Master Catalogue
5. INFORMATION USE		
5a) Information is readily available for users (e.g. Member Countries, developers, NMCs, Line Agencies)	◐ Multi-year delays occur for aquatic ecology data accessiblity **(AE3, IU1)**	◐ Format, accessibility and timeliness of data could be improved for HP-relevant info needs, with particular attention to data integration capabilities **(IU1)**
5b) Links to tools are available for decision-support and analysis	✗ Analytical approaches and tools for biomonitoring data relevant to HP have not yet been developed **(AE1, IU1, IU2)**	◐ Some decision-support tools are available but not specifically targeted at hydropower information needs; need better indicators and tools for HP-relevant info **(SWH1, IU1, IU2)**

KEY:

✓ = Fully met
◐ = Partially met
↗ = Not fully met, but action in progress
? = Unsure if met
✗ = Not met

Summary Gap Analysis for Hydropower-Relevant Information *(page 3 of 3)*

Guiding Principles for MRC Basin-Scale HP Planning & Mgmt Info	Water Quality		Hydrology	
1. LOCATIONS OF DATA COLLECTION				
1a) Cover all Mekong River hydro ecological zones	✓		✓	
1b) Near proposed or operational hydropower project or group of projects	◐	Missing some Upper Lao locations near HPPs	✓	More flow information from upstream of LMB would be useful
1c) Enable understanding of mainstream processes	◐	Missing some priority tributary locations near HPPs	✓	
1d) Facilitate understanding of changes occurring across national boundaries	◐	Missing some priority transboundary locations	✓	
2. PARAMETERS MONITORED				
2a) Provide inputs to indicators related to hydropower planning and management	◐	WQMN monitoring suite could be enhanced by integrating sediment and water quality monitoring and including additional nutrient and organic carbon parameters **(SWH2)**	◐	Understanding hydrologic cycle could be improved by augmenting HYCOS with additional parameters (e.g. evaporation, wet bulb temp) for modelling, and obtaining better understanding of groundwater in basin
2b) Able to be replicated across the basin	✓	Standard WQMN suite of analyses agreed upon by all countries	✓	
2c) Able to be measured and analysed at a low cost	◐	Integration of water quality and sediment monitoring could reduce field costs at some sites **(SWH2)**	✓	
2d) Able to help predict as well as explain cause and effect of changes	◐	Low frequency of monitoring limits HP-related interpretation; existing data could provide more info through further data analysis, and linkages with other disciplines **(SWH2, SWH1)**	✓	Hydrologic information suitable for modelling, existing hydrologic data could provide more information through integration and analysis with other disciplines (SWH1)
3. TIMING OF DATA COLLECTION				
3a) Length of record covers the cycles of natural variability (seasonal, annnual, decadal)	✓	Available data record is long	✓	Will continue to improve with increasing length of data record
3b) Frequency captures natural or operational system changes and migratory cycle	◐	Frequency of water quality sampling too low to capture short-term changes asociated with HP operations **(SWH2)**	◐	Frequency of river level and rainfall good. Groundwater information lacking
4. INFORMATION MANAGEMENT				
4a) Quality management systems are in place to ensure consistency across countries	✓	WQMN responsible for QA/QC	✓	IKMP responsible for QA/QC of HYCOS data
4b) Systems allow information to be centrally archived and shared	✓	Data available on Master Catalogue	✓	HYCOS Data available on Master Catalogue
5. INFORMATION USE				
5a) Information is readily available for users (e.g. Member Countries, developers, NMCs, Line Agencies)	◐	Diagnostic WQ studies and WQ Report Cards are useful; data format could be improved for HP-relevant needs through integration with other disciplines **(IU1)**	◐	Format, accessibility and timeliness of data could be improved for HP-relevant info needs, with particular attention to data integration capabilities **(IU1)**
5b) Links to tools are available for decision-support and analysis	◐	Some decision-support tools are available but not specifically targeted at hydropower information needs; need better indicators and tools for HP-relevant info **(SWH1, IU1, IU2)**	◐	Some decision-support tools are available but not specifically targeted at hydropower information needs; need better indicators and tools for HP-relevant info **(SWH1, IU1, IU2)**

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8 Considerations for Decision-Making on ISH11 Improvement Proposals[7]

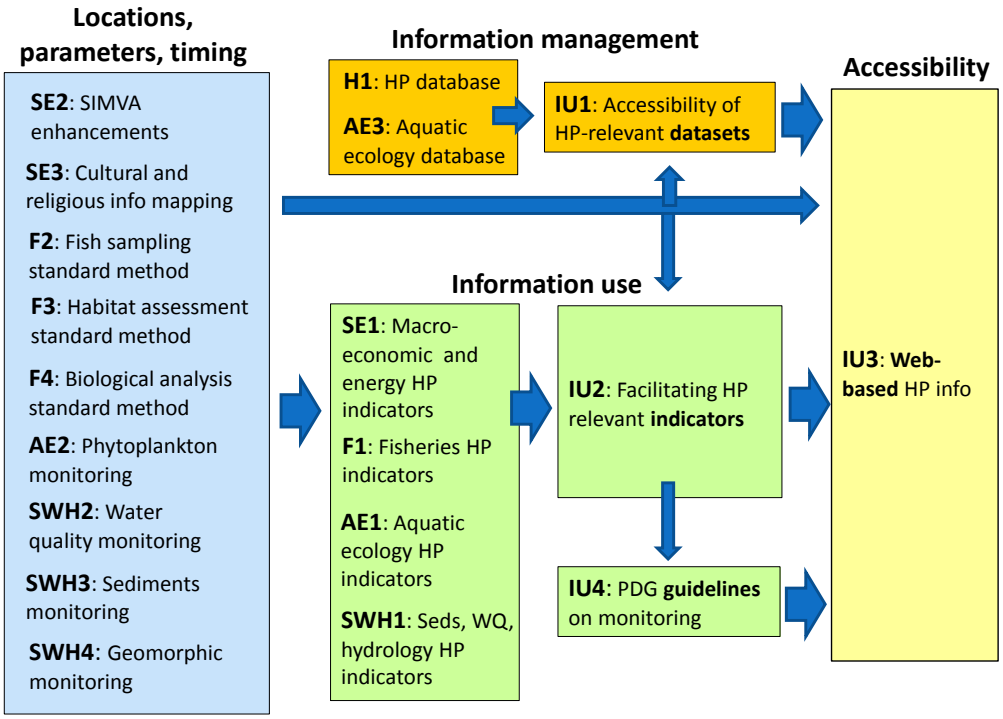

Figure 9.1 – Linkages and Dependencies amongst the ISH11 Improvement Proposals

[7] Figure 9.1 and Table 9.1 are extracted from ISH11 External Draft 1.0 Phase 2 Main Report Section 5.2

Table 9.1 – Links between the ISH11 Improvement Proposals and Current Studies

ISH11 Improvement Proposal	Relevant MRC Programme or Activity	Outcomes	*Contributes to:*				
			Capacity-Building	BDP processes	Council Study	Delta Study	RSAT info needs
H1: Hydropower Project Database	ISH core activity	Up-to-date and comprehensive information on hydropower and dams projects in the LMB	✓	✓	✓		✓
SE1: Macro-Economic and Energy Indicators for HP Information	BDP Socio-Economic Database	More complete socio-economic information relevant to hydropower planning and management	✓	✓	✓		
SE2: SIMVA Enhancements for HP Information	EP SIMVA	Socio-economic information at hydropower-relevant locations; potential to combine with environmental			✓		✓
SE3: Mekong River Cultural and Religious Sites	IKMP-IS	More complete socio-economic information relevant to hydropower planning and management		✓			✓
F1: Fisheries Indicators for Hydropower Information	FP fisheries	Improved information for planning and managing hydropower-related issues with fisheries.	✓	✓	✓	✓	✓
F2: Fisheries Fish Sampling Standard Methods	FP fisheries	Fisheries data is more representative and less variable over time, leading to clearer interpretation and feedback to hydropower management.	✓	✓			✓
F3: Habitat Assessment Standard Methods	FP, EP EHM and WQ, IKMP DSMP, HYCOS	Habitat characteristics and changes are monitored and can inform hydropower management issues.	✓	✓			✓
F4: Biological Analysis Standard Methods	FP fisheries	Fish condition, diet, reproduction and other indicators are monitored and can inform hydropower management issues.	✓	✓			✓
AE1: Aquatic Ecology Indicators for HP Information	EP EHM	Improvements to aquatic ecology monitoring to support development of hydropower-relevant indicators, including integration with other disciplines	✓	✓	✓	✓	✓
AE2: Phytoplankton Monitoring for HP Information	EP EHM, FP fisheries	Trialling of phytoplankton monitoring to support fisheries and EHM monitoring to better inform hydropower management issues.	✓		✓	✓	✓
AE3: Strengthening the Bio-Monitoring Database	EP EHM	Enhanced, well-organised database for aquatic ecology routine monitoring data that can be used for hydropower information.	✓	✓	✓	✓	✓
SWH1: Integrating Sediments, Water Quality and Hydrology for HP Indicators	IKMP DSMP and HYCOS, EP WQMN	Improved understanding of sediments, water quality and hydrology in the LMB to assist hydropower planning and management	✓	✓	✓	✓	✓
SWH2: Water Quality Monitoring Enhancements for HP Information	IKMP DSMP, EP WQMN	More representative and comprehensive water quality information to inform hydropower planning and management	✓	✓	✓	✓	✓
SWH3: Sediment Monitoring Enhancements for HP Info	IKMP DSMP	More comprehensive sediment information for hydropower planning and management	✓	✓	✓	✓	✓
SWH4: Geomorphic Methods for Hydropower Information	IKMP	Filling of an information gap important for hydropower planning and management.		✓	✓	✓	✓
IU1: Improving Accessibility of Datasets for HP Information	IKMP-IS	Member Countries have improved access to hydropower-relevant information.	✓	✓			✓
IU2: Facilitating Application of HP-Relevant Indicators	BDP Indicator Framework project	Member Countries have improved awareness of and tools for information use to inform hydropower planning and management	✓	✓	✓	✓	✓
IU3: Web-based Presentation for HP-Relevant Information	IKMP-IS	The MRC website is enhanced with hydropower-related information more accessible for Member Countries	✓				✓
IU4: Guidelines on Monitoring in Support of the PDG	ISH	Guidance on monitoring for hydropower information needs is developed to supplement the Preliminary Design Guidance for HPPs	✓				