Watershed Vulnerability and Adaptation Assessments in the Greater Mekong Subregion

GMS Roundtable on Climate Adaptation

Guidelines for Climate Change Practitioners

Abbreviations

ADB	Asian Development Bank
AMICAF	Analysis and Mapping of Impacts under Climate Change for Adaptation and Food Security
CEP	Core Environment Program
ChaRL	Challenge and Reconstruct Learning
CLUE	Conversion of Land Use and its Effects
CRF	Climate Resilience Framework
FAO	Food and Agriculture Organization of the United Nations
GCM	General Circulation Model
GIS	Geographic Information System
GMS	Greater Mekong Subregion
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
Lao PDR	Lao People's Democratic Republic
LMB	Lower Mekong Basin
M&E	Monitoring and Evaluation
MCA	Multi-Criteria Analysis
MERFI	Mekong Region Futures Institute
MerSim	Mekong Region Simulation
MOSAICC	Modelling System for Agricultural Impacts of Climate Change
NGO	Nongovernment Organization
PERDO	Science and Technology Postgraduate and Research Development Office (Thailand)
RDS	Robust Decision Support
SDF	Sustainable Development Foundation
SEA-START RC	Southeast Asia START Regional Center
SEI	Stockholm Environment Institute
SIEP	Sirindhorn International Environmental Park
SLD	Shared Learning Dialogue
SUMERNET	Sustainable Mekong Research Network
TEI	Thailand Environment Institute
USAID	The United States Agency for International Development
USAID Mekong ARCC	USAID Mekong Adaptation and Resilience to Climate Change
USFS	United States Forest Service
VAA	Vulnerability and Adaptation Assessment
W-VAA	Watershed-Scale Vulnerability and Adaptation Assessment
WACC	Watershed-Based Adaptation to Climate Change
WEAP	Water Evaluation and Planning

Table of Contents

Figures

Tables

Box

Acknowledgements

The guidelines were jointly authored by Alex Smajgl, Albert Salamanca, Ashley Steel, Geoffrey Blate, Jonathan Long, Paul Hartman, Ornsaran Manuamorn, Puja Sawhney, Richard Friend, Shelley Gustafson, and Suppakorn Chinvanno.

The guidelines benefited from important contributions by Robert Mather, Saengroaj Srisawaskraisorn, Shannon Dugan, Soojin Kim, Sumit Pokhrel, and Tom DeMeo.

Copyright © 2018, GMS Roundtable on Climate Adaptation, Bangkok, Thailand

Photo credits:
Shutterstock: Pages cover, 10 and 47;
Environment Operations Center: Pages i-iv, 1, 5, 6, 48 and 60;
Stockholm Environment Institute: Pages 7, 11-18, 23, 24, 27, 32, 34, 36, 41, 44, 45 and 59;
USAID Mekong Adaptation and Resilience to Climate Change: Pages 9 and 30.

The Greater Mekong Subregion Roundtable on Climate Adaptation

Background

A number of organizations in the Greater Mekong Subregion (GMS) work closely with the six member countries of the GMS to help them more effectively integrate climate-change considerations into development-related decisions.[1] Such support covers numerous areas, including policy analysis, technical research, tools and approaches, and the piloting of field-based interventions. In early 2013, the GMS Core Environment Program initiated the GMS Climate Adaptation Roundtable as a platform for bringing together researchers and practitioners from various regional organizations to exchange knowledge and best practices, identify gaps, and work together to plug those gaps.

The Bangkok-based roundtable partners are:

(i) GMS Core Environment Program

(ii) The International Union for Conservation of Nature (IUCN)

(iii) Mekong Region Futures Institute (MERFI)

(iv) United States Agency for International Development Mekong Adaptation and Resilience to Climate Change (USAID Mekong ARCC) project

(v) United States Forest Service (USFS)

(vi) Stockholm Environment Institute (SEI) and Sustainable Mekong Research Network (SUMERNET)

(vii) Thailand Environment Institute (TEI)

(viii) Southeast Asia START Regional Center (SEA START RC)

(ix) Food and Agriculture Organization (FAO) Regional Office for Asia and the Pacific

These regional guidelines on watershed-scale vulnerability and adaptation assessments (W-VAAs) are the product of a multiyear collaboration among the institutions listed above. The guidelines synthesize the shared knowledge and experience of the roundtable partners in developing frameworks for vulnerability and adaptation assessments (VAAs) and implementing them in the GMS over the past decade. Specifically, these guidelines incorporate the direct experience of recent projects that have used watersheds as an organizing element for climate-change VAAs.

1 The Greater Mekong Subregion includes 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 an economic-integration area naturally linked by the Mekong River and strengthened by growing transport connectivity, cross-border trade and investment, and labor mobility.

About the Roundtable Partners

Greater Mekong Subregion Core Environment Program

The Core Environment Program supports the Greater Mekong Subregion by helping to deliver environmentally friendly economic growth. Anchored in the Asian Development Bank (ADB)-supported GMS Economic Cooperation Program, the CEP promotes regional cooperation to improve development planning, safeguards, biodiversity conservation, and resilience to climate change—all of which are underpinned by building capacity. The CEP is overseen by the environment ministries of the six GMS countries and implemented by the ADB-administered Environment Operations Center. Cofinancing is provided by ADB, the Global Environment Facility, the Government of Sweden, and the Nordic Development Fund.

GREATER MEKONG SUBREGION
CORE ENVIRONMENT PROGRAM

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.

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

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 known for its physical, biological, and cultural diversity. In fact, it routinely garners international headlines because of the new species discovered there every year. But for each one of these reports, there are countless more stories about uncertainty, not just regarding the basin's ecology, but also the societies of this six-nation region, as their exposure to the effects of climate change is predicted to be among the most extensive in the world.

What is not being reported, however, is the fact that a new form of diversity is rapidly evolving in response to this uncertainty. It is both bottom-up and top-down. It involves village elders paired off with industry executives, and old-school sandals-on-the-ground surveys combined with supercomputer models. It is an interdisciplinary, inter-sector, and intensively interactive planning movement led by a diverse set of stakeholders who are pioneering various approaches and tools with one goal in mind: to strengthen the region's capacity to reduce climate change risk by creatively applying watershed-scale vulnerability and adaptation assessments (W-VAAs).

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

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

Chapter 2 lays out seven principles that the Roundtable has concluded are critical for guiding the formulation, implementation, and evaluation of an effective W-VAA process. These are: focus on informing decision-making; stay within a well-defined scope; consider the complexities of socio-ecological systems; take future risks and uncertainties into account; ensure a participatory approach; increase the social capacity to reorganize in the face of risks; and monitor, evaluate, and learn.

Chapter 3 outlines five main steps in conducting a W-VAA. These are: scope the assessment context, particularly the decision or policy it is intended to influence; conduct a baseline vulnerability assessment; identify, evaluate, and prioritize adaptation options; integrate adaptation options into action plans and watershed-management plans; and synthesize learning and improve the W-VAA process. The remainder of the chapter provides seven replicable examples of how W-VAAs are being implemented in the Mekong region, with each example illustrating specific W-VAA principles and steps in the W-VAA process.

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

Lastly, these guidelines and the W-VAAs are works in progress. Represented here is the state-of-the-art versions of how W-VAAs are being conducted on the ground in the Mekong region. The Roundtable looks forward to the continued evolution of W-VAA techniques through the 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 the resilience of the Mekong region's complex socio-ecological system.

Chapter 1

Introduction

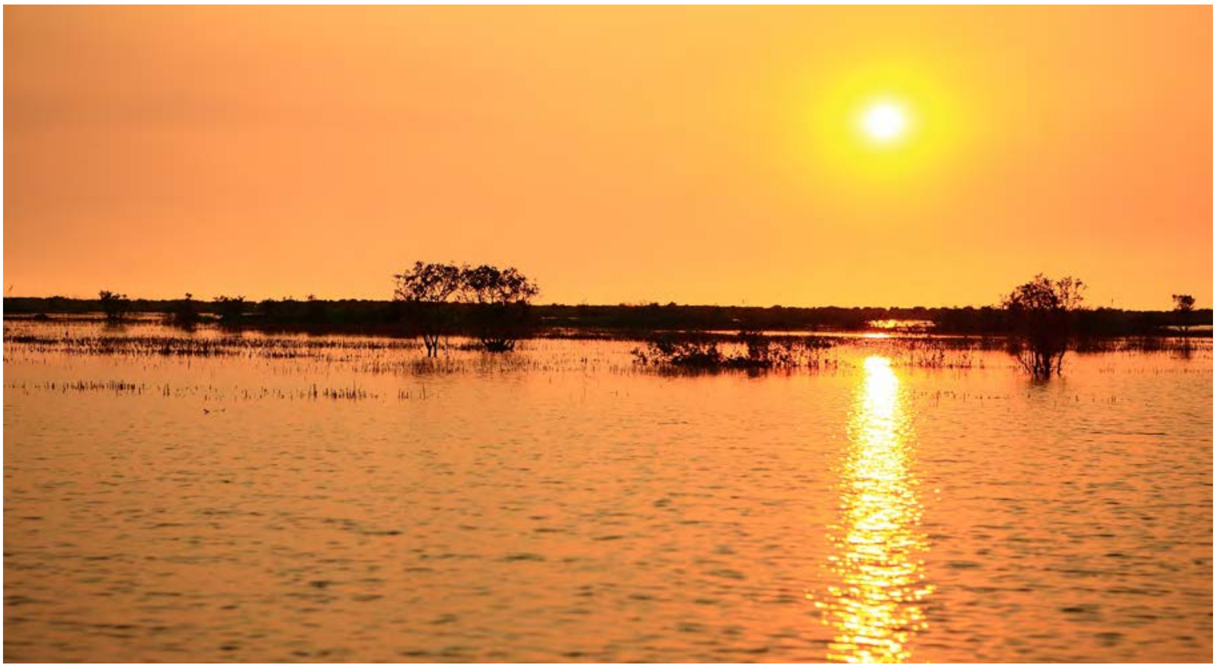
The countries of the Mekong River Basin face some of the highest levels of climate change risk in the world. Extreme weather events—the primary way in which most people experience the effects of climate change—are already taking their toll on the region. Over the past two decades, losses from floods, droughts, heat waves, and severe storms in the Mekong River Basin have dwarfed those occurring throughout much of the rest of the world (Kreft et al. 2015). This pattern will only worsen unless strategies are developed 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 opportunities to minimize them. Called **"vulnerability and adaptation assessments"** (VAAs), these structured, though flexible, processes explore vulnerabilities across all social, economic, and ecological conditions. From individuals to communities, infrastructure to industry, environment to ecological services, both climate and non-climate risks are identified, and adaptation strategies are explored and prioritized. Most importantly, the VAA process becomes an integral part of planning, policy formation, and investment decisions.

A growing body of knowledge and practices in climate-change planning is now evolving across the Mekong River Basin countries. International development organizations, national and regional agencies, and local communities have begun applying VAA principles and producing valuable assessments. Nonetheless, the full potential of VAAs has not yet been realized, as their use in the region is not keeping pace with the rising risks caused by climate change. Efforts must be made to overcome the key shortcomings in VAA practices in the Mekong River Basin. Otherwise, the societies there, and the environment that sustains them, 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 (M&E). 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. Currently, 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 socio-ecological interactions at play. Otherwise, their findings might overlook key drivers, causing future risks that the VAAs could fail to address.

What is Different about Watershed-Scale Vulnerability and Adaptation Assessments?

Watersheds are how nature breaks up the landscape. They are unique areas of land in which all the precipitation that falls onto it drains into a common outlet. They can be as large as the Mekong River Basin or just a component thereof (such as the Tonlé Sap Lake, in Cambodia). Every home, community, and country belong to one. Watersheds have long guided human settlement and economic activity because of the high value of water and the many ecosystem services their waters provide.

Fundamentally, the focus of VAA assessments needs to shift the locations where the effects of climate change are mainly developing: in the watersheds.

Ecological changes follow the rules and pathways of nature's landscapes, indifferent to the political and administrative borders that societies have placed upon them. Hence, it is critical that the frame of reference for VAAs reflect the ecological boundaries that drive the changes societies will experience.

The importance of watersheds as the basis for integrated planning is well established and has been recognized in international agreements and national policies. 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, and within every watershed there is a set of critical dependencies that link communities to each other and to the natural landscape.

Watershed-scale vulnerability and adaptation assessments (W-VAAs) explicitly integrate several components of the socio-ecological system, identifying linkages between natural landscapes and human systems, operating over large spatial scales, and using watersheds as an organizing element.

During W-VAAs, the designated watershed boundaries need not adhere to strict hydrological definitions, but instead reflect the critical dependencies among communities and between communities and the environment.

W-VAAs are based on an engagement of partners representing a range of economic sectors, nongovernment organizations (NGOs), government agencies, and ecological interests, as well as on an explicit consideration of complex relationships inherent in socio-ecological 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, W-VAAs can enable the further use of integrated water resource management as a response to climate change. W-VAAs can also mobilize climate-related financing opportunities for the Mekong region. International climate donors have demonstrated a strong willingness to fund adaptation projects that adopt ecosystem-based approaches and transcend administrative boundaries.

Who Should Use These Guidelines, and How?

These guidelines are intended to help practitioners properly scope and structure a W-VAA by sharing experiences and expertise. Planners and investors can also use these guidelines to develop W-VAAs that target strategic investment decisions. Additionally, these guidelines can help with the drafting of terms of reference for W-VAAs and for the quality control afterwards.

Any stakeholder interested in advancing the climate-change resilience of the Mekong River Basin will gain insights from the materials contained herein, but the content of these pages will be particularly meaningful to practitioners working for governments, river basin organizations, and community-based organizations in the GMS.

The guidelines reflect the current state of knowledge, and they are based on the experiences of the Roundtable partners, who have been working on a diverse set of W-VAA initiatives in the GMS. They are also informed by relevant international practices. The guidelines can inform stand-alone W-VAAs and those that are embedded in larger policy initiatives by practitioners with both environmental and economic mandates. These guidelines do not presuppose that the approaches and steps presented herein are the only ones or the best ones; nor are they intended to provide a detailed all-in-one manual. Rather, they articulate guiding principles, describe the key steps of conducting a W-VAA, provide explicit lessons learned through case studies, and introduce a range of practical tools.

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 Assessments

Seven guiding principles form the foundation of the design and implementation of successful W-VAAs. They define seven underpinning responsibilities that are also valid for most other types of applied research.

W-VAAs can take many forms, as they differ in scale, objectives, and outcomes. Common to them all, however, is the set of seven principles. Though specific to W-VAAs, these principles are similar in purpose and intent to the international standards and best practices routinely applied to participatory planning and social and environmental assessment processes. The seven W-VAA principles are intentionally broad, generic, and non-prescriptive, and they are applicable regardless of the governance or management structure a W-VAA intends to review. Practitioners and stakeholders should use these principles as a compass that they can regularly refer back to, so as to reinforce their shared purpose in undertaking a W-VAA, and better understand the elements necessary to deliver a high-quality and effective result.

Principle 1: Focus on Informing Decision-Making

While much of work undertaken for W-VAAs involves fact-finding and scientific analyses, these efforts are not undertaken strictly as an intellectual pursuit. The main objective is the delivery of the best information and recommendations to aid decision-making regarding the area spanning a watershed. Therefore, identifying the relevant decision-making space and engaging decision-makers at the outset will both be vital to a W-VAA's effectiveness.

Such identification can be rather complex, as decision-making with regard to a watershed happens at multiple levels. For example, villages, communities, and local authorities may be restricted to incremental decision-making that reduces their individual and collective vulnerabilities to climate change, 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 that, in some cases, may intersect with regional platforms and transboundary alliances.

Principle 2: Stay within a Well-Defined Scope

W-VAAs are restricted in their level of detail, largely due to time and resource constraints. It is therefore important to clearly define the issues that the W-VAA will consider and, equally important, those that must be set aside or ignored. The core questions that a W-VAA should consider are: what and whose vulnerabilities are to be assessed, and why; what the geographical parameters are; what components of the socio-ecological system must be evaluated; where the data will come from; and over what time frame will the analysis be conducted. Many of these core questions require a gender-specific assessment, as vulnerabilities, livelihoods, and adaptation options will vary according to gender. Ignoring gender is likely to lead to maladaptive recommendations.

Similarly, the specific decision(s) and associated decision-making processes to be informed by the W-VAA findings and recommendations must be identified. This decision-making space will likely include multiple agencies, and they may have plans and policies that could inform or be informed by the W-VAA process.

It is also critical to define the stakeholder interests that should be considered. Within the watershed context, there are many stakeholders, including community members, government line agency staff, decision-makers, practitioners, NGOs, industry associations, investors, and researchers. Successfully articulating and clarifying the values and preferences of such a broad range of interests will be challenging, but essential. Ultimately, the stakeholders are the ones who will have to make the tough choices and come to an agreement on the scope of an assessment that will be feasible and worthwhile. Therefore, along with the choice of the issues driving the W-VAA, the identification of the stakeholders to be engaged must be made strategically and explicitly.

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 that 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 the associated transportation infrastructure, triggers human migrations and resource extraction upstream. Such basic relationships represent just the beginning of the complexities that W-VAAs must recognize to effectively assess vulnerabilities and adaptation strategies. Downplaying or ignoring complexity will lead to ill-considered investments that could 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 the complexities, as well as the tools needed to evaluate their collective impacts on the watershed's socio-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.

There will also be complexities due to the multiple levels of government and multiple economic sectors operating within a watershed, and there will likely be conflicts of interest and values. Accounting for these conflicts will be critical for evaluating how vulnerabilities are perceived and acted upon.

Principle 4: Take Future Risks and Uncertainties into Account

Stripped to its core, a vulnerability assessment is about managing risks in an uncertain future, and W-VAAs are no exception to this rule. For generations, society has become all too familiar with planning processes that detail the specifics of a desired future and how various sectors of society must organize themselves to realize that future. This is particularly true for infrastructure, such as that for transportation, energy, and water supplies. But the uncertainties surrounding climate change has demonstrated that this straightforward approach to planning is impractical, as the impacts of climate change seem to become less clear with each new published forecast. Predicting future global climate conditions is immensely challenging, and the posited scenarios are constantly changing. Furthermore, downscaling results from global models to particular locations and time scales is even more difficult and prone to error.

Instead of developing action plans for specific future conditions, suites of scenarios should be developed that encompass a range of outcomes. At a minimum, these should include scenarios that reflect probable cases, including the best case and the worst case. The use of scenarios and Shared Vision Planning (SVP) processes, rather than blueprints, could improve the policymakers' understanding of the risks and uncertainties involved, and help them develop measures that would not undermine their ability to make adjustments later on, should reality deviate from their predictions.

W-VAAs must also carefully consider uncertainties when defining vulnerabilities. In the GMS, where strong economic development is ongoing, current conditions and near-term trajectories for change could create or exacerbate risks. Development patterns, economic growth, migration, changing demographics, and shifting land use all entail particular unknowns. And the risks surrounding their associated vulnerabilities become even more uncertain when factoring in climate change variables. Making development decisions that will be effective now and, in the future, will entail identifying and quantifying multiple uncertainties, developing mechanisms for regularly updating information, and making information accessible to stakeholders in meaningful ways.

In conjunction with scenario development, another tool for characterizing ecological risks is the determination of thresholds, also referred to as "tipping points." This method reinforces the understanding of policymakers that they will need to consider other scenarios if a particular threshold is crossed. Regardless of the tools employed, the emphasis of W-VAAs should be on understanding and taking into account the uncertainties associated with climate change; identifying ranges of possible outcomes and scenarios for the future; and recommending ways to build resilience in the face of the inevitable changes, shocks, and crises that lie ahead.

Principle 5: Ensure a Participatory Approach

Climate change policies should be locally oriented, as adaptation is place- and context-specific. No single adaptation approach can be effective in all settings, so the best approaches are those that accurately reflect societal choices at the local level. And these approaches can only be developed through strong participatory processes that integrate local knowledge with outside expertise. It is also critical to be gender aware during the participatory process, as local knowledge, decision-making, and livelihood-related activities are often gender specific.

What is local is relative. Village or neighborhood planning is local to communities, while communities are local to cities, and cities local to provinces, etc. The residents of any given geographical area, regardless of its size, will have the most in-depth knowledge of their situation, so participation in the planning process should be structured accordingly, from the bottom up as well as from the top down. 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 that the communities face might not overlap, it is important that all communities understand the needs and concerns of their neighbors and find common ground. This will enable them to utilize the W-VAA process in such a way as to develop outcomes that will work out best for all. In so doing, the communities themselves must ensure that their participation in the W-VAA reflects their own diversity. They must incorporate the perspectives of multiple stakeholders when seeking information inputs, by engaging in process discussions and working on joint visualizations of future scenarios. The more diverse the stakeholder base, the more robust the knowledge base for the W-VAA.

Where watersheds are home to indigenous peoples who, for many generations, have used and managed the landscape for their livelihoods, their participation will enable them to continue a tradition of stewardship that has been an important aspect of their culture. Participatory approaches also ensure the transparency of negotiations among stakeholders and a more equal treatment of the inevitable winners and losers after adaptation decisions have been implemented. Finally, participatory W-VAAs generally lead to greater ownership of the implementation and monitoring of adaptation strategies, and they help strengthen the capacity of all stakeholders, including institutions and practitioners. That increased capacity could then enable the replication of the W-VAA process elsewhere in the region.

Principle 6: Increase the Social Capacity to Reorganize in Response to Risks

The risks and vulnerabilities evaluated by W-VAAs are unlikely to disappear entirely should the assessment's recommendations be fully implemented. They may even get worse if forecasts prove inaccurate or implementation is 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 to emphasize that W-VAAs are not one-time exercises, but iterative. Mechanisms need to be established to continuously assess any changes in the patterns of vulnerabilities and in the social perspectives regarding the risks associated with those vulnerabilities.

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

Creating opportunities for local participation requires institutional leadership that continues to bring diverse stakeholders to the table. There are many tools and examples of how to construct multi-stakeholder dialogues that 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, a better understanding of climate change, and refined estimates of specific risks and associated uncertainties.

Principle 7: Monitor, Evaluate, and Learn

If the adaptation measures developed through a W-VAA process turn out to be ideal, robust, and widely accepted, there is still no guarantee that resilience and reduced vulnerability will be the result. 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 emerges from the W-VAA process and is implemented accordingly. This monitoring system would have the added benefit of strengthening local ownership, as communities continue to be engaged. The communities would also remain better able to react quickly to changing circumstances.

Establishing effective monitoring and evaluation (M&E) plans entails setting baselines and defining the indicators that will measure short- and long-term progress. At the 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 can also be valuable, such as those on air and water temperatures, water quality and availability, forest growth, and flood frequency.

All the required qualitative and quantitative metrics need to be well defined, with clear collection procedures. They must be understood by all those involved, not just the 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 should dovetail with other monitoring and review processes, particularly those occurring at the national level.

M&E activities should be designed to also function as participatory learning experiences or as "monitoring, learning, and evaluation" programs. So, M&E is not just an exercise for practitioners, but also for key stakeholders, engaging them in a co-learning environment that fosters greater cooperation and information sharing within and across the agencies leading the evaluation process. Such collective learning strengthens the capacity to adapt to a wide range of situations.

Chapter 3

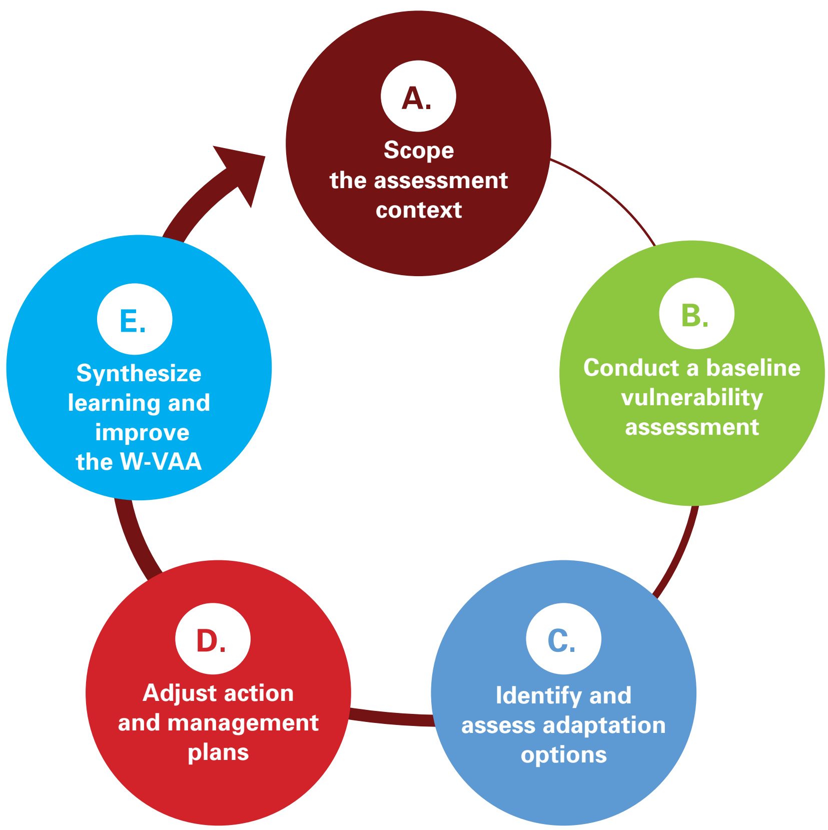
Processes for Conducting Watershed-Scale Vulnerability and Adaptation Assessments

1. The Steps of the Process

We define a "process" as the sequence of steps needed for the successful implementation of a W-VAA. These steps include the actual design and assessment activities, as well as the critical engagements with stakeholders.

There are five core steps that are common to all W-VAAs. The exact sequence of these steps may vary, depending on the choices of the practitioners. The steps will also depend on the context and goals of a particular W-VAA, though each one must clearly contribute to the successful conclusion of the W-VAA process. Figure 1 highlights these steps in the sequence in which they most commonly occur. Below the figure, each step is discussed in greater detail. Finally, a set of case studies is presented that will illustrate how the seven W-VAA principles described in Chapter 2, and the process steps laid out here, have been put into action.

Figure 1: The Principal Steps of a Watershed-Scale Vulnerability and Adaptation Assessment



Source: Authors.

Step A: Scope the Assessment Context

Purpose

Gain an in-depth understanding of the biophysical, socioeconomic, and governance-related context, including the identification of key stakeholders.

Actions

This step typically combines four activities:

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

(i) the physical aspects of the watershed boundaries, land use, topography, surface water flow, groundwater stores, and soil types;

(ii) historic and projected climate data, especially on precipitation and temperatures;

(iii) ecosystem services and their values, such as food, fresh water, medicine, and raw materials;

(iv) social, demographic, and economic factors, such as population, ethnicity, cultural traditions, income levels, livelihoods, and the use of natural resources; and

(v) the process of governance, both formally, in terms of administrative and political structures, and informally, through the participation of NGOs, community associations, and related stakeholders.

The synthesis of these data should serve 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 will be possible. The data may be both qualitative and quantitative, with any uncertainties surrounding a particular data set made explicit.

Second, the team identifies the stakeholders and undertakes an engagement process with them to elicit their aspirations, goals, and concerns. Practitioners are increasingly using visioning exercises about possible future scenarios to facilitate dialogue among the wide range of individuals, community groups, and other public and private stakeholders. This process should produce a list of the stakeholders' concerns related to climate change, and a list of the expectations that stakeholders have regarding W-VAA outcomes. The engagement process should then identify the specific decisions that the W-VAA will aim to influence, and at what point in the governance process those decisions are made.

Third, the team finalizes the scope of the assessment to ensure that sufficient baseline spatial, social, economic, and ecological parameters are assessed, with a view to reflecting the range of vulnerability concerns derived from stakeholder inputs.

Fourth, the team outlines an M&E protocol based on stakeholder expectations and the decision-making and planning context specific to the watershed. This should include at least three actions: assessing the W-VAA's impact on decision-making; quantifying resultant changes in vulnerability; and, lastly, devising a mechanism to enable stakeholders to better understand the principles behind the assessment process and its methodology. During this step, the team should collect baseline data to improve the W-VAA approach and to benefit from lessons learned.

Key Questions to Ask When Determining the Scope of a Watershed-Scale Vulnerability and Adaptation Assessment

(i) What decisions is the watershed-scale vulnerability and adaptation assessment (W-VAA) aiming to influence? Who are the decision-makers?

(ii) Whose vulnerability is the W-VAA trying to assess?

(iii) What policies and plans are being implemented or will be implemented in the watershed that may have implications for the long term?

(iv) Who will be involved in the assessment process?

(v) What sorts of future changes will be considered? And how will the predictions of change be derived?

(vi) What physical terrain will be considered by the W-VAA?

(vii) Which ecological components of the system will be considered and how?

Step B: Conduct a Baseline Vulnerability Assessment

Purpose

Develop a baseline assessment of climate-related vulnerabilities.

Actions

This step typically consists of five activities:

First, the team assesses the exposure of stakeholders to climate change effects by utilizing information gleaned from climate forecasts, biophysical dynamics, and socioeconomic projections. For instance, climate data might suggest spatial and temporal changes in rainfall patterns. Considering the land cover and geological features such as hills, increased precipitation might result in greater flooding. However, if there is a reservoir that captures the runoff, or if one is planned, actual exposure to flooding may be less. Forecasts based on General Circulation Models (GCMs) are essential to vulnerability assessments. The Intergovernmental Panel on Climate Change (IPCC) provides standardized scenarios using assumptions based on GCM findings. These scenarios, which range from business-as-usual levels of carbon emissions to levels resulting from extreme conservation and appropriate technology uptake, provide a common framework within 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 regarding future climate changes. Climate-forecasting data may then be fed into hydrological models to estimate future changes in surface water flow, erosion, sediment flux, and other important physical indicators.

Third, the team evaluates sensitivity, or the degree to which ecological and socioeconomic systems are impacted by climate-related hazards such as droughts, floods, and extreme heat. For example, if there are no settlements or agricultural activity in an area has an increased chance of flooding, the actual sensitivity is likely to be low. Conversely, a 3°C increase in the maximum temperature at high altitudes might transform glacier landscapes, thus causing high sensitivity. But that same 3°C increase at lower altitudes might only marginally affect the cultivation of prevailing crops, indicating low sensitivity. Such evaluations of relative exposure levels and sensitivities need to be applied to each climate-change hazard, as they will be relevant for each of the concerns (indicators) raised by the stakeholders. Some typical indicators are: crop productivity, livelihoods, the condition of forests, poverty, human migration, water quality and quantity, flood risk, and biodiversity.

Fourth, the team assesses the society's adaptive capacity. "Adaptive capacity" refers to the ability of a social system to adapt to stresses and continue to maintain its well-being. It can exist at the scale (i.e., level) of individuals, households, and communities, municipalities, and of the watershed as a whole. Households, for instance, might alter the crops they raise or change other agricultural practices if productivity is expected to decline. Communities can invest in an irrigation scheme if dry seasons are projected to lengthen. At the watershed scale, reforestation initiatives could be implemented to reduce flood risk and erosion, or a water-conservation campaign could be implemented throughout the basin.

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

Step C: Identify, Evaluate, and Prioritize Adaptation Options

Purpose

Generate a list of adaptation options, and for each option produce an assessment of how vulnerabilities are likely to be affected.

Actions

With scientific and other baseline information in hand, and with the identification of the vulnerabilities complete, adaptation options can be deliberated and agreed upon. These options can be: resource-specific, including forests, wildlife, or water; geographically specific, including villages, communities, subdrainage areas, or flood plains; and sector-specific, including energy, agriculture, transportation, or some kind of 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 that of the general assessment conducted in Step B, above. For the sake of consistency, the methodology should be the same as the one used in the baseline assessment. Once the estimates of vulnerability have been generated for each adaptation option, the effectiveness of each option can be assessed through a comparison with the baseline vulnerability. Each option's effectiveness estimates can then be evaluated, along with its associated cost estimates, to determine its relative efficiency. Cost estimates should include the direct financial requirements of implementation, as well as the costs of externalities (i.e., the external ecological or social costs that may be associated with the proposed option). Using a shared set of metrics agreed upon by the stakeholders, the prioritization of options can now occur. The assessments of the options may benefit from their own visioning processes or other structured, multi-criteria analyses that allow stakeholders sufficient opportunities to provide input.

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 developed into an action plan. Working with planners and governments at all levels, the W-VAA action plan must then 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, need to move forward. The actions taken on the basis of these decisions thus represent the first priority measures under any action plan, and by extension, the first indicator of a W-VAA's initial impact.

Step E: Synthesize Learning and Improve the Watershed-Scale Vulnerability and Adaptation Assessment Process

Purpose

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

Actions

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

2. Examples of Process Implementation

What follows are examples of W-VAAs in action. The presentation of each example describes how that assessment incorporated the W-VAA principles presented in Chapter 2, the process steps introduced above, and the lessons learned. Table 1 summarizes their key components, and the References section, beginning on page 60, is a solid resource for those seeking more detailed information about these cases and the tools involved.

Challenge and Reconstruct Learning

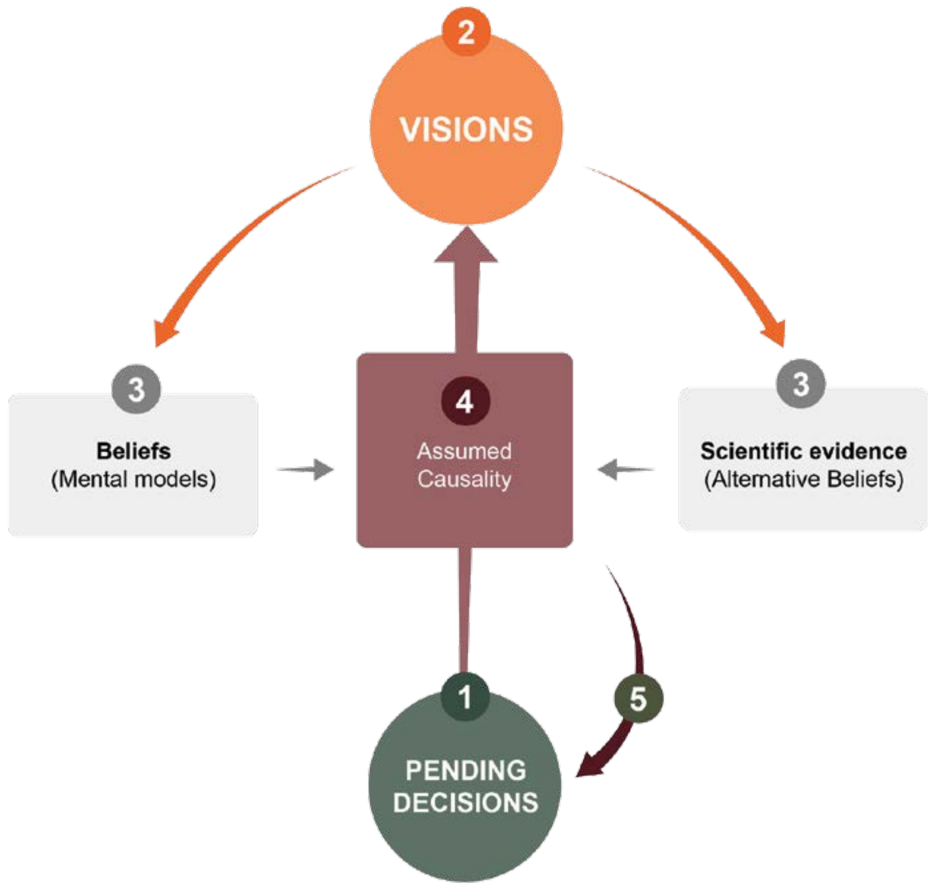
Special Focus

The focus is on policy-impact assessment and conflict resolution. Through the use of participatory research, belief systems are integrated with scientific evidence to promote improved stakeholder understanding of the implications of a given development strategy or adaptation plan.

The Challenge and Reconstruct Learning (ChaRL) framework seeks to guide participatory research in such a way as to bridge science and policy, and it has been widely used in the Lower Mekong Basin. Its systematic science-policy engagement framework applies W-VAA Principle 1 (informing decisions), Principle 2 (staying within a well-defined scope), and Principle 5 (ensuring participation), while placing the stakeholder learning at center stage. It utilizes visions, beliefs, and values as key entry points for the scientific evidence used to inform policy and planning processes.

Figure 2 illustrates the five-step process that the ChaRL framework employs to bridge science and policy. This process formally measures and questions underlying assumptions, then reframes and revises those assumptions by taking a broader view into account. Scientific knowledge is not assumed to be necessarily superior to stakeholder knowledge. Such an initiative, in which 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 (capacity to face risks). ChaRL's individual steps cover nearly all the W-VAA principles and process steps.

Figure 2: The ChaRL Framework—Challenge and Reconstruct Learning



Source: Authors.

ChaRL step 1 This 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 the assessment context). Inviting the relevant decision-makers to codesign the process is seen as a critical measure for ensuring high levels of stakeholder engagement.

ChaRL step 2 This is a visioning effort wherein stakeholders develop narratives of plausible visions of the future for a specified geographic location—also consistent with W-VAA Process Step A. This effort may require several iterations if the set of decisions is likely to affect multiple arenas of action, with each requiring separate facilitation measures. Such an iterative approach enables the revising of visions presented by participants from other locations or governance levels. An agreement on a set of shared visions is essential to prevent the participants from reverting back to their own individual goals when debating the benefits of various development strategies. These visions will provide an agreed-upon foundation for the consideration of competing interests, consistent with W-VAA principles 2 (staying within a well-defined scope) and 5 (ensuring participation). The method of visioning is explained in Chapter 4.

ChaRL step 3 At this point, scientific evidence is presented to assess the expected outcomes of the decisions under consideration. This is similar to W-VAA process steps B (baseline vulnerability assessment) and C (adaptation options). The beliefs of decision-makers regarding perceived causal relationships are to be noted. Assessments can be conducted through a variety of methods, including expert panel assessments, household livelihood surveys, hydrological modelling, and integrated agent-based simulation. This step is primarily guided by principles 3 (complexities of socio-ecological systems) and 4 (risks and uncertainties).

During this step, the team works mostly with a combination of tools (Chapter 4), including simulation models, visioning, household surveys, village transects, and livelihood analyses. As further explained in Chapter 4, the selection of tools depends on the assessment focus, particularly the adaptation options discussed by the stakeholders. The most appropriate methods are then likely to require input data that demand additional tools. For instance, most simulation models or socioeconomic tools require data on livelihoods or on the results of village transects.

ChaRL step 4 This is 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 (capacity to face risks) and Process Step D (integration of adaptation options into planning). Identified contrasts are discussed in view of how pending decisions will or will not contribute to the realization of the desired scenarios envisioned in ChaRL step 1. This activity facilitates the presentation of the underlying assumptions (based on beliefs) against the backdrop of desired futures. The goal is to develop an action plan that (i) reflects the disparities between beliefs and desired futures and (ii) shows sufficient promise of achieving the desired future scenarios and avoiding the undesirable ones.

ChaRL step 5 This step comprises a specific set of actions—debated, revised, and agreed upon—aimed at realizing the participants' desired objectives and vision for the future, per Process Step D (integration of adaptation options into planning). While focusing largely on Principle 1 (informing decisions), this step embodies all the W-VAA principles, with the exception of Principle 7 (monitor, evaluate, learn).

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

The ChaRL framework has been developed for situations characterized by high levels of complexity and a high occurrence of contested values among stakeholders. Within the Greater Mekong Subregion, the ChaRL process has been implemented as part of various multi-stakeholder planning processes, including those for:

(i) the Nam Ngum River in the Lao People's Democratic Republic (Lao PDR), to explore the benefits of large-scale irrigation against the backdrop of climate-change projections;

(ii) the Nam Xong River, in the Lao PDR, to assess the trade-offs between upstream mining and rubber plantations and downstream tourism, in the light of climate change;

(iii) Vietnam's Mekong Delta, to assess effective responses to rising sea levels;

(iv) the Tonle Sap Lake area of Cambodia, to assess the combined impacts of mainstream dams and climate change on local livelihoods; and

(v) northeastern Thailand, to assess climate-change adaptation strategies involving energy crops.

USAID Mekong ARCC Framework for Integrated Vulnerability Assessment and Adaptation Decision-Making

Special Focus

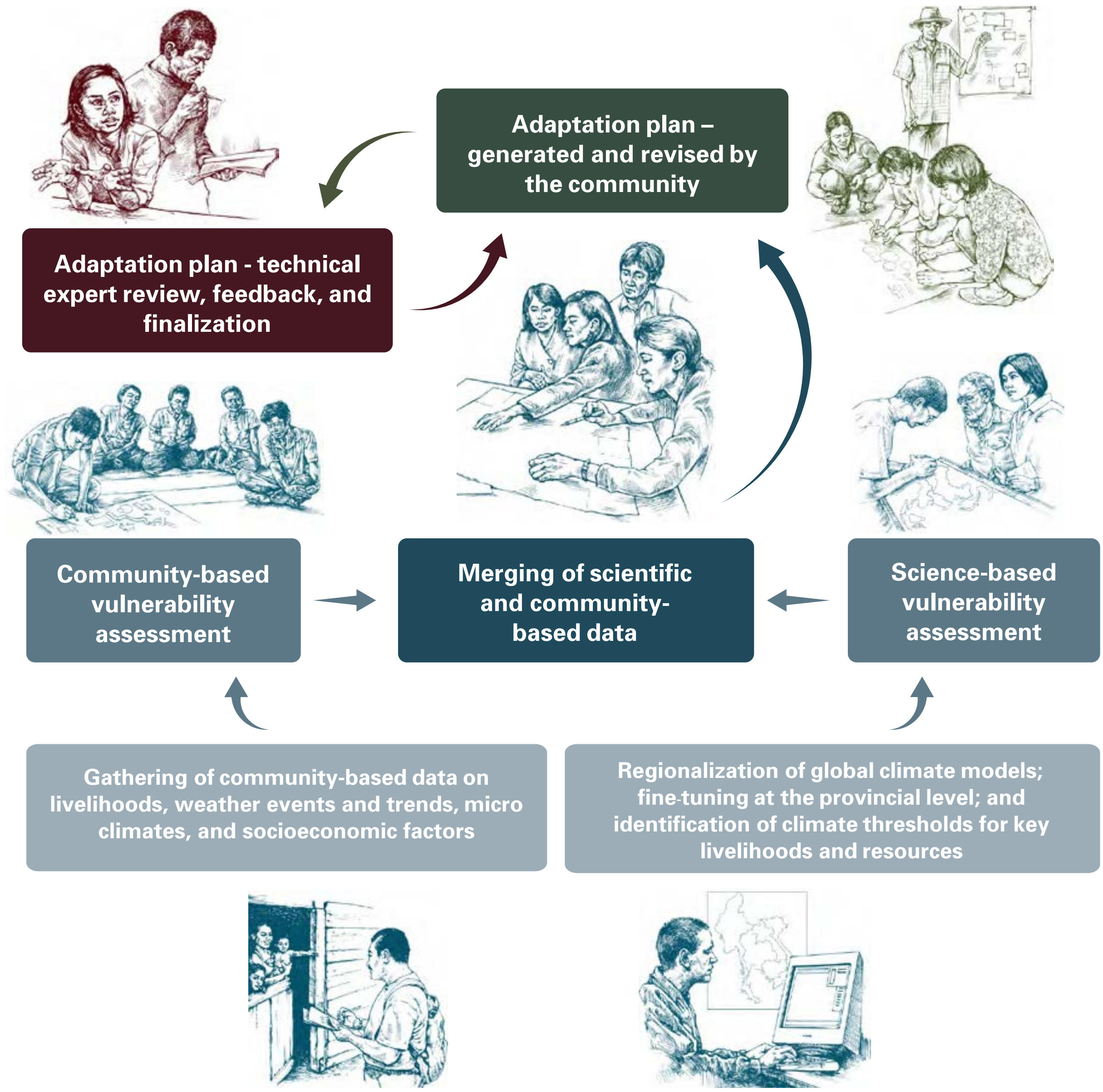
The United States Agency for International Development (USAID) seeks to integrate science-based vulnerability analysis and community-based perspectives with participatory community adaptation planning in such as way as to give equal consideration to both the scientific and community viewpoints.

The USAID Mekong Adaptation and Resilience to Climate Change (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 mechanisms for strengthening livelihood resilience in the face of climate change. The framework is designed to be implemented at the community level. As such, it could also function as part of an overall basin-wide assessment if one of the assessment's goals is to characterize community-level vulnerability. The process is depicted in Figure 3 and outlined in more detail below.

Regionalize Climate Models, Identify Climate Thresholds, and a Conduct a Science-Based Vulnerability Assessment

Downscaled global climate models are useful for refining more generalized projections to the watershed scale, as in Process Step A (scoping the assessment context). Various climate downscaling efforts have been completed for portions of the Greater Mekong Subregion (GMS), and they are available for public use (Chapter 4). For example, the *USAID Mekong ARCC Climate Change Impact and Adaptation Study for the Lower Mekong Basin* (2013) used the statistical downscaling of General Circulation Models to quantify specific shifts in climate and hydrology factors in the Lower Mekong Basin (LMB) by 2050, assuming a moderate emissions scenario. Impacts to agriculture and other important livelihood or economic sectors were then estimated, based on identified climate thresholds at which system shifts would likely occur. Geographic information system (GIS) data from the USAID Mekong ARCC project are publicly available from the GMS Core Environment Program's website: www.gms-eoc.org.

Figure 3: Summary of the Integrative Method of Climate-Change-Adaptation Planning



Source: USAID Mekong ARCC (2013)

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

Gather Local Data and Conduct a Community-Based Vulnerability Assessment

Community-identified vulnerability can be assessed by using a series of platforms, among them baseline awareness surveys, key informant interviews, and community workshops (process steps A, scoping the assessment context; and B, baseline vulnerability assessment). The steps are as follows:

(i) the identification of assets and important livelihood resources through community mapping of physical and natural resources, and the identification of livelihoods that are most important for subsistence and income generation (Chapter 4);

(ii) identification of the nature, location, and timing of climate threats, using climate hazard maps (e.g., of areas within villages that are prone to flooding, landslides, or drought), seasonal calendars (e.g., noting key livelihood activities and the typical timing of climate hazards such as droughts, heavy rainfall, and flooding), and historical climate hazard analysis—all to produce a timeline of significant past climate events that had grave impacts on livelihoods (Chapter 4); and

(iii) ranking livelihood vulnerability by comparing hazard maps with asset and livelihood maps, comparing climate-hazard calendars with production cycles (for key crops, livestock, forest products, etc.), and by considering factors related to community adaptive capacity.

Merge Scientific and Community-Based Perspectives, Conduct Community Visioning, and Develop a 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 assessment; C, adaptation options; and D, integration of adaptation options into planning). At a workshop, data drawn from both community and scientific inputs 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 the similarities and reasons for discrepancies. Ultimately, the communities either confirm or adjust their preliminary evaluations of livelihood vulnerability after they have considered the scientific analysis.

Following this review and synthesis of information, community members identify their problems and needs. The problems and needs assessment then leads to the formulation of a community vision and a list of desired outcomes. These outcomes are considered for three periods: the present, next 5 years, and the lifetimes of the community's children. Strategies are brainstormed on how to meet these desired outcomes, which are then ranked according to how well they address the identified climate threats and vulnerabilities. The ranking of the strategies provides the basis for developing a community adaptation plan.

Once a community adaptation plan has been drafted, there is an external review by technical experts who provide feedback regarding: (i) the technical requirements of the proposed activities and the potential for secondary impacts to other livelihoods and resources, (ii) the feasibility of the activities within the program timeline and funding limits, and (iii) the questions 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).

Villagers of Thuan Hoa Commune, in Kien Giang Province, Vietnam, re-ranked their vulnerabilities in order of priority after learning about USAID Mekong ARCC's climate projections for the province. (Photo: USAID Mekong ARCC)

Watershed-Based Adaptation to Climate Change

Special Focus

The focus is on the integration of community vulnerability assessments, downscaling of climate-change projections, monitoring of forest conditions, land-development planning, and water-management-system planning across a large geographic area.

The Watershed-Based Adaptation to Climate Change (WACC) initiative was undertaken as a regional collaboration financed by the National Research Council of Thailand, Government of Thailand, and USAID, with technical support from the United States Forest Service (USFS). The initiative sought to create a model for robust watershed-scale planning in the context of climate change. It produced an integrated set of community-scale vulnerability and adaptation assessments (VAAs) and ecological assessments that will inform development policymaking and water-management planning in Thailand's Phetchaburi Province, as well as the management of the Sirindhorn International Environmental Park (SIEP), also in Phetchaburi Province.

The W-VAA conducted by WACC was intended to assess climate change vulnerability and adaptation options from the basin's highest peaks down to its coastal shores. As the first project on this scale in Thailand, it involved the integration of plans produced by multiple project partners, and provided many lessons for future efforts to assess climate change vulnerability and adaptation across multiple components of an integrated socio-ecological system spanning a large geographical area.

The work was divided among a series of relatively independent endeavors, punctuated by coordination meetings. As these guidelines were written, the final integrated WACC products were still in preparation, but the first drafts of many components had already been produced. Below, four aspects of this large project are highlighted to offer some insights and guidance for future W-VAA practitioners.

Scoping the Physical Scale of the Assessment

The scoping took place over several meetings of the partners—both local and international (Process Step A, scoping the assessment context). The project was originally expected to focus on both the particular watershed that drained into SIEP and the entire Phetchaburi River watershed. In an early scoping meetings, it was determined that SIEP was not physically within the Phetchaburi River watershed, but instead received water from the Phetchaburi River that had been diverted through dams and canals. The question of 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 that drained into SIEP from nearby forested highlands, or, at the other extreme, the project scope could attempt to embrace the entire area that supplies water to SIEP and the adjacent communities. The latter approach would be quite extensive, encompassing an area that stretched from the headwaters of the Phetchaburi River, in Kaeng Krachan National Park, to the downstream reaches of 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. Having the W-VAA cover just the local SIEP watershed, however, would not provide stakeholders with the understanding they needed of the vulnerabilities to climate change of municipal areas, tourism, industry, agricultural interests, and rural communities.

The stakeholders ultimately found a middle way. Climate downscaling work, for example, would be conducted over the largest possible area, including the Phetchaburi River watershed. Project activities requiring on-the-ground data collection would then focus on small target areas identified by the Sustainable Development Foundation (SDF) within the larger area. The target areas either represented key economic sectors or were struggling with particular management issues. They were subject to more intensive study because they were felt to be representative examples of the types of communities and key issues found across the larger area. In the upper watershed, SDF focused on the indigenous community of Huay Krazoo. Key issues for this community revolved around land rights and agricultural productivity. In the central section of the watershed, SDF identified four villages that depended on a particular cash crop: rose apples, sugar palms, rice, or limes. In the lower watershed, three communities suffering from floods and droughts were selected, as well as a community where many livelihoods depended on salt farming. SDF also identified two additional communities in the central part of the watershed, both struggling with urban expansion and water supply management. SIEP was the focal area for the WACC project's ecological data collection.

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

Identifying and Coordinating Multiple Project Partners

During the first stage of scoping, the project partners were identified (Step A, scoping the assessment context). Four key project partners were identified in addition to the National Research Council of Thailand, which initiated the effort, and the USFS, which provided technical support during a series of visits. SDF, a Thai nongovernment organization (NGO) with experience in community-scale VAAs, coordinated meetings in each of the target communities to foster an understanding of critical climate vulnerabilities, conducted research on development and water-management policies, and synthesized climate and non-climate factors to identify adaptation options. Ramkhamhaeng University was charged with coordinating the baseline data, developing climate-change scenarios through climate downscaling, and modelling the impacts of climate change on water resources by using the Water Evaluation and Planning (WEAP) model. SIEP and Kasetsart University's Department of Forest Management installed forest vegetation plots, collected scientific data on soils and water quality near SIEP, and developed a land use map. The government's Land Development Department modelled the effects climate change on soil quality, environmental conditions, agricultural production, and farmers' incomes in the watershed. The partners were all able to complete their parts of the W-VAA successfully, but it was difficult to maintain communication and coordination while working simultaneously, especially without a lead entity dedicated to integration. For example, SDF needed to use climate forecasts in early community meetings before the climate modelling by Ramkhamhaeng University had been completed. Once the modelling was completed, however, innovative ways of summarizing the forecasts were required to better communicate the likely future changes at the community level.

Future W-VAAs would benefit from a diversity of project partners, each offering different areas of expertise. Without such diversity, balancing trade-offs among community concerns, water management, urban planning, and ecological integrity will be challenging. However, such a complex arrangement would probably be more efficient if there is a single coordinating entity, a careful scoping of project timelines, and frequent communication among project partners.

Integrating Downscaled Climate Data into Vulnerability Assessments

Downscaled climate data provide important scientific information but translating the 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 the WACC initiative (Step A, scoping the assessment context). The broad scope of the project enabled detailed forecasts and the pairing of project partners with very different backgrounds and needs. The project created a three-step process that grouped the activities in the various targeted areas into the overall endeavor (i.e., that concerning the larger area).

During the first step, SDF staff used information garnered 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 would most likely affect each target community. For example, in Tambon Railuang, the community group was worried about the increased incidence of Kangguh, a disease that was damaging their lime crops. The particular facet of climate change related to this disease is the number of days per year that have over 1 millimeter of rainfall and temperatures over 35°C. SDF identified 20 climate facets that approximated this threshold, some as simple as mean daily temperatures and others more specific, such as the occurrence of diseased lime crops. During the second step, Ramkhamhaeng University summarized a messy time series encompassing 25 years of climate hindcasts (probable past conditions) and 25 years of forecasts into a description of annual facets. During the third step, SDF brought the climate forecasts back to the community groups in this customized and synthesized climate-facet format to enable a clearer understanding of how future climatic conditions were likely to affect specific areas of community interest.

Applying the Climate Change Performance Scorecard

Under the WACC initiative, SDF modified the Climate Change Performance Scorecard, which had been developed by the USFS to assess climate-change preparedness (Step B, baseline vulnerability assessment). The original scorecard included 10 questions to be answered annually by each national-forest or grassland management unit to help track climate readiness. For example, the scorecard asks if the unit actively worked with the scientific community to improve its ability to respond to climate change. SDF tailored this approach to the WACC W-VAA by designing a scorecard that assessed activities already being conducted by local agencies and governments. The SDF scorecard contained 27 questions that covered four dimensions: (i) learning and development within the agency, (ii) the established management structures for working on climate-change issues, (iii) the existing VAA, and (iv) the effectiveness of climate-change integration. One question, for example, was whether the responding agency had assigned at least one person to coordinate climate-change activities, answer questions on climate change, and encourage all projects to consider climate-change issues. The scorecard approach can be modified in any number of ways to improve the assessment of climate-change readiness across agencies and community groups. It is particularly useful for collecting baseline information for comparisons with future monitoring efforts. SDF's adaptation of the scorecard approach is also an example of the potential benefits to be gained from having diverse partners share their experience and expertise.

The Analysis and Mapping of Impacts under Climate Change for Adaptation and Food Security Project and the Modelling System for Agricultural Impacts of Climate Change

Special Focus

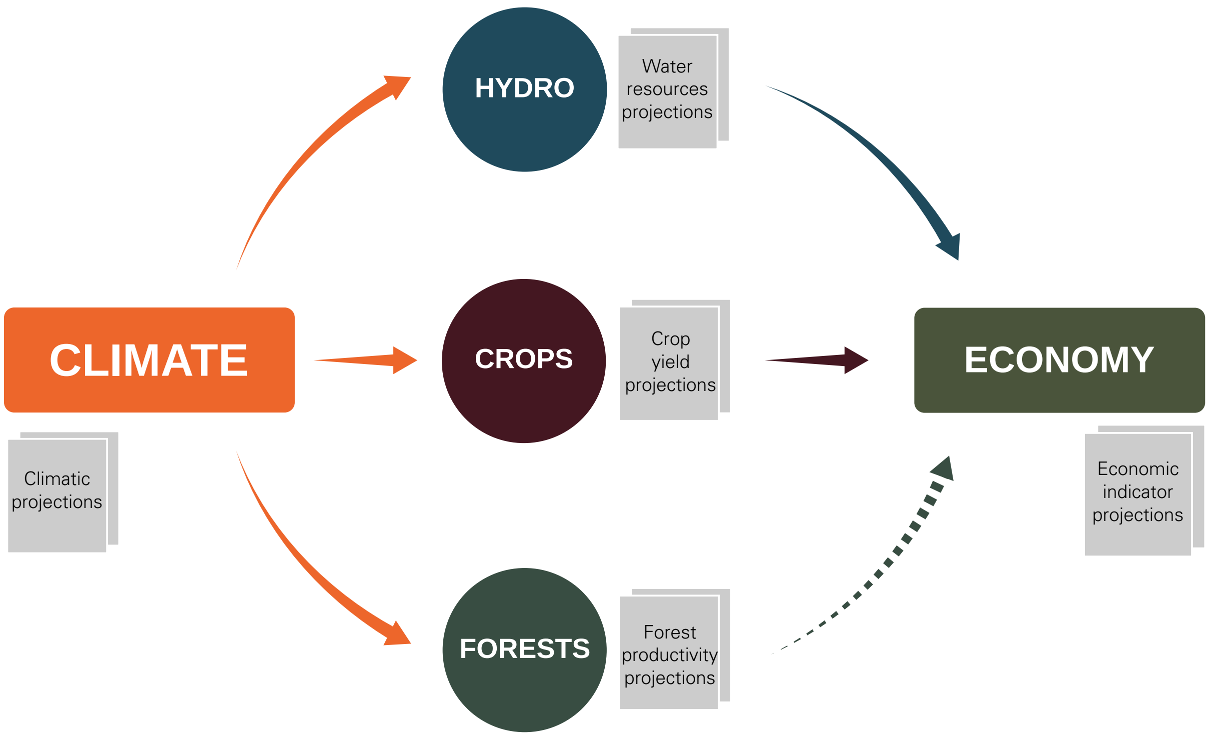
The focus is an interdisciplinary assessment of climate change impacts on agricultural and food-security vulnerability, with a view to emphasizing the need for climate-change adaptation planning.

The United Nation's Food and Agriculture Organization (FAO) considers VAAs of agricultural systems in support of adaptation policies and programs to be highly important. The Analysis and Mapping of Impacts under Climate Change for Adaptation and Food Security (AMICAF) project, implemented in the Philippines and Peru, builds country-level capacity to produce evidence-based information on climate-change impacts on agricultural systems and food security to inform a country's long-term climate-change adaptation planning.

One of the project's key planning tools is the Modelling System for Agricultural Impacts of Climate Change (MOSAICC), an interdisciplinary climate-change impact assessment tool containing modules for climate downscaling, crops, water resources, forests, and economic modelling (Figure 4). The selected models are robust and can ensure scientific quality even with suboptimal data quality, which occurs frequently in developing countries. The tool is designed for large-scale assessments (regional, national, or subnational) with spatial disaggregation. This enables policymakers to understand differences in levels of risks among provinces and within a region, country, or basin.

Interdisciplinary teams of national institutes and universities were formed, and an extensive training program was provided to train international experts to use MOSAICC when carrying out assessments in their own countries. 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 need for climate-change risk and vulnerability information.

Figure 4: Schematic Diagram of the Modelling System for Agricultural Impacts of Climate Change, with Five Modules



Source: Authors.

MOSAICC employs a top-down vulnerability framework. It uses coarse-resolution climate projections drawn from global climate models to estimate local changes in climate, projected yields of the country's main crops, river discharges, forest species and growth, and the gross domestic product (GDP) based on the agricultural sector (Figure 4). A set of eight global climate models and two representative concentration pathways are available for use in the 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. MOSAICC'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 sharing among participating institutions, but this preparatory process is essential for ensuring a strengthened institutional capacity and the sustainability of the technical work.

The AMICAF project in the Philippines also includes an agricultural market model that has identified the impacts of climate change on farm-gate prices. The project also uses a bottom-up approach to vulnerability assessment in order to gauge the vulnerability of household food security to climate-change impacts. The econometric methodology employed identifies the pathways through which the impacts of climate change pass as they make their way to households and farms. This modelling also identifies and maps vulnerable groups (profiling), considers the adaptive-capacity options for farmers, and evaluates the efficiency of alternative policy tools. This analysis makes use of extensive household surveys on nutrition, family income, expenditure, and other socioeconomic indicators to characterize vulnerable groups.

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

Climate Resilience Framework

Special Focus

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

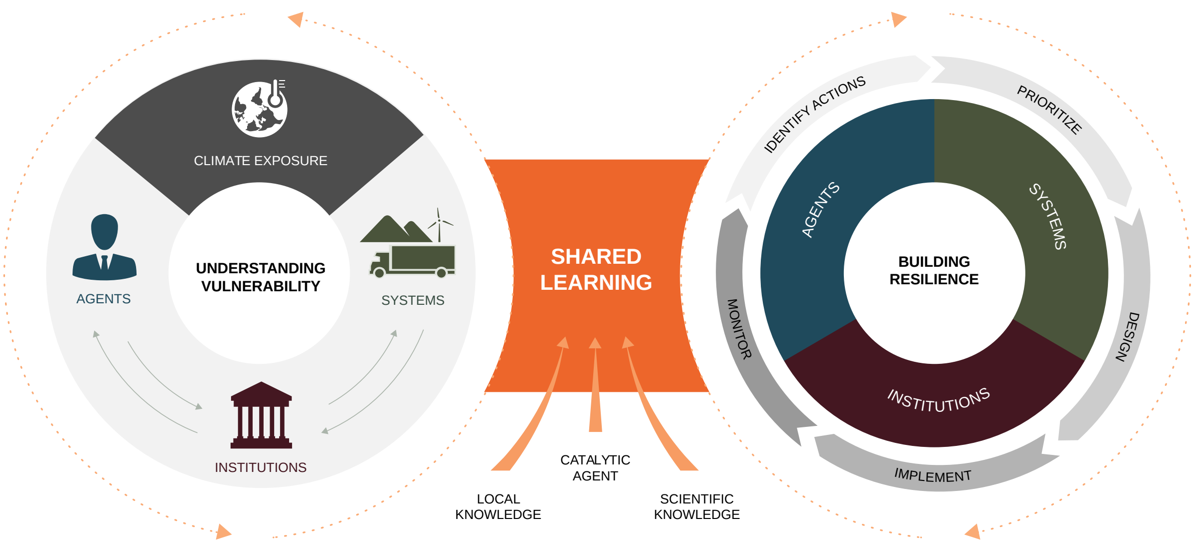
Threshold-based climate assessments have been applied in the Mekong region to address vulnerabilities that arise as a result of continued urbanization. They focus on the wider landscape in which urbanization occurs, rather than simply on urban spaces. Urbanization requires the increased use of resources that come from the outlying rural areas. Water, food, and energy consumed in urban areas all originate from beyond the city limits. 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 in order to protect domestic water supplies in towns and cities.

Systems depend on complex institutional arrangements that in many cases are overlapping, competing, or poorly coordinated, and that have limited mandates, technical capacity, or financial resources (Principle 3, complexities of socio-ecological systems). The ways in which institutions deal with crises point 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 across state and nonstate actors.

Fragility or failure can become manifest in how well physical infrastructure and technology hold up during climatic events or series of events that exceed their design capacities. Moreover, since many infrastructure systems are interlinked (particularly those for water and energy), fragility or failure in one system can have a cascading effect, often with unanticipated consequences. Even when physical systems themselves do not fail, the institutions responsible for their management, operation and maintenance, or for the distribution of their benefits can also fail. The technical and managerial capacities of institutions have their own thresholds. These may include an institution's ability to function with a wide range of changing or uncertain responsibilities, legal constraints on its mandate, and limited financial and human resources.

Threshold approaches enable watershed stakeholders to contextualize the potential impacts of future climate change through a better understanding of the ways in which current trajectories of change (in land use, demographics, the economy, urbanization, etc.) create vulnerabilities that will be exacerbated by future climate change. By viewing climate planning through the lens of agents, the CRF enriches one's 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 socio-ecological systems into 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, complexities of socio-ecological systems).

Figure 5: Diagram of the Climate Resilience Framework



Source: Authors.

In recognition of the social dimensions involved in determining crisis points and appropriate actions, threshold approaches that assess vulnerability apply the principles of deliberative and informed public dialogue, in which different stakeholders and different types of knowledge are brought together in facilitated public dialogues. These are referred to as Shared Learning Dialogues (SLDs), and SLD processes have an established tradition of addressing complex, multi-scale environmental and social policy challenges that affect a wide range of stakeholders, each with a unique set of perceptions, values, and interests (principles 3, complexities of socio-ecological systems; and 5, ensuring participation).

The SLD process is central to ensuring that stakeholders understand resilience as the ability to learn to handle challenges in the face of changing circumstances and shifting patterns of shocks and crises (Principle 6, capacity to face risks). It is intended to generate discussion and innovation by (i) drawing on scientific and local knowledge; (ii) fostering a new understanding of climate change, risk, and uncertainty; and (iii) considering patterns and trajectories of change.

Threshold-based approaches apply a range of different methodologies, drawing on a broad range of disciplines. Some of those methodologies are as follows:

(i) applying a historical perspective to analyze how changes in recent decades and continued trajectories can create vulnerabilities for different actors and different locations (Process Step A, scoping the assessment context);

(ii) focusing on the complex web of urban infrastructure and technology to identify elements within these systems that are fragile and might fail, and applying critical analysis to address the implications of such system failures (e.g., whether systems can fail safely) as well as the severity of possible failures (Process Step A);

(iii) using climate projections to analyze the degree of climate variability that might push emerging vulnerabilities and systems to critical points (Process Step B, baseline vulnerability assessment); and

(iv) conducting a case study analysis to assess how different actors—individuals, households, groups, organizations—have responded to historical events of climate-related shocks and crises (Process Step B).

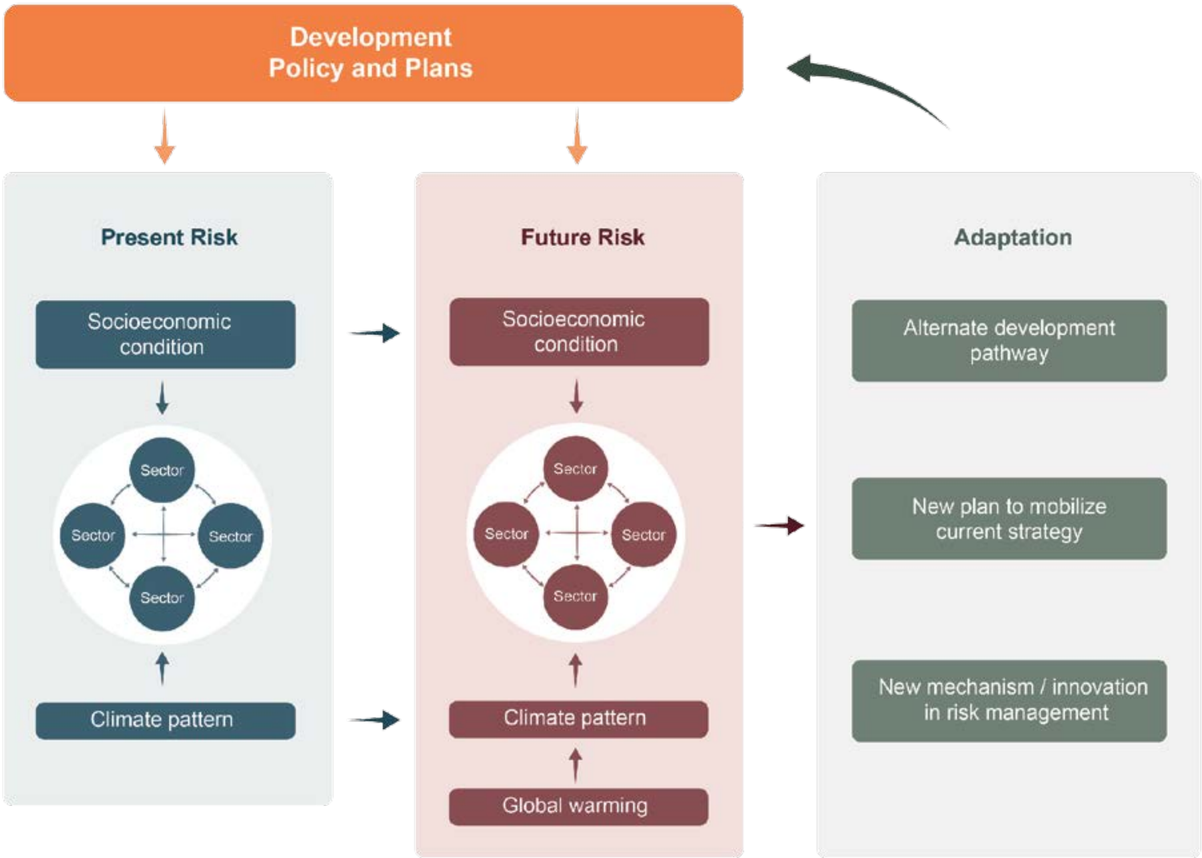
Large Landform Holistic Assessment Framework

Special Focus

The focus here is on climate-change adaptation assessments of large landforms. The assessment process takes into account the linkages and interactions between and among multiple components of the socio-ecological system, across multiple scales and multiple threats. It also considers the pressures on each economic sector of the system from both climate and non-climate (e.g., socioeconomic conditions) factors.

The Large Landform Holistic Assessment, developed by SEA START RC, is a framework for climate-change-adaptation assessment at the watershed scale or provincial level. It was recently used for a climate-change-adaptation assessment of the Huay Luang watershed, Udon Thani Province, Thailand, as part of the Thailand Research Fund's climate-change-adaptation research program (2015–2017).

Figure 6: Diagram of the Large Landform Holistic Assessment Framework



Source: SEA START RC.

The framework aims to develop adaptation strategies and plans that can be integrated into the development plans of various government line agencies. It also aims to harmonize the adaptation strategies and plans of multiple components of the socio-ecological system, with an eye toward increasing the resilience of all the relevant components and minimizing conflict among them.

The principle concept advanced by the framework is that watersheds and other large landforms consist of multiple sectors that are linked together through their physical and socioeconomic aspects. The risks facing various economic and social sectors within these landforms can result not only from external factors that may affect them all, such as new development policies or a warming climate, but also from interactions between and among the sectors themselves, as shown in Figure 6. For example, the responses of one sector to its risks may generate negative consequences to businesses or activities within other sectors. The Large Landform Holistic Assessment framework seeks to account for these dynamic linkages when devising appropriate climate-change-adaptation strategies and watershed-management plans.

The Large Landform Holistic Assessment can be broken down into three major steps:

Step 1. Contextualize the watershed (Process Step A, scoping the assessment context). The purpose of this step is to understand how key economic sectors within a large landform can be at risk due to pressures from 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 the mechanisms through which the response of one sector to its risks may cause impacts on other sectors. For example, infrastructure built to prevent floods in a city may exacerbate flooding in the surrounding rural areas. Contextualizing the watershed can be done through a historical review and consultations with key stakeholders and policymakers in the watershed.

Step 2. Foster an understanding of any changes in emerging risks or future risk profiles within each economic sector of interest (Process Step B, baseline vulnerability assessment). Risks may result from climate change as well as socioeconomic conditions. There should be an understanding of changes occurring within an economic sector and between economic sectors. Also assessed here is the potential success of development plans for the watershed. Specifically, this step assesses whether plans are likely to achieve the stated goals and gauges the effectiveness of the plan's responses to current risks within each economic sector (i.e., whether the response to risks will still be applicable and effective under future conditions). This step might include such activities as scientific analyses of the impacts of projected changes in climate on the drivers of risk, a review of area policies and plans, stakeholder consultation, and a 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 socio-ecological system in the context of future change (Process Step C, adaptation options). Adaptation can take the form of an alternative development strategy, a new plan for mobilizing the current development strategy, or an innovation in risk management. Putting the adaptation of every economic sector into the same planning process and analyzing the potential linkages and interactions across economic sectors within the watershed will help formulate a holistic watershed adaptation strategy. Coordinated adaptation plans minimize cross-sector pressures and effectively increase the resilience of the watershed to future changes.

Udon Thani is a major province in northeastern Thailand. The rain-fed agricultural areas and the city of Udon Thani are under climate threat from a shift in rainfall patterns that has caused both flooding and water shortages. Various changes have had an impact on water-demand patterns (including cropping) and on economic growth in Udon Thani city (especially in the service and industrial sectors). These changes have been driven by various socioeconomic conditions (e.g., government policies and market conditions) and by sector-focused plans for coping with water stresses (e.g., flood and drought management), and they are likely to have cross-sector impacts. Future climate change is expected worsen the pressures on the province, as shifts in rainfall patterns and temperatures affect water availability throughout the year. Moreover, current coping strategies may no longer be viable. Adaptation needs to be planned and mainstreamed into long-term development plans for Udon Thani Province. It should aim to increase the resilience of the Udon Thani city, where municipal planning may need revisions, and of the agriculture sector, where the cropping system needs to be transformed. And sustainable water-resource management must be put in place.

Holistic adaptation strategies and plans can be created or improved by stress testing current development strategies, based on the results of the climate-change-impact assessment described in Step 2, above. The stress testing of current development plans may lead to revisions, especially in plans with long-term implications. This also enables the development of climate-risk mitigation plans for addressing changes in risk profiles, as well as newly emerging risks. Alternative development strategies that are increasingly robust with regard to future conditions, and that enhance resilience within and across economic sectors, can be developed through multiple stakeholder consultations and visioning exercises.

Robust Decision Support

Special Focus

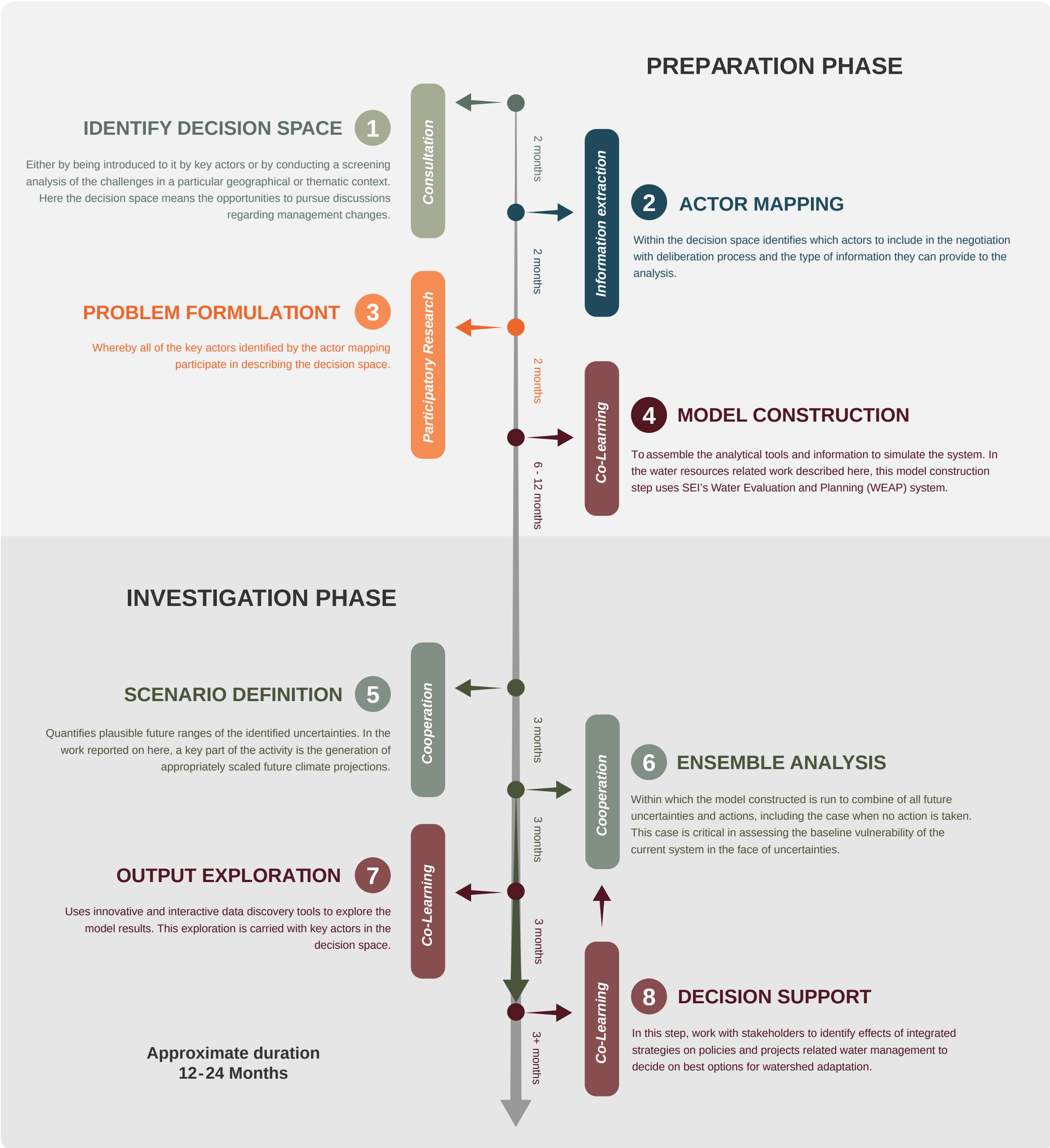
Robust Decision Support (RDS) is a methodology that seeks to effectively embed cutting-edge water-resource system modelling and large-data-visualization tools in stakeholder participation and engagement.

The RDS process informs decision-making concerning the reduction of the socio-ecological vulnerability of water-resource systems. The main goal is to inform water resource policymaking and decision-making by working with stakeholders and planners in to identify strategies that demonstrate satisfactory outcomes over a broad range of plausible futures. Depending on the particular stakeholder, these outcomes could include access to clean water in municipalities, hydropower production targets, water supplies for irrigation, and meeting instream flow requirements in rivers (for the sustainability of native fisheries or the improvement of water scarcity management).

The uniqueness of RDS 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 critical early stage of the process is the selection of the key stakeholder groups to be involved in the policymaking for, and the management of, a particular water system. Their inputs 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 system performance. For the evaluation of results, a sophisticated and interactive visualization tool is used that allows negotiations and deliberations around potential options.

The RDS steps are grouped into two phases, preparation and investigation, as shown in Figure 7 and described briefly below.

Figure 7: Diagram of Robust Decision Support Processes



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

Source: Stockholm Environment Institute 2015. *Ríos del Páramo al Valle, Por Urbes y Campiñas: Building Climate Adaptation Capacity in Water Resources Planning; Final Report*. Bogotá, Colombia: United States Agency for International Development.

The Preparation Stage

Step 1: decision space definition. The decision space is defined by identifying the water resource challenges within the boundaries of the basin or the challenges within the political structure of water governance.

Step 2: actor identification map. For this decision space, individuals from key organizations are identified based on their influence on water resource policies. These actors provide their insights and facilitate the collection of specific data that will inform the technical analysis. Decisions on water resources management made at a sub-national or national level are often beyond the geospatial boundaries of a basin. 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" 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, with a view to improving the performance of a system. For example, the construction of a reservoir or canal.
>
> **R** – **Relationships** are the ways in which the various components of a system are interconnected through the choices of levers and the manifestation of the uncertainties. For example, the Water Evaluation and Planning (WEAP) software (Chapter 4), which employs a simulation model to analyze basin-scale water resource systems, has often been used to support the RDS approach. Other tools that have been used for the same purpose include the Soil and Water Assessment Tool (SWAT), the Storm Water Management Model (SWMM), and the Vensim model.
>
> **M** – **Performance Metrics** are performance standards set by decision-makers based on their desired management outcomes. These metrics determine the success or failure of a system's performance, and thus the desirability of the selected strategies. For example, a set of performance metrics could include the satisfaction of urban water demand, the amount of land irrigated, and the hydropower produced.

Step 4: model construction. The strategies (L), uncertainties (X) and performance metrics (M) connect via the R component, which represents the possible relationships among them as described in a model. In RDS practice, a calibrated WEAP model is typically developed as the R component. WEAP software uses a climate-driven simulation model for water resource management that captures various aspects of a system. Model input information includes precipitation, temperature, relative humidity, wind, melting point, freezing point, and land cover. This information is used to estimate the hydrological balance components of evapotranspiration, infiltration, surface runoff, and base flow; and 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. The output of a General Circulation Model (GCM) 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.) is then combined with the strategies under consideration. The scenarios defined by this integration of uncertainties and strategies represent possible future conditions.

The Investigation Stage

Step 6: a large ensemble of model runs. The combination described in Step 5 involves matching each uncertainty with each considered strategy, thereby producing a wide range of plausible futures, and resulting in a large ensemble of model runs: between 30 and 10,000. All these runs are evaluated using WEAP software. 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 then used to explore this large volume of model output. The tool provides a useful platform for exploring results and evaluating potential decision trade-offs. Laura Forni et al. (2016) describe a three-step process used in RDS for the development of an effective visualization platform that allows exploration, communication, and deliberation of potential policy options; as an example, Forni (2016) created an RDS visualization platform for Yuba County in California. These platforms enable a powerful integration of human cognitive processes related to decision-making, and they use powerful computational tools (such as WEAP).

Step 8: decision support. The research team works with the stakeholders and decision-makers to identify integrated water-resource strategies based on specific policies and investment projects. The visualization platform serves as an interactive tool for the evaluation of results and for the negotiations and deliberations related to the selection of promising management strategies. During this step, the stakeholders may choose to conduct a participatory trade-off analysis to support the negotiations and deliberations before reaching a decision.

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 (Argentina, Bolivia, Chile, Colombia, and Peru), Africa, and Asia. In the Mekong region, the RDS process has been used by the Sustainable Mekong Research Network (SUMERNET) to help improve water-scarcity management strategies that take into account the uncertainties of climate change and development. The projects in the region were as follows:

(i) Cambodia: Hydrological impact assessment for agricultural development in the Prek Thnot River Basin, for the Government of Cambodia's Department of Hydrology and River Works;

(ii) Lao People's Democratic Republic (Lao PDR): Climate-change and water-scarcity impact assessment in Champhone District, Savannakhet Province, for the environment and agriculture ministries' district offices for planning and investment;

(iii) Thailand: Water-scarcity management strategy targeting the Huai Sai Bat River Basin for the Department of Water Resources;

(iv) Myanmar: Water-scarcity management in the context of climate change and land use change, for the Directorate of Water Resources and Improvement of River Systems, Irrigation Department, and the Sagaing regional government; and

(v) Vietnam: Urban water management in the context of urbanization and climate change in the city of Can Tho, for the Can Tho Climate Change Coordination Office.

Table 1: Examples of Vulnerability and Adaptation Assessment Processes

Option	Scales	Resources and Inputs	Duration (years)	Contact Info and Website
Challenge and Reconstruct Learning (ChaRL)	Subnational, national, and regional	Medium cost; computer modelling required for scenario analysis	1-2	Alexander Smajgl, alex.smajgl@merfi.org, http://www.merfi.org/
Climate resilience framework	Community, subnational	Medium cost; computer modelling required for scenario analysis	2-3	Richard Friend, richardfriend10@gmail.com, http://i-s-e-t.org
Robust Decision Support (RDS)	Subnational, national, and regional	Varies from low cost to high cost; computer modelling capability necessary to conduct analysis; intensive stakeholder engagement process	1-2	Chusit Apirumanekul, chusit.apirumanekul@sei- international.org, http://www.sei-international.org/asia
Large Landform Holistic Assessment, Southeast Asia Global Change System for Analysis, Research and Training (SEA-START) network	Community, subnational	High cost; complex computer modelling capability necessary to conduct a range of biophysical and socio-economic analyses	3-5	Suppakorn Chinvanno, suppakorn@start.or.th, http://www.start.or.th/
Integrated Vulnerability Assessment and Adaptation Decision Making framework, USAID Mekong Adaptation and Resilience to Climate Change	Community, subnational	Low cost; low technology requirements, assuming access to regional climate projection data and analysis	1-2	Paul Hartman, Paul_Hartman@dai.com, http://mekongarcc.net/
Watershed-Based Adaptation to Climate Change	Community, subnational	High cost, due to multiple elements, including computer modelling of downscaled climate projections; assessments of multiple communities in the watershed; ground-level monitoring of forest conditions	1-2	Monthip Sriratana Tabucanon, monthip2007@gmail.com Ravadee Prasertcharoensuk, SDFravadee@sdfthai.org http://en.nrct.go.th/en/home.aspx

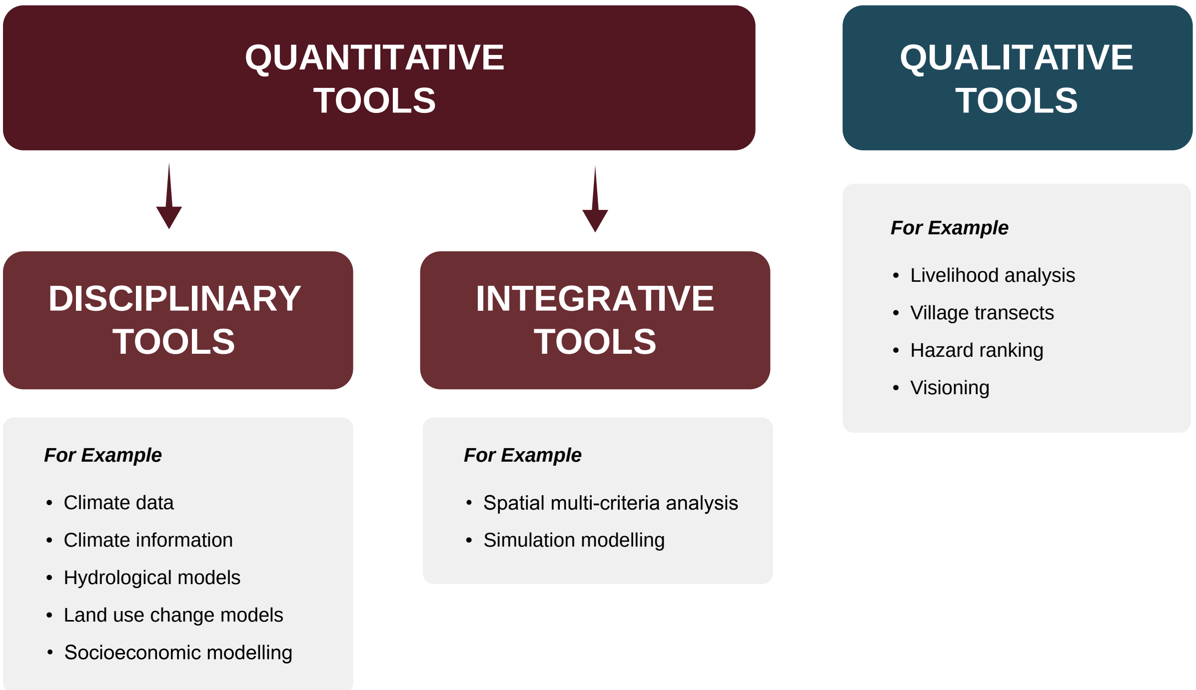
Note: Low cost = $10,000-$100,000, medium cost = $100,000-$500,000, and high cost > $500,000.

Chapter 4

Tools for Conducting Watershed-Scale Vulnerability and Adaptation Assessments

Watershed-scale vulnerability and adaptation assessments (W-VAAs) can benefit from the rapidly growing toolbox of data-gathering and modelling approaches that help forecast how complex social-ecological watershed systems will be impacted by climate change, and thus help stakeholders formulate alternative futures and prioritize adaptation options.

Figure 8: Examples of Quantitative and Qualitative Methods for Watershed-Based Vulnerability and Adaptation Assessments



Note: The content of this figure is based on the experiences of researchers and experts who are members of the Greater Mekong Subregion Roundtable on Climate Adaptation.

Source: Authors.

Figure 8 does not, of course, provide a comprehensive overview of research methods. Many integrated models are developed within a particular discipline, but include indicators from other disciplines. In this case, "integrated" refers to methods that are genuinely transdisciplinary, combining multiple disciplines.

The suite of tools utilized for a particular W-VAA can range from qualitative, low-tech approaches to highly quantitative computer models. Figure 8 provides a simplified overview of methods and tools used by the GMS Roundtable members. The tools are characterized as either quantitative or qualitative. Within the group of quantitative tools, there is a distinction between disciplinary and integrative tools. It is important to stress that most W-VAAs will require a combination of tools, rather than just one.

Regardless of where a particular approach may fall on the quantitative-qualitative spectrum, the mix of tools chosen for identifying and designing climate-adaptation options must capture the following elements:

(i) expected future climatic conditions, including rainfall patterns, mean and peak temperatures, wind-related events, and other locally important conditions;

(ii) vulnerabilities, including human life, livelihoods, and natural, economic, and social assets; and

(iii) adaptation capacity, including skills, experience, assets, technologies, and natural and ecological features.

Context matters. The interaction of hydrological, social, economic, ecological, and technological dynamics creates, in many situations, a highly complex and detailed social-ecological landscape. Failing to consider this complexity will likely result in the design and implementation of maladaptive strategies. As mentioned above, capturing this complexity within the assessment process by using a quantitative approach will require sophisticated tools that generally fall into two categories: disciplinary and integrative. Disciplinary tools focus on a specific aspect of the social-ecological equation, such as hydrology, climate, agriculture, or poverty. The outputs from a combination of disciplinary tools can be evaluated through a sequential and integrated process that, in turn, helps to generate an overall picture of future conditions in a watershed. By contrast, integrative tools combine inputs from various disciplines into one single method at the outset. Each type of tool has its advantages and disadvantages.

Disciplinary tools will have the advantage of keeping methodological requirements simple, and they can often draw on more human capacity because such tools employ more traditional methods. The disadvantage is that most complex feedbacks between disciplinary variables (i.e., economic, social, hydrological, ecological, and financial) cannot be considered, so there is a substantial risk that these tools will fail to reveal unexpected side effects.

Integrative tools are particularly valuable for helping to reveal the complex interactions that occur among the physical environment, built environment, and the social and economic fabric linking them. As a result, they are experiencing increased uptake. For example, climate change can cause a particular community's hydrology to change, resulting in crop failure and economic challenges that cause people to adjust land use or possibly modify the hydrology of adjacent areas to mitigate their losses; this, in turn, will cause further ripple effects. Disciplinary tools cannot effectively capture such complexity.

This integration of multiple variables relevant to the design and assessment of climate-change-adaptation strategies will allow for the identification of feedbacks, which can cause unintended side effects that may render certain adaptation options ineffective or cause investment strategies to generate maladaptive development initiatives. However, integrative tools 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 their accessibility to non-modellers. But new visualization technologies are being tested that will help stakeholders better understand how integrative models work, thus demystifying their "black box" nature.

Hybrid approaches can also be employed. These combine the advantages of the relatively simple disciplinary tools with those of the more complex integrative tools. Hybrid approaches allow additional validation, as their results can be cross-checked and compared across the different methods; for this reason, policy recommendations derived from their results tend to be more robust.

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

(i) strengthen communities' capacity to understand prevailing climate risks;

(ii) strengthen stakeholders' perception of what drives change;

(iii) produce a description of social networks;

(iv) define categories of vulnerabilities, adaptation options, and preferences; and

(v) produce a stakeholder-derived preferred vision of the future.

Gender is an important assessment dimension that can be considered part of most of the quantitative and qualitative tools, which are discussed in more detail below. However, gender indicators need to be clearly defined, and gender-specific data will be needed. For instance, climate change and the resulting adaptation options often modify the conditions for existing livelihoods. The change of household livelihoods is likely to shift the time requirements for female and male household members because many livelihoods are gender specific. Understanding these impacts is critical for avoiding increased gender inequality and for correctly evaluating the feasibility of adaptation strategies. To garner such insights, all tools should include gender-specific questions.

Disciplinary Quantitative Tools

The vast majority of current W-VAA approaches use a combination of disciplinary methods. Typically, these include the following:

(i) climate models,

(ii) hydrological models,

(iii) land use change models, and

(iv) socioeconomic models.

Climate Models

Climate modelling initially provides a high-resolution projection of critical climate variables, such as rainfall and temperature. Climate projections can be derived from GCMs or from high-resolution downscaled projections.

The Climate Change Data Distribution System is a web-based tool that generates future climate data for various climate-change scenarios by drawing from climate-change impact studies or risk and vulnerability assessments. This tool allows users to extract future climate-projection data for a specific geographic area, such as a sub-watershed or an administrative unit within mainland Southeast Asia. The data are high-resolution and serve to generate future climate projections based on global simulations and dynamic regional downscaling.

The data sets comprise scenarios, projected to the end of the 21st century, that depict plausible future changes in climate characteristics under different atmospheric greenhouse gas concentrations. The output data sets include the following climate variables: maximum temperature, minimum temperature, precipitation, wind speed, wind direction, and solar radiation.

Extensions of the Climate Change Data Distribution System are under way. There has been progress in the development of a new approach that provides climate-change data in a form that is relevant to particular risks, such as changes in the amount or intensity of rainfall or in extreme and average temperatures.

The Climate Change Data Distribution System was the result of a collaboration involving Chulalongkorn University, Thailand; ESRI (Thailand) Co., Ltd.; and the Southeast Asia Global Change System for Analysis, Research and Training Regional Center (SEA-START RC), with support from the Science and Technology Postgraduate and Research Development Office (PERDO), under the Thailand Office of Higher Education Commission (OHEC).

Figure 9: The Climate Change Data Distribution System On-Line Tool

Note: The tool can be accessed at: http://ccs.gms-eoc.org/climatechange/start2/index.html. This site provides quick visualizations of particular variables over time. For example, the map displays forecast changes in maximum air temperatures in the 2050s.

Hydrological Models

Hydrological models typically focus on surface water flows. They translate rainfall projections, in combination with evapotranspiration projections, into surface-water runoff scenarios that inform predictions of flood- and drought-related risks. In some cases, groundwater models incorporate aquifer dynamics into the surface water analysis. This is particularly relevant when the high connectivity of surface and ground water needs to be managed carefully to avoid floods. Also, when there is a high risk of drought, the analysis will benefit if groundwater is taken into account, as groundwater pumping can be a very effective drought-alleviation strategy. The Water Evaluation and Planning (WEAP) model is a climate-driven simulation tool for integrated water resource planning. It combines climate, hydrological, land-use, and demand variables to assess water availability (Yates et al. 2005).

Land Use Change Models

Land use change models forecast future changes in land use based on projections of shifts in the demand for land. These projections build on social and economic assumptions, as well as on climate, hydrological, and other bio-geophysical variables. Social dimensions might include the demand for food, available natural resources, urban sprawl, or the introduction of conservation-focused regulations to prevent land use changes. Economic aspects might include land use changes caused by the shift from an agrarian to a more diversified economy, or price projections for various crops to determine the incentives that might drive particular land use changes. CLUMondo is a land use change model that can work not only with the demand for land, but also with the demand for ecosystem services. CLUMondo is the latest application of the widely used Conversion of Land Use and its Effects (CLUE) model. Several recently developed agent-based models (Integrative Tools section) include land use change dynamics as part of more complex system models, including the Mekong Region Simulation (MerSim), which is described below.

Socioeconomic Models

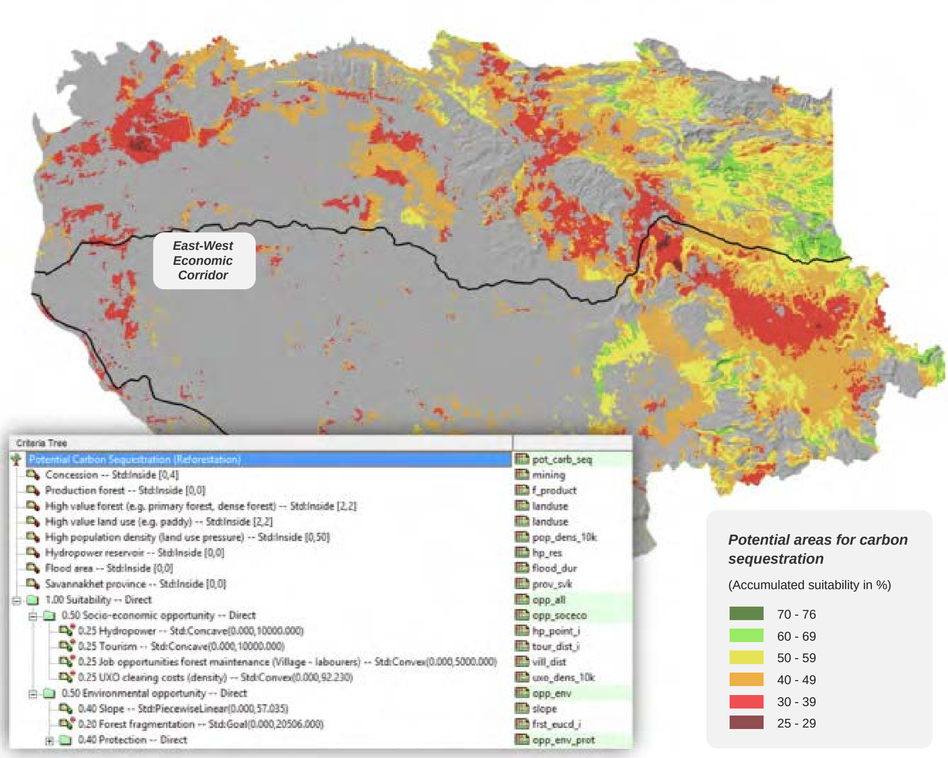
Socioeconomic models include a variety of tools. This adaptation-focused analysis usually includes such variables as poverty, gender, employment, economic value of ecosystem services, migration, and health. Depending on the particular climate-change risk a community may face, that community may change its socioeconomic priorities, thus requiring a more appropriate method to reflect its revised priorities. Most of these models are based on demographic data and/or household survey data, employ statistical approaches, and aim for project- or case-study-specific solutions. Serving as transferrable tools, socioeconomic models are typically linked to questions involving areas such as agriculture, macroeconomics, or land use change. It is worth noting that many of the integrative tools described below include socioeconomic elements.

Integrative Quantitative Tools

Multi-Criteria Analysis

Multi-criteria analysis (MCA) is an effective method of ranking investment alternatives and identifying suitable areas for specific investments. This method involves a multidisciplinary group of actors discussing and identifying criteria that can serve as a basis for a solution to a problem. Each actor assigns a numerical value to every criterion. The criteria are ideally derived from accepted standards (laws, guidelines, research) or, if that option is not available, from expert judgement. The experts then establish a weight for each criterion that reflects its importance to the problem relative to the other criteria identified. The resulting "criteria tree" is used to generate a weighted suitability score. When the criteria are linked to map layers, they become what is known as a "spatial MCA," and the output will be a map showing the geographic distribution of suitability scores, as shown in Figure 10.

Figure 10: A SMCA of Suitability for Carbon Sequestration along the East-West and Central Economic Corridors Traversing Savannakhet Province, Lao People's Democratic Republic



Note: Grey indicates unsuitable areas.

Source: Authors.

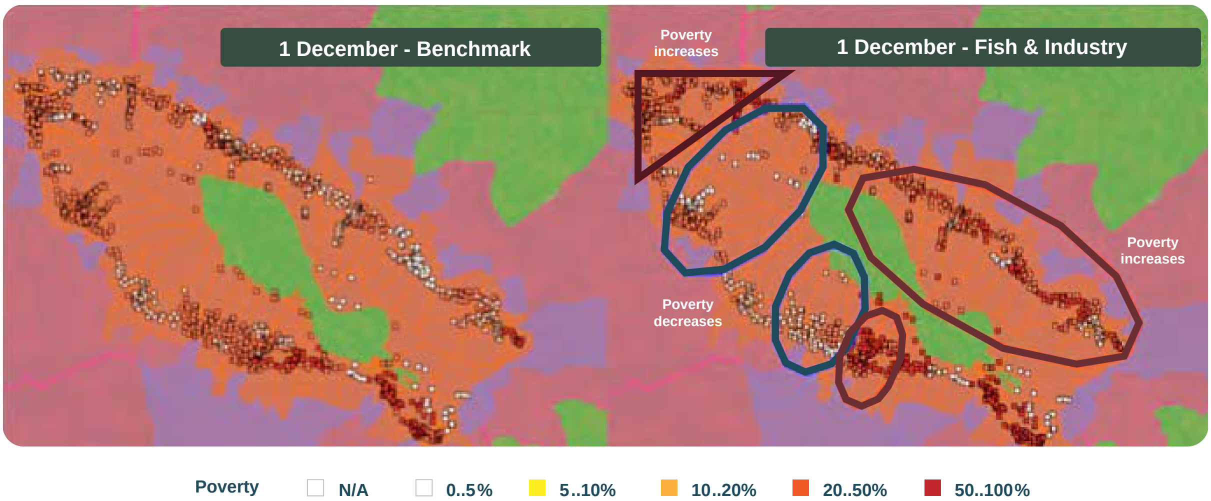
Agent-Based Models

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

In advanced agent-based modelling, social-ecological interactions are spatially referenced. In other words, the simulated system can be defined within a realistic landscape employing geographic information system (GIS) data. This spatial dimension provides big advantages for climate-adaptation-related modelling, as it allows the modeller 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. For instance, several small-scale models have focused on water-management issues. Developed by the French Agricultural Research Centre for International Development, they employ the "Companion Modelling" approach, which involves the codesigning of models with stakeholders. There is also the MerSim model, which was developed for the entire Greater Mekong Subregion (GMS) and considers 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 multiple factors at various spatial levels. For example, at the regional level, migration and price fluctuations are incorporated; at the basin-wide level, water flow, water quality, and sedimentation are added; and at the local level, water quality, poverty, and land use change are among the issues evaluated.

Figure 11: Poverty Maps Derived from Mekong River Simulations of Tonle Sap, Cambodia



Notes:

1. These maps compare two scenarios: (i) a representative benchmark, and (ii) a scenario assuming droughts, a collapse of fish stocks, and increased investments in industrial employment.

2. Village locations are marked with increasing intensities of red indicating higher levels of poverty.

Source: Authors.

Figure 11 displays the output of a MerSim model used to inform climate-adaptation policy. In this example, which involves the Tonle Sap of Cambodia, the assumptions included more frequent droughts across the Mekong Basin, the development of more mainstream dams in the People's Republic of China (PRC) and the Lao People's Democratic Republic (Lao PDR), and investments in the expansion of employment in Cambodia's industrial sector (providing alternative livelihoods to fishing). The results shifted the policy discussion in Cambodia towards a more differentiated approach to planning that accounts for the current heterogeneity of communities in the Tonle Sap area.

Water Evaluation and Planning

Water Evaluation and Planning (WEAP) is a software tool that employees an integrated approach to water resource planning. The WEAP model examines water supply and demand under a wide range of scenarios that generally describe projected futures based on current climate conditions, as well as input from downscaled General Circulation Models (GCMs) and variables (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 many economic sectors, yielding a large and detailed 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.

Table 2 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 the cropping risks associated with five different management options, which are presented horizontally as S0-S4. These options are repeated for each of eight sections of the basin (i.e., sub-basins), labeled C00-C007. Three different climate-change scenarios are evaluated: an average climate, a dry climate, and a wet climate. Decision-makers can choose the strategies or options they want while taking climate uncertainties into account. In this example, option S0 is to do nothing, S1 is to dredge some existing ponds, S2 is to extract groundwater for alternative water supplies, S3 is to change the cropping calendar, and S4 is to construct a small weir in the upper region. Decision-makers choose which option(s) will result in the desired levels of agricultural coverage, water coverage, industrial water coverage, and maintenance of environmental flows. They can also consider the options according to opportunity costs and the potential for failure.

Table 2: The Water Evaluation and Planning Model Applied to Cropping Risks in the Huay Sai Bat River Basin, Thailand

IRRIGATED_CROPS

Subbasins / Strategy

Climate Change	C00					C01					C02					C03				
	S0	S1	S2	S3	S4	S0	S1	S2	S3	S4	S0	S1	S2	S3	S4	S0	S1	S2	S3	S4
Age Climate	12%	12%	12%	14%	11%	4%	4%	3%	6%	4%	6%	6%	6%	9%	6%	40%	40%	40%	46%	40%
Dry Climate	17%	16%	17%	20%	16%	7%	6%	6%	9%	7%	9%	9%	9%	13%	9%	44%	44%	44%	47%	44%
Wet Climate	12%	12%	12%	13%	11%	3%	3%	3%	5%	3%	5%	4%	4%	8%	5%	38%	38%	38%	44%	38%

Climate Change	C04					C05					C06					C07				
	S0	S1	S2	S3	S4	S0	S1	S2	S3	S4	S0	S1	S2	S3	S4	S0	S1	S2	S3	S4
Age Climate	3%	1%	0%	5%	3%	0%	0%	0%	0%	0%	9%	9%	1%	13%	9%	47%	47%	47%	50%	47%
Dry Climate	6%	2%	0%	8%	5%	0%	0%	0%	0%	0%	13%	13%	1%	18%	13%	48%	48%	48%	50%	48%
Wet Climate	3%	1%	0%	5%	3%	0%	0%	0%	0%	0%	8%	7%	0%	11%	8%	43%	43%	43%	47%	43%

Vul_irrigation (color) broken down by Subbasins and Strategy vs. Climate Change

Vul_irrigation

Age = average.

Source: Authors.

Qualitative Tools

Livelihood Seasonal Calendar

This calendar is a participatory tool used in rural communities to review the annual distribution of livelihoods, natural resource production, and land use activities; and then to compare them with the seasonality of climate hazards. The calendar is presented as a table with the months of the year represented by the columns and key livelihood activities represented by the rows. The months can be grouped by seasons, 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 planting or harvesting. The participants may also indicate the 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 can divide an area into multiple transects and survey the community in a systematic manner to better identify and understand the magnitude and geographic boundaries of community features. As a transect walk can take a significant amount of time (depending on the size of the area assessed), a transect map may be used to simplify the activity while achieving the same objective. The communities can draw a two-dimensional map showing key topographic features, 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 regarding the activities and vulnerabilities tied to their area.

Plan Maps

Hazard, village, and resource mapping tools can also be used to depict a community. They can describe geographically the effects of climate and non-climate hazards over relevant areas, as well as natural resource stocks and ecosystems. Village maps provide an 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 important for maintaining secure livelihoods and protecting important cultural assets. Maps may also include gender-specific livelihood areas, such as the places where women traditionally gather particular items or where men hunt. Hazard mapping may be overlaid onto the resource or village map to indicate where in a community specific hazards exist.

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 to 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 that occurred within an estimated period, such as 20 years, helps to facilitate discussions on important, historically rare climate events. Participants may be able to use the data to frame a discussion on 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 that helps communities evaluate the vulnerability of their livelihoods as a result of climate and non-climate hazards. Facilitators use a flip chart or whiteboard that lists horizontally the community-identified hazards and vertically the community's livelihoods and/or 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 a specific livelihood or resource. For example, the villagers may rate drought as a 4 for the community water supply and as a 2 for the bamboo shoot harvest. If participants cannot reach a consensus on a specific rating, they can take a vote or choose to note its uncertainty. The Vulnerability Hazard Ranking tool provides an initial step toward the prioritization of key issues and the further development of adaptation initiatives.

Visioning

Visioning is a qualitative method used to identify the stakeholders' perceptions of possible future scenarios. These visions are typically developed in group discussions, which also serve to clarify the stakeholders' distinctions among the most desired, most likely, and least desired scenarios. In most cases, visioning involves the identification of drivers and their influences on a 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 future conditions in the locale using the most relevant indicators for the participating stakeholders. The goal is to identify the scenarios that all the stakeholders select as desirable or undesirable.

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

Table 3: Online Resources for Watershed-Scale Vulnerability and Adaptation Assessment Tools

Online Resource	Website
Water Evaluation and Planning (WEAP)	http://www.weap21.org/index.asp
Conversion of Land Use and Its Effects (CLUE)	http://portal.gms-eoc.org/tools?cmbToolsId=32
Climate 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	https://siteresources.worldbank.org/EXTTOPPSISOU/Resources/1424002-1185304794278/4026035-1185375653056/4028835-1185375678936/1_Transect_walk.pdf

References

Asian Development Bank (ADB). 2011. *Community-Based Climate Vulnerability Assessment and Adaptation Planning A Cook Islands Pilot Project*. Manila: ADB.

———. 2014. *Climate Change and Rural Communities in the Greater Mekong Subregion: A Framework for Assessing Vulnerability and Adaptation Options*. Manila: ADB.

Bousquet, F., J.C. Castella, G. Trébuil, C. Barnaud, S. Boissau, S.-P. Kam. 2007. "The Use of Multi-Agent Systems in a Companion Modeling Approach for Agroecosystem Management in Southeast Asia." *Outlook on Agriculture* 36 (1): 57-62.

Dale, Virginia H., and Suzanne C. Beyeler. 2001. "Challenges in the Development and Use of Ecological Indicators." *Ecological Indicators* 1 (1): 3-10.

Dung, L.C., C. T. Hoanh, C. Le Page, F. Bousquet, N. Gajaseni. 2009. "Facilitating dialogue between aquaculture and agriculture: lessons from role-playing games with farmers in the Mekong Delta, Vietnam." *Water Policy* 11 (Supplement 1): 80-93.

Foran, Tira, John Ward, Eric J. Kemp-Benedict, and Alex Smajgl. 2013. "Developing Detailed Foresight Narratives: A Participatory Technique from the Mekong Region." *Ecology and Society* 18 (4): 6.

Forni, Laura. 2016. "California Project: Robust Decision Support for the Yuba Integrated Regional Water Management (IRWMP)." *Laura Forni* (blog). February 11, 2016. https://lauraforni.com/2017/02/11/robust-decision-support-yuba-ca/.

Forni, Laura and Stephanie Galaitsi. 2015. "Getting the Picture: Using Data Visualization to Make Complex Models More Accessible to Policy-Makers." Stockholm Environment Institute Factsheet, SEI, Stockholm. https://www.researchgate.net/publication/289529209_Getting_the_picture_using_data_visualization_to_make_complex_models_more_accessible_to_policy-makers.

Forni, Laura, Josué Medellín-Azuara, Michael Tansey, Charles Young, David Purkey, and Richard Howitt. 2016. "Integrating Complex Economic and Hydrologic Planning Models: An Application for Drought under Climate Change Analysis." *Water Resources and Economics* 16: 15-27.

Friend, Richard, and Marcus Moench. 2013. "What is the Purpose of Urban Climate Resilience? Implications for Addressing Poverty and Vulnerability." *Urban Climate* 6: 98-113.

Friend, Richard, Pakamas Thinphanga, Justin Henceroth, Tran Van Giai Phong, Ken MacClune and G. Mendoza. 2016. *Threshold Analysis for Assessing Urban Climate Vulnerability: Case Studies from Three Southeast Asian Cities.* [Bangkok]: Institute for Social and Environmental Transitions-International, US Army Corps of Engineers, Institute for Water Resources.

Habermas, Jürgen. 2005. "Concluding Comments on Empirical Approaches to Deliberative Politics." *Acta Politica* 40 (3): 384-392.

Heath, Linda S., Sarah M. Anderson, Marla R. Emery, Jeffrey A. Hicke, Jeremy Littell, Alan Lucier, Jeffrey G. Masek, David L. Peterson, Richard Pouyat, Kevin M. Potter, Guy Robertson, Jinelle Sperry, Andrzej Bytnerowicz, Sarah Jovan, Miranda H. Mockrin, Robert Musselman, Bethany K. Schulz, Robert J. Smith, and Susan I. Stewart. 2015. *Indicators of Climate Impacts for Forests: Recommendations for the U.S. National Climate Assessment Indicators System*. General Technical Report NRS-155. Newtown Square, PA: US Department of Agriculture, Forest Service, Northern Research Station. http://www.fs.fed.us/nrs/pubs/gtr/gtr_nrs155.pdf.

Intergovernmental Panel on Climate Change (IPCC). 2014. "Summary for Policymakers." In *Climate Change 2014: Impacts, Adaptation, and Vulnerability; Summaries, Frequently Asked Questions, and Cross-Chapter Boxes. A Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, edited by Christopher B. Field, Vicente R. Barros, David Jon Dokken, Katherine J. Mach, Michael D. Mastrandrea, T. Eren Bilir, Monalisa Chatterjee, Kristie L. Ebi, Yuka Otsuki Estrada, Robert C. Genova, Betelhem Girma, Eric S. Kissel, Andrew N. Levy, Sandy MacCracken, Patricia R. Mastrandrea, and Leslie L. White. Geneva: World Meteorological Organization. pp. 1-32. https://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-IntegrationBrochure_FINAL.pdf.

Kreft, Sönke, David Eckstein, Lukas Dorsch, and Livia Fischer. 2015. "Global Climate Risk Index 2016: Who Suffers Most from Extreme Weather Events: Weather-Related Loss Events in 2014 and 1995 to 2014" (briefing paper, Germanwatch, Bonn and Berlin, Germany).

Meadows, Donella H., Dennis L. Meadows, Jørgen Randers, William W. Behrens III. 1972. *The Limits to Growth*. New York: Universe Books.

SEI and the Center for International Forestry Research (CIFOR). 2009. *Multiple-Scale Participatory Scenarios: Visions, Policies, and Pathways*. Stockholm: SEI and CIFOR.

Smajgl, Alex, John Ward, Tira Foran, John Dore, and Silva Larson. 2015. "Visions, Beliefs, and Transformation: Exploring Cross-Sector and Transboundary Dynamics in the Wider Mekong Region." *Ecology and Society* 20 (2): 15.

Smajgl, Alex, and John Ward. 2013. "A Framework for Bridging Science and Decision Making." *Futures* 52 (8): 52-58.

———. 2015. "A Design Protocol for Research Impact Evaluation: Development Investments of the Mekong Region." *Journal of Environmental Management* 157: 311-319.

Stockholm Environment Institute. 2015. *Ríos del Páramo al Valle, Por Urbes y Campiñas:* Building Climate Adaptation Capacity in Water Resources Planning*; Final Report. Bogotá, Colombia:* United States Agency for International Development.

Turnhout, Esther, Matthijs Hisschemöller, and Herman Eijsackers. 2007. "Ecological Indicators: Between the Two Fires of Science and Policy." *Ecological Indicators* 7 (2): 215-228. http://www.aphekom.uvsq.fr/IMG/pdf/Ecological_indicators.pdf.

United States Agency for International Development (USAID). 2013. *USAID Mekong ARCC Climate Change Impact and Adaptation Study for the Lower Mekong Basin: Main Report.* Bangkok, Thailand: USAID. https://www.usaid.gov/sites/default/files/documents/1861/USAID_Mekong_ARCC_Climate_Change_Impact_and_Adaption_Study_Main_Report.pdf.

United States Department of Agriculture (USDA), Forest Service. 2011. *Watershed Condition Framework: A Framework for Assessing and Tracking Changes to Watershed Condition*. Washington, DC: USDA. https://www.fs.fed.us/sites/default/files/Watershed_Condition_Framework.pdf.

Yates, David, David Purkey, Jack Sieber, Annette Huber-Lee, and Hector Galbraith. 2005. "WEAP21—A Demand-, Priority-, and Preference-Driven Water Planning Model." *Water International* 30 (4): 487-500.

GMS Roundtable on Climate Adaptation

Stockholm Environment Institute (SEI) Asia Center
15th Floor, Witthyakit Building,
254 Chulalongkorn University
Chulalongkorn Soi 64, Phyathai Road, Pathumwan
Bangkok, 10330 Thailand
E: info-asia@sei.org

Mekong Region Futures Institute (MERFI)
399 Interchange 21 (32nd floor), Sukhumvit Road
North Klongtoey, Wattana
Bangkok, 10110 Thailand
T: +66 (0) 95 657 1200
E: alex.smajgl@merfi.org and wan@merfi.org.