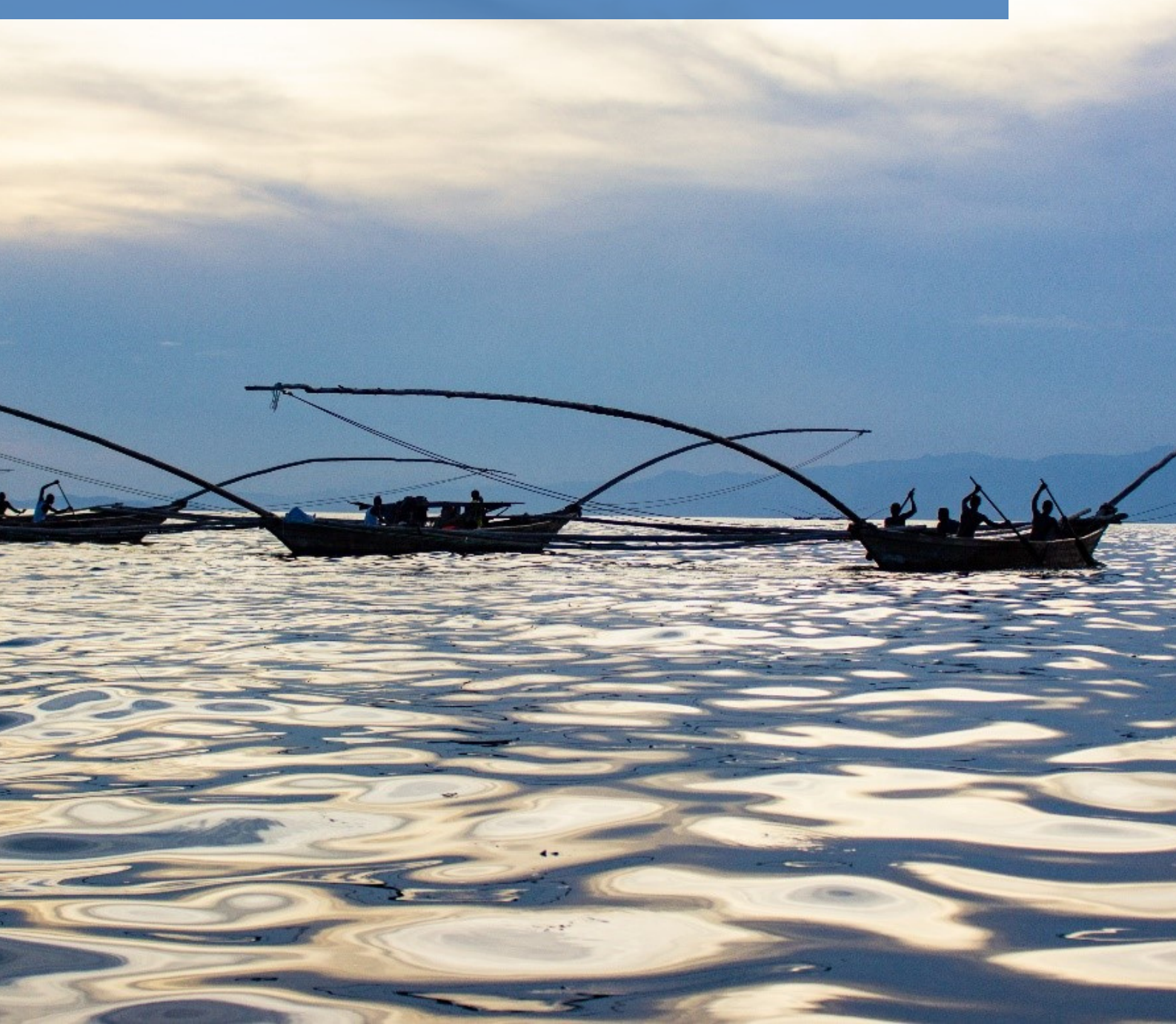


THE NIA NEXUS IMPACT ASSESSMENT (NIA) TOOLKIT

Turning Concepts into Action



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1. The Nexus Impact Assessment NIA Toolkit Introduction

Water resources, energy generation, and food production are interdependent (Allouche et al., 2015; Muller, 2015). Actions in one area often have effects in one or both other areas. For example, water is used in agricultural production and along the entire agri-food supply chain (Food and Agriculture Organization (FAO), 2011a). Agriculture accounts for 72 percent of total global freshwater withdrawals, making it the largest user of water (United Nations (UN) Water 2021). At the same time, food production and supply chain consume about 30 percent of total global energy (FAO, 2011b; 2022[1]).

Energy is required to produce, transport and distribute food as well as to extract, pump, lift, collect, transport and treat water. But one-third of all food produced globally is either lost or wasted (International Renewable Energy Agency (IRENA), 2015).

Efficiency measures along the agri-food supply chain can help save water and energy, such as drip and precision irrigation. Fossil fuel production, still a dominant part of the global energy mix, is highly water intensive, as is biofuel production and the growing practice of shale gas extraction. In contrast, other energy sources such as geothermal energy have great potential as a climate-independent resource that does not consume water or is less water-intensive (UN Water, 2022).

Overall, as global demand for water, energy and food is set to rise, due to changing consumption patterns and worldwide population growth, consideration for integrated problem solving is imperative. A further stressor is that the international supply chain system must deliver products and resources on a planet where predominant risks include extreme weather events, natural disasters, and resource depletion (World Economic Forum, 2018).

One of the main goals of the Nexus approach is to reduce or avoid negative trade-offs resulting from policy development in institutional “silos” (Belinskij, 2015). The Water-Energy-Food Security (WEF) Nexus approach gives recognition to the dynamic interlinkages between water, energy, and food security, with the intention of minimising unintended resource management risks and conflicts that arise with solely sectoral approaches.

Successful evaluation, documentation and communication of policy measures need reliable, and consistent data and information. Often, it is challenging to identify and quantify cross-sectoral resource dependencies, e. g. due to a lack of analytical tools and data that facilitate the operationalisation of the WEF Nexus or the identification of the added value of the integrated approach. This would support policy and decision-making processes for integrating the WEF Nexus approach into, for example, project development and monitoring processes. Furthermore, many projects are not direct Nexus projects, there are many projects at the interface of, for example, energy-water or water-agriculture, etc. Furthermore, critiques have emphasised the need for a transition from “nexus thinking” to “nexus action” and have called for the integration of qualitative and quantitative Nexus assessments (Simpson, G. B., and Jewitt, G. P. W., 2019).

In response to the needs and concerns, it was important to create a toolkit that would allow for example projects which are often built on a sector logic to think directly about the potential impacts on the other sectors during the project planning phase as well as during project implementation. The so-called Nexus Impact Assessment (NIA) Toolkit provides a comprehensive methodology and user-friendly tools that contribute to this transition, while the toolkit can be applied in different contexts,

[1] FAO 2022: Energy. Access: [Home | Energy | Food and Agriculture Organization of the United Nations \(fao.org\)](https://www.fao.org/energy/).

raise awareness of the benefits of the WEF Nexus and, for example, help project developers to plan and implement their projects across the WEF sectors.

The NIA Toolkit consists of four main elements, all of which can be used together, but also independently of each other:

- Firstly, the **WEF Nexus Principles**[2], which is a document with a selection of main principles that guide a successful application, implementation and operationalisation of the WEF Nexus approach at different levels and in different regions. It is based on concrete experiences of the WEF Nexus activities of the GIZ Nexus Regional Dialogues Programme. In doing so, it serves as a living document that can be further strengthened through exchanges and experiences with and of the global Nexus community and beyond.
- Secondly, the **WEF Nexus Safeguards** have been designed to enable policy makers as well as public and private project developers to determine whether a project or set of interventions and activities are improving water, energy, and food security, while avoiding negative impacts on another WEF sector. Using the developed WEF Nexus Safeguards checklists, it is easy to pre-assess whether the respective project or activities meet WEF safeguards requirements, imply WEF resource coherence and/or include measures that actively counteract negative trade-offs. After conducting the safeguards process, the project developer will either be aware of the WEF Nexus compliance of the projects and longevity and scalability and its significant co-benefits (e.g., in terms of climate mitigation, land restoration, and allowing for crowding-in private finance). Or the project developer learns where there is a need for improvement in terms of WEF Nexus compliance.

- Thirdly, both above-mentioned tools are accompanied with an excel-based **WEF Nexus Indicator** catalogue relevant to measuring WEF Nexus aspects, links to more information about how to measure each indicator, and where existing data may be retrieved. This catalogue is a dynamic tool, in that the set of indicators is non-exhaustive just like the endless possibility or combination of Nexus solutions. Interests and needs vary from project to projects, as does the way activities are measured, depending on what the project is trying to achieve. Therefore, the WEF Nexus indicators are not standard or mandatory indicators, but provide an overarching entry point, inspiration and help for the project developers themselves. In each case, it is possible to select indicators that are specific to the project under consideration.

Other products can be used to complement the NIA Toolkit: These include a **Monitoring and Evaluation (M&E) framework** within which projects can be monitored so as to evaluate if water, energy, food security components are improved, as well as other project objectives – such as land restoration, gender equality and improved livelihoods. It identifies the key elements of an M&E system, including the recommended steps, the basics of the Theory of Change, how to structure data collection activities and develop appropriate M&E indicators. In addition, the **Nexus Impact Assessment** of three demonstration projects in Ecuador, Peru and Niger, as well as **Cost-Benefit Analysis (CBA)** - methodology and applications of WEF Nexus projects can be taken into consideration. The CBAs offer stepwise approaches to quantify the outcomes of WEF Nexus projects and allow to assess the returns on investments in WEF Nexus project ex-post and ex-ante, from a private and societal perspective.

[2] Accessible at the Nexus Resource Platform: [nexus_principles.final.version.30-06-2020.pdf](https://nexus-principles.final.version.30-06-2020.pdf) (water-energy-food.org).

Overall, the NIA Toolkit is a tool to complement also other existing documents that are important for a successful project set-up such as existing national strategies, gender safeguards etc.

The primary target group of the NIA Toolkit includes professionals such as policymakers and project developers from the public and private sector, directly involved in the implementation of WEF Nexus activities. Or also those indirect involved stakeholders from development agencies, Non-Governmental Organisations (NGO), development banks, local communities, river basin organisations, etc.

For example, the applications of a Cost-Benefit Analysis and therein quantification of the outcomes of WEF Nexus projects and the monetary benefits they provide can be useful for agencies that are investing or considering an

investment in WEF Nexus activities and would like to assess whether the project is achieving what was intended and to estimate the potential or actual benefits of the WEF Nexus activities.

Figure 1 below shows the components of the NIA Toolkit and CBA, and the main steps associated with implementing, either or all of them.

Steps in using the Nexus Impact Assessment (NIA) Toolkit

In the very early stages, the project is conceived by the project developer. At this stage, the WEF Nexus principles and WEF Nexus Safeguards are applied to ensure that the project is WEF Nexus compliant (compared to other projects that could result in negative trade-offs).

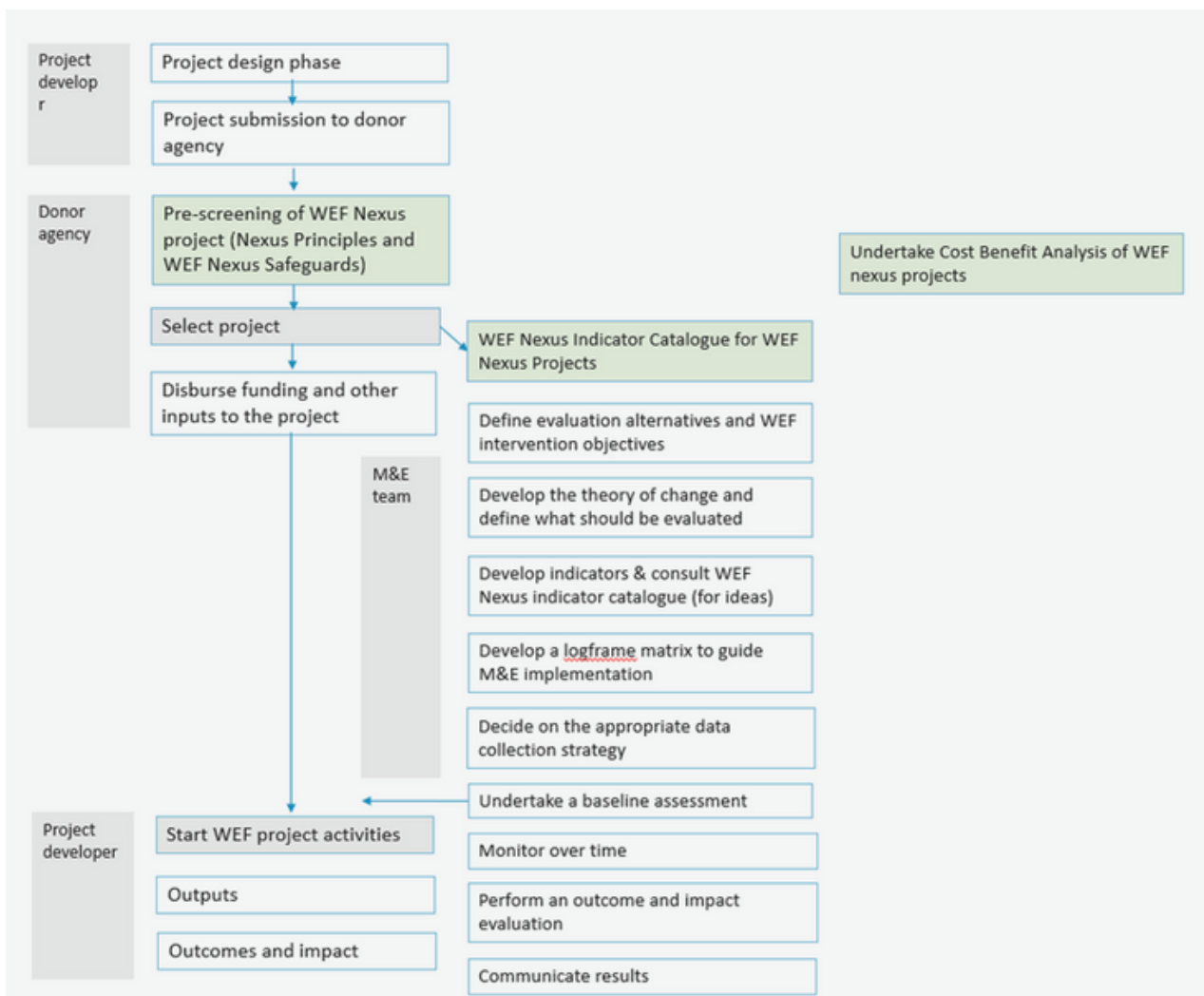


Figure 1: Components of Nexus Toolkit, Nexus Impact Assessment and Cost-Benefit Analysis

The WEF Nexus Indicator Tool can also be used to set up a project or activity cross-sectorally and define common indicators that guarantee long-term water, energy and food security. All this is to ensure that the respective project makes best use of existing interconnections and/or includes measures to actively counteract negative trade-offs.

A cost-benefit analysis (CBA) can be applied at different stages of a project cycle (ex-ante, inception, as a mid-term evaluation or ex-post) in order to determine the long-term net monetary value of project. The CBA can be ex-ante, e. g. to assess the case for investing in the project, or to help inform decision-makers about the value of the planned activities. Similarly, the CBA can be used ex-post to obtain a comprehensive understanding of the societal value of the WEF Nexus project and to determine whether there is a case for replicating the activities.

Overall, the various tools comprised in this NIA Toolkit serve the purpose of ensuring the highest degree of resource efficiency in relevant project and policy design. At the same time, it provides guiding documents to support a comprehensive assessment process to illustrate that an integrated approach ensures greater impact, despite higher-upfront transaction costs (monetary and non-monetary). This document seeks to highlight the importance of sound data management as an important pre-requisite for a WEF Nexus assessment. It therefore dedicates an entire document on the key factors/elements of a monitoring and evaluation (M&E) system and undertake a baseline assessment, against which project outcomes can be evaluated. Indicators and data collected for the M&E assessment may also serve to inform the CBA.

The NIA Toolkit was developed, in parallel to the piloting of the M&E and CBA framework, in four locations worldwide (running Q1 2021 to Q1 2023), including:

- **Niger:** A CBA of the implementation of a solar-powered irrigation scheme (SPIS), substituting fuel driven pumps, implemented on a communal land plot held by an association of women in Kollo (Verdone, M., 2022).
- **Peru:** An M&E Plan and CBA analysis for a set of WEF Nexus interventions in the community of San Pedro de Casta. The interventions include the building of a solar-powered greenhouse for crops production and, a guinea pig rearing facility as well as the rehabilitation of an ancient water pond. Jointly these activities are designed to increase food production throughout the year, increase groundwater infiltration and resilience to environmental disaster risks (see Sales, 2022).
- **Ecuador:** An intervention to help the Kallari association in the canton of Tena to switch from a fossil-fuel driven cocoa drying process to an innovative and energy efficient solar-powered process. Aside from reducing greenhouse gas emissions, this is likely to have positive impact on cocoa farmers, as they may be able to get higher prices for cocoa beans.
- **Uzbekistan and Turkmenistan:** A CBA of different sediment management options for the Tuyamuyun Hydro Complex (THC). These interventions are designed to enhance the lifetime of the reservoir to safeguard food, water and energy security, whilst making productive economic use of the sediment.

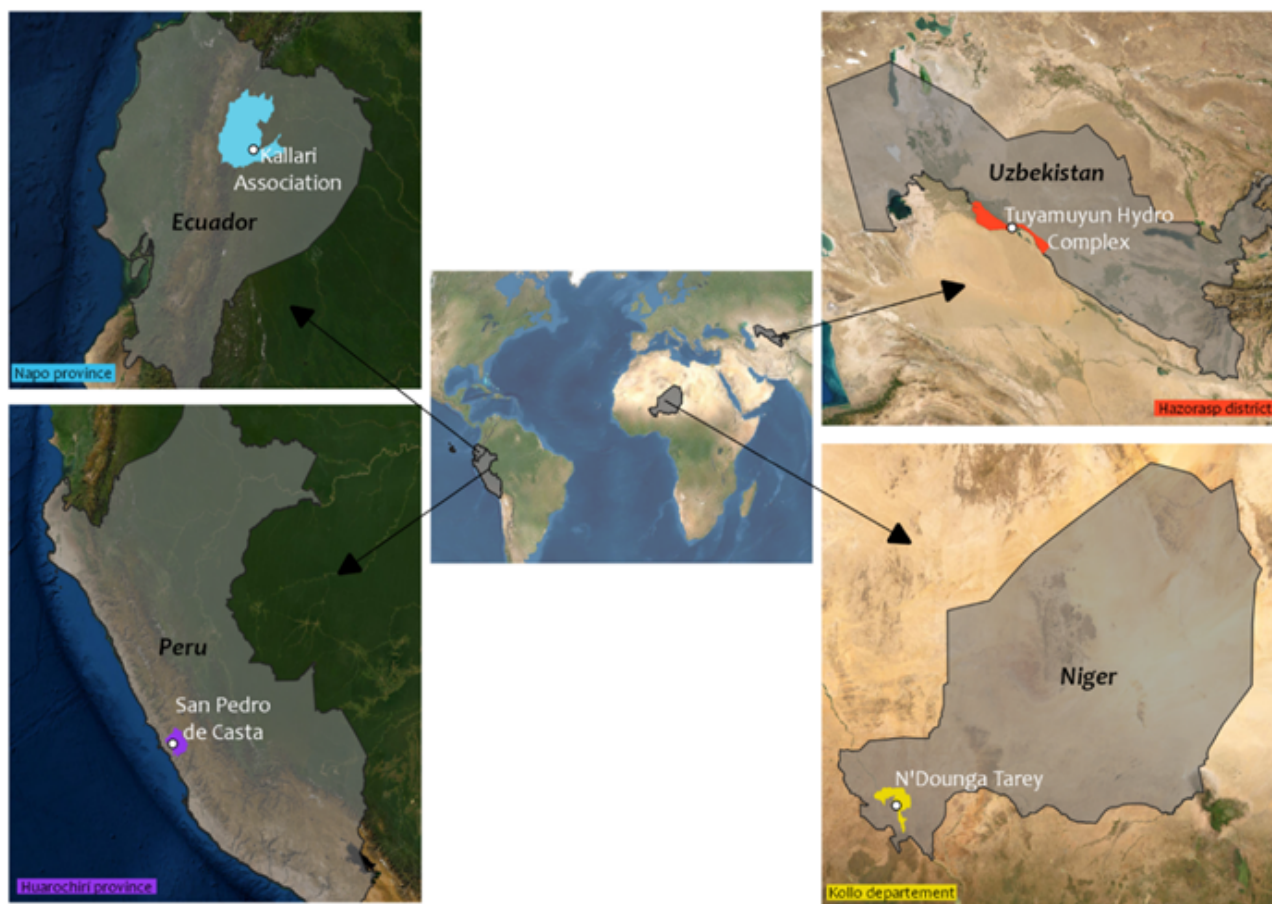


Figure 2: NIA Toolkit demonstration projects

These projects are referred to where appropriate in the NIA Toolkit. The interested reader can also consult the relevant publications or working papers for concrete examples. In addition, accompanying documents with more information on the respective tools complement the NIA toolkit and can be accessed if interested.

Thus, the NIA Toolkit raises awareness on the interlinkages between water, energy, food and environment and provides food for thought to reflect on and consider possible trade-offs on other sectors. With the help of the toolkit, the primary target group such project developers or decision-makers are supported in identifying the potential of multi-sectoral interventions, thereby ensuring cross-sectoral project planning and implementation and making sure that the project maximises synergies to increase the impact while not negatively impacting on the other sectors.

By using the tools, one is able to measure and evaluate cross-sectoral impacts (as well as benefit over cost ratio) across the WEF Nexus and beyond (such as livelihood and environment). It is a toolkit that helps to move from silo thinking to Nexus doing – from sectoral project planning and implementation to integrated planning and implementation.

2. The WEF Nexus Principles and WEF Nexus Safeguards

Water, energy, and food (WEF) security are interlinked so that actions in one sector commonly have impacts on the others (FAO 2019). To breach policy and decision-making silos, it is important to apply the WEF Nexus to reduce trade-offs and build synergies across sectors. This essentially implies that when a given policy or project serves to secure an aspect of water, energy, or food security (a so-called WEF element), no other WEF element should be compromised. Moreover, and to the extent possible, it is desirable to ensure that WEF are secured simultaneously, creating double or even triple win situations.

To gain a clearer understanding of the WEF Nexus, Table 1 in Annex 2 underlines how water, energy, and food security are defined in key literature. It reveals that water, energy, and food security are defined by various physical, market, environmental, and social variables. Two recurrent themes, however, relate to the available quantity of the resource (whether it be water, food, or energy), as well as the reliability or quality of the resource. These have been summarised under the heading of quality.

With this in mind, easy-to-use tools help for identifying and prioritising diverse WEF projects or activities. The Nexus Impact Assessment (NIA) Toolkit can facilitate the implementation of such a project that aims to build synergies across water, energy and food sectors. The 1) **WEF Nexus Principles** and 2) **WEF Nexus Safeguards of the NIA Toolkit** are two tools that allow for a preliminary exploration and assessment of projects, whilst helping the project developer consider aspects^[1] where more in-depth information or assessments may be needed to decide on whether to appraise the project or how to proceed with the planning and implementation.

The principles and safeguards complement not only the WEF Nexus Indicator catalogue and complement not only the WEF Nexus Indicator catalogue and cost-benefit analyses (CBA) of the NIA Toolkit, but also other existing documents and tools that are important for a successful project set-up (issues such as alignment with national strategies, gender safeguards, crowding-in financing etc.).

More concretely, the **WEF Nexus Principles** (see Annex 1) provide guidance on how to successfully apply, implement, and operationalise the WEF Nexus approach in various contexts. In addition to explaining the importance of the WEF Nexus approach and what it can achieve when used successfully, a selection of principles or recommendation are given as a guidance. Compliance with these principles, such as “leave no one behind” or “capacity building of people, institutions etc.” in project planning and implementation will be a first step towards successful integration of the WEF Nexus approach.

In addition, the **WEF Nexus Safeguards** (see Annex 2, Table 2 and 3) have been designed to provide policy makers as well as public and private project developers with an intuitive and user-friendly tool. In its application, the WEF Nexus Safeguards’ checklists can serve the following two purposes: First, ensuring that all intended and unintended consequences of natural resource management for WEF securities are duly considered in policy planning and project design (i.e., a project appraisal mission) and intersections^[2] among WEF Nexus dimensions are identified.

To assist the project developer in identifying which types of activities may lead to potential negative impacts on the environment and/or raise significant concerns among potentially aff-

[1] Critical aspects with respect to resource allocation, biodiversity and wider ecosystem, climate change adaptation and mitigation, gender, environmental impacts, institutions, and governance, inside or outside the project boundary. In case of adverse impacts, these should be mitigated.

[2] Interdependencies can occur between all three dimensions simultaneously or simply just between two elements of the Nexus. This means in practice, intersections can be drawn between the water and food sector, the energy and water sector, the energy and food sector or all three.

ected communities and individuals, Table 3 in Annex 2 provides a checklist for the identification of high-risk actions. For further guidance on high-risk activities, the developer may refer to Annex 2 of the United Nations Development Programme's (UNDP) Social and Environmental Screening Procedure (UNDP 2019). Secondly, serving the purpose of selecting and prioritising projects according to their level of cross-sectoral considerations. Once intersections among the sectors have been identified, the project developer can take one step further and highlight the characteristics of those intersections and determine affected stakeholders. Additionally, for projects that have been classified as coherent with the WEF Nexus safeguards, the possibility of undertaking further project assessment of key indicators, pertaining to wider sustainability impacts of WEF Nexus projects is of great importance.

3. Monitoring and Evaluation (M&E) for WEF Nexus projects

Background

To breach decision-making silos evidence is required to show that projects can be conceived to create synergies across Water, Energy and Food (WEF) sectors. Following the chapter on WEF Nexus Principles and WEF Nexus Safeguards we define a WEF Nexus project as a time-bound intervention or series of interventions aimed at improving synergies between at least two WEF sectors, or improving the resource-use efficiency of one WEF sector. [1] Achieving these ambitious goals requires rigorous evaluation so that public, private, and non-governmental agencies, involved in the implementation of WEF Nexus projects can witness the added-value of integrated solutions and continually improve their budget allocations and how they carry out their work and budget allocations.

This chapter has been designed to help lay solid groundwork for building M&E assessments of integrated projects, including the main steps in undertaking an M&E, the theory of change and how to develop relevant indicators. A complementary WEF Nexus Indicator catalogue is shortly introduced in the following chapter along with an excel-based spreadsheet. The importance of undertaking rigorous M&E, from the outset of the project, is not to be undermined.

Baseline data can prove valuable for the project lifespan, in facilitating an attribution of project outcomes to WEF Nexus projects and provide a basis upon which to undertake a Cost-Benefit Analysis (CBA; chapter of WEF Nexus projects). In term, such data can be used to conceive a WEF Nexus project database and build the needed evidence base for WEF Nexus projects.

The WEF Nexus approach have been criticised for lacking tools to quantify cross-sectoral impacts; facilitate monitoring processes and supporting decision-making processes for the integration of the WEF Nexus approach in resource governance (GNS 2020). Addressing this deficiency, the next three chapters demonstrates how carefully designed M&E assessments and Cost-Benefit Analysis can be used to track, value and communicate progress on enhancing WEF security and wider goals, such as improved livelihoods, enhanced climate change mitigation, and aggregate diverse benefits within WEF Nexus project interventions.

Starting with the M&E framework, in the following we provide an overview of the **main steps involved in undertaking monitoring and evaluation** and the important questions to ask along the way. Emphasis is placed on providing an easy to-use overview, as opposed to an exhaustive account of all the methods, tools and processes that can be deployed when undertaking M&E. We are drawing on resources from the BetterEvaluation (2022) framework, our experiences in implementing M&E in pilot case studies in Ecuador and Peru (chapter 1 for details) and an interview with senior M&E expert (Hastings 2021). For the most part we propose one approach to undertaking a given step. For further detail on the methods and tools, the reader is referred to BetterEvaluation (2022).

What is M&E for WEF Nexus projects

Monitoring and Evaluation are processes to help projects, programmes, and organisations in being accountable, adaptive, and sustainable through the sound use of data, research-evidence and continuous reflection.

[1] Efficiency gains can free up scarce resources to achieve more with less. The WEF Nexus project selection tool provides a further detail of what makes a project eligible to be classified as a WEF Nexus project.

The monitoring piece of M&E refers to the routine collection of data to track change over time. It helps us understand “What is happening?” The evaluation side is a periodic assessment that goes deeper to examine the data and discover the how and why a programme, project or WEF action is achieving what it is “Why did it happen like that?”. The evaluation can then be used to report on the tangible outcomes of the WEF intervention and where improvements can be made.

Finally, M&E should be complemented with learning[2]. Learning (L) is the continuous process to ensure that findings from monitoring and evaluation are used and incorporated into the future design of the project or any attempts to scale-up an existing project. Ultimately therefore, any ME(L) plan should therefore result in better decision making. For this purpose, WEF Nexus M&E assessment should provide timely, trusted, reliable and decision-useful information. In particular, we need to be really clear about what we want to measure, who is going to collect the information, and what we want to do with it once we have it? Data-collection and reporting are not in themselves the end goal.

The next section lays out the main steps in this process and Figure 1 summarises key elements of an M&E system.



Figure 1: Key elements of an M&E system

Step 1: Define intended users and uses of the M&E system

The actual uses of the M&E system should be defined at the outset. Questions of relevance are:

- What is the value of undertaking M&E in this given context?
- Who are the intended users of this evaluation?

For example, users could include project donors or funders, interest groups with a stake in the project, and the project implementers themselves, whilst the M&E system may be used to understand whether a WEF Nexus project is achieving its objectives and help inform where performance and outcomes should be improved.[3] Table 1 shows an example of some of the identified values and uses of the M&E frameworks in the context of a generic WEF Nexus project.

Step 2: Define responsibilities in M&E management

Once the overarching purpose and uses of the M&E system have been defined, decisions need to be made regarding who will undertake the evaluation? There is no one-size fits all approach. The evaluation can be done by community members, through an expert-review, external consultant(s), internal project staff (e. g. project developers themselves), a hybrid of internal staff, community and/or external consultants.

The chosen option depends on the resources available and the decisions on the frequency with which monitoring will be conducted. For example, if there is an interest in undertaking repeated and frequent measurement (monitoring) over time, it may be of interest to involve community members and internal staff, e. g. by using data measurements measured through a mobile phone-app.

[2] M&E is therefore sometimes referred to as a MEL in the common literature.

[3] Also, the selection criteria of the NIA Toolkit can be used to plan and develop a project to ensure that it follows a holistic approach and takes into account all possible trade-offs.

Value	Uses
<p>Understanding: How and to what extent are the WEF Nexus intervention achieving (or not) the desired changes? <i>E.g., is access to and availability of food supply improved whilst the water footprint is reduced?</i></p>	<p>Inform WEF Nexus interventions</p> <p>Build internal capacities in M&E amongst project implementers</p> <p>Understand value for money</p>
<p>Adaptation: How should the WEF intervention be adapted as a result of what we are learning?</p>	<p>Create a database for WEF security over time</p>
<p>Credibility: Do our interventions have the impact that they claim? With respect to enhancing synergies in water, energy and/or food security?</p>	<p>Impact communications regarding the value added of WEF Nexus projects</p>
<p>Publicity: What impact can be communicated to partners and other interest groups?</p>	<p>Donor reporting</p> <p>More...?</p>

Step 3: Define evaluation alternatives and high-level WEF intervention objectives

With an understanding of who undertakes and manages the M&E system, the objectives of the project need to be spelled out and compared to the situation without the project or the alternative project. At a very basic level, the first questions to be asked by the M&E staff are:

- What is the project about?
- What is the project seeking to achieve relative to the ‘without project’ situation or an alternative ‘single-sector’ project?

If the WEF project is not yet implemented, the “without-project” situation may be considered the baseline situation, depicting what would happen if we continued with Business As Usual. In some cases, the without-project situation may also be ‘single-sector project’, e. g. the farmland in Niger that was used to produce crops but was not accompanied with solar powers irrigation equipment which can serve to enhance energy and water security, simultaneously.

The same decisions are relevant when undertaking a CBA (see chapter on WEF Nexus Benefit-Cost Framework). Table 2 shows with and without project examples from the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH Nexus Regional Dialogues (NRD) Programme WEF Nexus projects and intended vision.

Box 1: When a CBA should precede a M&E Plan

In some cases, it may not be clear whether a project should be implemented, i. e. whether it is financially or economically viable. In that case, a Cost-Benefit Analysis (CBA) can provide clarity whether it is a worthwhile investment. The CBA can also be used to prioritise amongst different ‘with-project alternatives’ so as to choose the alternative that provide the highest net-benefits to society. In this case the CBA should inevitably precede the M&E plan that can only be planned once it is decided what the WEF Nexus intervention consist of. See chapter on WEF Nexus Benefit-Cost Framework for an overview.

Where / Toolkit application	'Without-project' alternative	'With-WEF Nexus project' alternative	Vision the project is seeking to achieve
Peru Activity: M&E	San Pedro de Casta: <ul style="list-style-type: none"> No land is under irrigation No vegetables greenhouse production No guinea pig rearing facility (Or: guinea pig rearing facility enabled without renewable energies) the q'ocha is not rehabilitated all electricity is derived from diesel powered generator 	<ul style="list-style-type: none"> Rehabilitation of the q'ocha for flood control and groundwater infiltration Construction of greenhouse for the production of fruits and vegetables A composting facility Increased ha of irrigated cropland Guinea-pig rearing facility enabled with solar powered irrigation 	<ul style="list-style-type: none"> Enhanced disaster risk resilience Improved incomes Enhanced food security Enhanced water and energy security
Ecuador Activity: M&E	Kallari Association: <ul style="list-style-type: none"> uses a highly energy-intensive and fossil fuel driven grain drying process 	<ul style="list-style-type: none"> Cocoa drying using an innovative and energy efficient solar powered process 	<ul style="list-style-type: none"> Improved energy efficiency Reduction of greenhouse gas emissions Higher premium price on cocoa output Increase in productivity and thus economic benefit
Niger, Kollo Activity: CBA	<ul style="list-style-type: none"> Residual water from rice field used for irrigation of a collective agricultural land plot 	<ul style="list-style-type: none"> Solar powered irrigation pump, providing a reliable supply of water to enhance agricultural produce in wet and dry season 	<ul style="list-style-type: none"> Increase the total annual harvest of agricultural crops Improve yields in the dry season Improve income
	'Without-project' alternative	'With-WEF Nexus project' alternative	Vision the project is seeking to achieve
Uzbekistan Activity: CBA	<ul style="list-style-type: none"> Continued silting of the Tuyamuyun Hydropower complex until it is no longer operational (estimated remaining) 	<ul style="list-style-type: none"> Reduce sedimentation of the Tuyamuyun Hydropower complex with dredging and/or flushing Reuse of sediments for building material / fodder production etc. 	<ul style="list-style-type: none"> Enhanced reservoir storage capacity for improved water, energy and food security of Uzbekistan, Turkmenistan, and Kazakstan

Table 2: Some examples of GIZ-funded WEF Nexus projects[4], and what the projects are seeking to achieve

[4] Further information on the demonstration projects can be found in respective chapters.

Step 4: Define what should be evaluated – using a Theory of Change

With an understanding of values, users, as well as responsibilities and alternatives to be considered as part of a WEF Nexus M&E assessment, the M&E assessment can be planned. This starts with an understanding of what needs to happen to achieve the intended vision of the project. By drawing up a Theory of Change (ToC)[5], we explain how WEF Nexus interventions contribute to outputs and outcomes that lead to the intended impacts.

“The theory of change tells us: What needs to happen to achieve the intended vision of the project.”

The Theory of Change will subsequently inform what are good evaluation questions, what should be measured, and provide a structure for data analysis and reporting.

In the context of WEF Nexus projects, it is advised that a ToC is drawn up during the project design phase, or prior to the implementation of WEF Nexus implementation activities have begun. If the M&E assessment is commissioned after WEF project activities have started it can be used to make sense of what has happened and the data that have already been collected.

As monitoring and evaluation data become available, stakeholders can periodically refine the Theory of Change and associated logframe (next section). This is often done during evaluations reflecting what has worked or not, in order to understand the past and plan for the future.

Key questions to address when developing a Theory of Change

In any order that may be fitting for the discussion, the key questions to be asked or addressed by the practitioner when developing the ToC are:

- What is the impact we want to achieve?[6]
- What are short/medium-term outcomes that are preconditions for the impact?
- What are the basic inputs and activities of the project? What kinds of outputs are expected as a result of these activities?
- What do we expect in terms of outcomes in the short and long term?

In answering these questions under the ‘Theory of Change’, it is important to draw on a range of evidence – previous research and evaluation, projects and programmes, the mental models of stakeholders (including planners, managers and staff, partner organisations, and intended beneficiaries) and observation of preliminary outcomes.

A ToC model is conveniently developed in a workshop with project stakeholders and by reading program documents, talking to stakeholders, and analysing data. As the starting point, long-term goals are typically defined in terms of desired impact. These impacts are then mapped backward to identify necessary preconditions, in terms of activities, outputs and outcomes (Brest 2010).

It is important to ensure that the process is adequately inclusive of relevant perspectives, values and evidence. Having worked out a change model, practitioners can make more informed decisions about **appropriate indicators and an evaluation strategy**.

WEF Nexus interventions should ultimately serve to enhance synergies between water, energy and/or food resources, with consideration to access, quantity, quality and governance of water, energy and food and related ecosystems. However, providing more water, energy or food does not guarantee that other challenges are addressed. WEF Nexus projects therefore typically aim to generate wider social, economic, and environmental benefits within the project area of interest.

[5] Brest, P. (2010). The Power of social change. Stanford Social Innovation Review. Spring.

[6] The impact describes long-term outcomes and can be understood as the change that one sees in society as a result of the activity.

In this context it is important, not only to be able to measure changes in W+E+F security, but also ensure that complementary indicators are developed, to measure for example, the creation of jobs and additional income.

A ToC is often illustrated as a flowchart that describes the steps and assumptions taking place between the intervention – activities, outputs, outcomes – and the ultimate change desired – impact. Diagrams should clearly show the direction of change. It is important to choose a format which will communicate clearly and allows for deliberation with project developers and non-M&E experts. A theory of change diagram is usually represented with an accompanying narrative (see Rivera (2022) as an example).

Note: A ToC was not done in Peru and Niger. Due to time pressure, in Peru a questionnaire has been developed and resorted to phone calls. In Niger a CBA were defined so that there was no need for a ToC.

Box 2: The Theory of Change for Ecuador and associated indicators

In the case of Ecuador, the main intervention concerns the installation of a solar powered cocoa dryer at the Kallari Association facilities to be used instead of a greenhouse dryer. Expected outcomes of the intervention are to enhance energy efficiency in the cocoa process, allow cocoa farmers to sell premium priced cocoa and generate more jobs within Association. To assess whether the new solar powered dryer is helping achieve these outcomes, the ToC was an essential tool for defining the indicators to be measured including, amongst others: Number of new jobs that are created, increased purchasing power and economic wellbeing of cocoa farmers in Tena and increases in the average farmgate price of cocoa. See log frame for the full range of indicators. For that purpose, documents, records, and logs, along with household questionnaires have been conceived to allow for the baseline assessment of these indicators. In parallel, cocoa yields and prices in control locations are observed, to ensure that any changes can be attributed to the actual WEF nexus intervention. Supplementary interviews with donors, also highlighted the importance of ensuring that the interventions would be long-lived. This led to the addition of other questions which assessed community members understanding of “who to go to” if there are technical problems and their overall confidence with the activities being unrolled by the Geological and Energy Research Institute of Ecuador (IIGE, for its acronym in Spanish), the project developer.

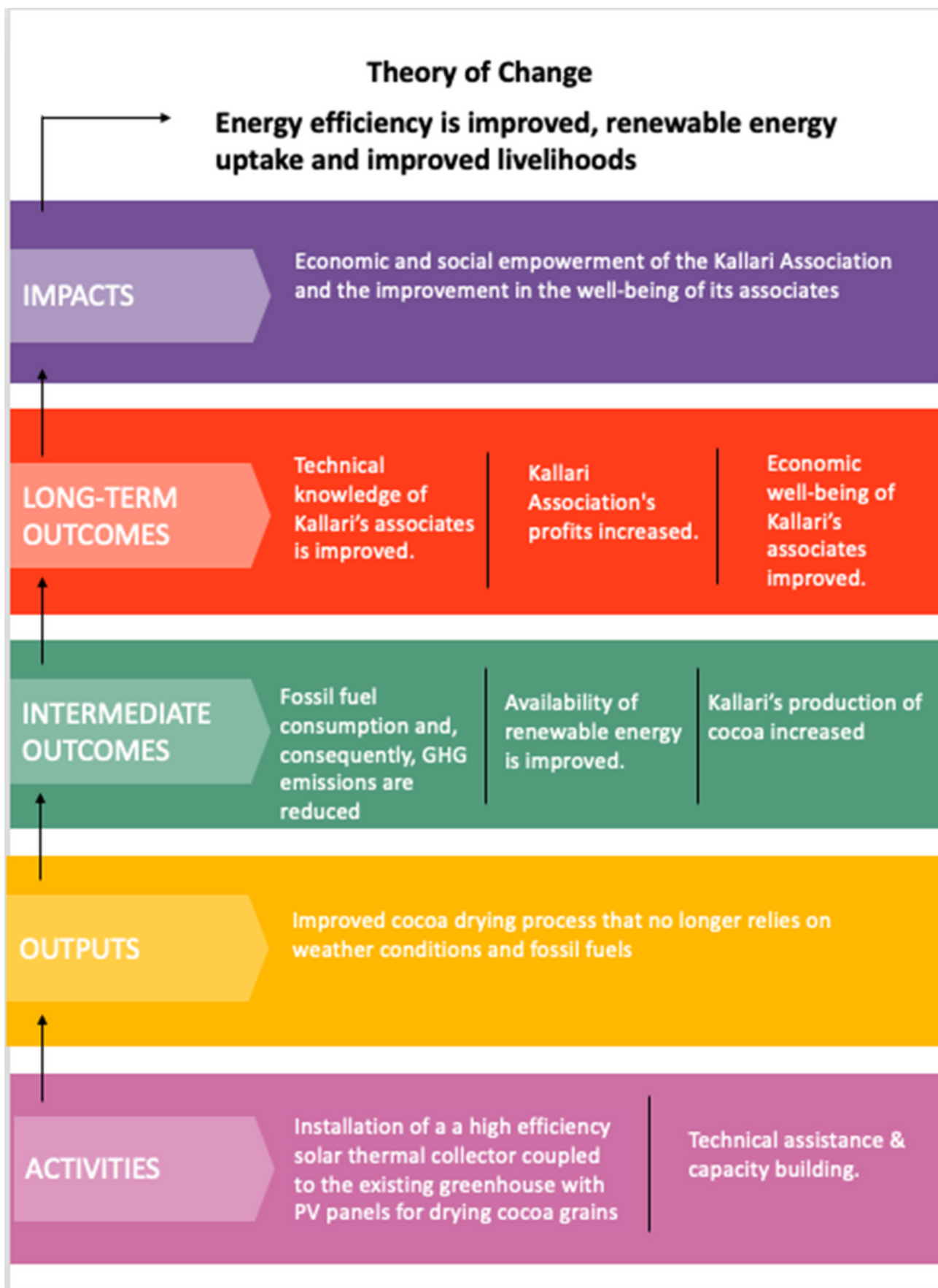


Figure 1: Example of the ToC developed in the context of the WEF Nexus project in Ecuador

Step 5: From the Theory of Change to a Logframe

Once the ToC is drawn up, it is advised that a logframe matrix is used to guide the implementation of the M&E plan. Logframe matrices assist in establishing the development pathways by which objectives in the ToC are reached, and how outputs and outcomes indicators are best monitored and evaluated. Unlike the ToC which gives a “big picture” of what the WEF Nexus intervention is seeking to achieve, the logframe is essentially for internal use to allow for more specific understating and elaboration of the monitoring component of the M&E plan.

Classical logframe components include:

1. the outputs, outcomes and impacts of the intervention, extracted from the ToC;
2. indicators for each of these outputs/outcomes/impacts;
3. baselines/ milestones/targets for each of these indicators;
4. roles for different stakeholders in terms of collection, analysis, and reporting of the data for this indicator;
5. the source of data for that indicator and the methods and data collection method;
6. any assumptions for each indicator that may impact on the ability to reach targets can also be included;
7. frequency by which this indicator data will be collected, and a proposed schedule.

The level of detail of the logframe can vary and the logframe can be revisited at any time, as the M&E plan is updated. Table 3 is an example of the logframe developed for Ecuador

Step 6: Devise the data and information gathering processes

Where to collect data

With the logframe developed, M&E practitioners can now collect data to answer questions about the situation prior to the WEF project intervention, or the WEF project intervention itself, in terms of the results it has had and the context in which it has been implemented. Data on relevant indicators will most likely need to come from a variety of sources. For example, high level data on the proportion of households that have access to portable water, may be obtained from the water utility or municipality, whilst other information may need to be gathered at the level of the household.

It is therefore also important to decide on the appropriate sampling strategies for data collection. Is it desirable to use probability sampling, such as a simple random sample, a stratified random sample, or convenience sampling? This depends on the required degree of statistical confidence that is sought and the budget that is available for data collection. In some cases - as we found in Ecuador - deliberation through direct interviews was considered a more suitable method for eliciting operational and financial data.

Table 4 provides an example of the various ways by which data can be collected. The reader is referred to the better evaluation framework for more detail on these and other methods.

Impact								
Economic and social empowerment of the Kallari association and the improvement in the wellbeing of its associates								
Outcome	Indicator	Baseline	Milestones/Target	Source of data/means of verification	Frequency	Responsible	Risks and assumptions	
Long-term Outcomes	Strengthening of the agro-industrial production chain of the Kallari Association	Increase in the average purchase price / quintal from local farmers by Kallari				Annual	Kallari Association	Risk: prices depend not only on domestic operations but also on the national and international market.
		Number of new jobs created within the Kallari partnership (disaggregated by gender)				Annual	Kallari Association	As cocoa production and sales may increase, the Association may need more labour. Risk: Improving efficiency in the process could make the work of some employees redundant.
		New Kallari associates: New male members / New female members						New drying system makes the drying capacity more efficient, allowing the integration of new cocoa producers into the Kallari Association
		New Kallari business partners (disaggregated by sex)						New solar dryer system increases the amount of dried cocoa per batch and, consequently, an increase in cocoa derived products.
	Economic well-being of Kallari's associates improved	Increased purchasing power and economic well-being of cocoa farmers in Tena			Household survey	Annual	Kallari Association ⁷	Due to the new drying system, the association increases production and thus the demand for fresh grain from local farmers, at a better purchase price.
	Kallari Association grows and profits are increased	% Increase in cocoa bean production						New solar dryer system increases the amount of cocoa dried per batch.
% Increased in processed cocoa sales							Dried cocoa grain quality improves since humidity level is better regulated.	
Medium-term Outcomes	Energy efficiency in the cocoa production chain is improved	Fossil energy (kWh) saved in conventional cocoa drying process derived from diesel	Kwh			Quarterly		The amounts of energy used are calculated from an absence of the project point of view/scenario.
		Fossil energy (kWh) saved in conventional cocoa drying process derived from GLP	Kwh			Quarterly		
		CO ₂ emissions (Kg) saved regarding conventional processes using diesel and LPG	Kg of CO ₂			Quarterly		
	Availability of renewable energy is improved	Energy (kWh) generated by the solar PV system used in the cocoa drying process				Quarterly		
		Energy (kWh) generated by the solar thermal collector used in the cocoa drying process				Quarterly		
	Technical knowledge of Kallari's associates is improved.	Number of employees from Kallari Association trained on the use and maintenance of the solar dryer system.	0 employees	At least 5 employees from Kallari	Reports from IIGE including attendance records	Annual		
		Number of technical guides, scientific papers or other informative documents generated from the implementation of the solar dryer system	0 documents	?	technical guides, scientific papers	Annual		
		Number of dissemination and training events on climate change issues and the benefits of the use of renewable energy in agricultural processes.	0 training events	1 training event	Reports from IIGE including attendance records	Annual		There is interest on the part of the Kallari's associates in receiving the training.
Short-term outcomes	Kallari's grain drying operations are improved.	Additional mass of cocoa grain (kg) dried per batch when implementing the solar dryer		Drying capacity per batch = 2,500 kg	Quarterly			

Table 3: Example of the logframe developed for Ecuador

[7] IIGE and Altus Impact will be responsible during the first year of the project.

Collect and retrieve data	
Information from individuals	Information from groups
<ul style="list-style-type: none"> ● Expert and stakeholder interviews ● Deliberative opinion polls ● Diaries ● Goal attainment scales ● Interviews with individuals/households <ul style="list-style-type: none"> ● In-depth interview ● Key-informant interviews ● Questionnaires (for surveys) <ul style="list-style-type: none"> ● Emails ● Face-to-face ● Computer assisted interviewing ● Mobile data collection 	<ul style="list-style-type: none"> ● Brainstorming ● Delhi study ● Fishbowl techniques ● Focus group discussions ● Concept mapping ● Participatory rapid appraisal methods ● Writing workshop

Table 4: Different examples of how data can be collected and retrieved (non-exhaustive)

Box 3: Recap of questions to consider when devising the data and information gathering process

Collect and/ or retrieve data:

- How will you collect and/ or retrieve data about activities, results, context and other factors?

Sample:

- What sampling strategies will you use for collecting data?

Manage data:

- How will you organise and store data and ensure its quality?

Combining information:

- How will you combine qualitative and quantitative data?

Analyse data:

- How will you investigate patterns in the numeric or textual data?

Assessing the counterfactual – what would have happened without the WEF nexus intervention?

In designing the M&E, it is important to consider how impact may be attributed to the project itself and not any external factors. The challenge is precisely to estimate a counterfactual, which is defined as a “situation

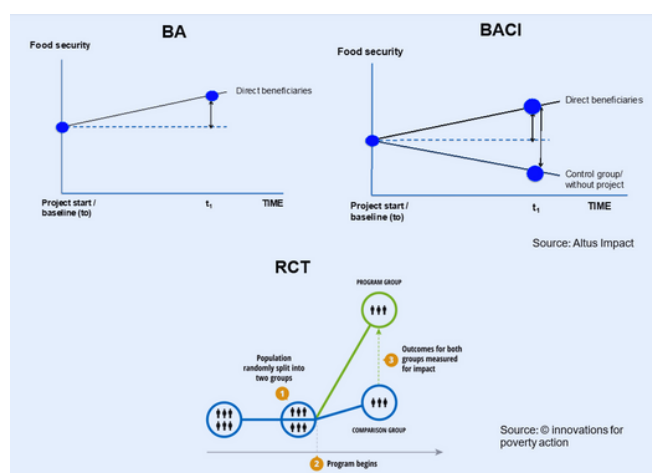
or condition which hypothetically may prevail for individuals or groups were there no WEF Nexus intervention”, i. e. which is not observed because of the intervention. This situation must therefore be simulated in some way. Several techniques are used to try to address this challenge. At a basic level the project or M&E team may seek to establish a baseline and assess project progress over time using a ‘simple before-after comparison’ e. g. with respect to food security or household income (Figure 2). When changes are observed, that have resulted from the project with some reasonable confidence, attribution may be expressed moderately as: “in light of the multiple factors influencing a result, [...] the intervention made a noticeable contribution to an observed result” (Mayne, 2012, p. 273).[8]

When there is doubt that outcomes cannot be attributed directly to the project, as opposed to external circumstances, e. g. due to an economic upswing within the region, or more favourable weather conditions, project teams may also consider measuring outcomes with a control group[9] in the context of an in-depth evaluation. There are various statistical methods that can be used to find a matching control group. Figure 2 (righthand panel) shows the example where the actual impact of the project intervention is larger than what would have been inferred from a basic before-after (BA) comparison without a control group.

[8] Mayne, J. (2012). Contribution analysis: Coming of age? Evaluation, 18(3), p. 270-280.

[9] A control group should come from a location nearby to the impact site that is not impacted by the WEF project intervention but has the same or similar characteristics to the intervention site.

Figure 2 (righthand panel) shows the example where the actual impact of the project intervention is larger than what would have been inferred from a basic before-after (BA) comparison without a control group. With sufficient resources for monitoring and evaluation, it may therefore be decided from the outset to do a baseline assessment of a control group/ 'non-WEF project' using or before-after-control-intervention (BACI) or Randomized Control Trials (RCT). Box 4 provides more information on these techniques.



Box 4: Information on before-after-control-intervention (BACI) and Randomized Control Trials (RCT)

When control and intervention sites are randomly assigned (using Randomized Controlled Trials), differences in observed impacts between control and intervention can be attributed to the actual impact of the project if there are a sufficient number of sites, beneficiary households and points in time (see as an example 'Innovation for Poverty Action' for evaluation that uses RCTs for designing poverty actions: <https://www.poverty-action.org/about/randomized-control-trials>). Most WEF Nexus intervention sites or beneficiaries however are not randomly chosen. They have features that make them desirable as a focus for WEF Nexus project. This non-random allocation of 'control and intervention sites' may lead to biased results (Damgaard, 2019; Larsen, Meng, & Kendall, 2019).

To confront this, the before-after/control-intervention (BACI) approach is generally considered an ideal experimental method for both the socio-economic and biophysical modules of initiative, with its potential to effectively control for confounding factors. Using the BACI approach, identical data are collected using various survey instruments at two time periods: before and after the implementation of initiative interventions, at the 'intervention' site (that is, the location that is impacted by the WEF project interventions within the initiative boundary) and the 'control' site (that is, the location nearby to the impact site that is not impacted by the WEF project intervention but has similar characteristics to the intervention site). The 'before' phase is cautiously defined as the period prior to the WEF Nexus' initiative interventions. The control site serves as counterfactual for intervention sites, that is, as a reference site that indicates what would have happened without the intervention. For examples and information on how to design BACI evaluations in the context of evaluating water quality, see AGI (2022), or the evaluation of REDD+ on household forest revenues (Solis et al., 2021).

Step 7: Undertake the evaluation of outcomes and impacts as well as synthesise findings

When data has been collected from the various sources of interest, it may be used to:

- Form a baseline assessment of the project indicators of interest – such as level of water, energy and food security and human wellbeing within the project area;
- Be combined to conduct a WEF project evaluation, which is a systematic, objective assessment of a WEF intervention, that is ongoing or completed.

Whilst a baseline assessment is useful for understanding the situation at the outset of the project (or without the project), an actual evaluation is conducted whilst project activities are ongoing or have been completed. The evaluation should be used to answer questions about:

What actions work best to achieve outcomes, how and why they are or are not achieved, what the unintended consequences have been, and what needs to be adjusted to improve execution?

When done well, evaluation is a powerful tool to inform decision making about how to optimise scarce resources for maximum impact. It is distinct from simple measurement that focus only on observing whether change has occurred, not why or how that change occurred.

Finally, it should be questioned if data and findings from the evaluation can be generalised to the future, or other potential WEF Nexus project sites and WEF projects. In all cases, data and findings should be presented in a way that is useful for intended uses of the evaluation and support them to make use of them. Along with the findings, the Theory of Change can be used as a “performance story” that provides a coherent narrative about how the WEF Nexus intervention makes its particular contributions to Water, Energy and Food security.

This can be useful for communicating about the Nexus interventions to potential partners, participants and policymakers, and for also providing a consistent point of reference for those involved in implementing and managing it. In a longer-term perspective, it is also of interest to develop a WEF Nexus project database.

Other considerations: Connecting M&E with Cost Benefit Analysis

In many cases, the data collected, and the questions answered as part of the M&E system can serve as valuable inputs for an actual Cost-Benefit Analysis of the economic interest in the WEF project. Evident overlaps concern the valuation alternatives (‘with-project’ and ‘without-project’) as well as the impacts (benefits).

Conclusion

This M&E chapter has been conceived to encourage project teams and M&E staff to be transparent, strategic, and systematic in deciding what and how to monitor and evaluate. Our aim is to help project teams to integrate M&E into the structure of their WEF Nexus projects and achieve early alignment with partners (donors, project stakeholders etc.) on what is being evaluated and why? This process can also help provide the evidence that is needed to scale successful WEF Nexus solutions and learn from experiences.

4. WEF Nexus Indicator Tool

The WEF Nexus Indicator tool is another helpful tool of the Nexus Impact Assessment (NIA) Toolkit that is designed to demonstrate the different interconnections/synergies and trade-offs in a measurable way. In doing so, the tool can be used as a guide to identify co-benefits that can be created or trade-offs that need to be prevented, while conceiving a project (ensuring all aspects are considered) and actually providing a canvas for a M&E system of an integrated project (we need more evidence of the added-value of the Nexus approach).

Water, energy, food (WEF) Security Nexus projects are wide and diverse, from drought-proofing of rainfed agriculture and systematic irrigation development, to multi-purpose hydropower dams, to restoring wetlands for food and water security, and rendering industrial processes more efficient, or climate smart through energy efficiency and renewable energy interventions. Their objectives are to enhance synergies and minimise trade-offs between water, energy, and food security (Simpson et al., 2022). Providing more water, energy, or food, however, does not guarantee that shared challenges are reduced (World Resources Institute (WRI), 2019). WEF Nexus projects therefore generally serve to implement activities that increase the likelihood of generating social, economic, and environmental benefits, whilst solving shared water, energy and food challenges.

This is crucial for monitoring and evaluation (M&E) purposes because it implies that any evaluation of a WEF Nexus project, should strive to monitor progress on achieving water, energy and/or food security, but also the associated incidence on wider concerns of interest. These will vary from project to project – according to the underlying Theory of Change (for more information see chapter on M&E for WEF Nexus projects) – which depicts the overall goal of the project and the outputs that conditions that goals. In many cases, the overarching objective is that of enhancing the wellbeing and livelihoods of rural communities (e.g., as seen in the demonstration projects in Ecuador and Peru – see the respective chapters of the cost-benefit analysis (CBA)). In these projects, indicators of relevance therefore also pertain to the number of jobs created, the additional income that is generated and the extent to which women are benefitting. Energy, water and food security may also be measured in widely varying ways, pending on what the project is seeking to achieve. Under the water security umbrella, some projects may be concerned with water quality, others with water affordability or efficiency. Their geographical boundaries as well as M&E budgets may vary.

Consequently, there is no standard, nor compulsory set of indicators to be measured under the WEF Nexus umbrella. Decision making over which indicators should be measured should be left to actual project teams and M&E staff. They are typically defined when conducting a Theory of Change or associated logframe. As such, indicators are specifically tailored to the project. This process helps ensure efficiency and cost-effectiveness in monitoring, in alignment with WEF Nexus philosophy. Only those indicators that meet the needs, uses and interests of concerned stakeholders – project partners, developers, donors, etc. – should be measured.

When the process is undertaken rigorously, project evaluation will serve its ultimate purpose, for example helping project developers and donors understand *if the WEF Nexus intervention achieved what was intended, and if not, why so and what can be improved going forward? What is the added-value of the WEF Nexus intervention, relative to the 'without-project' baseline? Has the project compromised any WEF Nexus dimension, in striving to improve water, energy or food security, etc.?*

Necessity of WEF Nexus Indicators

Whilst there are no “one size fits all” indicators for measuring progress of WEF Nexus projects, there is an incredible wealth of measurement frameworks, existing indicators and methodologies that pertain to water, energy and food security. Some are designed for the national level (e.g., the United Nations Sustainable Development Goals (SDGs)), others for the corporate reporting (see Reig et al., 2019, GRI), others at the project level (e.g., FAO 2001; CIFOR-PEN, 2007; WOCAT) or sector level (IEA, 2014), etc.

An excel-based catalogue compiles a set of quantitative and qualitative indicators from these different resources that are relevant to WEF Nexus projects or those projects that are at the interface of, for example, energy-water or water-agriculture. The purpose of this WEF Nexus Indicator tool is to:

- *provide an entry point that allows projects, which are often built on a sectoral logic, to think directly about the potential impact on the other sectors during the project appraisal / planning phase as well as during project implementation.*
- *inspire and help project developers and M&E staff in selecting indicators of relevance to monitor and evaluate WEF Nexus projects with respect to water, energy and food security, and selected co-benefits, such as climate mitigation and land restoration, and jobs created.*
- *offer information on how to measure indicators across the WEF Nexus and beyond (livelihood and environment etc.).*
- *show where to obtain information about an indicator for which global data is already being compiled. For example, several indicators, pertaining to the SDGs, are tracked at a national level, which allows for obtain benchmark estimates, against which one may compare indicator outcomes within a WEF Nexus intervention site.*
- *support policy and decision-makers to identify the potential of multi-sectoral actions and to ensure cross-sectoral project planning and implementation.*

The SDGs, in particular, offers a good entry point to monitor WEF security, and internationally WEF Nexus has become accepted as a mechanism for facilitating progress toward the relevant sector-related SDGs (Simpson et al., 2022; Simpson and Jewitt, 2019), i.e.

- *SDG 2 (End hunger, achieve food security and improved nutrition and promote sustainable agriculture)*
- *SDG 6 (Ensure availability and sustainable management of water and sanitation for all)*
- *SDG 7 (Ensure access to affordable, reliable, sustainable and modern energy for all)*
- *Many aspects of the WEF Nexus approach are also linked to other SDGs, such as SDG 13 (Climate Action) and SDG 15 (Life on Land), among others.*

To see why, the definitions in Annex 1 are repeated. Here, water security is defined as “the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socioeconomic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability” (UN Water, 2013). Energy security is defined as “the uninterrupted availability of energy sources at an affordable price” (IEA, 2021), and “access to clean, reliable and affordable energy services for cooking and heating, lighting, communications and productive uses” (AGECC, 2010). Food security is defined as the state in which “all people at all times have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active, healthy life” (FAO 2014). The security of each of these three core elements therefore share the same sub-divisions of ‘Access’ and ‘Availability’.

The Nexus Toolkit’s WEF Nexus Indicator tool (see Annex 3) focuses on a sub-set of relevant SDG indicators together with other indicators of relevance to the project level that are deemed useful for M&E purposes of WEF Nexus project or activity. The WEF Nexus Indicator tool lends in part from Simpson et al. (2022), who has developed a country-level WEF Nexus Index of 87 water-, energy-, and food-related indicators, that has been calculated for 181 nations using open databases. Visualisations associated with the WEF Nexus Index have been compiled in an interactive [website](#). As mentioned above, national estimates can be used as benchmark against which a project-level intervention can be considered. Finally, M&E teams may also draw inspiration from the full set of global SDG indicators used to track progress towards SDG 2, 6 and 7. These along with available country (compiled and verified by the responsible United Nations agencies), can be retrieved through the following links in Table 1:

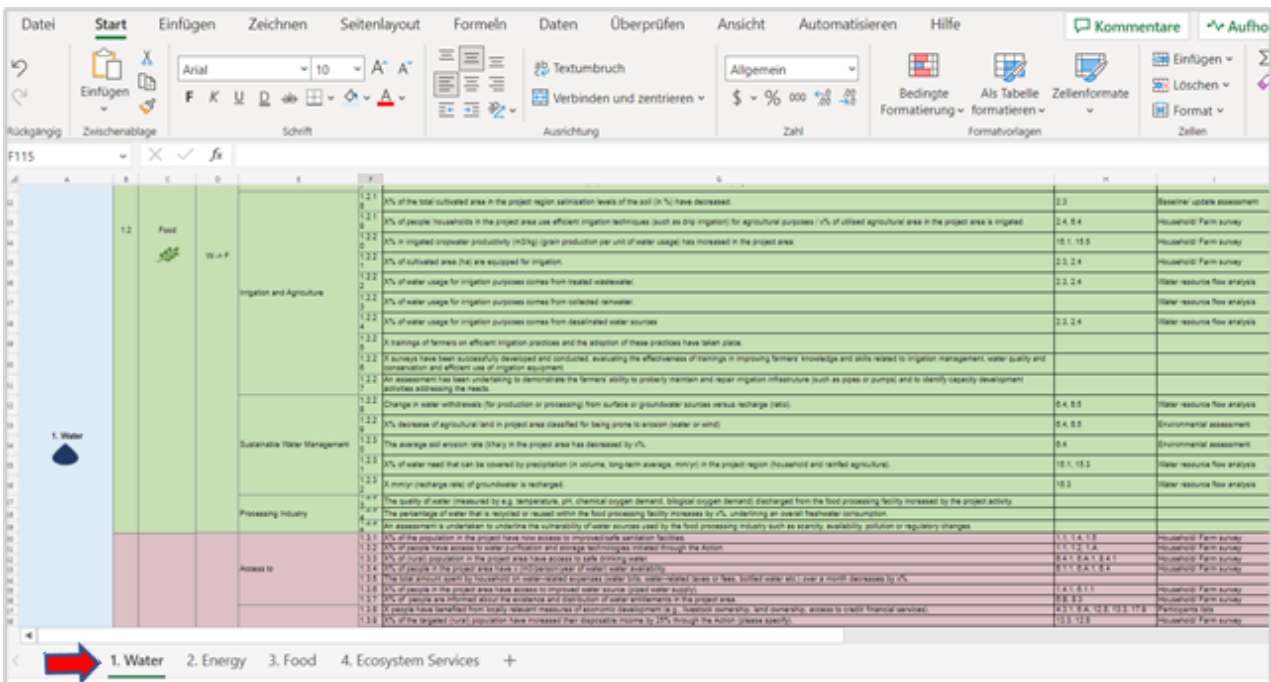
Sustainable Development Goal	Country data and global indicator source
SDG 2 - FOOD	https://sdg-tracker.org/zero-hunger
SDG 6 - WATER	https://www.sdg6data.org/
SDG 7 - ENERGY	https://trackingsdg7.esmap.org/about-us

Table 1: Data on WEF sector-related SDGs

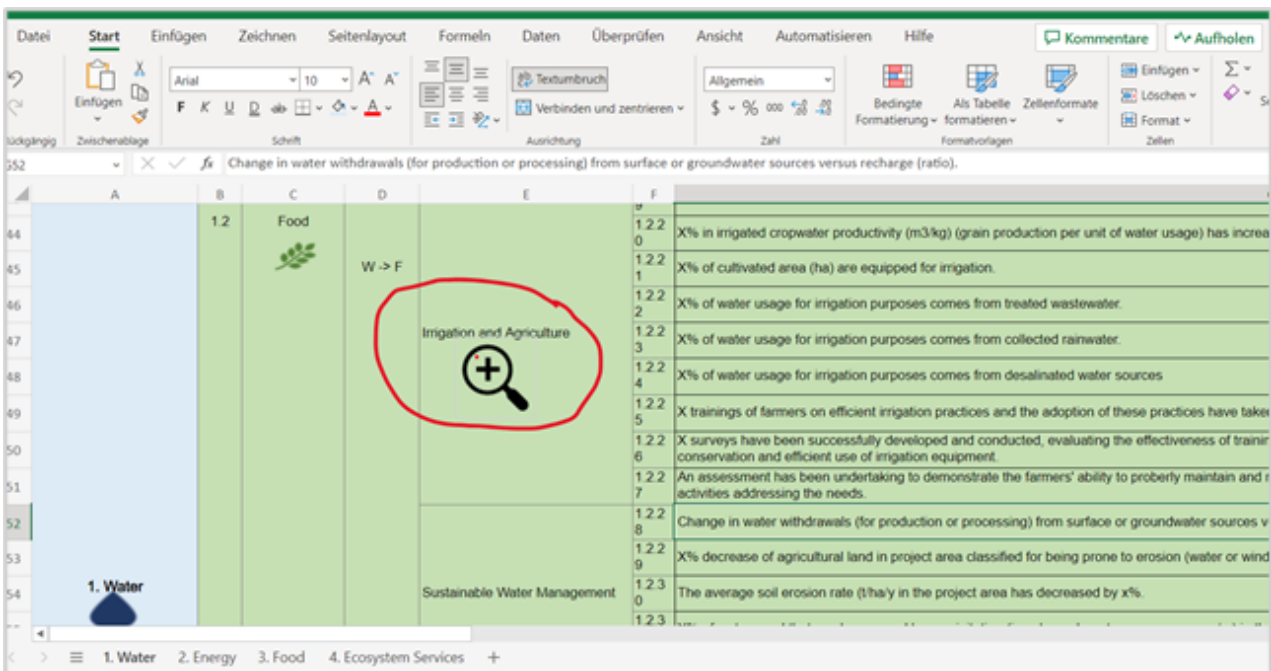
The WEF Nexus Indicator tool also has a special dedication to gender indicators. The purpose of including gender indicators is to obtain information that will inform the progress of a WEF Nexus project gender-related outcome and/or retrieve data that could be used to inform initiatives in the sectors of focus. These indicators refer to quantitative indicators based on sex disaggregated statistical data as well as qualitative changes over time, which can be classified into ‘gender-responsive’, ‘gender-sensitive’, or just ‘gender’ indicators. To define appropriate gender indicators for an M&E assessment of a WEF Nexus project, it is suggested first, to assess if the WEF intervention activities are planned to reach both women and men. Second, to evaluate if the expected outcomes for the WEF Nexus project are themselves gender sensitive. If this is not the case, then project developers and M&E staff should define, to the extent possible and within the framework of the WEF Nexus project, gender-related indicators aiming to provide data on progress towards desired changes on gender inclusiveness and/or gender equality. Gender indicators will have to be defined and adjusted accordingly to each WEF project context and goals.

Despite the seemingly complex Excel-based document, the handling of the Excel spreadsheet is easy and quickly explained. The following steps lead through the Excel spreadsheet and help develop adequate indicators for project planning. The entry point is project goal or topic (e. g. the aim is to establish a new project to overcome water scarcity in the project area):

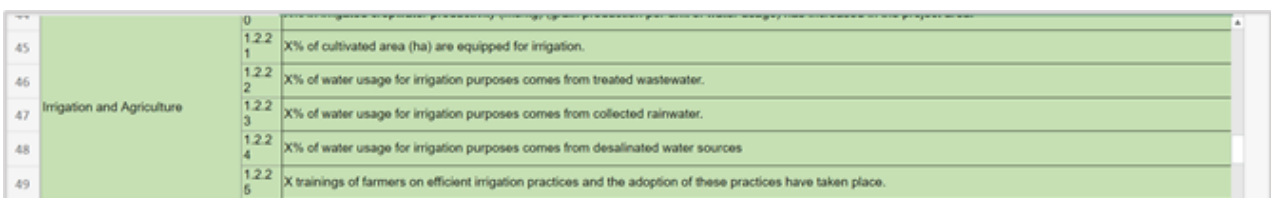
Step 1: Open the Excel sheet "Water".



Step 2: Closer look to the intersection of what is most interesting for the project such as Water and Food and then choose the sub-section such as "Irrigation and Agriculture".



Step 3: Take a look at the numerous indicators, that can be helpful for the project.



Step 4: Search for further indicators in the other subsections that are important for a successful M&E and a cross-sectoral set-up of a project.

Step 5: Define common indicators that strengthen WEF Security.

In a nutshell

*The **WEF Nexus Indicator** tool is divided into four categories (Water, Energy, Food, Environment), with five subgroups at each sheet (Water, Energy, Food plus Livelihoods, Governance, Climate Change). It highlights the WEF Nexus contributions to the Sustainable Development Goals (SDGs) and provides sources of verification. It is a dynamic tool and will constantly be in progress.*

In addition, the WEF Nexus Indicator tool is by no means exhaustive in terms of given the wide diversity of WEF Nexus projects and possible objectives underlying any WEF intervention. More importantly, as argued above, project indicators should be uniquely suited to the project under consideration and needs of the project team.

This requires careful deliberation amongst the project team, stakeholders, M&E staff and associated research (as explained above). In this regard, the WEF Nexus indicator tool can serve as inspiration, and as a learning resource, but should not replace the process of defining core WEF Nexus indicators as well as relevant co-benefits to be measured.

5. WEF Nexus Cost-Benefit Framework

Background

The Water-Energy-Food (WEF) Nexus is an integrated approach for the water, energy and food/agriculture sectors that attempts to reconcile the economic, social, ecological and political interests these compete for the same scarce resources by addressing the trade-offs while building intersectoral synergies that lead to win-win-situations. Designing, evaluating, and promoting effective WEF Nexus projects requires a strong understanding of each project's economic and financial case.

Cost-Benefit-Analysis (CBA) is a tool that can serve a variety of purposes when applied to WEF Nexus projects. CBA, which is a structured method for comparing the benefits and costs of alternative investments, can be used during the entire life cycle of a WEF project. The process of conducting a CBA as discussed in this framework is formulaic and simple, but CBA is a rich and nuanced topic that can hardly be summarised in a short document like this. Instead, the goal of the framework is to provide WEF decision makers, whether they are secretariate staff of a Non-Governmental Organisation (NGO) or on-the-ground project staff, with a brief document describing what CBA is, the steps required to conduct a CBA of a WEF project, examples of how this has been done, and methods, strategies, and guidance on how to use this framework to conduct CBA on other WEF projects at any stage of project development.

The framework presented in this report is intended for prioritising investments in Water-Energy-Food Nexus projects (WEF Nexus) across a variety of criteria, including: Net Present Value (NPV), Return on Investment (ROI), and multi-criteria decision-making. This information is useful for policymakers, restoration professionals, and natural resource managers who are interested in understanding more about the economic opportunities and trade-offs of making investments in WEF Nexus projects.

Using this framework in conjunction with the other tools of the Nexus Impact Assessment (NIA) Toolkit will make the application of the nine steps easier and more straightforward than applying it alone. For example, the information needed by the WEF Nexus Safeguards, which is used to pre-screen potential projects, can help identify the most important aspects of a project for CBA to focus on. The Safeguards Tool answers many of the questions necessary for conducting a CBA, like defining a project's primary benefits and beneficiaries in addition to documenting its potential negative impacts.

It is important to remember that CBA is a complex and rich topic. This framework, while simple, is sufficient to create reasonable analyses of project costs and benefits. However, as projects grow in scale and complexity, additional economic resources should be consulted to ensure appropriate methods and data are used. These resources could include academic textbooks, peer-reviewed journal articles, and discussions with economic consultants and other experts.

The remainder of this framework provides a brief overview of CBA, including its conceptual foundations, before discussing and demonstrating the nine steps to conducting a CBA. Each step includes a discussion on background, tools, methods, and guidance, in addition to examples from CBA's conducted as part of existing WEF projects. The framework concludes by provide discussion and guidance for using CBA results to appeal to different types of decision makers.

Introduction to Cost-Benefit Analysis

At its core, Cost-Benefit Analysis (CBA) is a method for systemically cataloguing positive impacts as benefits and negative impacts as costs, valuing these impacts in terms of currency, whether it is Dollars, Euros, or other local monetary units of exchange and estimating the net benefits (benefits – costs) of a project relative to the baseline situation (Figure 1). As humans, we tend to only value our own benefits and costs when making decisions, but CBA attempts to consider all of the costs and benefits to society as a whole. In this way, CBA is a weighing tool that quantifies and values all consequences of a project to all members of society.

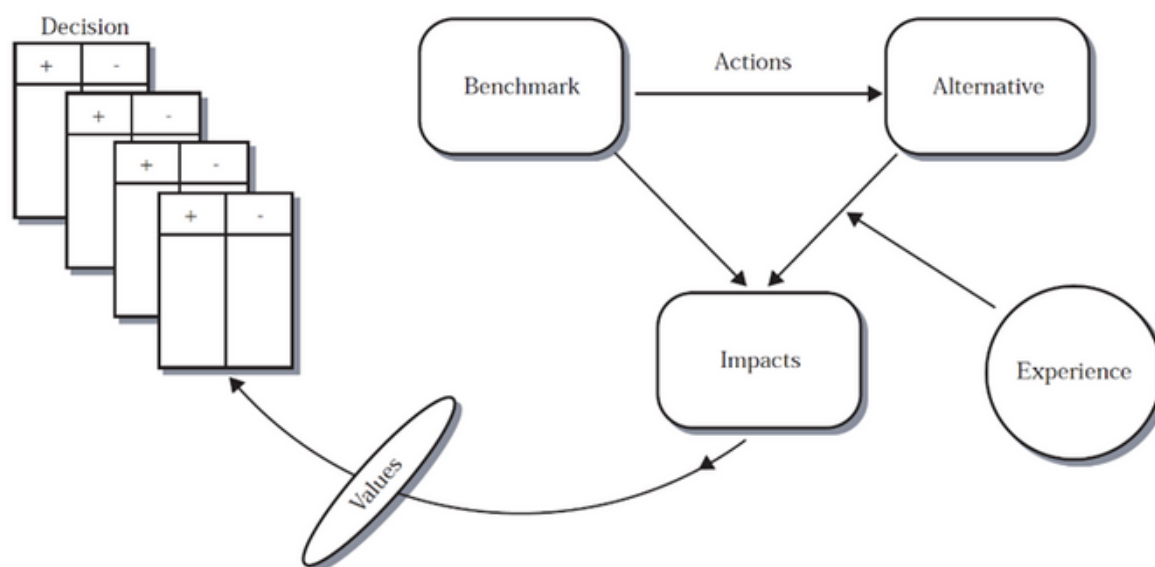


Figure 1: Process of Conducting a Cost-Benefit Analysis

CBA can and should be applied at different stages of a project cycle (ex-ante, inception, as a mid-term evaluation or ex-post) in order to determine the long-term net monetary value of project. In the design and development phase, CBA can be used as a tool to assess the economic and financial feasibility of a project or to help inform decision-makers about the value of the planned activities. In the early stages of project development, there is considerable uncertainty about a project's actual benefits and costs, and thus, its impact on social benefits. Conducting a CBA during the project design phase can help to make sure the project is designed in a way that it creates the highest probability of success.

Once a project reaches the operational phase, CBA can be used as a monitoring and evaluation tool to assess project impacts compared to initial expectations. CBA can also be used to highlight project impacts on local, regional, and national economies in addition to making a business or financial case for specific WEF activities. These types of backward-looking analyses are powerful because they not only show the impacts of a particular project, but their results can also be generalised to approximate the impact of similar projects.

Conceptual Foundations of Cost-Benefit Analysis

The objective of CBA is to make sure that scarce natural, human, and financial resources are being allocated efficiently. When thinking about a WEF Nexus project, for example, CBA is attempting to ask: Over a period of years and decades, will a given project generate sufficient benefits to justify the initial and ongoing investments required to sustain itself? In other words, CBA is a framework for measuring efficiency. It asks if resources invested in a WEF Nexus project are being used in their highest valued use.

Figure 2 shows the result of a CBA for three land use alternatives. In the figure, the benefits and costs of each alternative are added up, discounted, and compared to each other to determine which alternative creates the most benefits per dollar of cost. Benefits in the example include crop, timber, and non-timber (NTFP) production, carbon sequestration, and erosion prevention. Costs include the direct costs of the alternative as well as the indirect costs faced by society. As the figure shows, the WEF alternative creates more benefits per dollar of cost than the baseline and non-WEF alternatives.

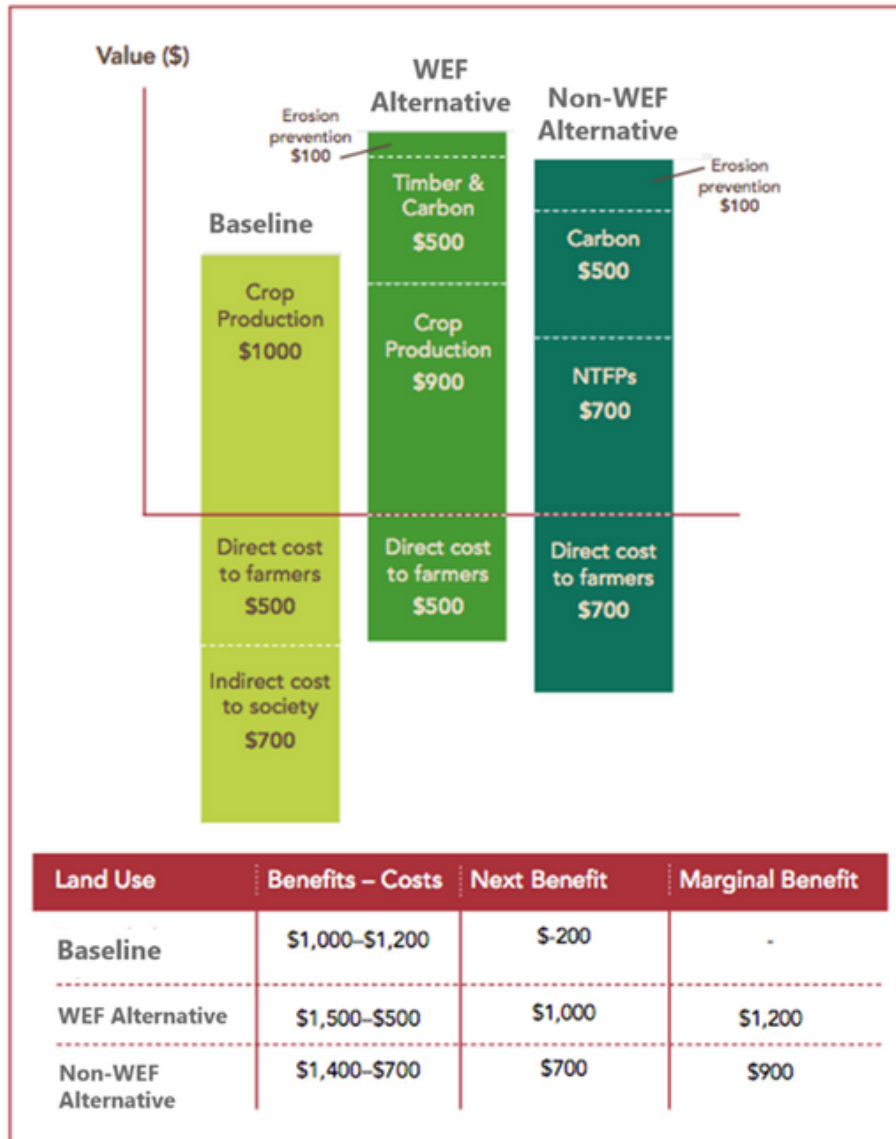


Figure 2: Illustrative Comparison of Benefits and Costs for Three Land-Use Alternatives

To better understand the logic of CBA, the concepts of willingness-to-pay and opportunity cost have to be understood. Willingness-to-pay (WTP) represents the amount of money stakeholders would pay or would have to receive to make them indifferent between the status quo or baseline and the proposed WEF Nexus project. The sum of each stakeholder’s WTP is the gross benefit of the project. For example, if a WEF Nexus project would impact three people and two of those people were willing to pay \$100 each to participate in the project, but the third person does not like the impacts of the proposed project and would have to receive \$100 to make them indifferent between it and the status quo, the gross benefit of the project would be $\$100 + \$100 - \$100 = \100 . That is, the gross benefit is the WTP of all three stakeholders.

WEF projects also require inputs, which include land, labour, materials, and equipment. These inputs have an opportunity cost, which is to say by using them in a WEF project, they are not available to be used for other opportunities. Opportunity cost measures the value of goods and services that society must give to implement a WEF project. The opportunity cost of inputs is generally measured by their market prices.

Once a project's benefits have been valued in terms of WTP and inputs have been valued in terms of opportunity costs, then its net benefits can be calculated to determine if the project is a good investment of society's scarce resources. This logic leads to the CBA decision rule: adopt all projects whose benefits are greater than their costs and reject all projects whose benefits are less than their costs. The logic is simple: WEF Nexus projects that create more benefits than costs are improving societal welfare and WEF projects that create more costs than benefits are reducing it.

While a straight comparison between benefits and costs is enough to justify investing in a project, it is not enough information to choose between different project alternatives. For that, the benefit-cost-ratio (BCR) is used. The BCR measures the value of benefits created by every dollar invested in a project. The BCR is always greater than or equal to zero and higher BCRs always indicate that a project is more beneficial than alternative projects with lower BCRs.

Steps in Process

Conducting a CBA is a nine-step process as shown in Figure 3.

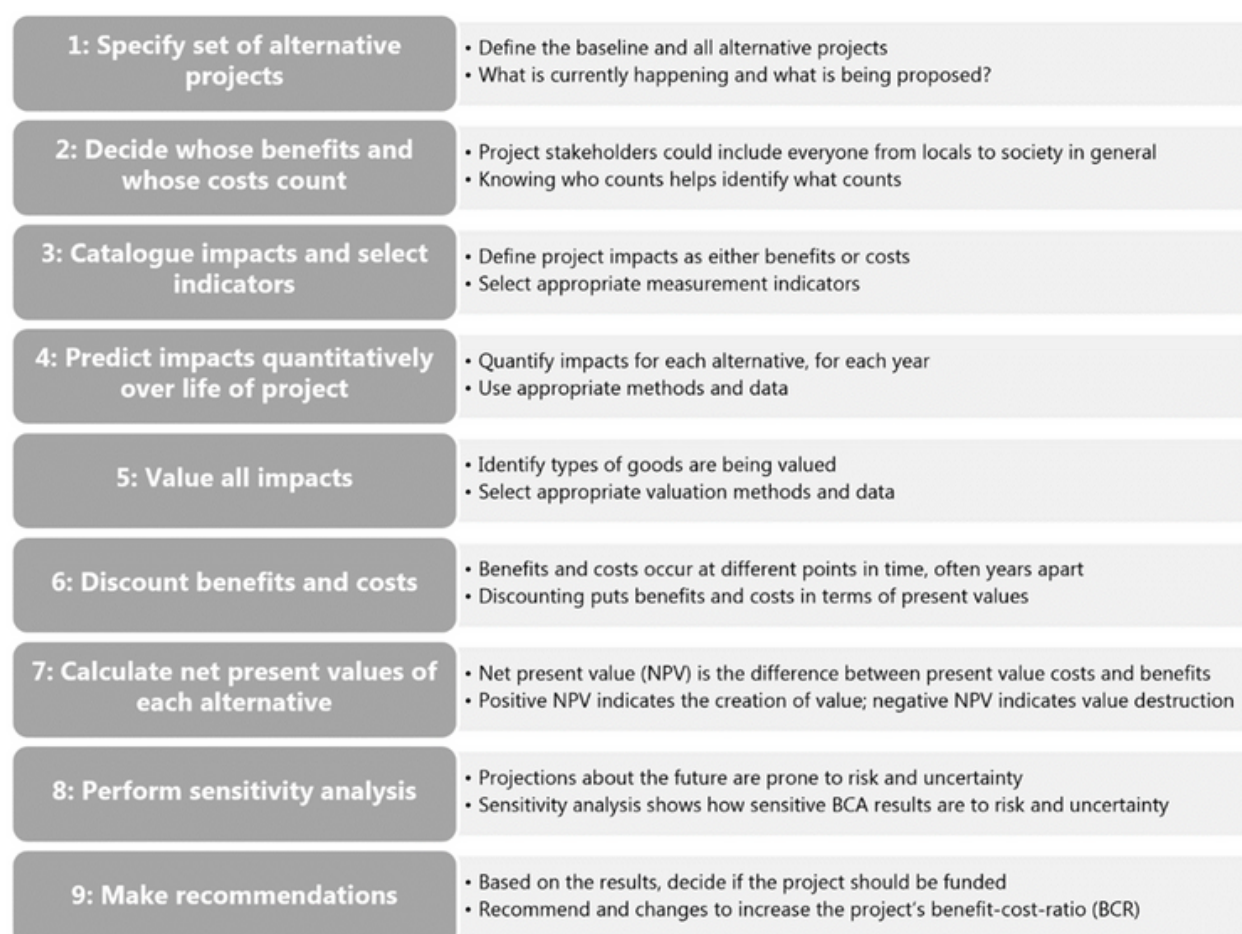


Figure 3: Nine Steps in Conducting a Cost-Benefit Analysis (CBA)

The accuracy of CBA depends on how well each step in the process is carried out. Each step is prone to uncertainty and error, particularly the steps 3, 4, and 5, but foresight and planning can mitigate this. Each step in the process will be discussed below using a WEF Nexus project in Niger to illustrate the process. The project, located in the Tillaberi region of the country, is a WEF Nexus project designed to improve food, water, and energy security on a plot of land farmed by a local woman’s group.

Step 1: Specify Set of Alternative Projects

The first step in conducting a CBA of WEF Nexus projects is to define the set of project alternatives to be analysed in terms of their impacts to water, energy, food, and other resources. For example, the comparison could be between the status quo or baseline situation and one project alternative. However, the comparison could also be made between the status quo or baseline situation and multiple alternative projects, each with their own set of costs and benefits.

Figure 4 shows the alternatives used to evaluate the benefits of taking a WEF Nexus approach to enhance water, energy, and food security at the Kollo Women’s Garden. Under the baseline conditions, the garden has two water sources. During the dry season a petrol-powered pump is used to extract ground water for the parcel two times per week. During the rainy season, the garden is irregularly irrigated by spill over from adjacent rice fields. However, this water supply is not controlled by the women and is not reliable water supply. Overall, the garden, which is currently used to grow potatoes and onions, does not produce as much food as it could because it does not have a secure supply of water or energy.

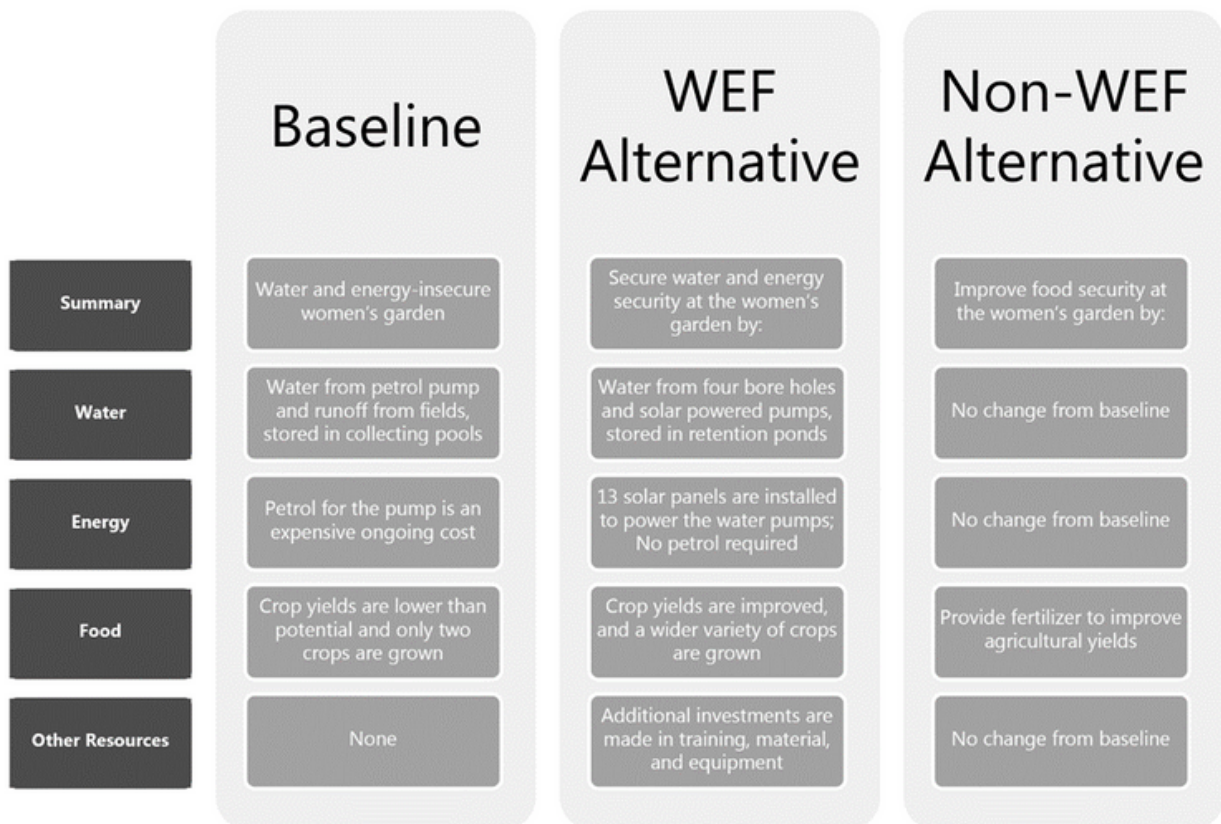


Figure 4: Specifying Alternative Projects

Under the proposed WEF Alternative, the productivity and food security of the garden would be improved by improving water and energy security. Four boreholes would be drilled at various points around the garden. Solar panels would power water pumps that would be used to supply the garden with irrigation water year-round. Additional investments of training, material, and equipment would further improve productivity.

With a more secure water and energy supply, the garden could produce more output and a wider variety of crops compared to the baseline. The increased agricultural output would increase food security for the households participating in the project. The investments would result in higher levels of water use due to higher crop diversification favouring crops that require more water than the crops grown under the baseline. The use of solar panels and electric motors in place of petrol-powered pumps would also reduce greenhouse gas emissions.

To show the value of the WEF Nexus approach, a single-sector alternative could be developed as a point of comparison as shown in Figure 4. Under the Non-WEF Alternative, food security would be improved by providing fertiliser to the women's garden with no further changes made to other resources as compared to the baseline situation.

Guidance

Economic analysis plays a critical role in the systematic formulation of alternative plans for WEF projects. Each alternative plan may consist of a system of structural and/or non-structural measures, land treatment, and other strategies or programmes. These strategies or programs will help to alleviate specific problems or take advantage of specific opportunities associated with water, energy, and food-related challenges in the project area. An alternative plan is developed to improve the security of at least two resources without damaging the third resource. Other alternatives can also be formulated to help understand the advantage of using a WEF approach as compared to a single sector approach. These additional plans should be formulated so that the decisionmaker can judge each alternative in a consistent manner. To do this, each plan requires an economic analysis.

Step 2: Decide Whose Benefits and Costs Count

In the second step of the CBA, the analyst must decide which stakeholder's benefits and costs will be included in the analysis. This is an important step because knowing who counts often tells you what counts. For example, if the CBA was focused on local stakeholders only, the primary benefits of the project would include impacts that directly benefit local stakeholders. This might include changes in crop output, and water and energy availability, quality, and reliability. Taking a broader perspective that includes local and global stakeholders would expand the types of costs and benefits that are accounted for.

In the example of the Kollo women's garden, a primary and secondary set of stakeholders were defined. The primary set of stakeholders are the women from the local community directly participating in the project. They are the project's primary beneficiaries as well as its main contributors. The women manage the daily activities in the garden and supply most of the project's labour. In a broader view, the project also benefits society as a whole by reducing greenhouse gas emissions.

Guidance

Answering the questions below can help identify which stakeholders to include in the analysis:

- What scale is the project primarily designed to impact (i.e., local, regional, national, global)?
- Who primarily benefits from the project (i.e., project participants, local communities, society in general, or a combination of all of these)?

For example, knowing that a project is designed to create impacts at a local level that primarily benefit project participants and the surrounding community helps place a geographic boundary around the CBA. When identifying stakeholders raises difficult issues, it is often useful to report the results at different levels instead of trying to fully resolve these issues prior to conducting the analysis. For example, the results could be reported for a specific village, for a region as a whole, and at the country level, or for society as a whole.

Step 3: Catalogue Impacts and Select Measurement Indicators

This step requires the analyst to make a list of each alternative’s physical impacts and classify them in terms of costs and benefits and define measurement indicators. Impacts refer to both inputs and outputs. Inputs generally show up as cost and outputs generally show up as a benefit. Explained differently, all desirable impacts of the project are benefits and all the undesirable impacts are costs.

Costs: Every WEF project requires inputs like land, labour, equipment, and materials. These costs are incurred directly through the physical process of implementing the project and indirectly through foregone production and negotiation as well as planning processes. The costs of each WEF Nexus project can be placed into one of three categories (see Figure 5):

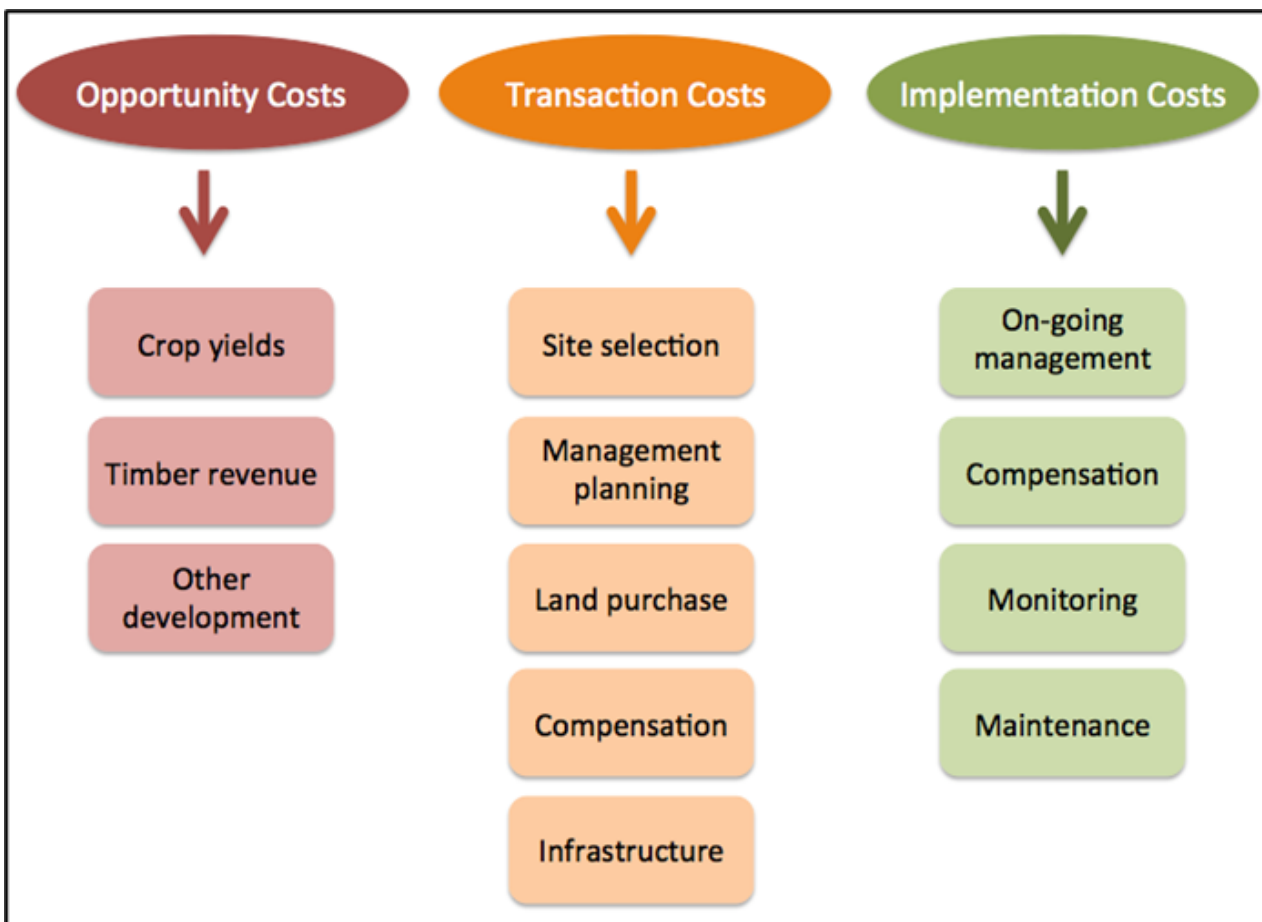


Figure 5: Three Categories of Cost Used in Cost-Benefit Analysis

Transaction costs and implementation costs are the only costs that are directly accounted for in the benefit-cost ledger, discussed in more detail below. Opportunity costs are accounted for in step 1, where each project alternative is defined.

Benefits: Since WEF Nexus projects are interested in improving resource security, most of the beneficial impacts from WEF Nexus projects will come from changes to output of commodities like crops, water, and energy, or in changes to the quality of those commodities. By changes in quality, we mean that projects can change the attributes of crop, water, and energy resources without changing the total amount of the resource that is available. Such changes in quality could be reflected in changes to reliability, price, or other indicators.[1]

The simplest way to account for benefits is to use an ecosystem services framework (see Figure 6).



Figure 6: The Four Types of Ecosystem Services

The Millennium Ecosystem Assessment (MEA (Millennium Ecosystem Assessment), 2005) defined four categories of ecosystem services; each category of services can impact different groups of stakeholders:

- **Supporting services** – Services that are necessary for the functioning of all other services.
- **Provisioning services** – The benefits from products, like food, fuel, fibre, and water that are obtained directly from nature. Private landowners and companies can harvest commodities directly from restored land like fuelwood, crops, or timber. Downstream stakeholders, such as fishing communities or water users, can also benefit if restoration improves the productivity of a fishery or enhances water quality.
- **Regulating services** – The benefits from processes like carbon sequestration, nutrient cycling, and water and air purification that regulate the functioning of ecosystems. While regulating services are generated at a parcel or landscape scale, they can provide benefits to local, national, regional, and international stakeholders alike. For example, carbon sequestrations effects on regulating the global climate everyone equally, although other regulating services like flood control may only benefit stakeholders within specific areas of a watershed.

[[1] Energy: Introduction of renewable energy (RE) would mean that energy supply is more reliable and cleaner (but maybe that means that there is not more energy than before); Water: Through water treatment one increases the water quality, however not the quantity; Crops: One can increase the crop quality without increasing the overall yield by introducing more nutrient-dense irrigation water, better temperature regulations, etc.

- Cultural services** – The nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and scenic beauty. These types of services are also improved by restoration at different spatial scales and therefore impact different groups of stakeholders. Local residents benefit from restoration through the enhancement of aesthetic, cultural, and natural quality of ecosystems. Eco-tourism is becoming an increasingly popular benefit for local communities, national and local governments, and international tourists. It is important to note that the value of cultural services depends on the cultural backgrounds of each stakeholder group and for that reason restorations impact on cultural values is often left out of cost-benefit analysis despite being an important impact.

Guidance

A useful approach for cataloguing impacts is to use a simple benefit and cost ledger, as shown in Figure 7 below. The ledger contains a benefit column and a cost column. The ledger is filled out by people familiar with the project and the types of impacts it will create. Recalling the previous step, the goal of this step is not to catalogue every possible impact of the project. Instead, it is to catalogue the impacts that will affect the project stakeholders positively (benefits) and negatively (costs).

Impacts	
Benefits	Costs
Additional crop output	Equipment and materials
Reduced emissions	Personnel
Avoided fuel costs	Monitoring
	Trainings
Other	Other
A	A
B	B
C	C

Figure 7: Example of Benefit-Cost Ledger

In the case of the Kollo Women’s Garden, there are three primary benefits of the project: the project will create additional crop output, thereby enhancing food security, reduce emissions from the burning of petrol, and reduce expenditures on petrol.

The project costs include expenditures on equipment and materials like solar panels, irrigation pipe, electric pumps, pesticides, and gardening equipment in addition to expenditures to pay personnel, set up monitoring frameworks, and conduct trainings.

Step 4: Predict Impacts Quantitatively Over Life of the Project

Step 4 of the framework is to quantify all the impacts for each alternative over the lifetime of the project in terms of the impact indicators identified in Step 3. This can be the most challenging aspect of CBA because there is not always complete data or sound methods for making projections. Projections must be made for each year and for each impact of each project alternative. Project time horizons are generally selected based on the expected life of the project, which could range from a few years to several decades. The correct time horizon for analysis will vary with each project.

In general, there are three ways to quantify the impact of each alternative as shown in Figure 8.

Approach	Strengths	Weaknesses	Tools
Expert opinion	Flexible, intuitive, simple, timely, not data intensive	Opinion-based, errors of judgement, prone to bias, experts may disagree	Delphi method, expert surveys, expert interviews, literature reviews
Mathematical prediction	Data-driven, transparent, objective, accepted methods	Data intensive, may require assumptions, time-intensive, uncertainty,	Ecosystem service models (e.g. INVEST), mathematical equations, statistical analysis, enterprise budgets
Field measurement	Greatest validity to real world, less prone to bias than other methods	Must wait for observations to be measurable, expensive and time consuming, no control over external factors	Field measurements, household surveys, benefit-transfer

Figure 8: Approaches for Quantifying Impacts of WEF Projects

In the expert opinion approach, experts are asked to evaluate the expected impacts of the project on the benefits identified in the previous step. In the prediction approach, mathematical models are used to predict project impacts. And in the measuring approach, the actual impacts of the project are measured and projected into the future. For most WEF projects, one or more of the above approaches will be used. For more information on modelling tools, see Christin et al. (2016).

Guidance

The correct approach depends on the context within which the CBA is being conducted. However, a few simple rules of thumb may be useful. The approach can be selected based on the state of the project. Expert opinion and mathematical prediction are best suited to pre-feasibility studies of a project’s potential impacts. Once a project has been active, field measurements will be the most accurate approach to quantifying benefits and costs.

Step 5: Value All Impacts

Economic valuation places monetary value on changes in ecosystem goods and services and puts ecological and biodiversity values on an equal footing with other economic benefits and costs. Not all values of ecosystem goods and services can be measured because they may be intrinsic or religious nature, but they need to be recognised, nonetheless. Other ecosystem goods and service, like the existence value people place on knowing a certain species exists even though they may never actually see it in person, can be valued but are difficult to turn into real flows of financial values. Finally, there are ecosystem goods and services, like carbon storage or water yield, that can be both valued and monetised. Choosing a valuation technique generally depends on the impact to be valued and the availability of resources, time and data for the study.

Economists have proposed several methods for valuing ecosystem goods and services depending on the nature of the good or service in question and the methods can be classified into one of three broad categories:

- **Revealed preference.** These methods use human behaviour to value ecosystem goods and services. For example, crop and timber production can be valued by observing the market prices people are able and willing to pay for different quantities and qualities of crop and timber.
- **Stated preference.** These methods rely upon hypothetical human behaviour to value ecosystem goods and services that are not bought or sold in markets. These methods elicit valuations by asking people, either through surveys or questionnaires, how much they would be willing to pay for a change in the amount and quality of an ecosystem good or services.
- **Benefit transfer.** These methods value specific ecosystem goods and services by transferring the results of valuation studies of the same goods and services from other locations. Benefit transfer methods are useful when valuation information is needed, but time and funding are not available to implement more rigorous valuation methods. The main drawback of using benefit transfer is that studies from other areas are likely to be less accurate in new settings.

Guidance

Revealed preference and benefit-transfer approaches are the simplest methods to implement for most WEF Nexus projects. Most revealed preference methods rely directly on market prices to value the benefits of WEF Nexus projects. For example, if a WEF Nexus project increased crop production by five tons compared to the baseline, the additional production can be valued simply by multiplying it by the market price for the crop. In most cases, this will be the method used to value most benefits of WEF Nexus projects.

Benefit-transfer is likely to be the second most useful method for valuing the benefits of WEF Nexus projects. The method is useful for valuing non-market benefits in a timely manner that does not require a great deal of data. The drawback of this method is that values are being transferred from study sites that may not be similar in any way to the site where the values are being projected, introducing errors and uncertainty. For more information on implementing benefit-transfer, see the following resource (USGS, 2022).[2]

Stated-preference approaches, while useful for valuing certain types of goods and services, requires preparing and conducting surveys and statistically analysing the results. Of the three methods discussed above, it is the most expensive and time-intensive valuation approach.

Step 6: Discount benefits and costs to present values

WEF projects create impacts that occur over times, sometimes for periods of several years and decades. Discounting makes it possible to compare events that occur at different points in time by assigning a weight to future events based on society's preference. While the concept of discounting is not contentious, the choice of which discount rate to use, is. This is because the discount has large influences on which projects are approved and which are not, and it also reflects the way current generations think about future generations.

[2] <https://sciencebase.usgs.gov/benefit-transfer/activityCalc/index>

The equation used to discount costs and benefits is shown below:

$$PV(X) = \sum_{t=0}^T X_t * \left(\frac{1}{1-r}\right)^t \quad [1]$$

Where:

PV(X) = the present value of a stream of benefits or costs

X = flow of benefits and costs over time according to X_t .

T = the time horizon

r = the discount rate

$\left(\frac{1}{1-r}\right)^t$ = the discount factor; its value is bounded between 0 and 1.

The larger the value of t, that is the further into the future something happens, the smaller the discount factor is and the less weight that event has. The opposite is also true.

Private Discount Rate. While the streams of benefits and costs are estimated in Step 4 and are empirical problems, the choice of the appropriate discount rate is a conceptual problem. Discounting goods and services reflects the fact that financial capital has an opportunity cost because it can be spent on other investments that could yield returns earlier. This sort of discounting is often referred to as the opportunity cost of capital and it is measured by observing the market yields on government bonds and other low risk investments.

Social Discount Rate. The other type of discounting reflects the different weight society places on the welfare of current and future generations and is commonly referred to as the rate of social time preference. Unlike the opportunity cost of capital, which discounts the consumption of goods and services at different points in time, the rate of social time preference discounts the welfare of aggregate welfare of generations at different points time. It is the tension between these two concepts that leads to disagreement over the appropriate rate of discount to apply to environmental decisions.

These issues are still being debating in the academic and policy literature because of the profound role the discount rate plays in environmental decision-making. Without a clear consensus, analysts must come up with their own rationale for which rate to use. Most environmental CBAs use discount rates of between 0 to 4 percent, but national and global oversight agencies generally give their own recommendations for appropriate discount rates to apply to projects in their jurisdictions.

Guidance

There is no correct discount rate to use for an analysis. The general guidance would be to use social rather than private discount rates for most CBAs applied to WEF projects. This is because WEF projects are based on improving societal wellbeing. While social discount rates are highly debated, each WEF project should consult the central bank or development banks of the region where the project is located to see if the banks recommend a social discount rate. If this information is not available, a discount in the range of 0 to 4 percent should be used.

Step 7: Compute the NPV of Each Alternative

Local communities, regional and national governments, and conservation organisations must decide whether to invest scarce human and physical resources into WEF projects. CBA helps inform these decisions by looking to see if sum of the discounted flow of benefits is greater than the sum of the discounted flow of costs. The net present value (NPV) concept formalises this logic and allows discounted flows of benefits and costs to be compared on equal terms across alternative projects.

The NPV for each alternative is calculated following:

$$NPV = \sum_{t=0}^T \delta^t (B_t - C_t) \quad [2]$$

Where:

B_t = is the annual benefit received from the degraded land use or restoration activity,

C_t = is the annual cost associated with that revenue, and

δ^t = is the discount factor.

The decision rule for the NPV concept is straightforward. A NPV less than zero suggests a WEF project will generate fewer benefits than costs, while a positive NPV suggests the opposite.

Step 8: Perform Sensitivity Analysis

The costs and benefits of WEF projects depend on random economic and ecological variables, including market prices, interest rates, precipitation, and tree growth rates. Lingering uncertainty over these values introduces an element of risk into the CBA.

Sensitivity analysis is a systematic method for examining how the outcome of cost-benefit analysis changes with variations in inputs, assumptions, or the structure of analysis. Sensitivity analysis can be performed by varying the value of a single variable at a time and observing the effects on the results of the CBA.

Guidance

There are limits to the amount of sensitivity analysis that can be conducted. Theoretically, every model parameter can be tested with an infinite range of values. However, in application, judgement has to be used to decided which variables are of most interest and/or most uncertain and the sensitivity analysis should focus on understanding how the result vary when the value of these variables changes.

There are also more rigorous methods of sensitivity analysis like Monte Carlo simulations, but for most purposes, simple and straightforward sensitivity analysis will be sufficient to understand how the model reacts to different values and assumptions.

Step 9: Make a Recommendation

Once the CBA is complete, a decision must be made about funding the project. The general rule is that the WEF Alternative with the largest NPV should be selected. Of course, other factors, both qualitative and quantitative, will influence the final decision, but projects with larger NPVs are preferred to projects with smaller NPVs, all else equal.

The output from the CBA can also be used to create other decision-making metrics, like Return on Investment (ROI) and the benefit-cost-ratio (BCR). ROI and BCR metrics are functionally the same and measure the percentage return on each dollar invested into a WEF project. ROIs and BCRs greater than one suggest that each dollar invested into a WEF project generates more than one dollar in societal benefits.

In some cases, it will be important to present other metrics depicting the trade-offs between different alternatives. These trade-offs could merely be different sets of benefits created by different alternatives, but trade-offs may also represent externalities, or negative impacts of an alternative. Graphically illustrating the benefits, costs, and externalities of an alternative, as shown in Figure 2 above, is the simplest way to display each alternative's trade-offs in a side-by-side comparison. Rose diagrams can also be useful for showing how a particular project impacts different types of benefits and costs in a comparative manner.

In other cases, decision makers may want to use the CBA results to make a business case for a project. When people refer to making a business case, they are often referring to a project's financial benefits and costs only. Benefits that cannot be bought or sold in currency are not included in the business case analysis.

A simple business case is showing that a project would produce a certain value of food for a given upfront investment and the recurring costs required to continuously grow the food. It would show what the upfront investment is, the annual stream of benefits that would result from the investment, and the amount of time required to recoup the project costs. Investors are also notoriously averse to risk, so information about how a project will reduce uncertainty will complement the CBA results when making a business pitch for a project.

Guidance

In general, it is useful to report many different metrics as part of a CBA of WEF projects. NPV, BCR, and ROI are all useful metrics to help understand how a project generates benefits. Still, recommendations should be based on the project that creates the largest NPV. Projects with higher BCRs and ROIs are more cost-effective than projects with lower metrics, but projects with higher NPVs create the most benefits for society even if they are not the most cost effective. As a result, the guidance of this section is always to recommend the project with the largest NPV.