Fostering Evidence-Based IWRM in the Stung Pursat Catchment (Tonle Sap Great Lake) Cambodia

CPWF-Mekong Basin Development Challenge

DSTs and Modeling Tools Report

March 2013

Prepared for:

Mekong Basin Leader CGIAR Challenge Program on Water and Food

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FOSTERING EVIDENCE-BASED IWRM IN THE STUNG PURSAT CATCHMENT (TONLE SAP GREAT LAKE) CAMBODIA

CPWF-MEKONG BASIN DEVELOPMENT CHALLENGE

DSTs AND MODELING TOOLS REPORT

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LIST OF ACRONYMS

ADM	Adaptation Decision Matrix
CBA	Cost-Benefit Analysis
CEA	Cost Effectiveness Analysis
CEPA	Culture and Environment Preservation Association
CPWF	Challenge Program on Water and Food
DHRW	Department of Hydrology and River Works
DSF	Decision Support Framework
DST	Decision Support Tools
EPA	Environment Protection Agency (US)
ETo	Potential Evapotranspiration (Penmann-Monteith)
GIS	Geographic Information System
HCP	Hatfield Consultants Partnership
IQQM	Integrated Quantity-Quality river basin simulation Model
ISIS	1D hydrodynamic model (developed jointly by Halcrow and HR Wallingford) that includes a number of ways to model floodplain flow, including extended cross-sections
IWMI	International Water Management Institute
IWRM	Integrated Water Resources Management
MCA	Multi-Criteria Analysis
MOWRAM	Ministry of Water Resources and Meteorology
MPWT	Ministry of Public Works and Transport
MRC	Mekong River Commission
MRC FMMP	Mekong River Commission Flood Management and Mitigation Program
MRC RFMMC	Mekong River Commission Regional Flood Management and Mitigation Center
MRC WUP	MRC Water Utilization Program
MSP	Multi-Stakeholder Platform
NAPA	National Plan of Actions
NGOs	Non-governmental Organizations
SNEC	Supreme National Economic Council
SWAT	Soil and Water Assessment Tool
TSA	Tonle Sap Authority
UNDP	United Nations Development Program

UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
URBS	Unified River Basin Simulation
WEAP	Water Evaluation and Planning

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EXECUTIVE SUMMARY

This report, entitled the *DSTs and Modeling Tools*, is prepared for, and at the inception phase of the project, “Fostering evidence-based IWRM in the Stung Pursat Catchment (Tonle Sap Great Lake), Cambodia” (also known as MK16). The MK16 project aims to improve water management practices in Cambodia through greater cross-sectoral collaboration and use of data and modeling techniques to inform decisions around water governance. The project is carried-out in Stung Pursat, a sub-catchment of the Tonle Sap basin in western Cambodia.

This report presents various decision support tools (DSTs) and modeling techniques for facilitating decision-making around water resource management. The objective here is to assess currently available and relevant DSTs, and to highlight the method of selecting most appropriate tool.

In Cambodia, MRC-supported projects and programmes have provided much support in using various modeling tools and other DSTs, like rainfall-runoff models based on SWAT; reservoir operation and hydrological routing models based on IQQM; hydro-dynamic model for the Mekong Delta based upon ISIS; and flood forecasting of Mekong River and its tributaries based on URBS model.

The most common methods used in Cambodia are economic analyses, namely Cost-Benefit Analysis (CBA), Cost Effectiveness Analysis (CEA), Multi-Criteria Analysis (MCA) and expert judgment. CBA calculates and compares costs and benefits, expressed in monetary terms, of different options. CEA is similar to the CBA, and computes the least costly option for meeting a pre-defined objective. Finally the MCA is used when a single-criterion approach, such as CBA falls short, and when the costs of environmental and social components cannot be expressed as dollar values. There are other useful economic analysis tools, like the Adaptation Decision Matrix (ADM) – which uses a decision matrix and MCA techniques to evaluate the relative cost-effectiveness of options for better water management – and the Livelihood Sensitivity Exercise – which is a sensitivity mapping exercise that allows for integration of existing knowledge about water insecurity with livelihood analysis.

When selecting the appropriate DST, the focus should be first on defining the “problem”, and then on how one or more of the DSTs may help in tacking that problem. A number of considerations exist, for example relevant physical processes, availability and quality of data, ability of the model to generate good results under extrapolated conditions, and gender.

1.0 INTRODUCTION

"Fostering evidence-based IWRM in the Stung Pursat Catchment (Tonle Sap Great Lake), Cambodia project" (also known as MK16) is funded by the CGIAR Challenge Program on Water and Food (CPWF)[1], with a grant from AusAID. It is collaboratively implemented by the Ministry of Water Resources and Meteorology (MOWRAM), Tonle Sap Authority (TSA), Supreme National Economic Council (SNEC), Hatfield Consultants Partnership (HCP), and Culture and Environment Preservation Association (CEPA).

MK16 is implemented in a single sub-catchment of Tonle Sap basin in western Cambodia, the Stung Pursat. This project seeks to address and/or improve three underpinning aspects of water management: (a) cross-sectoral collaboration in the management of water resources; (b) use of data or scientific analyses to inform water management in Cambodia; and (c) institutional mechanism for inter-sectoral management, or interpretation and use of existing or new scientific data.

Given these overall objectives, the Project will comprise of three components, namely:

Component 1: Data Review and Stakeholder Analysis

This will be done to assess whether existing data sets will enable the project to answer its research questions. Furthermore, data review and stakeholder analysis will reveal data gaps, which will determine the research direction for this project.

Component 2: The Stung Pursat IWRM Multi-Stakeholder Platform (MSP)

The intent of MSP is to define what actions need to occur in order to resolve identified problems related to water management.

Component 3: The Research Component

This component will determine water availability, appropriate decision support tools, and approaches for achieving level "playing field" in MSP.

In line with Component 3 above, this report presents current knowledge about the available and suitable tools for facilitating decision-making around key water issues in Cambodia. Furthermore, this report also provides criteria for evaluating and selecting these tools.

2.0 DECISION SUPPORT TOOLS (DST)

Decision Support Tools (DSTs) have been developed by various organisations (government agencies, international organizations, NGOs, universities, consultancy companies and think tanks) to facilitate decision making around a number of issues, including water governance and management. There are a

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[1] The research was carried out through the CGIAR Challenge Program on Water and Food (CPWF), which is funded by the UK Department for International Development (DFID), the European Commission (EC), the International Fund for Agriculture Development (IFAD), and the Swiss Agency for Development and Cooperation (SDC).

range of DSTs, distinguished by their function, quality of services (accuracy and precision), ease of use, time of application (project planning, implementation, monitoring, etc.), data requirements, data generated and other factors.

The main objective of this analysis is to assess currently available and relevant decision support tools (DSTs), and to highlight the method of selecting most appropriate tool.

To develop and maintain Cambodian modeling capacity, the most sustainable way is to have both universities and line agencies involved and working together. Furthermore, introduction and sensitization of national and sub-national level planning agencies to DSTs can help in enhancing accountability and transparency in decision-making processes.

When selecting the appropriate DST, the focus should be first on defining the "problem", and then on how one or more of the DSTs may help in tacking that problem. Furthermore, it is also useful to assess the complexity of the tool and capacity of its users. Simpler tools may be a strategy to decrease learning curves and improve application times.

Table 2.1 Key Questions in Determining Optimal Strategies For Water Management.

NO	KEY QUESTIONS
1	Why is this resource important? How is it used? Who are the stakeholders to whom it is valuable?
2	What are the key environmental and social variables that influence this resource?
3	What is the sensitivity of this resource to changes in key variables, such as climate variations and change on short (e.g., days); medium (e.g., seasons) and long (e.g., multi-decadal) time scales?
4	What changes (thresholds) in these key variables would have to occur to result in a negative (or positive) response to this resource?
5	What are the best estimates of the probabilities for these changes to occur? What tools are available to quantify the effect of these changes? Can these changes and effects be accurately predicted?
6	What actions can be undertaken in order to minimize or eliminate the negative consequences of these changes (or to optimize a positive response)?
7	What specific recommendations for policymakers and other stakeholders can be made?

2.1 EXPERIENCE WITH DSTS IN CAMBODIA

Within Cambodia, experience with DSTs has been gathered mainly through programmes and projects supported by the Mekong River Commission (MRC). A range of modeling tools and DSTs with different strengths and limitations are considered in this report. The most common methods are Cost-Benefit Analysis (CBA), Cost Effectiveness Analysis (CEA), Multi-Criteria Analysis (MCA) and expert judgment. These methods are most easily applied at the project level. Measures such as institutional and legislative reform require more informal or qualitative ways to evaluate attractiveness.

2.2 SELECTING APPROPRIATE DSTS

A step-wise identification and selection approach can be used to pick the most applicable modeling and water management and risk screening DSTs for Pursat MSP. First, all currently available DSTs can be compiled and sorted by type and theme. Second, the list of DSTs can be narrowed by a process of elimination, leaving only those classified as modeling tools and risk screening and decision support tools. A second level of elimination will remove those DSTs considered by expert judgment to be irrelevant.

It should be noted that many of the tools discussed above have direct implications for gender. In its use of the term "IWRM", the project recognises that the "betweenness" of things are typically where the greatest sources of tension reside in the Stung Pursat catchment's IWRM, and that the relations between male and female water users is of distinct relevance here. Hence, in all of its social (and political) surveys, the MK16 Project will explore ways in which gender affects access to water resources for households. In addition, gender inequality will be highlighted to the MSP as a key constraint in developmental processes within the catchment, and which has direct implications for economy, household well-being, and differential water use. As a cross cutting issue, gender analysis will not be a stand-alone output, but incorporated into all of the project's outputs.

Table 2.2 Criteria used for Water Management and Risk Screening DSTs.

1.	Corresponds to Cambodian needs and concerns
2.	Required input data exists and is accessible for Cambodia
3.	Ease of use
4.	Short learning curve
5.	Level of regional application
6.	Level of global application
7.	Accessibility of tool including training cost
8.	Promotes stakeholder participation
9.	Level of integrated and holistic approach

In Project MK16, members of the MSP, with advice and guidance from project partners, will select both water allocation scenarios and the multi-criteria analysis (MCA) – a tool used when a single cost-benefit assessment tool is insufficient. This will allow for participatory weighting of the MCA criteria for the different water allocation options. The environmental, social and economic impacts resulting from the evaluation will be deliberated and discussed within the MSP. Through a repeated process of problem and option framing, stakeholders will be provided with opportunities to re-weigh and assess the evaluation.

3.0 MODELING TOOLS

Application of modeling tools can be divided into two broad categories: (i) integrated environmental and water resources management; and (ii) specific applications for design, planning, impact assessment, or forecasting. **Integrated modeling tools** are of direct benefit when it comes to developing strategies and options for improved water governance and management.

3.1 AVAILABLE MATHEMATICAL MODELS WITHIN THE DHRW

The water balance study of the Pursat River basin requires an inventory of computational methods and mathematical models readily available in the DHRW. Over the last decade, much progress has been made in developing such tools at DHRW with the support of the MRC. The MRC WUP-A programme has led to the development of the Decision Support Framework (DSF), consisting of the rainfall-runoff models based on SWAT, the reservoir operation and hydrological routing models based on IQQM (covering water resources including irrigation and hydropower), and the hydro-dynamic model for the Mekong Delta based upon ISIS (1D hydrodynamics, channel sediment processes). In addition, the MRC FMMP programme has led to the modeling of flood forecast of the main Mekong River and its tributaries, based upon the URBS model. Some of these tools are discussed below.

Table 3.1 Assessment of MRC Toolbox.

	MRC Toolbox
Corresponds to Cambodian needs and concerns	Yes (floods, upstream impacts on flows, hydropower development etc.)
Data needs and applicability with limited available data	Has proven to work with available data; utilisation of data gap filling tools
Ease of use	Varies depending on the model; need to learn multiple models and interfaces (contrast to integrated models)
Balanced learning curve	Yes, compared to nature of each model. Certain technical background and training are needed.
Level of regional application	High, designed and developed for Mekong conditions
Accessibility including software and training costs	Free of charge (except ISISI); training by the MRC. Few modelers trained by MRC are either working in MOWRAM or MPWT. But some of them have moved up or moved out.
Level of integrated and holistic approach	Average, depends on what tools are utilised. Attention is being paid to improving its integration.
Quantified, accurate and relevant outputs	Yes; has been verified in large number of applications for some models only.
Ability to represent natural systems and human impact on them	Yes and no. Limitations for some models (for instance IQQM represents systems schematically, floodplain flows are not accurately represented by 1D models)
Level of existing applications and applicability in water management.	Some (Mekong flows and flooding; IWRM and 3D not considered)

SWAT (Soil and Water Assessment Tool) is a rainfall-runoff modeling system developed by the US Environment Protection Agency (EPA). Within each SWAT catchment, refinements can be introduced by defining sub-catchments with their own characteristics derived from GIS data bases.

Our partners in DHRW are also capable of applying URBS (Unified River Basin Simulation) modeling system for describing catchment rainfall-runoff processes that were introduced in 2007 at the MRC RFMMC. URBS combines the rainfall-runoff and runoff-routing components of the modeling process, and allows users to configure the model to match the characteristics of individual catchments with the use of the GIS package, CatchmentSIM.

IQQM (Integrated Quantity-Quality river basin simulation Model) simulates all the processes and rules associated with the simplified description of movement of water through a river system. The major processes include:

- System inflows and flow routing;
- On- and off-river reservoir modeling;
- Harmony rules for reservoir operation (operational management of multiple reservoirs, i.e., what and when to release from which reservoir);
- Crop water demands, orders and diversions;
- Town water and other demands;
- Hydropower modeling;
- Effluent outflow and irrigation channels;
- Wetland demands and storage characteristics;
- Water sharing rules for both regulated and unregulated river systems; and
- Resource assessment and water accounting; and interstate water sharing agreements.

IQQM can be configured for systems, which are operating a single, or multiple reservoirs functioning in series or parallel to one another. The model applies hydrologic flow routing for the simulation of the different ranges of flow conditions.

Simplified EXCEL Spreadsheet for water balance computation has been used by the DHRW staff to deal with water balance computation in the river basin, taking irrigation systems into account. These spreadsheets are very useful in computing Evapotranspiration (ETo), crop water requirement, and for confirming security of river basin water resources and proposing areas for new irrigation development projects, and so on.

3.2 MODEL SELECTION

A large number of specific models for hydrological, hydrodynamic, and water quality assessment are very important. For example, they can be used to plan for required storage capacity, flood protection, road embankment heights, and ecological impact assessment.

However, there are greater learning requirements for more versatile and powerful tools. For the easy-to-use tools, the learning involves understanding natural processes and human interventions, as well as obtaining, processing, analysing and presenting model outputs for decision making, planning and forecasting. The”modeling tools” will be assessed based on the following criteria:

Table 3.2 Criteria Used for Evaluating Modeling Tools.

1.	Corresponds to Cambodian needs and concerns
2.	Data needs and applicability with limited available data
3.	Ease of use
4.	Balanced learning curve
5.	Level of regional application
6.	Accessibility including software and training costs
7.	Level of integrated and holistic approach
8.	Quantified, accurate and relevant outputs
9.	Ability to represent natural systems and human impact on them
10.	Level of existing applications and applicability in water management

For the appropriate choice of a model the following aspects are important:

- The physical processes taking place, e.g., flash floods, backwaters, tidal flooding, etc. The nature of the flood processes determines what kind of model can be used. For example, hydrological routing models cannot be used for areas under strong backwater and flow reversal regimes, such as those of the Tonle Sap;
- The availability and quality of data. A well-known saying in relation to mathematical models is: "garbage in – garbage out". For example, the outputs of many flood models are constrained by the availability and quality of topographical data. Although, a good analysis of available data may reduce garbage content to a certain extent; and
- Ability of the model to generate results with a good degree of certainty under extrapolated conditions. Some models are unable to do so, even when good sets of data are available to calibrate them. This condition particularly relevant for flood models. Usually, one is interested in a range of events that rarely occur, and for which observations are usually not available. In these cases, a model that has been calibrated for more frequently-occurring events can also be applied for extreme events. As a rule, extrapolations are more reliable when using a model with more sound input data.

The following model types can be distinguished for water balance computation in the Pursat river basin:

- Rainfall-runoff models; and
- Hydrological routing models and/or Simplified EXCEL Spreadsheet for water balance computation.

Rainfall-runoff models can be used to provide discharge information. These models transform statistical information on rainfall data into statistical information on river discharges. If possible, the simulation of series of individual events should be replaced by the simulation of long time series. This has been done, for example, in the development of the Decision Support Framework (DSF) for the Lower Mekong Basin. In this project, Halcrow processed rainfall data for the period 1985 – 2000 to calibrate the SWAT rainfall-runoff models under the DSF. A better alternative could be to use newly developed URBS models, which have been calibrated under the FMMP-C1, particularly for flood conditions. In principle, these URBS models would show better calibrations than the SWAT models, a hypothesis which would have to be checked upon the selection of the appropriate set of models to be used for the study.

Hydrological routing models are used to identify impacts of water resources development, such as irrigation systems and hydropower dams on the flow regime and water balance of the river basin. However, for better understanding of the technical staff on steps and procedures for computing water balance, the Simplified EXCEL Spreadsheet could be the alternative choice.

4.0 ECONOMIC ANALAYSIS TOOLS

Increased efforts to improve water management require that robust and transparent assessment approaches exist to enable decision makers to efficiently allocate scarce financial, technological and human resources. Economic analysis tools provide monetary indications of economic, environmental and social costs and benefits of responses, thereby informing the decision-process (UNDP 2004; MRC 2010). When undertaking such assessments, planners have to first determine the core objectives and targets of their project. For example, objectives can be equitable allocation of water and related resources, or management of water flows, flooding, or other risks.

When assessing costs and benefits of water management strategies, there are three approaches that have been widely used and proven to be effective as DSTs in broader development and planning contexts:

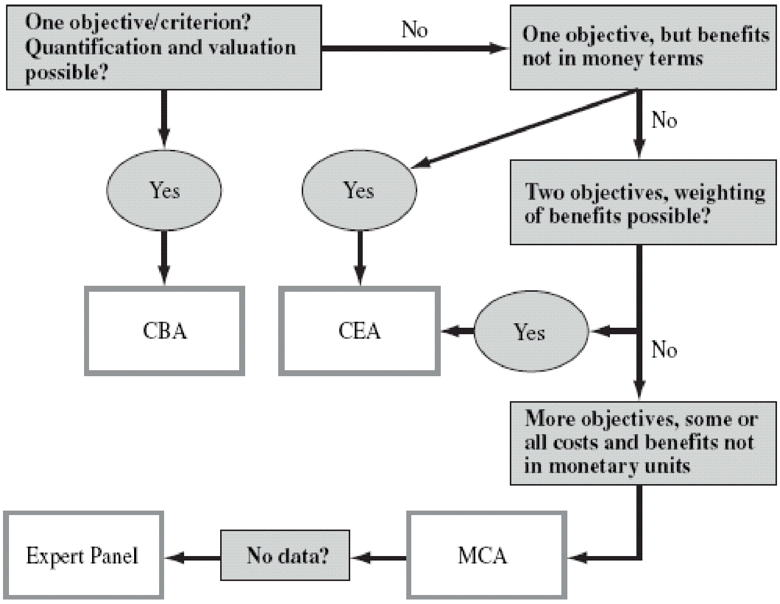
- Cost-Benefit Analysis (CBA);
- Cost-Effectiveness Analysis (CEA); and
- Multi-Criteria Analysis (MCA).

These methods of prioritization can be most easily applied at the project-level (sectoral or multi-sectoral). For larger cross-sectoral strategies that involve "soft interventions" such as institutional and legislative reform, it is more difficult to assess costs and quantify benefits, thereby requiring more informal or qualitative ways to determine attractiveness. UNDP (2004) presents a framework to determine the best economic analysis DSTs to use in the selection and prioritization of measures for better water management. Given the great importance in accuracy of results, this chart may be most applicable at later stages of the decision process (UNDP 2004).

Each of these approaches is explained in the sections that follow, in terms of their applicability, use, technical requirements and suitability in the Cambodian context.

4.1 COST-BENEFIT ANALYSIS & COST EFFECTIVENESS ANALYSIS

Figure 4.1 Method for identifying the best applicable economic analysis tool for prioritization and selection of various strategies (UNDP 2004).



Cost Benefit Analysis (CBA) uses a conceptual framework to assess various strategies for water management by calculating and comparing costs and benefits, expressed in monetary terms. CBA involves making explicit assumptions that can lead to the derivation of reliable estimates of things that are assigned monetary values in the markets (e.g., costs and benefits of environmental goods and services, cultural aspects, social values, etc.). This entails the possibility of non-market costs and benefits being excluded from the analysis, and results being skewed or misleading (UNFCCC 2011). A comprehensive CBA of water management measures has not been conducted to date in Pursat, Cambodia. This can be attributed to a number of reasons, including absence of necessary human, technical and financial resources to commission such studies (MOE/HCP 2012).

Expert teams conducting CBA must be knowledgeable and skilled in economics and valuation techniques and bio-physical, engineering, social and institutional aspects relevant to the estimation of costs and benefits. Technical training will be required on estimating monetary values to costs and benefits, and to address uncertainties, methodological issues, and potential biases (UNEP and IVM 1998).

Cost Effectiveness Analysis (CEA) is a variation of a CBA, which is used to find the least costly option for meeting a pre-defined objective. This method is attractive especially when it is difficult to quantify and monetize benefits. In this method, various strategies are compared based on their cost differences to achieve a given fixed level of effectiveness (UNEP and IVM 1998).

In a data- and resource-constrained context such as Cambodia, CEA may prove to be a more effective tool to help identify project options at the lowest possible cost. Although CEA is relatively easier and less resource-intensive to undertake, it is often not used as a stand-alone DST, but in combination with other tools, due to the fact that benefits are only defined in a single, common metric against which to assess cost-effectiveness. Assessment of other important dimensions, such as gender equity, feasibility, co-benefits, and awareness-raising may be undertaken in parallel to a CEA (UNFCCC 2011).

4.2 MULTI-CRITERIA ANALYSIS

Multi-Criteria Analysis (MCA) is a DST that is applicable in cases where a single-criterion approach such as CBA falls short, particularly where environmental and social component costs cannot be expressed in monetary terms. As such, MCA allows for comparing and ranking options based on a full range of criteria (e.g., environmental, social, technical, economic, financial, etc).

Table 4.1 Assessment of Multi-Criteria Analysis (MCA).

Corresponds to Cambodian needs and concerns	Assess multiple objective – Cambodian planners may want to use a range of criteria (environmental, social, technical, financial etc. in addition to economic criteria) to assess and rank options.
Required input data exists and is accessible for Cambodia	Relies on the judgment of the decision–making team to establish a set of objectives and assign relative weights to selected criteria - Accommodates consideration of both qualitative and quantitative information.
Ease of use	Depends on reliability of information used and the selection of criteria, relative weights and scores, and the degree to which an agreement is reached by the MCA team. Various sensitivity analysis techniques exist to test for the robustness (UNFCCC 2011).
Short learning curve	Short learning curve - Relatively simple tool to use. Time, cost and training required depend on the specific methodology used. Generally training required is minimal.
Level of regional and global application	Highly applicable. Framework to integrate different decision criteria in a quantitative analysis for NAPA. Can also be combined with other assessment approaches such as CBA and CEA to provide a foundation for more informed decision-making
Accessibility including software and training costs	Highly accessible (UNFCCC 2011).
Level of integrated and holistic approach	Produces economic estimates relatively quickly, yet with an adequate level of precision for decision making (no benefit is quantified or compared)
Promotes stakeholder participation	Benefits from representative stakeholder engagement, and allows beneficiaries of strategies to part-take in the selection of those strategies, creating a greater sense of ownership.

The key output is the identification of the single most preferred option, a set of ranked options, short-listing of options for further assessment, or characterization of acceptable and unacceptable options (UNFCCC 2012).

There are different variations of the MCA approach available. Some existing approaches include: the performance matrix approach; multi-attribute utility theory approach; linear additive models; analytical hierarchy process; outranking methods; and procedures that use qualitative data inputs (see DCLG 2009 for more details). All MCA approaches are generally similar in that they identify different options, assign relative weights to different criteria, and require judgment in weighting and scoring. They only differ in how they combine data (DCLG 2009).

As previously stated, a key feature of MCA is that it relies on the judgment of the decision–making team to establish a set of objectives and assign relative weights to selected criteria, and therefore, judge the contribution of each criterion to the overall performance of the strategy (MOE/HCP 2012). Using this weighting approach, an overall score for each option is generated, and the option with the highest score can be selected. The subjectivity that pervades assigning weights is generally a matter of concern in this approach. Therefore, the robustness of MCA approach depends not only on reliability of information used in the analysis, but also by the selection (inclusion of exclusion) of criteria, relative weights and scores given to selected criteria, and the degree to which an agreement is reached by the MCA team regarding weighting and scoring. Given the difficulties in reaching an agreement among stakeholders regarding criteria and their relative importance, various sensitivity analysis techniques exist to test for the robustness of MCA results to withstand scrutiny (UNFCCC 2011).

Another limitation in MCA is that it cannot indicate whether or not an option generates greater benefits than costs; and unlike CBA, there is no explicit condition that benefits should exceed costs. Therefore, similar to CEA, in MCA, the selected option may fail to improve welfare. However, MCA can also be combined with other assessment approaches such as CBA and CEA to provide a foundation for more informed decision-making (MOE/HCP 2013).

Nevertheless, MCA defines a framework to integrate different decision criteria in a quantitative analysis without assigning monetary values to all factors, thereby bringing a structure and transparency to decision-making (DCLG 2009). It accommodates consideration of both qualitative and quantitative information, and helps in the identification of strengths and weakness of each criterion (UNFCCC 2011). Furthermore, this approach benefits from representative stakeholder engagement, and allows beneficiaries of water management options to part-take in the selection of those options, creating a greater sense of ownership (UNFCCC 2011).

This approach also proves useful for Cambodia, where quantitative data are limited or unreliable, and where consideration of other criteria beyond economic efficiency and cost-effectiveness is crucial, for instance where social and ecological sustainability concerns need to be addressed (MOE/HCP 2012).

MCA is a relatively simple tool to grasp and use; however, the time, cost, and training required depends on the specific methodology used. Generally training required for MCA is minimal. All available MCA techniques rely on expert judgment to a certain extent. Input data for an MCA exercise depends on the criteria chosen for evaluation, and the indicators and metrics relevant for these criteria. The experience gained in applying this methodology for selection of various strategies will help in future application of this methodology in Cambodia.

4.3 ADAPTATION DECISION MATRIX

The Adaptation Decision Matrix (ADM) approach presents another option. This approach uses a decision matrix and MCA techniques to evaluate the relative cost-effectiveness of options for adaptation to climate change. Since adaptation can entail improving water use, distribution and allocation, ADM can find applicability in supporting water management. Cost measures are expressed as dollar figures, whereas benefits can be measured in a common metric, similar to MCA and CEA (UNEP and IVM 2009). This approach is also useful when important criteria for decision-making cannot be easily expressed in monetary terms.

Using this approach, the team generally defines criteria that will be used to evaluate adaptation options, and weight the criteria. Scenarios can also be used. Scoring is carried out to assess how well each selected criterion performs under a particular scenario for each decision option. Scoring can be based on either detailed analysis or expert judgment. Similar to MCA, scores are multiplied by weights and aggregated to determine which options best meet the selected criteria. The aggregated scores of all adaptation options are then compared to assess the relative cost-effectiveness of options.

Table 4.2 Assessment of Adaptation Decision Matrix (ADM) approach.

Corresponds to Cambodian needs and concerns	Yes. This approach is useful under the Cambodian context, where quantified/monetized data is not readily available, and consideration of multiple criteria (environmental, social, technical etc.) is important for decision-making.
Required input data exists and is accessible for Cambodia	Required data depends on adaptation objectives, criteria used, and the level of detail in research and analysis conducted. Detailed research and analysis may be required to provide a basis for evaluation of options against each criterion to reduce subjectivity in scoring.
Ease of use	Similar to MCA, this is a relatively easy tool to learn and use. A certain level of expertise is required for developing qualitative and quantitative estimates of how adaptation measures compare with regard to selected criteria, and estimating the cost of each adaptation measure. Comparing the cost-effectiveness of options requires that benefits are expressed in a common metric across all criteria. Developing cost-benefit estimates will require familiarity with results of existing impact assessments, potential changes in socio-economic conditions, current planning/investment plans, as well as relative cost-benefits of measures, implementation barriers, and other adaptation or mitigation policies.
Short learning curve	A user with an understanding of key policy objectives could learn this methodology within 1 to 2 days; however, additional training may be required to develop skills in estimating costs of adaptation measures.
Level of regional application	This tool has been applied in some countries in Asia (e.g., Pakistan, Kazakhstan), and remains a promising approach for developing countries, including least-developed countries such as Cambodia.
Level of global application	This methodology has been widely used by participants in the U.S. Country Studies and UNEP assistance programs (e.g., Kazakhstan, Cameroon, Uruguay, Bolivia, Antigua, Estonia, Pakistan and Barbuda).
Accessibility including training cost	There is no cost for obtaining documentation or diskette with template of the decision matrix. Additional training may be required to develop skill in estimating costs of adaptation measures.
Promotes stakeholder participation	This approach mainly relies on expert judgment, but provides scope for and benefits from the involvements of key stakeholders to define criteria and assign weights and relative scores.
Level of integrated and holistic approach	ADM allows for consideration of criteria other than simply economic and financial criteria, including social and environmental criteria.

Source: UNEP and IVM 1998; UNFCCC 2012

4.4 LIVELIHOOD SENSTIVITY EXERCISE

Livelihood sensitivity exercise is a sensitivity mapping exercise which allows for integration of existing knowledge about water insecurity with livelihood analysis (Garg et al. 2007; UNFCCC 2012). The exercise can be initially scoped through a rapid workshop breakout group, and eventually formalized using expert analysis, impact assessment models and historical observations.

The tool by nature promotes stakeholder participation, particularly at the scoping stage. The output of this exercise is a matrix with three blocks of rows – including ecosystem services (e.g., soil moisture), livelihood activities (e.g., crop production), and livelihoods themselves. Various development stresses (e.g., floods, droughts, windstorms, etc.) are considered in columns. Users fill out the matrix cells, rating the sensitivity of ecosystem services, livelihood activities, and livelihoods to a range of climatic hazards and stresses. Exposure across hazards and impacts across services, activities and livelihoods can be calculated as aggregate indices.

The tool can be more effective if it is accompanied by an estimation of the extent and level of sensitivity and impacts, particularly if it involves, for example, surveys that estimate the number of households sensitive to hazards (Garg et al. 2007).

Table 4.3 Livelihood sensitivity exercise.

Corresponds to Cambodian needs and concerns	Can be a useful tool for Cambodia to identify vulnerable livelihoods, and targeting strategies ➔ resiliency of particular livelihood strategies to climate change. Can be applied at the local/commune level, and for a single sector at any one time. The output is a ranking of vulnerable livelihoods and an overall livelihood sensitivity index.
Required input data exists and accessible for Cambodia	Much of input data on climate hazards, exposure, impacts, and livelihoods are available in Cambodia. However, climate change exposure-related data (both current data and future predictions) at the provincial, district, or communal levels are much more limited.
Ease of use	This index-based methodology for livelihood sensitivity exercise is relatively simple to use.
Short learning curve	While rapid workshop breakout groups can define the scope of the analysis, later stages require familiarity with rural livelihoods, expert knowledge elicitation, impact assessments and climate projections, vulnerability indicators etc.
Level of regional application	NAPA teams used it to identify and scope livelihood impacts of climate change.
Level of global application	Used in regional training workshops for the NAPA
Accessibility including cost	Free to obtain guidance notes and training documents for this exercise (NAPA workshops presentations and sample spreadsheets can be accessed at http://www.unitar.org/ccp/ and http://www.vulnerabilitynet.org..
Promotes stakeholder participation	Stakeholders are involved at the initial stage of this exercise to identify sensitivities, but results are later finalized through expert analysis.
Level of integrated and holistic approach	Can include a range of stakeholders, and combines participatory knowledge with scientific knowledge of impacts models, historical trends etc..

Source: UNFCCC 2012; Garg et al. 2007.

5.0 CONCLUSION

As decided during the 1st Technical Focus Group Meeting on 22 February, 2013, the following modeling tools and DSTs have been selected for the MK16: the Unified River Basin Simulation (URBS), Simplified EXCEL Spreadsheet or IQQM (with map interface), ISIS – 1D Hydrodynamic Model, the Water Evaluation and Planning (WEAP) and Multi-Criteria Analysis (MCA).

In April-June, 2013, the Project Team will meet to check, calibrate and validate the selected tools and to discuss the priority, needs, interface and synergy among them.

The tools and their results will then be discussed at the 2nd Technical Focus Group (scheduled for late April), and the 2nd MSP Meeting (scheduled for late August/early September, 2013).

6.0 CLOSURE

This is a work in progress. We trust the above information meets your requirements. If you have any questions or comments, please contact us.

7.0 REFERENCES

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