Economic & Financial Analysis Deep Dive

Acknowledgments

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Glossary[1]

BENEFICIARY → the stakeholder who derives a positive impact from the nature-based solutions implemented in the watershed to improve water security.

BUSINESS AS USUAL (BAU) SCENARIO → a baseline that predicts what the watershed will look like, in the future, without intervention.

CAPITAL STRUCTURE → in this document, the term refers to the way the program will finance its NbS through some combination of direct stakeholder investment, debt, equity, or hybrid securities.

CO-BENEFITS → additional valuable outcomes arising from source water protection or nature-based solutions implemented to improve water security.

CONSERVATION INTERVENTIONS → source water protection activities or other nature-based solutions that preserve or enhance the current state of the ecosystem function.

COST-BENEFIT ANALYSIS → a method for comparing the expenses (costs) and target outcomes (benefits) of a project.

DISCOUNT RATE → a rate used to calculate the present value of future costs or benefits. When calculating the ROI, you should discount all costs and benefits of the program through the time horizon to their present value using an appropriate discount rate.

ECOSYSTEM BENEFITS → while ecosystem services are the outputs or aspects of nature that support human uses, such as clean water flows, the derived ecosystem benefits would be the specific uses people make of ecosystem services, such as water available for municipal drinking water supply, or water available for irrigation or hydropower.

ECOSYSTEM FUNCTION → processes performed by ecosystem structure, such as soil retention or aquifer recharge.

ECOSYSTEM SERVICES → the outputs or aspects of nature that support human uses, such as clean freshwater flows for municipal water supply.

ECOSYSTEM VALUE → change in human well-being ecosystem benefits produce, such as avoided cost of municipal water treatment, of development of alternative drinking water sources or of water-related negative health effects.

EMPIRICALLY-BASED BENEFIT FUNCTIONS → quantitative relationships that financially value ecosystem services in a way that is meaningful to the beneficiary's bottom line. For example, a reduction in TSS concentration could reduce the treatment plant's application of a specific chemical, or proportionally reduce the amount of water lost in treatment sludge.

IMPLEMENTATION COST → the cost of implementing conservation interventions in the watershed.

LAND-USE-LAND-COVER (LULC) → Land cover data documents how much of a region is covered by forests, wetlands, impervious surfaces, agriculture, and other land and water types. Water types include wetlands or open water. Land use shows how people use the landscape—whether for development, conservation, or mixed uses (NOAA, 2018). The combination of land-use-land-cover notes what the landscape is covered by and how the landscape is used, e.g., conserved (use) wetlands (cover).

NATURE-BASED SOLUTIONS (NbS) → (in the context of water security) actions to protect, sustainably manage and restore natural or modified ecosystems that address water security challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits.

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1   Note, definitions listed are in the context of this guidance; economic analysis of source water protection or nature-based solutions for water security programs.

NET PRESENT VALUE (NPV) → the difference between the *present value* of inflows and the *present value* of outflows over a period of time. Often used in investment planning to analyze the profitability of a future project.

OPPORTUNITY COST → the difference between the profits landowners realize under business-as-usual land management and under conservation management.

Present value → the current worth of a future value or future stream of values. Sometimes referred to as the present discounted value

RESTORATION INTERVENTIONS → source water protection activities or nature-based solutions that improve ecosystem function.

RETURN ON INVESTMENT (ROI) → a common financial metric of profitability that measures the return—monetary value of the benefits the stakeholder receives—for the money they invested.

SOCIAL DISCOUNT RATE → the rate at which a society would be willing to trade present for future consumption (Lopez, 2008).

SOCIAL OPPORTUNITY COST (SOC) → the value to society of the next best alternative use of the resources devoted to the project in question (Lopez, 2008).

SOCIAL TIME PREFERENCE (STP) → assigns current values to future consumption based on society's evaluation of the desirability of future consumption (Lopez, 2008).

SOURCE WATER PROTECTION → protection of source water areas (e.g., by conserving and restoring forests and reducing agricultural pollution) in order to improve water security.

STAKEHOLDER → a person with an interest in or opinion about the proposed project, program or investment portfolio.

TIME HORIZON → how many years the model will project outputs into the future. Choosing an appropriate time horizon will allow you to compare the cost-effectiveness of your interventions with other solutions your beneficiary(ies) may be considering.

TIME VALUE OF MONEY → concept which argues that money available at the present time is worth more than the identical sum in the future, due to its potential earning capacity.

TRANSACTION COST (TAC) → the expenses indirectly associated with implementing source water protection or other nature-based solutions; not the cost of the intervention, itself, but rather, the incidental costs of coordinating among stakeholders. For example, costs associated with landowner outreach; with drawing up, monitoring and enforcing agreements with land users or owners; dispute resolution; or with establishment and operation of any compensation schemes.

WATER SECURITY → availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water-related risks to people, environments and economies (Grey and Sadoff, 2007).

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Abbreviations

BaU	Business as Usual		**NPV**	Net Present Value
BEFA	Basic Economic & Financial Analysis		**ROI**	Return on Investment
CBA	Cost-Benefit Analysis		**SOC**	Social Opportunity Cost
DEFA	Detailed Economic & Financial Analysis		**STP**	Social Time Preference
DSS	Decision Support System		**SWP**	Source Water Protection
LULC	Land-Use-Land-Cover		**TAC**	Transaction Costs
LCM	Land Change Modeling		**TSS**	Total Suspended Solids
NbS	Nature-based Solutions		**USD**	United States Dollar

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Introduction

Water insecurity is one of the greatest risks to global prosperity. Global water consumption has doubled since 1960, and by 2025, at least two-thirds of the world's population will likely be living in water stressed areas (Walker et al., 2019; UN, 2014). In the future, government, utility and industry actors will be required to better manage scarce water resources and allocate them against competing needs.

Conventional interventions to secure water focus on grey infrastructure—constructed, man-made structures such as treatment facilities, stormwater systems, storage basins, dams, pipes, etc.—to transport, store and filter water for use, but nature, or green infrastructure, can perform many of these same functions, often at more cost-effective rates. Our science shows, working with nature delivers sustainable, cost-effective solutions: 1 out of 6 cities could pay for green infrastructure solely through savings in water treatment costs (Abell et al., 2017). There is an urgent need to mobilize the power of nature to meet water security challenges in a sustainable way.

The costs and benefits associated with constructing, operating and maintain grey infrastructure are relatively well-known and, therefore, well-integrated into current planning and lending processes. The same cannot be said for nature-based solutions (NbS). Though becoming increasingly defined, the business case for investing in nature is still an emerging field: robust examples of application in the water sector are required so that these solutions can become a trusted, mainstream alternative or addition to grey infrastructure. A business case, in the most basic sense, would provide the reasoning for initiating an NbS project.

As such, it is useful to analyze the **return on investment (ROI)** of a package of NbS interventions so investors can objectively compare results with grey infrastructure investments that would provide similar benefits. A return on investment (ROI) analysis refers to a common financial metric of profitability that measures the return—monetary value of the benefits the stakeholder receives—for the money they invested.

Other indicators like net present value, benefit-cost analysis, and cost-effectiveness analysis can also indicate whether a project is a good investment. The types of indicators used will depend on factors like the stakeholders, the type of proposed investment and the potential investors. This guidance outlines the methodology for conducting financial and economic analyses, of which ROI, and the aforementioned indicators, are a component.

BUSINESS CASE VS. ECONOMIC AND FINANCIAL ANALYSIS

Identifying the magnitude of benefits, who receives them, how much they are worth and when investors can see a return on their investment is critical and forms the basis of a "good" business case, but more is needed to attract investments. There are critical elements of a preparatory package—economic and financial analysis, governance arrangements, financial structuring, etc.—that practitioners need to generate financeable & fundable NbS projects.

The economic and financial analysis—outlined in this guidance—is one component of a comprehensive business case and is meant to complement and build on other Deep Dives in this series, including the Sustainable Funding and Governance Deep Dives.

Prior to executing an economic and financial analysis, it is important to have completed key preassessment steps summarized in Box 1.

BOX 1. Analysis Preparation Steps

Prior to executing an economic and financial analysis, it is important to have completed key preassessment steps from the Pre-Feasibility phase. It is germane to understand the water security challenge and the potential 'scope' of the intervention program, including objectives, potential NbS options and geographic scope. Your situation analysis should also collect water sector information, including supply and demand, who is responsible for water resource management, who the largest water users in the basin are, who determines water pricing and what the process is for doing so, and characteristics of the legislative and regulatory environment. This information is important for determining how your economic and financial analysis can be leveraged, and it will help determine the governance and institutional arrangement for your NbS program down the line (Governance Deep Dive).

As your team collects water sector information, you should also undergo a stakeholder mapping exercise. Box 3 and the Stakeholder Mapping Deep Dive have more information about the mapping process, and it's advised to read Step I of the guidance to understand what the stakeholder mapping is in service to in the context of an economic and financial analysis. You'll need to understand the main actors and their level of influence in order to choose a beneficiary or beneficiaries for your analysis. Not all stakeholders identified may be 'beneficiaries' (e.g., derive a monetary benefit from the NbS program) but engaging these other stakeholders will still be important for the success of your NbS program. See Table 4 for stakeholder engagement guidance.

Before beginning an economic and financial analysis, it's also critical the team undertake a survey of the existing data available, and any current modeling and valuation efforts. Your analysis should be additive and avoid duplicating ongoing or past work as economic and financial analyses can carry a substantial price tag. It's possible this research was done during a pre-feasibility assessment, but if it was not part of a prior information gathering effort, do so now.

If you have not completed the analysis preparation steps, please refer to the Pre-Feasibility chapter of the How-to Guide, and Table 3 which outlines common pitfalls of economic and financial analyses.

BOX 2. What are Water Funds?

A Water Fund is one type of Watershed Investment Program that can leverage nature to improve water security outcomes. They unite civil society and the public and private sectors around the common goal of securing water for communities by protecting natural water systems in a way that promotes sustainable economic development.

Water Funds help to make sense of and manage the significant complexities associated with nature-based source water protection by creating a governance and management structure that ensures an inclusive approach to water security. The water fund's governance structure connects multiple groups who are responsible for identifying and implementing mechanisms for the long-term financing of water security programs. Usually in a water fund, a downstream user will pay into the collective action structure which pools contributions from multiple sector actors to fund nature-based solutions in the catchment upstream. These programs focus on mobilizing the power of nature to improve water quality and supply in a way that is adaptive to changes in population and climate.

The United Nations estimates that 68 percent of the world's populations will be living in urban areas by 2050 (UN, 2018). As populations increase, economies grow, and standards of living improve, cities will need to meet increasing water demands. Many of these same cities will also be adjusting to the effects of climate change. Changing weather patterns and inconsistent precipitation are likely to increase the severity of droughts and floods depending on where you're living in the world.

Water Funds employ nature to find resilient solutions to cities' water security challenges. These collective action vehicles work with people living upstream to help them manage watersheds by implementing source water protection activities that will improve the productivity and resilience of their lands. We estimate that upstream forest protection, reforestation and improved agricultural practices could improve water quality for 4 out of 5 large cities around the world, thereby supporting social development and reducing economic risk (Abell et al., 2017).

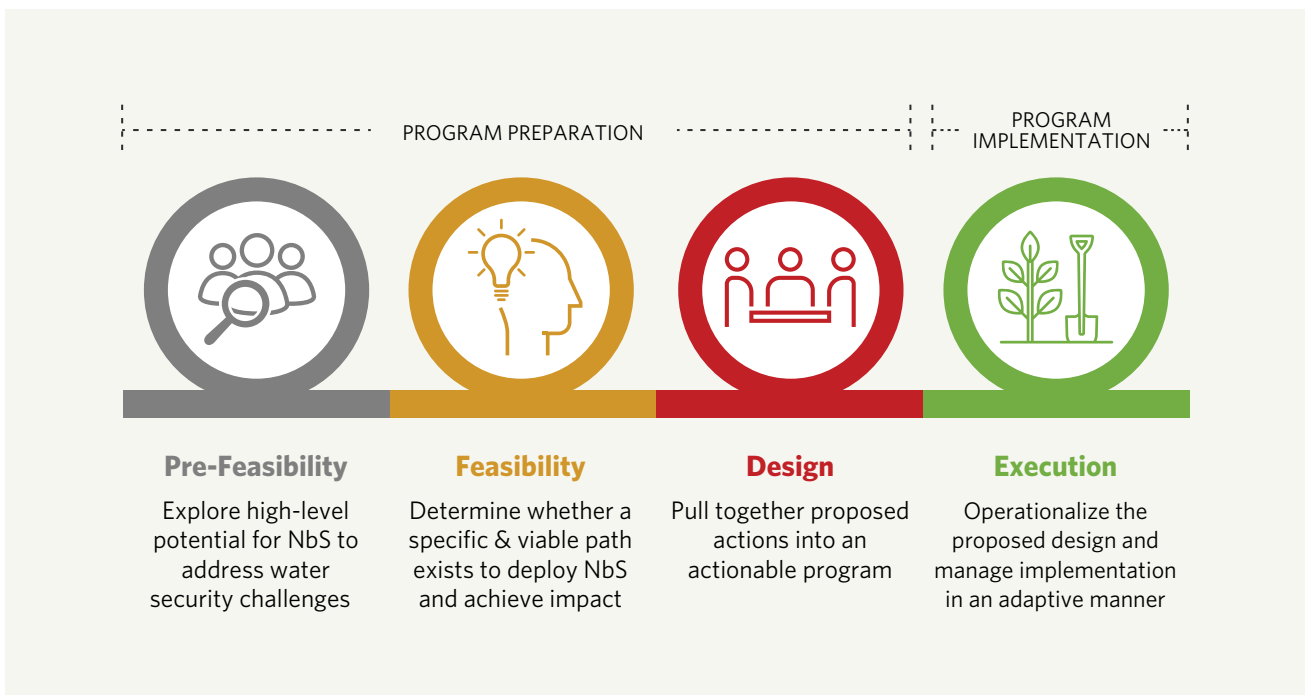|	PROGRAM PREPARATION		PROGRAM IMPLEMENTATION
Pre-Feasibility	**Feasibility**	**Design**	**Execution**
Explore high-level potential for NbS to address water security challenges	Determine whether a specific & viable path exists to deploy NbS and achieve impact	Pull together proposed actions into an actionable program	Operationalize the proposed design and manage implementation in an adaptive manner

FIGURE 1. The WIP Development Lifecycle. This Guidance is focused on the Economic & Financial Analysis usually performed during the Feasibility phase.

ECONOMIC AND FINANCIAL ANALYSES: DEGREES OF DETAIL

Before undertaking an economic and/or financial analysis, it is important to determine if they will meet the needs of—or are even the right tools to advance—your NbS project.

Whether an economic or financial analysis (or both), the same underlying methodology is used to value the benefits of NbS projects, but the difference lies in **who** benefits. In economic analyses, the beneficiary is generally society writ large. Public policy actors, for example, tend to use economic analyses to represent the total benefit of a project to the population in their jurisdiction. Financial analyses, on the other hand, typically quantify the financial benefits that accrue to one or more specific stakeholders, like utilities or corporations, rather than society writ large. These stakeholders are typically investors in the NbS program. While the underlying methodology—outlined in this document—is the same, the type of analysis you choose will undoubtedly affect some aspects like scope (analysis preparation), the type of valuation indicator chosen (Step VII), the discount rate (Step VII) and the value of benefits (Step VII), among others.

For simplification, this guidance jointly refers to the methodology of an economic and financial analysis since the underlying steps are the same. The guidance, however, will explicitly note differences when they arise.

Tables 1 and 2 outline the different degrees of detail—or scale—of economic and financial analyses that can be considered and how they can be leveraged to reach a project's goals.

In the WIP Project Cycle (Figure 1), the Detailed Economic and Financial Analysis (DEFA) and the Decision Support System (DSS) are prepared during the Feasibility Phase. These analyses are an essential building block to developing a compelling, actionable Strategic Plan (Design Phase) that not only articulates how the WIP will contribute to improved water security in the region, but how it will be managed, funded, and monitored and evaluated for impact. We suggest conducting the Basic Economic and Financial Analysis (BEFA) during the Pre-Feasibility phase of the WIP to help narrow the focus for your complete economic and financial analysis. A BEFA can also demonstrate whether there's even a preliminary ROI for your proposed project.

All three scales of the economic and financial analyses in Tables 1 and 2 have the same underlying methodology as outlined in this guidance. However, the detail of the analyses—and therefore the accuracy, applicability, and flexibility of the results—improves from left to right across the table. The primary difference between the Detailed Economic and Financial Analysis (DEFA) and the Decision Support System (DSS) is the ability to update the DSS over time to adaptively manage decisions as a program changes, e.g., to update biophysical models as in-field monitoring instruments begin generating data, or to reflect new beneficiaries that are investing in the program. The DEFA, by contrast, provides a snapshot in time for an investment, and therefore cannot be altered after completion to reflect these new realities. The analysis would need to be performed anew.

The BEFA provides a general estimate of the return on investment for a set of nature-based solutions. However, unlike the DEFA and DSS, the models used in the Basic Economic and Financial Analysis to calculate the ROI are usually built using readily available global or local data sets. As such, the BEFA will produce less accurate results than if a DEFA or DSS is employed. BEFAs are more useful for a quick assessment of whether NbS could produce the desired benefits in a cost-effective manner. However, building an NbS program and recruiting funders/investors will require more detailed analyses and should not be based on a BEFA. This scale of analysis is better used as a communications tool to socialize the potential NbS program with stakeholders and to secure their interest in performing a more rigorous assessment. It's important to caveat the results of the BEFA with your stakeholders so they understand what can and cannot be gleaned from the preliminary analysis. The Nature Conservancy has developed WaterProof, an online, open-source tool that conducts a high-level indicative return-on-investment analysis within 30-minutes. WaterProof is free and can be customized by the user.

It's worth noting upfront that all scales of economic and financial analyses will have a degree of uncertainty that needs to be addressed with your WIP's beneficiaries and stakeholders. The degree of uncertainty improves with more accurate, site-specific data, which may not be possible in all cases. Sites that may be great candidates for NbS interventions may not have invested in monitoring and evaluation and are, therefore, lacking a repository of data. If governments, utilities and/or regulators are interested in exploring the potential of NbS, it's recommended they begin a monitoring and evaluation program to improve the quality of their analysis and to verify the impact of their investments. Step VII has more information on how to better manage uncertainty and initiate monitoring & evaluation programs.

If, after reviewing Table 1, an economic and/or financial analysis seems to be the right tool to advance your NbS project, continue onto Table 2 to find the right economic and financial analysis for your purposes. The following section describes the format and content of this Guidance.

TABLE 1. Degrees of detail (scale) of economic and financial analyses that can articulate the economic and financial benefits of a watershed investment program

	BASIC ECONOMIC AND FINANCIAL ANALYSIS	**DETAILED ECONOMIC AND FINANCIAL ANALYSIS**	**DECISIONS SUPPORT SYSTEM**
Description	High-level ROI evaluation of a set of NbS catchment management interventions to generate water security. *A BEFA can indicate whether NbS interventions might be a viable option for solving local water security challenges. However, a project developer would need a DEFA or DSS to prepare an NbS project for investment.*	In-depth analysis that uses locational and stakeholder-specific data to ascribe the financial and economic benefits that accrue to specific downstream user beneficiaries or stakeholders. *A DEFA is a 'static' document, meaning it can show the potential benefits for an investor if they invested imminently. However, if they chose to implement the NbS program in 5 years, the analysis would need to be redone.*	In-depth scenario analysis tool that uses locational and stake-holder-specific data to ascribe the ROI benefits that accrue to downstream user beneficiaries or stakeholders; can be updated over time to assist decisions. *A DSS is a 'living' document + data management and visualization platform. It can be used for adaptive management of NbS programs to reflect increased implementation and investment.*
What is required *data inputs, cost, time*	Cost: US$20–40K Time: 2–4 mos. Data: portfolio of priority interventions & estimation of associated costs; global or readily available local data sets to use as inputs for ecosystem benefit model(s) **Note:** *TNC's WaterProof Tool is free and can provide a BEFA in less than 30-minutes.*	Cost: US$50–100K Time: 6–9 mos. Data: historical land-use-land-cover, hydrological data, regional or state-level driving policies, detailed costing of NbS interventions and operating platform, cost of competing grey solutions (i.e., filtration, pipes, etc.)	Cost: US$100K+ *Plus, additional ongoing mainte-nance requirements* Time: 9–12+ mos. Data: same as the Detailed Economic & Financial Analysis; impact reporting requires addition of implementation actuals
Typical modeling configuration[2] *See Appendix III*	Tier 1 model[3] (e.g., InVEST) and combined portfolio identification/ prioritization tool (e.g., RIOS)	Calibrated and validated Tier 2 model[4] (e.g., SWAT), maps of vetted intervention options (GIS), portfolio ROI optimization protocol (e.g., prioritize R library)	Same as business case, but includes visualization platform to facilitate scenario selection, adaptive management and impact reporting
Phase of WIP Project Cycle	Pre-feasibility, Feasibility	Feasibility, static	Feasibility + Design, adaptive
Comparison to DFI project lifecycle	Project Concept Development (Eligibility)	Project Preparation (Feasibility)	Project Preparation & Implemen-tation (Feasibility and Design)

TABLE 2. Pros and Cons of the scales of economic and financial analyses

2   There are other types of model configurations that can be used (Table 5). An example of a "typical" configuration is provided here to orient the reader.

3   Tier 1 model: long-term static analysis model based on average values across the time period, with basic representation of ecosystem processes intended for quick general results. Examples: InVEST, WaterWorld.

4   Tier 2 model: model with calculation time steps allowing for dynamic simulation, based on time series, with detailed results representing ecosystem processes. Examples: SWAT, HEC-HMS, HydroBID.

	BASIC ECONOMIC AND FINANCIAL ANALYSIS	DETAILED ECONOMIC AND FINANCIAL ANALYSIS	DECISIONS SUPPORT SYSTEM
What it allows you to do	• Communicate to stakeholders the potential opportunity for NbS to generate water security outcomes • Quantify potential economic or financial benefits of an NbS project • Stimulate interest in conducting a DEFA or DSS to develop an NbS project or program • Explore next steps for building an NbS investment program	• Evaluate the economic and financial benefits an NbS portfolio could provide to specific beneficiaries or stakeholders • Outline a portfolio of NbS interventions to inform funding/financing strategy and governance/institutional arrangement • Compare costs and benefits of alternative grey infrastructure or NbS investments • Build a monitoring & evaluation program to assess impact of NbS investment • Outline a specific implementation scenario for use in subsequent budgeting and fundraising exercises • Advocate for regulatory or policy change • Pursue funding for an NbS project or program	In addition to the capabilities outlined under DEFA, a DSS allows project teams to: • Facilitate partner collaboration, especially among multiple implementing parties • Flexibly model projected water security benefits under different funding scenarios • Identify potential for repayable financing • Provide impact reporting on implementation, spending and modelled benefits • Adaptively manage to refine the NbS program's implementation plan based on ex-post monitoring and implementation data
Pros	• Fewer resources and less capacity required to execute • Doesn't require detailed, locally specific datasets • Can be used to stimulate potential interest in NbS and fundraise for a DEFA or DSS	• Provides framework to support current needs of the NbS project • Identifies high-priority locations for intervention and informs project design • Quantifies financial and economic benefits for stakeholders and beneficiaries • May motivate funding and governance commitments from stakeholders • Strong communication & advocacy tool for beneficiaries and stakeholders	Same as DEFA, plus: • Living; provides framework to support ongoing needs of the NbS project • Iterative and can be updated over time with new base layers of information • Can flexibly evaluate implications of different funding and financing scenarios • Can be used to justify operating budget forecasts
Cons	• Very high degree of uncertainty • Low degree of attributability • Stakeholders and beneficiaries may not view as sufficiently credible to merit investment in the NbS program	• Static; does not support adaptive management • Requires high-level of stakeholder engagement • Data intensive • Significant capacity needs regarding ecosystem modeling and financial & economic analyses • Degree of uncertainty and risk that must be mitigated	Same as DEFA, plus: • Requires significant resources, including maintenance requirements for adaptive management • Stakeholder engagement and co-creation more extensive than DEFA process

THE GUIDANCE

This guidance is developed for non-expert practitioners, and therefore serves as an introduction to economic and financial analysis best practice to identify the most cost-effective package of NbS interventions. It provides an overview of,

(1) the economic and financial analysis methodology;

(2) the capacities required to complete the analysis;

(3) the types of economic and financial tools and indicators (return on investment, net present value, benefit-cost analysis, etc.) you can calculate;

(4) how to communicate results to your stakeholders, and

(5) how you can use the results to leverage funding

Each step of the methodology starts with a short introduction describing the purpose and expected outcomes of the step, and information the team should have in hand before advancing to the next phase. A series of key questions are also provided to help project teams navigate each stage.

Throughout, the guidance references key capacities that are important for specific phases of the methodology:

• Project Manager

• Ecologist

• Hydrologist/Modeling Specialist

• Stakeholder Engagement Specialist

• Economist

• Water Supply Systems Specialist (*if conducting an economic and financial analysis for a large water user*)

• Communications Specialist

A team member can represent more than one capacity listed above, but for the sake of the reader, we have separated the skills. While the team should be well-integrated and collaborative throughout the process, certain steps will require increased participation from specific team members. At the beginning of each step, alongside the introduction & key questions, these capacity profiles will be listed under Team Members, indicating their increased participation. Defined roles and responsibilities for each of these profiles can be found in Appendix I. While the guidance is developed with the non-expert practitioner in mind, you will need experts to complete this analysis.

The document is designed to follow the preparation of a theoretical economic and financial analysis as it progresses through the steps outlined in the methodology, Figure 2. The theoretical analysis focuses on reducing sedimentation for an invented utility who is interested in reducing its treatment costs by employing nature-based solutions in the watershed. Actual examples from past economic and financial analyses are scattered throughout the guidance so readers can get a broad sense of how the methodology can be applied to a range of scenarios.

There is a growing body of knowledge on the subject and this guidance is not all encompassing. Other partners and leaders in the field have produced valuable guidance on this topic (Pearce et al., 2016, Browder et al., 2019, Eastern Research Group, Inc., 2015). World Resources Institute's working paper *Green-Gray Assessment: How to assess the costs and benefits of green infrastructure for water supply systems* (Gray et al., 2019) presents a six-step methodology with three pre-assessment steps to assess the costs and benefits of integrated green infrastructure into existing water supply systems. We recommend readers also review this guidance once they gain an under-standing of the basic process.

The approach outlined in this document is based on past field experience and analyses performed by The Nature Conservancy, in particular, Kroeger et al., 2017, *Assessing the Return on Investment in Watershed Conservation: Best Practices Approach and Case Study for the Rio Camboriú PWS Program* which presents a series of principles and a framework for performing economic and financial analyses. Appendix II contains references to additional resources and case studies—including Kroeger et al., 2017—that can help the reader go further.

COMMON PITFALLS OF ECONOMIC AND FINANCIAL ANALYSES

The success of your economic and financial analysis is largely dependent on your team's level of preparation and stakeholder consultation, as well as your team's knowledge of the project development cycle. It's important the project manager understands how to use the economic and financial analysis to help inform a project's funding and financing strategy (Sustainable Funding Deep Dive) and future governance and institutional framework (Governance Deep Dive). Clear objectives for your NbS project or program will also clarify the scope of the analysis and drive more effective collaboration.

There have been cases where economic and financial analyses have not furthered a program's objectives due to poor execution and lack of preparation. Table 3 outlines common pitfalls to avoid during the process and how to do so. Revisiting this table throughout the project will help your team produce a practical return on investment study that can be leveraged to meet your program's objectives.
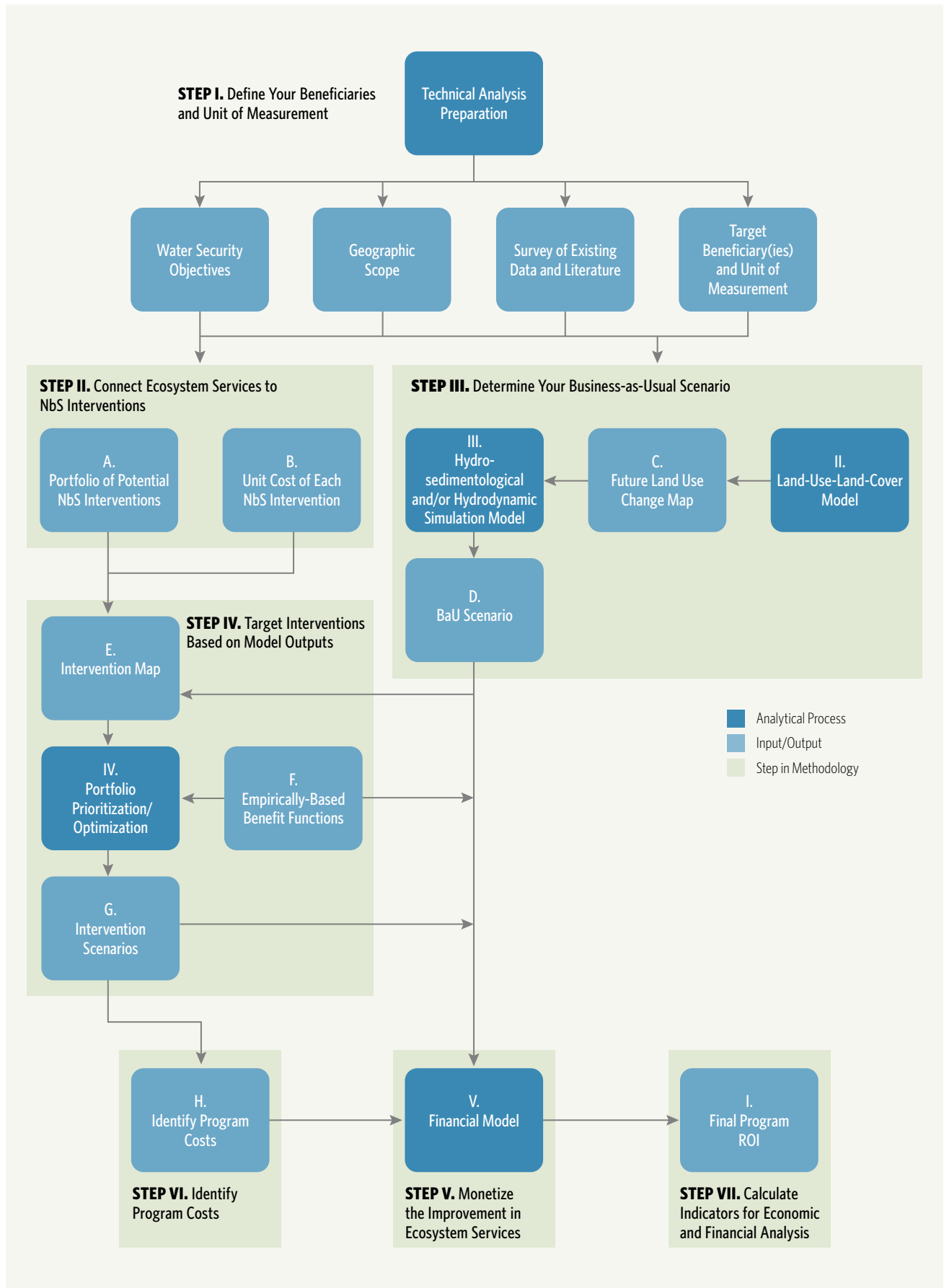

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TABLE 3. Common pitfalls when developing economic and financial analyses for Watershed Investment Programs

PHASE	PITFALL	DESCRIPTION	WHEN TO ADDRESS
Technical Analysis Preparation	Scope	The geographic scope and the NbS interventions considered in the analysis should reflect the programmatic objectives of the potential NbS project. The team should consult their beneficiaries and stakeholders to ensure they agree with the scope of the analysis before any modeling work begins. While the team will likely decide geographic scope and objectives of the NbS project in the analysis preparation phase, pre-feasibility or a situation analysis) the scope of this analysis should be confirmed with your beneficiary and/or stakeholders to ensure it will enable them to assess the viability of the proposed NbS program (Step I). Likewise, the refined list of potential NbS interventions considered in this analysis should reflect the stakeholders and beneficiaries' interests, as well (Step II). It will likely be a refined version of the potential NbS interventions your team identified in Pre-Feasibility.	**Objectives of NbS Project** Technical Analysis Preparation **Geographic Scope** Technical Analysis Preparation **Preliminary List of NbS Interventions** Technical Analysis Preparation **Refined List of Potential NbS Interventions** Execution (Step II)
	Leverage results for influence	Understanding how your results can be used to influence water sector actors, change policy and regulation, influence future water supply development plans, plug into existing planning and investment processes, etc. will be critical for the success of your NbS project. It's not recommended teams conduct an economic and financial analysis until they are certain of the use case, and understand how the analysis could be leveraged. It's also helpful to understand how the proposed NbS project aligns with environmental and social safeguards defined by development finance institutions (DFI). If your project intends to seek funding from, or is being developed in partnership with, a DFI, your project team should reference the appropriate safeguards throughout the project development process.	**Influencing Water Governance** Technical Analysis Preparation (Pre-Feasibility or Situation Analysis)
	Leveraging analysis for funding and governance	Teams should read the WIP cycle outlined in the How-to Guide for better insight into the project development cycle before beginning an economic and financial analysis. Foresight of subsequent steps can improve engagement with stakeholders and beneficiaries, and create a product that can be used to develop a funding & financing strategy and inform the permanent governance and institutional arrangement of a program. Many NbS projects have also found it helpful to establish interim governance and institutional arrangements—e.g., working group or steering committee—to aid in decision-making and provide advice or guidance to the burgeoning project. It helps stakeholders stay engaged and improves collaboration and buy-in when the time comes to formally establish the NbS project or program. The Governance Deep Dive outlines considerations for interim and permanent governance structures.	**Review Project Development Cycle** Technical Analysis Preparation; before Step I
	Inadequate resources: funding & capacity	Before beginning the analysis, it's important to build a team with the right capacities and ensure there's enough funding to complete the work. Don't choose an economic and financial analysis with the wrong degree of detail (Tables 1 and 2) because you don't have enough funding for the analysis your project really needs, e.g., don't perform a BEFA if you really need a DSS. When building your team, refer to Appendix I for a table of recommended team members and a description of their profiles and responsibilities. If outsourcing the analysis, see the accompanying Terms of Reference templates.	**Assemble Team & Secure Funding** Technical Analysis Preparation; before Step I

PHASE	PITFALL	DESCRIPTION	WHEN TO ADDRESS
Execution	Method	When choosing your modeling process, it's important to match the models and datasets your team is using to address the scope defined in Analysis Preparation and refined in Step I. In addition to consulting with your beneficiary to determine if they have any preferences, your team should consult other expertise whose endorsement of the methodology may be important to the success of your project. Get stakeholder endorsement early to ensure they will agree with the results of the analysis and how it was undertaken, once complete.	**Models, Datasets, proposed methodology** Step III
	Engagement with beneficiaries	Before building and running your models, the team should consult with its defined beneficiaries to ensure that they are valuing the ecosystem services that their beneficiary cares about. This will ensure you're using the right unit of measurement and empirically-based benefit functions to assess the benefit of the NbS program. Defining the valuation methodology will usually require looking into the stakeholders' own facility arrangements and overall investment program, e.g., agreeing upon the specific intake arrangement of the water treatment plant; the sediment management program of the hydropower dam; the alternative water supply options during a low-flow period, etc.

Once your team is ready to calculate the economic and financial value of the NbS program, ask your beneficiaries which discount rate and economic and/or financial indicator they prefer. It's particularly important for the team to get these right so the results of the analysis speak your beneficiaries' "language" and are therefore useful to them. | **Ecosystem Services & Metric** Step I

Empirically-based Benefit Function Step V

Discount Rate & Indicator Step VII |
| | Engagement with stakeholders | In addition to bringing in expertise and stakeholders to consult on the models and datasets used in the analysis, they should be involved in reviewing interim and final results. Review periods where their feedback can be solicited are built into the template Terms of Reference, and Table 4 has detailed information on how to engage stakeholders during each step of the process.

Before modeling your intervention scenario (Step V), the team should validate the practicality of the proposed NbS interventions by consulting with the stakeholders who will be responsible for implementation on the ground. For example, if your team is going to propose cover crops on agricultural lands in the basin, you should confirm that farmers are willing to implement these practices on their lands. If they are not, even with financial incentives, your team should remove this as a potential NbS under consideration. Alternatively, if farmers are willing to implement cover crops but the incentive payments for doing so are not feasible, you should consider whether it's truly a viable NbS. While this may not be necessary for a BEFA, it is definitely a necessary touchpoint for a DEFA and a DSS. | **Review Interim & Final Results** Step III, Step IV, Step VII

Validate NbS Practicality Step II & Step IV |
| | Leveraging analysis for funding & governance | As the analysis progresses, teams should keep in mind the subsequent steps that the economic and financial analysis will help inform: developing a funding and financing strategy Sustainable Funding Deep Dive) and establishing a governance and institutional arrangement (Governance Deep Dive). Having clear costs and benefits in financial and economic terms will help projects identify potential sources of funding and recruit their support. A clear portfolio of NbS interventions and the stakeholders who will be critical to their implementation—whether on the ground, directing funding, or creating favorable regulation—will help choose a suitable governance and institutional framework. | **Preparing for Sustainable Funding Strategy & the WIP's Governance arrangement** Step I–VII |
| **Post-Analysis** | Communication | Once your analysis is complete and you have the results in hand, it's time to present the outcomes to your beneficiaries and stakeholders using language and a format that resonates with them. As a result, the team will probably produce a few communications pieces, each with a different level of detail and focus. For example, a government agency responsible for watershed health may prefer a presentation with an in-depth analysis of the methodology, while a member of the public may prefer an infographic summarizing the high-level ecosystem services or co-benefits they may receive, e.g.,clean water, organic foods, increased green space or a nature preserve. | **Communicating Results to Stakeholders** Post-Analysis |

FIGURE 2. The methodology, analytical processes and inputs/outputs for an economic and financial analysis outlined in this Guidance.

STEP I. Define Your Beneficiaries and Unit of Measurement

Technical Analysis Preparation

Water Security Objectives

Geographic Scope

Survey of Existing Data and Literature

Target Beneficiary(ies) and Unit of Measurement

STEP II. Connect Ecosystem Services to NbS Interventions

A. Portfolio of Potential NbS Interventions

B. Unit Cost of Each NbS Intervention

STEP III. Determine Your Business-as-Usual Scenario

III. Hydro-sedimentological and/or Hydrodynamic Simulation Model

C. Future Land Use Change Map

II. Land-Use-Land-Cover Model

D. BaU Scenario

STEP IV. Target Interventions Based on Model Outputs

E. Intervention Map

IV. Portfolio Prioritization/ Optimization

F. Empirically-Based Benefit Functions

G. Intervention Scenarios

Analytical Process

Input/Output

Step in Methodology

H. Identify Program Costs

V. Financial Model

I. Final Program ROI

STEP VI. Identify Program Costs

STEP V. Monetize the Improvement in Ecosystem Services

STEP VII. Calculate Indicators for Economic and Financial Analysis

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STEP I:
Define your beneficiaries and unit of measurement

During this step, the core project team will define the (1) beneficiary(ies) of the NbS interventions and (2) ecosystem services that affect the water security challenges the defined beneficiary(ies) care about improving. The ecosystem services outlined in this section will influence which nature-based solutions, or interventions, the project team considers in subsequent steps of the economic and financial analysis. The analysis will only consider interventions that improve the ecosystem services defined during this step.

TEAM MEMBERS: Project Manager, Stakeholder Engagement Specialist (could also be the Local Lead), Ecologist, Hydrologist.

KEY QUESTIONS:

↗ Who are your target beneficiaries? What are their views about nature-based solutions? Do they understand the potential benefits?

↗ Who are your stakeholders?

↗ Does your team have a strong relationship with the stakeholders and beneficiaries you have outlined?

↗ What benefits do your beneficiaries and stakeholders care about?

↗ Are your beneficiaries willing to provide you with details about their operations and associated costs. *This will be very important in subsequent steps in order to calculate the beneficiary's return on investment (ROI).*

↗ What ecosystem services provide the benefits your beneficiaries and stakeholders care about?

↗ What metrics can you use to measure ecosystem services that represent their value to your beneficiaries and stakeholders?

DEFINING THE BENEFICIARY

In order to define the focus of your economic and financial analysis, you must first define the **beneficiary(ies)**. Your beneficiaries will be the stakeholders who derive a financial or economic benefit from the nature-based solutions implemented in the watershed because they have—or intend to—invest in the NbS program. Some examples of common beneficiaries are utilities, beverage companies, municipal governments, energy producers, etc. As noted in the introduction, your beneficiaries will be different depending on whether you are undertaking an economic or a financial analysis, and, therefore, not all stakeholders may be "beneficiaries".

It is important, however, that the project team chooses a beneficiary (or group of beneficiaries) with which they have a strong relationship. A stakeholder analysis can facilitate the process (Box 3). If the project team does not yet have a beneficiary with strong interest in the project, the Stakeholder Engagement Specialist can help cultivate the relationship. Before moving forward with the analysis, however, the team should have identified their beneficiaries and received confirmation that they will advise and engage in the process.

For a financial analysis to be compelling, it must accurately calculate the beneficiaries' **return on investment (ROI)**, so the project team will need input from them during this step of the financial analysis (Step VII). The ROI is a common financial metric of profitability that measures the return—monetary value of the benefits the stakeholder receives—for the money they invested. To assign monetary value to benefits, the project team will need a window into a beneficiary's operations, and the costs associated with these operations.

To give an oversimplified example, if we are calculating the ROI for a utility that is interested in decreasing the amount of sediment in the water it filters, it would be helpful for the project team to know their filtering process and the costs associated with that process. If the interventions in the watershed improve soil retention, thereby reducing the concentration of sediment that reaches the filtration plant, will the utility need to use less chemicals to purify the water? How much less will they need to use and what is the cost of that savings compared to what they invested in the watershed interventions?

As you can see, if a project team is unable to assign monetary value to these benefits, they will be unable to calculate the ROI for their stakeholder. We focus on how to identify the benefits a stakeholder cares about—referred to, from here on, as ecosystem services—in the section below.

IDENTIFYING THE RIGHT ECOSYSTEM SERVICES

Once you have chosen and defined the beneficiaries of your project, you can now focus on identifying the ecosystem services for your economic and financial analysis. But what, specifically, are ecosystem services? It's important to distinguish among e**cosystem services**, **function**, **benefits and values**, as they each have different definitions that can be confused in an analysis. Figure 3 defines each term and their relationships.

In your economic and financial analysis, you will specifically focus on the *final* ecosystem services, those components of nature that are directly enjoyed, consumed or used to produce human well-being, and you'll define these services with metrics that reflect the characteristics crucial to generating the benefits your stakeholders care about.

Let's continue with the example posed earlier in this section. You'll recall we chose a utility as our beneficiary. Figure 3 gives the example of *clean freshwater flows* for municipal water supply as the ecosystem service. However, this can be further defined for a utility as a reduction in concentration of total suspended solids (TSS) at the filtration plant's intake point. Focusing on the final, specific ecosystem service—TSS concentration at the intake point—will help avoid double counting the value of intermediate services.

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This is important because the value of a service, in this case reduced TSS concentration, can often vary widely depending on how that service is used. One cubic meter of water with reduced TSS concentration will produce different magnitudes of benefits whether that cubic meter of water is used for municipal water supply, crop irrigation, hydropower or swimming. Likewise, the value of that cubic meter of water can vary depending on location or the time that it is used; the value of TSS concentration will vary depending if it's high or low flows.

Before moving on to Step 2, it's important the project team ensures they can quantitatively relate the ecosystem service(s) they defined to benefits the beneficiary will experience. In essence, ensure that the ecosystem service(s) defined can be translated into economic or financial value for the beneficiary.

ENGAGING YOUR STAKEHOLDERS

Similar to Step I, throughout the analysis, your team will need to engage your beneficiaries and stakeholders during key steps to solicit their feedback and approval. Adequate consultation will ensure the results of your analysis are applicable to their needs and meet their expectations. Additionally, stakeholders who are consulted throughout the process are more likely to endorse or support the NbS program and invest.

Table 4 outlines key steps of the analysis where your stakeholders should be engaged and consulted.

FIGURE 3. Definition of ecosystem functions, services, benefits and values. Adapted from Kroeger et al., 2017.
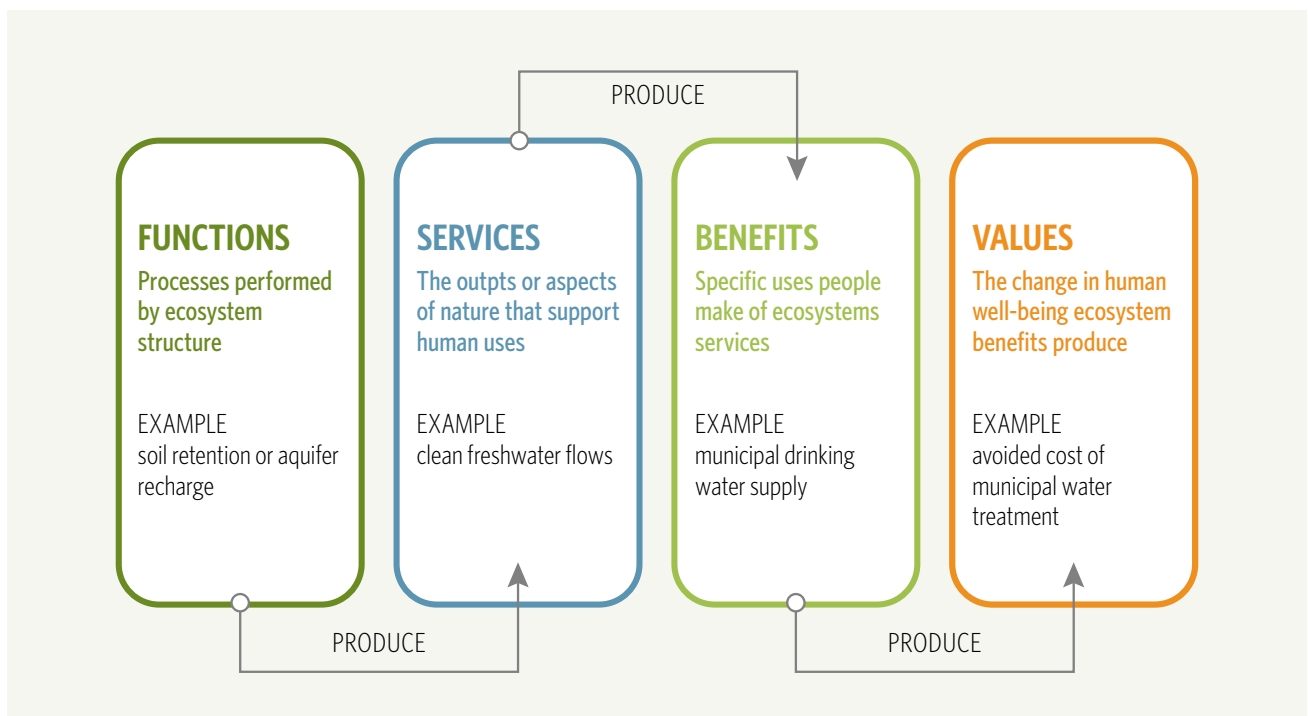
BOX 3: Defining Your Beneficiaries?

Before completing an economic and/or financial analysis, your WIP should have successfully completed Pre-Feasibility stage (Figure 1) during which your team would have completed a stakeholder mapping exercise and identified those stakeholders who could (1) benefit from the WIP, (2) become champions for the WIP, (3) may feel adversely affected by the WIP, and/or (4) have potential to influence or by influenced by the WIP, e.g., catchment management agencies, water services providers, water resource management agencies, etc.

At the end of the mapping exercise, stakeholders will have been categorized into one or more of the following groups:

- **MEMBER OF THE WIP:** support the project by being part of an interim (e.g., steering committee, working group, etc.) or permanent governance structure (e.g., board member). Stakeholders will participate in providing input and endorsing strategic direction of the project and may provide financial support to the WIP.

- **COLLABORATION AND COORDINATION:** stakeholders will not be members of the WIP, but will be important in supporting land use planning, development planning, and environmental regulation. These stakeholders could impact how results of the analysis are implemented in the watershed.

- **UPSTREAM STAKEHOLDERS:** stakeholders that live in or manage land in the watershed and that will be affected when the WIP implements activities on the ground. You may need their support to implement some of the NbS activities.

- **TECHNICAL EXPERTS:** typically includes institutions or individuals that hold detailed technical knowledge of the study area. Their endorsement of the financial and economic analysis methodology may be important, especially if they have provided similar services to institutions in the past.

- **NGOS AND OTHER ORGANIZATIONS:** typically includes organizations that are already implementing conservation actions on the ground or that have a specific expertise

- **DEVELOPMENT AGENCIES & PHILANTHROPY:** usually emerge if the study area is a priority for development agencies or a donor; such stakeholders can be important to building financial support for your Watershed Investment Program. Understanding DFI safeguards will be important in this context.

- **POTENTIAL OPPOSING STAKEHOLDERS:** any stakeholder that may oppose or criticize the WIP. A strategy should be developed to mitigate any opposition or risks that these stakeholders may pose.

To define your beneficiaries, return to your stakeholder map and identify those who would derive a seemingly disproportionate financial or economic benefit from the WIP's activities; usually, these stakeholders will have been identified as potential members of the watershed investment program. Conduct interviews with these stakeholders and gauge interest to financially invest; this may have been done in the Pre-Feasibility stage. In these interviews, it may be beneficial to find out whether your stakeholders have experience investing in NbS, have previously considered investing, or have current plans or potential limitations for investing in NbS. For example, a utility may already have plans to invest in catchment management but does not have a clear understanding of their potential return on investment. How can this process add value to their existing plans? Understanding their experience can help your team better communicate results and manage uncertainty and expectations. It's also helpful to understand the mandates of your stakeholder, e.g., managing catchments, bulk water treatment, reticulation, etc., so your analysis is as applicable to their context, as possible.

Ideally your beneficiaries should show interest in investing, and your business case can elucidate the economic and/or financial return their investment would incur.

More information on stakeholder mapping can be found in the Stakeholder Mapping Deep Dive.

TABLE 4. Steps of the economic and financial analysis where stakeholders should be consulted, and their feedback solicited. A selection of questions is included from each step. For a complete list of questions, refer to the specific step in the methodology.

STEP	STAKEHOLDER CONSULTATION
Technical Analysis Preparation *This should be done before your economic and/or financial analysis*	Before you begin the analysis, your team should have stakeholders and beneficiaries identified who are interested in partnering with you to demonstrate the benefits of the proposed NbS program. If your team has not identified the stakeholders and beneficiaries for your economic and financial analysis, refer to Box 3 to conduct a stakeholder mapping exercise. A BEFA will allow you to understand which stakeholders—in particular, beneficiaries—are most important for the NbS project. Before conducting a DEFA or DSS, your team will want specific beneficiaries, e.g., potential funders or investors, on board. During pre-work, your team will also identify the geographic scope and objectives of the NbS program, which should be clearly articulated with endorsement from your stakeholders and beneficiaries. A situation analysis should also be conducted to understand how results from the economic and financial analysis could be used to influence water sector actors, regulation, and/or spending. During this process, stakeholders are often interviewed to glean insights on how the analysis could be leveraged for influence, and to socialize them with the proposed NbS program early on. As you begin to assemble the team for the execution of the analysis, you should also solicit the support—even if solely advisory—of those stakeholders who may not be the beneficiaries of the analysis but who will have an opinion about the results and the future of the NbS program. This is especially important if there are already existing organizations or agencies doing catchment-related management work in the same geographic area. Your team will want to liaise with them to understand the potential additionality of your program's efforts and to leverage knowledge from existing implementation activities. Their input and endorsement of the process will be important in subsequent steps of the analysis, and it's necessary they commit to engaging in the process before the analysis begins in earnest. It may be advisable to review with them the overall proposed methodology (Steps I–VII) of this guidance to solicit any feedback or concerns. Please refer to Table 3 & Box 1 for more detail about the analysis preparation process.
STEP I *Define your beneficiary and unit of measurement*	During the initial stakeholder consultation, your team should define: • The benefits and co-benefits your beneficiaries and stakeholders care about; • The ecosystem services that provide the benefits your beneficiaries and stakeholders care about; • The metrics you can use to measure ecosystem services that represents their value to your beneficiaries and stakeholders. You should also confirm whether your beneficiaries are willing to provide you with details about their operations and associated costs. Understanding the true costs of your beneficiaries' operations (Step V), will help produce an accurate return on investment calculation in Step VII. If your beneficiary is the local utility, the Stakeholder Engagement Specialist can help your team understand the utility's concerns and craft messaging to get the utility on board. Utilities may not be convinced that NbS can improve ecosystem services to help meet demands, or that they can be more cost-effective than alternative grey infrastructure or help improve its functionality. During this step, you should inform the other local stakeholders and experts—identified during analysis preparation—of advancements in the process and any future requests for their time and input.
STEP II *Connect ecosystem services to conservation interventions*	After having identified the interventions that could improve ecosystem function, some teams choose to run this list of interventions past their stakeholders to solicit their feedback; particularly regarding the estimated costs of these interventions. Further, teams have found that consulting their stakeholders—even briefly—during this step provides an opportunity for them to raise questions or concerns before the modeling process begins and serves as another engagement touchpoint to strengthen relationships. In some cases, this step may have already been completed as preliminary work ahead of the economic and financial analysis as part of the Pre-Feasibility stage. Many teams use this to develop relationships and solidify commitments to collaborate.

STEP	STAKEHOLDER CONSULTATION
STEP III *Determine your business-as-usual scenario*	During the stakeholder consultation, your team should define: • The time horizon most appropriate for your stakeholders; • Whether your beneficiaries have peak and off-peak season demand patterns or temporally variable water quality concerns; • The level of uncertainty in hydrologic outputs that are acceptable to your beneficiaries; • The most appropriate models to demonstrate land-use-land-cover change, hydrologic & hydraulic conditions in the basin of interest, as appropriate; Your beneficiaries and stakeholders may also have preferences regarding the types of data—and their resolution and timescale—your team uses for the analysis. You should ask if they have a vested interest or preference, and the models and datasets chosen should match the scope defined during analysis preparation. Most teams will have confirmed data availability during analysis preparation. Using the same data your beneficiaries and stakeholders employ to make operation & management decisions could strengthen the results of the return on investment return-on-investment analysis; outputs are more likely to be comparable to other analyses your beneficiaries use to consider alternative infrastructure investments. During this step, your team should also consult with other well-regarded experts and stakeholders to ensure they agree with how the analysis is undertaken. After the BaU modeling, your team should reconvene with your beneficiaries and stakeholders to share preliminary results and solicit their feedback before moving into the interventions. In reality, this step is likely to require several touchpoints with your stakeholders depending on the complexity of the modeling, the data requirements, the level of uncertainty they're comfortable with, etc. It is important the Local Lead and/or Stakeholder Engagement Specialist maintain consistent, strong communication with your stakeholders, including prior notice to schedule meetings, and ample time to review and provide feedback on products from your modeling specialist(s).
STEP IV *Target interventions based on model outputs*	Before moving onto this step, it is important that your stakeholders have had the opportunity to review results of the BaU models. If they have not, do not move on to this next step. Using the list of potential interventions & their associated costs identified in Step II, your modeling specialists will choose the interventions that will create the highest improvement in ecosystem services, as compared to the BaU scenario, for the least cost. After your modeling specialist(s) has modeled the intervention scenario for your NbS project, you should communicate the preliminary results to your stakeholders. However, be very clear that these are not the final results, but rather the projected improvement in ecosystem services.
STEP V *Monetize the improvement in ecosystem services*	For your Economist to perform the return on investment analysis, you will need a strong relationship with your beneficiaries to get the required information for an accurate calculation. If you were unable to get clarity in Steps I and III regarding, • Your beneficiaries' peak and off-peak season demand patterns; • Your beneficiaries' projected water supply requirements, how they plan to meet the needs and projected cost of these planned interventions; • Your beneficiaries' temporally variable water quality concerns; • Whether your stakeholders are willing to provide you with details about their operations and associated costs; It's important to re-approach your beneficiaries to get clarity, if possible, so you can determine the empirically-based benefit functions most applicable to your stakeholders. Empirically-based benefit functions are those quantitative relationships that allow us to economically value ecosystem services in a way that is meaningful to the beneficiaries' bottom lines. For example, a reduction in total suspended solids concentration could reduce the treatment plant's application of a specific chemical "Y", or proportionally reduce the amount of water lost in sludge treatment. Your stakeholders should approve the benefit functions.
STEP VI *Identify program costs*	This step does not necessarily require consultation with your stakeholders, but some teams choose to touch base to validate program costs, including those assumed to be incurred by the beneficiary. For example, if your team intends to embed the results of this analysis as a permanent function in one of the beneficiaries' (e.g., utility's) operations it would be beneficial to get their input before calculating ROI.

STEP	STAKEHOLDER CONSULTATION
STEP VII *Calculate indicators for economic and financial analysis*	Before calculating indicators, it's important the team consult with its beneficiaries to, • Determine the appropriate discount rate; • Determine the economic and financial tools and indicators most useful to their decision making process; • Confirm an appropriate time horizon was used; • Brainstorm other co-benefits they might care about. It's important to communicate the preliminary results to get your beneficiaries' feedback and incorporate changes that will improve subsequent rounds of calculations. You should also use this time to review the assumptions made—and, ideally, approved by your beneficiaries—during the analysis, and note which portions of the analysis are important to them. This will help your team effectively communicate the final results and highlight those portions they weigh heavily when making decisions. Your team should also review the risks and uncertainties of the analysis with your beneficiaries at this time. If they have been closely involved, this should not be a surprise for them.
POST-ANALYSIS *Communicating results of the economic and financial analysis*	A polished report—and associated appendices, hi-res native files and geodatabase—will be prepared by the contractors (or team) to disseminate the results and details of the analysis. However, it's important you further distill the results for your beneficiaries and stakeholders. It's highly unlikely they will read an entire report, so it's important you consult them to determine what information they need to know and how they would like that information to be presented, e.g., abbreviated report, technical presentation, high-level presentation, etc. Though the full report will likely be distilled for your stakeholders, you should still ensure the appendices have a technical manual or methodology section describing in detail how the analysis was performed.

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STEP II:
Connect ecosystem services to NbS interventions

During this step, the project team will begin to associate the ecosystem services defined in Step I to NbS interventions, like reforestation or protection, that can improve their outcomes. In this section of the economic and financial analysis, the project team will focus on the improvements they can make to ecosystem function that will, in turn, improve the ecosystem services about which their beneficiaries care. Refer to the NbS Factsheet Deep Dives for helpful guidance on choosing potential NbS options.

Note, this step may have been partially completed during the Pre-feasibility stage. During the Pre-feasibility or situation analysis, the team will have likely already identified challenges the watershed is facing—water availability, flooding, water quality, etc.—and possible interventions that could improve ecosystem function and, therefore, ecosystem services.

TEAM MEMBERS: Project Manager, Ecologist, Hydrologist.

KEY QUESTIONS:

↗ What improvements in ecosystem function could, in turn, improve the identified ecosystem services?

↗ What conservation interventions can improve the identified ecosystem function?

IDENTIFYING ECOSYSTEM FUNCTION

In Step I, we defined ecosystem function as the processes performed by ecosystem structures. Figure 3 gave two examples of ecosystem function, soil retention and aquifer recharge. In our utility example, we are concerned about producing clean water flows for municipal drinking water supply (our ecosystem service) and have identified that we will measure the quality of this service using the concentration of total suspended solids (TSS), commonly expressed as milligrams per liter (mg/L) of water, because that is the metric relevant to our stakeholder.

To reduce the TSS concentration at the filtration plant's intake point, we need to consider the ecosystem function(s) that, if improved, will lower the amount of sediment reaching the plant. In our case, soil retention seems like the likely answer.

IDENTIFYING CONSERVATION INTERVENTIONS

Once the ecosystem function—soil retention—has been identified, determine which NbS interventions will likely generate the greatest improvement in the performance of the ecosystem function. Using soil retention as an example, there are a number of interventions that may be effective: reforestation, riparian buffers, forest or wetland protection, no till agriculture, etc. These interventions should be listed along with their relative unit costs.

The team will usually enter the economic and financial analysis with a number of potential interventions—referred to as **nature-based solutions** or **source water protection** activities—identified. The subsequent steps in the economic and financial analysis will help the team narrow down their list and determine which interventions will be most cost-effective.

There are two components that should be considered when determining if an intervention is cost-effective: spatial and temporal. In some locations, it may be more cost-effective to plant new trees while in other locations it may be more cost-effective to save the trees that are already there (Daigneault and Strong, 2018; The Nature Conservancy, 2019). These are spatial elements that should be considered in subsequent steps.

Likewise, how land is used often changes over time. Consider a relatively well forested sub-basin situated directly adjacent to farmland. While today this sub-basin is forested, the farmland it is next to, has slowly been expanding outward for the past five years. If this pattern continues, in five years from now, this previously well forested sub-basin could be converted to farmland. This land change indicates that, while we may not need to implement any activities now, in five years, we may need to plant a riparian buffer between the newly converted farmland and the nearby river. The model could also consider whether agricultural best management practices could adequately reduce the impacts of the new agricultural land. This is assuming that project teams have conducted the needed stakeholder outreach and know that farmers would be willing to undertake these practices.

In some areas of the world, the hydrology of watersheds is changing quite rapidly and will continue to do so as climate change advances (Fan and Shibata, 2015; Furniss et al., 2010). If applicable, your economic and financial analysis should consider how changes in hydrology due to future weather patterns, temperature, etc. could impact your watershed and the ecosystem benefits your team is interested in improving or maintaining.

We will address how to predict land use and hydrology changes in Step III, next.

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STEP III:
Determine your business-as-usual scenario

During this step, the project team will model a business-as-usual scenario. You will be modeling what the watershed would look like in the future without NbS intervention from your program, and how this is expected to impact the ecosystem service(s) you identified in Step I. You will need a specialist for this step who can model the projected land use and land cover change and how these will affect the hydrology of the watershed. Often, the team will contract with highly specialized, technical staff who will be able to build, calibrate and run a model for the study area—watershed, sub-basin, etc.—your team has identified.

Your contractor or modeling specialist(s) will perform this step, but it is explained below so the project team can understand the general process. A template Terms of Reference is included as an accompanying resource for teams who will contract out the modeling portion of the analysis.

TEAM MEMBERS: Project Manager, Stakeholder Engagement Specialist (could also be the Local Lead), Ecologist, Modeling Specialists & Hydrologist

KEY QUESTIONS:

↗ What are the recent patterns of land-use-land-cover change?

↗ Do you have LULC data stretching back at least 10 years?

↗ What is the spatial resolution of these LULC changes? Are the expected LULC changes detectable at the spatial resolution satellite imagery is available? If not, are in-situ data available?

↗ Do you foresee a change in any major drivers of recent LULC change (e.g., expected policy or regulatory changes, major changes in markets, or future infrastructure development)?

↗ Is accurate, reliable data for the watershed available on the hydrologic parameters of concern (e.g., precipitation, streamflow, suspended solids, nitrogen)? What is the length and spatial and temporal resolution of these data?

↗ What time horizon is most appropriate for your beneficiaries? Do your key beneficiaries have peak and off-peak season demand patterns or temporally variable water quality concerns (e.g., after high-precipitation event; during low flow periods) you should be aware of?

↗ What are your beneficiaries' current and projected water supply requirements and how do they plan to meet these needs? What are the projected costs of the planned interventions? It may also be useful to understand how they plan to fund the future options, e.g., water tariffs, repayable financing, etc.

↗ What is the current and projected water demand in the basin? (not just for your beneficiaries)

↗ What level of uncertainty in hydrologic outputs is acceptable to your beneficiaries?

BUSINESS AS USUAL: LAND-USE-LAND-COVER (LULC)

The **business-as-usual (BaU)** scenario models what the watershed will look like in the future if the NbS interventions identified in Step II are not implemented by your proposed NbS program. The BaU LULC model will produce a map of the projected land use and land cover over a specified time horizon to show how ecosystem function is expected to change over time. When combined with hydro-sedimentological and water quality modeling— explored in the next section—your BaU scenario will show how ecosystem services change over time without NbS intervention. The BaU model is referred to in this guidance as "the world without the NbS program interventions". Knowing what the watershed will look like in the future without your program's interventions, will allow you to measure the change in ecosystem functions, and ecosystem services, that you can attribute to the conservation interventions you implement (Step IV).

The **time horizon**—how far the model projects into the future—chosen for the BaU scenario should be something that makes sense to your beneficiaries, and you should consult with them on that point. In our example of the water utility, the time horizon would likely be between 25 and 30 years, as that is the typical lifetime of a traditional water treatment plant. In general, mechanical and electrical treatment plant systems and pumping stations have a lifespan of 15 to 25 years, while concrete structures have a lifespan of 60 to 70 years (EPA, 2002).

Choosing an appropriate time horizon will allow you to compare the cost-effectiveness of your interventions with that of other solutions your stakeholders may be considering. These solutions are often, though not always, traditional grey infrastructure interventions like increased water treatment or building a new reservoir to meet water needs. In the case of a green-grey infrastructure investment, you would model the combined intervention and compare it to a grey-only intervention. More about modeling interventions is explained in Step IV.

As mentioned, at the top of this section, one component of the BaU scenario is modeling **land-use-land-cover (LULC)** changes over your specified time horizon. **Land cover** data documents how much of a region is covered by forests, wetlands, impervious surfaces, agriculture, and other land and water types. Water types include wetlands or open water. **Land use** shows how people use the landscape—e.g., for timber, agriculture, development (transport and other built infrastructure, residential, commercial, industrial), conservation, or mixed uses (NOAA, 2018). The combination of land-use-land-cover notes what the landscape is covered by and how the landscape is used, e.g., protected (*use*) wetlands (*cover*).

Understanding how a landscape is being used will be important for your model because it will help you determine where NbS interventions will have the greatest impact on ecosystem function. For example, unless groundwater exploration in wetland catchment areas are allowed, it is unlikely that a protected wetland will experience development in the future. Therefore, it may be beneficial to concentrate your NbS interventions in another, unprotected area of the watershed that is at risk for development.

The common methodology for predicting future LULC is projecting forward the magnitude and patterns of past LULC from a recent "reference" period, e.g., the past 10 years. The "reference" period of LULC should be from a time that you believe represents the conditions that will affect land cover and use during your chosen time horizon, e.g., the next 25–30 years.

This methodology – projecting future LULC change based on past LULC change during a recent "reference" period—assumes there will be no major change in the factors that cause LULC change. In cases where the number, size or effect size of these factors is expected to change—e.g., demand for commodities can drive changes in LULC that are difficult to foresee—more complex LULC models may be needed to produce LULC change projections. However, the cost and time required to develop such models should be carefully weighed against how much these models are expected to improve your prediction of LULC change.

In many cases, there may be other, more straightforward ways to incorporate certain changes in some LULC change causal factors such as expected changes in relevant LULC laws and regulations or their enforcement. Additionally, other partners or agencies may already be employing NbS in the basin and have plans to continue to do so into the future. If possible, the trajectory of this work should be included in your model.

The spatial resolution of the analysis will be determined by the size of observed actual LULC changes during the reference period. If a sizeable proportion of undesirable LULC changes are very small scale, a finer spatial LULC resolution is required to model LULC change. Conversely, if most of the LULC change occurs in large patches, then coarser-resolution LULC change modeling is sufficient. For example, small family farmers may be more likely to expand their operations at the scale of meters per year, while large agroforestry can expand at the scale of hectares per year. Slash-and-burn agriculture, on the other hand, can expand at a rate surpassing both of these operations. Knowing the past pattern of LULC change can help your project team understand what might be driving the change in LULC, and therefore, determine the appropriate spatial resolution for your LULC model.

In all cases, you should work with your stakeholders to figure out what level of uncertainty they are comfortable with, and whether they prefer a particular method for projecting LULC changes. In some cases, it may be necessary to employ a formal modeling approach using custom-designed models or off-the-shelf-software like Land Change Modeler (LCM). See Table 5 for a selection of models.

BUSINESS AS USUAL: HYDRO-SEDIMENTOLOGICAL AND WATER QUALITY ANALYSIS

Understanding how land cover and use may change over your time horizon is the first part of this step, but you'll need to take the modeling a step further to understand how this land use change will affect the hydrology, sedimentology and water quality of your basin. The Soil & Water Assessment Tool, or SWAT, model is commonly used during this phase. Again, Table 5 lists commonly used models.

To continue with our example, we have just modeled the future land-use-land-cover change of our watershed over a 25-30-year time horizon because that is the most appropriate timeframe for the utility. The BaU LULC model has identified areas of the watershed where land use or cover change is expected to occur, and is likely to impact the ecosystem function, soil retention, identified in Step II. The hydrologic analysis can estimate how much this change in soil retention—resulting from the change in LULC—will affect the hydrologic parameters your stakeholders care about: flow of water and concentration of sediments in the watershed.

For our purposes, let's assume the model has projected that previously forested areas will be converted to pasture or cropland within the next 15 years. The loss of ecosystem function resulting from this land-use-land-cover change will impact the ecosystem service in which our utility has a vested interest, in the form of clean freshwater flows for municipal water supply. Specifically, our beneficiary is particularly interested in the clean freshwater flows that are available for abstraction at municipal water intakes, which ultimately feed the municipal water supply. To do this, the model's outputs must be generated (1) for the specific locations at which ecosystem services are used ("beneficiary locations") and hence generate economic and/or financial benefits, and (2) at the required temporal resolution.

To demonstrate what this change in ecosystem function means for the utility, we should use the metric defined in Step I—the concentration of TSS, commonly expressed as milligrams per liter (mg/L), of water at the intake of the municipal water supply.

BUILDING & TESTING YOUR HYDRO-SEDIMENTOLOGICAL AND WATER QUALITY MODELS

Note, if you are focused on modeling flood risk, also see Box 5 for hydrodynamic modeling considerations.

Your contractor should follow the modeling protocol and apply established minimum best-practice guidelines for hydro-sedimentological and water quality model development and evaluation (e.g., split-sample approach for calibration and testing), and the model's performance on key outputs (e.g., discharge; TSS or total sediment) should meet established criteria for at least fair model performance to ensure credibility of the overall ROI analysis (Moriasi et al., 2007). The protocol stipulates when performing mathematical modeling, one must first characterize the process, then build a conceptual model. Once your contractor has this conceptual model, they will evaluate which model (or set of models) is the most appropriate.

The modeling approach is also affected by the temporal (annual, monthly, daily, or hourly) and spatial resolution (at specific points in the catchment) of model outputs required for the analysis of priority ecosystem services for the beneficiaries. As mentioned, the spatial resolution of the analysis will be determined by the size of observed actual LULC changes during the historical reference period. Model data needs, and the extent to which they can be met with data that is already available or that can be generated through field experiment, will also impact the appropriate modeling approach.

Your beneficiaries and stakeholders may also have preferences regarding the types of data—and their resolution and timescale—your team uses for the analysis. You should ask if they have a vested interest or preference, and the models and datasets chosen should match the scope defined during analysis preparation. Using the same data your beneficiaries and stakeholders employ to make operation and management decisions could strengthen the results of the return-on-investment analysis; outputs are more likely to be comparable to other analyses your beneficiaries use to consider alternative infrastructure investments. During this step, your team should also consult with other well-regarded experts and stakeholders to ensure they agree with the data and models used.

See Figure 4 for a diagrammatic representation of the steps in building a predictive model that connects interventions with ecosystem services.

These criteria should be stipulated in the Terms of Reference for your contractor. See the associated Terms of Reference template.

IDENTIFYING POTENTIAL AREAS FOR INTERVENTION

The areas of your watershed where modeled changes in ecosystem function lead to the greatest improvement in ecosystem services your beneficiaries care about, are areas where you should initially consider implementing your interventions. It's unlikely, however, that you will end up targeting every area, as not all will be equally cost-effective in producing your target ecosystem services. For some, the cost of implementing your interventions may exceed the economic or financial benefit your beneficiaries would receive. We discuss how to choose locations and interventions in Step IV.

If climate change is affecting—or is likely to affect—the hydrology of your study area within the specified time horizon, then it should be considered in the analysis. Available information on the local impacts of climate change on temperature and precipitation should be incorporated into the hydro-sedimentological and water quality models as appropriate.

In many watersheds, however, water-use and demand are far-more urgent drivers of water insecurity in the study area, and climate change may not significantly alter the results of the models. Additionally, if locally-verified data is unavailable, incorporating climate predictions could introduce a level of uncertainty that is difficult to mitigate. Teams should consult with their beneficiaries and stakeholders to understand the level of uncertainty they are comfortable with and review available existing literature to decide whether climate change is in scope.
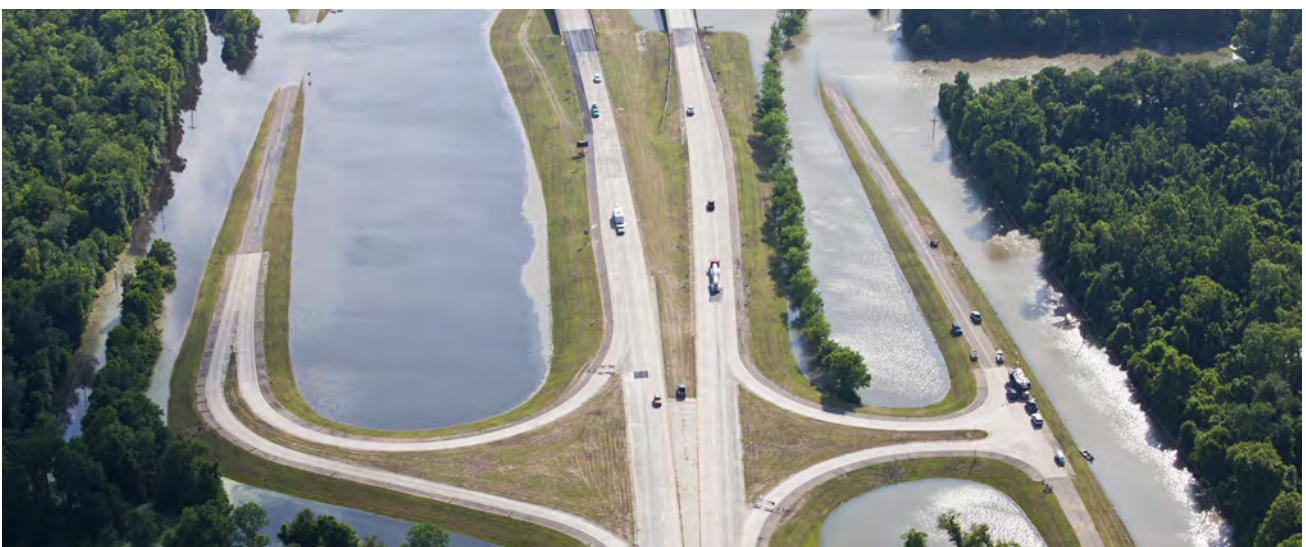
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TABLE 5. Selection of models that can be used to model ecosystem function in a watershed. This list is not all encompassing, and several models may be used in conjunction.

MODEL	DESCRIPTION
RIOS	**Resource Investment Optimization System (RIOS)** Provides a standardized, science-based approach to watershed management in contexts throughout the world. It combines biophysical and social data to help users identify the best locations for protection and restoration activities to maximize the ecological return on investment, within the bounds of what is socially and politically feasible. *Note: At the time of writing, RIOS is still available for download, but its support and updates have been removed.*
ROOT	**Restoration Opportunities Optimization Tool (ROOT)** Performs optimization and tradeoff analysis using information about potential impact of restoration or management change activities together with spatial prioritization or serviceshed maps to identify key areas for ecosystem service provision. Multi-objective analysis allows users to consider how to best manage tradeoffs between different project goals.
InVEST	**Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST)** A suite of free, open-source software models used to map and value the goods and services that nature provides. Enables decision-makers to assess quantified tradeoffs associated with alternative management choices and to identify areas where investment in natural capital can enhance human development and conservation.
SWAT	**Soil and Water Assessment Tool (SWAT)** A small watershed to river basin-scale model used to simulate the quality and quantity of surface and ground water and predict the environmental impact of land use, land management practices, and climate change. Widely used to assess soil erosion prevention and control, non-point source pollution control and regional management in watersheds.
HEC-HMS	**Hydrologic Engineering Center – Hydrologic Modeling System (HEC-HMS)** Designed to simulate the complete hydrologic processes of dendritic watershed systems. Includes event infiltration, unit hydrographs, and hydrologic routing; evapotranspiration, snowmelt, and soil moisture accounting; and gridded runoff simulation. Supplemental tools provided for model optimization, forecasting streamflow, depth-area reduction, assessing model uncertainty, erosion and sediment transport, and water quality.
Marxan	**Marxan** Provides decision support for a range of conservation planning problems including designing new reserve systems, reporting on performance of existing reserves, and developing multi-use zoning plans for natural resource management. Identify areas that meet targets for a range of biodiversity features, select planning units to complement the conservation area network, and identify tradeoffs between conservation and socio-economic objectives.
Hydro-BID	**Hydro-BID** Open-source simulation tool to support the management and planning of water resources in the Latin America and Caribbean region; represents over 230,000 catchments in the region and their corresponding topography, river and stream segments. Useful to organize and aggregate scarce data, to simulate basin hydrology driven by climate, and to model water resources at all time scales. Suitable for planning and design of water resources infrastructure.
WaterWorld	**WaterWorld** A testbed for the development and implementation of land and water related policies for sites and regions globally, enabling their intended and unintended consequences to be tested *in silico* before they are tested *in vivo*. Can be used to understand the hydrological and water resources baseline and water risk factors associated with specific activities under current conditions and under scenarios for land use, land management and climate change. A series of interventions (policy options) are available which can be implemented, and their consequences traced, through the socio-economic and biophysical systems.

BOX 5: Special Cases: Hydrodynamic Modeling

In some cases, water funds or NbS projects may want to address flood attenuation and control, in which case a hydrodynamic model must also be employed. The hydrodynamic model uses data from the hydrologic models to consider the whole regime of possible event sizes and their statistical likelihood of occurrence in any given year, referred to as a return period.

In addition to a hydrologic model, which provides the river discharges resulting from particular precipitation events, to model flooding, your team will need digital elevation models (DEMs) with a vertical resolution sufficiently high to reflect local morphological characteristics in the area of flood concern; at least 1 m, preferably finer in densely developed areas. A digital elevation model uses elevation data to create a 3D representation of a terrain's surface and is one key input to a hydrodynamic model, which analyzes how a high-flow event will inundate the area of interest. Generally, hydrodynamic models should be run on return periods of 1, 5, 20, 100 and, sometimes, 500 years. Model calibration should use available data from recent flood events (precipitation, flood footprints).

To model flooding in the BaU scenario, the hydrologic model considers the entire basin to generate hydrographs (discharge curves) for each of the return period precipitation events for a point immediately upstream of the area of flooding concern. Where appropriate, the hydrologic model should incorporate the impact of future climate change on precipitation. While the solution to reduce flooding may be—and often is—located upstream of this point, the model needs the volume of water flowing to this point so the hydrographs can be fed into the hydrodynamic model, which propagates the flows through the area of concern, generating an estimate of the flooded area for each return period. The hydrodynamic model outputs for each return period are then integrated to yield the mean expected annual inundation area in the BaU scenario. Maps of land-use-land-cover, buildings and infrastructure can be overlaid with the flood maps to identify the land uses and covers and number of buildings or infrastructure affected by flooding in the BaU scenario. The same process is then used in the intervention scenario, in which the BaU LULC map is modified to reflect interventions that reduce overland flows ("runoff") or attenuate the propagation of those flows downstream (e.g., expansion or restoration of natural wetlands; creation of constructed vegetated flood retention ponds; or "grey" infrastructure such as stormwater retention basins), thus changing the shape and height of the hydrograph ahead of the areas of concern for flooding. The difference between the flood footprints and affected assets represents the expected flooding mitigation impact of the interventions.

To adequately assess the benefits of flood mitigation interventions, the flood maps should include as many assets that are damaged by flooding as possible. At a minimum, it should differentiate the flooded structures by type (e.g., residential homes, businesses, industry, schools, hospitals, transport and other infrastructure). Flood damages are a function of both inundation depth and duration as well as the velocity of flood waters. Thus, adequately assessing the damages to constructed infrastructure, especially buildings, may require use of two-dimensional hydrodynamic models that can represent flood height as well as flow velocity, such as FLO-2D, HEC-RAS 2D, Iber 2D, Flood Modeller 2D, PCSWMM 2D, SRH-2D, Hydro_AS 2D, or FATHOM-Global.

It should be noted that detailed estimations of flood damage—impact forces and structural stability—for water supply infrastructure can be very difficult. Hydrodynamic modelling can also be very expensive, so if cost is a barrier, meet with your stakeholders to understand what level of uncertainty they are comfortable with and if they would be open to exploring other options. For example, if there is data on flooding events and it can be correlated with precipitation return periods and flows, the hydrological model at the watershed may suffice. It would tell you under which conditions you would expect a flood and how NbS could contribute to reducing that flow and, therefore, the severity of a flooding event.

FIGURE 4. Process to create predictive models that connect interventions with ecosystem services. Adapted from Anderson and Woessner, 1992.
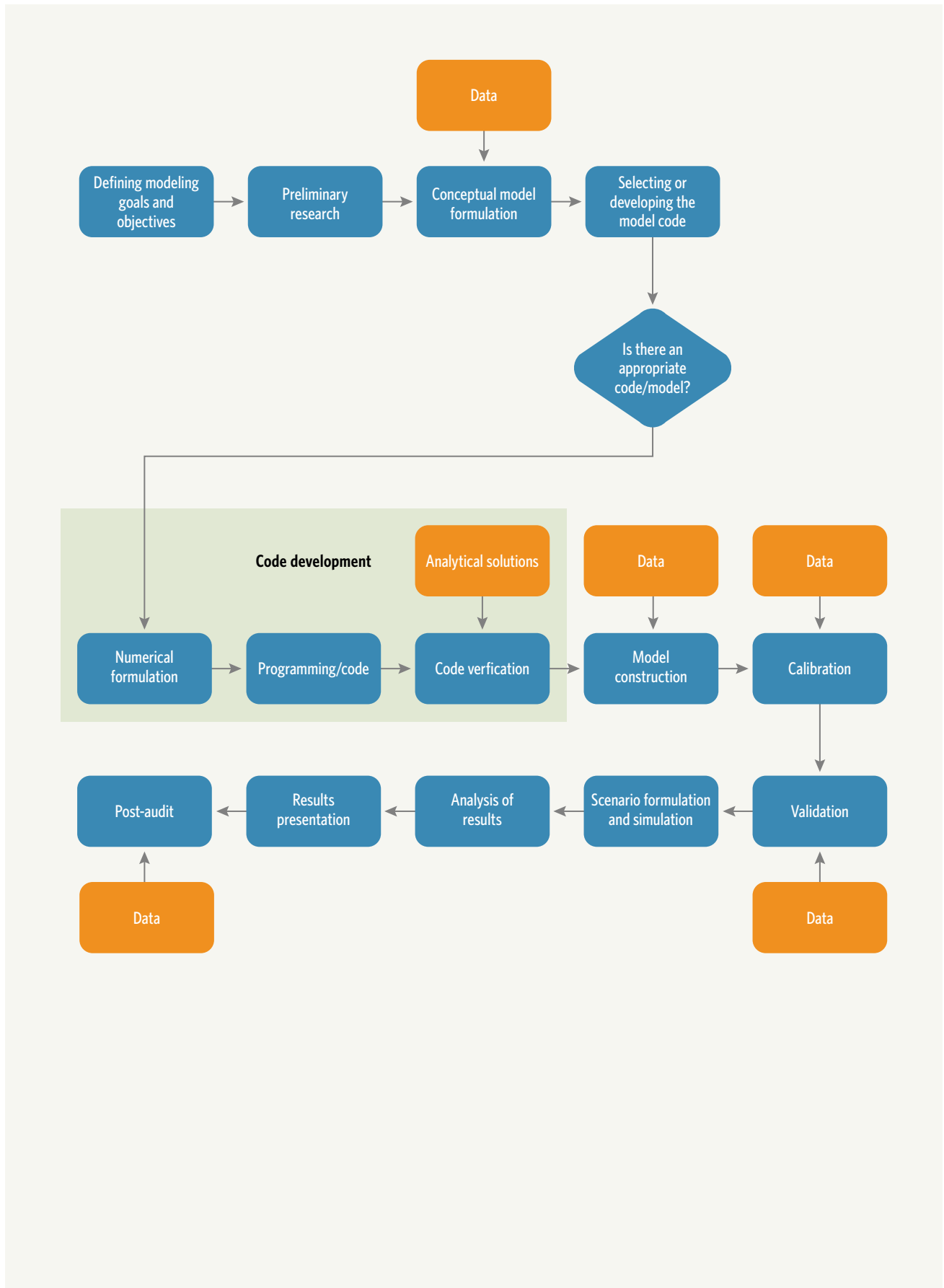
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STEP IV:
Target interventions based on model outputs

During this stage of the economic and financial analysis, your project team will develop an intervention portfolio based on the costs and benefits of potential NbS. The intervention portfolio describes the type of activities that will be implemented, where they will be implemented within the watershed and when they will be implemented. You'll also model what the watershed will look like when the activities in your intervention portfolio are implemented, so in order to move on to this next step, your BaU LULC and hydro-sedimentological and water quality (and, where flood mitigation is a key objective, your BaU hydrodynamic) modeling will need to be complete. Results from the intervention scenario will be compared to the BaU LULC & hydro-sedimentological and water quality and/or hydrodynamic models to quantify the difference in performance of the ecosystem function.

Your contractor or modeling specialist(s) will perform this step, but it is explained below so the project team can understand the general process. A template Terms of Reference is included as an accompanying resource for teams who will contract out the modeling portion of the analysis.

TEAM MEMBERS: Project Manager, Ecologist, Modeling Specialists, Hydrologist, Economist.

KEY QUESTIONS:

↗ What restoration activities are included on the list of potential interventions? How much do these interventions cost?

↗ What conservation activities are included on the list of potential interventions? How much do these interventions cost?

↗ Where in the watershed does the BaU LULC model indicate the greatest amount of land change?

↗ Of the LULC areas indicated, which will have the greatest impact on ecosystem function as indicated by the hydro-sedimentological and water quality models?

↗ What is your cost-effective intervention portfolio?

↗ What is the difference in ecosystem function—and ecosystem benefits—between your BaU and Intervention scenario?

REFINING YOUR PORTFOLIO

Recall the list of potential interventions—nature-based solutions or source water protection activities—created in Step II. *Your contractor will refine the list during this step, but the process is explained below for full understanding.*

Here is where you will identify regional or sub-regional priorities, which is a key objective of this analysis. **Priority intervention sites will be those that, compared to the BaU scenario, would yield the highest avoided loss (or largest gain) in priority ecosystem services per unit cost.**

In essence, you are conducting a least-cost exercise. To identify priority intervention sites, consider the interventions you have chosen, their associated costs, any identified feasibility constraints (legal, political-institutional, social), the land use change and the flow of water, nutrients, sediments, etc. in your watershed. For a DEFA and DSS, it's important that the NbS interventions you're using for this step have been vetted with your beneficiaries and your stakeholders. If your model indicates agricultural best management practices could be a solution for nutrient management, your team should vet the application of these NbS with the farmers upstream who would ultimately be responsible for implementing these activities.

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Using the feasibility and cost-effectiveness selection criteria—where will your program see the greatest improvement in ecosystem services for the least cost—your contractor should select an intervention portfolio subject to expected budget constraints.

RESTORATION, MANAGEMENT OR CREATED NBS INTERVENTIONS

Let's take our utility case, for example. Recall we're interested in improving the soil retention in our watershed, thereby producing cleaner freshwater flows and reducing the concentration of TSS in one cubic meter of water at the intake point of our utility's treatment plant.

For restoration, management or created NbS activities, we'll first identify lands that are already bare or mostly bare, e.g., degraded pasture, agricultural lands, etc. and consider where, out of these areas, the hydro-sedimentological and water quality models indicate the highest expected sediment flows. We'll then select the NbS activities that will reduce sediment flows in these areas. NbS could include floodplain restoration, agroforestry, created wetlands, etc. We should consider how these lands will change over time and exclude any currently bare lands that are expected to revert to forest by the end of our time horizon. These areas may be better suited for other interventions, like conservation.

CONSERVATION NBS INTERVENTIONS

To determine which areas of the watershed are best suited for conservation, we'll repeat a similar methodology. We'll first select the lands that our land-use-land-cover model predicts would either change from the desired ecosystem to bare/mostly bare land—e.g., wetland converted to farmland—or would, inversely, change from bare/mostly bare to the desired ecosystem—e.g., pasture to forest, by the end of our 25 to 30-year time horizon. Then consider, out of these lands, where the model indicates the highest expected sediment yield. Our team might then select for immediate conservation, those lands that are predicted to yield the greatest amount of sediment and that are predicted to be converted from forests or wetlands to other uses by the end of our time horizon. For those areas that the model predicts will naturally revert to the desired ecosystem over the 25- to 30-year time horizon, we might consider conservation measures 10-15 years into the NbS program.

It's important for project managers to understand that in order to incorporate the identified NbS interventions into the models your contractor built in Step III, they will need to convert your list of NbS into a spatially explicit representation across the area of intervention. This is referred to as an intervention map in Figure 3.

INTERVENTION SCENARIO: RUNNING THE MODELS AGAIN

Now that you have your BaU model and have identified where you can implement your NbS interventions, you are ready to model how your watershed will perform under the implementation scenario.

When creating your LULC implementation scenario, you will first model what the land use change will be with the identified NbS activities identified, and then subsequently model how that land use change will affect the flow of water, nutrients, sediments, etc. in the watershed using hydro-sedimentological and water quality models. Again, you will want to connect these NbS interventions with improvements in ecosystem function and, thereby, your ecosystem service. For our utility example, we would want to know the concentration of TSS, commonly expressed as milligrams per liter (mg/L), after the nature-based solutions have been implemented. The modeling output will lay the groundwork for the economic and financial analysis in subsequent steps.

INTERVENTION SCENARIO: HYDRO-SEDIMENTOLOGICAL AND WATER QUALITY MODELS

After you have modeled the LULC for the intervention scenario, repeat the hydrologic modeling. Again, the Soil & Water Assessment Tool (SWAT) is commonly used, see Table 5. It is important to consider the temporal dimension in terms of attenuation of benefits for modeling ecosystem function. For example, if you are reforesting an area or planting riparian buffers, it will take time for the trees to reach their full soil attenuation potential, and, therefore, the amount of benefits incurred over time will vary. Ecosystem function will improve as the trees grow and, eventually, they will reach their full potential, at which point, the benefits will level out.

Conversely, let's pretend you are interested in increasing the volume of water available for use, rather than concentration of TSS. In this example, your interventions involve removing invasive plants which use a lot of water to grow. Benefits—increased volume of water—will be apparent almost immediately and will level out when the SWP activities transition from removing invasive plants to maintaining the level of invasive plants, e.g., low-level of invasives or free of invasives. The Nature Conservancy is addressing invasive plant removal in Cape Town, South Africa. The reader can find more information about the South Africa analysis in Box 6.

In the next step, you will monetize the improvement in ecosystem services that were produced by the interventions, so it's important you leave this step with a good understanding of the improvement your beneficiaries will receive. Again, your beneficiary can be a single utility, multiple private companies or society writ large. The latter is common for economic analyses that are performed for governments or other public policy actors.

At the end of this step, your contractor will have built an implementation portfolio of NbS activities noting where in the watershed and when throughout the time horizon they will be implemented.

While we have presented Step IV as a linear process, it is often, in reality, an iterative method that may take the team through several rounds of trial and error to find the most cost-effective NbS portfolio. It can be a complicated process, and the contractors and team will need to closely collaborate to find the portfolio that best accomplishes the objectives identified with your stakeholders and beneficiaries at least cost.

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STEP V:
Monetize the improvement in ecosystem services

In this section, your team will take the analysis a step further by monetizing the benefits of these ecosystem services, specifically as they relate to your beneficiary. At the end of this step you should have an estimate of the benefits to your beneficiaries.

Your contractor or Economist will perform most of this step, but it is explained below so the project team can understand the general process. Sometimes teams prefer to conduct the stakeholder engagement process, themselves, while other times, they prefer to contract out. A template Terms of Reference is included as an accompanying resource for teams who will contract out the economic and financial analysis.

TEAM MEMBERS: Project Manager, Economist, Stakeholder Engagement Specialist (could also be the Local Lead), Ecologist, Water Supply Systems Specialist.

KEY QUESTIONS:

↗ Do you have a strong relationship with your beneficiaries?

↗ Do your beneficiaries have capacity to collaborate with your team at this time?

↗ What are the operations of your beneficiaries' businesses and what are their operations associated costs?

↗ Do your beneficiaries have peak and off-peak demand seasons you should be aware of?

↗ When will your NbS interventions be implemented?

↗ When will investors start to see benefits? By what time will full benefits accrue?

EMPIRICALLY-BASED BENEFIT FUNCTIONS

To quantitatively relate ecosystem services to specific, actual benefits for your beneficiary, your team should use **empirically-based benefit functions**. Empirically-based benefit functions refer to those quantitative relationships that allow us to economically or financially value ecosystem services in a way that is meaningful to the beneficiary's bottom line. For example, a reduction in TSS concentration could reduce the treatment plant's application of a specific chemical "Y", or proportionally reduce the amount of water lost in treatment sludge. In some cases, it may be beneficial to consider potential avoided capital costs of reduced TSS concentration in addition to operational costs.

This step requires intimate knowledge of the beneficiary's operations and associated costs, so, during this stage, the team will be expected to work closely with their beneficiaries to ensure the results of the analysis are relevant to their needs. As noted in the introduction, it's important to build a strong, collaborative relationship with your beneficiaries and stakeholders before starting the economic and financial analysis process. Poor engagement is one the common pitfalls of financial and economic analyses (Table 3). As you'll note, it's pivotal to successful execution of Step VII in the process.

TEMPORAL CHANGE: MONETIZING AND ACTUALIZING BENEFITS

When monetizing ecosystem services, it's important to keep in mind any temporal shifts in benefit from the perspective of your beneficiary. From an environmental perspective, there may not be any change in the performance of our ecosystem service—the TSS concentration per liter of water may remain constant all year round—but our utility may have a peak and off-peak demand season which changes how they value that TSS concentration. Many tourist destinations, for example, see vastly increased demand during the summer months due to an influx of vacationers.

In The Nature Conservancy's Camboriú, Brazil study, the team distinguished between peak and off-peak demand periods (Kroeger et al., 2019). The team assumed that in off-peak months the plant was able to meet their water needs, and therefore, there was no demand for any additional water output. As such, the team decided that the reduced water loss from lower TSS concentrations could be used to reduce water intake—rather than increase water outtake—overall, during off-peak months.

On the other hand, during peak months, when excess supply to meet peak demand frequently approaches zero, the team assumed that the reduced water loss from lower TSS concentration could be used to increase the water

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output from the plant. The increased output would allow the plant to keep their short-term storage infrastructure at capacity.

From season to season, the lower TSS concentrations did not change. However, the benefits that lower TSS concentrations bring to the plant differ in value depending on peak vs. off-peak demand. The valuation changes depending on the portion of the treatment plant's operation cycle that is affected—reducing water intake (off-peak) and increasing water output (peak).

In addition to seasonal variation in benefit valuation, we should revisit the temporal incidence of benefits that was discussed in Step IV. If you are reforesting an area or planting riparian buffers, it will take time for the trees to reach their full soil attenuation potential, and, therefore, the amount of benefits incurred over time will vary. Ecosystem function will improve as the trees grow and, eventually, they will reach their full potential, at which point, the benefits will level out.

In the Camboriú case, they assumed that the impact of forest restoration on TSS increased linearly from zero in Year 1 to 100% in Year 10. Conservation activities, on the other hand, avoid forest loss and therefore achieve full functionality in the year they are implemented. Economists, in this case, spread the total conservation and restoration interventions evenly over their implementation period, 2015–2022. As such, because they assumed forest restoration would take 10 years for benefits to actualize, the full TSS control potential is first achieved in 2032; 10 years after the last restoration work in 2022.

This step may, in reality, blend with Step IV as empirically-based benefit functions are important for determining the NbS intervention scenarios that can generate the most benefit for your beneficiaries and/or stakeholders. However, to ensure the accuracy and practicality of the economic & financial analysis, it's pivotal the project team correctly defines these benefit functions, so we've emphasized this step, separately, for the reader. Additionally, the valuation and monetization of ecosystem benefits will be combined with the program costs identified in the next step (Step VI) to create a financial model that depicts program costs and benefits over time. The subsequent steps explore this further.

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STEP VI:
Identify program costs

In this phase of the analysis, you will identify the costs associated with your program in order to prepare for the economic and financial calculations in the next step; Step VII. At the end of this process, you should have a list of the costs associated with the overall program and the costs incurred by the beneficiaries. These costs will be combined with the outputs from Steps III–V to create a financial model that captures how costs and benefits will decrease or accrue over the lifetime of the NbS program.

Your contractor or Economist will perform most of this step, but it is explained below so the project team can understand the general process. The project teams will need to provide some data to the contractor so this step can be performed, including, but not limited to, costs incurred by the program to-date and the capital structure of the NbS program. A template Terms of Reference is included as an accompanying resource for teams who will contract out the economic and financial analysis.

TEAM MEMBERS: Project Manager, Economist, Ecologist.

KEY QUESTIONS:

↗ What are the full costs of the proposed NbS program activities to date?

↗ What are the projected future annual costs of the proposed NbS program based on the expected time profile of each activity?

↗ How much are your beneficiaries investing in the NbS program or NbS activities?

↗ What is the capital structure? Are there other stakeholders investing? How much are they investing? Are they interested in funding certain NbS activities? Here, capital structure refers to the way the program will fund or finance its NbS through some combination of direct stakeholder investment, debt, equity, or hybrid.

PROGRAM COST CATEGORIES

To calculate your economic and financial metrics in Step VII, it's important to first distinguish between total program costs and the portion of those costs borne by the program's beneficiaries. Distinguishing between these costs allows your team to assess two aspects of the program's ROI: (1) the financial case for the beneficiaries' investment and (2) the economic case for the program, which will indicate whether it's economically justifiable solely based on the ecosystem function and associated ecosystem services. For our example, the ecosystem function would be sediment control/retention.

ESTIMATING FINANCIAL COSTS

In calculating total program costs, compile all costs associated with the evaluated natural infrastructure interventions. This total cost entails several discrete components:

1) the **design and construction costs (CAPEX)** which entail the initial site-level direct implementation costs, e.g., site-level design, permits and construction. These costs may be variable over time and typically are incurred during the construction phase. For example, initial tree installation would fall under this category, but subsequent tree replacement would be considered a maintenance cost under the next category (OPEX);

2) the **operating and maintenance costs (OPEX)** which entail the implementation costs to maintain the value of natural capital and ensure compliance over the long-term investment lifecycle. This includes costs associated with regular inspection, maintenance and replacement efforts, site-level monitoring, and incentive payments to change practices (see opportunity costs below). These costs are typically variable and recurrent, with the time interval dependent upon the intervention. For example, replacing signage or fencing could occur a few times, versus monitoring and enforcement which is usually ongoing;

3) the **opportunity costs** landowners incur as a result of the interventions, which is the difference between the profits they realize under business-as-usual land management and under the NbS implementation scenario. For example, annual profit losses if an area is converted from timber use or mining to forest conservation. The opportunity cost would be the foregone revenue. Opportunity costs to landowners is considered a subcategory of OPEX, but we've referenced it separately in this guidance, given its importance in NbS projects. It's variable and incurred on an annual or bi-annual basis, depending on the intervention;

4) any **program management costs** associated with running the NbS investment program, e.g., implementation coordination, M&E management, auditing and insurance, rent, office materials, phones, etc. These costs are fixed and incurred on an annual basis; and

5) the **transaction costs (TAC)** associated with activities needed to bring about the change in land management. Transaction costs cover efforts to organize investment activities. For example, costs associated with

landowner and stakeholder outreach; with organizing landowner payment schemes; dispute resolution; or training implementers on relevant techniques. These costs are variable over time and usually incurred in regular or irregular intervals during the project's lifecycle, depending on the activity.

To help categorize and project these costs, it's helpful to compile the full costs of individual activities to date in addition to your program's projected future annual costs. Future costs should be based on the expected time profile of the NbS interventions previously identified. These activities can include but are not limited to:

• Hydrologic, political and economic feasibility studies

• Coordination, communication, marketing and program design

• Program management and administration

• Landowner engagement and contract development

• Planning and implementing interventions (restoration and conservation)

• Payments to landowners

•- Monitoring and evaluation, including compliance monitoring

Total program costs include grants from multilateral institutions and private foundations that supported the development and implementation of the program, and costs borne by other institutions investing in the program.

For tracking and transparency, it's also helpful to keep the costs of different interventions separate. This way, you can track how much your program will spend on each activity, e.g., forest conservation, riparian buffers, agricultural best management practices, etc.

COSTS INCURRED BY BENEFICIARIES

The costs incurred by your program's beneficiaries will usually be less than the total program costs. To distinguish between the two, review the list of your total program costs and note those associated with implementing the NbS your team identified in Step IV, and subsequently monetized, in Step V.

Depending on whether you're conducting an economic or financial analysis, the costs included in your analysis will vary. Again, if your beneficiary is a private company, you're likely to include costs more commonly associated with financial analyses. However, if your beneficiary is the local government or another public policy actor, you're more likely to include additional costs commonly associated with economic analyses.

Box 6 provides an example of estimating costs per hectare for invasive alien plant control in the Greater Cape Town region (TNC, 2018). The analysis focused on the cost of the overall NbS program as compared to alternative grey infrastructure investments that could be made by the local government. Appendix I has a direct link to the Greater Cape Town Water Fund Business Case.

ESTIMATING ECONOMIC COSTS

For an economic analysis, some cost estimates would need to be modified to include costs that are not captured in the financial data of the program or its beneficiaries. For example, if a project enrolls volunteers for tree planting, their financial cost to the project would be zero, but their opportunity cost can be estimated based on the value of their time, either in employment or at home. This should be included as an economic cost.

Additional costs like negative externalities—welfare-reducing impacts on third parties that are uncompensated—should also be included. An example of negative externalities would be conservation activities that reduce some

uses of the watershed (e.g., timber harvest, ranching or crop production), resulting in loss of employment or increases in local food prices.

When in doubt about which costs to include, check with your beneficiaries. They will be able to tell you what aspects are most important to them.

BOX 6: Estimating the costs per hectare of invasive alien plant control based on local conditions

The Greater Cape Town Water Fund examined the feasibility of removing invasive trees in a series of sub-catchments to increase water flows coming into the Greater Cape Town Region's water supply system. Invasive tree removal can be time and resource intensive—especially in the upper headwaters—so the case study provides an excellent example of calculating program costs.

The cost to clear invasive plants and to maintain a sub-catchment over a 30-year period was calculated by extracting the needed information from a partner's water data; the relationship between invasive alien plant species; density and initial/follow-up clearing; and person-days required for clearing a specific area. Person-days refers to the number of people required to remove invasives from an area times the number of days required for the removal, e.g., the workload. An existing model was modified that incorporated ecosystem dynamics of regrowth and response to fire. The model accounts for the fact that invasive alien plant clearing is not a one-off intervention and can be influenced by stochastic events like fire, which are hard to predict but can increase invasive plants spread and densification.

Current cost per person-day was used as the baseline and expressed as rand per person-day (R/PD). Rand per person-day was used to calculate the cost of rand per hectare, and the cost per hectare is multiplied by the number of hectares treated to give a total clearing cost per intervention over a period of 30 years (present value).

Initial invasive control operations are the costliest, up to R40,000/ha in very dense invasions in rugged terrain and riparian areas. Thereafter the cost gradually declines over time as invasive plant density and size decline following each intervention. Factoring in costs of long-term maintenance and management is essential to ensure areas or catchments are kept free of invasions and water gains are maintained in perpetuity.
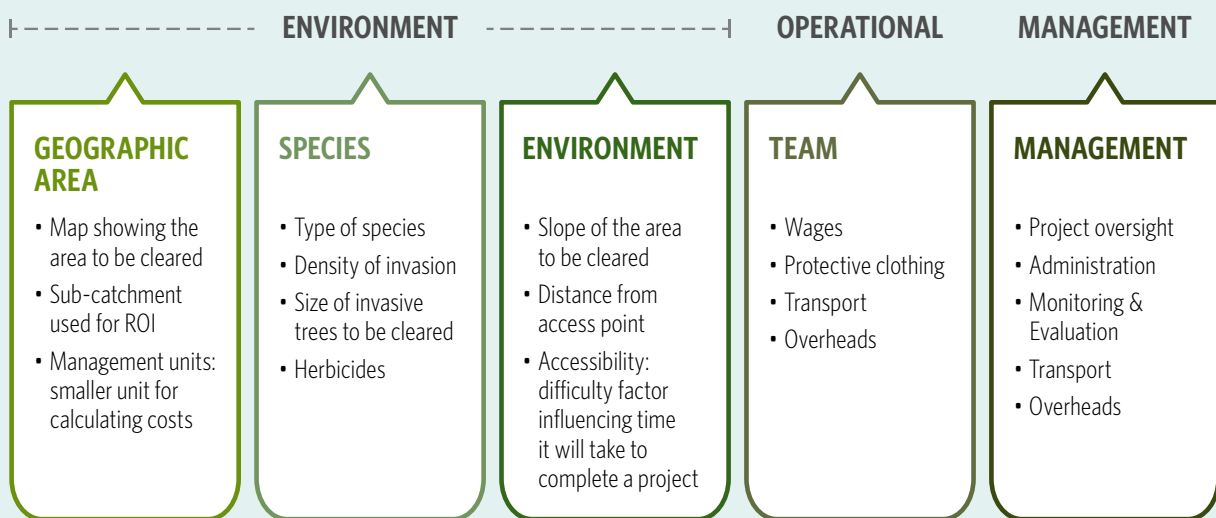
|---------------   ENVIRONMENT   -------------| OPERATIONAL   MANAGEMENT

GEOGRAPHIC AREA
- Map showing the area to be cleared
- Sub-catchment used for ROI
- Management units: smaller unit for calculating costs

SPECIES
- Type of species
- Density of invasion
- Size of invasive trees to be cleared
- Herbicides

ENVIRONMENT
- Slope of the area to be cleared
- Distance from access point
- Accessibility: difficulty factor influencing time it will take to complete a project

TEAM
- Wages
- Protective clothing
- Transport
- Overheads

MANAGEMENT
- Project oversight
- Administration
- Monitoring & Evaluation
- Transport
- Overheads

FIGURE 5. Different components of clearing cost in the Cape Town Water Fund economic and financial analysis. Adapted from TNC, 2018.

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STEP VII:
Calculate indicators for economic & financial analysis

During this step your team will calculate the indicators that are most appropriate for your analysis, whether that's the ROI for a particular beneficiary or group of beneficiaries, the benefit-cost ratio, the cost-effectiveness of the program, overall, or the cost-effectiveness of the change in a particular ecosystem service. In most cases, more than one type of indicator will be calculated. You can also describe the co-benefits of the program which may not be among the ecosystem service(s) targeted, and the program's positive externalities, e.g., the positive benefits to parties who do not contribute, whether financially or in-kind, to the NbS program. Both co-benefits and positive externalities could justify cost-sharing of the program with additional parties. Some co-benefits are often difficult to quantify or monetize but may be crucial in building support for your program now and in the future.

Your contractor or Economist will perform this step, but it is explained below so the project team can understand the general process. A template Terms of Reference is included in Appendix III for teams who will contract out the modeling portion of the analysis.

TEAM MEMBERS: Project Manager, Economist, Stakeholder Engagement Specialist (could also be the Local Lead), Communicator.

KEY QUESTIONS:

↗ What are the full costs of program activities to date?

↗ What are the projected future annual costs based on the expected time profile of each activity?

↗ How much are the beneficiaries investing in the NbS program?

↗ What is the capital structure? Are there other stakeholders investing? How much are they investing? Are they only interested in funding certain NbS?

↗ What is (are) the most appropriate financial and/or economic analyses tools and indicators for your stakeholders and/or beneficiaries? What metrics, or indicators, do they use to make investment decisions?

↗ What is the appropriate discount rate?

↗ Did your team use an appropriate time horizon?

↗ What other co-benefits is the program producing?

FINANCIAL AND ECONOMIC ANALYSES

As mentioned in the introduction, an economic analysis will assess whether the investment is worthwhile for society, while a financial analysis will assess whether the project is viable from the investor's point of view. It can also help determine whether an NbS program is justified in receiving external support because it provides broader benefits for society. It's possible for a project to be viable from an economic perspective because it generates multiple co-benefits whose combined value exceeds the total costs of the program, but not from a financial perspective if the benefits for project investors are less than their costs. This can be the case for programs that generate substantial positive externalities or co-benefits for program investors that may not be monetizable or whose value is not fully recognized.

First and foremost, the analysis your team chooses to undertake will depend on your beneficiaries' and stakeholders' preferences; many will prefer and require more than one type. However, some analyses are used more commonly for economic or financial valuation so it's important your project team confirm with your beneficiaries and stakeholders. A cost-benefit analysis, for example, is typically used by public policy actors to evaluate the total net benefit of the NbS project and is, therefore, a common valuation method for economic analyses. In other cases, the analyses listed below can be used for either financial or economic analyses, depending on the scope of the impacts (benefits and costs) and beneficiaries or other stakeholders included in the analysis. This is why it's particularly important to speak with your beneficiaries and stakeholders to understand their preferences.

After projecting the estimated costs and benefits of an NbS project—or program—using one or more of the analyses below, your team will also need to decide which summary indicators, or metrics, they will calculate to assess the viability and profitability of the project or program. Again, the indicators chosen should be what your beneficiaries or stakeholders use to make their investment decisions.

A **cost-benefit analysis (CBA)** helps assess whether a proposed NbS investment is worthwhile for society, as a whole. This tool can help define the optimal investment package for society and the environment by valuing a broader set of impacts. Monetizing a large number of benefits, however, can be challenging especially if attempting to do so rigorously and for many beneficiaries. Instead of attempting full monetization, most CBAs focus on valuing key economic costs and benefits while capturing others in qualitative terms.

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A cost-effectiveness analysis (CEA) assesses how an NbS intervention or a combination of NbS interventions performs in terms of cost per unit change in a single targeted ecosystem function, or, inversely, the change in ecosystem service per unit cost (e.g., the concentration of TSS of water at the intake of the municipal water supply). You can use this value to compare the program's ROI to that of other alternative interventions investors may be considering that produce the same ecosystem service. For example, the cost of removing invasive plant species versus the cost of constructing a new desalination plant to increase water supply.

A CEA can assess how much a given investment in the program will change the target ecosystem service, for a specific intervention portfolio. This calculation can be performed per beneficiary or for the group of beneficiaries investing in the NbS program. Including a larger number of beneficiaries in the calculation will increase the ROI of the program because the quantity of beneficial impacts captured in the analysis, likewise, increases. Similarly, for any given program size, a larger number of financial contributors to the program will tend to increase the ROI for each beneficiary because of increased cost sharing. Your team can produce cost-effectiveness measures for each intervention and the whole portfolio of measures.

If your analysis is assessing multiple ecosystem services, you'll want to assess the cost-effectiveness of your NbS intervention scenario for each ecosystem service; with indicators such as cubic meter of additional water supply during times of scarcity; reduction in sediment flowing into reservoirs; reduction in sediment concentrations in water abstracted directly by households and by the public utility; reduced number of flooded structures, etc. This will result in one cost-effectiveness metric for each target outcome, with all conservation scenario costs assigned to that outcome. These are called single-objective cost-effectiveness metrics.

On the other hand, multi-objective cost-effectiveness metrics allow you to assess how cost-effective your full intervention scenario is in achieving the complete suite of target ecosystem services. With multi-objective metrics you can compare your intervention scenario with a bundle of alternative, conventional interventions that provide the same suite of ecosystem services. This is particularly useful when a beneficiary is considering several investment options.

However, since the target outcomes have different units (cubic meter of additional water supply during times of scarcity; reduction in sediment concentrations in water abstracted directly by households and by the public

utility; reduced number of flooded structures, etc.), no single cost-effectiveness metric can be calculated for a multi-objective intervention suite.

If the NbS interventions generate multiple important benefits, then calculating cost-effectiveness separately for each benefit ignores the multi-benefit nature of the NbS program and distorts its comparison with common single-objective, grey alternatives. There are ways around this, by assigning costs to individual ecosystem services based on their relative importance, which is not always easy. One way of determining these shares is to base them on the relative costs of an alternative, conventional intervention portfolio that produces similar quantities of the suite of target ecosystem services you're interested in. For example, you could look at the cost of water storage infrastructure that's been combined with sediment removal and floodwater retention infrastructure. Your consultant can help your project team explore other rationales for deriving cost shares.

Cost-benefit analysis, however, avoids this challenge by expressing all beneficial impacts using a common metric (monetary value), and thus is better suited to analyzing programs that generate several important benefits.

The Nature Conservancy's Rio Camboriú business case provides a good example of these calculations and the different results they can produce, see Box 8.

FINANCIAL AND ECONOMIC INDICATORS

Your team should view summary indicators, or metrics, as tools to assess and communicate the financial or economic viability of your proposed NbS program. It's recommended that your team calculate the same indicators your beneficiaries or stakeholders use to make investment decisions.

The **net present value (NPV)** is often used in investment planning to analyze the profitability of a future project. A positive NPV indicates that the earnings generated by a project are projected to exceed its anticipated costs. Therefore, a project with a positive NPV will be profitable and a project with a negative NPV will result in a net loss.

To understand how NPV is calculated, it's important to understand present values and discount rates. The **present value (PV)** (sometimes referred to as the present discounted value) is the current worth of a future value or future stream of values. To get this present value, future values are discounted using an appropriate **discount rate**; explored further in the following section and in Box 7.

For now, it's important to understand the concept of discounting and the reasons behind it. Discounting is a common method used to measure the value of a current investment based on its expected future cash flows (Chappelow, 2020). Discounting is based on the '**time value of money**' concept which argues that money available at the present time is worth more than the identical sum in the future, due to its potential earning capacity. If invested now, that sum of money can earn interest and increase in value. Therefore, even though the sums of money being offered now, and in the future, are of the same absolute value, the money being offered now is actually worth more because of its investment potential.

With this concept in mind, let's revisit **net present value (NPV)**. NPV is the difference between the *present value* of inflows (returns) and the *present value* of outflows (costs) over a period of time (Kenton, 2020). Therefore, if a project needs a certain investment now (and in future months) and we can predict the future returns this project will generate, then—using the discount rate—we can calculate the current value of all such cash flows (Chappelow, 2020). If the NPV is positive, the project is considered viable. If the NPV is negative, it is considered unviable.

The **benefit-cost ratio (BCR)** is used to express the size of a project's benefits relative to its costs, both expressed in PV terms. If a BCR is greater than 1, benefits exceed costs and the project is considered a potentially justified investment, depending on the BCRs of competing projects.

The **internal rate of return (IRR)** is the rate at which the net present value of a project reaches zero; the discount rate (see next section). It uses financial rather than economic costs (Step VII) and refers to the rate of return—or annual rate of growth an investment is expected to generate—for the project implementer. The higher the rate is, the more attractive the project would be for the implementer. IRR is one way to compare different types of investments because it can be used to rank multiple prospective projects using relatively objective criteria.

The **monetized ROI** divides the monetary value of the ecosystem service improvements (caused by the NbS program) by the cost of the program. While the IRR indicates annual rate of growth, ROI indicates total expected growth of the investment over its lifetime. An ROI exceeding 1 indicates a positive return on investment; an ROI less than 1 indicates a negative return on investment.

If your calculation does yield a negative ROI, it doesn't necessarily mean that the program is not economically viable as it may produce co-benefits of value to your beneficiaries or other stakeholders that have not been included in your analysis.

It's worth noting that there are many factors that can influence ROI. Common assumptions are explored in the following section.

FACTORS THAT INFLUENCE ROI

Time horizon

Per instructions in Step III, you chose a time horizon for your ROI calculation that made the most sense for your beneficiaries' circumstances. In our utility example, we chose a timeline of 25–30 years. This time horizon indicates the period over which your program should generate a positive return on investment in order to be competitive with grey infrastructure alternatives. This can be more difficult if your program has high upfront costs and realizes its benefits slowly.

If your program includes restoration interventions, for example, your financial model will likely show low annual benefits initially, followed by a gradual increase over time. As discussed in Step IV, it takes time for restoration interventions to reach their full potential. Your implementation costs will level out once your program is up and running, but because of the inverse time profile of costs and benefits—meaning, initially, high but declining costs and low but increasing benefits during the first few years—longer time horizons will, in general, increase the ROI. A longer time horizon is often advantageous because more years will be included during which the program is producing benefits that outweigh the costs.

When estimating the ROI of your overall program, the scope of costs included in the analysis will differ. To review the types of costs that should be considered, refer to Step VI.

Your time horizon will also affect which interventions are chosen for your program. Your BaU LULC model from Step III shows how your basin is predicted to change over your chosen time horizon. You then choose the interventions—which activities and where they're implemented—that will most improve your ecosystem services based on the BaU scenario. If you extend your time horizon, it's possible that your BaU LULC model may indicate different sites that, if protected or restored, could produce better outcomes for your ecosystem services. However, since these sites are predicted to change only at a later point in the future, they did not make it into the original intervention portfolio. Thus, changing the time horizon of the analysis may affect the "optimal" interventional portfolio. The process for prioritizing interventions is outlined in Step IV.

Discount rate

Discounting is the process of estimating the present value of a future value or future stream of values. When calculating the ROI, you should discount all costs and benefits of the program incurred during your time horizon (e.g., 30 years) to their present value using an appropriate discount rate. Choosing the right discount rate can be difficult, and teams should consult with their beneficiaries and stakeholders to gauge their preference. For private individuals and private companies, these rates are typically based on the private rate of pure time preference (individuals) and the private cost of capital or its rate of return from competing investments (companies), respectively. On the other hand, public investments in long-lived conservation projects such as watershed natural infrastructure conservation and restoration are often discounted using a long-term **social discount rate**.

Social rates, rather than market discount rates, are usually used when evaluating long-term publicly financed projects like environmental protection (Arrow et al., 2013). Given the time profile of costs and benefits characteristic of many watershed nature-based solutions, higher discount rates will tend to lower the ROI while lower rates will tend to increase the ROI. A private entity's discount rate will likely exceed the public discount rates. However, in a recent 2018 paper *Discounting Disentangled*, Drupp et al. conducted a survey of leading discounting experts and found that most agreed a two percent discount rate was appropriate, much lower than discount rates commonly used (Drupp et al., 2018).

The discount rate will have a large impact on the results of your ROI analysis, so it's important to choose a commonly accepted rate for your beneficiaries. See Box 7 for more information on social discount rates, and how the ROI is affected by choice of rate and time horizon.

Co-benefits

In addition to improving the targeted ecosystem service(s), the program's interventions could produce several **co-benefits** that are important to the beneficiary, other program investors or the public. While it can be difficult to quantify these co-benefits, they can improve the program's overall ROI and the ROI for a give beneficiary.

In the case of the Camboriú PWS program (Box 8), two important co-benefits, in addition to biodiversity conservation, were likely to drive a wedge between the broader, socio-economic case and the specific financial case for the utility, which focused on sediment attenuation: (1) reduced risk of flooding and (2) reduced risk of

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water supply disruptions. While it was out of the study's scope to analyze the value of these two co-benefits relative to the value of the reductions in sediment treatment plant operation and capital costs, findings from other studies suggested that these values could be substantial. Even though the ROI to the water utility was <1, they still decided to lobby the regulator to approve future investments in NbS.

A **multi-criteria analysis** is not a tool to assess ROI, but some stakeholders and beneficiaries—mostly those concerned with broad economic benefit—may be in support of the methodology when it comes to considering co-benefits. It can be more comprehensive than a cost-effectiveness analysis in that it accounts for more than one criterion, but it does not usually entail monetization of all costs and benefits. Criteria can be either quantitative or qualitative, and it's usually a mix of both.

Multi-criteria analyses are useful for comparing investment options based on the priorities of stakeholder groups, which can include the potential for realizing multiple co-benefits as well as choosing an investment that has a high ROI. Criteria are typically weighted to reflect the preferences of stakeholder groups, and in some cases investment options are graded on a scale (e.g., 1–5) against the criteria that is more difficult to value like biodiversity or mental health improvements from access to green space. (Liquete et al., 2016; Sheppard and Meitner, 2005)

A number of studies address other options for assessing benefits and trade-offs associated with co-benefits, including the Fuzzy Cognitive Map approach applied to the Lower Danube (Giordano et al., 2020), and a grading evaluation system comparing similar sites (Watkin et al., 2019).

Scale of intervention

Transaction and program management costs often account for a high share of total program costs. However, some components of these costs are not affected by—or increase less than proportionally with—the geographic scale of intervention. In other words, increasing the total intervention area to include additional high ROI sites may not incur a proportionate increase in transaction and overhead costs and thus could improve program ROI. For example, increasing conservation and restoration areas by ten percent might only increase transaction costs by six percent and might increase overhead costs by an even smaller percentage, thus raising total program costs by much less than ten percent (Fisher et al., 2017).

Transaction costs that are generally strongly influenced by total intervention scale include,

- Expenses related to landowner outreach and engagement;
- Landowner enrollment in intervention programs, including preparation of site-specific intervention designs and contracts, and agreement on ecosystem service payments, if any;
- Monitoring of landowner compliance with contracts, where applicable.

Program overhead costs generally less strongly influenced by total spatial scale of interventions include,

- Program creation, engagement and coordination of key program supporters, partners and other stakeholders (e.g., industry, government);
- Program management, including strategy design, fundraising, administration, communications with the public of key stakeholders;
- Technical analyses, e.g., modeling.

ADDRESSING RISK & UNCERTAINTY

Natural ecosystems—and therefore NbS—can have an inherent level of unpredictability. It is, therefore, important to assess to what extent the results of your analysis reflect relevant risks and uncertainties. This is usually done

using a risk and/or sensitivity analysis. The goal is to quantify how robust the estimated benefits and costs of your NbS project are to changes in assumptions, and therefore produce a range of potential values for your chosen indicators. For example, rather than calculating a single ROI value of 1, you'll end up with a range of ROI values that better reflects likely outcomes, e.g., 0.80–1.20. A single ROI value essentially reflects the mean values of key assumptions and incorporating uncertainty will help your results better reflect the range of these assumptions.

During a **risk analysis** the team will identify potential issues that could negatively impact their NbS project, the probability that these issues would occur and the magnitude of impact it would have on their results. Potential variables could include natural disasters like wildfires and tornadoes. In order to conduct a risk analysis, however, you must know the probability that a wildfire or tornado will occur in your project area.

While a risk analysis only examines downside possibilities, a **sensitivity analysis** examines both upside and downside possibilities. It also does not need clearly defined probabilities, and is, therefore, well-suited for uncertain variables. The sensitivity analysis shows how the costs and benefits of your NbS program change if certain variables or assumptions were to change. For example, perhaps the team assumed the unit cost of reforestation was about US$200 per hectare. A sensitivity analysis would help you calculate the change in ROI if the unit cost of reforestation were to increase to US$250 or US$300 per hectare.

Understanding the strengths and limitations of your economic and financial analysis is critical to managing stakeholder and beneficiary expectations. Even during project preparation, your team should be working with your beneficiary to determine what level of uncertainty they are comfortable with, and how you can potentially mitigate any factors.

MONITORING & EVALUATION

Upon completion of the financial and economic analysis, it is recommended that an M&E program be established —if one is not already in place—to verify and validate the model (Figure 6) and to assess whether the predicted financial returns come to fruition. M&E can also help evaluate partner satisfaction which is important to ensure continued investment. Otherwise, partner commitment can be lost and, once lost, it's difficult to regain momentum. This specific monitoring and evaluation plan should be complementary to—and, ideally, developed in conjunction with—your project's overall monitoring & evaluation program.

Your M&E program should be undertaken to observe, record, compare, track, and adaptively manage the projects you are implementing. Clear goals, accurate baselines and monitoring data are the foundation through which science-based, sound investments are made and validated. If possible, an M&E expert should be retained for defining monitoring needs and developing a plan that will work for your project.

Note that a successful monitoring program is not necessarily one that collects a lot of information, but one that requires that the right kind of information is efficiently and effectively gathered and analyzed to address management needs and judge progress toward meeting short and long-term project goals.

If your beneficiary is very involved in the operation and management of the NbS program, it may be advantageous to align parts of your M&E program with that of your main benefactor.

You can learn more about M&E best practice, in the Monitoring Deep Dive.

FIGURE 6. Process for developing a monitoring & evaluation program for a watershed investment program (Leisher, et al. 2019)

BOX 7: Social Discount Rate

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The social discount rate measures "the rate at which a society is willing to trade present for future consumption" (Lopez, 2008). As such, the social discount rate is especially important for projects whose benefits are only apparent after many years to decades, like NbS or green infrastructure projects. In the previous sections we noted how the right discount rate and time horizon will have an impact on your return on investment results. The World Bank (Lopez, 2008) offers an illustrative example replicated here:

With a 2 percent discount rate, a project with a cost of US$1 today producing benefits of US$2.7 in 50 years from now, would be socially acceptable. However, this would not be the case if the discount rate is 5 percent in which case the break-even benefit would be almost four times as large; US$11.5.

More dramatically, these discrepancies increase markedly as the time horizon expands.

With a two percent discount rate, the break-even benefit of a US$1 project that has a pay off in 10 years is US$7.2, but it increases more than twenty-fold to US$131 when the discount rate is 5 percent.

As such, social planners using a high discount rate will have the tendency to favor projects with short-run benefits over those with payoffs in the long run. However, those who are using low discount rates will be more amenable to finance interventions with long-run benefits.

Two types of discount rates have traditionally been advocated: social opportunity cost (SOC) of the investment and social time preference (STP). The SOC, defined as "the value to society of the next best alternative use of the resources devoted to the project in question" (Lopez, 2008), is based on the idea that the decision to invest in a project means that these resources will no longer be available to invest in the private sector. If using a SOC, then investors will choose to take on a project if their social benefit is larger than the loss that results from removing these resources from the private sector.

However, many have argued (Sen, 1961 and Feldstein, 1964) that an individual's time preference may depend on whether he is acting alone or as part of a group. In other words, if others are willing to save, he may be willing to save as well. This is where the social time preference (STP) comes in. The STP will assign current values to future consumption based on society's evaluation of the desirability of future consumption.

In practice, the analysis of different public interventions often requires the use of different discount rates. The European Commission recommends, for instance, using a SOC rate in cases where the financial return of a project is of concern to the public, e.g., investment by a public enterprise that will operate without subsidies. However, for standard cost benefit analyses of public projects, the European Commission recommends the use of an STP.

It will be important for your project team to work with your beneficiaries and contractor quite closely to determine the appropriate discount rate. Many of your stakeholders will already use discount rates to assess the viability of their future investments and will have a preference on which to use.

BOX 8: Rio Camboriú Financial Analysis Calculations

In addition to reducing total suspended sediment, the Rio Camboriú PWS program also produces co-benefits of high concern to the two municipalities: flood attenuation, and reduction in the risk of municipal water supply shortages during the tourist high season. These positive externalities justified cost-sharing of the PWS program.

In calculating the ROI metrics, they discount all costs and benefits of the PWS program through 2045 to their 2014 present value (PV) equivalents using Brazil's estimated social discount rate of 3.85 percent. The 30-year time horizon for their analysis was chosen to ensure broad comparability of their cost-effectiveness estimates for the Camboriú PWS program with that of investments in grey drinking water treatment infrastructure.
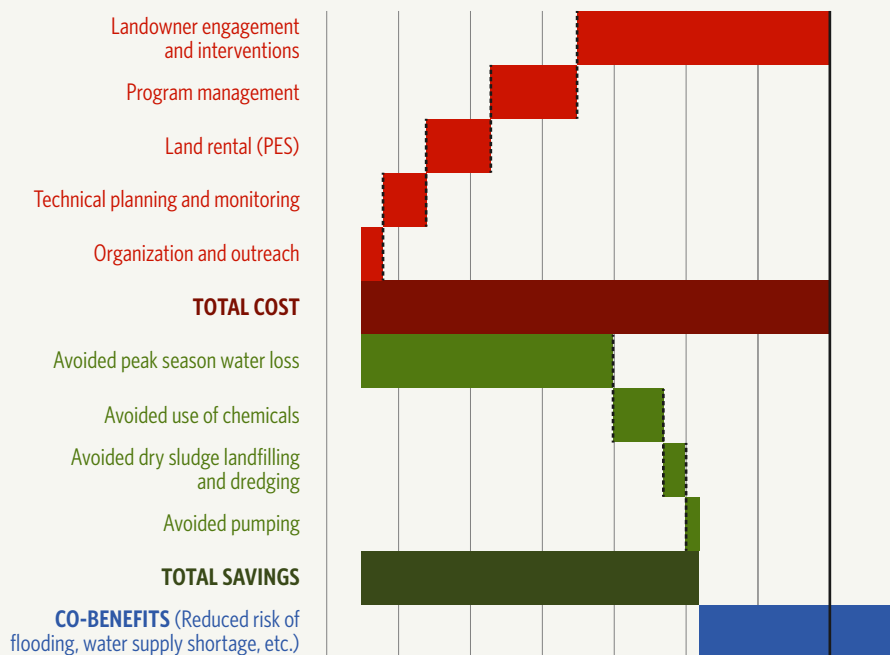

FIGURE 8. Comparison and composition of annual costs and benefits of the Camboriú PWS program, amortized over 30 years using Brazil's 3.85% social discount rate. Note: The value of co-benefits was not quantified in this analysis (Kroeger et al. 2017)

Their analysis indicates that, if analyzed purely as a sediment control measure for the municipal water supply, the Camboriú PWS program has an ROI<1 over a 30-year time horizon. This is true both for the program overall (all costs counted) as well as for EMASA (their beneficiary) in particular (Table 6). This remains true even if the reduced peak season water losses that result from reduced sediment concentrations in intake water had been used to reduce the size of the recent capacity expansion of the water treatment plant (see Scenario 2 in Table 6). Given the front-loaded time profile of costs relative to benefits, this outcome is sensitive to the time horizon of the study.

Note that only benefits associated with sediment reduction are reflected in these ROI metrics. The biodiversity conservation, peak-season water supply risk, and flood risk reduction values produced by the program are treated as co-benefits, the quantification of which was beyond the scope of this study. Even though the ROI to the water utility was less than 1, EMASA still decided to lobby the regulator for the ability to invest in NbS because of the other, non-quantified co-benefits.

TABLE 6. Estimated ROI metrics of the Camboriú PWS program as a sediment control measure for municipal water supply, 2015 to 2045.

ROI FOR	SCENARIO	MG TSS PER LITER PER MILLION USD[1]	KG TSS PER USD	B/C
Program overall	1	2.1	1.70	0.59
	2	2.2	1.78	0.63
EMASA	1	2.8	2.24	0.77
	2	3.0	2.39	0.83

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Post-Analysis:
Communicating results of the economic and financial analysis

COMMUNICATING TO YOUR STAKEHOLDERS

At the end of the process you'll have a polished report—and associated appendices, hi-res native files and geodatabase—prepared by the contractors (or team) to disseminate the results & details of the analysis, but it's important you further distill the results for your beneficiaries and stakeholders. The final report will note your portfolio of interventions and its associated costs; where, spatially, these NbS should be implemented; the timeline over which these NbS solutions should be implemented and in what sequence; which ecosystem benefits & co-benefits they will produce and over what timeline; etc.

It's highly unlikely, however, your stakeholders will read an entire report, so it's important you consult them to determine what information they need to know and how they would like that information to be presented, e.g., abbreviated report, technical presentation, etc.

As noted in Step VII, it's critical to communicate results using the same indicators and methodology with which your stakeholders and beneficiaries are familiar. Your team's ability to use language that comports with their decision-making processes will be key. This will be particularly important when communicating risk and uncertainty in the analysis. Be clear about the factors that can cause increased risk or uncertainty in your analysis like the lack of site-specific data to feed into models, or unforeseen impacts to LULC caused by natural disasters, changes in policy or demand for commodities, climate change, etc.

Your project team can also leverage the economic and financial analysis to garner support among current and potential investors. Having a clear idea of the viability of your project and its proposed NbS—and timeline for implementation—will enable you to market and pitch its benefits for funding and/or investment.

The economic and financial analysis will also be the basis for your WIP's strategic plan.

CONCLUSION

Once the project team has a clear idea of the benefits and return of their proposed program, they should then consider which governance mechanism—whether a water fund or not— should fund NbS and manage its implementation.

As stated in the introduction, the economic and financial analysis is only one component of a complete business case for investment. To be compelling for an investor, the analysis will also need a clear governance and sustainable funding/financing strategy.

The governance proposal should outline who will make decisions regarding when and how funds are deployed; which organization(s) are responsible for implementation; which organization(s) are responsible for monitoring and evaluating the program's success; how stakeholders are consulted and when decisions and activities are communicated to them; etc.

The funding and financing strategy should outline how the program will be funded and who will pay for it. Importantly, the strategy should outline the financial sustainability of the program and clearly articulate how it plans to tackle the challenge of longevity. Investors will want to know how and when their investment will be paid back and how the program will sustain its activities in the long run.

The finance and governance components of the business case are outlined in accompanying Deep Dives; Sustainable Funding and Governance Deep Dives, respectively.

Together, these components make the complete business case for investing in NbS and can be used to advocate for the creation of a watershed investment program—including a water fund, if collective action is deemed the best governance and implementation mechanism to reach your program's goals.

Appendix I:
Core Team Profile & Responsibilities

TABLE 1. Responsibilities & profiles of core team members, Detailed Economic & Financial Analysis. Will vary for the Basic Economic & Financial Analysis and the Decision Support System.

ROLE	STEPS OF METHODOL-OGY	TIME (DAYS)	PROFILE	RESPONSIBILITIES
Project Manager	Steps I–VII Analysis	45–60	Does not need to have technical expertise, but they should be familiar with the methodology and know when to seek feedback and review from technical experts. The project manager should be organized, process-driven, action-oriented and resourceful. They should be good at facilitating conversation and synthesizing feedback into actionable next steps. Should be familiar with the proposed NbS project or WIP. Should speak the language.	Facilitate the project from start to finish, manage the project team and hold to the agreed timeline; manage budget; lead creation of Terms of Reference; manage contracts for outsourced components; plan and run team meetings; pull in technical experts for review, as needed.
Ecologist	Steps I–VII	27–36	Does not need to have expertise in economics, but they should be familiar with the economic and financial analysis methodology and know when to seek feedback and review from technical experts. They should be very familiar with the proposed NbS project or WIP and should be confident with representing the technical aspects of the project. At a minimum, the Ecologist should be familiar with commonly used ecosystem service models, but ideally, they would have built or calibrated models in the past. If not, they should recruit someone to serve as a subject matter expert for these steps of the methodology. Should speak the language.	Work with the project manager and the larger project team to identify conservation interventions for the NbS project; review outputs from contractors (modeling specialist and economist); if appropriate, work hand-in-hand with the contractors to build, calibrate and test models, develop a list of costs for the proposed NbS interventions, and gather applicable data sets (e.g., hydraulic, hydrologic, LULC, etc.); review Terms of Reference and contracts for outsourced components; attend team meetings; serve as technical reviewer, as needed.

ROLE	STEPS OF METHODOL-OGY	TIME (DAYS)	PROFILE	RESPONSIBILITIES
Hydrologist	Steps III–V	27–36	A trained engineer, ecologist, or related field, with specialization in hydrology with 5+ years of experience in analysis of water systems. Must be familiar with hydro-sedimentological mathematical modeling and water quality. Must understand how to translate complex, technical concepts and communicate to a non-technical audience. Ideally, would be familiar with the proposed NbS project and must be organized, collaborative, results-driven and responsive. Should speak the language.	Work with the project manager and the larger project team to define hydrologic ecosystem services targets and goals, characterize water demands in the study basin, and discuss NbS efficiency for hydrologic objectives. The hydrologist will take an active role with the contractor (Modeling Specialist) and their responsibilities may range depending on programmatic needs. The Hydrologist may lead the mathematical model selection process with the contractors, including definition of objectives and goals; collect and analyze hydro-climatological information and process time series of hydro-climatic variables; formulate the conceptual model; review and select mathematical models, or work hand-in-hand with the contractors to build, calibrate and test models; develop a conceptual technical guide for the hydro-sedimentological and water quality mathematical modeling; and review outputs from contractors (modeling specialist). At a minimum, the hydrologist must review the Terms of Reference and contracts for outsourced components, attend team meetings, and serve as technical reviewer, as needed.
Stakeholder Engage-ment Specialist (can also be Local Lead)	Steps I–VII	40–50	Does not need to have technical expertise, but they should be familiar with the methodology and know when to seek feedback and review from external stakeholders. Ideally, the Stakeholder Engagement Specialist would have a strong, ongoing relationship with the program's beneficiaries. If not, the Stakeholder Engagement Specialist should have a demonstrated ability to develop productive relationships via stakeholder engagement, in the past. Is a strong communicator and able to synthesize complex concepts; is organized, results-driven and responsive; sympathetic of stakeholder needs; and familiar with the proposed NbS project or WIP. Should speak the language.	The Stakeholder Engagement Specialist will serve as the liaison between the core team and the beneficiaries of the economic & financial analysis. They are responsible for ensuring the final product meets their beneficiaries' expectations and is presented in a format that is applicable to their needs and operations. They will manage expectations, communicate the timeline and progress of the analysis, bring the stakeholders in for review, as appropriate, and ensure the final product will be useful to their decision-making processes. They should work with the beneficiaries to define the ecosystem services they care about; the appropriate discount rate, time horizon & ROI calculations; the level of uncertainty they are comfortable with; and the empirically-based benefit functions to translate ecosystem function into economic and financial value for the beneficiaries. Attend team meetings. Serve as technical reviewer, as needed.

ROLE	STEPS OF METHODOL-OGY	TIME (DAYS)	PROFILE	RESPONSIBILITIES
Economist [*usually contracted*]	Steps IV–VII	27–36	A trained economist with 3+ years of experience evaluating the competitiveness and efficacy of NbS projects. Should be familiar with NbS and source water protection activities; understand how to translate complex, technical concepts & communicate to a non-technical audience; is organized, collaborative, results-driven and responsive. Should speak the language.	Convert the improvement in ecosystem function caused by the proposed NbS program to economic and financial value for the beneficiaries of the economic & financial analysis. Work with the Project Manager—the point of contact for the Economist—and the core project team to choose the correct discount rate, time horizon, ROI calculations, empirically-based benefit functions, and include the correct costs. Relay preliminary and final results to the core project team in a clear
Modeling Specialist [*usually contracted*]	Steps III–V	45–60	A trained hydrologist and/or hydrogeologist with 5+ years of experience building and calibrating models for evaluating land-use-land change in watersheds and assessing the efficacy of NbS projects. Should have technical expertise in how NbS and source water protection activities alter ecosystem function and, the resulting ecosystem services. Should understand how to translate complex, technical concepts & communicate to a non-technical audience; is organized, collaborative, results-driven and responsive; and comfortable working under deadlines. Should speak the language.	Choose, build, calibrate, and test models for the business-as-usual scenario and the intervention scenario, incorporating the proposed NbS or source water protection activities. Work with the Project Manager—the point of contact for the Modeling Specialist—and the core project team to prioritize the most cost-effective portfolio of interventions; collect drivers of change in the project area (LULC, weather patterns, etc.); identify where in the project area the efficacy of ecosystem function will be assessed (e.g., plant intake points); and identify the unit(s) of measure for the ecosystem service(s). Relay preliminary and final results to the core project team in a clear and concise manner. Incorporate feedback. Notify Project Manager of any challenges or project delays.
Communi-cator	Step VII Post-Analysis	9–12	Does not need to have technical expertise, but they should be familiar with the proposed NbS project or WIP. Must be comfortable translating complex concepts, sourcing & managing design contractors, and developing dissemination plans for stakeholders and earned media. Should speak the language.	Work with the team to communicate the results of the economic & financial analysis to pertinent stakeholders—public or private—as appropriate. Coordinate the design, translation and public dissemination of a polished report so other practitioners can learn from the analysis.

For more information about the role and responsibilities of the Modeling Specialist and Economist, see the accompanying Terms of Reference template.

Appendix II:
Case Studies & Additional Resources

CASE STUDIES

TABLE 2. Selection of case studies addressing return on investment for nature-based solutions and source water protection interventions for water security.

CASE STUDY	LOCATION	ECOSYSTEM SERVICE(S)	BENEFICIARY(IES)	INTERVENTIONS	CO-BENEFITS
Assessing the Return on Investment in Watershed Conservation: Best Practices Approach and Case Study for the Rio Camboriú PWS Program	Santa Catarina, Brazil	• Sediment retention	Water Utility (EMASA)	• Restoration of riparian & headwater zones (planting native tree seedlings, enrichment) • Conservation of forest • Cattle fencing	• Biodiversity Conservation • Peak-season water supply risk • Flood risk reduction
Natural Infrastructure in São Paulo's Water System	São Paulo, Brazil	• Sediment retention	• For local water infrastructure operators, generally	• Reforestation	• Water flows • Flood risk reduction • Rural livelihood improvements
The Greater Cape Town Water Fund: Assessing the return on investment for ecological infrastructure restoration	Cape Town, South Africa	• Water flows • Sediment retention • Nutrient retention	• The Greater Cape Town Water Fund, composed of private & public stakeholders	• Invasive plant removal • Wetland restoration & protection • Decommissioning forestry • Restoration	• Job creation • Biodiversity
Upper Tana-Nairobi Water Fund: A Business Case	Nairobi, Kenya	• Water flows • Sediment retention	• Farmers in sub-watersheds • Utility (Nairobi City Water and Sewerage Company) • Hydropower Energy Utility (KenGen)	• Riparian management (buffer zones) • Agroforestry Terracing • Reforestation • Grass strips • Road erosion mitigation	• Drinking water for local communities • Habitat for pollinators & seed dispersal agents • Carbon sequestration • Opportunities for urban processors, spurring job creation, foreign exchange & economic growth

Sebago Clean Waters	Maine, USA	• Sediment retention • Nutrient retention	• Commercial & industrial water users • Local government	• Forest protection	• Clean drinking water • Provision of fuel & fiber • Climate and water regulation • Storm protection • Recreation • Biodiversity habitat
Mississippi River Headwaters	Minnesota, USA	• Nutrient retention • Pollution retention	• Drinking water service providers & wastewater treatment • State government • Minnesota homeowners & property owners	• Protection of wetlands, grasslands and forests • Land restoration	• Property value and tax retention • Avoided flood damages • Tourism revenues & jobs • Carbon mitigation • Human health benefits from cleaner air • Biodiversity habitat

ADDITIONAL RESOURCES

Browder, G., et al. (2019). *Integrating Green and Gray: Creating Next Generation Infrastructure.* World Bank and World Resources Institute, Washington, DC, USA.

ERG (Eastern Research Group, Inc.). (2015). *A Guide to Assessing Green Infrastructure Costs and Benefits for Flood Reduction.* National Oceanic and Atmospheric Administration, Office of Coastal Management, Silver Spring, MD, USA.

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Appendix III:
Common modeling approaches & technical tools for predictive modelling for the identification of measures to protect and maintain the watershed

For constructing an ROI analysis, it is likely that it will require combining multiple modeling platforms to appropriately evaluate, prioritize, and visualize a set of desired ecosystem services per a given portfolio of catchment management interventions. Below is a set of commonly used software tools for conducting ROI assessments to generate water security outcomes.

TABLE 3. Software tools used to conduct ROI assessments, and their suitability for water security challenges.

	SURFACE WATER QUALITY	SURFACE WATER QUANTITY		GROUNDWATER
	Sediments and Nutrients	Continuous Simulation	Extreme Flow Events	Quality and Quantity
HBV		■		
HEC*		■	■	
HSPF		■		
HydroBID*	■	■		
InVEST*	■	■		
J2000 Jams	■	■		
MapShed/GWLF	■			
MIKE	■	■		+ FEFLOW
RORB		■		
SIWA	■	■		
SSARR		■		
SWAT*	■	■		+ MODFLOW
Tank		■		
TETIS	■	■	■	
UBC		■		
VIC		■		
WaterWorld*	■	■		
WEAP	■	■		
WEPP	■			

*indicates models described in Table 5.

PREDICTIVE MODELLING FOR AN ECONOMIC AND FINANCIAL ANALYSIS

Modelling plays a key role in any *ex ante* WIP economic and financial analysis because such an analysis compares the predicted future outcome *with* the WIP (i.e., in the intervention scenario) with the predicted future outcome *without* the WIP (i.e., in the "business-as-usual" [BaU] or counterfactual scenario). Neither outcome is observable *ex ante*, so predictive modelling is required to construct both the intervention and counterfactual scenarios.

Prior WIP economic and financial analyses, combined multiple methods to assess its potential impact, such as (i) a spatial model to target the investment portfolios; (ii) a model to assess the biophysical impacts and benefits of the investments; and (iii) a range of economic valuation tools to estimate the economic benefits for upstream and downstream users, ultimately informing an assessment of the return on investment (ROI) (TNC, 2018; TNC, 2015). There must be a strong rationale for selection of methods and tool(s) used. For all modelling undertaken, the WIP activities and associated benefits and costs would ideally be analysed over a 30-year time horizon, but alternatives can be arrived at during study period. In the modelling exercise, established best practices must be applied in constructing 1) intervention and 2) counterfactual—or "business as usual" (BaU) scenarios, as demonstrated in other economic and financial analyses (Kroeger et al., 2019; TNC, 2018; Vogl et al., 2017).

At the most fundamental level, in the case of the BaU scenario, this entails the forecasting of future changes in the parameters that determine the outcomes of interest and assessing the impact of those changes on outcomes. The intervention scenario then assesses how relevant parameters are affected through the interventions and how those effects modify the outcomes of interest compared to the BaU scenario.

Both the BaU and the intervention scenarios therefore must be based on quantitative, evidence-based (i.e., empirical) relationships between key parameters and the outcomes of interest wherever possible. In particular, the impact of interventions on outcomes of interest must be assessed through quantitative, causal linkages, via changes in ecosystem structure, functioning, services and, finally, benefits and associated human welfare impacts. In practice, this involves integrated biophysical-economic modelling to answer the following questions:

- Which set of watershed investments (in which activities, and where) will yield the greatest returns towards multiple objectives?

- What change in ecosystem services can I expect from these investments?

- How do the benefits of these investments compare to what could have been achieved under an alternative investment strategy?

EXAMPLE OF INTEGRATED BIOPHYSICAL-ECONOMIC MODELING PROCESS FOR TECHNICAL ANALYSIS

A BaU scenario is constructed to describe how land cover and land use are expected to change over the time horizon covered in the analysis, and how those changes are expected to affect outcomes of interest and associated economic values, both of which may be defined with guidance from the consultancy supervisors. To the extent that an outcome is hydrologically mediated, the impact of predicted changes in land cover or land use on that outcome would be modelled using a model to assess the biophysical impacts and benefits of the investments on the watershed, such as the Soil and Water Assessment tool (SWAT), the Water Evaluation And Planning system (WEAP), the Integrated Valuation of Ecosystem Services and Trade-offs tool (InVEST), the Automated Geospatial Watershed Assessment tool (AGWA), MODFLOW or a similar tool.

Based on the current and projected future characteristics of the watershed, the analysis would identify where particular interventions should be implemented and what their impacts are on key outcomes of concern. Out of

the possible interventions identified in the prior feasibility studies and in collaboration with the consultancy supervisors, interventions are selected for inclusion in the analysis. Targeting of interventions across the study area would be based on both biophysical and socio-economic criteria and total WIP budget (to be defined by the consultancy supervisors) using a spatial model to target the investment portfolios. Examples of such models are the Resource Investment Optimization System tool (RIOS), the Restoration Opportunities Optimization tool (ROOT), the Artificial Intelligence for Ecosystem Services tool (ARIES) and other similar tools.

To the extent that the interventions lead to changes in land cover or land use practices, their impact on hydrologic parameters would be modelled using the biophysical impacts and benefits model. Finally, the economic and financial analysis would quantify the welfare changes associated with hydrologically-mediated (e.g., water quality, stream discharge) or other (e.g., crop yield changes due to conservation agriculture practices) intervention outcomes.

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