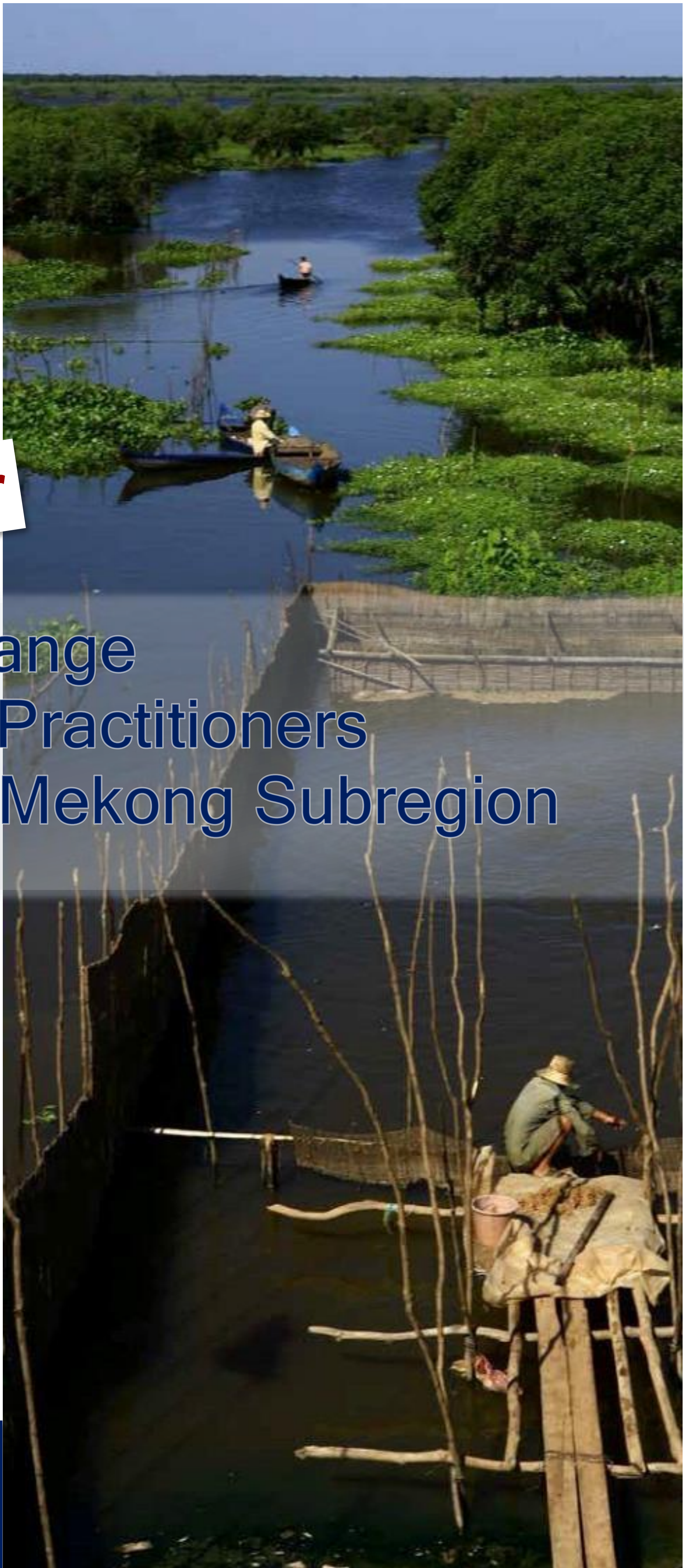
GMS Roundtable on Climate Adaptation

Guidelines for

Climate Change Adaptation Practitioners for Greater Mekong Subregion



Watershed-scale Vulnerability and Adaptation Assessments (W-VAA)

Working Draft
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Abbreviations

ADB	Asian Development Bank
AMDI	Asian Management and Development Institute
AMICAF	Analysis and Mapping of Impacts under Climate Change for Adaptation and Food Security Project
APN	Asia-Pacific Network for Global Change Research
ChaRL	Challenge and Reconstruct Learning Framework
DAI	Development Alternatives Inc.
FAO	Food and Agriculture Organization of the United Nations
GCM	Global Circulation Models
GIS	Geographic Information System
GMS	Greater Mekong Subregion
GMS CEP	GMS Core Environment Program
GMS-EOC	ADB's GMS Environment Operations Center
ICEM	International Centre for Environmental Management
IGES	Institute for Global Environmental Strategies
IPCC	Intergovernmental Panel on Climate Change
ISET	Institute for Social and Environmental Transition
IUCN	International Union for Conservation of Nature
KU	Kasetsart University
LAO PDR	Lao People's Democratic Republic
LEAP	Long-Range Energy Alternatives Planning System
LDD	Thailand's Land Development Department
M&E	Monitoring and Evaluation
M-BRACE	USAID Mekong-Building Resilience to Climate Change in Asian Cities
MCA	Multi-criteria Analysis
MERFI	Mekong Region Futures Institute
MerSim	Mekong Region Simulation
MOSAICC	Modelling System for Agricultural Impacts of Climate Change Tool
NGO	Non-Government Organization
NRCT	National Research Council of Thailand
PERDO	Thailand's Science and Technology Postgraduate and Research Development Office
PRC	People's Republic of China
RDS	Robust Decision Support
RU	Ramkhamhaeng University
SDF	Sustainable Development Foundation
SEA START RC	Southeast Asia START Regional Center
SEACAM	Southeast Asia Climate Analyses & Modeling Project
SEI	Stockholm Environment institute
SIEP	Sirindhorn International Environmental Park
SLDs	Shared Learning Dialogues
SUMERNET	Sustainable Mekong Research Network
TEI	Thailand Environment Institute
TRF	Thailand Research Fund
USAID	The United States Agency for International Development

USAID Mekong ARCC	USAID Mekong Adaptation and Resilience to Climate Change
USDA	United States Department of Agriculture
USFS	United States Forest Service
VAA	Vulnerability and Adaptation Assessment
W-VAA	Watershed Vulnerability and Adaptation Assessment
WACC	Watershed-based Adaptation to Climate Change
WEAP	The Water, Evaluation and Planning Model
WFP	The United Nations World Food Programme
WRI	World Resources Institute

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Figures and Tables

Acknowledgements

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The GMS Roundtable on Climate Adaptation

The Greater Mekong Subregion (GMS[1]) Environment Operations Center (EOC) of the Asian Development Bank (ADB) initiated roundtable discussions in March 2013 to (1) bring together organizations working on climate change vulnerability and adaptation assessments (VAAs) in the Mekong region, (2) take stock of ongoing initiatives, and (3) exchange experiences and lessons learned. The Roundtable partners are primarily international development organizations and research institutions working on sustainable livelihoods, natural resources management, and climate change planning in the GMS. The Bangkok-based Climate Adaptation Roundtable consists of:

- GMS Environment Operations Center (EOC) of the Asia Development Bank (ADB)
- The International Union for Conservation of Nature (IUCN)
- Mekong Region Futures Institute (MERFI)
- USAID Mekong Adaptation and Resilience to Climate Change (USAID Mekong ARCC) program
- United States Forest Service (USFS)
- Institute for Global Environmental Strategies (IGES)
- Thailand Environment Institute (TEI)
- Stockholm Environment institute (SEI)
- SEA START (or Southeast Asia (Global Change) System for Analysis, Research and Training Center)
- Food and Agriculture Organization (FAO) Regional Office for Asia and Pacific

These regional guidelines on Watershed-scale Vulnerability and Adaptation Assessments (W-VAA) are the product of a multi-year collaboration among the institutions listed above working in partnership as the GMS Climate Change Adaptation Roundtable. These guidelines synthesize the shared knowledge and experience of the Roundtable partners in developing frameworks for and implementing VAAs in the GMS over the past decade. Specifically, these guidelines incorporate direct experience from recent projects that use a watershed as an organizing element for climate change VAA.

International Union for Conservation of Nature

The International Union for Conservation of Nature (IUCN) helps the world find pragmatic solutions to our most pressing environment and development challenges. IUCN's work focuses on valuing and conserving nature, ensuring effective and equitable governance of its use, and deploying nature-based solutions to global challenges in climate, food and development. IUCN supports scientific research, manages field projects all over the world, and brings governments, NGOs, the UN, and companies together to develop policy, laws, and best practice.

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[1] The GMS refers to Cambodia, the People's Republic of China (PRC), specifically Yunnan Province and Guangxi Zhuang Autonomous Region, Lao People's Democratic Republic (Lao PDR), Myanmar, Thailand, and Viet Nam. The GMS is a natural economic integration area linked not only through the Mekong River, but also by growing transport connectivity, cross-border trade and investment, and labor mobility. While Yunnan and Guangxi are not located in the Mekong River Basin, they are part of the GMS regional integration due to transport, trade, social and cultural connectivity.

IUCN is the world's oldest and largest global environmental organization, with more than 1,300 government and NGO Members and around 16,000 volunteer experts in some 160 countries. IUCN's work is supported by over 1,000 staff in 45 offices as well as hundreds of partners in public, non-government organizations (NGOs), and private organizations around the world.

Mekong Region Futures Institute

The Mekong Region Futures Institute (MERFI) aims to effectively contribute to evidence-based decision-making that leads to more sustainable policy outcomes in the GMS. MERFI's highly participatory assessments combine climate adaptation and development strategies with household perceptions of hazards and their willingness and capacity to adapt. Climate vulnerability and adaptation assessments have been conducted at the watershed scale for various basins across the Mekong region. These assessments combine dynamic interactions of hydrological, economic, and livelihood related processes to better understand how vulnerabilities shift, land use changes, migration occurs, and poverty patterns change.

USAID Mekong Adaptation and Resilience to Climate Change

The United States Agency for International Development (USAID)'s Mekong Adaptation and Resilience to Climate Change (USAID Mekong ARCC) project was a five-year program (2011-2016) funded by the USAID Regional Development Mission for Asia. The key objective of the project was to assist highly exposed and vulnerable rural populations in ecologically sensitive areas of the Lower Mekong Basin (LMB) in strengthening their capacity to adapt to projected climate changes and impacts on water resources, agricultural and aquatic systems, livestock, and ecosystems.

The project began by downscaling climate science models and identifying the environmental, economic, and social effects of climate change across the LMB. Given the top-down nature of scientific projections, the USAID Mekong ARCC team sought inputs from communities to validate recent shifts in weather patterns and prioritize adaptation strategies that best address their needs in a sustainable fashion. After establishing a framework to connect science, local impacts, and decision-making, the project supported community implementation of adaptation plans that benefited close to 30,000 rural people and became a valuable evidence base of tested adaptation measures potentially of relevance across rural areas of the LMB. Development Alternatives Inc. (DAI) implemented the project in partnership with the International Centre for Environmental Management (ICEM), World Resources Institute (WRI), International Union for Conservation of Nature (IUCN), Asian Management and Development Institute (AMDI), and the United Nations World Food Programme (WFP).

US Forest Service

The US Forest Service (USFS) has over a century of experience in domestic and international forestry and natural resource management. Drawing upon the diverse expertise of its 37,000 specialists, the USFS provides technical assistance internationally on a wide range of issues including forest management, biodiversity conservation, climate change adaptation and mitigation, and watershed management. Internationally, the agency works in close cooperation with other US agencies, including USAID and the US State Department; multilateral institutions such as the World Bank and FAO of the United Nations; and nongovernmental organizations, universities, and host country governments in over 90 countries.

The USFS has conducted climate change vulnerability and adaptation assessments in many of the watersheds across the 78 million hectares of land under the agency's management. The USFS also has contributed to assessments internationally including the Watershed-based Adaptation to Climate Change (WACC) project in Thailand. Lessons from the integrative approach applied in USFS assessments are incorporated in these guidelines.

Stockholm Environment Institute

The Stockholm Environment Institute (SEI) is an independent international research institute engaged in environment and development issues at local, national, regional, and global policy levels for more than a quarter of a century. Since its establishment in 1989, SEI has developed a reputation for rigorous and objective scientific analysis in the field of environment and development. SEI's goal is to bring about change for sustainable development by bridging science and policy. We do this by providing integrated analysis to support decision makers.

The SEI Centre in Asia is registered in Thailand as an international nongovernment, nonprofit organization. SEI Asia hosts the Sustainable Mekong Research Network (SUMERNET) Secretariat and plays a coordinating role for research granting, capacity building (through mentorship), reviewing products, and disseminating the work of network partners. SUMERNET is an initiative for research and policy engagement bringing together research partners working on sustainable development in the Mekong Region. Since 2005, it has established a successful and expanding regional research network of 68 member institutes with expertise in several policy areas critical to sustainability.

Thailand Environment Institute Foundation

The Thailand Environment Institute Foundation (TEI) is a non-governmental think tank based in Bangkok, Thailand, which focuses on scientific and policy issues in Southeast Asia, especially environmental issues and the conservation of natural resources. Founded in 1993, TEI advocates a participatory approach to shared environmental responsibility, and works closely with a range of organizations and local communities to link policy with action to encourage environmental progress in Thailand and across the Mekong region.

TEI has been a lead actor in supporting urban climate resilience, working with a network of secondary cities across Thailand. TEI also was a lead partner for the USAID-funded Mekong Building Climate Resilience in Asian Cities (M-BRACE) project, and the country lead for the Rockefeller Foundation Asian Cities Climate Change Resilience Network (ACCCRN). TEI partnered with the US Army Corps of Engineers (USACE) Institute of Water Resources in the development of shared vision planning (SVP) approaches to building urban resilience. TEI is the regional lead for the IDRC/SSHRC-funded Urban Climate Resilience in Southeast Asia (UCRSEA) partnership in collaboration with the University of Toronto, and partners in the region.

Southeast Asia START REGIONAL CENTER

The Southeast Asia START Regional Center (SEA START RC) is the regional hub for the Global Change System for Analysis, Research and Training (START) network established in collaboration with the International START Secretariat, the National Research Council of Thailand and Chulalongkorn University, Thailand. SEA START RC's main goal is to promote research-driven capacity building to advance knowledge on global environmental change in Southeast Asia. This is accomplished through research grants and fellowships, knowledge assessments and syntheses, curricula development, advanced training institutes, multi-stakeholder dialogues, and place-based strategic planning. SEA START RC's actions target science, as well as the interface of science, policy and practice, and inform actions toward fostering more resilient and adaptable development.

Executive Summary

The Mekong River Basin is renowned for its physical, biological and cultural diversity. Its native habitat alone routinely garners international headlines proclaiming new species discovered annually. For each one of these reports, however, are countless more stories about uncertainty, not just for the Basin's ecology, but the exposure the societies of this six-nation region face to climate change — exposure forecasted to be amongst the most extensive across the globe.

What is not being reported, however, is a new form of diversity that is rapidly evolving in response here. It is top-down and it is bottom-up. It is village elders pairing off with industry executives. It is old-school, sandals-on-the-ground surveys meet supercomputer models. It is an interdisciplinary, inter-sectoral and intently interactive planning movement being led by a diverse set of stakeholders pioneering diverse approaches and tools with one goal in mind: strengthen the region's capacity to reduce climate change risk through the creative application of what is called Watershed-scale Vulnerability and Adaptation Assessments (W-VAA).

Authored by the Greater Mekong Subregion's Climate Change Adaptation Roundtable, this document represents a natural iteration of these efforts. The Guidelines herein are a coalescence of the knowledge and experience of its members, distilled in a fashion to help facilitate W-VAA uptake in the Mekong region and beyond. The aim is to provide a consistent, yet flexible approach to W-VAA that practitioners from local governments, international and local organizations, and local communities can utilize to improve the effectiveness of their climate change adaptation planning. These guidelines are presented in four chapters.

Chapter 1 introduces W-VAA's by first charting its evolution from the limitations of earlier vulnerability and adaptation assessment (VAA) frameworks and identifies how W-VAAs fill critical gaps inherent to those approaches. The chapter then outlines why framing these efforts in the watershed perspective is critical, stressing that since watersheds are nature's units of ecological and landscape organization, which have historically guided human settlements and their economic activities, watersheds are ideal units of analysis for understanding the interplay of socioeconomic and ecological considerations in the face of climate change. The chapter concludes by elaborating further on the types of practitioners and stakeholders who should consider incorporating W-VAA into their climate change planning efforts.

Chapter 2 lays out a set of Seven Principles the Roundtable has concluded are critical to guiding the formulation, implementation and evaluation of an effective W-VAA process. These are: a focus on policy-relevant products, a clearly defined scope, embracing complexity and uncertainty, be participatory and reinforce the importance of local consensus, include opportunities for learning and reorganization, and embed monitoring and evaluation plans.

Chapter 3 outlines Five main Process Steps for conducting a W-VAA. These are: understanding the assessment context, particularly the decision or policy it is intended to influence; evaluating baseline vulnerabilities; identifying and evaluating adaptation options; integrating adaptation options into local plans, and evaluating the effectiveness of the approach. The remainder of the chapter provides a suite of seven replicable examples of how W-VAA is being implemented in the Mekong region. Each example contains references that illustrate specific W-VAA Principles and Process Steps.

Chapter 4 presents a wide range of qualitative and quantitative tools that W-VAA practitioners can employ in conducting their assessments. While the principle output for these tools is gathering and evaluating information on climate change, vulnerabilities and adaptations options, many of the tools also help to reinforce public participation, consensus building and the importance of local leadership in driving the process and its outcomes.

Lastly, these Guidelines and W-VAA are a work in progress. Represented here is the state of the art as W-VAA is playing out on the ground in the Mekong Region. The Roundtable looks forward to the continued evolution of W-VAA techniques through incorporation of future lessons learned and the resultant growth in the basin's capacity to make more effective, long-term decisions that minimize climate change risk and maximize resilience for the Mekong Region's complex social-ecological system.

CHAPTER 1: INTRODUCTION

Mekong River Basin countries face some of the highest levels of climate change risk in the world. Extreme weather events, the primary way most people experience the effects of climate change, are already taking their toll in the region. Over the past two decades, losses from floods, droughts, heat waves and severe storms in the Mekong basin dwarf those incurred throughout much of the rest of the world (Kreft et al. 2015). This pattern will only worsen unless actions are taken to develop response strategies to reduce climate change-induced ecological and socioeconomic losses.

The first step toward furthering basin-wide development gains during this era of climate change is to embrace more robust, participatory and integrated planning processes that anticipate vulnerabilities and identify adaptation opportunities to minimize them. Called vulnerability and adaptation assessments or VAAs, these structured, though flexible, processes explore vulnerability across all aspects of the socio, economic and ecological condition. From individuals to communities, infrastructure to industry, environment to ecological services, both climate and non-climate risks are identified and adaptation response strategies are explored and prioritized. Most importantly, a VAA process becomes an integral component to planning efforts, policy formation, and investment decisions.

A growing body of knowledge and practice in climate change planning is now evolving across Mekong River Basin countries. International development organizations, national and regional agencies, as well as local communities have begun applying VAA principles and producing valuable assessment. Nonetheless, VAA's full rewards have yet to be realized nor is its uptake in the region keeping pace with the rising risks inherent to climate change. Efforts must be made to overcome key shortcomings in VAA practices in the Mekong River Basin, otherwise the society and the ecology that sustains it will fall further out of balance.

First, outcomes must be used to inform policymaking and planning. Too often VAAs are undertaken as stand-alone exercises, with findings bound in reports that are seldom acted upon.

Second, resources must be devoted to monitoring and evaluation. Like planning, VAA is not a one-time activity, but an ongoing process that requires continuous appraisal and review to ensure its long-term impact and success.

Third, a VAA's scope must be comprehensive and interdisciplinary. Presently, the majority of VAAs focus on individual economic sectors or on risks to physical infrastructure. To be most effective, however, VAAs must embrace the complexity of the social-ecological interactions at play, otherwise their findings may overlook key drivers causing future risk and fail to develop responses necessary to manage them.

What's different about Watershed-scale VAAs?

Fundamentally, responding to climate change entails responding to the ecological changes brought about by a warming atmosphere. Since ecological change follows the rules and pathways of nature's landscape, indifferent to the political and administrative borders societies places upon it, it is critical that the frame of reference for VAAs reflect the ecological boundaries that drive the changes society will experience.

Watersheds are how nature breaks up the landscape. These are unique areas of land, where all precipitation that falls upon it drains into a common outlet. Watersheds can be as large as the Mekong Basin or just a component thereof, such as the Tonle Sap in Cambodia. Every home, community and nation belongs to a watershed. Watersheds have long guided human settlements and economic activities because of the high value of water and the many ecosystem services that their waters provide.

The importance of watersheds as the basis for integrated planning is well established, and is recognized in international agreements and at national level policy. Moreover, major climate change risks, such as water availability, groundwater recharge and flooding are all determined by watershed boundaries. These ecological changes impact many of the socioeconomic drivers of climate vulnerability. Watersheds represent the highly interconnected systems operating over large spatial areas within which a set of critical dependencies link communities together and to the natural landscape.

Watershed-scale vulnerability and adaptation assessments (W-VAA) address these challenges by explicitly integrating information across components of the socioecological system of interest, identifying linkages between natural landscapes and human systems, operating over large spatial scales, and using watersheds as an organizing element. When undertaking W-VAA, watershed boundaries need not comport to strict hydrological definitions, but rather ensure the spatial area chosen reflects the set of critical dependencies linking communities together and to the natural landscape.

W-VAAs are based on engagement of partners representing a range of economic sectors, non-governmental organizations, government organizations, and ecological interests as well as on explicit consideration of complex relationships inherent in socioecological systems. W-VAA outcomes typically articulate not one, but multiple visions of the future, in order to reflect the uncertainty inherent in such complex interconnected systems. Building on concepts and approaches that underpin integrated water resource management (IWRM), W-VAAs can enable further uptake of IWRM as a response to climate change. W-VAAs can also mobilize climate finance opportunities for the Mekong region. International climate donors have demonstrated a strong willingness to fund adaptation projects which adopt ecosystem-based approaches and which transcend administrative boundaries.

Who should use these guidelines and how?

Any stakeholder interested in advancing climate change resilience in the Mekong Basin will gain insight from the materials contained herein, but the contents of these pages will be particularly meaningful to practitioners working for governments, river basin organizations, and community-based organizations within the Greater Mekong Subregion (GMS). These guidelines are intended to help practitioners properly scope

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Rain-fed rice fields in Kok Klang village, Sakon Nakhon Province, Thailand. (Photo: USAID Mekong ARCC)

CHAPTER 2

Principles for Conducting Watershed-scale Vulnerability and Adaptation Assessment (W-VAA)

Watershed vulnerability adaptation assessments can take many forms: differing in scale, objectives and outcomes. Common to them all, however, are a set of seven guiding principles. Though specific to W-VAAs, these principles are similar in purpose and intent to the types of international standards and best practices routinely found guiding participatory planning and social and environmental assessment processes. These W-VAA principles are intentionally broad, generic, and non-prescriptive, and are applicable regardless of the governance and management structure the W-VAA is intended to inform. Practitioners and stakeholders should use these principles as a compass they can regularly refer back to so as to reinforces their shared purpose in undertaking a W-VAA, and the elements necessary to deliver a high-quality and effective product.

Principle 1: Focus on informing decisions

While much of work undertaken for W-VAAs involves fact-finding and scientific analysis, it is understood that these efforts are not undertaken strictly for intellectual pursuits. The main objective for those involved is the delivery of the best information and recommendations to aid decision-making across a watershed. Therefore, identifying the relevant decision-space and engaging decision-makers at the outset is vital to a W-VAA's effectiveness.

Such identification can be rather complex, as decision-making within a watershed happens at multiple levels. For example, villages, communities, and local authorities may be restricted to incremental decisions that reduce their individual and collective vulnerabilities in the face of a changing climate, but they are the ones most knowledgeable about how policies from above may or may not prove effective. Provincial and national governments are capable of making wide ranging planning decisions with long-term implications, which in some cases may intersect with regional platforms and transboundary alliances.

Principle 2: Adhere to a well-articulated scope

W-VAAs are restricted in their level of detail largely due to time and resource constraints. It is therefore important to define clearly the issues and questions the W-VAA will consider — and equally important, those which must be set aside or ignored. What and whose vulnerabilities are to be assessed, and why; what are the geographical parameters; what components of the socio-ecological system must be evaluated; where will data come from; and over what timeframe will the analysis be conducted? These are core questions W-VAA scoping should consider.

Similarly, the specific decision(s), and associated decision-making processes, to be informed by W-VAA findings and recommendations must be identified. Additionally, this decision-making space likely contains multiple agencies that have existing plans and policies that can inform on, and may be informed by, the W-VAA process.

Defining the scope of stakeholder interests that should take part is also critical. Within the watershed context there are many stakeholders: community members, government-line agency staff, decision-makers, practitioners, non-governmental organizations, industry associations, investors and researchers. Successfully articulating and clarifying the range of values and preferences from such a broad range of interests is challenging, but essential. Ultimately, these are the individuals who will need to make tough choices and come to agreement on the scope of an assessment that is feasible and worthwhile. Therefore, along with the choices made to frame the issues driving the W-VAA, identifying the stakeholders to be engaged must be made strategically and explicitly.

Assessment team considers scope of W-VAA assessment and geographic and socio-economic complexities of Phetchaburi watershed near one of several reservoirs in Phetchaburi Province, Thailand (Photo: US Forest Service)

Principle 3: Consider the complexities of socio-ecological systems

Watershed boundaries determine the physical conditions for many ecological processes that contribute to human well-being. Clean water, fertile soil, biodiversity and flood-regulating forests are just some of the services watershed ecosystems provide. For example, forest, agricultural and industrial practices upstream impact river flows and the quality and quantity of water for communities downstream. Meanwhile, economic development downstream with associated transportation infrastructure triggers human migrations and resource extraction upstream. Such basic relationships represent just the beginning of the complexities W-VAAs must recognize to effectively assess vulnerabilities and adaptation strategies. Downplaying or ignoring complexity leads to maladaptive investments, which can increase rather than decrease vulnerabilities over the long-term.

Once these complexities are outlined, W-VAA practitioners face another challenge: gathering the data to accurately explain them as well as the tools to evaluate their collective impacts on the watershed's social-ecological system. Moreover, while increasingly sophisticated tools are being developed that incorporate the complex relationships within a watershed, the data requirements are often well above what is available in target GMS countries.

Complexity also exists amongst the multiple levels of governance and multiple economic sectors operating within a watershed. These interests and values vary and compete, whether between levels of governance, sectors of the economy or both. Accounting for these interactions is critical to evaluating how vulnerabilities are perceived and acted upon.

Principle 4: Embrace and communicate future uncertainties and risks

Stripped to its core, a vulnerability assessment is about managing risks in uncertain futures, and W-VAAs are no different. For generations, society has become all to familiar with planning processes that detail specifics on a desired future and how various sectors of society may organize themselves to realize it. This is particularly true for infrastructure, such as transportation, energy and water supplies. Uncertainties surrounding climate change has demonstrated that this straight-line approach to planning is impractical, as the uncertainties surrounding climate change impacts grow with each new forecast published. Moreover, forecasting future global climate conditions is immensely challenging, and their results constantly changing. Furthermore, downscaling results from global models to particular locations and time-scales is even more difficult and error prone.

Therefore, instead of developing action plans for specific future conditions, suites of scenarios should be developed that encompass a range of outcomes. At minimum these should include scenarios that reflect a probable case, a best case and a worst case. Using scenarios and shared vision planning processes, rather than blueprints, can help society better understand uncertainties and risks as well as develop actions that do not undermine abilities to make adjustments should reality deviate from predictions.

W-VAAs must also carefully consider uncertainty when defining vulnerabilities. In the GMS, where strong economic development persists, current conditions and near-term trajectories for change can create and exacerbate risks. Development patterns, economic growth, migration, changing demographics, and shifting land use all carry with them particular unknowns. And the risks surrounding their associated vulnerabilities become even more uncertain when factoring in climate change variables. Making development decisions that are both effective now and in the future requires that we identify and quantify multiple uncertainties, include mechanisms for regularly updating information, and make information accessible to stakeholders in meaningful ways.

In conjunction with scenario development, another tool W-VAA practitioners may find useful for characterizing risks is the use of thresholds or tipping points. Such strategies reinforce the understanding that other scenarios are necessary if a particular threshold is crossed. Regardless of the tools employed, the emphasis in W-VAAs should be on understanding and embracing the uncertainties associated with climate change; identifying ranges of possible outcomes and visions for the future and recommending ways to build resilience to the inevitable changes, shocks, and potential crises that lie ahead.

Principle 5: Ensure a participatory approach

Climate change adaptation is local, as adaptation is place and context-specific. So no single adaption approach can be effective across all or even many settings. Therefore, the best adaptation options accurately reflect societal choices at their local levels of implementation. Such accuracy can only be obtained through strong participatory processes that fill information gaps by integrating local knowledge with expertise and understanding from the outside.

What is local is relative. Village or neighborhood planning is local to communities, which in turn are local to cities, and cities to provinces, etc. Each geographical area, regardless of size, knows their situation best, and should structure participation accordingly from both the top down and the bottom up. This is particularly true of W-VAAs, which are often large-scale assessments that straddle administrative boundaries and include many communities.

Since the range of issues communities face may not overlap, it is important that all communities understand the needs and concerns of their neighbors, as they will need to find common ground to utilize collective resources of the W-VAA process to develop collective outcomes that work best for all. In so doing, communities themselves must ensure participation reflects their own diversity. They must incorporate the perspectives of multiple stakeholders when seeking information inputs, engaging in process discussions, and working on joint visualization of future scenarios. The more diverse the stakeholder base, the more diverse and robust the knowledge on which the W-VAA can be built.

Where watersheds are home to indigenous peoples who, for many generations, have used and managed the landscape for their livelihoods, their participation provides a venue to continue the stewardship that has been an important aspect of their culture. Participatory approaches also ensure transparency in how stakeholders negotiate trade-offs and in treatment of the inevitable winners and losers for particular sets of adaptation decisions. Finally, participatory W-VAAs generally lead to greater ownership in the implementation and monitoring of adaptation strategies and help strengthen capacity of all stakeholders, including institutions and practitioners. That increased capacity can then enable replication of the W-VAA process in new places and contexts within the region.

A community leader explains key watershed features during one of several participatory meetings in the Petchaburi watershed assessment, Petchaburi Province, Thailand. Credit: USFS

Principle 6: Increase social capacity to reorganize in the context of risk

The risks and vulnerabilities evaluated in W-VAAs are unlikely to disappear entirely should the assessment's recommendations be fully implemented. They may even get worse should forecasts prove inaccurate or implementation too lax. Moreover, new risks and vulnerabilities will likely emerge over time that were either unknown or deemed inconsequential during the W-VAA process. It is therefore critical that W-VAA processes reinforce that they are not one-time exercise, but iterative. Mechanisms need to be established to continuously assess changing patterns of vulnerability, and changing social perspectives on risks assigned to that vulnerability.

Because climate-related vulnerabilities and impacts differ by location, land-use patterns, economic activity, wealth, ethnicity, and gender, the mechanisms to regularly assess risks and risk thresholds need to be sufficiently local and participatory. What constitutes acceptable risk thresholds are determined by values and interests, and these are not always shared across stakeholders nor consistent over time. It is incumbent upon W-VAA practitioners to instill the need for stakeholders to continuously revisit and reassess vulnerabilities.

Creating such opportunities requires institutional leadership to continue to bring diverse stakeholders to the table. There are many tools and examples of how to construct multi-stakeholder dialogues to address complex, multi-scale environmental and social policy challenges while allowing stakeholders to learn from each other and from the assessment process. Long-term resilience requires the ability to learn and reorganize in the face of changing circumstances, and shifting patterns of shocks and crises. This is why W-VAA processes need to include plans for continued discussion and innovation based on evolving scientific and local knowledge, new understandings of climate change and refined estimates of specific risks and associated uncertainty.

Principle 7: Monitor, evaluate and learn

Regardless of how ideal, robust or embraced are the adaptation measures developed through any particular W-VAA process, reduced vulnerability and resilience is not guaranteed. Even as the adaptation measures are implemented, many uncertainties will remain. This is why long-term adaptation effectiveness requires management that itself adapts through ongoing learning. This learning, however, can only be realized if a strong monitoring system is conceived through the W-VAA process and implemented accordingly. This monitoring has the added benefit of further building local ownership, as communities will continue to be engaged, enabling them to react more quickly to changing circumstances.

Establishing effective monitoring and evaluation plans includes setting baselines and defining the indicators to measure short and long-term progress. At its most basic level, such metrics should include tracking exposure and sensitivity and highlighting unresolved impacts of climate change. Social systems can be evaluated by examining agency preparedness or movement toward revised water management plans. Data on ecological conditions too can be valuable: air and water temperature, water quality and availability, forest growth and flood frequency.

All required qualitative and quantitative metrics need to be well defined with clear collection procedures. They must be understood by all those involved, not just practitioners. The number of metrics should be manageable and the data for each metric should be easily obtainable on an ongoing basis. Where possible, monitoring plans should leverage existing data sets and they should also dovetail with other monitoring and review processes, particularly those occurring at the national level.

Monitoring and evaluation activities should be designed to also function as a participatory learning experience, or Monitoring, Learning and Evaluation (MLE) program. Here, monitoring and evaluation is not merely a practitioner exercise, but engages key stakeholders in a co-learning atmosphere that also fosters greater cooperation and information sharing within and across the agencies leading the evaluation process. Such collective learning strengthens capacity to advance adaptation actions across a wide range of situations.

CHAPTER 3

Processes for Conducting Watershed-level VAAs

3.1 Process Steps

There are five core steps that are common to W-VAAs. While the exact sequence practitioners may choose to order these steps depends on a particular W-VAA's context and goals, each step will need to be accounted for to bring an W-VAA process to a successful conclusion. Figure 1 highlights these steps in the sequence in which they are most commonly followed, after which each step is discussed in greater detail. Finally, a set of case studies is presented that illustrate how the W-VAA principles of Chapter 2, and the Process Steps laid out here, have been put into action.

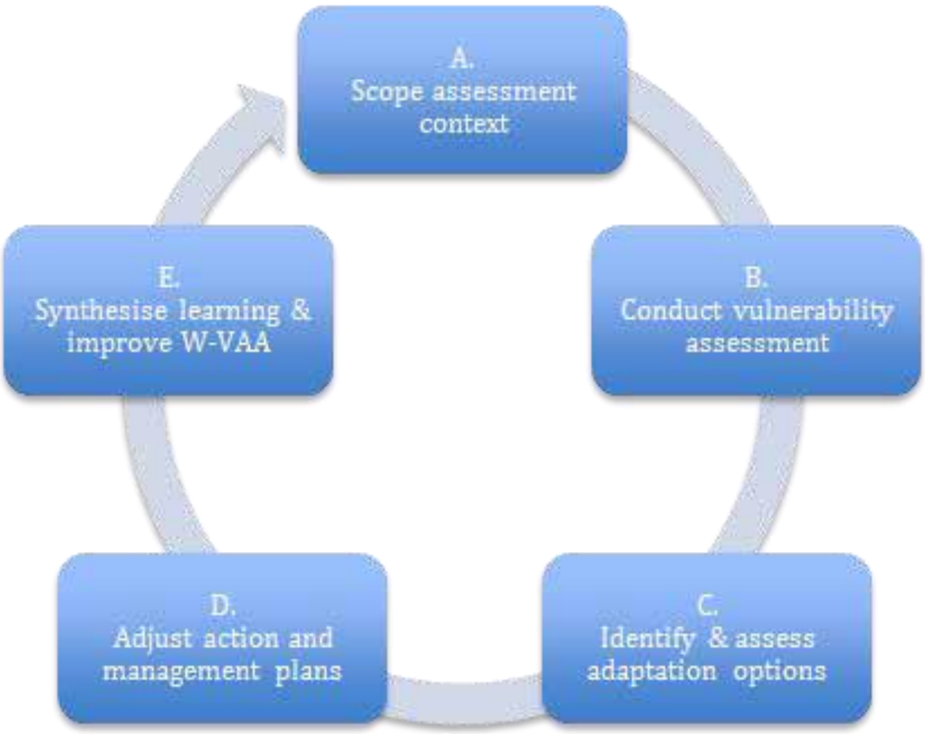


Figure 1: Principal Process Steps of W-VAA

Step A: Scope the assessment context

Purpose: Gain an in-depth understanding of the bio-physical, socio-economic and governance related context, including the identification of key stakeholders.

Actions: This step typically combines three types of activities.

First, the assessment team compiles a dataset describing the most critical characteristics of the watershed, including:

- Physical description of watershed boundaries, land-use, topography, surface water flow, groundwater stores, soil types;
- Historic and projected climate data especially precipitation and temperature;
- Ecosystem services and their values such as food, fresh water, medicine and raw materials;
- Social, demographic and economic data including population, ethnicity, cultural traditions, income levels, livelihoods, natural resources use, and
- Governance, both formal in terms of administrative and political structure, and informal through participation of non-governmental organizations, associations and related stakeholders.

The synthesis of these data should aim to develop the best understanding of the state of the watershed in social, ecological, physical, institutional and economic terms. Therefore, practitioners should strive to obtain data of sufficient detail and quality such that a high-resolution understanding of processes and diversity within the watershed is obtainable. The data may be both qualitative and quantitative, with any known uncertainty surrounding a particular data set made explicit.

Second, stakeholders need to be identified and an engagement process undertaken with them to elicit their aspirations, goals, and concerns. Increasingly, practitioners conduct visioning exercises about possible futures to facilitate dialogue across the wide range of interests represented by individuals, community groups and public and private stakeholders. This process should produce a list of climate change related concerns and a list of expectations stakeholders have for W-VAA outcomes. The engagement process should then identify the specific decisions that the W-VAA aims to influence and where within the governance process those decisions are made.

Third, finalized the scope of the assessment ensuring that sufficient baseline spatial, social, economic and ecological parameters are assessed to reflect the range of vulnerability concerns derived from stakeholder inputs.

Fourth, outline a monitoring and evaluation (M&E) protocol based on stakeholder expectations along with the decision-making and planning context specific to the watershed. This should include at least three components: assessing the W-VAA's impact on decision-making; quantifying resultant changes in vulnerability, and lastly, a mechanism to improve learning amongst stakeholders in the principles behind the assessment process and its methodology. To help improve on the W-VAA approach and realize lessons learned, baseline data should be collected during this step.

Box 3.1: Key questions to ask in determining the scope of a watershed-scale vulnerability and adaptation assessment

- What decisions is the W-VAA aiming to influence? Who are the decision-makers?
- Whose vulnerability is the W-VAA trying to assess?
- What policies and plans are being or will be implemented in the watershed that may have implications in the long term?
- Who will be involved in the assessment process?
- What sorts of future change will be considered and how will predictions of change be estimated?
- What physical terrain will be considered by the W-VAA?
- Which ecological components of the system will be considered and how?

Step B: Conduct baseline vulnerability assessment

Purpose: Develop the baseline assessment of climate related vulnerabilities.

Actions: This step typically consists of four activities.

First, assess the exposure of stakeholders to climate change factors by utilizing the combined knowledge of climate forecasts, biophysical dynamics and socio-economic projections. For instance, climate data might suggest spatial and temporal changes in rainfall patterns. Considering land cover and geology, such as hill slopes, this increased precipitation might result in greater flooding exposure. However, if a reservoir exists, or is planned, that captures this runoff, actual exposure may be less.

Forecasts based on Global Circulation Models (GCM) are essential to vulnerability assessments. First, the Intergovernmental Panel on Climate Change (IPCC) provides standardize scenario assumptions that calibrated to GCM findings. These various scenarios, from business-as-usual carbon emissions to extreme conservation and appropriate technology uptake, provide a common framework from which to evaluate adaptation needs and potential. Second, GCM results are routinely used to feed localized (downscaled) climate models that in turn generate localized predictions for future climate. Forecast climate data may then be fed into hydrological models to estimate future changes in surface water flow, erosion, sediment flux and other important physical indicators.

Second, evaluate sensitivities. Sensitivity relates to the degree to which ecological and socio-economic systems are impacted by climate-related hazards such as droughts, floods and extreme heat. For example, if no settlement and no agriculture exists in an area that is exposed to an increased chance of flooding, the actual sensitivity is likely to be low. Conversely, a 3°C increase in maximum temperature at high altitudes might transform glacier landscapes, thus causing high sensitivity. However, that same 3°C increase at lower altitudes might only marginally affect productivity of prevailing crops, indicating low sensitivity. This relative exposure evaluation needs to be applied to each climate change hazard as it pertains to each of the concerns (indictors) raised by stakeholders. Some typical indicators are: crop productivity; livelihoods, forest condition, poverty, human migration, water quality and quantity, flood risk and biodiversity.

Third, assess the society's adaptive capacity. Adaptive capacity refers to the ability of the social system to adapt to stresses to which it is exposed and to continue to maintain its well being. Adaptive capacity can exist at the level of individuals, households, communities as well as the watershed as a whole. Households, for instance, might alter crops or other aspects of the agricultural system if productivity is expected to decline. Communities can invest in an irrigation scheme if dry seasons are projected to lengthen. At the watershed scale, re-forestation initiatives could be implemented to reduce flood risk and erosion or a water conservation campaign could be implemented basin-wide.

Fourth, coalesce exposure, sensitivity and adaptive capacity to determine vulnerability at all relevant scales of the system: household, community, municipality and watershed. This synthesis can be articulated both quantitatively and qualitatively.

Step C: Identify, assess and prioritize adaptation options

Purpose: Generate a list of adaptation options, and for each options produce an assessment of how vulnerabilities are likely to respond.

Actions: With scientific and other baseline information in hand, and identification of vulnerabilities completed, adaptation options can be deliberated and agreed upon. These options can be: resource specific including forest, wildlife or water; geographically specific including villages, communities, sub-drainages, flood plains, and sector specific including energy, agriculture, transportation, or some hybrid appropriate to the context and stakeholders involved.

Each option must then have its relevant exposure, sensitivity, and/or adaptive capacity explained in a fashion similar to the general assessment conducted in Step B above. For consistency sake, the same methodology should be employed as in the baseline assessment. Once estimates of vulnerability are created for each adaptation option, the effectiveness of each can be estimated through comparison with the baseline vulnerability. Each option's effectiveness estimates can be evaluated with its associated cost estimates to determine their relative efficiency. Cost estimates should include the direct financial requirements for implementation as well as the cost of externalities — external ecological or social costs that may be associated with the proposed option. Using a shared set of metrics agreed upon by stakeholders, prioritization of options can now occur. Such options' assessment may benefit from its own visioning process or other structured, multi-criteria analysis that allows stakeholders sufficient opportunities to contribute.

Step D: Integrate adaptation options into action plans and watershed management plans

Purpose: Produce explicit and operational action plans.

Actions: Through the stakeholder engagement process, the results of the vulnerability assessment are revised into an action plan. Working with planners and governments at all levels, the W-VAA action plan then needs to be incorporated into local planning and decision-making frameworks. Before any of this can occur, however, the decisions to be influenced by the W-VAA as identified in Step A above, need to be moving forward. As such, action on these decisions represent the first priority action for any action plan, and by extension, the first indicator of a W-VAA initial impact.

Step E: Synthesize learning & improve W-VAA

Purpose: Determine what lessons have been learned and apply them toward improving the W-VAA approach.

Actions: When W-VAA monitoring and evaluation is conducted, data is typically obtained through stakeholder surveys or ecological assessments. The data are analyzed to reveal the effects of particular process steps and/or specific tools on the decision making and planning process. They are also used to identify the W-VAA's real-world outcomes on vulnerabilities. This effort faces three main challenges, however. First, W-VAA decision-making processes are often delayed, demanding a prolonged M&E approach. Second, a robust assessment often requires that team members assess other influences, external to the W-VAA, which are neither part of the decision-making nor the processes being monitored. Lastly, the majority of evidence resulting from a W-VAA informs what not to do, which is particularly challenging to evaluate by M&E, other than to say that something was not done. This is why it is critical that these challenges are all addressed during the design of M&E as prescribed for in Step A above.

3.2 Examples for Process Implementation

What follows are examples of W-VAA in action. In presenting them, references are made to how they incorporate the W-VAA Principles presented in Chapter 2, the Process Steps introduced above, as well as lessons learned. Table 1 summarizes their key components, and the reference section, beginning on page 59, provides a solid resource for those seeking more detail about these cases and the tools they employ.

Challenge and Reconstruct Learning (ChaRL)

Special Focus: Policy impact assessment and conflict resolution. Using participatory research, belief systems are integrated with scientific evidence to promote improved stakeholder understanding of implications of a given development strategy or adaptation plan.

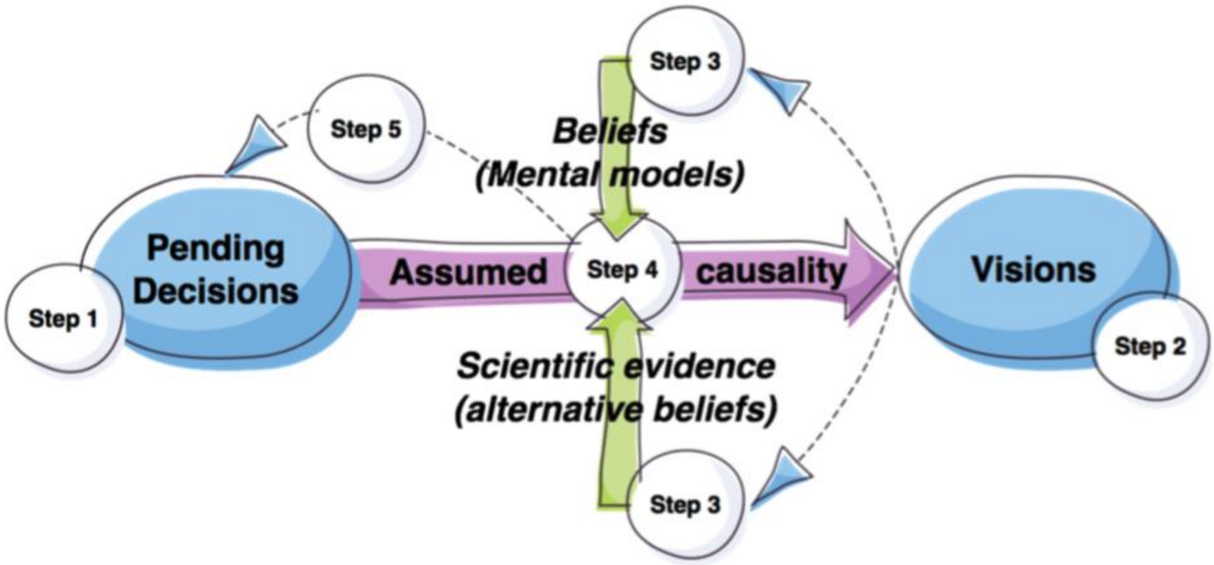
The Challenge and Reconstruct Learning (ChaRL) framework aims to guide participatory research to bridge science and policy, and has been widely used in the Lower Mekong basin. Its systematic science-policy engagement framework realizes W-VAA Principles 1, Informing Decisions; Principle 2, Scoping and Principle 5, Participation, all while placing stakeholder learning at center-stage. It utilizes visions, beliefs, and values as key entry points for scientific evidence to inform policy and planning processes.

Figure 2 illustrates the five-step process the ChaRL framework employs to bridge science and policy. The steps comprise a process that formally questions and measures underlying assumptions, then reframes and revises those assumptions by taking into account a larger systems' view. Here, scientific knowledge is not assumed to be necessarily superior to stakeholder knowledge. Such an initiative, where stakeholders collectively reconstruct existing views through a facilitated exchange of intuitive knowledge, represents the type of active learning process consistent with W-VAA Principle 6, Embracing Risks. Looking more closely at ChaRL's individual steps, one finds nearly all aspects of the W-VAA Principles and Process Steps represented.

ChaRL step 1 is a scoping exercise to: define objectives, establish the decision making context and options, and identify the relevant success indicators as perceived by the decision makers. This is similar to W-VAA Process Step A, Scoping. Inviting the relevant decision makers to co-design the effort is seen as critical to ensure high levels of stakeholder engagement.

ChaRL step 2 is a visioning effort wherein stakeholders develop narratives of plausible futures for specified geographic location — also consistent with W-VAA Process Step A, Scoping. This effort may require several iterations if the set of decisions is likely to affect multiple action arenas, with each demanding separate facilitation. Such an iterative approach allows for revising visions based on the visions presented from other locations or governance levels. Buy-in on a suite of shared visions is essential to prevent participants from reverting back to their own individual goals when debating the benefits of development strategies. These visions provide an agreed upon foundation from which competing interests can move forward, which is consistent with W-VAA Principles 2, Scoping and Principle 5, Participation.

Figure 2: The ChaRL Framework – Challenge and Reconstruct Learning



ChaRL step 3 is when scientific evidence is presented to assess the expected outcomes of the decisions under consideration. This is similar to W-VAA Process Step B, Vulnerability Assessment and C, Adaptation Options. Beliefs, expressed as statements that articulate perceived causal relationships held by decision makers are to be noted. Assessments can be conducted through a variety of methods including expert panel assessments, household livelihood surveys, hydrological modeling, and integrated agent-based simulation. This step is primarily guided by Principles 3, Complexity and 4, Uncertainty.

ChaRL step 4 constitutes the core learning step. Previously recorded beliefs are explicitly compared with each other and with scientific evidence. This is consistent with W-VAA Principle 6, Embracing Risks and Process Step D, Adaptation Options. Identified contrasts are discussed in the context of how pending decisions will or will not contribute to the realization of the desired visions articulated in ChaRL step 1. This activity facilitates the presentation of the underlying assumptions (beliefs) against the backdrop of desired futures. The goal is to develop an action plan that one, reflects the disparities between beliefs and desired futures, and two, illustrates sufficient promise to achieve the desired future outcomes while avoiding the undesirable outcomes.

ChaRL step 5 constitutes a specific set of actions, debated, revised and agreed upon, to realize the participants' desired objectives and future vision (Process Step D, Adaptation Options). While focusing largely on Principle 1, Informing Decisions, this step embodies all Principles with the exception of Principle 7, M&E.

W-VAA Principle 7, M&E, is accounted for in the ChaRL framework, however, along with Process Step E, Learning, by means of an innovative, psychometric monitoring and evaluation approach that quantifies which particular actions and methods lead to which policy outcomes.

The ChaRL framework has been developed for situations that are characterized by high levels of complexity and high levels of contested values between stakeholders. Within the GMS region, the ChaRL process has been implemented in various multi-stakeholder planning processes, including:

- in the Nam Ngum in Lao PDR to explore the benefits of large-scale irrigation against the backdrop of climate change projections;
- in the Nam Xong in Lao PDR to assess the tradeoffs between upstream mining, rubber plantations, and downstream tourism considering climate change;
- in Vietnam's Mekong Delta to assess effective responses to sea level rise;
- in the wider Tonle Sap area of Cambodia to assess the combined impacts of mainstream dams and climate change on local livelihoods; and
- in northeast Thailand to assess climate adaptation strategies involving energy crops.

USAID Mekong ARCC Integrated Vulnerability Assessment and Adaptation Decision Making framework

Special Focus: Integration of science-based vulnerability analysis and community-based perspectives. Participatory community adaptation planning that gives equal consideration to both viewpoints.

The USAID Mekong ARCC Integrated Vulnerability Assessment and Adaptation Decision Making framework merges the best available climate science research with local expertise and knowledge to design technical solutions for strengthening livelihood resilience in the face of climate change. The framework is designed for working at the community level. As such, it can also function as a component of an overall basin-wide assessment if characterizing community-level vulnerability is one of the objectives of the higher-level initiative. The process is depicted in Figure 3 and outlined in more detail below.

Regionalize climate models, identify climate thresholds, and conduct science-based vulnerability assessment: Downscaled global climate models are useful to refine more generalized projections to the watershed scale (Process Step A, Scoping). Various climate downscaling efforts have been completed for portions of the GMS and are available for the public to use. For example, the USAID Mekong ARCC Climate Change Impact and Adaptation Study for the Lower Mekong Basin (2013) used statistical downscaling of Global Climate Models (GCM) to quantify specific shifts in climate and hydrology factors for the Lower Mekong Basin (LMB) by 2050, assuming a moderate emissions scenario. Impacts to agriculture and other important livelihood or

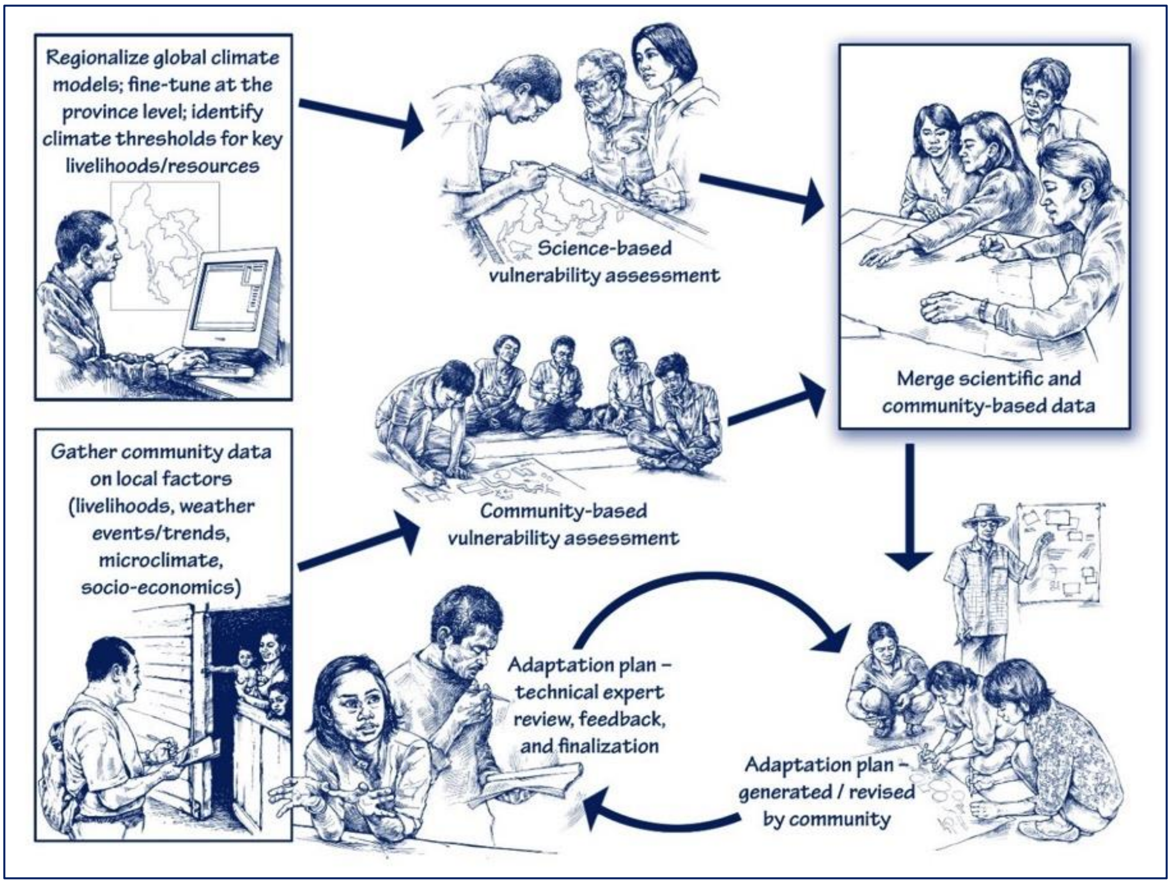


Figure 3: Summary of Integrative Method for Climate Change Adaptation Planning

economic sectors were then estimated, based on identified climate thresholds where system shifts would likely occur. Geographic information system (GIS) data from the USAID Mekong ARCC project are publicly available at ADB's GMS Core Environment Program website - www.gms-eoc.org

Under the USAID Mekong ARCC process, vulnerability is assessed by relating factors of exposure, sensitivity, impact, and adaptive capacity. This is consistent with approaches recommended by the Intergovernmental Panel on Climate Change (IPCC). Exposure refers to the projected level of a specific climate threat, such as temperature, drought, rainfall intensity or flood duration. Sensitivity refers to the relative impact the threat will have on a crop, livestock species, forest product or other community resource of concern. Impact is determined as an amplifying function of exposure and sensitivity. Adaptive capacity reflects the local context and ability to respond to or reduce the impact. For example, remote communities with less access to training and agricultural extension support tend to have lower adaptive capacity than communities located near main transportation routes with more established support structures. Ultimately, vulnerability is determined as a function of impact reduced by adaptive capacity.

Gather local data and conduct community-based vulnerability assessment: Community-identified vulnerability can be assessed using a series of platforms ranging from baseline awareness surveys, key informant interviews, and community workshops (Process Steps A, Scoping and B, Baseline Vulnerability). The steps are:

1) Identification of assets and important livelihood resources through community mapping of physical and natural resources, and identification of livelihoods that are most important for subsistence and income generation.
2) Identification of the nature, location, and timing of climate threats using climate hazard maps (e.g., areas within villages that are prone to flooding, landslides, drought), seasonal calendars (e.g., noting key livelihood activities and typical timing of climate hazards such as droughts, heavy rainfall, flooding), and historical climate hazard analysis to produce a timeline of significant past climate events that had grave impact on livelihoods.
3) Ranking livelihood vulnerability. Hazard maps are compared to asset and livelihood maps; climate hazard calendars are compared to production cycles for key crops, livestock, forest products, etc., and community factors relating to adaptive capacity are considered.

Merge scientific and community-based perspectives, conduct community visioning, and develop the community adaptation plan: Under the USAID Mekong ARCC framework, the merging of scientific and community perspectives is facilitated through a side-by-side review of the two assessments (Process Steps: B, Baseline Vulnerability; C, Adaptation Options and D, Action Plans). Via a workshop, data from both viewpoints are presented in a manner that is easy to interpret (maps, charts, and graphics) and community members are encouraged to do their own comparative analysis with ample discussion of similarities and reasons for discrepancies. Ultimately, the communities either confirm or adjust their preliminary evaluations of livelihood vulnerability considering the science-based analysis.

Following this review and synthesis of information, community members identify their problems and needs. The problems and needs assessment leads to the formulation of a community vision and a list of desired outcomes. These outcomes are considered for three time periods: today, next 5 years, and their children's lifetime. Strategies are brainstormed to meet these desired outcomes, which are then ranked in the context of how well they address the identified climate threats and vulnerabilities. The prioritized options provide the basis for developing community adaptation plans.

Once a community adaptation plan has been drafted, external review by relevant technical experts is conducted. These experts provide feedback regarding: (1) the technical requirements of the proposed activities and potential for secondary impacts to other livelihoods and resources, (2) the feasibility of conducting the activities within the program timeline and funding limitations, and (3) validation of whether and how the proposed activities would increase the community's climate change resilience. Ideally, the experts present their feedback directly to community members so that the plan can be finalized during the same session(s).

81 Villagers of Thuan Hoa Commune re-ranked their prioritized vulnerabilities after learning about USAID Mekong ARCC's climate projections of Kien Giang Province, Vietnam. (Photo: USAID Mekong ARCC)

Watershed-based Adaptation to Climate Change (WACC)

Special Focus: Integration of community vulnerability assessments, downscaled climate change projections, forest condition monitoring, land development planning, and water management system planning across a large spatial extent.

The Watershed-based Adaptation to Climate Change (WACC) Initiative was undertaken as a regional collaborative initiative financed by the National Research Council of Thailand (NRCT), Royal Thai Government, and USAID with technical support from the

US Forest Service. The WACC initiative aimed to create a model for robust watershed-scale planning under climate change. The project produced an integrated set of community-scale VAA and ecological assessments that will inform development policy and water management planning in Thailand's Petchaburi province as well as management of Sirindhorn International Environmental Park (SIEP).

The WACC W-VAA was envisioned as an assessment of climate change vulnerability and adaptation options from the basin's highest peaks down to its coastal shores. As the first project at this scale in Thailand, it provides many lessons for future efforts to assess climate change vulnerability and adaptation across multiple components of an integrated socioecological system that spans a large spatial extent, and involves integration of work plans produced by multiple project partners.

Work was carried out through a series of relatively independent endeavors, punctuated by coordination meetings. As these guidelines are written, final integrated WACC products are still in preparation, but first drafts of many components have been produced. Below we highlight four aspects of this large project, which provide insight and guidance for future W-VAA practitioners.

Scoping the Physical Scale of the Assessment: Project scoping took place over several meetings of project partners, including both local and international partners (Process Step A, Scoping). The project was originally expected to focus on both the watershed draining to SIEP and the entire Petchaburi River watershed. In the first scoping meetings, it was determined that SIEP is not physically within the Petchaburi River watershed but rather receives water from the Petchaburi River through diversion dams and canals. Learning how much of the water supply originated through such trans-basin diversions had significant implications for how vulnerability was influenced by natural processes (such as storm events) and how much was under more direct human control. There seemed to be two choices. Either the project could focus on the smaller physical watershed draining into the SIEP from nearby forested highlands, or at the other extreme, the project scope could attempt to embrace the entire area supplying water to SIEP and adjacent communities. The latter approach would be quite extensive, spanning the headwaters of the Petchaburi River in Kaeng Krachan National Park to the downstream reaches of the Petchaburi River as well as SIEP's coastal watershed and adjacent watershed areas from which water was delivered via a second array of reservoirs and canals. Such a comprehensive W-VAA would require far more than the allotted resources. Conducting the W-VAA just over the SIEP local watershed, however, would not have met stakeholder needs to understand vulnerabilities from climate change to municipal areas, tourism, industry, agricultural interests, and rural communities.

Stakeholders ultimately sought a middle path. Climate downscaling work, for example, would be conducted over the widest possible extent including the Petchaburi River watershed. Project activities requiring on-the-ground data collection would then focus on small target areas, identified by Sustainable Development Foundation (SDF) within the larger area, which represented either key economic sectors or were struggling with particular management issues. These more intensive study areas were felt to be representative examples of the types of communities and key issues within the larger study area. In the upper watershed SDF focused on Huay Krazoo. Key issues for this indigenous community revolve around land rights and agricultural productivity. In the middle watershed SDF identified four villages that each depend on a particular cash crop, such as rose apples, sugar palms, rice, and limes. In the lower watershed, three communities suffering from floods and droughts as well as a community where many livelihoods depend on salt-farming were selected. Two additional communities struggling with urban expansion and water supply management in the central part of the watershed were also identified. SIEP remained the focal area for ecological data collection.

Through this extensive scoping process of the physical condition, a great deal of contextual information was collected and a deep understanding of water management issues in the project area was gained by all project partners. The challenges of working at large spatial extents were tackled and the trade-offs of reducing project scope were explicitly considered. Eventually, WACC created a tiered approach that allowed project partners to maintain a watershed perspective while using their limited resources to collect only on-the-ground data in targeted, representative areas within that watershed. Through the intensive scoping exercise, the team struck an unusual and innovative balance.

Identification and coordination of multiple project partners: In the first stage of project scoping, project partners were identified (Step A, Scoping). Four key project partners were identified in addition to NRCT, who initiated the effort, and the US Forest Service, who provided technical support during a series of visits. SDF, a Thai NGO with experience in community-scale VAA, coordinated meetings in each of the focal communities to understand critical climate vulnerabilities, conducted research on development and water management policies, and synthesized climate and non-climate factors to identify adaptation options. Ramkhamhaeng University (RU) was charged with coordinating baseline data, developing climate change scenarios through climate downscaling, and modeling impacts of climate change on water resources using the Water Evaluation and Planning (WEAP) model. SIEP and Kasetsart University (KU) Forestry Department installed forest vegetation plots, collected scientific data on soils and on water quality near SIEP, and developed a land-use map. The Land Development Department (LDD) modeled effects of watershed change on soil quality, environmental conditions, agricultural production, and farmer's income. The partners were each able to complete their parts of the W-VAA successfully but it was difficult to maintain communication and coordination while working simultaneously and without a lead entity dedicated to integration. For example, SDF needed to use climate forecasts in early community meetings before climate modeling by RU was completed. Once the modeling was complete, innovations in summarizing the forecasts were required to communicate likely future changes at the community level.

Future W-VAAs will benefit from a diversity of project partners, each bringing different expertise and each representing a different type of knowledge. Without such diversity, balancing trade-offs between community concerns, water management, urban planning, and ecological integrity will be challenging. However, such complex arrangements may be more efficient if there is a single coordinating entity, the careful scoping of project timelines, and frequent communication between project partners.

Integrating downscaled climate data into vulnerability assessments: Downscaled climate data provide important scientific information, but translating these scientific forecasts into information that is relevant at the community level and that can be used in a participatory process was a particular challenge for WACC (Step A, Scoping). The large scope of the project provided detailed forecasts and paired project partners with very different sets of experiences and needs. WACC created a three-step process to weave together the larger endeavor.

In the first step, SDF staff used information from community meetings, local reports, and scientific papers to identify not only the key community concerns and vulnerabilities, but also the specific facets of changing weather patterns that were most likely to be of concern to each target community. For example, in Tambon Railuang, the community group was concerned with increased Kangguh, a disease of lime crops. The particular facet of climate change related to this disease is the number of days with over 1 mm of rainfall and temperature over 35°C. SDF identified 20 climate facets that approximated this threshold, some as simple as mean daily temperature and others customized to specific issues like lime disease. In the second step, RU summarized the messy time series of 25 years of hindcast (probable past conditions) and 25 years of forecast climate predictions into these annual facets. In the third step, SDF brought climate forecasts back to the community groups in this customized and synthesized climate facet format to enable clearer understanding of how future climatic conditions were likely to affect specific areas of community interest.

Application of Climate Change Preparedness Scorecard: Through WACC, SDF modified the Climate Change Scorecard developed by the US Forest Service to assess climate change preparedness (Step B, Baseline Vulnerability). The US Forest Service scorecard includes 10 questions to be answered annually by each national forest or grassland to track climate readiness. For example, the scorecard asks whether the unit actively participates with the science community to improve its ability to respond to climate change. SDF modified this approach for use in WACC by designing a scorecard to assess activities already underway within local agencies and governments. The SDF scorecard contained 27 questions over 4 dimensions: 1) learning and development within the agency, 2) established management structures to work on climate change issues, 3) existing VAA, and 4) effectiveness of climate change integration. For example, in one question, the scorecard tracks whether the agency has assigned at least one person to coordinate climate change activities, answer questions related to climate change, and encourage all projects to consider climate change issues. The scorecard approach can be modified in any number of ways for assessing climate readiness across agencies and community groups. It is particularly useful for collecting baseline information for comparison with future monitoring efforts. The SDF's adaptation of the scorecard approach is also an indication of the potential benefits of sharing expertise and experience across diverse partners.

Analysis and Mapping of Impacts under Climate Change for Adaptation and Food Security (AMICAF) and Modelling System for Agricultural Impacts of Climate Change (MOSAICC)

Special Focus: An interdisciplinary assessment of climate change impacts on agriculture and food security vulnerability to reinforce the need for climate change adaptation planning.

The United Nation's Food and Agriculture Organization (FAO) considers VAA of agricultural systems in support of adaptation policies and programs highly important.

The AMICAF project, developed in the Philippines and Peru, builds country-level capacities to produce evidence-based information on climate change impacts to agricultural systems and food security to inform a country's overall, long-term climate change adaptation planning.

One of the project's key planning tools was MOSAICC, an interdisciplinary climate change impact assessment tool containing modules for: climate downscaling, crops, water resources, forests and economic modeling (Figure 4). The selected models are robust and can ensure scientific quality even with sub-optimal data quality, which is more prevalent in developing countries. The tool is designed for large-scale assessment (regional, national, or sub-national) with spatial disaggregation. This enables policy makers to understand different levels of risks among provinces within s region, country or basin.

An interdisciplinary team of national institutes and universities was formed. An extensive training program was provided to develop national experts who can use MOSAICC when carrying out assessments in their own country. The project team and its experts regularly meet with the Department of Agriculture (in the case of the Philippines) and associated government departments to respond to their needs for climate change risk and vulnerability information.

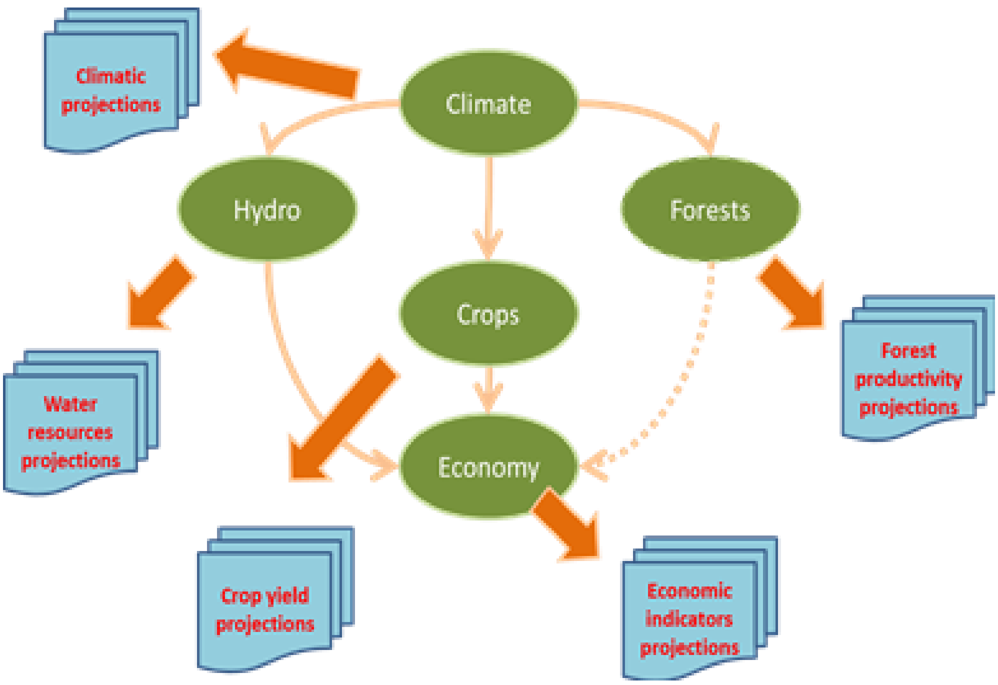


Figure 4: MOSAICC Schematic Diagram and Five Modeling Modules

MOSAICC employs a top-down vulnerability framework. It uses coarse resolution climate projections from global climate models to estimate local changes in climate, projected yields of the country's main crops, river discharge, forest species and growth, and gross domestic product based on the agricultural sector (Figure 4). A set of eight global climate models and two representative concentration pathways are available for statistical downscaling of climate projections to account for uncertainties. The simulations run on a centralized server so that the results can be shared and validated by peers to ensure transparency and replicability. The modeling system's integrated design facilitates interactions among experts from multiple disciplines and fosters a collaborative working environment. It may take time to establish a technical working group and to agree on data

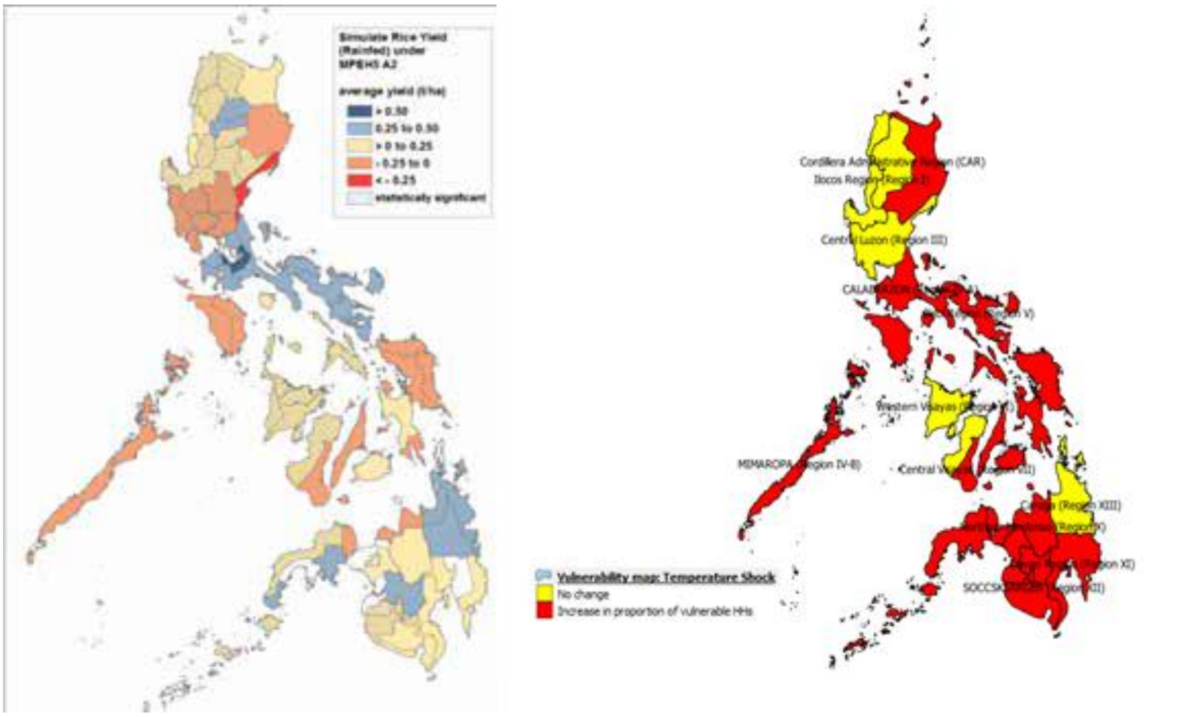


Figure 5: (Left) Projected rain-fed rice yield change from the present time to a future period in a global climate model and an emission scenario in the Philippines;
(Right) Vulnerability to food insecurity under climate change (temperature).

sharing among participating institutions, but this preparatory process is essential to ensure strengthened institutional capacities and sustainability of technical work.

The Philippines project also includes an agricultural market model that identified impacts on farm-gate prices. The AMICAF project also uses a bottom-up approach to vulnerability assessment in order to characterize climate change vulnerability to food insecurity at the household level. The econometric methodology employed explores and identifies the pathways through which the impacts of climate change pass as they make their way to the household/farm level. This modeling also identifies and maps vulnerable groups (profiling), considers the adaptive capacity options of farmers (agronomic and economic level) and then explores the efficiency of alternative policy tools. The analysis makes use of extensive household surveys on nutrition, family income, expenditure, and other socio-economic indicators to characterize vulnerable groups (see Figure 5).

The rich information produced by MOSAICC and associated tools in the AMICAF project enables policy makers to identify vulnerable areas, the characteristics of these vulnerabilities along with their underlying causes, in order to develop effective adaptation planning.

Climate Resilience Framework (CRF)

Special Focus: The climate resilience framework (CRF) is a thresholds-based process for urban areas. The approach begins by examining current trends in climate risk and vulnerability, followed by analysis of urbanization patterns and climate trajectories. Shared learning dialogues among a wide range of stakeholders are critical.

Climate thresholds based assessments have been applied in the Mekong region to address urban area vulnerabilities that arise as a result of continued urbanization. They focus on the wider landscape in which urbanization occurs, rather than simply the urban space. Urbanization requires the increased use of resources that come from the wider rural area. Water, food and energy consumed in urban areas all originate beyond the urban boundary. In times of shock and crisis, rural areas are often sacrificed to protect urban economic and population centers. During flooding, rural areas are inundated to protect built-up urban centers. In times of drought, irrigated agriculture may be prohibited to protect urban domestic supplies.

Systems depend on complex institutional arrangements that in many cases are overlapping, competing or poorly coordinated, and have limited mandates, technical capacity or financial resources (Principle 3, Consider Complexities). The ways in which institutions deal with crises points to their own complexity and fragility. Urban systems increasingly depend on complex institutional arrangements, often across different government agencies or tiers or government, and often cutting across state and non-state actors.

Fragility or failure can become manifest in the way that physical infrastructure or technology experiences climatic events or sequences of events that exceed their design capacity. Moreover, since many infrastructure systems are inter-linked (particularly water and energy), fragility or failure in one element of the system can have cascading effects, often with unanticipated consequences. Even where physical systems themselves do not fail, the institutions that are responsible for their management, operation and maintenance or the distribution of their benefits, can fail. The technical or managerial capacity of institutions also face thresholds. These may include their ability to function within a wide range of changing and uncertain responsibilities, the legal constraints of their mandate or their limited financial and human resources.

Climate thresholds approaches enable watershed stakeholders to contextualize the potential impacts of future climate change by better understanding the ways in which current trajectories of change, such as land use change, demographics, economics and urbanization, create vulnerabilities that will be exacerbated by future climate change. By viewing climate planning through the lens of agents, the CRF stimulates understanding of how different people are impacted and respond, both positively and negatively, during climate related shocks and crises. Often, only slight variations in climatic conditions are necessary to push already fragile social-ecological systems into situations of crisis or failure. Current development trends alone may push many systems past their crisis thresholds. Climate projections help to warn of the potential for increased future risks of crossing crisis thresholds (Principle 3, Consider Complexities).

In recognition of the social dimensions of determining crisis points and appropriate action, thresholds approaches that assess vulnerability are based on principles of deliberative informed public dialogue, where different stakeholders and different types of knowledge are brought together in facilitated public dialogues—referred to as Shared Learning Dialogues (SLDs). These dialogue processes have an established tradition in addressing complex, multi-scale environmental and social policy challenges that affect a range of different stakeholders, each with their own perceptions, values and interests (Principles 3, Complexity and 5, Participation).

The SLD process is central to ensuring stakeholders understand resilience as: the ability to learn and reorganize challenges in the face of changing circumstances and shifting patterns of shocks and crises (Principle 6, Risk Context). The SLD process is intended to generate discussion and innovation by: one, drawing on scientific and local knowledge; two, reinforcing new understandings of climate change, risk and uncertainty, and three, considering patterns and trajectories of change.

Threshold approaches apply a range of different methodologies drawing on a broad range of disciplines. In essence the approach involves the following key steps (see Figure 6):

Analysis of trends and trajectories of change: Applying an historical perspective allows for analysis of how change in recent decades and continued trajectories create vulnerabilities for different actors and different locations (Step A, Scoping).

Systems' fragility and failure analysis: Focusing on the complex web of urban infrastructure and technology allows for analysis of elements within these systems that are fragile and that might fail. Criticality analysis addresses the implications of such system failures, such as whether systems might fail safely and the severity of possible failures (Process Step A, Scoping).

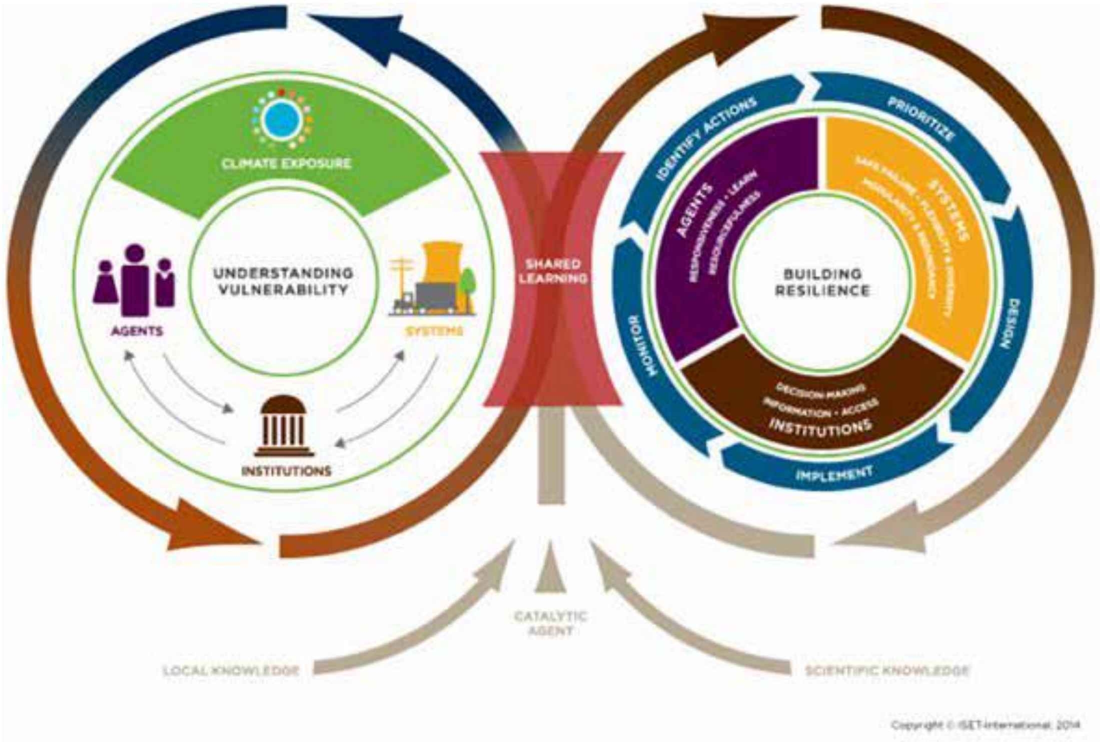


Figure 6: The Climate Resilience Framework

Applying climate projections allows for analysis of the degree of climate variability that might push emerging vulnerabilities and systems to critical points (Process Step B, Baseline Vulnerability).

Case study analysis allows for assessment of how different actors—individuals, households, groups, organizations—have responded to historical events of climate related shocks and crises (Process Step B, Baseline Vulnerability).

Large Landform Holistic Assessment

Special Focus: Climate change adaptation assessment for large landforms. This assessment process takes into account linkages and interactions between and among multiple components of the socioecological system, across multiple scales, and multiple threats. It also considers pressures on each economic sector of the system from both climate and non-climate (socioeconomic condition) factors.

The Large Landform Holistic Assessment is a framework for climate change adaptation assessment at the watershed scale and/or at the provincial level. It has been developed by the Southeast Asia START Regional Center based in Bangkok. It is now being used for climate change adaptation assessment in Huay Luang Watershed, Udonthani Province, Thailand, as part of the Thailand Research Fund's climate change adaptation research program (2015-2017).

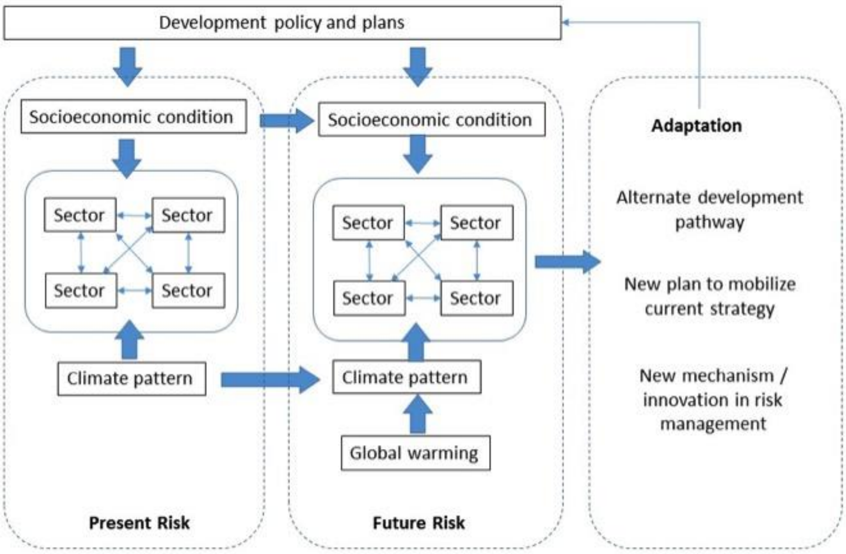


Figure 7: Large Landform Holistic Assessment Framework by SEA START RC

The framework aims to develop adaptation strategies and plans that can be integrated into the development plans of various line agencies. In turn, it aims to harmonize the adaptation strategies and plans of multiple components of the socioecological system with an eye toward increasing the resilience of all relevant components and minimizing conflict between components. As shown in Figure 7, a sector is considered to be any component of the economy in which businesses provide the same or a related product or service, including also the non-profit and agricultural sectors.

The principle concept advanced by the framework is that watersheds and other large landforms consist of multiple sectors that are linked together through physical and socioeconomic aspects. The risks facing various economic and social sectors within these landforms do not only result from external factors that may effect them all, such as new development policies and plans or a warming climate, but also must address risk resulting from interactions between and among the sectors themselves. For example, the responses of one sector to its risks may cause negative consequences to businesses or activities within other sectors. The large landform holistic assessment seeks to account for these dynamic linkages when devising appropriate climate change adaptation strategies and watershed management plans.

The assessment can be broken down into three major steps:

Step 1: Contextualizing the watershed (Step A Scoping). The purpose of this step is to understand how key economic sectors in the large landform are at risk from pressures of socioeconomic conditions (market conditions, expansion of human settlements, etc.), and climate patterns (seasonal patterns, extreme weather events, etc.). Linkages between and among sectors (e.g., water resource sharing) are defined, including mechanisms through which the response of one sector to its risks may cause impacts across sectors. For example, infrastructure to prevent floods in the city may exacerbate flooding in surrounding rural area. Contextualizing the watershed can be conducted through historical review and consultation with key stakeholders and policy makers in the watershed.

Step 2: Establish an understanding of changes in the future risk profile and the emerging risks within each economic sector of interest (Process Step B Baseline Vulnerability). Risks may result from climate change as well as in socioeconomic conditions. Understanding is sought for both changes that occur within an economic sector and also between economic sectors. Also assessed here are the potential success of development plans in the watershed. Specifically, this step assesses whether plans are likely to achieve stated goals and assesses the effectiveness of responses to current risks within each economic sector (i.e., whether the response to risks will still be applicable and effective under future conditions). Activities in this step might include scientific analyses of the impacts of projected changes in climate on drivers of risk, review of area policies and plans, stakeholder consultation, and visioning of future conditions with the watershed's key stakeholders and policymakers.

Step 3: Develop adaptation strategies and measures for each economic sector. The goal here is to increase the resilience and robustness of the watershed's integrated socioecological system to future change (Process Step C, Adaptation Options). Adaptation can take the form of an alternate development strategy, a new plan to mobilize the current development strategy, or an innovation in risk management. Putting adaptation of every economic sector into the same planning process and analyzing the potential linkages and interactions across economic sectors within the watershed helps formulate a holistic watershed adaptation strategy. Coordinated adaptation plans minimize cross-sectoral pressures and effectively increase the resilience of the watershed to future changes.

Udonthani province is a major province in the northeastern region of Thailand. The rain-fed agricultural sector and the City of Udonthani, which is among the largest cities in Thailand, are under climate threat from a shift in rainfall patterns that causes flood and water shortages. Various changes impact on water demand pattern, including cropping patterns, and the growth in various economic sectors in the City of Udonthani, especially the service sector and the industrial sector, which is driven by various socioeconomic conditions, e.g. government policy, market condition, etc. Sector-focused plans to cope with water stresses, e.g. flood and drought management, are likely to have cross-sector impacts. Future climate change is expected to add pressure to the province as change in rainfall patterns and temperature will affect water availability from season to season throughout the year and current coping strategies may no longer be viable options. Adaptation needs to be planned and mainstreamed into long-term development plans for Udonthani province. It should aim at increasing the resilience of the city, where city planning may need alteration, robust agricultural system, where the cropping system needs to be transformed, and sustainable water resource management needs to be put in place.

Developing holistic adaptation strategies and plans can be conducted by stress testing current development strategies with results from the climate change impact assessment in step 2 above. Stress testing current plans may lead to revised development policies, especially plans with long-term implications. They also allow development of climate risk mitigation plans that address changes in risk profiles as well as new emerging risks. Alternate development strategies that are increasingly robust to future conditions and that also enhance resilience within and across economic sectors can be developed through multiple stakeholder consultation and visioning exercises.

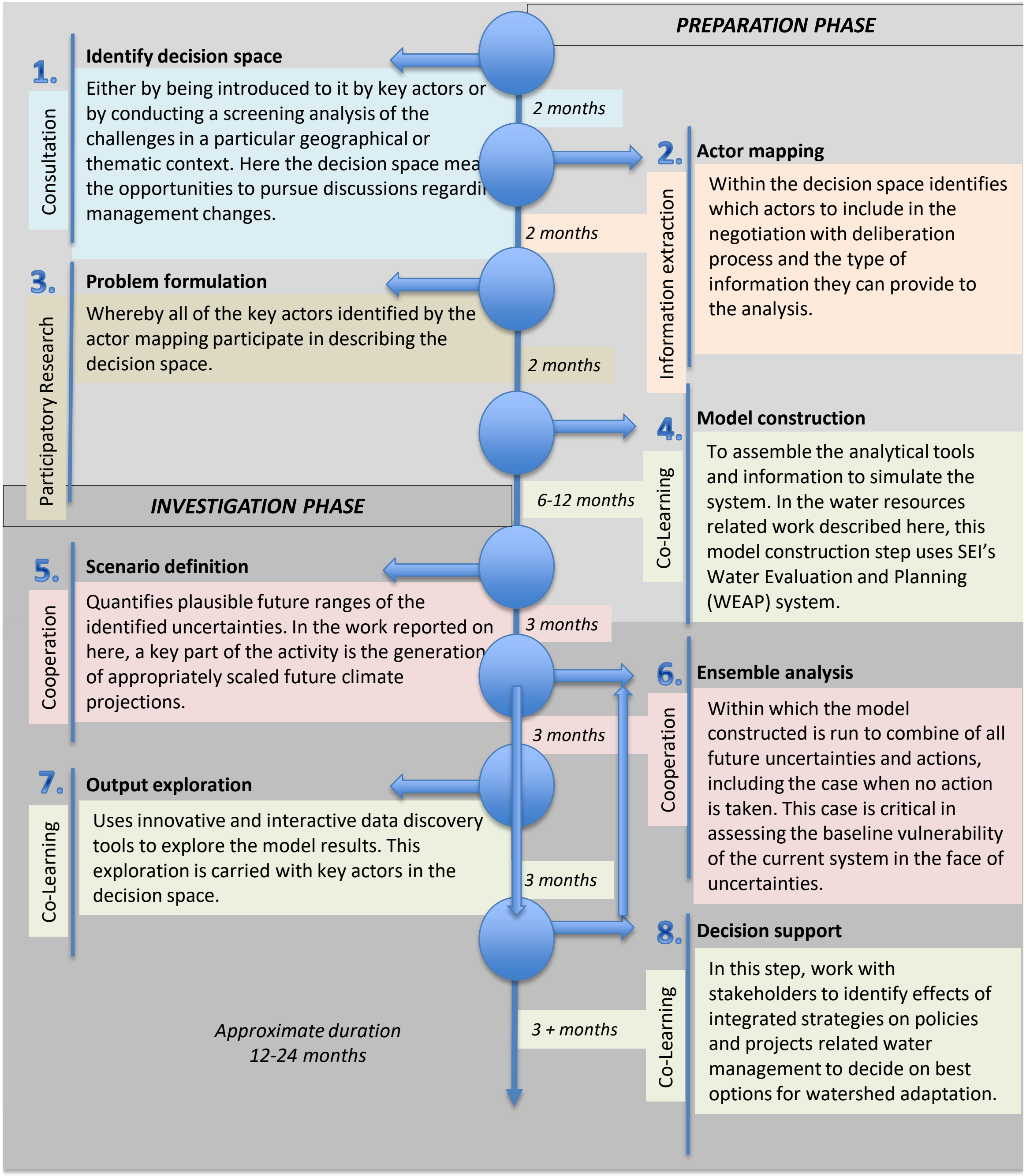
Robust Decision Support (RDS)

Special Focus: The Robust Decision Support (RDS) is a methodology that seeks to effectively embed cutting-edge water resources system modelling and large data visualizations tools within stakeholder participation and engagements.

The RDS process informs decision making regarding actions that can be taken to reduce the socio-ecological vulnerability of water resources systems. The main goal is to inform water resources policy settings and decision making by working with stakeholders and decision makers in the identification of strategies that demonstrate satisfactory outcomes over a broad range of plausible futures. This goal is achieved by working closely with stakeholders and decision-makers in identifying strategies that can achieve their desired management outcomes. Depending on the particular stakeholder these could include access to clean water within municipalities, hydropower production targets, water supply for irrigation, or meeting instream flows requirements in rivers for the sustainability of native fisheries or improvement of water scarcity management strategies considering uncertainty of climate change and other factors.

The uniqueness of the RDS process is that stakeholders are engaged in the technical analysis carried out throughout the course of the process, from problem formulation to the selection of management strategies. As such, one key initial stage in the process is the selection of key actors group involved in water resources management and policy for a particular water system. Their inputs are gathered to define the scope of the analysis, produce an accurate model representation of the basin and its management, evaluate results, and select potential strategies. Through this active engagement, the stakeholders become aware of the current and future implications of external factors such as climate change on the system performance. For the evaluation of results, a sophisticated and interactive visualization tool is used, that allows for negotiation and deliberation around potential options.

The RDS steps are grouped in two phases: preparation and investigation as described briefly below and shown in Figure 8.



Increased participation

Participation level legend	Example
Participatory (Action) Research	Research is directed by participants, with the researcher acting as a facilitator
Co-Learning	Working together to define problems and find solutions
Cooperation	Working with people to determinate priorities, but the process is directed by the researchers
Consultation	Local opinions are sought and some dialogue occurs
Information Extraction	Researchers ask people questions and process the information

Figure 8. Diagram of Robust Decision Support (RDS) processes . Originally sourced from: Stockholm Environment Institute. (2015, September). RÍOS DEL PÁRAMO AL VALLE, POR URBES Y CAMPIÑAS, Building climate adaptation capacity in water resources planning. United States Agency for International Development.

[1] Yates, D., Sieber, J., Purkey, D., Huber-Lee, A., 2005. WEAP21—A Demand-, Priority-, and Preference-Driven Water Planning Model. Water Int. 30, 487–500. doi:10.1080/02508060508691893

Preparation Stage

Step 1 Decision Space Definition: The decision space is defined by identifying the water resources challenges within the boundaries of the basin, or the political structure for water governance.

Step 2 Actor's Map Identification: For this decision space, individuals from key organizations are identified based on their influence on water resources policies. These actors provide their insights and facilitate the collection of specific data that will inform the technical analysis. In some cases, decisions on water resources management are made at a sub-national or national level even, beyond the geospatial boundaries of a basin, hydrological data or. Therefore, it is important to ensure the participation and engagement of key actors operating at the different relevant levels of decision-making.

Step 3 Problem Formulation: The identified key actors participate in an exercise to formulate the specific decision-making challenge. A problem formulation framework, called XLRM (Lempert, 2003), is used to structure this exercise. The XLRM framework consists of four distinct, but interconnected, elements:

X - Exogenous Factors, or uncertainties, are impact factors that are outside the control of decision-makers but can influence the performance of the system. For example, climate change.

L - Levers are investment options, strategies, or actions that decision-makers want to explore to improve the performance of the system. For example, the construction of a reservoir or canal.

R – Relationships are the ways the various components of the system are interconnected through the choices of levers and the manifestation of the uncertainties. For example, the WEAP software (see description in Section 4), a simulation model for the analysis of basin-scale water resources systems, has often been used to support the RDS approach. Other tools that were used to support the RDS approach include SWAT, SWMM, and Vensim

M – Performance Metrics are performance standards set by decision-makers based on their desired management outcomes. These metrics determine the success or failure of the system performance and therefore the desirability of the selected strategies. For example, a set of performance metrics can be urban water demand satisfaction, area irrigated, and hydropower produced.

Step 4 Model Construction: The strategies (L), uncertainties (X) and performance metrics (M) connect in the (R) component which represents the possible "relationships" between them as described in a model. In the RDS practice, a calibrated WEAP model is typically developed as the R component. The Water Evaluation and Planning (WEAP) software is a climate driven simulation model for water resources management that captures various aspects of a system. Model input information includes precipitation, temperature, relative humidity, wind, melting point, freezing point, and land cover to estimate the hydrological balance components of evapotranspiration, infiltration, surface runoff, and base flow. These estimates provide the context for simulated water system operations.

Step 5 Scenario Definition: Once a WEAP model is calibrated based on historical conditions, a set of future projections is implemented to represent the identified uncertainties. In long-term water resources planning, a key uncertainty is climate change. GCM output is downscaled to obtain climate data at a more locally refined scale. The set of climate and non-climate uncertainties (e.g. population growth, expansion of agricultural areas, etc.) are then combined with the strategies considered. The cases defined by this integration of uncertainties and strategies represent possible future conditions.

Investigation Stage

Step 6 Large Ensemble of Model Runs: The process of combining each uncertainty with each strategy (producing a wide range of plausible futures), results in a large ensemble of model runs (between 30 to 10000). All these runs are evaluated in WEAP. For each run, the results associated with the selected performance metrics in the problem formulation step are exported.

Step 7 Output Exploration or Visualization: The ensemble of model runs produces a substantial database of results. An interactive visualization tool is used to explore this large volume of model output. This tool provides a useful platform for exploring results and evaluating potential decision tradeoffs. Forni et al., 2016 describes a three-step process used in RDS for the development of an effective visualization platform that allows the exploration, communication, and deliberation around potential policy options. See an RDS visualization platform for Yuba County in California: https://lauraforni.com/2017/02/11/robust-decision-support-yuba-ca/ These platforms allow for a powerful integration of human cognitive process related to decision making and powerful computational tools such as WEAP.

Step 8 Decision Support: In this step, the research team works with stakeholders and decision makers in the identification of integrated water resources strategies based on specific policies and investments projects. The visualization platform serves as an interactive tool for the exploration of results and the negotiation and deliberation related to the selection of promising management strategies. During this step, the stakeholders may choose to conduct participatory trade-off analysis to support the negotiation and deliberation before reaching a decision as well.

Applications in different parts of the world

The RDS process has been applied in various parts of the world such as North America (in California), Latin America (Colombia, Peru, Bolivia, Chile, Argentina), Africa, and in Asia. For the Mekong Region, the RDS process has been used by SUMERNET network to help improve water scarcity management strategies considering uncertainty of climate change and development for the stakeholders in following countries.

- Cambodia: Hydrological impact assessment for agricultural development in the Prek Thnot River Basin for Department of Hydrology and River Works.
- Lao PDR: Climate change and water scarcity impact assessment in Champhone District, Savannakhet Province for District Offices for Planning and Investment, Natural Resources and Environment and Agriculture and Forestry
- Thailand: Water scarcity management strategy in Huai Sai Bat river basin for Department of Water Resources.
- Myanmar: Water scarcity management under climate change and landuse change for Directorate of Water Resources and Improvement of River Systems, Irrigation Department and Sagaing Regional Government.

  Vietnam: Urban water management under the urbanization and climate change in

Can Tho City for Can Tho Climate Change Coordination Office

Table 1: Examples for Vulnerability and Adaptation Assessment Processes

Option	Scales	Resources & inputs	Time	Point of Contact & Website
Challenge and Reconstruct Learning (ChaRL)	Sub-Nat'l, Nat'l, and Regional	Medium cost*; computer modeling required for scenario analysis	1-2 yrs	Alexander Smajgl, alex.smajgl@merfi.org, http://www.merfi.org/
Climate Resilience Framework (CRF)	Community, Sub-Nat'l	Medium cost*; computer modeling required for scenario analysis	2-3 yrs	Richard Friend, richardfriend10@gmail.com, http://i-s-e-t.org
GMS Core Environment Program, Asian Development Bank (ADB)	Community, Sub-Nat'l	Low cost*; low technology requirements assuming access to regional climate projection data and analysis	1-2 yrs	Sumit Pokhrel, Sumit@gms-eoc.org http://www.gms-eoc.org/
Robust Decision Support (RDS)	Sub-Nat'l, Nat'l, and Regional	Vary from low cost* to high cost*; computer modeling capability necessary to conduct analysis, intensive stakeholder engagement process	1-2 yrs	Chusit Apirumanekul, chusit.apirumanekul@sei-international.org http://www.sei-international.org/asia
Large Landform Holistic Assessment Southeast Asia (SEA) START	Community, Sub-Nat'l	High cost*; complex computer modeling capability necessary to conduct a range of biophysical and socio-economic analyses	3-5 yrs	Suppakorn Chinvanno, suppakorn@start. or.th, http://www.start.or.th/
USAID Mekong ARCC Integrated Vulnerability Assessment and Adaptation Decision-making Method	Community, Sub-Nat'l	Low cost*; low technology requirements assuming access to regional climate projection data and analysis	1-2 yrs	Paul Hartman, Paul_Hartman@dai.com, http://mekongarcc.net/

Watershed-based Adaptation to Climate Change	Community, Sub-Nat'l	High cost* due to multiple elements, including computer modeling of downscaled climate projections; assessments with multiple communities in the watershed; ground-level monitoring of forest conditions	1-2 yrs	Dr. Monthip Sriratana Tabucanon, National Research Council of Thailand monthip2007@gmail.com Ravadee Prasertcharoensuk, SDF ravadee@sdfthai.org

*Low Cost: US$10,000-100,000; Medium Cost: US$100,000-500,000; High Cost: >US$500,000

CHAPTER 4

Tools for Conducting Watershed-scale VAA

Watershed-scale Vulnerability and Adaptation Assessments (W-VAAs) can benefit from a rapidly growing toolbox of data gathering and modeling approaches that help to forecast how complex social-ecological watershed systems will be impacted by climate change, which in turn help stakeholders formulate alternative futures and to prioritize adaptation options.

The suite of tools utilized for a particular W-VAA can range from qualitative, low-tech methods, to highly-quantitative computer models. Regardless of where a particular approach falls on this spectrum, the mix of tools chosen for identifying and designing climate adaptation options must capture the following elements:

1) Expected future climatic conditions, including rainfall patterns, mean and peak temperature, wind-related events, and other locally-important conditions;
2) Vulnerabilities, including human life, livelihoods and natural, economic, and social assets, and
3) Adaptation capacity, including skills, experiences, assets, technologies, and natural and ecological features.

Context matters. The interaction of hydrological, social, economic, ecological and technological dynamics creates, for many situations, a highly complex and contextually-detailed social-ecological landscape. Failing to consider this complexity will likely result in the design and implementation of maladaptive strategies. Capturing this complexity within the assessment process require sophisticated tools. These tools generally fall into two categories: disciplinary and integrative. Disciplinary approaches focus on a specific aspect of the social-ecological equation, such as hydrology, climate, agriculture or poverty. The outputs from a combination of these disciplinary models can then be evaluated in a sequential and integrated process to help formulate an overall picture for future conditions in the watershed. On the other hand, integrative methods work to combine inputs from various disciplines into one single method at the outset. Each approach has advantages and disadvantages.

The combined use of disciplinary approaches has the advantage of keeping methodological requirements simple and can often draw on more human capacity because they employ more traditional methods. The disadvantage is that the majority of complex feedbacks between disciplinary variables (i.e. economic, social, hydrological, ecological, and financial) cannot be considered, which introduces substantial risk by failing to reveal unexpected side effects.

Integrative tools are particularly valuable for helping to reflect the complex interactions that occur between the physical environment, built environment and the social and economic fabric linking them. As a result, integrative methods are experiencing increased uptake. For example, climate change can cause a particular community's hydrology to change, resulting in crop failure and economic changes that cause people to adjust land use or possibly modify the hydrology of adjacent areas to mitigate their losses, which in turn causes further ripple effects. A combination of disciplinary approaches cannot effectively capture such cross-disciplinary complexity.

This integration of multiple variables relevant to the design and the assessment of climate change adaptation strategies allows for the identification of feedback effects. These feedbacks can cause unintended side effects that may render certain adaptation options ineffective or cause investment strategies to generate maladaptive development initiatives. However, integrative methods have the disadvantage of being new to the scene, with fewer well-trained researchers available to properly apply them. Additionally, integrative designs are often complex, which reduces accessibility by non-modelers. New visualization technologies are being tested, however, to help stakeholders better understand how integrative models work, so as to demystify their "black-box" nature.

Hybrid approaches too can be employed. These combine advantages of the relative simplicity of disciplinary tools with those of more complex integrative tools. Hybrid approaches allow for additional validation as their results can be cross-checked and compared across the different methods, thus increasing the robustness of the policy recommendations derived from their results.

Qualitative methods are an additional group of methods often utilized by W-VAAs. This group of methods aims to reveal: experienced or expected impacts of climate change or development interventions; intended behaviors or richer descriptions of past, present, and future circumstances. Examples of qualitative methods include: visioning, the development of climate stories, participant observation, interviews or focus group discussions. Within the context of a W-VAA, qualitative methods can:

- strengthen communities' capacity to understand prevailing climate risks;
- strengthen stakeholders' perception of what drives change;
- produce a description of social networks;
- define categories of vulnerabilities, adaptation options and preferences, and
- produce a stakeholder-derived preferred vision of the future.

Disciplinary Approaches

The vast majority of current W-VAA approaches use a combination of disciplinary methods. Typically, these incorporate the following types of models and tools:

- climate downscaling;
- hydrological modeling;
- land use change, and
- socio-economic models.

Climate Modeling provides an initial, high-resolution projection of critical climate variables, such as rainfall and temperatures. Climate projections can be derived from General Circulation Models (GCMs) or from high resolution downscaled projections.

Climate Change Data Distribution System is a web-based online tool that generates future climate data for various climate change scenarios from climate change impact studies or climate change risk and vulnerability assessments. This tool allows user to extract future climate projection data of a specific area, such as a sub-watershed or administrative units within mainland Southeast Asia. The data is high resolution for purposes of generating future climate projections based on global simulation and dynamic regional downscaling.

These datasets are scenarios projecting out to the end of the 21st century. The scenarios depict plausible future change in climate characteristics under different atmospheric greenhouse gas concentrations. The output datasets consist of the following climate variables: maximum temperature, minimum temperature, precipitation, wind speed, wind direction and solar radiation.

Additional extensions of climate change data distribution system are underway. There is progress toward an approach in which climate change data are provided in a form that is relevant to particular risks, e.g. change in trend of rainfall amount and intensity, change in trend of extreme and average temperature.

The system was established through collaboration between Southeast Asia START Regional Center (SEA START RC), Chulalongkorn University, Thailand and ESRI (Thailand), Co., Ltd., under support from Science and Technology Postgraduate and Research Development Office (PERDO), Thailand.

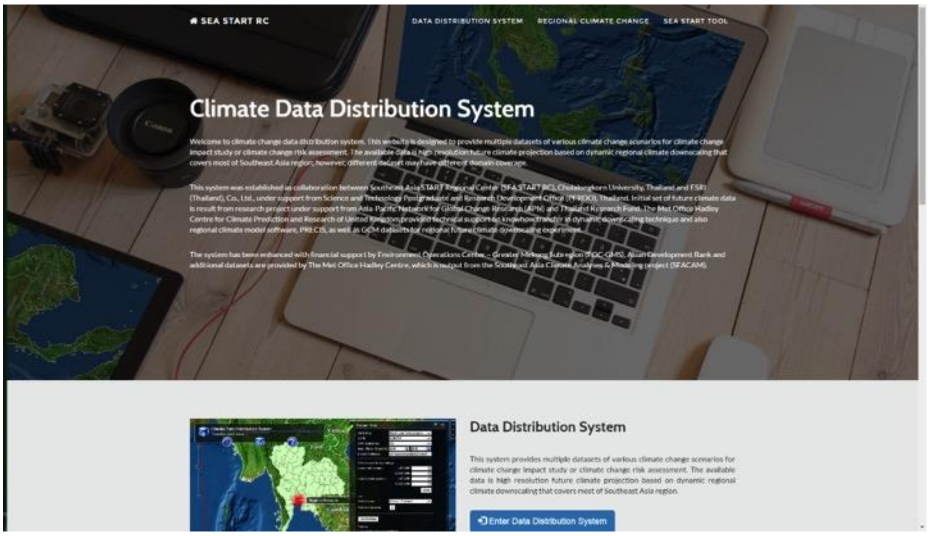


Figure 9: Example on-line tool from SEA START (http://ccs.gms-eoc.org/climatechange/start2/index.html) to provide quick visualizations in particular variables over time. This map displays changes in maximum air temperature forecast for the 2050s

under the ECHAM4 A2 PRECIS RCM scenario.

Hydrological models typically focus on surface water flows and translate rainfall projections in combination with evapotranspiration projections into surface water run-off scenarios. These scenarios inform predictions of flood and drought related risks. In some cases **groundwater models** are connected to incorporate aquifer dynamics into the surface water analysis. This is particularly relevant where the high connectivity of surface and ground water needs to be managed carefully to avoid floods. Also, situations with high drought risks benefit from considering groundwater as groundwater pumping can provide a very effective drought alleviation strategy. Water, Evaluation And Planning (WEAP) is a climate driven simulation tool for integrated water resources planning. It combines climate, hydrological, land use and demand variables to assess water availability (Yates et al., 2005).

Land use models capture the current land use baseline and forecast future land use change. These projections build on climate and hydrological variables and add social and economic assumptions. Social dimensions might include urban sprawl or the introduction of conservation-focused regulation to prevent land use change. Economic aspects might include price projections for various crops to determine incentives that might drive a particular land use changes. The CLUE Model (Conversion of Land Use and Its Effects) is a widely used example of this type of model. Several agent-based *(see Section "Integrative Tools" for a detailed explanation of agent-based models)* models have been developed in the recent past that include land use change dynamics as part of more complex systems model including the Mekong Region Simulation (MerSim) described below.

Socio-economic models are comprised of a variety of tools. Usually, adaptation-focused analysis includes variables such as poverty, gender, employment, economic values of ecosystem services, migration or health. Depending on the particular climate change risk communities face, the communities may change their socio-economic priorities, thus requiring application of an appropriate method to reflect the desired change. Most of these models are based on demographic data and/or household survey data and employ statistical approaches. Most of these are project or case study specific solutions. Serving as transferrable tools, socioeconomic models are typically linked to questions in areas like agriculture, the macroeconomy, or land use change. Also many of the integrative tools described below include socio-economic elements.

Integrative Tools

Multi-criteria Analysis (MCA)
is an effective method for ranking investment alternatives. Here a multidisciplinary group of actors discusses and defines criteria that are contributing to a problem or solution. Each actor assigns a value to the criteria from his or her own perspective. A resulting multi-dimensional "criteria tree" is used to generate a weighted suitability score. When the criteria are linked to map layers, they become what is known as spatial MCA, and the output will be a map showing the geographic distribution of suitability scores as shown in Figure 10.

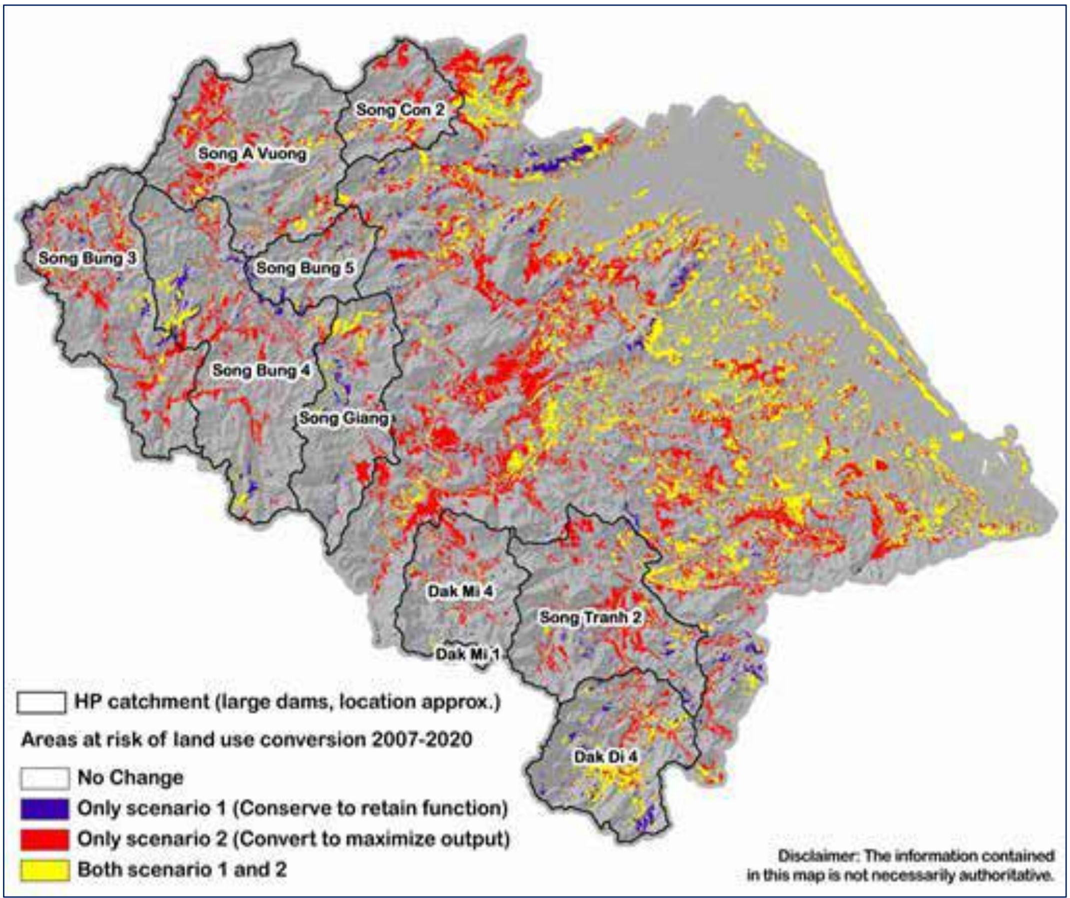


Figure 10: Shows how spatial MCA helped mapping and categorizing the risk to landscapes of various sector investments under the GMS Regional Investment Framework to guide investment prioritization, and indicate potential mitigation measures.

Agent-based Modeling

is a simulation methodology that is typically employed in situations where the behavior of disaggregated system elements can be described, but the overall system behavior is unknown. In contrast to most modeling techniques, agent-based modeling allows for response functions to be defined not only in mathematical equations, but also in qualitative logical structures. This advantage introduces the possibility to explicitly incorporate human decision-making processes. Connecting the multitude of system elements and their interacting behaviors provides the analytical capacity to understand emerging system-wide outcomes. These emerging outcomes can include land-use change, spatial and temporal poverty patterns, community and regional vulnerabilities, patterns of resilience, and migration.

In advanced, agent-based modeling, social-ecological interactions are spatially referenced. In other words, the simulated system can be defined within a realistic landscape employing GIS data. This spatial dimension provides large advantages for climate adaptation related modeling as it allows the modeler to more accurately integrate climatic, hydrological, ecological, agronomic, social, behavioral, technological and economic variables.

A few agent-based models have been developed for the Mekong region. Several small-scale models focused on water management issues and were developed by the French research agency CIRAD and employ the so-called Companion Modeling approach, which co-designs models with stakeholders. The Mekong Region Simulation (MerSim) model was developed for the entire GMS and considered climate change adaptation in the context of broader development strategies, such as irrigation, large-scale plantations, dams and dikes. Its design allows for the interaction of multi-scale dynamics at various spatial levels. At the regional level climate change, migration and price fluctuations are incorporated. At the basin-wide level water flow, water quality and sediment are added. And at local level local water quality, poverty, land use change are among the issues evaluated.

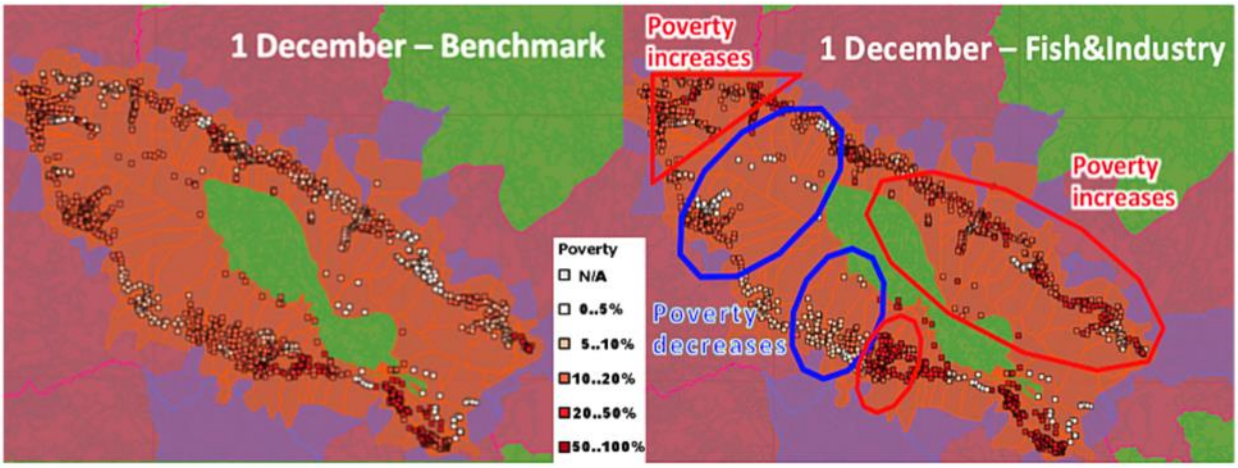


Figure 11: Poverty maps from MerSim simulations for the Tonle Sap for a representative benchmark (Left) and a scenario (Right) that assumes a collapse of fish stocks a parallel investments in industry employment. Village locations are marked with increasing levels of red indicating higher levels of poverty.

Figure 11 displays output from MerSim used to inform climate adaptation related policy. In this example for the Tonle Sap, assumptions include more frequent droughts across the Mekong basin combined with the development of more mainstream dams in Laos and China, and investments into the expansion of manufacturing industry employment in Cambodia— alternative livelihoods to fishing. The results shifted the policy discussion in Cambodia towards a more differentiated approach to planning that accounts for the heterogeneity of communities in the Tonle Sap area.

WEAP: The Water Evaluation And Planning is a software tool employing an integrated approach to water resources planning. The WEAP model examines water supply and demand under a wide range of scenarios. Scenarios generally describe projected futures based on current climate conditions as well as input from downscaled GCM models and other uncertainties, such as land use changes that are outside the managers' mandate. The application of WEAP across a wide range of plausible scenarios and management alternatives generates multiple metrics for multiple economic sectors yielding a large and complicated set of results. Frameworks such as Robust Decision Support (RDS), described in Chapter 3, can be used to distill these results into meaningful outputs for decision-makers.

Figure 12 provides sample output from a WEAP application for the Huay Sai Bat River Basin in Thailand. The table presents the probability of failure due to uncertainty of five different management options presented horizontally as S0-S4. These options are repeated for each of eight sections of the basin labeled C00-C007. Vertically are the three different climate change scenarios evaluated. Decision-makers can choose the strategies or options they want to pursue while taking into consideration climate uncertainties. In this example option S0 is to do nothing; S1 is to dredge some existing ponds; S2 is to extract groundwater for alternative water supply; S3 is to shift cropping calendars and S4 is to construct a small weir in the upper region. Decision-makers chose which among these options will result in more or less agricultural coverage, more or less water coverage, more or less industrial water coverage and maintenance of environmental flows. Decision-makers can also consider options according to opportunity costs and the potential for failure.

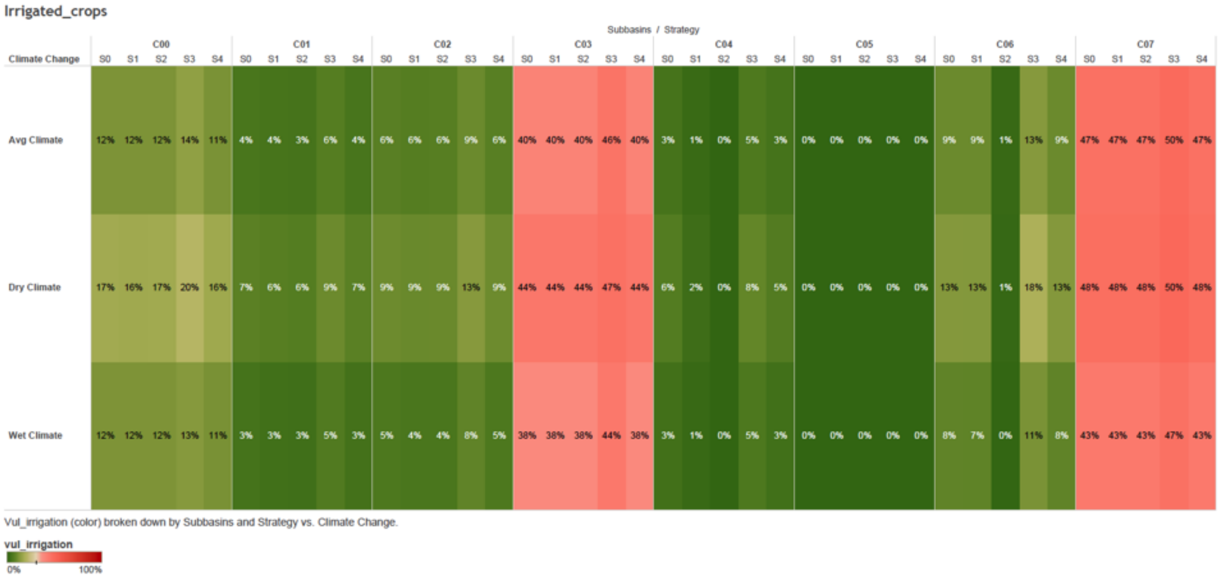


Figure 12: WEAP application to the Huay Sai Bat basin planning context indicating cropping risks for various management options under different climate change scenarios (C00-C07).

Qualitative Methods

Livelihood Seasonal Calendar

This calendar is a participatory tool used in rural communities to review the annual distribution of livelihoods, natural resource production, land use activities and to compare them with the seasonality of climate hazards. The calendar is presented as a table with the months of the year as columns and key livelihood activities as rows. The months may be grouped by season such as dry or rainy. Villagers discuss what activities take place in which months and note priority activities at different points of the year, for example planning or harvesting. Participants may denote gender specific livelihood activities within the calendar.

Village Transect Mapping

The village transect map provides a cross-sectional representation of a community that includes: topographical features; community assets such as temples, schools, clinics, utilities and infrastructure; housing; natural resources, and general land use patterns. The map is constructed via a transect walk. Participants may divide an area into multiple transects and survey the community in a systematic manner to better understand and identify the magnitude and geographic boundaries of community features. As a transect walk can take a significant amount of time (depending on the spatial area assessed), a transect map may be used to simplify the activity but meet the same objective. The map may be drawn by communities from a two dimensional view to show key topography, housing, natural resources (e.g., ponds and streams), community assets, and land use (e.g., rice fields). The map is used to support village discussions in defining activities and vulnerabilities tied to geographic location.

Plan Maps

Hazard, village, and resource mapping tools can also be used to provide a plan view of the community and its resources. They can describe geographically the effects of climate and non-climate hazards over relevant areas and natural resource stocks and ecosystems. Village maps provide a base overview of the area of interest, depicting general features of importance including village boundaries, housing areas, water sources, roads, and specific land uses. Resource maps identify in more detail the important resource areas and assets that are significant to maintaining secure livelihoods and to protecting important cultural resources. Maps may also include gender-specific livelihood areas such as where women traditionally gather particular items or where men hunt. Hazard mapping may be overlaid on the resource/village maps to indicate where in a community specific hazards occur.

Historical Hazard

The historical hazard tool explores prior climate events and other critical events within the community, along with the mechanisms the community implemented to respond and cope with the hazards. Without easy access to meteorological and other recorded data, many rural people tend to remember key events and past hazards that may have had devastating impacts on their villages. Having them recall the historical hazards within an estimated time period, such as 20 years, helps to facilitate discussions on large, historically rare climate events. They may be able to use this data to frame a discussion that determines whether large flood events may be increasing in frequency and severity due to climate change

Vulnerability Hazard Ranking (or Vulnerability Matrix)

Vulnerability Hazard Ranking is a participatory tool to help communities evaluate the vulnerability of livelihoods as a result of climate and non-climate hazards. Facilitators use a flipchart or whiteboard positioned in view for all community participants, which lists horizontally the community-identified hazards and vertically the livelihoods and/or community resources. For each hazard, such as heavy rain, extreme heat or drought, participants are asked to evaluate on a scale from 1 (low) to 4 (very high) the relative risk of the specific hazard to the specific livelihood or resource. For example, the villagers may rate drought as a 4 for community water supply and as a 2 for harvesting bamboo shoots. If participants cannot reach consensus on a specific rating, they can vote to take a decision on the value or choose to note its uncertainty. The Vulnerability Hazard Ranking tool provides an initial step toward prioritizing key issues in the further development of adaptation initiatives.

Visioning

Visioning is a qualitative method to identify stakeholders' perceptions of possible future situations. These visions are typically developed in group discussions and distinguish between most desired, most likely, and least desired situations. Visioning involves, in most cases, the identification of drivers and their influences on the current situation. This is often combined with a quantitative trend analysis. Next, the future development of the most influential drivers is categorized by the perceived levels of uncertainty. The potential combined effects of these drivers are then translated into a description of the future conditions for the area using indicators that are most relevant to the participating stakeholders. The goal of this approach is to identify scenarios that all stakeholders select as desirable and as undesirable.

Based on these visions, action plans can be developed which one, are most likely to achieve the most desirable future, and two, are capable of managing the risks of the most undesirable futures. In a multi-stakeholder context, such shared visions can be powerful guides in the planning process even in the presence of conflict. Most importantly, visions can provide effective normative benchmarks for the discussion of scientific evidence. They can replace aspirations that reflect the needs and values of only one economic sector, thereby reducing the potential for conflict.

Table 2 Online Resources for W-VAA Tools	
Water, Evaluation and Planning (WEAP)	http://www.weap21.org/index.asp
Conversion of Land Use and Its Effects (CLUE)	http://www.ivm.vu.nl/en/Images/Exercises_tcm234-284019.pdf
Climate Change Data Distribution System	http://ccs.gms-eoc.org/climatechange/home/index.html
Multi-Criteria Analysis (MCA)	http://eprints.lse.ac.uk/12761/1/Multi-criteria_Analysis.pdf
The Mekong Region Simulation (MerSim)	https://www.researchgate.net/publication/253645367_Validating_simulations_of_development_outcomes_in_the_Mekong_region
Village Transect Mapping	http://siteresources.worldbank.org/EXTTOPPSISOU/Resources/1424002-1185304794278/4026035-1185375653056/4028835-1185375678936/1_Transect_walk.pdf

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