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AB InBev

# Measuring and Evaluating the Impact of Corporate Watershed Projects

## A Guide to Set Project Objectives, Track Progress and Assess and Communicate Impact

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# GLOSSARY

| | |
|---|---|
| **Adaptive management** | A framework that acknowledges the uncertainties inherent in predicting the outcomes of management decisions within complex systems, thus building in mechanisms for adapting approaches based on data and information gained over time. |
| **Baseline information** | Information about initial conditions which can be used for comparison with later data. A baseline provides a critical reference point for assessing changes and impact of a project, as it establishes a basis for comparing the situation before and after an intervention, and for making inferences as to the effectiveness of the project. |
| **BACI and BACRI** | Logical model for monitoring approaches Before/After/Control/Impact and Before, After, Control, Reference, Impact that determines how the monitoring will be established. |
| **Collective action** | Coordinated engagement among interested parties within an agreed-upon process in support of common objectives. Water-related collective action refers to specific efforts to advance sustainable water management, whether through encouraging reduced water use, improved water governance, pollution reduction, river restoration, or other efforts. |
| **Goals** | A goal is an idea of the future or desired result that is aimed to be reached within a finite time. |
| **Key performance indicators** | Indicators most closely aligned with the critical objectives of the project. |
| **Monitoring and evaluation** | The processes by which data are systematically collected, analyzed and interpreted to track project progress towards goals and to measure impacts. |
| **Objectives** | Monitoring objectives are "big picture" quantitative statements that provide a means of evaluating whether goals were achieved. |
| **Performance indicators and metrics** | Systems of measurements used to quantify changes associated with actions implemented in a project. Performance metrics can be quantitative (measure changes numerically) or qualitative (use non-numerical, interpretative approaches based on descriptions, observations and interviews) |

| | |
|---|---|
| **Project effectiveness** | The extent to which the activities or interventions implemented have achieved, or are expected to achieve, their objectives, taking into account their relative importance. |
| **Project efficiency** | Whether or not the tasks and deliverables outlined for the project implementation phase were accomplished within the expected timeline and budget. |
| **Project impact** | How conditions in the watershed have changed because of the project results. Changes can be positive or negative, intended or unintended, based on primary or secondary project objectives, and a direct or indirect result of interventions. |
| **Stakeholder** | Entity or individual that can reasonably be expected to be significantly affected by the given organization's activities, products, and services, or whose actions can reasonably be expected to affect the ability of the organization to successfully implement its strategies and achieve its objectives. |
| **SMART criteria** | Criteria that ensure that indicators are specific, measurable, attainable, relevant and time-bound. |
| **Spatial scale** | Extent of the area (length, distance, geographic area). |
| **Temporal scale** | Duration of time. |
| **Watershed** | The geographical zone where surface or groundwater flows, is captured, and eventually is discharged at one or more points. Watershed is often used interchangeably with 'catchment' or 'basin'. A surface water catchment includes the area where precipitation collects, enters streams and rivers, and flows toward the mouth of a single river, whether this empties into a larger river, a lake, or the sea. A groundwater catchment is defined by the geology of an aquifer and groundwater flow paths (Alliance for Water Stewardship 2019).<br>A subcatchment is a distinct part contained within a watershed. |
| **Water stewardship** | The use of water that is socially and culturally equitable, environmentally sustainable, and economically beneficial, achieved through a stakeholder inclusive process that involves site- and catchment-based actions. |
| **Water stress** | Ability, or lack thereof, to meet human and ecological demand for fresh water—including water quantity, quality, and accessibility. |

## Types of Indicators

- **Input indicators**
  Account for the amount of investment in the project, in dollars or in-kind.
- **Process/Activity indicators**
  Assess actions taken to transform inputs into outputs and achieve project goals (e.g., hours spent planting trees).
- **Output indicators**
  Measure the first level or short term results of activities completed to achieve project goals, such as number of trees planted, capacity building, workshops held, etc.
- **Outcome indicators**
  Quantify specific and observable changes that represent achievement of project goals. Examples include increase in base flow level or decrease in turbidity in streams.
- **Impact indicators**
  Show whether the ultimate project goals (including social, environmental and economic goals) are being met. They include the delivery of primary objectives across stakeholders such as equitable water access, or improvement in water use efficiency by farmers.

## Water stewardship project roles

- **Funder**
  An individual or entity that provides resources – in cash or in kind – to enable the execution of project activities. Companies often play this role in water stewardship projects.
- **Champion**
  An individual or entity that offers leadership and increased visibility to the initiative who can help recruit others and leverage networks to advance the project. Companies often play this role in water stewardship projects.
- **Implementing partner**
  Entities implementing all or part of the project, such as governmental or non-governmental organizations, who are contracted to execute on-the-ground activities needed achieve the project goals.
- **Monitoring partner**
  An individual or entity that has been contracted to conduct monitoring, evaluation and learning of the funded activities. This is often, but not always, the implementing partner.
- **Technical expert**
  An individual or entity that is qualified to provide specific scientific, technical, methodological and sectoral knowledge and/or expertise to advise any of the other project stakeholders.
- **Stakeholder**
  Entity or individual that can reasonably be expected to be significantly affected by the project's activities, products, and services, or whose actions can reasonably be expected to affect the ability of the organization to successfully implement its strategies and achieve its objectives. Examples of stakeholders include company leadership, local community members, and municipal or government agencies.

# INTRODUCTION 01

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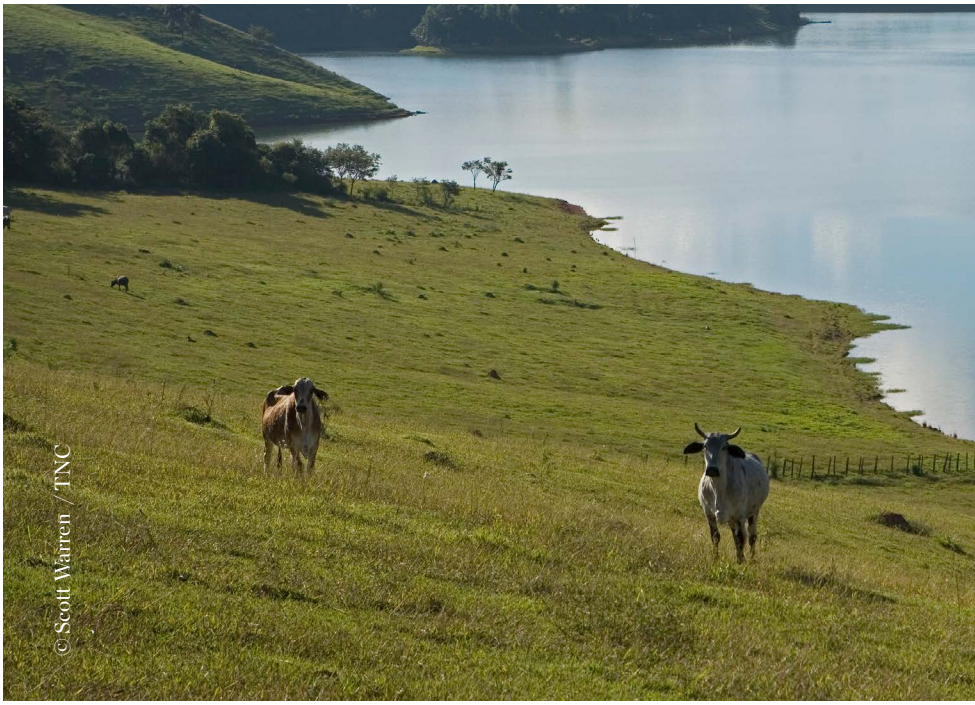
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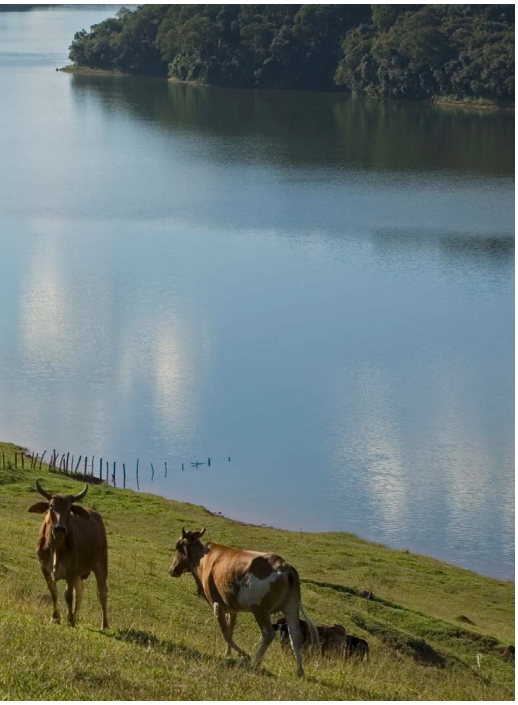
# INTRODUCTION

The availability of good quality water underpins healthy communities, economies and ecosystems. Water stress, defined as the "ability, or lack thereof, to meet human and ecological demand for fresh water"—including water quantity, quality, and accessibility—is becoming an increasing concern in watersheds globally **(CEO Water Mandate, 2017)**. In order to address water stress and plan for future sustainability, effective interventions are needed to protect and enhance water resources, use water efficiently and maintain good quality supply to diverse users. Companies have an important role to play in addressing water stress as stewards of the water that comes through the company's operations and through the water impacts of sourcing of ingredients. The Nature Conservancy (TNC) and AB InBev are collaborating globally to improve stewardship of vital freshwater sources for the communities and ecosystems that depend on them. This guide is one resource developed through our collaborations both on-the-ground and globally. This document aims to provide guidance for corporate practitioners engaging in water stewardship to effectively engage and communicate with key stakeholders on measurable impact. The purpose of this guide is to assist users in establishing site-specific goals, measurable objectives, and monitoring plans for priority sites or intervention areas, in support of achieving the company's broader water stewardship goals.



Water is a shared resource, so it is critical to tailor projects to the local context, support collective action, and make contributions that help catalyze action, not only to deliver on specific company targets but more importantly, to improve the health of watersheds and reduce water risk for the long-term. As the CEO Water Mandate says: "Freshwater management has certain multifaceted and unique characteristics. [...] Water is required for life; it supports community livelihoods and sustains ecosystems. It is also viewed by many as a commodity that enables economic production and consumption. The use of water is inherently subject to public good expectations and can easily raise sociopolitical tensions, particularly when a use or waste discharge has, or is perceived to have, negative impacts on local communities or ecosystems. These situations require cooperation—and sometimes compromises—among interested parties." **(CEO Water Mandate, 2013)** There are various roles that these interested parties can play in water stewardship projects, which will be referred to throughout this guide, including:

- **Funder**
  An individual or entity that provides resources – in cash or in kind – to enable to execution of project activities. Companies often play this role in water stewardship projects.
- **Champion**
  An individual or entity that offers leadership and increased visibility to the initiative who can help recruit others and leverage networks to advance the project. Companies often play this role in water stewardship projects.
- **Implementing partner**
  Entity implementing all or part of the project, such as governmental or non-governmental organizations, who are contracted to execute on-the-ground activities needed achieve the project goals.
- **Monitoring partner**
  An individual or entity that has been contracted to conduct monitoring, evaluation and learning of the funded activities. This is often, but not always, the implementing partner.
- **Technical expert**
  An individual or entity that is qualitied to provide specific scientific, technical, methodological and sectoral knowledge and/or expertise to advise any of the other project stakeholders.
- **Stakeholder**
  Entity or individual that can reasonably be expected to be significantly affected by the project's activities, products, and services, or whose actions can reasonably be expected to affect the ability of the organization to successfully implement its strategies and achieve its objectives. Examples of stakeholders include company leadership, local community members, and municipal or government agencies.

With the many interested parties involved in water stewardship projects, selecting, designing, and operating water stewardship projects requires a system to set goals and evaluate performance. Robust measurement and evaluation can help companies ensure they are making contributions that are meaningfully and measurably contributing towards watershed health. Adaptive management is a framework that acknowledges the uncertainties inherent in predicting the outcomes of management decisions within complex systems, such as watersheds. Within the adaptive management framework monitoring and evaluation provides the essential information to assess progress as well as to identify barriers to progress. A key feature of the adaptive management framework is its iterative structure based on the feedback between monitoring and decision-making. Results from monitoring are routinely evaluated so plans can be adjusted on the basis of what has been learned. Monitoring is also helpful to discover drivers of system change and improve model predictions of future interventions. The adaptive management framework (Figure 1) will be referred to throughout this guide.


**Figure 1.** Adaptive management framework used for managing watersheds.

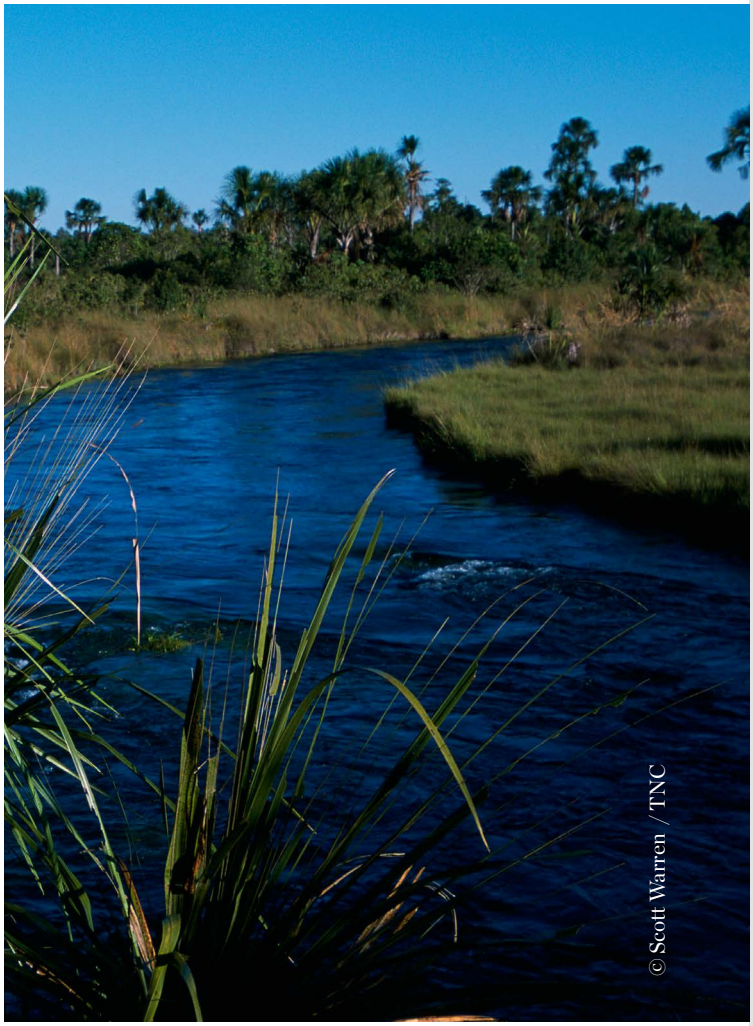
## The purpose of this guide

Monitoring and evaluation is used to track progress towards projects objectives and to quantify impacts. The purpose of this guide is to help non-scientists understand the rationale and process of developing a monitoring and evaluation plan in order to assess progress, evaluate impacts, and adaptively manage projects to provide benefits for communities and ecosystems. The Nature Conservancy's Primer for Monitoring Water Funds **(found here)** contains practical information on field monitoring methods and sampling designs for collecting monitoring data that can be useful for a company's implementing

or monitoring partners; hence, the focus of this guide is on developing metrics and selecting performance indicators, the type of data that should be collected, and how to analyze the information generated to assess project success and communicate the key findings.

## What is in the guide?

- Basic principles of an effective monitoring and evaluation plan.
- Step-by-step information on how to develop metrics and select key performance indicators (KPIs), including:
  - Types of metrics.
  - How to develop relevant environmental and social-economic metrics and select strong KPIs.
  - Menu of KPIs based on typical water problems and solutions (Table 4).
- Guidelines for developing a strategic monitoring plan to quantify changes in water quantity and/or quality in the watershed.
- Examples of performance indicators related to three different projects being implemented in partnership with TNC.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## Prerequisites for using this guide

The questions below should help identify the most relevant information along different stages of engagement in watersheds, from convening and outreach to communication, as it relates to monitoring and evaluation.

**Convening and outreach:**

- What is the objective of the water stewardship project?
- Who are the key players (stakeholders, interested parties)?
  - Who will use the information generated by the monitoring and evaluation efforts?
  - What organizations, government agencies, universities or other research institutions may have relevant data or plan to collect data?
  - Who are potential partners to help implement a monitoring program, and finance or facilitate monitoring?

**Problem identification and prioritization:**

- What are the watershed conditions and features, including user accessibility, drivers of water quality issues or water scarcity, etc.?
- Does baseline information exist or need to be collected?
- What are the critical areas in the watershed and critical periods impacting water quality and quantity?
- What are the knowledge gaps and information needs?

**Solutions agreed:**

- What actions and activities (interventions) have been selected to be implemented in the watershed and what are the specific goals?
- How will the impact of the project be measured?
- How does the project relate to the company's broader water stewardship goal(s)?

**Implementation plan, governance and finance, and communication:**

- What interventions have already been implemented, where and when?
- What future interventions, if any, are planned?
- What financial resources and capacities are available from different partners for both implementation and measurement and evaluation?
- Who will analyze data and information and communicate the knowledge generated, and who does the knowledge need to be communicated to?

## Putting this guide in context with existing frameworks

Over the past few years, a number of guidance documents and processes have been released, aimed at companies and other stakeholders to incorporate watershed context, account for benefits and set meaningful targets. See the Table 1 for details on each initiative.

**Table 1.** Existing corporate water target setting and impact frameworks.

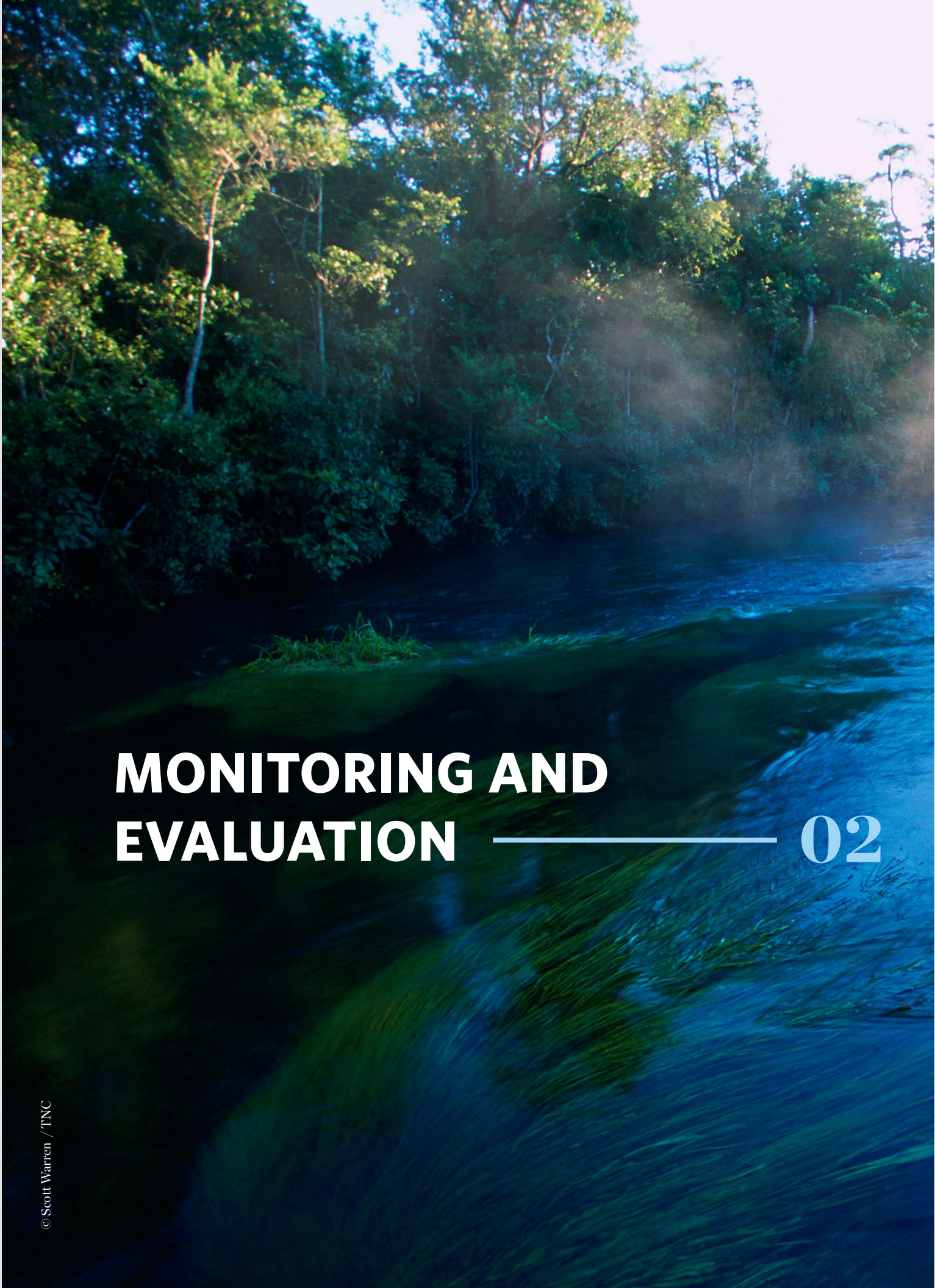
| Framework | Objective | Primary Focus | Authors & Partners | Date Published |
|---|---|---|---|---|
| Site Water Targets Guide | Support companies in setting effective site water targets that are informed by catchment context | Facility and watershed level | CEO Water Mandate and Pacific Institute, CDP, TNC, UNEP-DHI, WRI, WWF | August 2019 |
| Volumetric Water Benefit Accounting Paper | Calculate and communicate the benefit (in terms of water volume) of water stewardship activities | Project level | WRI, Quantis, LimnoTech | August 2019; further guidance released in January 2021 |
| Net-Positive Water Impact Concept of the Water Resilience Coalition | Support companies to make contributions that exceed their impact on water stress in a given watershed | Watershed level | CEO Water Mandate Water Resilience Coalition | March 2020 |

| Framework | Objective | Primary Focus | Authors & Partners | Date Published |
|---|---|---|---|---|
| **Science Based Targets for Water** | Support companies in setting effective site water targets that are informed by catchment context | Facility and watershed level | CEO Water Mandate and Pacific Institute, CDP, TNC, UNEP-DHI, WRI, WWF | August 2020 |
| **Benefit Accounting of Nature-Based Solutions for Watersheds Guide** | Provide a standardized method to account for the stacked water and carbon benefits, and identify wider co-benefits of NBS for watersheds (biodiversity and socioeconomics) | Project level | CEO Water Mandate and Pacific Institute, Danone, LimnoTech, TNC | March 2021 |
| **Measuring and Evaluating the Impact of Corporate Watershed Projects** | Provide detailed guidance on how companies can engage in the monitoring and evaluation of water stewardship projects to demonstrate measurable impacts in watersheds | Links project and watershed level | AB InBev, TNC, and University of Maryland | August 2021 |

This guide complements other frameworks by offering detailed guidance on how companies can engage in the monitoring and evaluation of water stewardship projects to demonstrate measurable impacts in watersheds. This guide is not meant to be redundant but rather aims to help users leverage these and other frameworks to make progress towards measurable watershed impact.

This guide also aligns well with these other existing frameworks by providing a stepwise process for monitoring and evaluation at the project level, which is an important part of measuring the overall achievement and impact of a company's broader water stewardship goal(s). This guide provides users with the information they need to answer whether watershed investments are making progress towards their site-based objective(s), in addition to answering other important questions about project outputs, outcomes and impacts that other stakeholders are interested in. This guide provides additional support and pragmatic guidance to users in ensuring the successful outcomes of water stewardship initiatives by:

- providing information on defining the objectives of monitoring and evaluation,
- providing complementary information on the typical actions that can be taken to address common shared water challenges
- focusing on a range of indicators from input to impact and providing common metrics to assess progress and impact, and
- providing additional information on reporting and communicating monitoring information to stakeholders.



# MONITORING AND EVALUATION 02

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# MONITORING AND EVALUATION

## What is monitoring and evaluation and why is it important?

Monitoring and evaluation are the processes by which data are systematically collected and analyzed to track project progress towards goals and to measure impacts. An effective monitoring and evaluation program provides valuable information about whether project or program objectives are being achieved, to inform adaptative management of specific projects, and to help inform further investments in watershed projects based on a deeper understanding of elements of success. For watershed projects, it is recommended that monitoring and evaluation be done at the individual project level to assess effectiveness in addition to the watershed or


sub-watershed scales to evaluate cumulative effects. However, financial, logistical, and other constraints may limit monitoring efforts, allowing only the cumulative impacts to be monitored. Mathematical models can be used to complement field monitoring efforts. However, depending on the complexity, data availability and scale of the watershed, model predictions can have large uncertainties which need to be carefully assessed and any assumptions used in the modeling need to be clearly communicated.

## Developing an effective plan

The effectiveness of a monitoring and evaluation program depends on clear objectives and good planning. The specifics of the planning process will vary depending on the project context, but all effective monitoring and evaluation programs share common components that must be addressed. The remainder of this guide is structured around these five core components.

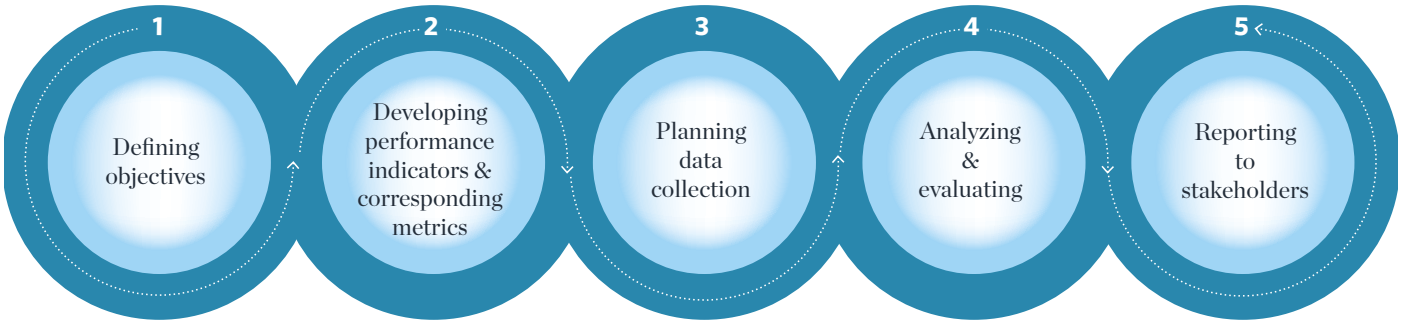



**Figure 2.** The five steps of monitoring and evaluation.


## Step 1.
## Defining objectives

In order to define the objectives of the monitoring and evaluation program, it is important to first understand the specific challenge(s) that the project is aiming to solve, what solutions are being considered and what the goals are of each solution or set of activities that comprise the solution. Therefore, it might be helpful to ask the following questions:

- **i.** What is the problem that the project is trying to solve?
- **ii.** What is the solution proposed?
- **iii.** What are the actions and activities being considered to solve the problem?
- **iv.** What are the specific goals of each action/activity?


For example, if the problem is water quality degradation from deforestation upstream of the water abstraction point, the answers to the above questions might look like this:

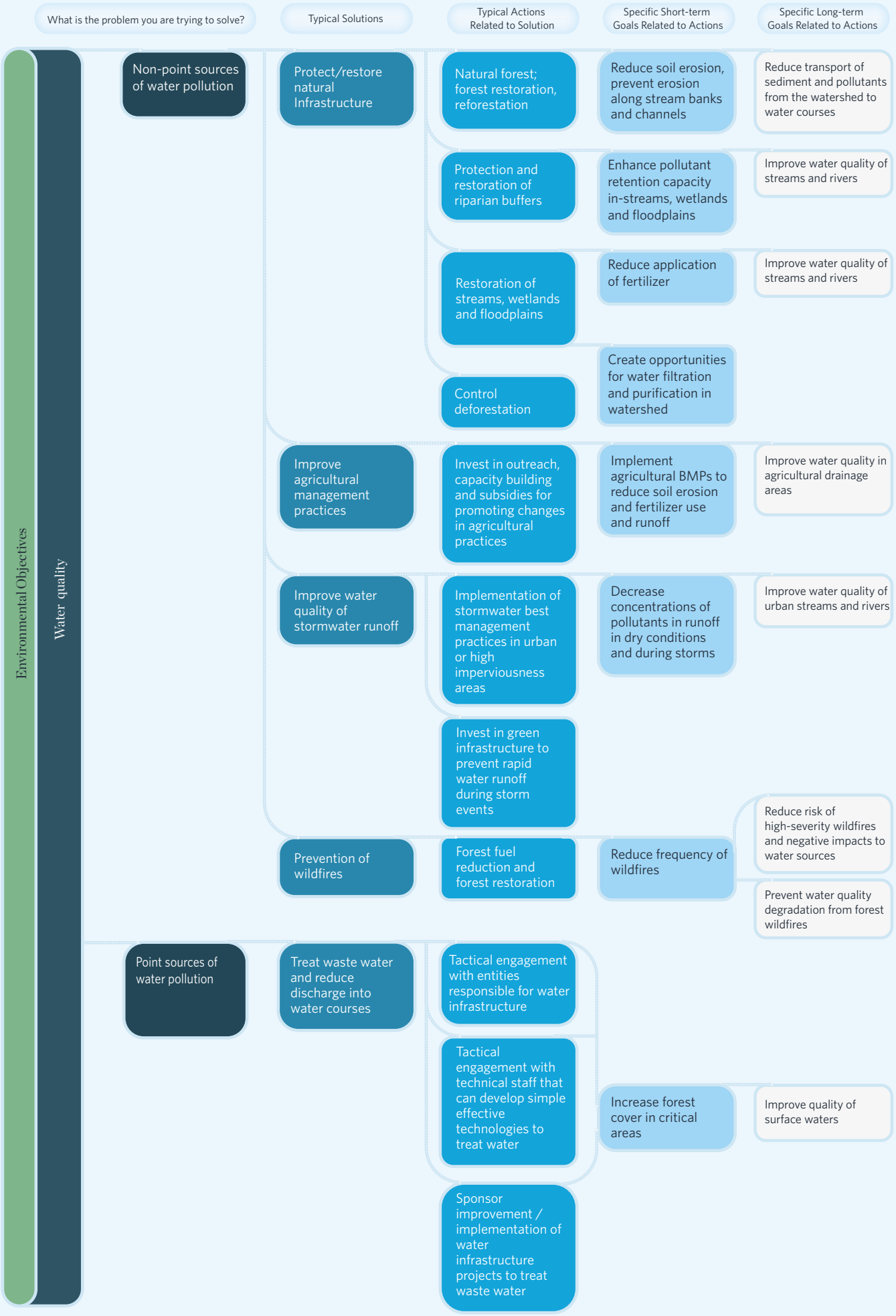
- **i.** Degradation of water quality due to conversion of forest into cropland upstream.
- **ii.** To conserve and/or expand the area of forest cover upstream and improve agricultural practices on land already converted to cropland.
- **iii.** Reforestation where possible and provision of incentives to farmers to conserve existing forest (i.e. not convert to cropland) and implement more sustainable agricultural practices on already converted land.
- **iv.** To reduce soil erosion, reduce surface runoff, increase groundwater recharge.

In this example of water quality degradation due to deforestation upstream, the solution is to control deforestation and increase forest cover in critical areas, and improve agricultural practices on land already converted to cropland in order to reduce the transport of sediment and other materials to surface waters. However, solutions usually include multiple actions, and each action has specific goals. A clear understanding of the goals makes it is easier to define what to measure in the monitoring and evaluation program. Once you know what to measure, the next step is the development of performance indicators to assess project progress and success.

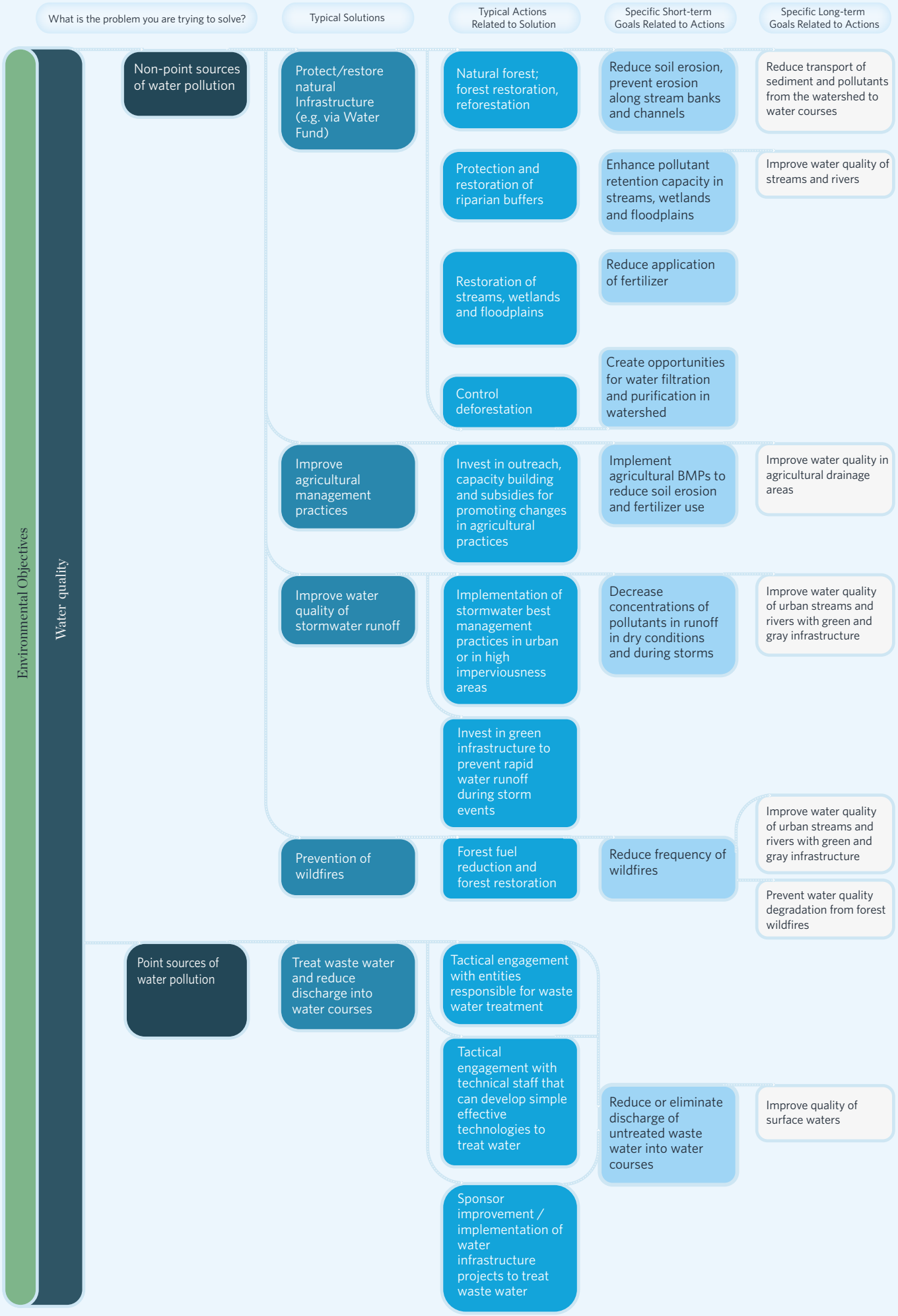
Table 2 provides details on defining objectives for initiatives that could address common environmental and socioeconomic challenges in watersheds.

**Table 2.** Examples of short- and long-term goals associated with typical problems and solutions in watersheds facing high water stress.

| Environmental Objectives | Water availability | What is the problem you are trying to solve? | Typical Solutions | Typical Actions Related to Solution | Specific Short-term Goals Related to Actions | Specific Long-term Goals Related to Actions |
|---|---|---|---|---|---|---|
| | | Limits and variability on water availability; seasonal changes; floods; drought | Restore natural infrastructure | Restoration of natural forests, reforest critical areas | Increase forest cover in critical areas | Mimic natural processes to enhance water availability (e.g., water infiltration, retention and storage in aquifers, groundwater recharge, baseflow in streams) |
| | | | | Restoration and protection of recharge areas (wetlands, floodplains) | Create or restore water recharge areas | Increase water storage and residence time in watershed |
| | | | | | Increase water infiltration capacity in recharge areas | |
| | | | Prevent loss of forest cover in watershed | Promote agroforestry in critical areas | Prevent deforestation | Increase water storage in aquifers |
| | | | | | Increase forest cover in critical areas | |
| | | | | | Reduce surface runoff and increase water infiltration | |
| | | | | | Protect source water areas | |
| | | Growing demand from agriculture, industry and population | Repair or improve physical infrastructure | Tactical engagement with entities responsible for water infrastructure | Reduce water loss from poorly performing or failed infrastructure | Improve water distribution and access in watershed |
| | | | | Sponsor repair/ improvement of water infrastructure projects | | |
| | | | Reduce and prevent illegal water abstraction with policy/ regulatory reform | Tactical engagement with regulators and policy makers | Reduce illegal abstraction points | Reduce water consumption and improve water-use efficiency |
| | | | | Develop simple effective technologies to improve water access to end users relying on illegal water abstraction | | |
| | | | | Policy reform | | |
| | | | Promote equitable allocation among users with policy/ regulatory changes | Work on governance equity concerns and/or allocation efficiency | Assessment of water allocation among users | Improve water allocation in watershed or perception of fair allocation among users |
| | | | Reform agriculture practices to promote water use efficiency using tactical engagement/ sponsorship | Invest in outreach, capacity building and implementation of best management practices (BMPs) | Support and sponsor programs to reform agricultural practices to reduce water loss in irrigation | Implement BMPs to reduce water loss in irrigation |
| | | | | | | Improve water use efficiency in agriculture |


What is the problem you are trying to solve?
Typical Solutions
Typical Actions Related to Solution
Specific Short-term Goals Related to Actions
Specific Long-term Goals Related to Actions
Environmental Objectives
Water quality
Non-point sources of water pollution
Protect/restore natural Infrastructure
Natural forest; forest restoration, reforestation
Reduce soil erosion, prevent erosion along stream banks and channels
Reduce transport of sediment and pollutants from the watershed to water courses
Protection and restoration of riparian buffers
Enhance pollutant retention capacity in-streams, wetlands and floodplains
Improve water quality of streams and rivers
Restoration of streams, wetlands and floodplains
Reduce application of fertilizer
Improve water quality of streams and rivers
Control deforestation
Create opportunities for water filtration and purification in watershed
Improve agricultural management practices
Invest in outreach, capacity building and subsidies for promoting changes in agricultural practices
Implement agricultural BMPs to reduce soil erosion and fertilizer use and runoff
Improve water quality in agricultural drainage areas
Improve water quality of stormwater runoff
Implementation of stormwater best management practices in urban or high imperviousness areas
Decrease concentrations of pollutants in runoff in dry conditions and during storms
Improve water quality of urban streams and rivers
Invest in green infrastructure to prevent rapid water runoff during storm events
Prevention of wildfires
Forest fuel reduction and forest restoration
Reduce frequency of wildfires
Reduce risk of high-severity wildfires and negative impacts to water sources
Prevent water quality degradation from forest wildfires
Point sources of water pollution
Treat waste water and reduce discharge into water courses
Tactical engagement with entities responsible for water infrastructure
Tactical engagement with technical staff that can develop simple effective technologies to treat water
Increase forest cover in critical areas
Improve quality of surface waters
Sponsor improvement / implementation of water infrastructure projects to treat waste water


What is the problem you are trying to solve?
Typical Solutions
Typical Actions Related to Solution
Specific Short-term Goals Related to Actions
Specific Long-term Goals Related to Actions
Socioeconomic Objectives
Water availability
Declining water availability and increasing variability
Restore natural infrastructure (e.g. via Water Fund)
Restore and protect wetlands, floodplains, forests
Invest in nature-based solutions
Ecosystem restoration; planting of trees, reforestation; removal of invasive plants
Mimic natural processes to enhance water availability (e.g., water infiltration, retention and storage in watershed)
Reduce domestic water supply risk
Reduce domestic water supply risk
Tactical engagement/ sponsorship to prevent loss of forest cover in watershed
Promote agroforestry in critical areas
Promote water reducing technologies or practices
Educate farmers about more sustainable alternatives for farming in critical areas
Reduce agricultural water supply risk
Growing demand from agriculture, industry and population
Repair or improve physical infrastructure
Tactical engagement with entities responsible for water infrastructure
Sponsor repair/ improvement of water infrastructure projects
Improve water infrastructure
Improve water distribution and access in watershed by all users
Reduce and prevent illegal water abstraction with policy/ regulations reform
Tactical engagement with regulators and policy makers
Develop simple effective technologies to improve water access to end users relying on illegal water abstraction
Policy reform
Reduce illegal abstraction points
Sustain enforcement
Social support of enforcement of illegal abstraction
Promote equitable allocation among users with policy/ regulatory changes
Work on governance equity concerns and/or allocation efficiency
Improved water rights agreements
More equitable distribution of water rights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Invest in green infrastructure to prevent rapid water runoff during storm events
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Reduce frequency of wildfires
Improve water quality of urban streams and rivers with green and gray infrastructure
Prevent water quality degradation from forest wildfires
Point sources of water pollution
Treat waste water and reduce discharge into water courses
Tactical engagement with entities responsible for waste water treatment
Tactical engagement with technical staff that can develop simple effective technologies to treat water
Reduce or eliminate discharge of untreated waste water into water courses
Improve quality of surface waters
Sponsor improvement / implementation of water infrastructure projects to treat waste water

## Step 2. Developing performance indicators and corresponding metrics

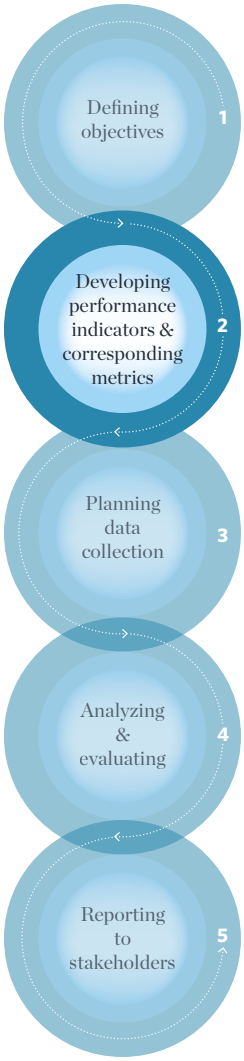



Table 2 provides details on defining objectives for initiatives that could address common environmental and socioeconomic challenges in watersheds.

Performance indicators and corresponding metrics are systems of measurements used to quantify changes associated with actions implemented in a project; key performance indicators (KPIs) are the most closely aligned with the critical objectives of the project. Performance metrics can be quantitative or qualitative. Quantitative metrics measure changes numerically (e.g., rates, percentages, cost, etc.), while qualitative metrics measure changes using non-numerical, interpretative approaches based on descriptions, observations and interviews.

Quantitative metrics are the most helpful to compute changes and rate of changes towards precise measurable goals, hence, they are commonly used to measure biophysical changes and economic outcomes. Qualitative metrics, on the other hand, provide a less precise estimate of changes, so they are typically used to assess social impacts and the effects of actions and interventions on people's well-being.

Deciding on the best performance metrics or KPIs for the monitoring and evaluation program is not always easy given the many factors that need to be considered, but the questions below should help in the selection process:

- What are the expected results or desired changes of actions implemented?
- What type of information can demonstrate the desired changes?
- What is possible to monitor given resources, time and capacity?
- When does the monitoring information need to be available?
- Can existing monitoring data be used or augmented or does new data need to be collected?

Selection of performance indicators should consider not only those that assess expected environmental and biophysical changes, but also benefits to people and the environment.

It is important to keep in mind that the indicators need to be relevant to the project, measurable within the required time frame and resources available, and relatively easy to measure while providing an accurate description of the changes expected. The SMART criteria can be helpful to decide which KPIs would be the most informative and also practical for the specific conditions of a particular monitoring and evaluation program.


**Box 1.** SMART Criteria

- **Specific:**
The indicator should accurately describe what is intended to be measured and should not include multiple measurements in one indicator.
- **Measurable:**
Regardless of who uses the indicator, consistent results should be obtained and tracked under the same conditions.
- **Attainable:**
Collecting data for the indicator should be simple, straightforward, and cost-effective.
- **Relevant:**
The indicator should be closely connected with each respective input, output or outcome.
- **Time-bound:**
The indicator should be measurable within a specific time frame.

Table 3 provides a list of potential indicators that can be used to monitor and evaluate watershed projects. The indicators in this table are grouped by broad objectives that are typical in watershed projects and matched with commonly used measurements. This information should help in the exploration of potential indicators most suitable to assess project success and also practical for the monitoring program indicators most suitable to assess project success and also practical for the monitoring program.

**Table 3.** Matching general objectives of watershed projects with potential indicators and measurements.

| Objectives | Potential Indicators | Measurements |
|---|---|---|
| | **Environmental and Biophysical** | |
| Address changes in water availability or quantity | Total stream discharge or volume | 1 2 3 |
| | Baseflow discharge | 4 5 6 7 |
| | Droughts | 8 |
| | Flood flows | 9 10 |
| | Flashiness of stream flow | 11 12 13 14 |
| | Channel dimensions, geomorphology | 15 16 |
| | Sediment in the channel | 17 |
| | Channel erosion rates | 18 |
| | Environmental flows | 34 |
| | Biodiveristy of aquatic organisms | 39 |
| | Health of aquatic ecosystems | 40 |
| | Groundwater storage, level, recharge | 19 |
| | Spring and baseflow discharge | 20 |
| | Soil infiltration in recharge areas | 21 |
| Address changes in water quality | Pollutant and bacteria index | 22 |
| | Concentrations and loads of priority pollutants | 23 |
| | Dissolved oxygen concentrations | 24 |
| | Turbidity, suspended solids, organic matter | 25 26 27 |
| | Water electrical conductivity | 28 |
| | Odor | 29 |
| Improvement in aquatic habitat | Stream condition index | 30 |
| | Trophic state | 31 32 |
| | Stream habitat | 33 |
| | Flows for fish | 34 |
| | Stream temperature | 35 |
| | Organic matter composition | 36 |
| | Community structure and function, aquatic biodiversity | 37 |
| | Stream functional capacity | 38 |
| Improvement in riparian habitat | Buffer condition | 41 |
| | Buffer area | 42 |
| | Plantings cover and survival | 43 |
| | Species diversity | 44 |

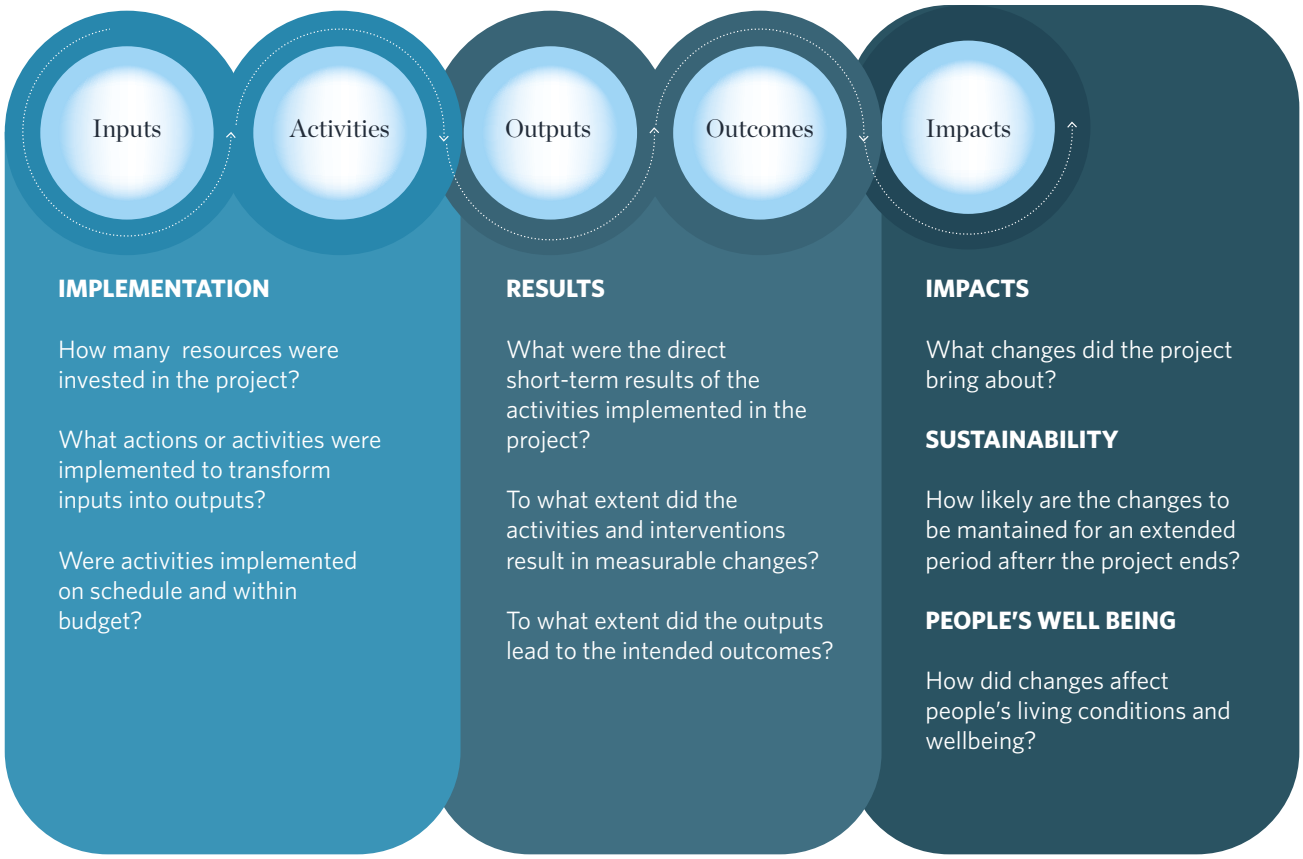
| Objectives | Potential Indicators: Environmental and Biophysical | Measurements |
|---|---|---|
| Improvement of watershed conditions | Changes in land use/land cover | 45 |
| | Protected aquifer recharge areas | 46 |
| | Land management, area implemented with BMPs, soil erosion | 47 |
| | Presence of natural infrastructure | 48 |
| | Regional coverage of sewage and water conveyance systems | 49 |
| | Conditions of water infrastructure | 50 |
| | Illegal water abstraction points | 51 |
| | Point sources of pollution | 52 |

| Objectives | Potential Indicators: Socioeconomic and Governance | Measurements |
|---|---|---|
| Improvement of socioeconomic conditions | Water use efficiency by ag sector | 53 |
| | Water prices by economic sector | 54 |
| | Risk of business disruption | 55 |
| | Company reputation | 56 see Appendix 2 |
| | Perception of fair water allocation | 57 see Appendix 2 |
| | Income from low-impact agricultural activities | 58 see Appendix 2 |
| | Public environmental education | 59 see Appendix 2 |
| | Water treatment cost/avoided costs | 55 |
| | Crop failure risk | 60 |
| | Water infrastructure, pollution sources | 61 |
| | Regulatory: Water abstraction permits, agricultural irrigation regulations | 62 |

| Objectives | Potential Indicators: Human Well-being | Measurements |
|---|---|---|
| Improvement in people's well-being | Balanced water supply and demand | 61 |
| | Water security | 63 see Appendix 2 |
| | Recreational use | see Appendix 2 |
| | Aesthetics | see Appendix 2 |
| | Food security | see Appendix 2 |
| | Job oportunities | see Appendix 2 |

The results chain in Figure 3 is a linear representation of the theory of change, which describes the sequence of events that will generate changes over time. This simple diagram shows the linkages between inputs and impacts, and can be useful to define the appropriate indicators for different phases of a project. Figure 3 also provides a series of questions applicable for each phase of a project to help in the selection of indicators for different aspects and phases of a project.

**Figure 3.** Result chain with performance indicators for different phases of the project.





As a rule, the selected KPIs should align with the different phases of a project. Initially, a project is typically evaluated for implementation efficiency and, later, for the effects and impacts of activities implemented. The implementation phase is usually assessed using **input and activity** indicators (Figure 3), while the measurable effects are primarily assessed using **outcome** indicators, as well as **output** indicators in the short-term. Also, input indicators can be compared against output indicators to assess the cost-effectiveness of a project. The broad project goals (i.e., the impact of the project on people's lives or the environment) are assessed using **impact indicators.**

As in Figure 3 above, indicators that monitor the implementation phase (left dark blue box) of the project are indispensable to track critical steps that ensure that the project will be successful. Indicators that assess results (middle blue box) are important for determining the short-term measurable results and whether outputs lead to the intend outcomes. Finally, impact indicators (right light blue box) are essential to determine whether the project produced desired broad long-term changes.

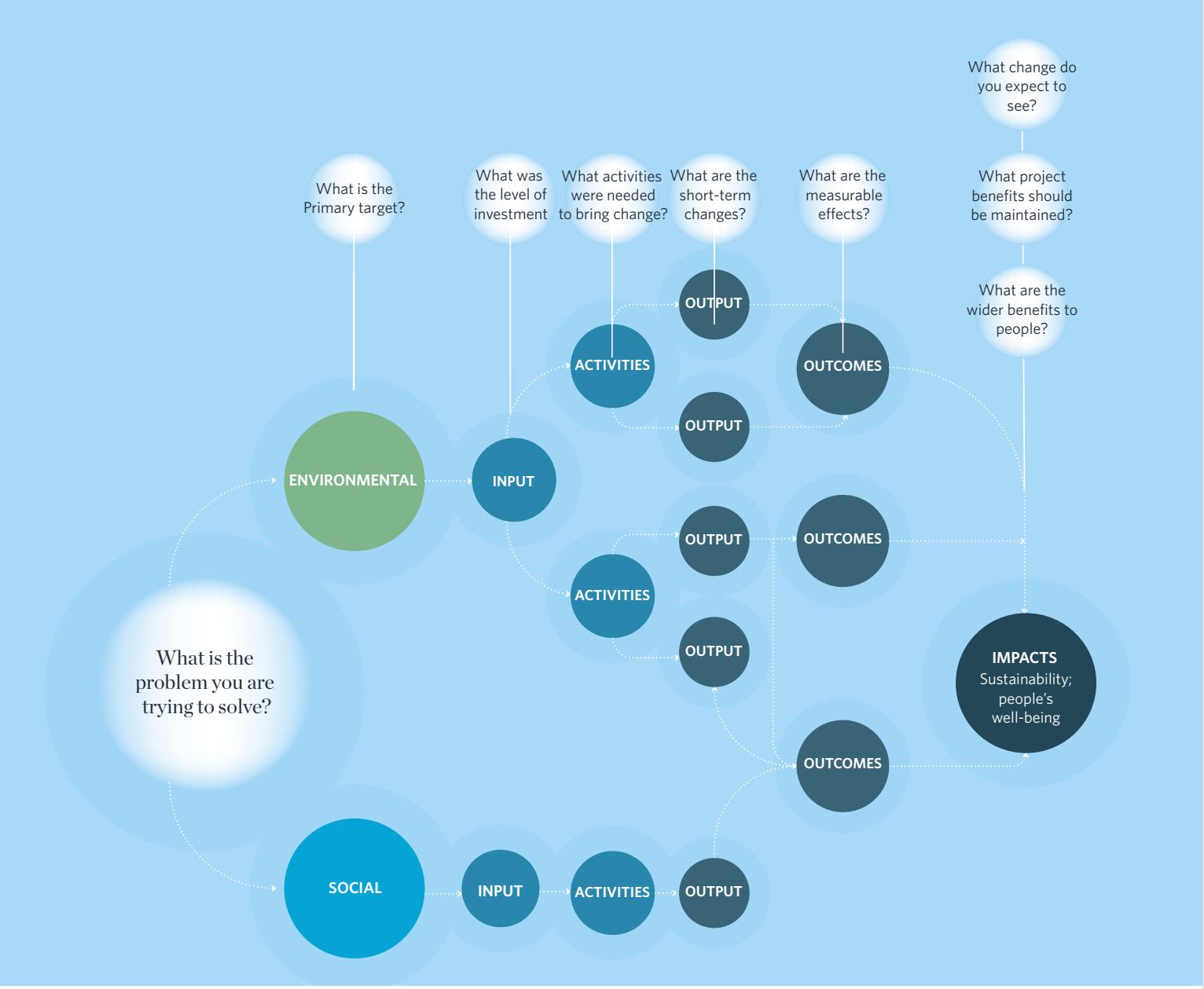



**Figure 4.** Flow chart illustrating how different types of indicators can be used to assess different levels and phases of a watershed project **(indicators defined in Glossary)**.

A strong monitoring and evaluation program is not characterized by the number of indicators it tracks but rather by the relevance of indicators included. Ideally, a monitoring and evaluation program will have a mix of different types of indicators that meet varying needs of stakeholders and managers. The final selection of KPIs should be decided with the input of project partners in addition to that of experts.

Table 4 provides a comprehensive list of indicator options that can be used to assess the success of projects from the implementation phase to impacts. The list can serve as a menu of options to choose from to evaluate environmental and socioeconomic aspects of watershed projects. Again, the ultimate selection of KPIs should follow the criteria described above, while considering the needs of individual projects and stakeholders.

**Table 4.** Examples of indicators associated with typical actions and goals of corporate projects in watersheds facing high water stress (including outcome and impact indicators).

| What is the problem you are trying to solve? | | | What is the primary environmental target? (Long-Term Goal from Table 2) | Environmental Performance Metrics: Input/Activities | Outputs | Outcomes | Impact |
|---|---|---|---|---|---|---|---|
| Environmental Indicators | Water availability | Limits and variability on water availability; seasonal changes; floods/drought | Mimic natural processes to enhance water availability (e.g., water infiltration, retention and storage in aquifers, groundwater recharge, baseflow in streams | Investment in nature-based solutions | Restoration of natural forests, reforest critical areas, areas cleared of invasive plants | **Surface water quantity:** | Measured change in annual or average daily baseflow levels |
| | | | | | | Annual or daily average discharge in stream/river (m^3/s; L/s) | Reduced streamflow variability |
| | | | | Ecosystem restoration; planting of trees, reforestation; removal of invasive plants | | Surface runoff (mm/yr) (modeled) | Measured change in % annual water flow extracted (separated as consumptive & non-consumptive) – as a measure of limits to growth |
| | | | Increase water storage and residence time in watershed | | | Baseflow levels (average annual L/yr); % contribution of baseflow or stormflow to total stream flow | |
| | | | | | | Water storage in wetlands - annual average (m3/yr) | Health of streams and rivers (stream metabolism) |
| | | | | | | **Hydrologic regime:** | Measured change in aquatic biodiversity, habitat |
| | | | | | | Streamflow flashiness; magnitude of peak flows, flood frequency, ratio of storm runoff volume to precipitation, mean duration of floods, frequency of floods and days of no flow, or below-average flows (d/yr) | |
| | | | | | | **Groundwater:** | |
| | | | | | | Groundwater recharge (modeled); Groundwater level | |
| | | | | | | Water infiltration rate (cm/hr), soil water holding capacity (mm/m) | |
| | | | Increase water storage in aquifers | Financial support or other incentives for farmers to change agricultural practice or reduce irrigation water use | Time spent engaged with farmers to inform about or promote alternative sustainable practices (person-hours) | Estimated (modeled) water saved or returned to the system | Measured reduction in frequency of floods |
| | | | | | | Groundwater recharge | Groundwater levels not reducing or slower decline |
| | | | | | # of farmers enrolled | Average baseflow in streams and rivers (L/s) | |
| | | | | | # of farmers committing to making changes | Groundwater level (m) | |
| | | | | | # of farms with agroforestry or improved irrigation plans | Water infiltration rates (mm/m) | |
| | | | | | | Streamflow variability (days of no flow, or below-average flows (d/yr) | |
| | | | | | % critical area with agroforestry | | |
| | | | | | # of ha with improved irrigation | | |

| What is the problem you are trying to solve? | | | What is the primary environmental target? (Long-Term Goal from Table 2) | Environmental Performance Metrics | | | |
|---|---|---|---|---|---|---|---|
| | | | | Input/Activities | Outputs | Outcomes | Impact |
| Environmental Indicators | Water availability | Growing demand from agriculture, industry and population | Improve water distribution and access in watershed | Engagement with regulators and policy makers<br>Engagement with technical staff that can develop simple effective technology | # of meetings held with responsible entities<br>$ spent on repairs<br># of institutions engaged (addresses whether you are engaging all interested parties)<br># of monitoring metrics shared with local institutions<br># of failing infrastructure repaired<br># of programs initiated to fill institutional/ governance gaps | Estimate of water saved (liters); modeled<br>Water saved (liters); measured | Measurable improvement in water infrastructure |
| | | | Reduce water consumption and improve water-use efficiency | Engagement with regulators and policy makers<br>Engagement with technical staff that can develop simple effective technology<br>Education to promote behavioral changes | Time spent engaged with technical staff and end users to develop simple & effective technology or behavioral changes (person-hours)<br># of water rights awarded/retired<br># of users committing to making changes<br># of boreholes registered<br># of illegal abstraction points<br># of users adopting technology or changing behavior | Estimated (modeled) change in water use from illegal abstraction<br>Change in % annual water flow extracted<br>Measured change in groundwater levels near points of water abstraction | Measured change in view of illegal abstraction by users<br>Reduced consumption |
| | | | Improve water allocation in watershed or perception of fair allocation among users | Engagement with regulators and policy makers<br>Education to promote behavioral changes | $ spent supporting supply chain partners<br># of volunteer hours to support implementing community projects | Per capita residential water use (v. low and v. high use undesirable, so positive direction for metric may depend on location)<br>Total water use by economic sector | Measured change in trends in water supply or demand from management efforts<br>Measured water use efficiency by urban and industrial sectors (e.g., liters per unit output or per production value) |

| | | What is the problem you are trying to solve? | What is the primary environmental target? (Long-Term Goal from Table 2) | Environmental Performance Metrics | | | |
|---|---|---|---|---|---|---|---|
| | | | | Input/Activities | Outputs | Outcomes | Impact |
| Environmental Indicators | Water availability | Growing demand from agriculture, industry and population | Implement BMPs to reduce water loss in irrigation<br>Improve water use efficiency in agriculture | Engagement with farmers<br>Engagement with technical staff that can help inform farmers about sustainable options<br>Engagement with technical staff that can develop simple effective technology to reduce water loss in irrigation | Engagement with technical staff that can develop simple effective technology to reduce water loss in irrigation<br># of farmers educated about water efficiency options<br># of farmers enrolled in program | Total volume of water used for irrigation ($m^3$); measured or modeled<br>Modeled amount of water lost (not incorporated in crops)<br>% agricultural land with sufficient water for production<br>Measured water use efficiency by agricultural sector (e.g., liters per production value)<br>Measured reduction in water loss (observed data) | Measured change in annual water flow extracted (consumptive & non-consumptive use) (liters) |
| Environmental Indicators | Water quality | Non-point sources of water pollution | Reduce transport of sediment and pollutants from the watershed to water courses<br>Improve water quality of streams and rivers | Planting of forest, reforestation<br>Fencing and restoration of riparian buffers<br>Restoration of streams, wetland and floodplains | Area of forest restoration and reforestation (ha) or % cover<br># of forest restoration and reforestation projects implemented<br>Area of restored wetlands and floodplains (ha)<br>% change in area of floodplain, wetland, or forest recharge area<br>Deforestation rate; % natural vegetation area in water recharge zones<br>Rate of retention/loss of pollutants in riparian buffers | Observed concentrations of pollutants in streamflow (mg/L)<br>Pollutant loads (modeled)<br>Water electrical conductivity<br>Water turbidity<br># point sources of pollution eliminated<br>Abundance of macro-invertebrates and fish<br>Sediment export in streams (tons/yr) | Measured increase in natural vegetation cover<br>Measured reduction in pollutant loads to water courses<br>Measured improvement in aquatic habitat conditions and aquatic biodiversity |
| | | | Improve water quality in agricultural drainage areas | Engagement with farmers<br>Educational meetings to promote implementation of new agricultural practices | # of farms with new BMPs<br># of meetings with farmers<br>% of catchments with comprehensive resource plans | Concentrations and loads of suspended sediments and nutrients (mg/L)<br>Modeled loads of sediment and nutrient to streams and rivers<br>Water turbidity in streamflow | Measured reduction in sediment loads in water courses<br>Reduced water treatment costs |

| What is the problem you are trying to solve? | | | What is the primary environmental target? (Long-Term Goal from Table 2) | Environmental Performance Metrics | | | |
|---|---|---|---|---|---|---|---|
| | | | | Input/Activities | Outputs | Outcomes | Impact |
| Environmental Indicators | Water quality | Non-point sources of water pollution | Reduce risk of high-severity wildfires and negative impacts to water sources | Prescribed fire and mechanical treatment | Acres of fuels reduction and forest restoration | Sediment loads delivered to streams and avoided sediment in water supplies (metric tons) – measured | Measured reduction in sediment removal costs to water supplies (dollars) |
| | | | | Forest restoration | Acres of active crown fire reduced | | Measured improvement in condition of aquatic ecosystems |
| | | | Prevent water quality degradation from forest wildfires | | | Sediment loads delivered to streams and avoided sediment in water supplies (metric tons) – modeled | |
| | | Point sources of water pollution | Improve quality of surface waters | Engagement with regulators and policy makers | # of point sources eliminated upstream | Volume of waste water treated (measured) | Elimination of point sources of pollution upstream |
| | | | | Meetings with responsible entities | # of waste water treatment projects implemented | Volume of waste water treated (modeled) | Measured reduction in organic matter content and nutrient loads in streams and rivers |
| | | | | Investment in waste water treatment projects | # of meetings held with responsible entities | Concentration of dissolved organic matter and dissolved oxygen (mg/L) | Measured reduction in water quality treatment costs |
| | | | | Meetings with stakeholders | $ spent on waste water treatment projects | Water turbidity in streamflow | Measured improvement in condition of aquatic ecosystems |
| | | | | Engagement with relevant institutions | # of stakeholders engaged (meeting attendance) | Primary production in water column | |
| | | | | | # of institutions engaged (addresses whether you are engaging all interested parties) | | |

| What is the problem you are trying to solve? | | | What is the primary environmental target? (Long-Term Goal from Table 2) | Socioeconomic Performance Metrics: Input/Activities | Outputs | Outcomes | Impact |
|---|---|---|---|---|---|---|---|
| Socioeconomic indicators | Water availability | Declining water availability and increasing variability | Reduce domestic water supply risk | Hours spent identifying the distribution and severity of drinking water risk | % people at risk who are potentially positively affected by restoration project(s) | Number of people or communities with greater access to water than in previous year (days/year) | Improved well being due to less time spent gathering and storing water |
| | | | Reduce industry water supply risk | Effort (money, person-hours) spent increasing efficiency of water use | Change in % annual water flow extracted (separated into consumptive & non-consumptive) | Number of days that businesses had to decrease or cease production due to water supply problems | Improved business climate and more secure job opportunities |
| | | | | Effort spent developing alternative water sources | Change in % water extraction during low flow periods (e.g., dry season) | Lost profits due to water supply problems (incorporates capacity to adapt to low flow days) | |
| | | | Reduce agricultural water supply risk | Effort (money, person-hours) in educating farmers about alternative practices to reduce water use or dependence | # of farmers (or ha) converting to water efficient technologies or practices | Value of agricultural yield ($/ha ) | Improved well being of agricultural producers |
| | | | | | Adopting high efficiency irrigation technologies / practices | Water consumptive use in agriculture (liters/year) | Lower risk of crop failure |
| | | | | | Converting to low water demand crops | | Improved well being of agricultural communities |
| | | | | | % critical area with agroforestry | | |
| | | | | | Area of cropland converted to agroforestry (ha) | | |
| | | Growing demand from agriculture, industry and population | Improve water distribution and access in watershed by all users | # of meetings held with responsible entities | # of boreholes registered | Change in water flow in areas affected by illegal abstraction (monitoring + modeling) | Reduced illegal appropriation of water |
| | | | Increase enforcement | $ spent in enforcement | # of illegal abstraction points (trends) | % of people who think it is acceptable to drill illegal wells | |
| | | | Change social acceptance of theft | $ spent offering economic incentives to register wells | # of people provided with incentives not to steal water | | |
| | | | | # of person-hours spent changing attitudes (education, behavioral techniques) | # of reports of water theft | | |

| | | What is the problem you are trying to solve? | What is the primary environmental target? (Long-Term Goal from Table 2) | Socioeconomic Performance Metrics | | | |
|---|---|---|---|---|---|---|---|
| | | | | Input/Activities | Outputs | Outcomes | Impact |
| Socioeconomic indicators | Water availability | Growing demand from agriculture, industry and population | Redistribute water rights | # of meetings held with responsible entities (regulators, policy makers)<br>$ spent supporting supply chain partners<br># of person-hours spent meeting with cross-section of stakeholders<br># of institutions engaged<br># of people provided with education on how water rights are allocated | # of programs initiated to fill institutional / governance gaps<br># of water rights awarded/retired | Water users with well-defined water rights (consumptive use is allocated and limits are enforced) (%)<br>Water prices by economic sector are consistent with marginal value of production and equity concerns<br>% of interested parties who feel water allocation is conducted fairly | Improved perception of fair allocation among users |
| Socioeconomic indicators | Water qualityy | Non-point sources of water pollution | Reduce transport of sediment and pollutants from the watershed to water courses<br>Improve water quality of streams and rivers | $ and person-hours spent fencing and restoring riparian buffers | Area of forest restoration and reforestation (ha) or % cover<br># of forest restoration and reforestation projects implemented<br>Area of restored wetlands and floodplains (ha)<br>% change in area of floodplain, wetland, or forest recharge area<br>Deforestation rate; % natural vegetation area in water recharge zones<br>Catchments with comprehensive resource plans (%) | Total retention/loss of pollutants in riparian buffers (modeled)<br>Ambient water quality metrics (trends)<br>Reduced water treatment costs | Improved water quality for all users and improved aesthetics of water bodies |
| | | | Improve water quality in agricultural drainage areas | $ spent offering economic incentives to adopt BMPs<br>Person-hours spent engaging farmers<br>Person-hours spent engaging policy makers | # of farms (or ha) adopting BMPs<br># of farmers with nutrient or sediment management plans<br>% of farms required to manage nutrients in policy or regulations<br># of farmers attending educational meetings / events on agricultural nutrient and sediment management practices<br>Fertilizer sales<br>% of manure applied at agronomic rates (not overapplied because of local animal production)<br>Km of stream with animal exclusion devices | Total retention/loss of pollutants in practices (modeled)<br>Ambient water quality metrics (trends)<br>Reduced water treatment costs | Improved concepts of water quality stewardship among farmers<br>Improvements in stream safety |

| What is the problem you are trying to solve? | | | What is the primary environmental target? (Long-Term Goal from Table 2) | Socioeconomic Performance Metrics | | | |
|---|---|---|---|---|---|---|---|
| | | | | Input/Activities | Outputs | Outcomes | Impact |
| Socioeconomic indicators | Water qualityy | Non-point sources of water pollution | Improve water quality of urban streams and rivers with green and gray infrastructure | Monetary investment in stormwater projects<br>Person-hours spent in engagement with stakeholders and watershed managers | % of urban areas draining into stormwater BMPs<br># of urban BMP projects implemented | Ambient water quality metrics (trends)<br>Reduced water treatment costs | Improved water quality for all users (including local ecosystems) and improved aesthetics of water bodies |
| | | | Reduce risk of high-severity wildfires and negative impacts to water sources<br>Prevent water quality degradation from forest wildfires | Monetary investments in fire prevention<br>Person-hours spent on outreach | Acres of fuels reduction and forest restoration<br># of institutions offering training or other resources | Ambient water quality metrics (trends)<br>Reduced water treatment costs<br>Acres of active crown fire reduced | Reduced social and economic disruption |
| | | Point sources of water pollution | Improve quality of surface waters | # of meetings held with responsible entities<br>$ spent on waste water treatment projects<br>$ or person-hours spent on stakeholder engagement | Concentration and load from points sources<br># of facilities reducing loads through management outside of technological upgrades<br># of waste water treatment projects implemented<br># of stakeholders engaged (meeting attendance)<br># of institutions engaged (addresses whether you are engaging all interested parties) | Ambient water quality metrics (trends)<br>Reduced water treatment costs | Ambient water quality metrics (trends) |

## Step 3. Planning data collection


After the KPIs and associated metrics are selected, reviewed by partners and other key stakeholders and confirmed for relevance, the next step is to determine how to measure progress, the expected changes and impacts.

As an initial step to ensure that the necessary data are collected and that they are consistent and representative of the project goals and monitoring objectives, it is important to know:

- The background information about the targeted watershed and individual project sites.
- After how much time are measurable changes expected to occur at different geographic locations in the watershed.
- The types of actions implemented, such as green or gray infrastructure, policy or regulatory change, tactical engagement or sponsorship, reform of agricultural practices, public-private collective action, etc.
- The availability of resources (human and financial) to conduct monitoring activities and for expert or technical assistance.

Other factors to consider for data collection plans include:

- Are there partners to help implement and conduct a monitoring program?
- Are baseline data already available?
- Who will use the information generated?

### Developing a strategy to maximize effectiveness and minimize cost

A strategic monitoring plan focuses on the most important expected outcome(s) at the most desirable scale. The data collected should serve a specific purpose, and the scale and frequency of sampling optimized to provide the most information at the lowest effort and cost possible.

To develop a well strategized monitoring plan, it is important to have a good understanding of the extent of the problem that the project is trying to solve, knowledge of where and when interventions or activities have been implemented in the watershed, the frequency of which the problem occurs and whether or not there are lag-times associated with the expected changes. The stability of baseline conditions is also an important consideration. The following questions will help guide the development of an effective monitoring plan:

- What is the extent of the problem(s)?
- Are baseline conditions changing?
- What are the types and spatial distribution of interventions implemented in the watershed?

- What are the expected results? What is the range of target values anticipated?
- What are the expected lag times for the results? Where are the results expected to occur?

In essence, these questions are formulated to help discover the optimal spatial (geographical area) and temporal (time-based) scales for monitoring water quantity and/or quality in the watershed. The process should involve inputs from stakeholders as well as the company, based on the scale and precision of the information that they need.

Ideally, monitoring should combine both:

**LOCAL AND LARGE SCALE APPROACHES**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## Determining appropriate spatial scale

The spatial scale of watershed monitoring can vary from a single site or specific area to the entire watershed. Monitoring at the local scale should be used to measure the effectiveness of a specific activity, while monitoring at larger scales should be used to capture the cumulative effects of multiple actions and interventions implemented in the watershed or sub-catchment areas. For example, monitoring may occur in a tributary stream to determine the effectiveness of a riparian buffer implemented just upstream of the monitoring point, but could also occur at the outlet of the main river to account for the overall impacts of a suite of activities, which include riparian buffers but also agricultural best management practices elsewhere in the river's watershed.

As outlined visually in Figure 5 below, individual interventions are typically monitored when the outcomes are uncertain, at least in the region, and for the purpose of model development and validation. Local-scale monitoring is also useful when interventions are spatially concentrated or when a long lag time is expected for the impacts to be quantifiable at the whole watershed scale. In contrast, watershed or catchment-scale monitoring is typically used when multiple interventions are dispersed throughout the entire watershed and the potential effectiveness of all of the interventions implemented is well known or easy to predict. Watershed-scale monitoring is also used when resources are scarce or access to the watershed is difficult, although these should not be the only deciding factors.

Ideally, monitoring should combine both local and large scales; local scale for interventions that are expensive or have uncertain outcomes, and large scale to capture the overall impact of the entire watershed project. If time, resources, or other issues prevent monitoring of individual or clustered projects, then measuring project outputs may be a reasonable option and can be used to estimate or model outcomes. For instance, measuring the number of acres of new groundwater recharge zone implemented in the watershed can help predict changes in groundwater recharge as a consequence of project implementation. However, monitoring outputs alone will only provide indirect evidence of actual impacts.

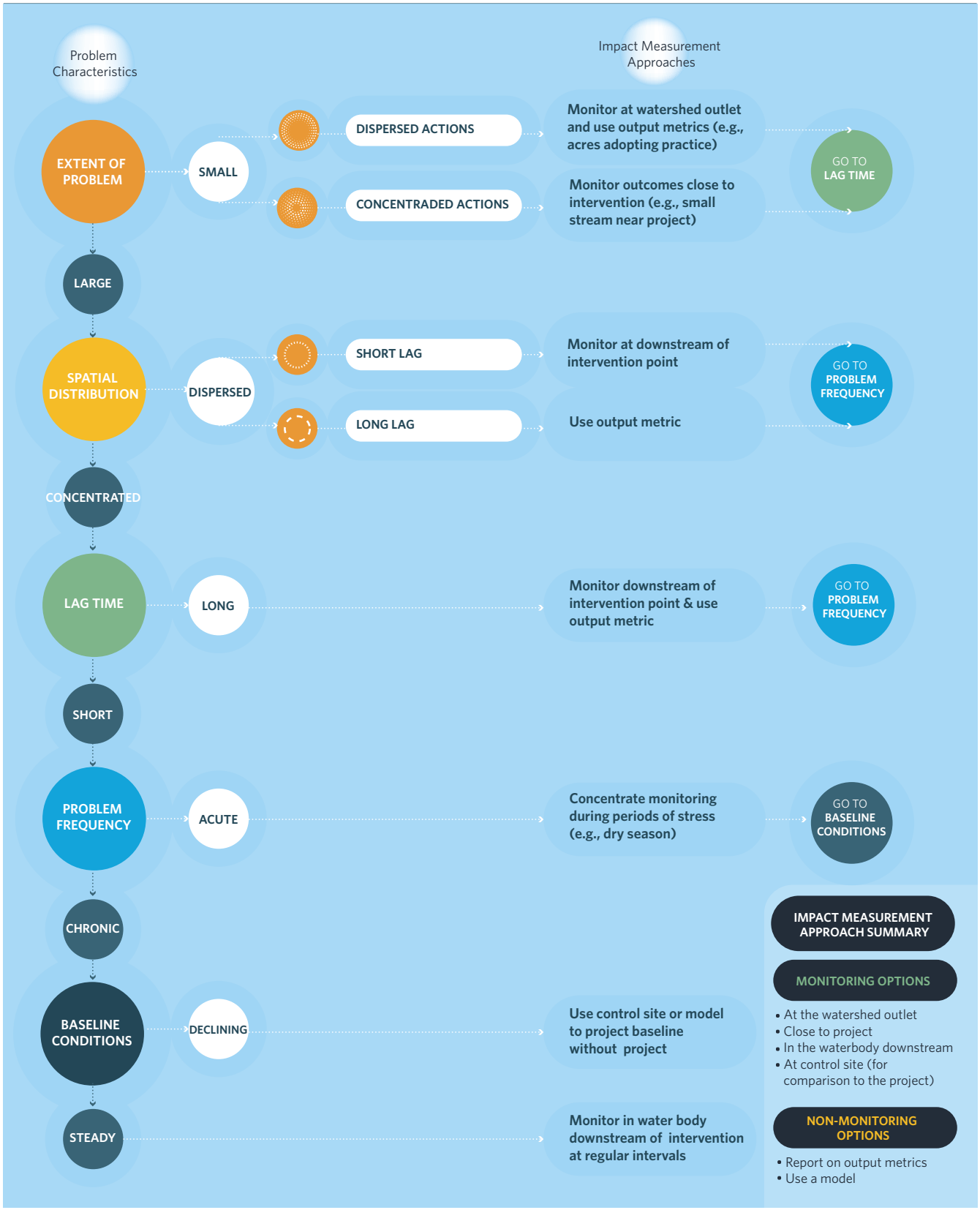
## Determining appropriate time scale

Like spatial scale, the time scale or frequency of sampling can also vary depending on several factors. Key considerations include type and size of the water body being monitored, the anticipated time frame of impacts or expected changes, and the availability of resources for

monitoring. Sampling can be more frequent or concentrated if the project is trying to address acute problems or stressful periods. Sampling can be less frequent but should be regular, continuous and for a longer period when the objective of the project is to resolve a chronic problem or when the lag time between implementation of actions and expected results is long.

The flow chart below (Figure 5) provides a visual representation of issues commonly considered in strategic monitoring and the choices that need to be made:

**Figure 5.** Decision tree flow chart to develop a strategic plan to maximize effectiveness and minimize cost of field monitoring.



## Defining methodologies and experimental designs

Data should be collected with proven approaches. The TNC Water Funds Primer **(click here)** provides detailed information about field sampling methodologies and experimental designs recommended for monitoring watershed projects. It includes information on how to select the most appropriate design for different projects as well as the best methodologies for water quantity and quality monitoring. Ultimately, however, the design should be decided with the input from project partners as well as from the company.

The "gold standard" approaches recommended for a project partner to use for watershed monitoring are the BACI (Before/After/Control/Impact) and BACRI (Before, After, Control, Reference, Impact) approaches. These approaches are particularly robust because they allow for inferences about causation: that is, is the observed change primarily attributable to project interventions? By utilizing areas for comparison (i.e. control and reference watersheds) and monitoring changes over time, these study designs enable evaluation of the project intervention effects specifically—as distinct from other watershed activities or changes which may cause similar effects. Alternative study designs without comparison watersheds are possible but they suggest association rather than causation: that is, does the observed change coincide with project interventions? Project partners, in collaboration with experts, should make study design decisions explicitly, recognizing that different design choices provide different levels of evidence about those effects specifically attributable to project interventions.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## Step 4. Analyzing & evaluating

### Monitoring Data Analysis

The information produced through monitoring can provide valuable insights into whether the project is delivering on objectives, or heading in a positive direction, through the comparison of baseline conditions or model predictions against estimates of measured responses. It is important to understand that, given the complexity of environmental processes within watersheds, there might be many factors influencing the measured changes. Our confidence in project interventions as the primary driver of the measured outcomes increases as the amount of unexplained variability in the observed data decreases.

Some of this unexplained variability can be accounted for by selecting a robust study design (see above discussion on BACI/BACRI). Other aspects of variability depend upon the specific context of a given watershed. For example, some watersheds exhibit large changes in hydrologic parameters (e.g. flow or discharge) between years, irrespective of human activities. The study design, along with sampling frequency and duration, are key determinants of the preferred analytical approach for a given set of watershed monitoring data. While decisions on specific analytical approaches are determined by the monitoring partner, project funders should ensure that appropriate expertise is secured to ensure valid statistical interpretation of the collected monitoring data. Watershed monitoring data represents a significant intellectual asset, but leveraging this asset requires careful analytical consideration to deliver the "last mile" of monitoring results.

Watershed monitoring data represents a **SIGNIFICANT INTELLECTUAL ASSET,** but leveraging this asset requires careful analytical consideration

### Project Evaluation

Evaluation is the systematic and objective assessment of an on-going or completed project. The purpose of project evaluation is to:

- determine the fulfillment of broad and specific project goals,
- determine the impacts of changes that have occurred,
- analyze the implementation process,
- identify problems and constraints that have been encountered,
- use the results to update knowledge and adjust management actions, and
- inform future watershed investment and project selection decisions.

The evaluation should start with a review of the project goals and the KPIs developed to evaluate the

**EFFICIENCY, EFFECTIVENESS AND IMPACT**

of the project

Every monitoring and evaluation plan should include designated moments for evaluation in order to review the information generated and decide whether to make any changes in the program or stay the course. The evaluation should start with a review of the project goals and the KPIs developed to evaluate the **efficiency, effectiveness, impact** and, in some cases, the sustainability or longevity of the project.

The **efficiency** of a project is usually determined by whether or not the tasks and deliverables outlined for the project implementation phase were accomplished within the expected timeline and budget. Efficiency can be also determined by the relationship between the input of resources (inputs or activities) and the outputs and outcomes. For that, it is important to review the plans, tasks, and deliverables outlined for the various activities of the project, and the timeline and costs estimated to accomplish them. Ideally, the information gathered during the implementation phase is evaluated on a regular basis. The results of this evaluation inform mid-course corrections to program implementation and shed light on implementation processes, including the process by which partnerships are created and maintained.

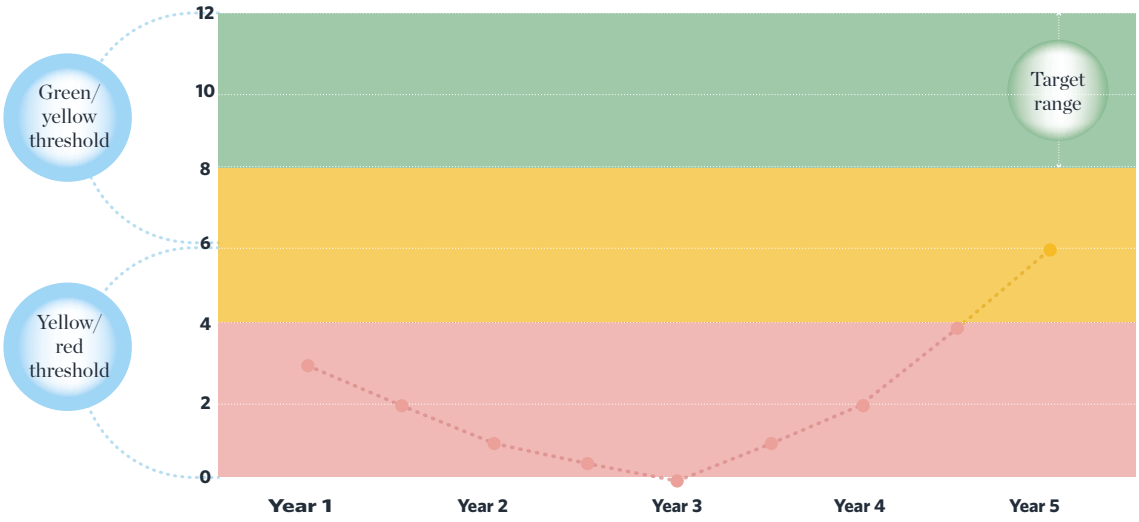
The **effectiveness** of the project is generally determined by the extent to which the activities or interventions implemented have achieved their objectives, taking into account their relative importance. Project effectiveness is typically determined by progress towards the outcomes. Questions that can be used to assess project effectiveness include:

- Have the goals of the intervention(s) been achieved?
- How do the results of the project compare to the objectives (comparing planned versus result)?

With respect to evaluating project **efficiency** and **effectiveness**, specific determinations depend on the size of changes observed for water quality and/or quantity in the watershed. While monitoring data provides evidence of observed changes, the significance of any observed change cannot only be based on statistical tests; even if a change is observed through monitoring, those involved in the project must determine if that observed change is socially meaningful as well.

A useful concept is the application of target ranges and threshold values—developed from monitoring and/or modelling data or the scientific literature, or from goals set in the watershed management plan. The values used should be relevant to the water related feature monitored (e.g., stream flow, groundwater level, water quality, etc.), but thresholds can be either quantitative (Figure 6) or qualitative (i.e. set without the use of numerical targets). Such ranges or thresholds can further be connected to specific actions, thereby helping to close the adaptive management 'loop.' Setting thresholds can help you determine whether actions are moving the desired conditions in the right direction over time. In complex systems like watersheds, it may take some time for progress to move in the desired direction, but setting a threshold can help to communicate when significant progress has been made.

**Figure 6.** Example of quantitative threshold approach.

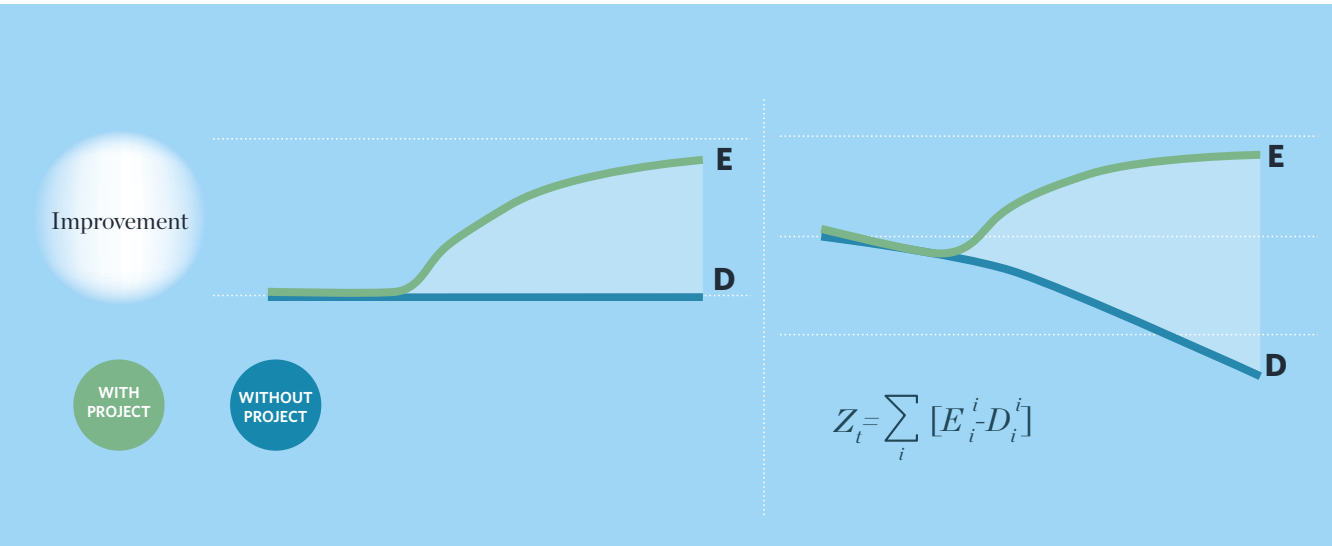



The **impact** of a project is determined by how conditions in the watershed have changed because of the project results. Changes can be positive or negative, intended or unintended, based on primary or secondary project goals, and a direct or indirect result of interventions. Questions to help assess project impact include:

- What has happened as a result of the project?
- What difference has the project made to the environment or people?
- Does the project contribute to the achievement of sustainable use of water resources?
- Are people living in the watershed better off because of the project?
- What are the effects of the interventions compared to the situation before or in a similar watershed?

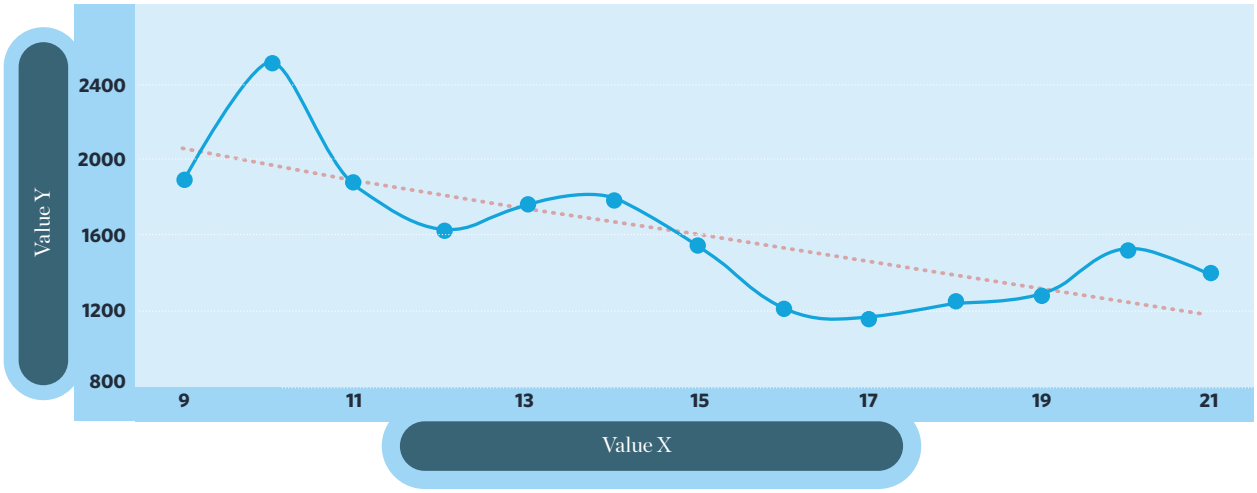
Furthermore, to help assess project impact, data should be compared to baseline profiles and should be checked for any trends. Baseline profiles should be developed before the actual implementation of interventions so as to serve as a benchmark for examining what change is triggered by the intervention. A baseline can be fixed or moving. One example of a moving baseline is in the case of climate change, where a factor outside of the control of the project would influence water-related measures with or without the project. Even if a baseline is moving, it is critical to quantify change, as illustrated in Figure 7.

**Figure 7.** Demonstration of change in comparison to fixed and declining baseline conditions.



In addition to comparing outcomes to baseline profiles, impact analysis should identify any trends in the data over time (Figure 8). There are various tools and methods to determine trends in data, including special statistical methods and trend analysis to predict what will happen in the future. However, even simple analyses of trend patterns can be highly informative to evaluate project progress for indicators with long lag times and time series collected over a long period.

**Figure 8.** Example of a declining trend pattern.




At any given time, knowledge gained from monitoring and evaluation is used to inform the selection of future actions. As more information becomes available and knowledge grows, so too is the decision making improved by greater understanding of the project. The iterative cycle of decision making, monitoring, and evaluation should gradually lead to improvements in the watershed project as scientists, managers and other stakeholders learn together how the socioenvironmental system works, so project goals can be achieved. For that, open and effective communication is key.

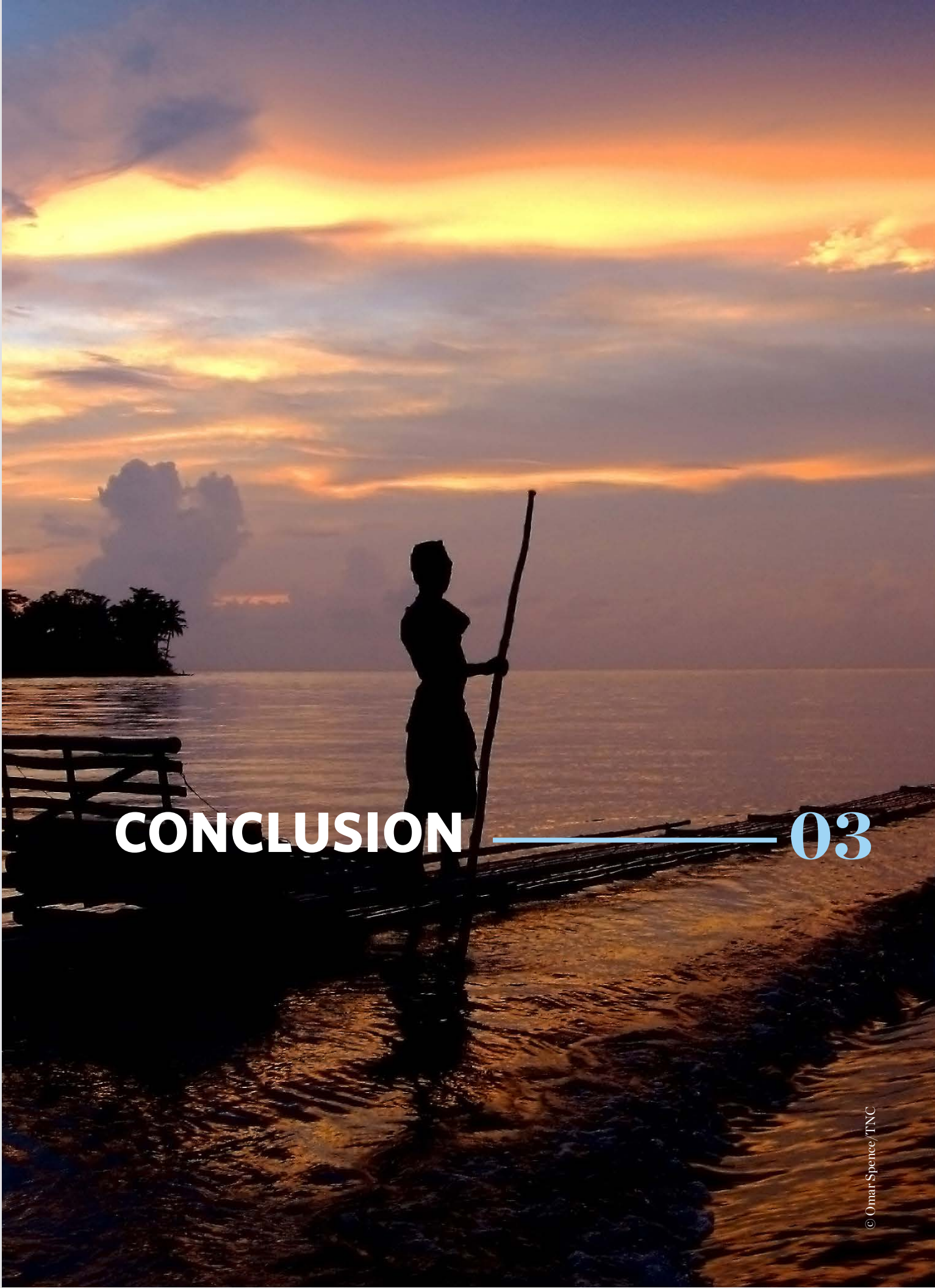

## Step 5. Reporting to stakeholders

Reporting and communicating results are a critical part of the monitoring and evaluation program. The main purposes for reporting and communicating results are accountability, transparency, tracking progress, and learning. Accountability and transparency are important to gain legitimacy and credibility for the project, among both internal and external stakeholders.

It is important to recognize that for communication to be effective, the message needs to be tailored to the needs and interest of the audience, such as why the water problem being addressed is relevant to them. Interactive approaches to communication, where audiences are able to ask questions and provide feedback, are most effective regardless of the audience.

The keys to successful and effective communication include: (1) being aware of the diversity of stakeholders of interest, (2) making sure that the organization or person delivering message is credible, (3) adapting information to the audience, (4) ensuring that key messages are based on solid information, and (5) remembering that interactive communication approaches are most engaging. Examples of communication tools include:

- **Summary sheets,** or research briefs or policy briefs. A shorter document is much more likely to be read than a long detailed report.
- **Findings tables.** While it may seem ineffective, presenting the raw findings can communicate your messages very strongly.
- **Scorecards** or dashboards are good tools used to communicate in real time and for decision making.
- **Interactive webpages** or web apps.
- **Photo story** including cartoons, photographs, and pictures.
- **Case studies** to showcase a project and its lessons learned, challenges and successes.
- **Infographics** to quickly communicate information or data visually rather.
- **Blogs** can be used in the process of evaluations as well as for discussing use.
- **Multimedia video report** to tell a story visually rather than through a traditional report.
- **Webinar** to share project outcomes and engage stakeholders.



# CONCLUSION 03

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# Conclusion

Monitoring and evaluation are essential to water stewardship. While monitoring and evaluation is a complex process, engaging the right partners and following the process outlined in this guide will help ensure progress is made in in the company's water stewardship journey. The critical pieces of an effective monitoring and evaluation framework include:

- **being clear from the start on the problem a project is trying to solve and what the project goals are,**
- **having a clear plan, and**
- **using data to inform the plan.**

By following the five steps laid out in this measurement and evaluation guide, practitioners will be able to work with partners to effectively set site-specific goals, measurable objectives, and monitoring plans for sites located in areas facing high water stress. In addition, a company will be able to make progress towards its overarching water stewardship goal(s) and promote environmental sustainability and community well-being by implementing this guide and its adaptive management framework. Lastly, the company should create opportunities for its teams to share lessons learned and success stories (like those provided in Appendix 3 and Appendix 4) so that they can learn from one another, deepen their understanding of measurement and evaluation, and continually make progress toward desired goals and impact.

# APPENDIX 1

# COMMON PARAMETERS FOR SELECTED BIOPHYSICAL AND SOCIAL INDICATORS

**Surface water availability**

1. **Stream discharge or volume** (mean annual or seasonal (L/s; m3/yr.; mm/yr.)) calculated by obtaining a continuous record of stage, making periodic discharge measurements, establishing and maintaining a relation between the stage and discharge, and applying the stage-discharge relation to the stage record to obtain a continuous record of stream discharge (USGS). Other useful link: **http://dnr.maryland.gov/streams/Documents/2015TFTrainingStreamDischarge.pdf** **(return to Table 3)**
2. **Flow velocity** (m/s; ft/s) **(return to Table 3)**
3. **Stage** (average or during base flow or stormflow conditions). It is the water level above some arbitrary point in the river and is commonly measured in cm or feet (cm, ft). **(return to Table 3)**
4. **Baseflow discharge** (mean annual or seasonal (L/s; m3/yr.; mm/yr.)) measured during dry weather conditions. **(return to Table 3)**
5. **Average annual 3-day minimum daily streamflow.** **(return to Table 3)**
6. **Baseflow recession constants** (Kb), used to characterize the interaction of groundwater and surface water systems. **(return to Table 3)**
7. **Baseflow to stormflow ratio** (dry to wet flow ratio). **(return to Table 3)**
8. **Droughts:** Days of no flow by measuring fraction of time that flow is absent or using historical data and probabilities of streamflow exceeding specific drought streamflow thresholds using maximum likelihood logistic regression (MLLR). Useful link: **https://www.usgs.gov/centers/va-wv-water/science/methods-estimating-drought-streamflow-probabilities-virginia-streams?qt-science_center_objects=0#qt-science_center_objects** **(return to Table 3)**
9. **Flood flow frequency** to predict the probability of occurrence of different magnitude floods. The method used by the United States Army Corps of Engineers (USACE) is recommended. It follows a flood frequency analysis method based on fitting a Log Pearson Type III (LP3) probability distribution to annual peak flow data. Many other sources detail the methods of fitting an LP3 distribution, including the interactive tutorial on the OSU Streamflow Evaluations for Watershed Restoration Planning and Design website. **(return to Table 3)**
10. **Flood duration** measured using the number of "high pulse" days when flow is greater than the 75th streamflow percentile. **(return to Table 3)**
11. **Peak flow frequency** using peak flow data and regression equations. **(return to Table 3)**
12. **Magnitude of peak flows** can be assessed using the average annual 1-day maximum daily streamflow (TNC toolkit) or channel geometry analyses. **(return to Table 3)**
13. **Runoff coefficient:** Changes in streamflow in response to precipitation. **(return to Table 3)**
14. **Flow variability** can be measured as fraction of time that daily mean streamflow exceeds the annual mean streamflow (TQ, mean). **(return to Table 3)**

15. **Channel dimensions:** Cross sections and longitudinal profile, aerial photography. (return to Table 3)

16. **Channel geomorphology.** (Useful link: https://www.epa.gov/hwp/examples-geomorphology-assessments-watershed-health) (return to Table 3)

17. **Characteristics of sediment in the channel** (Useful link: https://pubs.usgs.gov/wri/wri984052/pdf/wri98-4052.pdf). (return to Table 3)

18. **Channel erosion**, using a combination of cross sections and erosion pins to determine erosion rates (mm/yr.), sediment size analysis (e.g. mean bed material size (mm); bulk sediment density (kg/m3)) and sediment tracing to determine stream bed stability and sediment sources, and photogrammetry from multiple years to assess changes in channel width (m/yr.). (return to Table 3)
Other useful links for surface water hydrological changes: https://pubs.usgs.gov/wsp/wsp2175/wsp2175.pdf; https://www.usgs.gov/special-topic/water-science-school/science/how-streamflow-measured?qt-science_center_objects=0#qt-science_center_objects; https://pubs.usgs.gov/tm/04d02/pdf/TM4-D2-chap1.pdf

### Groundwater availability

19. **Change in groundwater storage, level and recharge** estimated through water-budget balance using models, measurement of regional-aquifer water levels in a carefully designed network of monitoring wells in the catchment combined with measurements or estimates of rainfall inputs; measurement of near-stream alluvial-aquifer water levels, near-stream vertical gradients, streamflow permanence, and aquifer-storage change measured with microgravity (useful link: https://pubs.usgs.gov/circ/circ1217/pdf/circular1217.pdf; https://new.azwater.gov/sites/default/files/sir20165114.pdf (return to Table 3)

20. **Spring and baseflow discharge** to stream channels. (return to Table 3)

21. **Soil infiltration rates in recharge zones, acres of protected or restored recharge zones (output indicators).**
Useful links: http://www.fao.org/3/S8684E/s8684e0a.htm; Other useful links: https://pubs.usgs.gov/tm/04d02/pdf/TM4-D2-chap1.pdf; https://www.nature.com/articles/s41598-018-31210-1 (return to Table 3)

### Water quality

22. The **Water Quality Index** (WQI) is used to assess and compare water quality more easily by combining several parameters into one score between 0 and 100. The higher the score the better the quality of water. The following water quality parameters are commonly included in WQI, but others can be used, depending on the region and objectives: Biochemical Oxygen Demand (BOD), dissolved oxygen (DO), fecal coliform, nitrate concentrations, pH, water temperature, total dissolved solids, total phosphorus, turbidity. (return to Table 3)

23. Pollutant concentrations in water or pollutant loads. **Concentration** is the mass of a pollutant in a defined volume of water (for example, milligrams of nitrate-nitrogen per liter, or PPM). Concentrations should be examined in relation to a water quality criteria developed to determine when the water has become unsafe for people and wildlife using the latest scientific knowledge. **Pollutant load** estimation requires accurate measurement of both pollutant concentration and water flow and careful calculation. Helpful link: https://www.epa.gov/sites/production/files/2016-05/documents/tech_notes_8_dec_2013_load.pdf
(return to Table 3)

24. **Dissolved oxygen** concentration (mg/L) can be measured with field probes or lab methods (Winkler method). **(return to Table 3)**

25. **Turbidity** is caused by particles and colored material in water and it can be measured indirectly relative to water clarity (using a Secchi disk), or directly with a turbidity instrument such as a turbidimeter or turbidity sensor and reported in turbidity units (e.g. NTU or FNU). **(return to Table 3)**

26. For **total suspended solids (TSS)**, the most common and accurate method to measure is by weight, where a water sample is filtered, dried, and weighed. This method is the most accurate but also more difficult and time-consuming. TSS can be also calculated from acoustic Doppler meter backscatter (method developed by the USGS) and, while this method is not as accurate as a weigh scale, it provides the opportunity for continuous suspended sediment measurements, just as turbidity sensors that allow for continuous turbidity measurements (**https://www.fondriest.com/environmental-measurements/measurements/measuring-water-quality/turbidity-sensors-meters-and-methods/**). **(return to Table 3)**

27. Particulate organic carbon (**organic matter**) is measured by determining mass lost upon combustion of a sample. In aqueous samples, this can be done by measuring the dry mass of a filter that had a known amount of water passed through it before and after it is subjected to combustion. **(return to Table 3)**

28. **Water electrical conductivity** measures dissolved ions (salts) and provides a bulk indication of water quality alteration that is easy to measure. **(return to Table 3)**

29. **Odor:** Certain odors, such as chemical, petroleum, decay, fecal matter, and "rotten egg" can indicate water quality problems. Assessing odor using analytical instrumentation to accurately identify and quantify the odor producing substance is quite expensive. Most public utilities utilize sensory panels to detect and determine a 'threshold odor number' (TON) or establish a category for the description of the contaminant in accordance with established procedures (useful link: **https://www.wqa.org/LinkClick.aspx?fileticket=UzyTWNS66UY%3D&portalid=0**).

    Other useful links: **https://new.azwater.gov/sites/default/files/sir20165114.pdf**; **https://pubs.usgs.gov/fs/fs-077-02/**; **(return to Table 3)**

**Aquatic habitat**

30. **Stream Condition:** Stream biomonitoring using macroinvertebrates or other assessments using biological indicators. **(return to Table 3)**

31. **Trophic state** of streams can be measured by assessing the whole system metabolism, in which productivity and respiration are measured and compared. Diurnal patterns of dissolved oxygen can be used to estimate both whole system primary production and whole system respiration. **(return to Table 3)**

32. **Trophic state** can be also appraised by the availability of N and P, the stoichiometry of N:P, and by the concentration of stream benthic chlorophyll (Dodds & Smith, 2017). **(return to Table 3)**

33. **Habitat:** ripple, run, pool composition is determined using longitudinal survey. (Useful link: **https://pubs.usgs.gov/wri/wri984052/pdf/wri98-4052.pdf**) **(return to Table 3)**

34. **Environmental flows:** Integrates the requirements for aquatic species and biologic processes in order to determine the optimally supportive flow regime **(return to Table 3)**

35. **Stream temperature:** Measured using data loggers or temperature probes. **(return to Table 3)**

36. **Organic matter composition:** Fluorometry, absorbance, mass spectrometry of water samples. **(return to Table 3)**

37. **Community structure and function:** Field surveys to assess abundance of key native species, native fish and macroinvertebrate communities. **(return to Table 3)**

38. **Stream functional capacity:** Field measurements and experimental assays to assess changes in stream metabolism, litterfall decomposition, nutrient uptake. **(return to Table 3)** Useful links: **https://www.epa.gov/sites/production/files/2015-08/documents/a_function_based_framework_for_stream_assessment_3.pdf**

39. **Biodiversity of aquatic organisms:** **(return to Table 3)**

40. **Health of aquatic ecosystems:** **(return to Table 3)**

Other useful links: UNISDR. (2013). From shared risk to shared value – the business case for disaster risk reduction. UN Office for Disaster Risk Reduction; **https://www.epa.gov/sites/production/files/2015-08/documents/flood_resilience_guide.pdf**

**Riparian habitat**

41. **Buffer condition:** Assess buffer integrity, width, contiguity using aerial photography, remote sensing, field surveys. **(return to Table 3)**

42. **Buffer area:** Estimate percent cover of natural vegetation using aerial photography, remote sensing imagery and GIS. **(return to Table 3)**

43. **Plantings cover and survival:** Field surveys and aerial photographs. **(return to Table 3)**

44. **Species diversity:** Field surveys. **(return to Table 3)**

**Watershed conditions**

45. **Changes in land use and land cover:** For example, forest area, imperviousness, estimated with field surveys, aerial photography, remote sensing image and GIS. **(return to Table 3)**

46. **Protected groundwater recharge areas:** Field surveys and satellite imagery, aerial photography, hydrological models to define recharge areas. **(return to Table 3)**

47. **Land management and % area or farms implemented with BMPs** by conducting assessments, identification, inspections using forms and checklists and visualization tools. Assess soil erosion using field measurements and models. Useful links: **http://www.fao.org/3/T0848E/T0848E00.htm**; **(return to Table 3)**

48. **Presence of natural infrastructure** using assessments, identification, inspections using forms and checklists. (return to Table 3)

49. **Regional coverage of sewage and water conveyance systems:** Field surveys, existing data collected by government agencies. (return to Table 3)

50. **Conditions of water infrastructure:** Field surveys, inspections, existing data collected by government agencies. (return to Table 3)

51. **Illegal water abstraction points:** Field surveys, inspections, existing data collected by government agencies, satellite imagery to track illegal activity. (return to Table 3)

52. **Point sources of pollution:** Field surveys, inspections, existing data collected by government agencies to assess reduction in the number of point sources, and biophysical outcomes through time (e.g., water quality and volume at remaining discharge points, especially from urban stormwater). Lost profits due to water supply problems (incorporates capacity to adapt to low flow days). (return to Table 3) (Useful links: https://www.epa.gov/water-research/visualizing-ecosystem-land-management-assessments-velma-model-20; https://www.epa.gov/nps/guidance-federal-land-management-chesapeake-bay-watershed).

**Socioeconomic conditions and governance**

53. **Water use efficiency by ag sector:** Includes a number of potential efficiency measures, including conveyance, application, and harvestable yield—in relation water abstracted volume. (return to Table 3)

54. **Water prices by economic sector:** Gather existing data on water prices and track changes. (return to Table 3)

55. **Cost reduction or avoidance with water treatment, risk of supply/business interruptions:** Use models and existing data collected by industry and government agencies. (return to Table 3)

56. **Company reputation:** Interviews and/or surveys tailored to the drivers and outcomes of interest. (return to Table 3)

57. **Perception of fair water allocation:** Interviews and/or surveys tailored to the drivers and outcomes of interest. (return to Table 3)

58. **Income from low-impact agricultural activities:** Use data collected by government agencies. (return to Table 3)

59. **Public environmental education:** Develop surveys tailored to assess level of environmental education; collect data such as number of people attending public education programs, seminars, receiving printed materials, etc. (return to Table 3)

60. **Crop failure risk:** Estimated based on crop models. Working with stakeholders to identify timing of risks is key to risk assessments. Climate change risks and adaptation capacity should be considered as well. Useful links: http://www.fao.org/3/t8166e/t8166e03.htm; https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5738966/ (return to Table 3)

61. **Pollution sources and water infrastructure conditions:** Determine sources to streams, number of point sources of pollution, quality of urban runoff discharged to rivers, estimating pollutant inputs from non-point sources (using models), data on improved water infrastructure. **(return to Table 3)**

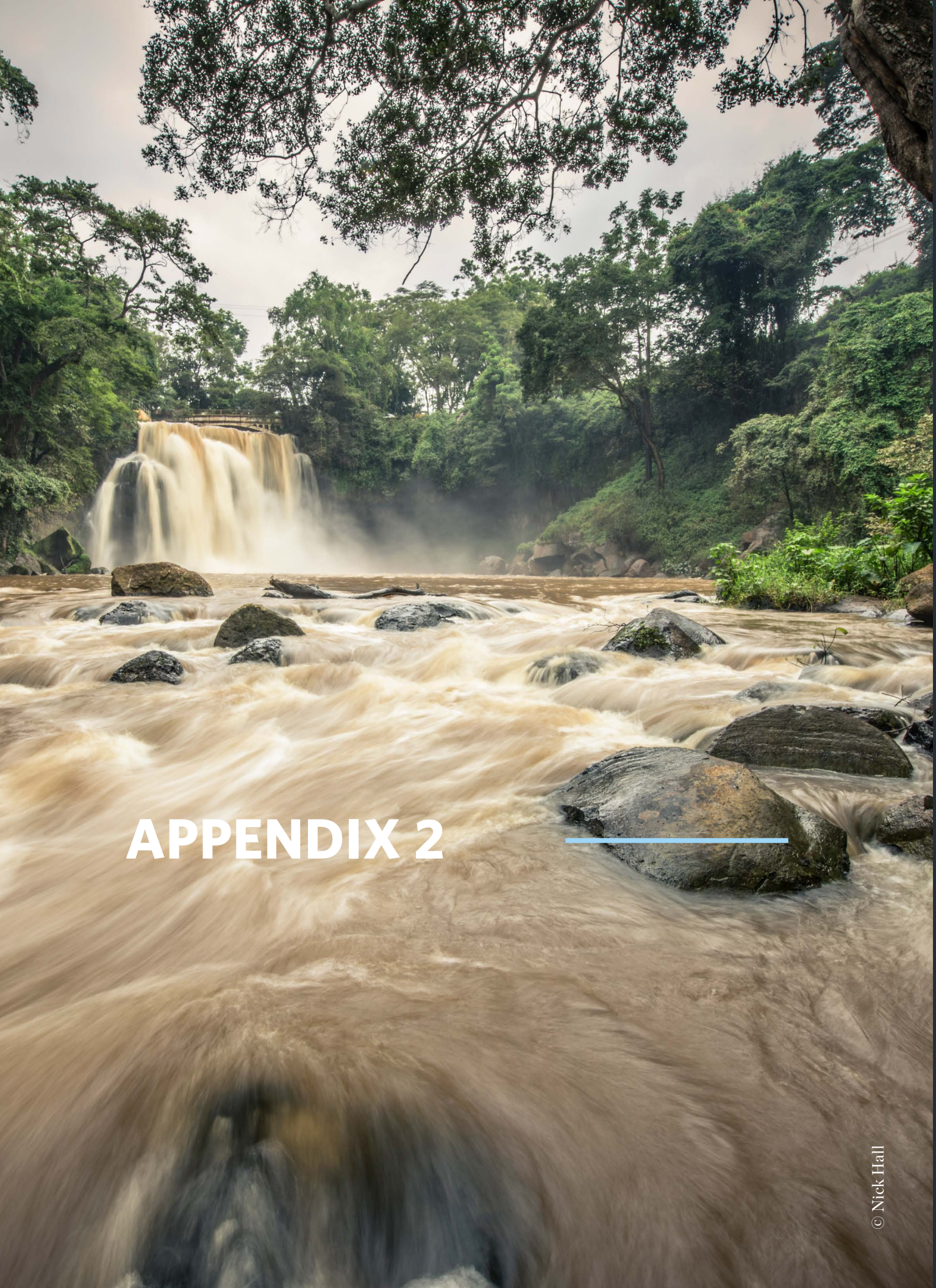
62. **Regulatory:** Water abstraction permits, agricultural irrigation regulations: Obtain data from government agencies and other pertinent organizations. **(return to Table 3)**

**Well-being**

63. **Water supply:** Inter-annual variability, drought resilience: Inter-annual variability can be measured by streamflow variability, % of annual water flow extracted (separated as consumptive & non-consumptive). Drought resilience can be measured as a function of hazard, vulnerability, and coping capacity using indicators for each factor. Hazard indicators can be developed using historical meteorological data, in addition to inputs of experts, extension officers, industrial sector and farmers in the study areas. Data can be collected in different ways according to context and need, e.g. household surveys, qualitative community discussion, key informant interviews, and third-party sources, and each source is graded by trained staff working with the community. Useful link: **https://new.azwater.gov/sites/default/files/sir20165114.pdf** **(return to Table 3)**

64. **Water demand:** Water-use efficiency, groundwater stress: Determined based on water use efficiency in terms of liters per unit output by urban and industrial sectors or per production value. Seasonality should be considered; efficiency can be also measured using observed data on reduction in water loss; groundwater stress can be assessed using a water balance between surface and groundwater and surface water availability and groundwater demand using hydrologic models, reported groundwater withdrawal statistics and other data (useful links: **https://www.un-igrac.org/sites/default/files/resources/files/Assessing%20Groundwater%20Stress%20-%20web%20version.pdf**. **(return to Table 3)**

65. **Water security:** Maintenance of groundwater level for reliable abstraction can be estimated using data on regional aquifer water levels measured in well networks and analyzed for trends; maintenance of reliable levels for surface water abstraction can be assessed by source protection efforts, safety of drinking water, and data of acceptable abstraction levels be monitored by environmental agencies. A variety of other metrics (e.g. recreational use, aesthetics, food security, job opportunities) and methods can be used to track progress towards people's well-being. **(return to Table 3)**



# APPENDIX 2

# MONITORING GUIDANCE FOR KEY OUTCOMES

## Biophysical outcomes

### Water Quantity

#### Surface water

Changes in surface water flow are usually quantified by differences in the average volume of water in runoff or open channels (e.g., millimeters or millions of liters) or discharge (e.g., L/s or m3/s). In some cases, the depth of flowing water (stage) is more informative. Depending on the kind of information needed and the purpose of the data, changes can be also determined from differences in the average annual discharge, average baseflow levels, the relative contribution of baseflow and storm flow to annual discharge, the frequency of low- or no-flow days (days/yr), magnitude of peak flows, and flood stage and frequency.

Regardless of how changes in surface water are determined, stream flow data from open channels are fundamental. Not only can these data be used to assess hydrological changes in the watershed and the environmental conditions of streams and river ecosystems, but they can also be used to calculate pollutant loads, determine the optimum levels for sustainable water use in the watershed, develop water budgets, and assess changes in groundwater levels.


Different approaches and methods can be used to measure stream flow or discharge; the method best suited for a given project depends on accuracy required, stream size and volume, accessibility of the terrain, and financial and physical resources available. The weir and flume methods are the most suitable for long-term studies, especially in small hillslope streams, where using flow-measuring structures is the only way to obtain accurate results; however, these methods are relatively costly. In flat terrain, different velocity-area methods can be considered, including the float method, when operational ease and cost are important considerations. For larger streams in flat terrain, non-contact measurement methods such as particle image velocimetry or remote sensing can be complementary and cost-effective for some situations where traditional gage-based methods may not be available, but they can also be costly.

Hydrological models are another option to estimate discharge from a watershed or sub-watershed, but uncertainties can be significant if the model is not properly calibrated and the results not validated with field observations. For large rivers, recent improvements in remote sensing have enabled detection of river water-surface width from satellite observations, making possible to track changes in streamflow from space and calibrate models without field data. Combining remote sensing data with estimates from hydrological models is a promising approach for estimating discharge and water depth in ungauged watersheds.

## Groundwater

The effects of watershed projects on groundwater can be measured using several different approaches and methods. The method best suited depends on project goals and the aspect of the project that is most important to measure.

The total volume of groundwater stored in an aquifer is determined by the balance between inflows (e.g., recharge from rain and irrigation, seepage from surface water bodies) and outflows (e.g., discharge to surface waters, abstraction, evapotranspiration). Changes can be quantified by measuring the balance of inflows and outflows within a timeframe that is appropriate for expected changes to occur, taking into account natural or seasonal variability. However, the complexity of flows within aquifers present many challenges to measuring changes directly. Water budget models are often used, but they too have limitations due to calibration difficulties.

A method to assess changes in water storage is through measurement of water levels in a well-designed network of monitoring wells in the catchment, combined with measurements or estimates of rainfall inputs. Long-term declines in water levels are often indicative of over-abstraction. Similarly, stable water levels generally indicate that inflows are in balance with outflows. However, declines can represent local or regional cones of depression created by the lagged nature of aquifer responses to pumping or changes in inflow, not actual over-abstraction. Furthermore, aquifers can take hundreds of years to equilibrate to changes in extraction and recharge, so assessing the impacts of interventions in the watershed may have a long lag time. Similarly, if the network of monitoring wells is poorly designed, wells may tap multiple aquifers, generating information that is misleading or difficult to interpret. Such difficulties highlight the importance of having experienced specialists assist with monitoring of groundwater and the need for continued innovation in groundwater assessment.

In many projects, the environmental goals of interventions focused on groundwater are relatively straightforward, and thus, should be easier to monitor. For instance, the outcomes of projects focused on the recovery of discharge to surface waters, protection of recharge zones, and resilience of groundwater levels can be quantified by measuring spring and baseflow discharge to stream channels, rates of soil infiltration in recharge zones or acres of protected or restored recharge zones (output indicator). Outcomes of projects with goals such as maintenance of groundwater level for reliable abstraction can be measured by determining the number of times that the aquifer storage falls below a normal condition after the watershed project is implemented in comparison to the period before it. However, as with other methods, confounding factors need to be taken into consideration.


### Water Quality

Water quality is a term used to express the suitability of water to sustain various uses or processes. Consequently, it is determined by the variables that limit water use or processes that sustain healthy ecosystems.

In a monitoring program designed to evaluate the water quality impact of an implemented intervention(s), it is critical that the monitored variables focus on the dimensions of water quality expected to change in response to the intervention. For example, if the intervention is intended to prevent soil erosion in agricultural land, water quality monitoring should focus on suspended sediment

concentration and turbidity as these are the relevant variables likely to respond to the intervention. Other water quality variables may be monitored, but only to provide ancillary information, especially if the intervention is likely to cause unintended impacts.

For surface waters, changes in water quality can be assessed by examining differences in chemical, physical, and biological characteristics of the water with and without project implementation. Some of the most common chemical variables monitored include dissolved oxygen (mg/L), biological oxygen demand (BOD in mg/L), pH, metals (µg/L), and nutrients (nitrogen and phosphorus) in inorganic and organic forms (mg/L). However, water quality is determined by different criteria and requirements depending on whether the water is used for drinking, irrigation, food processing, or industrial use. Therefore, the water quality variables monitored should reflect the appropriate criteria and the critical pollutants depending on the end-use of the water. Generally, water quality criteria developed for human health and aquatic life should be sufficient to protect agricultural and industrial designated uses because those uses are generally less sensitive than human health and aquatic life designated uses **(EPA 2017)**. However, in some instances, designated uses may require more stringent criteria to protect them. In such cases, criteria specifically designed to protect such designated uses should be considered as well.

Common physical water quality variables include transparency, specific conductance, total dissolved and total suspended solids, suspended sediment concentration, temperature, and turbidity. Specific conductance is an easy indirect method to assess content of dissolved solids in water, which can be an inexpensive proxy to measure water pollution from common solutes such as nitrate, ammonium and chloride.

While water quality monitoring is traditionally based on physicochemical variables, biological water quality variables such aquatic organisms and habitat are increasingly used in monitoring programs because they inform about the condition of the whole system. Aquatic organisms are particularly useful to assess conditions of freshwater ecosystems because they integrate the exposure to various stressors over time. Measures of biological communities (e.g., macro-invertebrates, fish) can integrate the effects of different stressors like excess nutrients, toxic chemicals, increased temperature, altered hydrology and riparian degradation, and provide an aggregate measure of the impact of stressors on the watershed. When the objectives of a watershed project focus on biological response (e.g., restoration of fish in a stream) or when treatment in the watershed focuses on in-stream practices like habitat restoration, biological monitoring is essential.

In groundwater, changes in water quality can be assessed by examining chemicals present in the water or by assessing pollution risk or vulnerability to pollution before and after project implementation. Chemical variables commonly used include heavy metals, nitrate, pH and water hardness, among others. The risk of pollution is generally determined by the proximity of a well or group of wells to a pollution source, pollution migration and transport patterns, aquifer type, and groundwater depth. Groundwater samples for analyses can be collected in production wells or well networks specifically designed for monitoring water quality. The use of well networks is useful to reduce spatial variability problems.

# Socioeconomic and Governance Outcomes and Impacts

Some aspects of socioeconomic well-being are directly observable but other aspects depend on self-reported conditions that require conducting interviews and/or surveys. As a result, a variety of methods are used to track progress towards social and economic goals. In addition, multiple metrics and sometimes models are needed to suggest whether a project had a positive effect on a given outcome, since many biophysical, economic and legal factors are typically acting simultaneously to affect well-being. For example, a project may aim to increase water security among rural households using well water by supporting the installation of efficient irrigation technology. The social outcome metric could be 'days in which well water yield was at or above a target level' across multiple communities. However, simultaneous with the project, farmers could be changing cropping decisions based on market prices and changing the area of land in production due to changes in enforcement. Also, weather variability after installation of technology could impact groundwater levels. Therefore, performance metrics cannot be judged in isolation.


© TNC

A common low-cost approach to measuring well-being outcomes is to use existing socioeconomic data that is routinely collected by governments. Such data are used to track change through time using an index or metric dashboard. Data that is routinely collected by governments can be examined for relevance to the project and tracked through time to identify potential effects. Types of social data that may be available include levels of agricultural production, poverty, and disease incidence. Legal data can also be useful in tracking legal actions and fines. The number of and nature of complaints to governments and facilities may also be logged in some cases and can be monitored for trends.

Existing government or other data can be effective proxies for progress, particularly if data can be isolated for a region and time period of interest. However, existing data are rarely ideal for demonstrating direct project cause and effect due to limits of scale and scope. For example, disease incidence may be reported from a regional medical facility that serves the project area but also other unaffected areas. To robustly measure changes in socioeconomic variables that are due to a project requires conducting field investigations. Those field investigations must be tailored to the drivers and outcomes of interest and are likely to involve measuring biophysical outcomes through time (e.g., well yields), as well as conducting interviews and surveys. More specifically, methods include: 1) positioning observers at key areas of interest; 2) conducting interviews with key informants, or those who can represent conditions for a group (government officials or community organizers); 3)

Examples of intangible outcomes include

**SATISFACTION WITH THE LEVEL OF ENVIRONMENTAL PROTECTION, COMMUNITY WELL-BEING, OR WATER GOVERNANCE PROCESSES.**

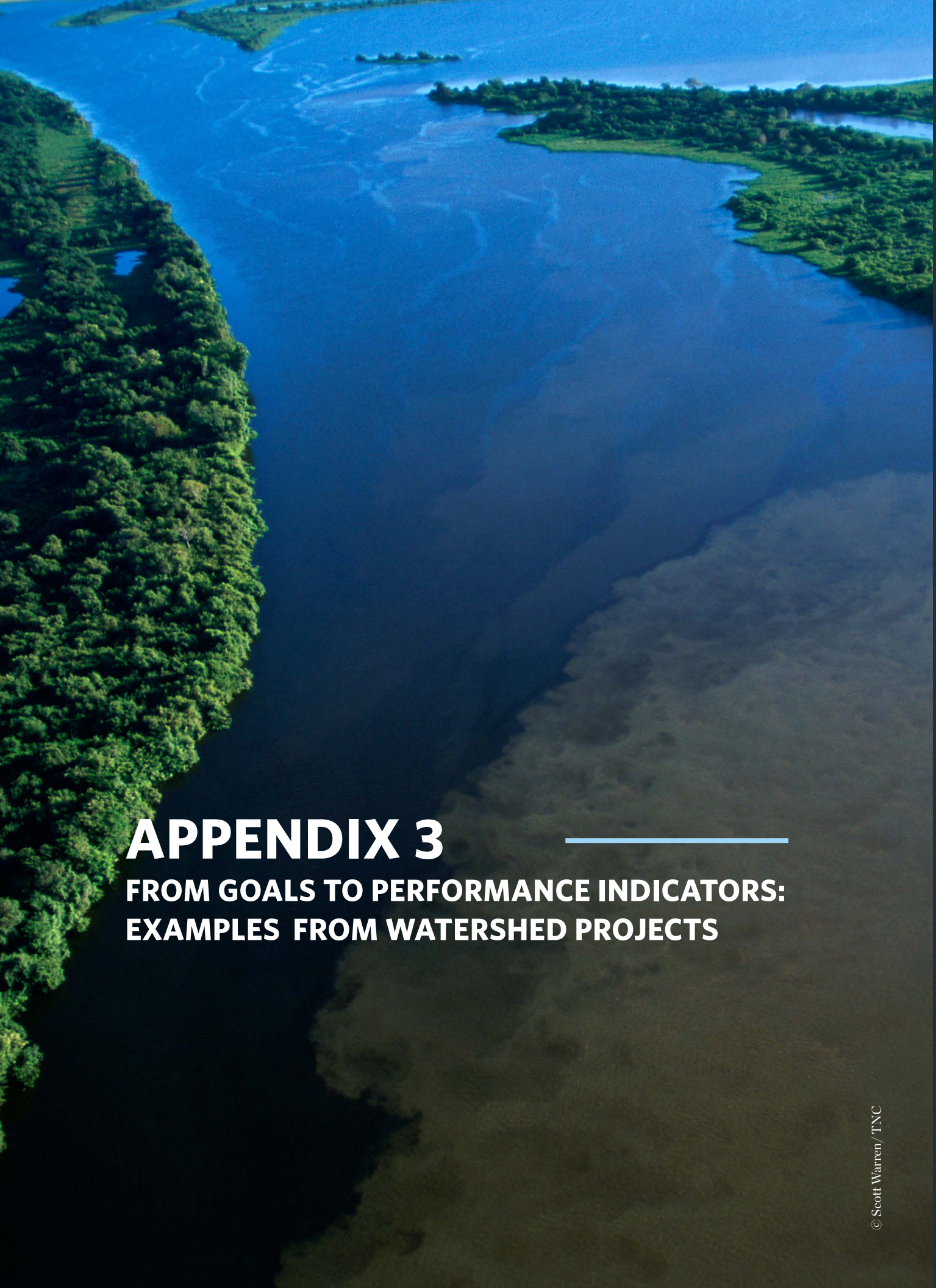
conducting random household surveys, with follow up interviews.

For the first method, observers can report such conditions as the number of people drawing water from a water source or visiting a beach. They can also conduct intercept surveys in which they approach a subset of visitors and ask them to describe their actions or perceptions. For example, they might ask: Do you consider the water safe for swimming? Or, have you experienced any health problems after swimming here?

Interviews with key informants can be used to evaluate changes in areas of concern. Typically, these informants are asked to speak for a group because they are in a position to understand conditions broadly. Key informants can often be identified by asking community members questions such as: Who do you rely on for information about water safety? Or, who do you report problems to? Although human perceptions of change are prone to bias, interviews can be structured to minimize such bias.

A randomized household survey would be considered one of the most robust approaches to tracking change through time and for certain outcomes will be the only reliable tool of measurement. Surveys require substantial investment if they are to be effective at gathering information since they need to be carefully designed to elicit objective information, reach the affected people, and provide useful information. It is critical to engage an experienced survey design team for creating effective surveys and getting a sufficient response rate. The team will need to conduct interviews and survey pre-tests with some members of the affected population to understand issues and to ensure questions are understood. Surveys will be the only way to track the unobservable benefits of water projects that encompass intangible outcomes. Examples of intangible outcomes include satisfaction with the level of environmental protection, community well-being, or water governance processes.

Increasingly, remote sensing is being applied to track activities that may be relevant for understanding changes in well-being. If cell phones are in widespread use, it is possible to create apps that allow consenting people to self-report activities and gain quantitative information on relevant issues (e.g., time spent in water collection). Another approach is to use satellite imagery to examine indicators such as land use practices. It is important to ensure that all such remote sensing or monitoring methods are conducted in accordance with applicable laws and regulations governing data use and privacy prior to implementation.

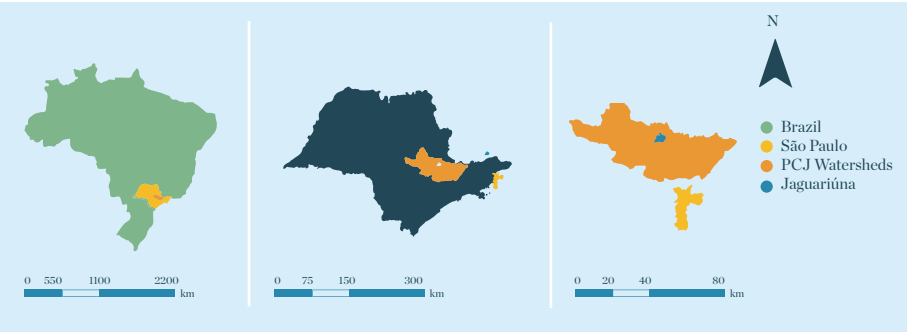


# APPENDIX 3

## FROM GOALS TO PERFORMANCE INDICATORS: EXAMPLES FROM WATERSHED PROJECTS

# Jaguariúna Project Example

## The Challenge




The city of Jaguariúna is located in São Paulo State, in the center of one of the most important water resource management units in Brazil, the Piracicaba, Capivari, and Jundiaí Rivers (PCJ) Watersheds. Currently, surface water demand in the PCJ Basins represents approximately 78.7% of surface water availability, with some sub-basins with demands greater than availability. Approximately 45% of the total demand for water use in PCJ Watersheds is for urban use, 30% for industrial use and 22% for irrigation (Basin Plan 2020-2035).

Currently 93% of Jaguariúna's water supply comes from the Jaguari River, but the import of wastewater is being considered to supply the city's economic and population growth.

With the wider region's industrial and population growth, the risk of water scarcity in the PCJ basins is worsening. According to projections made by the Brazilian National Water Agency (ANA), it is estimated that by 2035 the macro-metropolis of São Paulo will demand an additional 60 thousand liters per second - double the current flow of the Cantareira system. Despite having large surface water supplies, according to the 2019 Situation Report (PCJ Agency), per capita water availability reduced by 4% from 2014 to 2018 due to continued population growth and drought—and in a location where water stress is high, any reduction can have a significant impact.

Water quality is also a challenge in the area. Only 31% of households in the PCJ Basins are connected to the sewage network; the remaining households use rudimentary or septic pits, which can introduce pollutants into the environment. Water quality is also impacted by the low forest cover in the area, leading to soil erosion and increased sedimentation.


**The Vision**

This project, known as the Bacias-Jaguariúna Program, aims to increase water security for the population, industry and agriculture of Jaguariúna through the implementation of green infrastructure projects aimed at improving base flow levels, reducing sediment transport and fertilizer runoff to waterways, and more broadly improving financing flow and long-term viability of other water security projects. This is achieved through a payment for ecosystem services program that incentivizes local producers to join the program and implement these sustainable practices.

**Project Goals**

The Bacias-Jaguariúna Program has been focused on developing and implementing a model for the conservation and recovery of water resources within the municipality of Jaguariúna, which could be replicated within the context of the PCJ and other basins. Stakeholders engaged in the project are investing in conservation actions focused on five practices: protection of forest remnants, active reforestation of degraded lands, passive regeneration (focusing on riparian areas within private rural properties), rural sanitation and better soil management practices in agriculture.

These nature-based solutions promote land protection and sustainable land use, with the ultimate goal of improving water security and watershed resilience through the maintenance and restoration of ecological functions and establishment of good water governance. The project model has made it possible to improve financial and local governance mechanisms, enabling the municipality to raise funds from different sources, both private and public, to invest sustainably in nature-based solutions.

The flow chart below was adapted from Figure 4 and includes environmental and socioeconomic performance indicators for different phases of the project, based on present plans for the Jaguariúna Basin.

**Problem: Growing water demand and decline of water quality**

| What is the primary target? | What is the level of Investment? **input** | What activities were proposed to bring change? **activities** | What are the short-term changes? **output** | What are the measurable effects? **short-term outcome** | What change doyou expect to see? **long-term outcome** | What project benefits should be maintained? **sustainability** | What are the wider benefits to people? **well-being** |
|---|---|---|---|---|---|---|---|
| **Environmental** | | | | | | | |
| Reduce nutrient and sediment loads to water courses | Financial support, # person-hours spent with Basin Committees or in meetings with stakeholders and partners (hrs/yr) | Ecological restoration (active and passive) with a focus on riparian areas; forest conservation | Increase in area of ag land implemented with BMPs, restored forest, or under conservation practices (% ha, # ha) | Soil erosion reduction in areas implemented with mitigation actions (kg soil/ha) (See Table 3, ref 47 for how to measure) | Reduction in sediment transport and fertilizer runoff to waterways (kg/yr) (Table 3, refs 1 to 18 for how to measure) | Measurable improvement of water source critical areas (ha source areas with established vegetation (Table 3 ref 46 for how to measure)) | Water security for all users, increased clean water supply (L/capita/yr) (Table 3 refs 22, 23, 61, 63 for how to measure) |
| Maintenance of natural baseflow levels | | Implementation of best management practices in ag fields and along roads to reduce soil erosion | More roads with best practices to reduce erosion (# km, # roads) | Increase in water infiltration in areas implemented with conservation actions (See Table 3, ref 47 for how to measure) | Improvement in baselfow levels (Table 3, refs 4,5,6,7 for how to measure) | Positive trends in discharge dynamics in stream channels (Table 3, refs 1 to 18 for how to measure) | Improved water quality for all users and improved aesthetics of water bodies (Table 3, refs 22-29 also Appendix 2 for how to measure) |
| | | Support the formulation of actions to protect the quality and quantity of surface water resources within the Basin Committees | Increase support from institutions and other partners to improve water resources (# signed agreements, commitments) | Stronger institutional arrangements for conservation and restoration projects in PCJ basins (recognition, support) | Improvement of financing flow & support for water security projects | Balanced sediment dynamic in stream channels (Table 3, refs 25 - 26 for how to measure) | Socioeconomic stability and job opportunities with reduced social and economic disruption Table 3, ref 55, also Appendix 2 for how to measure) |
| | | Encourage the creation and maintenance of real-time monitoring databases to help reduce the vulnerability of watersheds and their productive sectors. | Revised watershed management plans; development of a real-time monitoring plan | Higher number of programs conducted or resources dedicated to conservation and restoration practices | | Measurable water quality improvement in water courses (Table 3, ref 23 for how to measure) | |
| | Amount of support for outreach, public education, and funds for monitoring and management plans | | | | | Improved aquatic biodiversity (See Table 3, ref 37 for how to measure) | |
| **Social-economic** | | | | | | | |

(see next page)

**Problem: Unsustainable increase in groundwater demand**

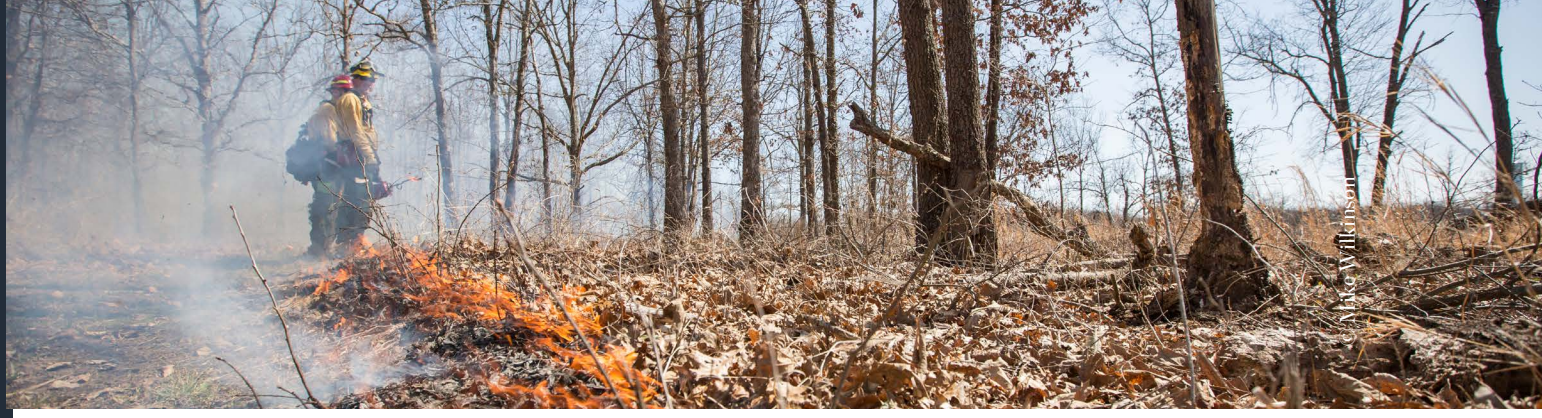
Socioeconomic

| What is the primary target? | What is the level of Investment? **input** | What activities were proposed to bring change? **activities** | What are the short-term changes? **output** | What are the measurable effects? **short-term outcome** | What change doyou expect to see? **long-term outcome** | What project benefits should be maintained? **sustainability** | What are the wider benefits to people? **well-being** |
|---|---|---|---|---|---|---|---|
| Pay farmers for ES to improve water quality/ quantity stewardship; support outreach programs to raise awareness of water pollution problems and solutions in the region | Money invested in PES | Invest in PES outreach, and capacity building to promote changes in agricultural practices | Farmers commitment to restoration and conservation practices (# farmers, farms) | Better engaged and informed farmers about BMPs and water issues (from surveys, questionnaires) | Better and more cohesive watershed management plans (rate of implementation success, level of agreement among interested parties, perceived fairness) | Development of sustainable agriculture in the region (ha, # of farms, Table 3, ref 45, also Appendix 2 for measurements) | Sustainable long-term agricultural development in the region (ha, # of farms) |
| | Effort (money, person-hours) spent towards public education outreach | Strengthen institutional arragements for the conservation and restoration of critical areas developed in te PCJ Basins. | PES made ($ spent with PES for conservation/ restoration of critical areas in farms, # of farms) | Better agreement among institutions/ organizations on actions to protect the quality of surface water in the region (questionnaires, surveys) | Improved concepts of farming to support water quality stewardship in the region (based on survey & interview data) | Improved conditions of water sources areas (Table 3, refs 30-44 for how to measure) | Improved feeling of well being in agricultural communities and supportive business climate (see Appendix 2 for measurements) |
| | Effort (money, person-hours) in meetings to engage institutions and potential partners | | Implementation of outreach and public education programs about best ag practices (# programs, events, participants) | | Reduced water treatment costs; cost-avoidance with water treatment (Table 3, ref 55 for how to measure) | Improved environmental flows (Table 3, refs 30, 64 for how to measure) | Reduced water treatment costs (Table 2, ref 55) |
| | | | Stronger institutional commitment for conservation and restoration efforts (# of signed agreements, # institutions) | | | | |
| | | | Farm profitability conserved or enhanced (payments, # farmers, farms) | | | | |

The table below includes a list of environmental and socioeconomic performance indicators that could be used for different phases of the Jaguariúna Basin project. The indicators are based on present plans for the basin as well on suggestions from Table 3 menu.

| Key Problems | | Solution | Actions | Short-term goals | Long-term goals | Environmental performance metrics | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Process/Activity | Outputs | Outcomes | Impact |
| Water Availability | **Growing water demand** from agriculture and urbanization; falling baseflow discharge in streams and river | **Increase water infiltration and recharge in critical water source areas** | **Water Fund** Restore forests along riparian corridors and in critical areas; Implement forest conservation measures | Expand and protect forest cover in critical areas (water sources)<br><br>Reduce surface runoff | Increase soil infiltration capacity in critical areas<br><br>Increase water recharge to aquifers and groundwater | Selection of areas to restore forest or protect along riparian buffers<br><br>Formalize legal agreements with landowners for implementation of forest restoration and conservation projects | # of hectares authorized for forest restoration and conservation projects<br><br># of farmers committed to forest restoration<br><br>Area of riparian forest, restored or protected (ha)<br><br># of restoration projects implemented | Measurable increase increase in soil water holding capacity and infiltration in areas of forest restoration (cm/day)<br><br>Decrease in number of days that baseflow levels are below normal daily average. (long term)<br><br>Increase in baseflow levels (avg, daily L/s) (long term) | Measured increase in daily average streamflow levels<br><br>Measured reduction in number of days that baseflow level was below normal |
| | | **Implement best management practices in ag fields and along roads to reduce surface runoff** | **Tactical engagement with local/ farmers/ sponsor implementation of BMPs, including PES**<br><br>Invest in outreach and sponsor implementation of BMPs in farms | Increase adoption of best management practices in agriculture and roads<br><br>Reduce surface runoff and soil erosion | Reduce soil compaction in ag areas<br><br>Improve soil quality and carbon content<br><br>Increase water infiltration to reduce surface runoff and water loss | Support farmers to change agricultural practices to reduce soil compaction and improve soil quality | Time spent with farmers to inform about or promote alternative sustainable practices (person-hours)<br><br># of farmers committing to making changes<br><br># of farms adopting improved agricultural practices<br><br>% critical area planted with soil enriching plant species<br><br>Area of cropland adopting minimum or no-tillage (ha)<br><br>Number of ha with organic fertilizer application | Measurable (modeled or observed) decrease in surface water runoff (mm/yr)<br><br>Measurable (modeled or observed) decrease in soil erosion (kg/ha)<br><br>Measurable increase in water infiltration rates (cm/h)<br><br>Measurable increase in soil organic carbon content (%)<br><br>Measurable increase in soil water holding capacity (%) | Groundwater levels not reducing or slower decline<br><br>Improvement of soil conditions and reduction of soil loss from erosion<br><br>Reduced farmer expenditure related to application of synthetic fertilizer<br><br>Improvement of water use efficiency in agriculture |
| Water Quality | Non-point sources of water pollution | Protect/ restore natural infrastructure - **Water Fund** | Natural forest; forest restoration, reforestation<br><br>Protection and restoration of riparian buffers<br><br>Restoration of streams, wetlands and floodplains<br><br>Control deforestation | Reduce soil erosion, prevent erosion along stream banks and channels<br><br>Enhance pollutant retention capacity instreams, wetlands and floodplains<br><br>Reduce application of fertilizer<br><br>Create oportunities for water filtration and purification in watershed | Reduce transport of sediment and pollutants from the watershed to water courses<br><br>Improve water quality of streams and rivers | Planting of forest, reforestation<br><br>Fencing and restoring riparian buffers<br><br>Restoration of streams, wetland and floodplants | Area of forest restoration and reforestation (ha) or % cover<br><br># of forest restoration and reforestation projects implemented<br><br>Area of restored wetlands and floodplains (ha)<br><br>% change in area of floodplain, wetland, or forest recharge area<br><br>Deforestation rate: % natural vegetation area in water recharge zones<br><br>Rate of retention/ loss of pollutants in riparian buffers | Observed concentration of pollutants in streamflow (mg/L)<br><br>Polluntant loads (modeled)*<br><br>Water electrical conductivity*<br><br>Water turbidity*<br><br># point sources of pollution eliminated<br><br>Abundance of macro-invertebrates and fish<br><br>Sediment export in streams (tons/yr) | Measured increase in natural vegetation cover<br><br>Measured reduction in pollutant loads to water courses<br><br>Measured improvement in aquatic habitat conditions and aquatic biodiversity |

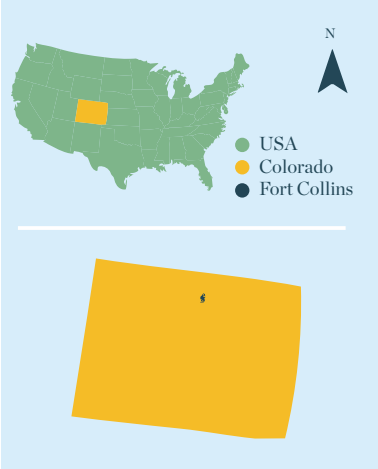
| | Key problems | Solution | Actions | Specific short-term goals | Specific long-term goals | Environmental performance metrics | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Process/Activity | Outputs | Outcomes | Impact |
| Socioeconomic | **Growing water demand** from agriculture; unsustainable groundwater use<br><br>Perception and knowledge among farmers about water use issues in the region and possible solutions | **Water Fund** Provide subsidies to implement natural solutions to reduce water losses and soil degradation | Invest in nature based solutions<br><br>Support tactical engagement with local farmers to facilitate access to information about best management practices that improve soil conditions and reduce water loss<br><br>Invest in outreach, capacity building and implementation of BMPs | Work with local farmers to improve agricultural practices that increase water use efficiency<br><br>Creation and implementation of outreach and public education programs that promote the adoption of agricultureal best management practices by local farmers | Improve perception and knowledge among farmers about water use issues in the region and possible natural solutions | Hours spent identifying farmers willing to commit to improving ag management practices<br><br>Hourspent in outreach and public education efforts | % or # of farmers committed to at risk who are potentially positively affected by restoration project(s)<br><br>Area of forest restoration and reforestaton (ha) or % change in forest cover area<br><br># of forest restoration and reforestation projects implemented<br><br>% change in area of floodplain, wetland, or water recharge area<br><br>More outreach and public education about agricultural best management practices (# programs, events, participants | Number of farmers or communities with greater access to information about ag practices that reduce water losses<br><br>More awareness of water waste and natural solutions among farmers (% of farmers, level of awareness based on surveys) | More sustainable farming practices in the region<br><br>Creation of long term commitments to protect the environment and reduce water losses<br><br>Farming practices in the region are consistent and in harmony with the core principles promoted by Water Fund<br><br>Improved water security<br><br>More resilient agricultural production |
| | | **Provide subsidies to improve irrigation systems and reduce water loss** | Tactical engagement with local farmers to facilitate access to information and tools to improve irrigation techniques and water use efficiency in ag<br><br>Subsidies to farmers to improve irrigation systems | Implementation of outreach and public education programs that educate about irrigation techniques that reduce water loss<br><br>Identify farmers and provide subsidies to improve irrigation systems<br><br>Replace or improve old irrigation systems with superior water use efficiency ones | Improve knowledge among farmers about irrigation options that improve water use efficiency<br><br>Reduce agricultural water supply risk | Hours spent in outreach and public education efforts<br><br>Hours spent identifying farmers willing to commit to improving irrigation practices<br><br>Effort (money, person-hours) in educating farmers about alternative practices to reduce water waste<br><br># peron-hours spent changing attitudes (education, behavioral techniques) | # farmers committed to improving water irrigation methods<br><br># of irrigation systems | Lost profits due to water supply problems<br><br>Water consumption use in agriculture (liters/year) | Advancement of farming practices to optimize water use and crop yields<br><br>Development of water stewardship in farming community<br><br>Improvement of farmer livelihoods and more secure water supply-<br><br>Lower risk of crop failure<br><br>Improved well being of agricultural communities |


Mike Wilkinson

# Fort Collins Project Example

## The Challenge

Increasing drought, a changing climate, and decades of fire suppression have put forested watersheds and water sources critical to Fort Collins, Colorado, at risk of high-severity wildfires, which threaten the quality of these water sources. For example, the 2012 High Park Fire generated so much sediment, ash, and other contaminants in the Cache la Poudre River that it left the water unusable for three months after the fire. Colorado's three largest fires in recorded history all occurred in 2020. The Cameron Peak Fire of 2020, which burned more than 208,000 acres over the course of approximately three months, further highlighted the need for forest management and wildfire risk reduction to protect water resources for the Fort Collins region.




### The Vision

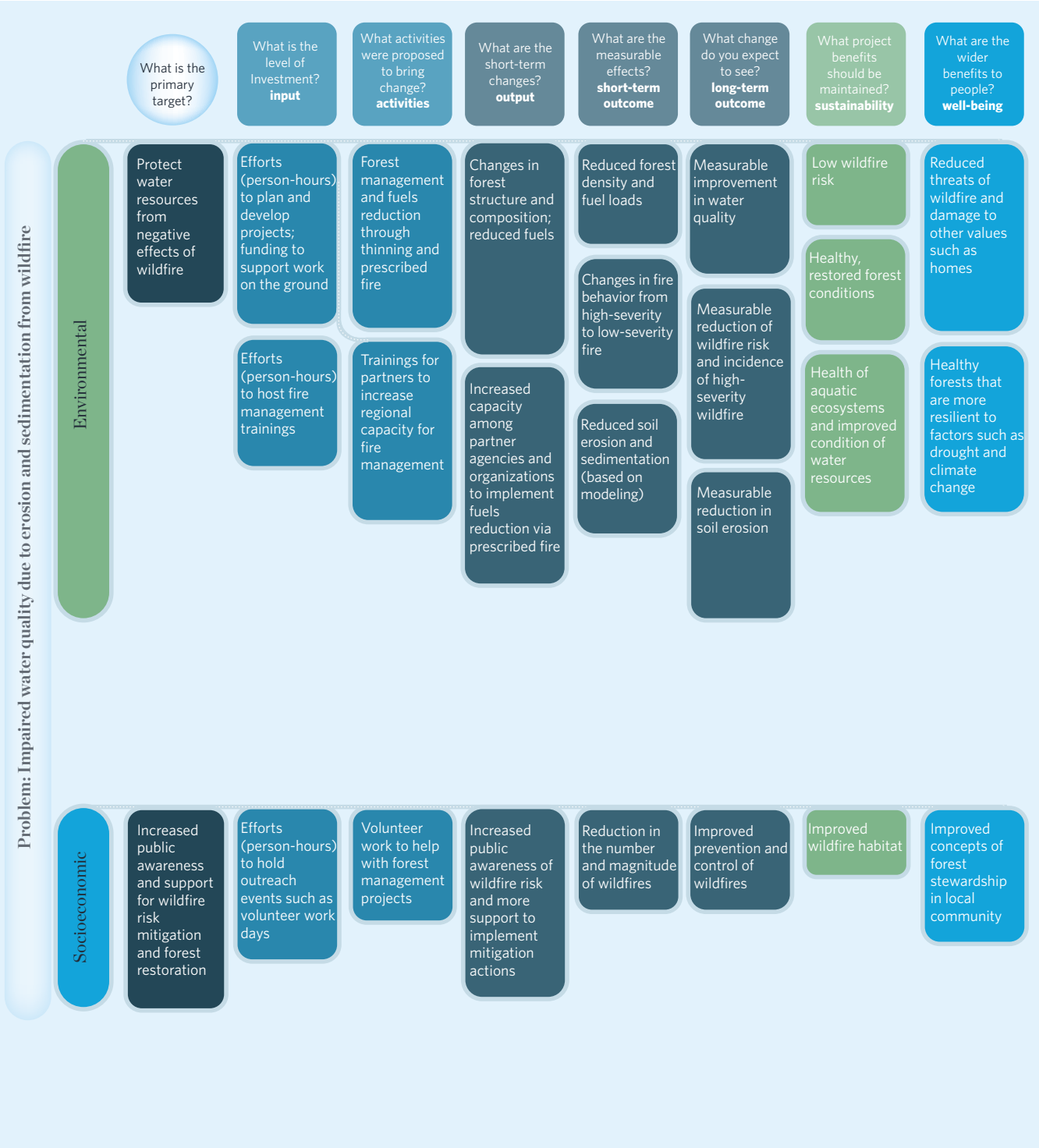
The project envisions a Fort Collins where water quality is better protected through proactive forest management in the Cache la Poudre and Big Thompson River watersheds, the primary sources of water for the city and area businesses. The project aims to reduce the risk of high-severity wildfires, securing water quality and a resilient water supply, by restoring key forested areas through thinning and prescribed burning. Additional expected benefits of this work include the protection of critical habitat and reduced risks to nearby communities. The project is working towards a more sustainable and secure water future that is managed in partnership with local NGOs, government agency partners, and the local utility, Northern Water. Commitments from funders like the Anheuser-Busch Foundation leverage additional financial support from partners dedicated to proactive forest management.

### Project Goals

The project aims to protect the watershed from sediment, ash, and other minerals from uncontrolled wildfires, with the following goals:

1. Deliver successful forest management treatment on 500-1,500 acres using mechanical and manual cutting and thinning, pile burning, and broadcast burning.
2. Expand regional capacity for forest restoration through classroom and on-the ground trainings.
3. Increase regional investment in forest restoration through partnerships with stakeholders such as Northern Water and Peaks to People Water Fund; and.
4. Achieve measurable scientific results that demonstrate and communicate the benefits of proactive forest management for watershed health and water security.

The flow chart below was adapted from Figure 4 and includes performance indicators for different phases of the project, based on present plans for Fort Collins.



The table below includes a list of environmental performance indicators that have been selected for different phases of the Fort Collins project.

| Key Problems | | Solution | Actions | Short-term goals | Long-term goals | Environmental performance metrics | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Process/Activity | Outputs | Outcomes | Impact |
| Water Availability | **Negative impacts to water resources and water quality from wildfire-caused soil erosion and sedimentation** | Protect water supplies<br><br>Manage forests and fuels to change wildfire behavior and reduce post-fire impacts to water resources | Forest management-forest thinning and prescribed fire | Reduced forest densities and hazardous fuels | Restored forest structure and composition<br><br>Improved forest health and resilience<br><br>Reduced wildfire risks<br><br>Protected municipal water supplies | Risk assessment to identify high priority areas for forest management<br><br>Project planning and development of treatment prescriptions<br><br>Implementation of work on the ground<br><br>Effectiveness monitoring and modeling | Forest density<br>Fuel loads<br>Predicted/modeled wildfire behavior<br>Modeled changes in erosion and sedimentation potential | Measurable reduction in density structure (# trees/acre) and fuel loads (tons/acre)<br><br>Reduction in high-severity wildfire<br><br>Reduced potential for post-fire erosion, sedimentation and water quality impacts | Water resources not threatened by wildfire impacts<br><br>Forests that are heañthy and resilient to factors such as drought, wildfire, and climate change; and continue to provide a wide range of ecosystem services, including clean and abundant water. |
| | | Increase regional capacity for prescribed fire | Provide fire management trainings to partner agencies and organizations | Increase number of partners capable of implementing prescribed fire | Forest and fuels managed with good fire, not high-severity wildfire | Fire management trainings | # partners trained (people and agencies) | Increased capacity to implement prescribed fire | Increased number and scale of prescribed fire projects<br><br>Work force for prescribed fire |

# APPENDIX 4

## EXAMPLES OF COMMUNICATION MATERIALS FROM TNC

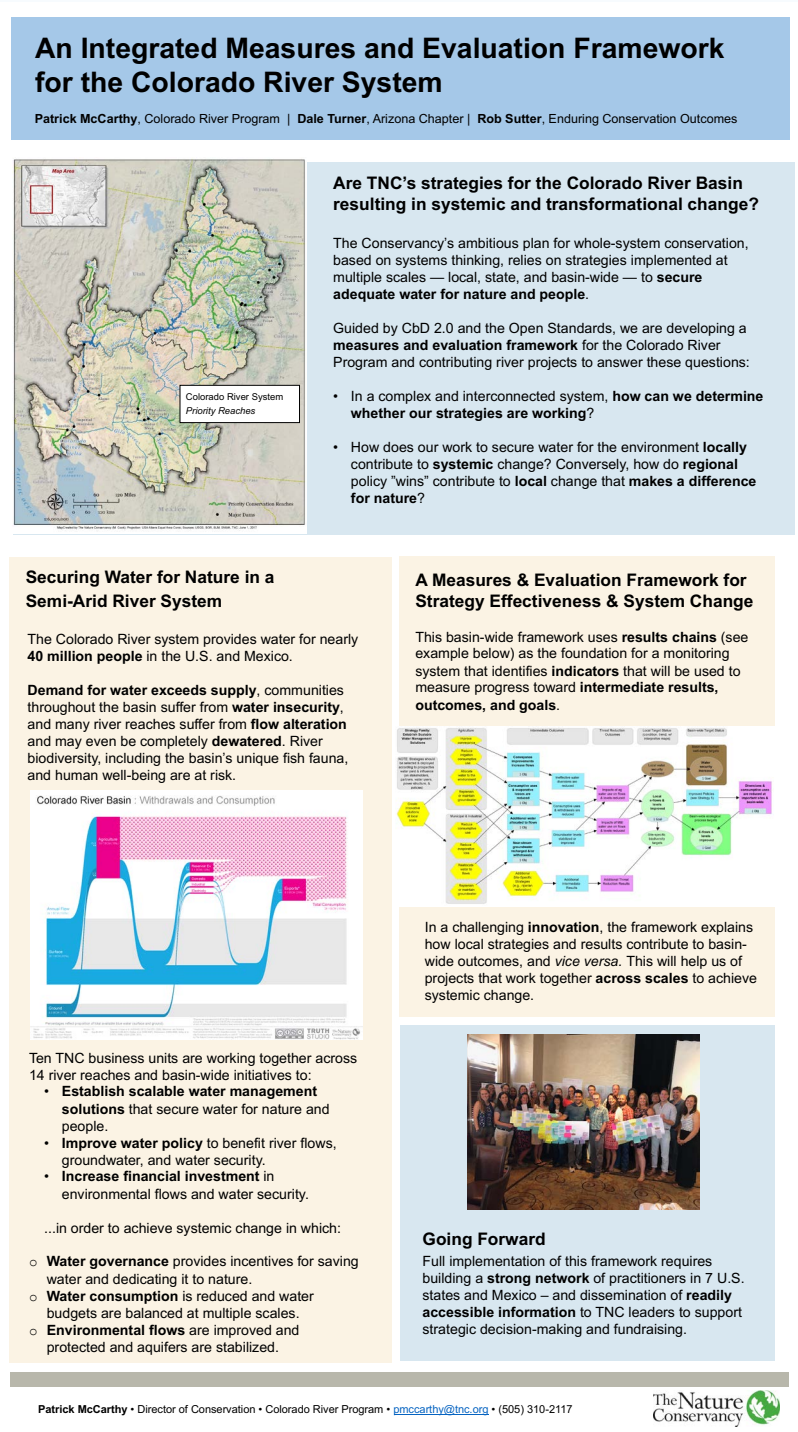
Adriano Gambarini / TNC

## Interactive Examples

- **The Peaks to People Water Fund Watershed Investment Tool**, which is used to prioritize projects.
- **The Peaks to People Water Fund Watershed Health Outcomes Tracker tool**, which is used to measure and summarize progress across projects.

## Visual Examples

The Integrated Measures and Evaluation Framework for the Colorado River System is an example of collaborative work to build a tool for analyzing whether actions taken to address water security are leading to transformational change.



The Improving the Efficiency, Accuracy and Cost-Effectiveness of Desert Riparian Habitat Restoration Monitoring is an example of due diligence to determine a cost-effective method of assessing ecosystem health.

# Improving the Efficiency, Accuracy, and Cost-Effectiveness of Desert Riparian Habitat Restoration Monitoring

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Alejandro Rosas, Hydrologist, Sonoran Institute, Mexicali, Baja California, México
Eloise Kendy, Senior Freshwater Scientist, The Nature Conservancy, Helena, Montana, USA

Above: 2016 DJI Phantom 4 drone with RedEdge MicaSense camera

**We are using drone-mounted cameras and NDVI sensors to track vegetation greenness, foliar cover, and species composition in riparian restoration and control sites.**

**Can drone-based surveys rapidly assess vegetation extent and health in restored desert riparian ecosystems?**

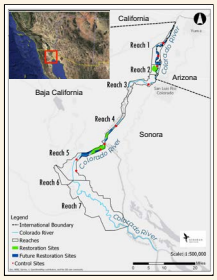
**On-the-ground-surveys are accurate, but expensive and time consuming.** As we expand the area of restored habitat in the Colorado Delta from 1,100 to 4,300 acres by 2026, we need a more cost-effective, efficient way to monitor outcomes.

**Satellite-based data are readily accessible, but the resolution is too coarse.** We need detailed maps to correlate vegetation condition with water deliveries and other restoration activities. We use this information for adaptive management.

**Are drone-based data the happy medium?**

## Bringing back the Colorado Delta

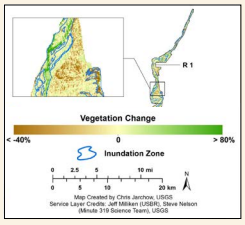
The Colorado River no longer flows to the sea. Its Delta, once among the world's most extensive and productive wetland forest complexes, is now desert and farmland. Under Minute 323, an NGO coalition called Raise the River partners with U.S. and Mexican governments to restore water flows and native habitat.




Along the riparian corridor – a pinchpoint on the Pacific Flyway -- we are clearing saltcedar and establishing willow, cottonwood, mesquite, and other native plant species to provide habitat for resident and migrating birds.

In these restoration sites, vegetation health and vigor depend on managed water deliveries to maintain acceptable ranges of soil salinity and moisture.


Right: Measuring vegetation volume.




Left: Change in vegetation greenness from 2014 to 2015, following the 2014 pulse flow, from satellite-based normalized difference vegetation index (NDVI). Going forward, water is being delivered directly to restoration sites, where native riparian forests are being re-established.

Left: Setting location coordinates.
Above: Completing a drone flight.

## Monitoring restoration outcomes

Vegetation monitoring by the binational Minute 323 science team guides restoration efforts and provides donors with evidence of tangible outcomes. As restoration efforts expand, the monitoring team needs a rapid-assessment approach to evaluate vegetation responses.

Although drone-based data are used for precision agriculture, their application to ecological restoration is novel and will likely increase now that drones and sensors are readily available in the consumer market.

| | Vegetation greenness | Foliar cover | Percent cover by species |
|---|---|---|---|
| Satellite NDVI | ✓ | | |
| Drone NDVI | ✓ | ✓ | |
| Drone photo-grammetry | | ✓ | ✓ |
| Ground surveys | | ✓ | ✓ |

2018 drone surveys have just been completed. This winter, we will analyze the data and compare the results, accuracy, efficiency, and cost between the different platforms.

Right: Predetermined flight plans take the stress out of drone piloting.

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# Measuring and Evaluating the Impact of Corporate Watershed Projects

## A Guide to Set Project Objectives, Track Progress and Assess and Communicate Impact


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