# Using Scenario Analysis to Assess Water Security in an Uncertain Future

## A WATER SECURITY CASE STUDY

## Challenge: Increasing water security despite a changing climate

The USAID Sustainable Water Partnership (SWP) worked with local stakeholders to improve water security in the Mara River Basin (MRB) in Kenya and Tanzania (Figure 1) and the Stung Chinit River Basin in Cambodia (Figure 2). In both locations, the uncertain future impacts of climate change and planned infrastructure, such as dams, irrigation systems, and municipal water supply, have made it difficult to forecast water availability. Uncertainty of future water availability has major consequences when planning for infrastructure that is designed for a long-term useful life. For example, the storage capacity may need to be increased if a drier climate is expected in the region. Irrigation systems may need to account for crop shifts to accommodate climate change, as well as projected reductions in base flow and/or increased extreme rainfall events which can cause flooding and soil erosion. Cities may need to find additional or alternative sources of potable water and may want to consider wastewater reuse for agriculture.

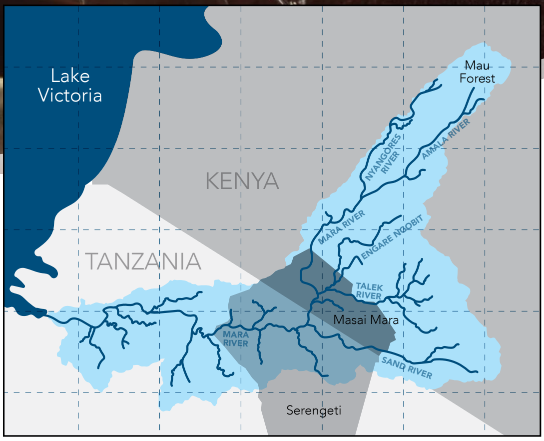



**FIGURE 1: THE MARA RIVER BASIN**

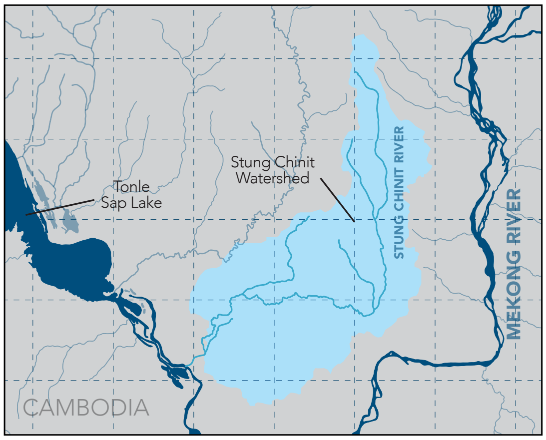



**FIGURE 2: STUNG CHINIT WATERSHED**

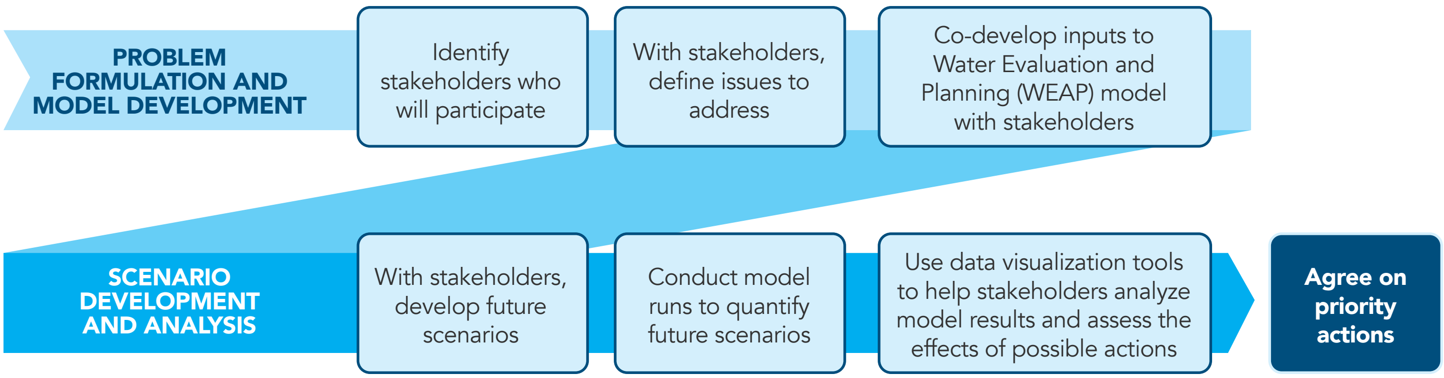
An equally critical consideration is whether the ecosystem health of both basins can be maintained sufficiently to support existing livelihoods, such as fishing in the Stung Chinit, and tourism in the Mara, where a major portion of the economy depends on the Maasai Mara National Reserve in Kenya and the Serengeti National Reserve in Tanzania. If ecosystem degradation is projected, the governments may need to begin investing now in alternative livelihoods. To identify actions that will improve water security as the climate changes over time, stakeholders in both basins need to understand how a range of possible climate change scenarios will affect water availability and plan for extreme events in the future.

## Intervention: Work with stakeholders to model the impact of future scenarios on water availability

In partnership with the Stockholm Environment Institute, SWP piloted a methodology called Robust Decision Support (RDS) to model and assess the impacts of future climate change and development scenarios on water availability in the MRB and the Stung Chinit River Basin. Over the past ten years, RDS has been applied globally in the context of planning for water, energy, and the water-energy-food nexus in order to quantify the impacts of uncertainty, such as climate change, and identify strategies to increase security.

RDS involves iterative engagement with stakeholders to identify the problems to be modeled, co-develop a qualitative and quantitative water planning model, and use the model to quantify future impacts on water availability (Figure 2). To ensure the models are accurate and relevant to key problems on the ground, stakeholders must help define the water availability issues to be modeled and the future scenarios to be analyzed. Stakeholder participation builds trust between stakeholders, facilitating discussion of sensitive issues, like competing water uses, during the planning and decision-making process. To facilitate stakeholder participation, SWP provided translation to local languages and adapted the RDS process to accommodate the level of knowledge of stakeholders in each basin. For example, Stung Chinit stakeholders were not familiar with quantitative modeling, so SWP created an applied game where stakeholders simulated irrigating rice crops while also keeping sufficient flows in the river for fish. The game helped participants understand some of the tradeoffs under consideration.

**FIGURE 2: THE ROBUST DECISION SUPPORT METHODOLOGY**



# Problem Formulation in the Mara River Basin

SWP organized a series of workshops with key water resource management stakeholders to document their water-related challenges, goals, and uncertainties (Table 1). Stakeholders included representatives from national and local government agencies for agriculture, water, and the environment, as well as the World Wildlife Fund. Separate workshops were carried out in Kenya and Tanzania to capture the situation in each country and the downstream effects of possible development in Kenya. For example, Kenya is considering building one or more dams, which are likely to increase uncertainty of water availability in Tanzania. The stakeholders defined a baseline scenario and two future scenarios for further analysis:

- **Baseline –** represents the current state of water management in the basin;
- **Reserve Enforced –** prioritizes providing sufficient river flows to support aquatic ecosystems and associated livelihoods, such as fishing, and water for basic human needs; and
- **Upstream Development –** considers the impacts of potential projects in Kenya to expand irrigated areas and transfer water to an adjacent basin.

## Scenario Analysis and Data Visualization

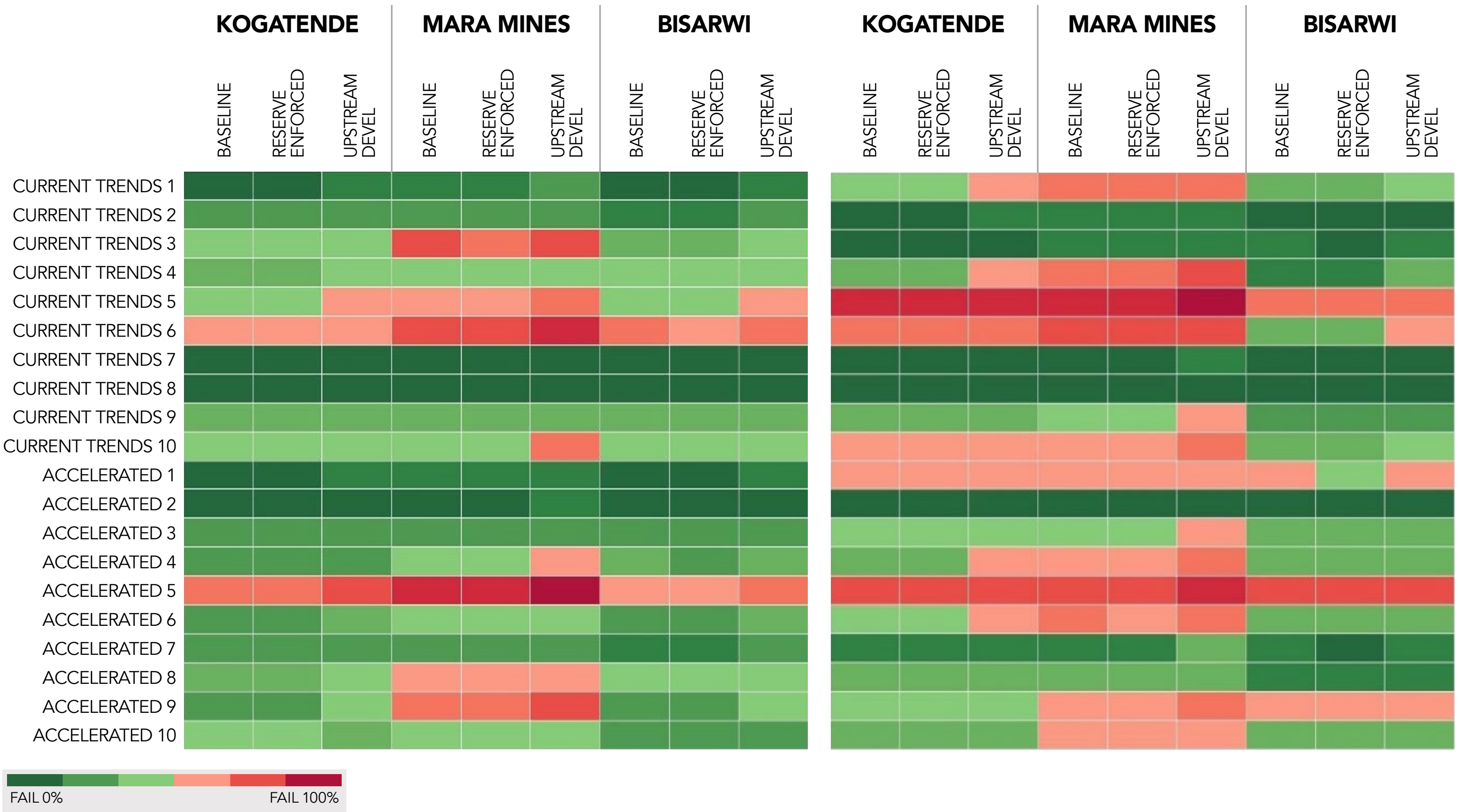
Following the problem formulation workshops in each country, SWP organized a series of trainings on Water Evaluation And Planning (WEAP), a user-friendly software tool which models current and projected water supplies and demands within a basin. SWP used WEAP to model the effect of different climate change projections on the scenarios defined in the problem formulation workshops at three points in the Mara River: Kogatende, in Kenya; and Mara Mines and Biswari, downstream in Tanzania.

The WEAP modeling output was a heat map (Figure 3) showing that the Reserve Enforced and Upstream Development scenarios have similar, modest impacts on water availability in the near term, but looking out ten years or more, the Upstream Development scenario may further reduce base flows, making it more challenging to meet flow targets in all three locations. Stakeholders will therefore need to prioritize strategies that maximize water reliability for these vulnerable communities.

**TABLE 1: STAKEHOLDER CHARACTERIZATION OF WATER SECURITY CHALLENGES, GOALS, AND UNCERTAINTIES IN THE MRB**

| CHALLENGES |
|---|
| • Climate change and variability creating uncertainty about water availability (Both countries)<br>• Impacts of climate change on wildlife and tourism (Both countries)<br>• Development objectives of Kenya may be in conflict with downstream development goals in Tanzania (Tanzania) |
| **GOALS** |
| • Healthy ecosystems (Both countries)<br>• Achieve water-related development potential (Both countries)<br>• Resilience to climate change and climate variability (Both countries)<br>• Equitable water use across the basin (Tanzania)<br>• Enhanced water governance (Kenya) |
| **UNCERTAINTIES** |
| • Climate change (Both countries)<br>• Land use and ecological change (Tanzania)<br>• Natural disasters and epidemics (Kenya) |

**FIGURE 3. THE WEAP MODEL USED THE 2015 INTERNATIONAL PANEL ON CLIMATE CHANGE (IPCC) CLIMATE PROJECTIONS REPRESENTING CURRENT TRENDS AND ACCELERATED GREENHOUSE GAS EMISSIONS, SHOWN HERE IN THE ROWS. EACH COLUMN REPRESENTS A SCENARIO DEFINED BY THE STAKEHOLDERS IN THE PROBLEM FORMULATION WORKSHOPS. THE CELLS SHOW WHETHER WATER AVAILABILITY WILL MEET RESERVE FLOW TARGETS UNDER A SPECIFIC CLIMATE PROJECTION AND DEVELOPMENT SCENARIO FOR A PARTICULAR LOCATION. GREEN CELLS INDICATE THAT RIVER FLOWS ARE MET MORE THAN 50% OF THE TIME; DARKER GREEN CELLS ARE CLOSER TO 100% SUCCESS. RED CELLS INDICATE THAT RIVER FLOWS FAIL TO MEET WATER SUPPLY GOALS MORE THAN 50% OF THE TIME, DARKER RED CELLS ARE CLOSER TO 100% FAILURE.**




# Problem Formulation in the Stung Chinit River Basin, Cambodia

Similar to the process in the Mara basin, SWP organized a series of workshops with key stakeholders in the Stung Chinit River Basin to gain an understanding of the challenges, goals, and uncertainties they face (Table 2). Selected stakeholders included commune and district government leaders, representatives from the Provincial Departments of Agriculture, Forestry, and Fisheries, Environment, and Water Resources and Meteorology, as well as leaders and members of natural resources management community groups that depend on fisheries, forests, and irrigation water for agriculture. The workshops were held in Khmer, the local language, and engaged the same group of stakeholders over the course of several workshops, allowing them to build trust and an understanding of each other's priorities. Stakeholders defined the following priority water use scenarios:

- Growing rice in the existing irrigated area
- Increasing the total irrigated area
- Supporting fish and other aquatic species in the lower part of the basin

## Scenario analysis and data visualization

SWP used WEAP to model the effects of three climate change projections on the scenarios defined above. To understand the vulnerability and viability of proposed water security actions, a total of 64 scenarios were analyzed in the model, representing every potential combination of the variables listed in Table 3 and assessing eight different irrigation schemes as well as two reserve flow scenarios. SWP discussed the model results with stakeholders and made adjustments to ensure the model represented their experiences and knowledge of the river basin.

The WEAP model results for the Stung Chinit showed that the addition of more than one rice crop per year greatly reduces the system's ability to meet demands for environmental flows to support fish and aquatic species. Two rice crops per year may be possible with well-coordinated water management to avoid negative impacts on fish habitats downstream. Further modeling may be required for sub-areas of the river basin to see if additional cropping cycles in specific locations might be feasible while still protecting environmental flows.

### ADDRESSING DATA QUALITY ISSUES IN THE STUNG CHINIT WATERSHED

SWP worked closely with a local, respected water management and modeling expert to collect existing data to inform the WEAP model and analysis. Data were sourced from ministries and national-level government authorities. Where gaps existed with historical data and climate projections, we downscaled global datasets where appropriate.

For cropping patterns and plating methods, which vary by location and individual, which vary by location and individual choices, SWP used the best available information, compared it with existing literature, and verified it with local stakeholders during the RDS workshops.

**TABLE 2. STAKEHOLDER CHARACTERIZATION OF WATER SECURITY CHALLENGES, GOALS, AND UNCERTAINTIES IN THE STUNG CHINIT WATERSHED**

| CHALLENGES |
|---|
| • Water contamination from gold mining and economic land concessions<br>• Water contamination from modern agricultural practices including chemical fertilizer and pesticide use<br>• Lack of tertiary canals for irrigation<br>• Lack of drinking water, sanitation and hygiene services |
| **GOALS** |
| • Increase crop productivity and profitability of agricultural production<br>• Provide flood protection as well as drought resilience<br>• Ensure the integrity of aquatic ecosystems<br>• Provide safe and clean water for people |
| **UNCERTAINTIES** |
| • Climate change<br>• Degradation of soil quality<br>• Migration |

**TABLE 3: VARIABLES USED IN THE STUNG CHINIT WATERSHED WEAP MODEL**

| Variable | Description |
|---|---|
| **CLIMATE CHANGE PROJECTIONS** | |
| C1 | Current trends |
| C2 | Accelerated climate change scenario, 2000-2050 |
| C3 | Accelerated climate change scenario, 2050-2100 |
| **RICE CROP SCHEDULE** | |
| R1 | Wet season rice planted in all irrigation schemes |
| R2 | Early wet season and wet season rice planted in in all irrigation schemes (2 crops per year) |
| R3 | Early wet season, wet season and dry season rice planted in all irrigation schemes (3 crops per year) |
| R4 | Four rice crops per year planted in all irrigation schemes |
| **INCREASE IRRIGATED AREA** | |
| I1 | Maintain irrigated areas at 2017 size for all irrigation schemes |
| I2 | Increase area of all irrigation schemes by 10% |
| **PRIORITIZE WATER FOR DIFFERENT DEMANDS** | |
| P1 | During shortages, ensure supply to irrigation as first priority |
| P2 | During shortages, ensure 95 percentile flow downstream of reservoirs as first priority, before delivering irrigation water |

## Results

The WEAP model results made it clear that if Kenya prioritizes meeting its flow reserves, Tanzania will be able to meet its reserve requirements as well. The WEAP model results informed the Lake Victoria Basin Water Board's Water Allocation Plan for the Lower Mara River Basin, which included provisions to monitor climate change and development impacts over time. Additional scenario planning using the WEAP model will inform ongoing discussions between Kenya and Tanzania on water sharing arrangements.

In the Stung Chinit River Basin, SWP briefed the newly formed Stung Chinit River Basin Management Committee (SC-RBMC) on the results of the RDS process, including the WEAP analysis, during the Committee's launch meeting. Based on the results of the WEAP analysis, SC-RBMC's Reservoir and Irrigation Operations and Maintenance Working Group commissioned a study of two irrigation schemes in the Stung Chinit River Basin. Local SWP partner, the Irrigation Services Center, used drones to map the irrigation schemes and worked with Farmer Water User Committees to implement a water distribution schedule for each scheme. Over one cropping cycle, the schedules achieved timely and equitable water distribution to farmers and de-escalated water-related conflicts, proving that with good water management and coordination, there was sufficient water available for all farmers. The SC-RBMC used the findings from the RDS process to develop activities in their Strategic Action Plan to improve coordination and planning for irrigation water management within irrigation schemes and throughout the entire system.

## Lessons Learned

Lessons learned from implementing RDS in the MRB and Cambodia include:

> Given the uncertain impacts of climate change and future infrastructure development on water resources, scenario planning requires modeling a considerable range of variables and options related to demand, supply, policies, and land use change. Quantifying the impacts of a range of scenarios provides a sense of the range of possible futures that decision makers could face. This has allowed for better informed water management plans and stakeholder negotiations around water allocation, water infrastructure, and water use priorities.

> RDS enabled SWP to improve the WEAP modeling process by increasing stakeholder input and buy-in to the scenarios modeled, which in turn increased the utility of the model results.

> RDS is an effective approach for engaging stakeholders in complex planning and decision-making processes. RDS facilitates local inputs and perspectives in order to ensure multiple perspectives are taken into account, a wide range of planning options considered, and a consensus among stakeholders on what next steps should be taken. SWP used RDS to achieve effective stakeholder participation by:

- understanding where each person is starting from in the learning process;
- allowing sufficient time and repeated interactions for people to absorb new approaches and tools;
- engaging a range of stakeholders to develop a shared understanding of the challenges and vulnerabilities of different actors and ecosystems; and
- using videos, games, and interactive visualizations of data to increase stakeholder understanding of complex scenarios.

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**ABOUT THIS SERIES**
This case study is part of a series of products of approaches under the Water Security Improvement (WSI) process. This series is produced by USAID's Sustainable Water Partnership (SWP) activity and can be found here: www.swpwater.org.