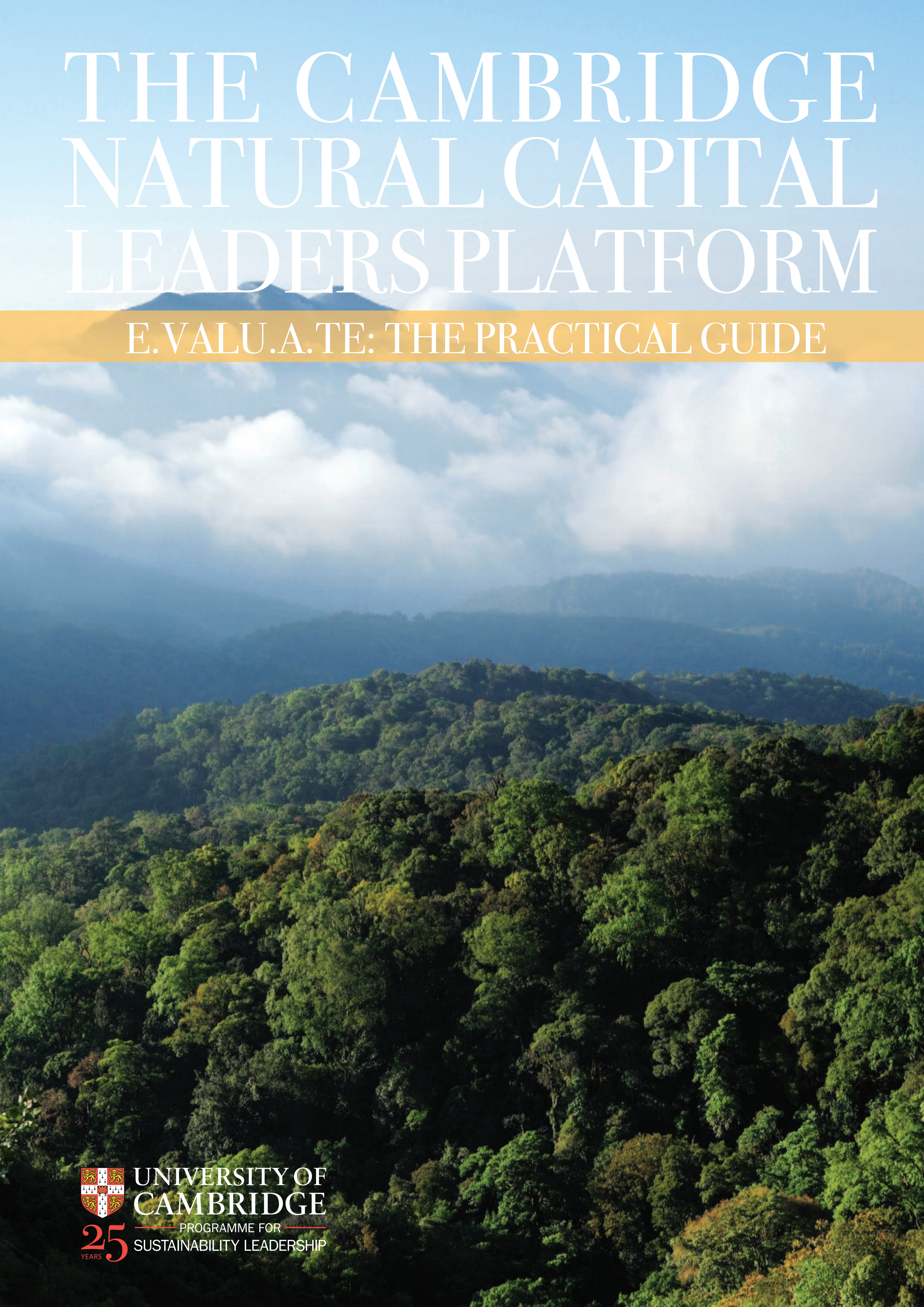
THE CAMBRIDGE NATURAL CAPITAL LEADERS PLATFORM

E.VALU.A.TE: THE PRACTICAL GUIDE



UNIVERSITY OF CAMBRIDGE
PROGRAMME FOR SUSTAINABILITY LEADERSHIP
25 YEARS

THE PRACTICAL GUIDE

HOW TO PERFORM AN ENVIRONMENTAL EXTERNALITY ASSESSMENT

Contents

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Natural Capital Leaders Platform members

1 Introduction

Members of the Natural Capital Leaders Platform came together to strengthen their understanding of, and to develop practical guidance around, how to undertake an evaluation of the un-costed impacts of their business operations, known as externalities. E.Valu.A.Te (Externality Valuation Assessment Tool) represents a suite of resources that brings together comprehensive guidance for environmental externality assessment, stimulated directly by business needs. This has resulted in the first online, step-by-step tool that guides users through the evaluation process for environmental externalities.

E.Valu.A.Te provides more evidential support around the process of valuation using a step-wise, bottom-up approach. The work, driven by business, aims to generate the critical mass required to enhance the addressing of unintended impacts of business upon natural capital.

E.Valu.A.Te: The Practical Guide forms a part of this suite of resources, including an online Tool[a]. The Practical Guide provides the technical background and additional information to assist the use of the online Tool.

The Practical Guide also describes the necessary steps of the scoping phase that needs to be completed before the actual assessment (with the online Tool) can be undertaken. In addition, it explains what externalities are and why they are relevant to assess.

[a]The Tool is introduced in E.Valu.A.Te: Summary and Signposting which can be downloaded at www.cpsl.cam.ac.uk/natcap. For access to E.Valu.A.Te : the Tool, please contact John.Pharoah@cpsl.cam.ac.uk

1.1 Objective

To help corporate sustainability teams action an evaluation of environmental externalities within a particular context – so that they can undertake an externality assessment themselves or organise one and evaluate the quality of the results. It aims to provide a stronger basis for communication within businesses and inform response strategies.

1.2 Approach

a) The Practical Guide provides information on how to perform an on-site assessment of corporate externalities using a stepwise bottom-up approach. The use of site-specific data is regarded as the most accurate way of assessing externalities and therefore preferred where possible;

b) The Practical Guide does not provide a one-size-fits-all approach or standardised metrics that can be applied in any context or production process in the world. Markets and ecosystems vary considerably within and between countries, and therefore externalities and their values will vary accordingly;

c) The Practical Guide explores the impact of business activities on the environment and on human welfare;

d) The Practical Guide provides practical guidance on potential ways of assessment, depending on the context and available data. It provides examples of useful tools and metrics and data requirements, but does not provide a comprehensive overview of all existing models, tools and (valuation) techniques;

e) The Practical Guide provides worked examples from different companies showing the potential and bottlenecks of externality assessment;

f) The Practical Guide is developed in collaboration with corporates and uses on-site data whenever possible. It builds upon existing initiatives, frameworks and tools, including those of WBCSD[11], Trucost/TEEB for Business[3] and BAT[4]. CPSL is part of the TEEB for Business Coalition.

1.3 Scope and Focus

a) The Practical Guide focuses on environmental externalities, but does not address social externalities (e.g. related to labour conditions, job satisfaction, etc);

b) The Practical Guide focuses on the agricultural sector;

c) The Practical Guide focuses on externalities related to the growing phase of the agricultural production/value chain;

d) The Practical Guide focuses on a subset of externalities that are likely to be most relevant to the business;

e) The Practical Guide builds upon knowledge from existing case studies on agricultural commodities.

This scope is further detailed in **Section 2**.

1.4 The Approach: Stepwise, bottom-up externality assessment

E.Valu.A.Te defines (business) externalities as:

Costs (benefits) resulting from (business) activities that are not accounted for in market prices or otherwise compensated, borne by parties who did not choose to incur those costs (benefits).

Linking environmental impacts to human welfare enables valuation

Operational activities can have environmental impacts. These impacts can be assessed by measuring or modelling changes in the environment and are expressed in biophysical units. These impacts can be positive or negative changes in the quality or quantity of the environment, i.e. natural capital and its ecosystem services.

When people also depend on this environment (for health, drinking water, food, recreation, housing, etc), the changes in the environment have an impact on human welfare and well-being. Using environmental valuation techniques, the impact on human welfare can be estimated and a monetary value can be assigned to this impact.

Figure 1 gives an example of how pesticide use (operational activity) may have an unintended environmental impact (eutrophication) that can have a negative impact on human welfare, for example on drinking water, fish (that can be used for recreation or consumption) or water recreation benefits.

Figure 1: Example of how an operational activity can have environmental impacts that lead to human welfare impacts

Strategic aim of externality assessment:

- to provide management information and insight into
  - how operations result in environmental externalities
  - how operations can be adjusted or changed to reduce corporate risk

- to seize opportunities for strategic investment and improve corporate reputation.

The E.Valu.A.Te Practical Guide provides a stepwise bottom-up approach to assess the externalities and lists the key questions that companies need to answer.

The Practical Guide assumes that a case study has been selected and it has been decided for which product and production site the assessment will be undertaken, for instance, based on data availability, interest, relevance, or representativeness or replicability across the company.

Practical Guide Structure:

The Practical Guide is structured around a set of steps and key questions:
- Understanding what externalities are **(Section 2)**
- Defining the business case and scenarios **(Section 3)**
- A step-wise bottom-up externality assessment **(Sections 4-5)** supporting the use of the online Tool.

Section 6 provides key findings and suggestion for how to use the results of the assessment.
The Glossary defines some commonly used terms.

The Practical Guide supports the use of the Tool:

The Tool provides guidance and decision making options, through an interactive interface, that are required to complete an evaluation of environmental externalities. Based upon the decisions made, the tool directs the user to the appropriate analysis sections to inform the next choices, guiding through the whole evaluation process. These decisions and outputs are highlighted using buttons; these are also highlighted throughout the Practical Guide:

Decisions to make throughout the process

Outputs to be calculated/collected

Structure of the Practical Guide and Tool

STEP	QUESTIONS IN EACH STEP	WHY IS THIS STEP
Understanding externalities	What are externalities?	This step is needed to un operational activities per human welfare are site-s
Scenario Selection	What scenario do I want to assess?	Externality assessment loc welfare by comparing sce relative to an alternative si compare various manage activities relative to that al
Activities and Impacts	What environmental impact do I want to consider? What operational activities do I want to focus upon?	The main externalities tha their relevance in the cont resource use and b) the co
Models and Data	What model can I use to assess these? What data do I need to undertake this assessment? Where can I get the appropriate data?	Various models and meth the environment. These h Practical Guide describe a (dis)advantages to suppor
Human Welfare Impact	How do the environmental changes impact human welfare?	Externalities arise because impacts that a company g biophysical impacts to hu the welfare of people (st business activities. This un
Valuation	What kind of value data do I need? How should I apply them to my case?	The valuation step places the welfare of other peopl common metric, they can results. This may guide tra

NEEDED?	WHAT WILL IT HELP ME DO?	DESCRIBED IN
derstand which externalities may result from the formed to grow crops, and why the impacts on pecific and context dependent.	This step will help you to understand how business activities relate to impacts on the environment and human welfare at the site-level.	Practical Guide: **Section 2**
oks at net changes in the environment and human enarios. The actual impacts of business activities are tuation or strategy. Using scenarios, businesses can ment options and assess the net impact of their ternative situation or strategy.	This step will help you to define your scenarios and specify them such that the assessment results support the corporate strategy.	Online tool and Practical Guide: **Section 3**
t will be quantified have to be selected based on ext of a) the business operational activities and rporate sustainability strategy and risk.	This scoping step will show you the relationships between different environmental impacts and business activities and help you to determine which to focus upon.	Online tool and Practical Guide: **Section 4**
ods can be used to analyse biophysical impacts on ave different data requirements. The online Tool and set of suitable models, their data requirements and t the selection of a suitable model.	This step will help you to determine which models and data are appropriate for your assessment.	Online tool and Practical Guide: **Section 5.1**
other people are affected by the environmental enerates, either positively or negatively. Relating man welfare impacts is necessary to understand how akeholders outside the company) is affected by derstanding is needed for the valuation step.	This step will help you to link environmental impacts (the outputs of the biophysical models) to the associated changes in human welfare.	Online tool and Practical Guide: **Section 5.2**
a value on the environmental impacts that affect e. By expressing the environmental impacts in a be compared to one another and to other financial de-offs and management decisions.	This step will help you to identify the most appropriate valuation study and to apply this to your particular case, so that the various impacts can be compared.	Online tool and Practical Guide: **Section 5.3-5.6**

2 Understanding Environmental Externalities

2.1 Environmental externalities in the agricultural supply chain

E.Valu.A.Te focuses upon the agricultural supply chain. The different phases of the agricultural production chain, from seed use to consumption and disposal were associated with various impacts on the environment; these were developed with a wide stakeholder group and included a detailed review of other approaches.

The resulting schematic (**Figure 2**) shortlists the environmental impacts that may result from corporate activities at each stage.

This conforms to existing frameworks such as the UK National Ecosystem Assessment[1]: it lists environmental impacts that are directly related to human welfare as they represent goods/benefits, and therefore excludes so-called supporting ecosystem services which have no direct link to human welfare[2].

Biodiversity is also excluded (**Box 1**). The externalities that are outlined overlap with the environmental Key Performance Indicators as used in the TEEB for Business Coalition Natural Capital at Risk report[3].

For agricultural production, the environmental impacts were related to each stage in the product value chain. The schematic does not provide an exhaustive list of impacts, but lists many of the relevant ones.

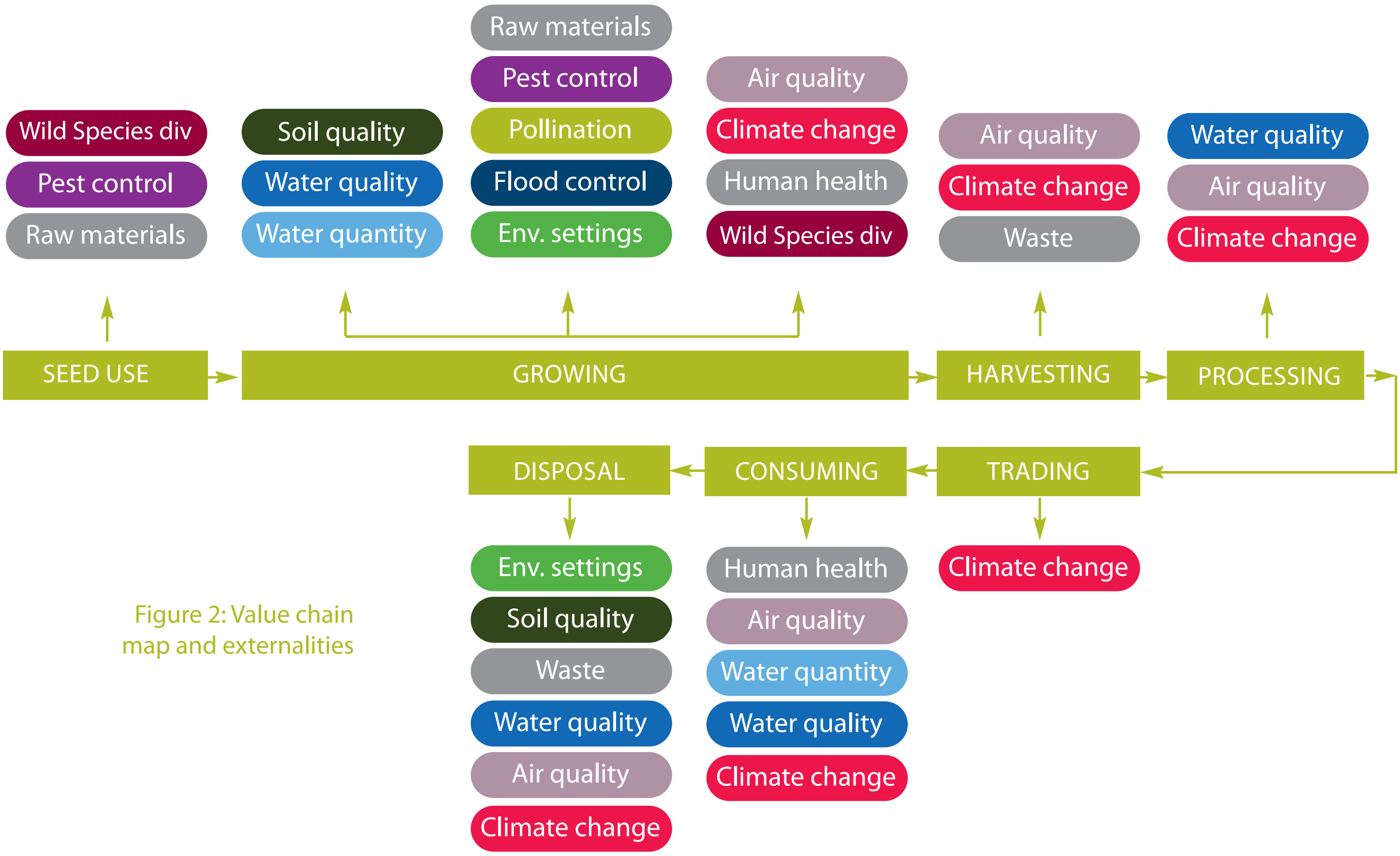


Figure 2: Value chain map and externalities

Box 1: Biodiversity

The E.Valu.A.Te Tool and Practical Guide do not include biodiversity in the list of human welfare impacts. Biodiversity supports fisheries, soil quality, pollination, pest control, etc. The Practical Guide regards biodiversity as an enabling factor for the provision of environmental benefits. It plays a role as an environmental indicator, and impacts on/change of this indicator can be assessed and monitored. However, the Practical Guide does not aim to put a value on biodiversity directly, but suggests to value the related human welfare, including impacts on recreation, education, seeing wildlife and knowing that wildlife exists.

The impact of operational activities on biodiversity can be approximated with indicators such as species diversity (e.g. Shannon index), species evenness (e.g. Simpson's index), or richness. Many of these indicators simplify biodiversity to the extent that they do not provide useful information about the actual impact of the company's operations on biodiversity. Indicators such as habitat extent and habitat integrity may be more suitable.

Impacts on biodiversity are very site-specific so that it is generally recommended to involve an expert on local biodiversity to assess the potential impact (positive and negative) that the company's operations are likely to have under the current operations or alternative strategies. Such consultations may also result in the specification of a list of (simple) measures that the company can take to reduce its impact on biodiversity.

As an example of biodiversity assessment for the private sector, British American Tobacco have set up the BAT Biodiversity Partnership, which aims to address conservation and management of biodiversity within agricultural landscapes[4]. This Partnership has developed an approach to embed sustainability thinking into the culture of organisations .

E.Valu.A.Te focuses on the growing phase of the agricultural product supply chain, thereby covering a sector that is among the largest contributors to global environmental impacts, and capturing the most relevant phase in the product supply chain. Measured in monetary terms, the production of rice and maize is globally the main contributor to water and land use related externalities, associated with the highest air pollution impacts after coal mining, and among the largest water users (together with other agricultural commodities such as wheat and cotton)[3]. For agricultural products, the growing phase is associated with the majority of water use as well as carbon emissions.

To explore the externalities related to the growing phase in more detail, the map was further developed with business stakeholders. The environmental impacts were related to each of the activities in the growing phase of the agricultural product value chain **(Figure 3)**. **Table 1** gives a brief overview of the different environmental impacts related to activities in the agricultural product value chain, their causes and the impacts they have on human welfare.

When natural habitat is converted to agricultural land, all human benefits from the natural habitat are affected, including the aesthetics of landscapes (environmental settings), the ability of land to regulate water flows, increase flood risk and decrease drinking water etc, provide habitat for pollinators, other species (biodiversity), regulate climate through carbon sequestration.

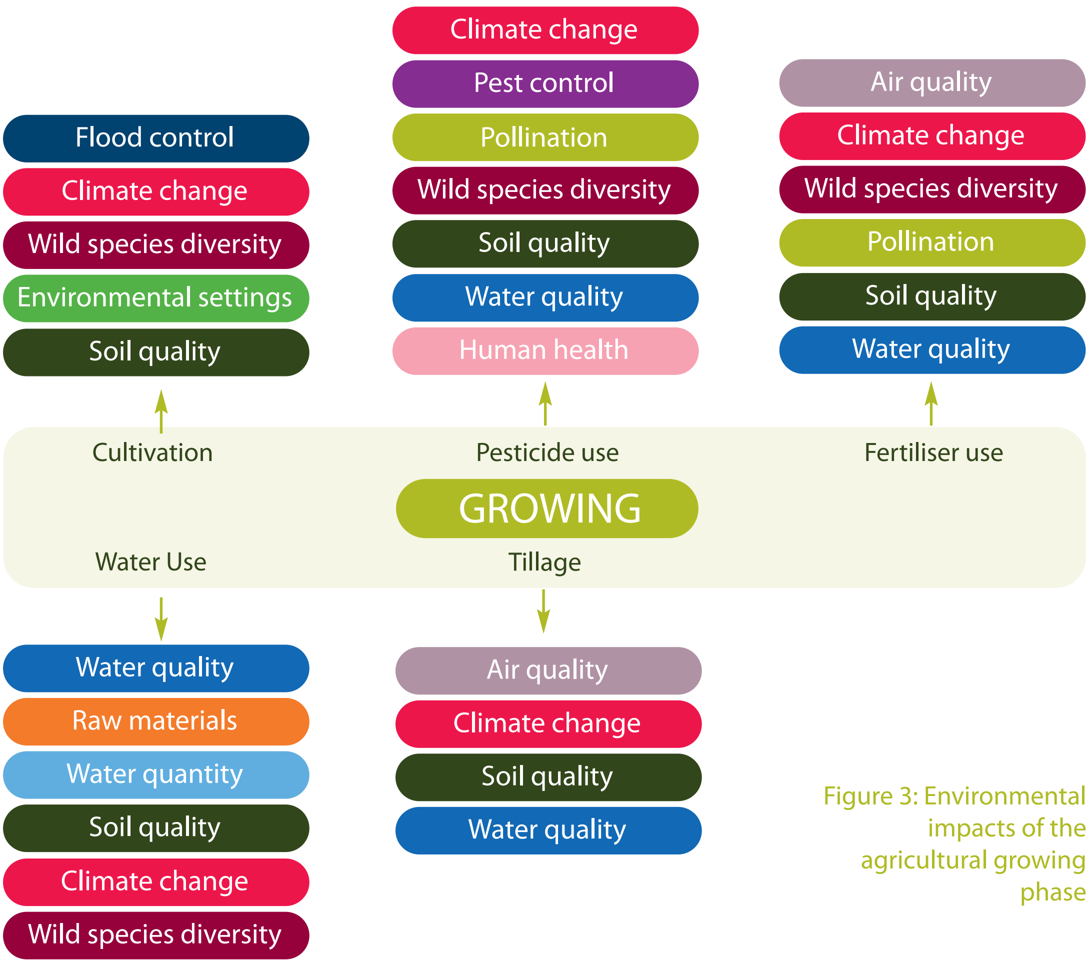


Figure 3: Environmental impacts of the agricultural growing phase

Environmental impacts:

Change in…	Cause	Human welfare impact
Environmental settings	Changes in cultivation techniques that affect the aesthetics of the landscape, and changes in water quantity and quality conditions that affect the landscape indirectly.	Recreational as well as cultural/spiritual benefits that people derive from environmental settings.
Water quantity	Water use/extraction, e.g. for irrigation. Water availability changes are also related to changes in water quality (see below).	Drinking water (human health), irrigation (crop production) and industrial uses. Indirect effects include cultural/recreational benefits of environmental settings and wild species (e.g. fishing), because water sustains habitats, plants and animals. Reductions in water flow may reduce flood protection.
Water quality	Pesticide use, fertiliser use (nitrates), land and water use.	Drinking water (human health), irrigation water (crop production) and industrial uses. Indirect effects through impacts on biodiversity and ecosystem health affect benefits of products (e.g. fish catch) and recreational benefits of environmental settings and wild species.
Climate change	Greenhouse gas emissions emissions result from cultivation, fertiliser use, tillage (through changes in the soil) and the use of energy/fuel for irrigation, fertilisation, tillage, pesticide spraying, etc.	The emission of greenhouse gases has negative impacts on climate stability. Negative impacts of climate instability include damages of extreme weather events to crops and infrastructure, human health, production losses, etc.
Air quality	Emissions of methane, nitrous oxide, carbon dioxide etc. mainly related to fuel combustion, fertilising, and tillage.	Human health, recreational and cultural/spiritual benefits of environmental settings.
Soil quality	Directly by cultivation, tillage practices, pesticide use, fertiliser use, water use.	Directly on crop production, flood control. Lower quality soil may also store less carbon leading to higher greenhouse gas emissions (climate change). Lower soil quality may lead to dust release (lower air quality) and affect water quality through sedimentation.
Raw material (crops, timber, bio-energy, etc)	Mainly affected through changes in water and soil quality, pest control, biodiversity, pollination, and water quantity.	Benefits from crops, timber, bio-energy, (wild) food, fisheries, fodder for grazing, etc.
Wild species diversity	Affected through changes in biodiversity, water quality and quantity, pollination and pest and disease control.	Recreational, cultural, spiritual, educational values for wildlife.
Flood control	Directly by cultivation (vegetation), indirectly through changes in soil composition and water quantity (desiccation).	Protection of human life and human/capital assets against floods, including crop production.
Pest and disease control	Directly by pesticide use, indirectly by the use of genetic material.	Human health, agricultural production, and the cultural and recreational benefits of wild species diversity.
Pollination	Pesticide use, and indirectly through impacts on biodiversity (pollinators).	Agricultural products, and other natural products that people harvest (fruits, flowers, timber, etc), and wild species diversity.
Human health	Human health can be directly impacted by pesticide use, and indirectly through other environmental impacts.	Human health is one of the main factors of human wellbeing.

Table 1: Environmental impacts - changes, causes and impacts

2.2 Focal environmental impacts of E.Valu.A.Te Practical Guide

Ideally, the full set of externalities is evaluated. However, businesses may decide to focus assessments on a subset of externalities for practical or strategic reasons.

Building on business led case studies of agricultural production, the E.Valu.A.Te Tool and Practical Guide cover examples of environmental impacts with high societal welfare impacts and high corporate risks, for which worked examples were available from the business case studies. The focal environmental impacts are:

- Climate change (related to the emission of greenhouse gases, such as carbon dioxide: CO_2, methane: CH_4, nitrous oxide: N_2O, and ozone: O_3)
- Changes in habitat, including associated carbon stock changes
- Air quality changes (air pollution)
- Water quality
- Water quantity (water pollution)

The Practical Guide covers the growing phase of the agricultural commodity chain – users of this Guide have to decide if this scope is sufficient for their externality assessment.

For some products the scoping phase may reveal that a wider scope of the commodity chain should be regarded, as CS1[a] below shows.

CS1: A comparison of water use for tomato and almond production suggests little difference in water requirements between the two products in the growing phase. However, subsequent tomato processing increases the company's water use. This example shows the importance of commodity chain mapping and scoping: which steps in the production chain are accounted for.

[a] CS1 represents a business case study. These are outlined in **Section 2.4.**

2.3 Importance of site specific assessments for detailed decision making

Economic values are inherently spatial. The monetary value of externalities is therefore site-specific, because externality values, like prices, depend on supply and demand.

- **Supply:** ecosystems, resource availability and scarcity of the environmental resource vary across countries and localities – impacts in areas with high supply will have lower values;

- **Demand:** demand for environmental goods and benefits varies across countries with people's dependency on environmental resources, and with population size and density and the number of people that are affected, their characteristics and preferences: the higher the demand for the impacted environmental good/service, the higher the value.

The economic value of environmental impacts hence depends on the environmental and social context in which the business operates. Therefore, the monetary externality value of corporate actions on ecosystems and their services is location-dependent.

For example, near cities, air pollution will carry major welfare impacts as many people may be affected. Water quantity deterioration may have impacts on wild species diversity, but the level of impact (both in biophysical and monetary terms) depends on the species that are present at that location.

The impact that groundwater use for irrigation has on human welfare is more immediate where communities use groundwater on a daily basis, compared with a country where people primarily use tap water (**Figure 4**).

Figure 4: The human welfare impact of groundwater use varies between locations and with people's dependency on the groundwater resources.

Understanding of the business context (social and environmental) is essential for understanding environmental externalities and associated risks.

2.4

Case Studies

A variety of case studies were developed with participating businesses. These case studies led to the development of methodologies which have supported the development of this guide. They have been highlighted in this guide to exemplify each of the steps. **The SABMiller case study** has been used as a worked example and utilised to show the flow from step to step and where decisions in each phase influence the outcomes. The case studies are summarised in **Table 2**. These case studies are referred throughout the Practical Guide (using their numbering) to illustrate individual steps and decisions made by companies.

Case Study	Externality assessment	Brief Description
SABMiller - Barley and other crops production in Rajasthan, India - WORKED EXAMPLE[a]	Examining land use choices relating to barley production	Compares externalities associated with the production of barley with those associated with rice and other crops grown in a water scarce area.
CS1. Water use in an almond plantation and tomato cropping in Central Valley, California	Comparing different types of cropping, taking water use as the lens through which to assess impacts of land use and fertiliser use.	Contrasts the use of natural capital in the management of (a) a plantation and (b) an annual crop in the same water catchment area.
CS2. Consumptive water use for crops and milk production in Punjab, India	Comparing two different land uses through the lens of water use	Examines stress on water sources through ground¬water irrigation in agri¬cultural production. It explores a practical and achievable optimisation method for water use given the varying pressures exerted by different crops.
CS3. Polluted water treatment for different uses in South Africa	Assessing how different technologies work together to reduce negative - and create positive - externalities	Examines the treatment of polluted water to produce clean water for drinking water, produc¬tion processes and to feed into ecosystems. This is a water stressed area with extraction by local stakeholders above sustainable limits.
CS4. Comparing the profitability of a crop per unit of water	Using the financial returns for a company as an approach to valuing externalities in Argentina.	Compares water consumption for different uses of a commodity and relates it to its profitability.
CS5. Cultivation of corn in France and Germany	Comparing externalities for food and biogas production.	The resultant measure could inform water use, and allows a broader analysis of the financial value of other natural resources used for a specific commodity.
CS6. Cultivation of corn in the US Mid-West	Comparing externalities for food and agri-fuel production	Contrasts the valuation of corn production emerging from different policy frameworks within the same regulatory environment. Contrasts corn production for food stuffs and agri-fuels.
CS7. Soy and corn production in Mata Grosso, Brazil	Examining externalities for soy and corn production in different geographies	Compares externalities associated with the production of soy and corn between farms in different geographies and between different modes of management

[a] The SABMiller case study is also used in the Tool and highlights what decisions were made at each step. A full paper provides more details and can be accessed at www.cpsl.cam.ac.uk/natcap

Table 2: Business led case studies

Scenario Selection | Activities and Impacts | Models and Data | Human Welfare Impacts | Valuation

3 Getting started: Defining scenarios of change

Externality assessments can be motivated by different reasons, for example, a need to raise awareness of the current environmental impacts, or to deepen understanding of the potential improvements in environmental performance under a new business strategy, such as the introduction a new crop or adoption of a new seed variety.

Objective:

Externality assessment looks at changes in the environment resulting from the operational activities of a company and the effect of these changes on other stakeholders of the environmental resource. It does so by comparing scenarios. The objective of defining scenarios is to ensure that the assessment is aligned with the company's strategy and leadership aspiration and its stakeholders' demands and will produce results that support this.

- The **E.Valu.A.Te Listening to Business**[b] report describes the results of interviews conducted with participating companies about the motivations and interests in externality assessment.

Process: The definition of scenarios involves a group of experts thinking about the strategic objective of the assessment, the potential impacts of the operational activities on the environment and consideration of how the land would be used under different circumstances. Scenarios have to be plausible storylines or narratives that are internally consistent and coherent, they are broad and descriptive, but may include some quantifications as far as the available information allows. The step takes time and (external) expertise.

Expertise: Knowledge about both the business operations at the site scale, as well as the trends and drivers in land use in the area are useful. The group that defines the scenarios should include the Sustainability Manager, operational managers that know the operations at the site, and experts that are familiar with the site's history and policies of land use and environmental conditions. Existing information and data about the site should be used as much as possible. Input from local experts in socio-economics and environmental issues can help to define plausible, context dependent scenarios.

Output: The outputs of this process include a description of the business case and the 'counterfactual', the most plausible alternative scenario of land use for the site.

[b]Listening to Business can be accessed at www.cpsl.cam.ac.uk/natcap

3.1 Comparing scenarios

It is important to consider that the impacts of the business activities relate to a change the environmental conditions caused by a particular action of the company. The net impact relates to the difference between the state of the environment with and without that action. Using scenarios, business can compare various management options and assess their impact relative to an alternative.

To assess the net impacts of business operations, two alternatives must be compared:

1) **The business case:** the first alternative is usually based on a particular way of operating by the company. By using natural resources, e.g. water, the operations may have a positive or negative impact on the environmental conditions. In the externality assessment, the business case is the option of strategic interest to the business for which externalities need to be assessed.

2) **The counterfactual:** The counterfactual scenario describes a **plausible alternative** state of the site and its environmental conditions that would result if the company did not operate as described under the business case. The company or other people make a **different** use of natural resources.

It is the difference between these scenarios that matters for externality assessment.

Counterfactual scenarios describe the most plausible, likely state of the environment given the local context, the best available current information and a set of consistent and coherent assumptions about how key drivers and pressures change or have changed the environment[5]. Counterfactual scenarios are site-specific.

The definition of the counterfactual is crucial to externality assessment. It is important to note that the counterfactual is not necessarily the business-as-usual scenario!

Decision 1:
Will the externality assessment address the externalities related to current practices or a change in practices?

3.2 Defining the business case and the counterfactual

The development of scenarios is the key starting point for the assessment. There are two generic options to specify the business case: the assessment can focus on the externalities related to either the current operations or operations under a new strategic course. The plausible counterfactual scenario depends on the business case:

1) Business case: If a company wants to assess the externalities related to its **current practices**, possible **counterfactuals** include:

- a scenario where the land is covered by **natural habitat**. This counterfactual may be most plausible when the land conversion took place to provide cropland for the company;
- a scenario where the land is under **alternative, human use**. This counterfactual may be most plausible if the land would have been used by people (e.g. for different types of farming, or for residential or industrial use) if the company did not use the land.

2) Business case: If the company wants to assess the externalities related to a **change in current practices**, the counterfactual is:

- The **current practices / business-as-usual**. This is the most plausible alternative scenario if the company does not change its current practices.

Example 1:
The company is interested in the environmental impacts related to a change in operations: from handpicking to mechanical harvesting. In this example, the business case relates to mechanical harvesting **(Figure 5.1)**, and the counterfactual is the current practice **(Figure 5.2)**.

(1) **Business case:** a change in current operations

(2) **Counterfactual:** the conditions without the change

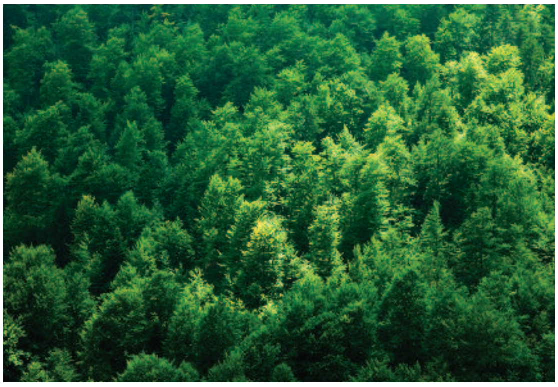
Figure 5: Developing scenarios for the business case and counterfactual, example 1.

The difference between the counterfactual and the business case represents the impact of the business operations. In this example this could be an increase in emissions of greenhouse gases due to fuel use for machinery.

Example 2:

The company is interested in the environmental impacts of their current operations. In absence of the company, the land would not have been converted to cropland and there would still be forest. So the business case here is the current practice **(Figure 6.1)** and the counterfactual is the natural forest **(Figure 6.2)**.

(1) Business case: current practice



(2) Counterfactual: natural habitat

Figure 6: Developing scenarios for the business case and counterfactual, example 2

The difference between the counterfactual and the business case represents the impact of the business operations, and in this case could include a loss of wild species diversity, a loss of carbon stored in the trees and soil, and multiple other benefits/goods that natural habitats provide but cropland does not.

Specifying the counterfactual: Temporal data on (changes in) land use and land use cover can provide insight in suitable counterfactuals. Information for the baseline can come from environmental or other site-specific studies. The description of the counterfactual is likely to include: a biophysical description of the area (location, size, topography, land use, environmental characteristics) and a socio-economic description (population, main economic activities, etc).

Spatial and temporal dimension: Land use varies across space and may change over time. Scenarios may therefore be defined as plausible storylines over a certain period (e.g. 20 years) in which current trends in land use continue. Alternatively, more extreme hypothetical scenarios may be explored, for example to assess how drastic changes affect externalities and business operations.

Decisions 2 and 3:
Scenario selection: What is the business case? What is the counterfactual?

Output 1:
A description of the business case and the counterfactual.

The SABMiller scenarios: Program of change

SABMiller sources its barley for its beer production, among others, in India, in the Jaipur district in the region of Rajasthan. The company needs more barley for its expansion of brewing capacity. It has invested in agronomic extension services and higher quality barley varieties to promote the production of malting barley. The company wants to assess the environmental externalities of increasing the production of barley, typically grown in the dry season and therefore irrigated, to understand the sustainability of promoting barley in the region. In the counterfactual scenario, more traditional production of mustard, wheat and gram by small-scale farmers is expected to continue.

Other examples

PUMA: The EP&L used the natural habitat prior to PUMA's operations as its counterfactual, and included all environmental benefits of these natural habitats in its environmental losses.

CS1: The case study uses the natural background situation. It then looks at the bundle of ecosystem services that the natural habitat would have provided if conversion to agricultural land had not taken place.

CS2: In a study on milk and wheat production in the Punjab district in India, alternative cropping patterns are compared with various reductions in rice production and increases in milk production, to assess the impacts on groundwater depletion.

4 Identifying and prioritising externalities: Scoping

Objective:

The purpose of the scoping exercise is to identify the main issues that the externality assessment will focus on, through a better understanding of the environmental changes and impacts on human welfare caused by a company's activities. The scoping process should therefore assess where production takes place, who may be affected by the business operations and how these stakeholders are affected.

Process: Scoping often involves a group of people meeting and brainstorming to discuss the objective of the externality assessment, exploring how to best meet the need of the business and the availability of resources and relevant information to undertake the assessment. In practice scoping is often an iterative process that may require multiple consultations. **Figure 7** shows the main scoping steps, including the description of the site and context, the operational activities and resource use, the potential externalities and their risk profile.

Expertise: The scoping step can be completed by the business itself. The sustainability manager may want to discuss relevant issues with external stakeholders that are key to business operations and strategy, such as financiers and suppliers. Involvement of agronomists, agricultural extension officers, and the operational manager at the study site will help to assess the resource use (inputs, outputs, activities). Further involvement of environmental scientists who are familiar with the environmental context and regulations may help to assess resource limits and potentially relevant activities and impacts. The sustainability manager has to link the main environmental impacts to the corporate strategy, risk and opportunities.

Output: The output of the scoping process is a short, qualitative description of the most relevant externalities for the business operations, the given context in which it operates, and the corporate sustainability strategy and risk. The selection of relevant activities and impacts is annotated in a checklist **(Table 5)**. Note that the scope is likely to be adjusted during the actual assessment **(See Section 5)**, as more data and knowledge become available.

Steps: Scoping involves five steps **(see Figure 7).**

Note that the steps presented in this chapter build upon other tools such as the CEV[11] and BROA[12], but focuses on the growing phase of the agricultural value chain. It uses the value chains maps **(Figures 2 and 3)** to identify relevant externalities in this context. It provides particular guidance on the considerations of limits to natural resource use in order to help setting the scope and selecting the relevant externalities.

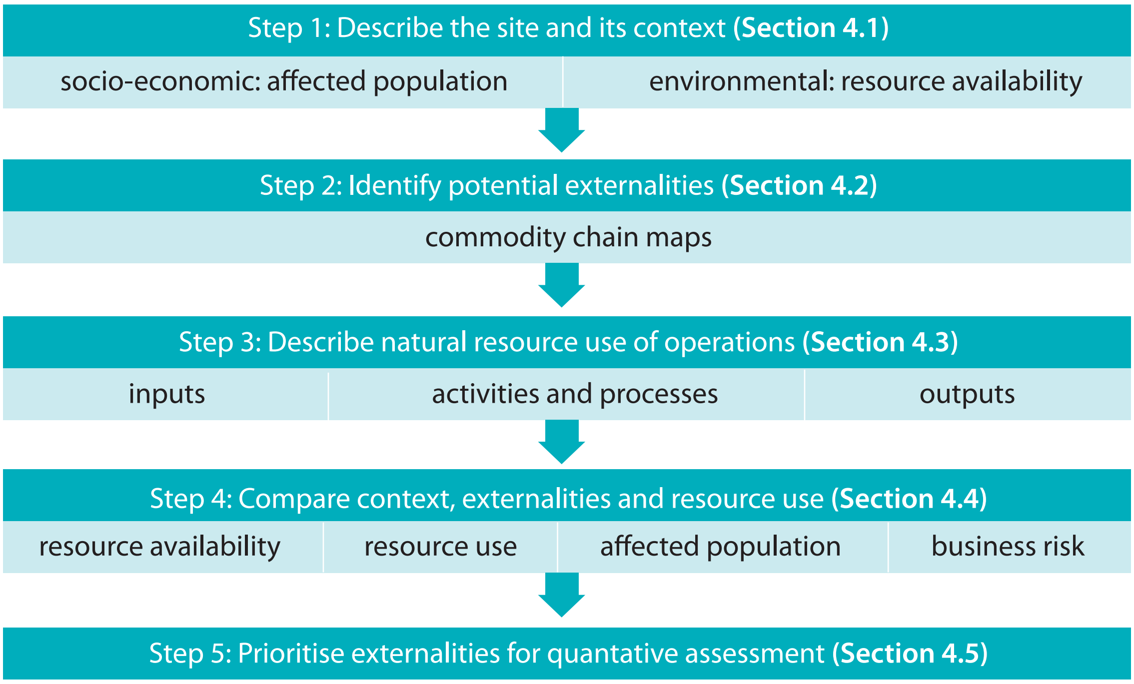


Figure 7: Steps in the scoping process.

4.1 Step 1: Describe the context

Questions: What are the main environmental issues in the area around the site? Which natural resources are scarce (and relevant) at the site? Who might be affected by the environmental impacts of the business?

For site-specific assessment **(see Section 2.3)**, the context in which the business operates has to be described in short and mainly qualitative terms. This helps to understand what the environmental conditions and issues at the site are, and who the affected stakeholders may be. The scoping step therefore considers:

1) the environmental context of the site;
2) the socio-economic context of the site.

Environmental context: To understand the main environmental issues and scarcity of natural resources, the environmental context has to be described by looking at characteristics including (but not limited to):

- type of habitat in the region – a land cover map;
- carbon storage in the soil and vegetation;
- climatic conditions (temperature, rainfall, seasonality);
- local and regional water availability and quality conditions (e.g. trends in river flow, groundwater resources);
- biodiversity and protected area management in the area;
- soil conditions.

Why? Environmental conditions at the site, such as soil and temperature, may determine the required levels of tillage, fertiliser and pesticide use and thereby influence the level of externalities.

CS5: A comparison of corn production in France and Germany shows that fertiliser use has larger environmental impacts (measured in N leaching) in France simply because of the local soil conditions.

Socio-economic context: To understand who the people are that may be affected by the environmental impact of business operations, the socio-economic context has to be described. This is done by looking at factors that mainly relate to (proximity to) communities, social attitudes and legal/governance frameworks, including (but not limited to):

- population, population growth, population density (urban/rural);
- income and wealth levels, Human Development Index;
- local dependency on (or direct use of) natural resource to identify competition over land and water resources, e.g. **(Figure 8)**
  - recreational use of natural habitats;
  - surrounding land-use;
  - irrigation levels;
  - direct use of drinking water from natural sources;
  - use of timber, wild food, firewood, fodder etc from land;
  - dependence on natural pollinators for cropping;
- (non-)physical infrastructure that regulates access to and use of these natural resources;
- cultural meaning attached to the environment, cultural/spiritual importance of species, social attitudes towards conservation;
- main policies and regulations with respect to natural resources (e.g. nitrate/carbon emission levels regulations, air quality, water quotas, environmental impact assessments requirements).

Why? Local socio-economic conditions, including income levels, culture, infrastructure, and governance, indicate which natural resources are locally important to stakeholders and in regulations. Higher stakes and regulatory levels may be associated with higher risk/relevance of the environmental impacts.

Figure 8: Context matters: forest uses vary with socio-economic contexts

The SABMiller environmental and socio-economic context

SABMiller uses barley production in the Jaipur district in the Rajasthan region, India. The main land use in the area is agriculture and the area is ideal for wheat growing, but recently production has been observed to fall. Groundwater resources in the area are declining rapidly. Farmers continuously extract groundwater for irrigation at rates that exceed natural recharge. The population in the area depends on water resources for drinking water, nutrition and income from farming.

As a very first step, global maps and data sources can be examined to provide a first indication of the context. **Box 2** provides a brief list of maps and data sources that can be used to inform the context description. The scale of these maps is often too coarse for site-specific, quantitative assessment.

Box 2: Maps and data sources to gauge resource availability and the socio-economic context

Biodiversity:
Protected areas

Land use:
Natural habitat [see ecoregions],
Human-driven land use

Climate change: Soil carbon

Water:
Water scarcity,
Groundwater stress, baseline water stress, etc

World population

Human Development Index

Agricultural and other resource data

4.2 Step 2: Identify potential externalities using commodity chain maps

Questions: What are the potential externalities of growing crops?

The commodity chain map for the growing phase presented earlier (**Figure 3**) shows which environmental impacts relate to each on-site activity performed in the growing phase. Agricultural products differ in their environmental impacts; e.g. some crops require more water than others. Therefore, the most relevant externalities to the selected crop, operations and location of the business have to be selected using expert knowledge.

Table 3 provides more detail for **Figure 3** and reveals that:

- habitats (natural and agricultural) can provide a range of benefits, and conversion [from natural habitat] to agricultural land use impacts on all these benefits, i.e. a change in a bundle of benefits;
- activities can have multiple impacts on human benefits, i.e. multiple externalities. The Practical Guide provides examples of the quantification of some of these impacts. These examples show that simplification of these relationships can provide partial, yet meaningful and relevant results;
- impacts are linked and have knock-on effects on other types of benefits. There are many links and the complexity of these relationships is shown in **Figure 9**. In **Figure 9**, the red arrows show that some of the benefits are related, e.g. soil quality and the provision of crops, wild food, timber and bio-energy. These relationships need to be taken into account in the valuation step to avoid double counting and overestimation of the impacts (**Section 5.3.1**).

Scope of the Practical Guide (refinement)

Table 3 describes the links between activities and impacts. However, the Practical Guide does not provide methods, metrics or values for all links and impacts. The following are currently beyond scope of the Practical Guide : impacts on flood control, pest and disease control, pollination, wild species diversity, environmental settings, and human health. Also, there are no models or quantifications provided for: tillage and genetic material (seeds) use.

The E.Valu.A.Te Practical Guide and Tool have been generated by contributions from business case studies undertaken within the Natural Capital Leaders Platform; some impacts have not been fully evaluated.

Environmental metric	Environmental impact	
Cultivation	Environmental settings	Change of land use to (another type of) cultivation may impact on the aesthetic quality, with associated recreational and cultural values.
	Biodiversity Wild species diversity	Loss of biodiversity due to land conversion can have knock-on effects on the benefits supported by biodiversity. Human benefits of wild species diversity for recreational and cultural reasons may be lost when land use changes (including changes in on-farm cultivation operations).
	Climate change	Rice cultivation results in methane emissions, which contribute to climate change.
	Climate change	Net change in soil carbon may lead to greenhouse gases emissions.
	Fuel use Climate change	Fuel combustion leads to greenhouse gases emissions
	Soil quality	Land conversion and preparation for cultivation changes the soil, soil composition, nutrient cycling, and the productivity of the land.
	Flood control	Removal of vegetation can affect the land's capacity to absorb excess water.
Tillage	Climate change	The impact of tillage methods versus no tillage may be mixed. Tillage reduces carbon compounds in the soil.
	Fuel use Climate change	Fuel combustion leads to greenhouse gases emissions
	Fuel use Air quality	Fuel combustion leads to NOx emissions
	Soil quality	Tillage leads to a reduction in nutrients and water storage ability, soil erosion, and soil compaction, which results in a loss of land productivity.
	Water quality	Tillage results in higher rates of fertiliser and chemical runoff, with impacts on water quality.
	Air quality	Tillage of dry soils leads to dust pollution with impacts on human health.
Fertiliser application	Soil quality	Fertilising may lead to soil degradation (e.g. calcium and nutrient losses), acidification, loss of soil micro-organisms, leading to lower land productivity.
	Climate change	Nitrogen (N) volatilisation from fertilisers generates nitrous oxide (N_2O) emissions, contributing to climate change.
	Water quality	Nitrogen (N) from fertilisers leaching into ground- and surface water causes low oxygen levels, and eutrophication. Water quality reduction has knock-on effects on human and environmental health (biodiversity, land productivity, etc)

Table 3: Linking operational activities to environmental changes for the agricultural growing phase

Environmental metric	Environmental impact	
Fertiliser application cont.	Air quality	Ammonia (NH_3) emissions related to nitrogen in fertilisers may have negative human health effects
	Air quality	Nitrogen oxide (NOx) emissions react to form smog and acid rain, with negative impacts on human health (respiratory and heart diseases). Acid rain is detrimental to forests, soils, freshwater and organisms. It also negatively impacts upon the ozone layer.
	Water quality	Fertilisers contain Potassium (K) that, when leached into surface water, may damage plant/crop growth
	Water quality	Fertilisers contain Phosphorous (P, P_2O_5) that, when leached into surface water, causes eutrophication and has knock-on effect on human and environmental health.
	Biodiversity Wild species diversity	Direct and indirect (through pollution) loss of benefits supported by biodiversity Loss of recreational and cultural value
	Fuel use Air quality	Fuel combustion leads to NOx emissions
	Fuel use Climate change	Fuel combustion leads to Green House Gas emissions
	Pollination	Reduction of species richness and evenness due to pesticide application reduces natural pollination, leading to loss of yield, etc.[6]
Pesticide application	Soil quality	Pesticides may reduce the ability of soil bacteria to fix nitrogen (natural fertiliser), leading to yield losses.
	Pollination	Reduction of species richness and evenness due to pesticide application reduces natural pollination, leading to loss of yield, etc.[7]
	Water quality	Pyrethroid that enters surface water is toxic to fish, insects and invertebrates – causing food web effects (biodiversity), as well as other impacts of water quality reduction. Effects may be on-site or downstream.
	Biodiversity Wild species diversity	Pesticide residues are poisonous to animals that eat them, or accumulate within food chains. Loss of species may imply a loss of recreational and cultural value.
	Pest & disease control	Pesticides may harm natural pest control, as well as change species richness and evenness, leading to loss of yield, etc.[7]
	Human health	Pesticides have negative human health impacts when workers are directly exposed.
	Fuel use Air quality	Fuel combustion leads to NOx emissions

Environmental metric	Environmental impact	
Pesticide application cont.	Fuel use Climate change	Fuel combustion leads to Greenhouse Gas emissions
Water use	Water quantity - groundwater	Extraction of surface water reduces water availability for other users (industry, municipalities, transport) as well as environmental functionality, e.g. disappearance of wetlands, fishing options. Effects may be at the site or downstream.
	Water quantity – surface water	Extraction of surface water reduces water availability for other users (industry, municipalities, transport) as well as environmental functionality, e.g. disappearance of wetlands, fishing options. Effects may be at the site or downstream– and be positive in case of reduced downstream flooding.
	Water quality	Reduced water availability can result in higher concentrations of pollutants and reduce water quality
	Soil quality	Soil erosion and degradation due to siltation of land after irrigation.
	Biodiversity Wild species diversity	Water scarcity can result in a loss of benefits supported by biodiversity Loss of recreational and cultural value
	Raw materials	The provision of crops, timber, wild food, bio-energy etc depends on the availability and quality of water

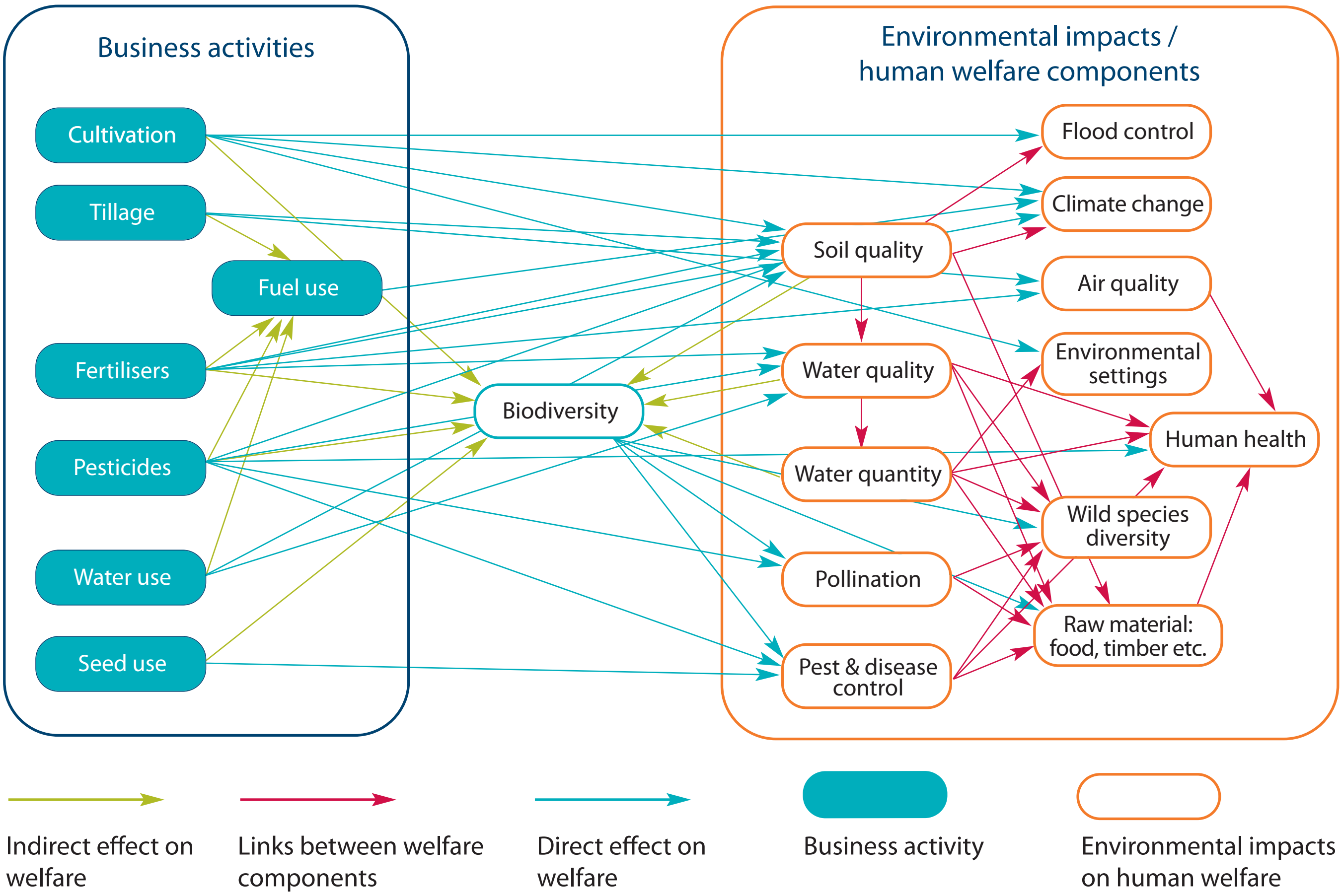


Figure 9: Links between activities and human welfare impacts

4.3 Step 3: Describe natural resource use of operations

In this step, a short, qualitative description is needed of the operational process at the business site, including its inputs, activities and non-product outputs that relate to the use of natural resources.

Questions: How are the operations related to the use of natural resources?

1) What are the main **inputs** to production?

Describe the inputs (the resources used by a company) to understand if (and how much) the company uses the following materials and resources (these may lead to other non-product outputs):
- Land;
- Fertilisers;
- Pesticides, fungicides, herbicides, other chemicals to improve soil conditions and avoid pests;
- Water from groundwater and surface water resources.

2) What are the main operational **activities and processes** during production? How is the land managed?

Describe other operational activities and processes that may generate environmental impacts:
- Land management, including tillage;
- Machinery use – related to energy use, including pumping and grain drying.

3) What are the main **non-product outputs** of production?

Describe other non-product outputs to understand potential negative impacts, such as:
- Waste;
- Chemical emissions into soil, air or water, such as methane, nitrous oxide, ammonia, etc.

The SABMiller operational activities, inputs and outputs

The main inputs into the system include land, pesticides, and synthetic and organic fertilisers. Irrigation uses water mainly from ground water resources. It also requires the use of electricity for pumping.

Fertilisers and pesticides are related to greenhouse gas emissions. Fertiliser use also has negative impacts on water quality.

4.4 Step 4: Compare context, externalities and resource use

In this step, the relative resource availability (environmental context) and affected population (socio-economic context) (Section 4.2) can now be compared with the information about the potential externalities (Section 4.3) and the production activities and resource use (Section 4.4).

Questions: Which of the potential externalities are relevant, because they affect corporate risk and relate to the corporate strategy?

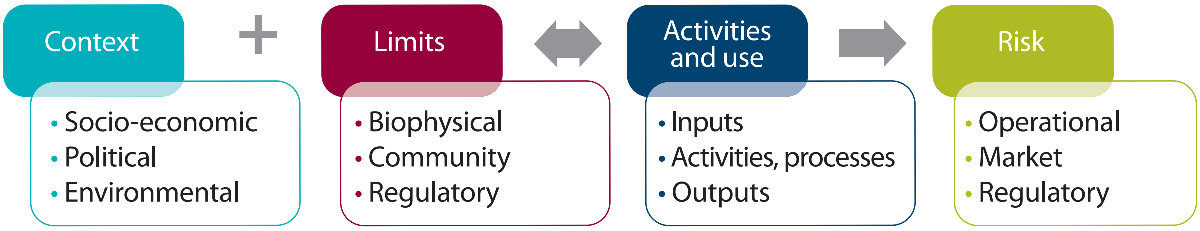


Figure 10: Comparing the availability of resources and limits to resource use to actual use to identify

The use of natural capital (either by using it as an input to production or by producing non-product outputs) have to be compared to the potential or limits to its use. This provides insight to the externalities that are relevant from a risk perspective. They need to be addressed in order to meet the corporate strategic objectives. **Figure 10** shows this process. There are three categories of relevant limits[a]:

- Biophysical limits: The 'stock' of natural capital or ecosystems on and around the production site cap the potential use. In the presence of demand: the lower the stock, the higher the value of the environmental impact. A comparison of the **biophysical limits** with the natural capital use of the company determines the relevance of environmental impact. Resource use close to or larger than the sustainable natural supply increases **operational risks**.

- Regulatory limits: Limits may be set by **regulatory standards**, for example, limits on chemicals used or put into the environment, may be set to protect human health or other aspects of human welfare. The company needs to comply with these standards to avoid **regulatory risks**.

- Informal constraints: These include consumer demands, relations with local communities, voluntary standards of the private sector, certification regulations as well as criteria put forward by financial institutions. If they are not considered, these limits may increase **reputation or market risk.**

Table 4 gives potential indicators for these limits. It is not necessary to collect information on all items and they may not be available for the case study site of interest. For any of the items where the company's resource use is close to natural, regulatory or local community limits, risks are higher and further assessment is considered relevant/important.

Each company's risk assessment will be different and depend on the sector and location of operations. In general, environmental impacts with a high value to society may generate a larger response by either the government or consumers who may put pressure on the private sector to reduce these impacts. For further guidance on environmental risk assessment we refer to:

- the Corporate Ecosystem Services Review[8]
- Running the risk: Risk and Sustainable Development: A business perspective[9]
- the E.Valu.A.Te '**Listening to Business**' report describes the different risk categories and the motivations to take action on environmental externalities.

[a]The Metrics Selection Framework contains more information on context-based metrics. This can be accessed at www.cpsl.cam.ac.uk/NatCap.

Table 4: Local constraints/limits[10]

Impact	Biophysical limits
Land use	Cropland / Grazing land surplus / deficit[a] Status of threatened habitats/species Habitat fragmentation measurements
Environmental settings, wild species diversity	Deforestation rates Minimum forestry cover levels for specific habitats Forestry land / wetland surplus / deficit[a] Status of threatened habitats/species[b] Minimum wetlands for specific species
Water quantity	Groundwater levels and recharge rates River (flow) levels Soil salinity limits
Water quality	Water quality measurements indicators[c] Proportion of fish stocks within safe biological limits
- Fertiliser	Eutrophication levels Maximum nutrient levels for water consumption by humans
Climate change – greenhouse gas emissions	Any threshold temperature rises which cause significant local impact Ocean acidification limits
Air quality	Country/region pollutant concentration levels versus thresholds; Soil acidification index versus generally accepted min levels
- Fertiliser	Country Greenhouse gases/N_2O emissions versus agreed limits
Soil quality - Land use	Country/region soil erosion rates percentage of land with soil erosion;
- Tillage	Country/region soil erosion rates and percentage of land with soil erosion; Organic matter levels versus thresholds; Overall agricultural productivity levels; Land with high soil salinity levels; soil acidification
- Pesticides	Status of threatened habitats/species in region/country - see list above
- Fertiliser	Average land productivity for specified region/country

[a]Data from Global Footprint Network may be of use (http://www.footprintnetwork.org)

[b]For example: Living Planet index, Red List index, Protected area coverage (SPAs, Natura 2000, High Conservation Value, World Heritage sites), Wild Commodities index

[c]For example, biological - macroinvertebrates, BOD levels; chemical - ph levels; physical - sediment, turbidity.

Regulatory constraints	Informal constraints
Legal constraints on land use e.g. nitrate vulnerable zones etc. Thresholds for receiving subsidies or tax rates	Local targets and best practice guidance on cropland management
Legal constraints on maximum permitted deforestation rates, minimum wetland requirements, offsetting, etc. Legal protection for threatened species/habitats Protected area / other designations coverage	Local conservation targets employment requirements infrastructure needs local economic development plans
Relevant water withdrawal/usage limits Tax thresholds for different water use consumption levels	Water required for local community Impact across whole watershed (including impact on other countries)
General water quality legal/licence limits	Local water targets
Legal requirements on maximum fertiliser application levels per ha Maximum eutrophication levels in water	Local water quality targets
Country Greenhouse gases emissions legal limits Any local ocean acidification legal limits Local carbon taxes	Country/Industry Greenhouse gases emissions targets
Any relevant air quality legal limits	Any best practice local limits on air emissions and/or lower thresholds given proximity to urban populations etc.; Any change in tax rates etc. for different levels of emissions
Any relevant regulatory requirements on maximum fertiliser input levels per ha and emissions levels; legal limits on NOx levels	Any best practice local limits on fertiliser application levels and emissions levels
Legal requirements on rehabilitation standards Any legal limits on maximum sediment levels in rivers	Local good practice guidance on managing site overburden; restoration guidance etc. Food security targets and impact of company land on these targets
Any legal limits on maximum sediment levels in rivers, minimum organic matter content etc. Maximum land used for biofuels	Any local good practice on cropland management Food security targets and impact of company land on these targets
Legal limits on pesticide use etc. per ha	Any local good practice limits
Any legal requirements on maximum fertiliser application levels per ha	Any best practice application levels and approaches

[d]For a list of existing environmental legislation on air quality that may impact on your business, see: http://www.environment-agency.gov.uk/business/142629.aspx

Operational risks

In many cases, environmental impacts may affect a company's own operations, including decreased soil and water quality, water resource depletion, reduction of natural pest control and natural pollination. These are discussed in more detail in the **Listening to Business** report.

Regulatory and market risks

The value of externalities reflects the real price of the environmental resource used or affected by the company. These values are currently immaterial in financial terms – by definition. Companies are not yet held accountable for the environmental impacts. However, the economic figures are important to consider, as they give an indication of potential future costs when these values are internalised in the price of natural resource use.

Potential new market or regulatory developments, that could lead to such costs include:

- New environmental markets, created by new regulations, changes in property rights, subsidies (such as 'greening' direct payments under the EU CAP):

  a. Air quality: emissions of SOx, NOx, particulate matter, e.g. particulate matter emissions allowances are further reduced in the EU

  b. Water (quality and quantity): water rights, water quality trading (see the US Environmental Protection Agency);

  c. Biodiversity: biodiversity banking/offsets, such as the Biodiversity Banking and Offsets Scheme in New South Wales, Australia;

  d. Climate: new European Emissions Trading System regulations, raising its emissions reductions ambitions, and changes under the Kyoto protocol.

- Regulatory quotas and limits:

  a. Raw material: quota on fish and other resource extraction, fleet efficiency limits;

  b. Air quality: end of pipe emission limits, air quality standards;

  c. Water quality: regulation of water quality, nutrient standards.

- Access restrictions, such as protected areas, drilling bans, limitations of use;
- Changing consumer demands, e.g. boycotts, more sophisticated and informed green purchasing, labelling and certification, such as MSC, FSC and Rainforest Alliance;
- Changing demands in financial markets, e.g. IFC Performance Standards, Equator Principles;
- Changing community demands, e.g. direct action against pollution or damage;
- Increased litigation against existing legal frameworks or new legal frameworks, e.g. EU environmental liability directive, Ecuadorian system of legal rights for the 'environment' etc.

Example of regulatory risk

Pesticide application for corn production can lead to contamination of surface water at higher than EU-standards for drinking water allow. Thereby, the use of pesticides imposes water treatment costs on society where surface water is used for domestic consumption. These costs are now addressed by imposing stricter EU-wide regulations on pesticide use, e.g. under the EU Water Framework Directive.

The **Listening to Business** report discusses and gives examples of the impacts regulatory risk on

SABMiller compares context, externalities and resource use

The business case relates to growing barley in Punjab, India, which is grown in the dry season and relies on irrigation from groundwater, and also uses land, fertiliser and pesticides. Growing barley (business case) instead of mustard, wheat and gram (counterfactual) may reduce the water needed for irrigation. Other externalities include climate change effects of fertiliser use, fuel use and soil changes.

Water scarcity is the main environmental and social issue in the study region. Population density is high and people rely intensively on irrigated agriculture for income and nutrition. Even though quantitative information about the resource limits is unavailable and legislative limits are currently absent, the qualitative information about water issues drove the selection of environmental impacts. Water reduction possibilities would therefore have benefits in terms of reduced **operational risk**.

CS1: A Californian land owner wants to decide between producing almonds or tomatoes, and tillage is one of the production activities (preparation for seeding). Tomatoes require more frequent tillage than almonds, and therefore lead to more carbon emissions, soil erosion and water quality degradation through downstream sedimentation. The externalities associated with these environmental impacts include climate change impacts and reduced water availability downstream.

These are impacts on human welfare for which companies currently do not have to pay, but since water shortages are a major environmental and social concern in California, there is a reputational/market risk created when the landowner is linked to downstream water quality degradation. Moreover, inapt tillage practices leading to soil erosion may also lead to higher future fertiliser requirements, having a direct impact on the landowner's **operational** and **financial** position.

CS2: A company wants to understand the water use of different crop systems and the implications on income. Local famers produce rice in an area that is densely populated and water scarce. Rice growing requires more irrigation water and leads to methane (GHG) emissions yet results in less water quality degradation (as a result of lower fertiliser use) than wheat. Irrigation water use will impact on drinking water availability and food security for local population **(reputational risk)**. Water scarcity may threaten sustained production at the site **(operational risk)**.

CS3: A mining company in South Africa extracts minerals in water stressed regions. Further damage to limited water resources may lead to increased social unrest **(reputational risk)**, especially since local communities benefit little from mining activities yet bear the losses of water resource degradation.

The company is aware of the business risks of water use and therefore aim to improve their water management. Mining uses water as an input to make bare rock give up its minerals. The production processes create acidic, highly saline, sulphur and heavy metal rich water, which, if left untreated, leads to a degradation of freshwater resources. As a result, soils have been contaminated, leading to reduction in agricultural yields, threats to human health via consumption of crops irrigated with contaminated waters, and to livestock that graze on contaminated vegetation.

4.5 Step 5: Shortlist externalities for quantitative assessment

The results and outputs of the scoping process include:

- Description of the product and production process;
- List of the potential externalities of this production process;
- Description of the main social and environmental context characteristics that may limit the resource take by the company (now or in the future);
- The potential risk associated with the externalities.

Based on these results, a first checklist in **Table 5** can be filled to score the importance of potential environmental impacts by labelling them as 'high importance', 'medium importance', or 'low importance' given the context in which the company operates. Companies may select also externalities of interest, for example when a full externality assessment is not the objective, or when the strategy focuses on a externality. This provides a shortlist of the externalities that are likely to be most relevant for the product and site.

	Impact level	Resource limits	Business risk	Overall importance
Environmental settings				
Water quantity (groundwater, surface water)				
Water quality				
Climate change – greenhouse gas emissions				
Air quality				
Soil quality				
Raw materials, e.g. crops, food, timber				
Wild species diversity				
Flood control				
Pest and disease control				
Human health				
Pollination				

Table 5: Scoping checklist to select priority externalities

Score and assessment of effect and risk:
++ potential considerable positive effect/risk
+ potential positive effect/risk
0 no/negligible effect/risk
- potential negative effect/risk
-- potential considerable negative effect/risk

Importance score
High
Medium
Low

Decisions 4 and 5:
Which environmental impacts and operational activities will be quantified?

Output 2:
A completed checklist with a short qualitative description of the most relevant externalities, their context and associated corporate risks.

The SABMiller scoping results:

SABMiller decided to assess water impacts (quantity and quality) of irrigation and fertiliser use. The business decided to assess climate change impacts too, because of the company wide interest in its carbon footprint in relation to its global reputation. The activities assessed included fuel use for pumping irrigation water from groundwater resources.

Other impacts related to pesticides (e.g. on water quality and biodiversity) were considered but not assessed, partly because of lower relevance and partly because of data absence.

4.6 What is next?

After the scoping has been completed, a decision has to be made on how to proceed with the externality assessment and make a planning.

Conducting an externality assessment may require the following company resources:

- Support of senior (sustainability) executives;
- Management of the assessment by sustainability managers;
- Gathering data and providing local knowledge by site managers and (operational) staff;
- Expert contribution of staff and/or consultants in ecology, environmental sciences, sociol sciences and environmental economics / valuation.

The sustainability manager has to ensure that the proposed assessment plan fits within the company's leadership strategy and is budgeted.

If the company decides to do an externality assessment, further guidance on practical planning can be found in:

- The Guide to Corporate Ecosystem Valuation (page 43)[11]
- The BROA (Biodiversity Risk and Opportunity Assessment) Handbook[12]

5 Measuring externalities

The scoping phase (Section 4) highlights the externalities that may be of key strategic importance to assess in both scenarios.

To determine a valuation, the impacts of production activities on human welfare must be assessed in biophysical and monetary terms, for which models and data are needed. **Section 5** gives examples of suitable models, describes and provides their data requirements and (dis)advantages, and provides guidance on the interpretation of the output.

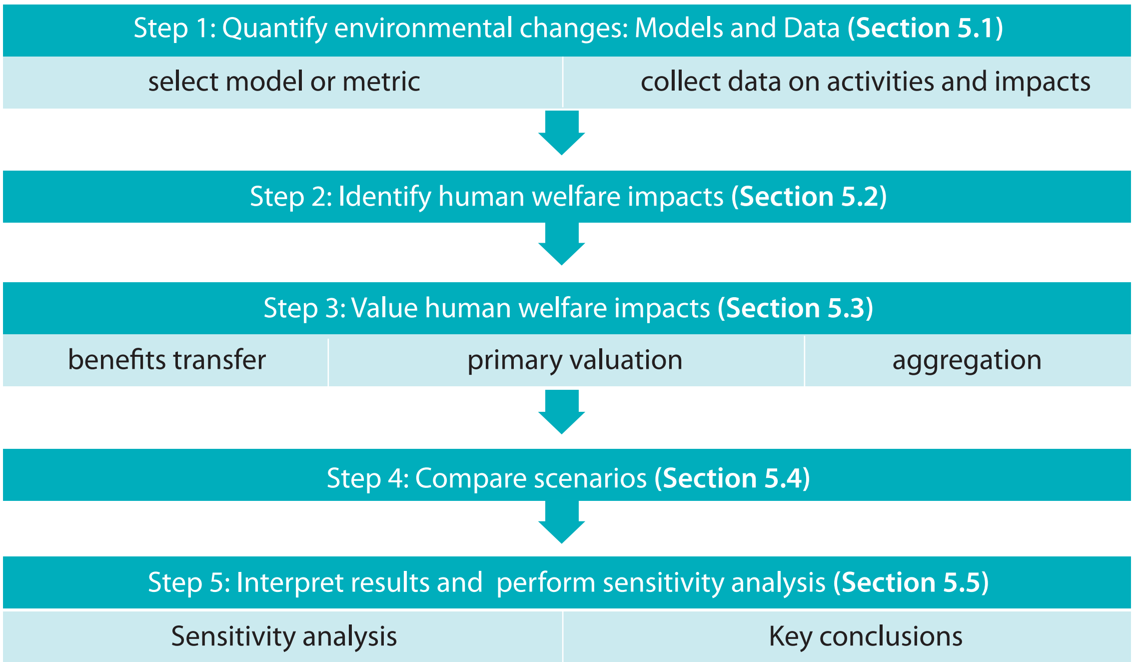


Figure 11: Shows the steps of the assessment of externalities.

5.1 Step 1: Quantifying environmental changes

Objective:

After deciding on the focal impacts for the externality assessment, the next step is to quantify the link between a company's activities and the environmental change in biophysical terms.

Questions:

What is the nature of the environment impacts?

- Is it a positive or negative impact?
- What is the temporal and spatial nature of the impact?
- What is the scale of the impact (local, regional, global)?

How can these environmental impacts be modelled or assessed? Which method is appropriate?

- What kind of output does the model/method produce?
- What are the advantages and disadvantages of the model/method?
- What is the quantity of the impact? In which unit is it expressed?

What kind of data is required to use the model/method? How can the data be collected?

Process: Decisions on model choice and data collection are interdependent, and may be bounded by budgets and time. Model choice, data collection and preparation, and modelling itself all take time. Impacts related to the business case as well as the counterfactual scenario have to be quantified. The sustainability manager has to decide on the time and resources available for this step, ensuring that the results are suitable and evaluate the quality of the biophysical assessment. Involvement of a social scientist/economist may help to make the link with human welfare impacts in later steps.

Expertise: Depending on the complexity of the model/method, the company may have to buy-in expertise to quantify externalities. Input from natural scientists and local environmental experts specialised in the externality of interest will often be required for modelling and data collection methods, especially when site-specific data and models are preferred. For the provision of data, operational managers and local experts can be consulted.

Output: The outputs of this step are the estimates of the selected externalities in biophysical units, together with a description of the method and the assumptions made and limitations that are associated with it. This quantification is performed for both scenarios! The results need to be described, including the nature of the environmental impact (direction, temporal and spatial scale).

5.1.1 Modelling environmental changes

Various methods can be used to analyse the biophysical impact. Related to **Figure 9**, models that give insight into the direct links (blue arrows) are most useful. When models only explore the indirect impacts (green arrows), the link to human welfare impacts (value) remains unclear and further biophysical assessment is needed before the valuation step can be taken.

Table 6 gives an overview of the models that were used in the case studies, with their (dis)advantages and data requirements.

How to pick a model?

Model choice depends on the externality of interest, the resources and skills required to use a model, the data requirements and availability, and the relevance and accuracy of the output it produces in relation to externality assessment (including the economic valuation step). The process of model choice and data collection is interdependent. The limitations of each model are important and need to be considered when interpreting the output and for the sensitivity analysis. It may be recommended to use multiple models (if available) for the same externality, because different stakeholders may have more trust in different approaches.

Models have to be selected for the quantification of environmental impacts under both scenarios!

Decision 6:
Which models will be used?

The SABMiller model choice

For irrigation water use, CROPWAT was used with local data on cropping pattern and crop data.

For water quality impacts, dilution standards were compared with EU runoff and leaching standards

For carbon emissions from fertilisers and soils, IPCC standards were used.

For emissions from fuel use, CROPWAT information on water extraction was combined with local information on well depth and type of energy, and literature-based information on emissions per well depth and energy type.

Box 3: Modelling Tools

The Practical Guidelines provide examples of the application of these tools. There are numerous other toolboxes for the assessment of environmental impacts, some of which we will list here:

- Water: WBCSD Global water tool, an excel based tool to produce groundwater and surface water balances

- Multiple impacts: INVEST, an ArcGIS based tool to map ecosystems, services and values. It is dataintensive and uses mainly spatial data

- Multiple impacts: ARIES. Web-based technology to assist rapid ecosystem service assessment and valuation. ARIES requires no resources for basic functionality, but site-specific analysis may require data input for region of interest.

For more alternatives, see collections of assessment tools at:
- the Ecosystem-Based Management Tools Networ
- ECO4Biz
- the Sustainability Consortium
- the ecoinvent database

Table 6: Models for quantifying externalities

Env. impact	Activity	Model	Output	
			Description	Unit
Water quantity	Irrigation	CROPWAT 8 tool[13] + consumptive water use[14] to estimate groundwater use given site-specific crop, soil and climate conditions	Water quantity used from surface/ groundwater sources	M^3/ha; M^3/t of crop
Water quality	Fertiliser	Dilution standards[15] + run-off & leachate values[18] to estimate how much chemicals enter the surface water and how much water would be needed to dilute to safe standards	Quantity of water needed to dilute chemicals from fertiliser to safe standards for human use.	M^3/ha M^3/t of crop
Water quality	Fertiliser	Nitrogen leaching model[20,21] to assess the amount of nitrogen leached into groundwater	NO_3 leaching into groundwater from fertiliser.	N/ha/yr
Water quality	Pesticide use (Pyrethroid)	GENEEC2 model that calculates run-off in a standardised setting (from 'typical field' into 'typical water body')[22]	Quantity of chemicals leached into surface water (peak and after 90 days) to estimate pesticide exposure to aquatic ecology.	µgN/l
Climate change	Fertiliser	IPCC tier 1 guidelines[23] to assess the quantity of N_2O (greenhouse gas) emitted into the atmosphere	Quantity of N_2O emitted into atmosphere related to fertiliser use.	Kg N_2O /ha, kg N_2O /t of crop
Climate change	Fertiliser	Literature based estimate of CO_2 produced in fertiliser production[24]	Quantity of CO_2 emitted in the production of inorganic fertiliser related to fertiliser used	tCO_2/ha/yr

[a]These settings are also provided with the CROPWAT software.
[b]Texture, depth and available water capacity (AWC) can be determined using CROPWAT software data.

Advantages	Limitations	Data - activities (metrics)	Data - external context	Examples
Widely recognised, clear figures, relatively robust	Difficult to acquire local crop coefficients.	Crops; Cropping pattern; length of growth period, water sources	Local climate data[15]; crop coefficients for different steps in the growth period[16]; rooting depth, critical depletion fraction, yield response, crop height[a]; soil data (texture, depth, water capacity)[17,b]	SABMiller
Well documented.	Results not reflect real water use, only a 'virtual' water need.	Kg/ha or kg of fertiliser used; type of fertiliser or N and P content of fertiliser.	Water quality standards[19]	SABMiller
General model.	Output cannot be linked directly to human welfare; method does not take volatilisation (loss of nitrogen as free ammonia) and denitrification (conversion of nitrate into nitrous oxide, a greenhouse gas) into account; local rainfall and flooding patterns are not taken into account.	Kg/ha or kg of fertiliser used; type of fertiliser and N-content; cropping pattern.	Soil type (soil percolation rate, soil clay content).	CS5, CS6
Readily available; rapid assessment.	Not based on site-specific ecological conditions (e.g. rain, soil); output cannot be linked directly to human welfare.	Pesticide type and product information; dose rate (pounds/ acre); method, number and time intervals of application;		CS5, CS6
Readily available metrics; CO_2-equivalents can be valued directly.	Does not reflect effects of climate, soil types and soil management (i.e. not site-specific)	Quantity and type of fertiliser input. OR Fertiliser need per crop, crops and area planted per crop.		SABMiller
Simple factor	Not site-specific; takes larger scope (supply chain effects, beyond site) than other assessments here.	Inorganic fertiliser use.		CS6

Table 6: Models for quantifying externalities

Env. impact	Activity	Model	Output	
			Description	Unit
Climate change	Fuel use	Literature-based estimates[25,26] of the quantity of carbon emitted when using fuel.	Quantity of carbon emitted into atmosphere related to using fuel.	KgC
Climate change	Fuel use	Literature based estimates on C emissions for pumping groundwater[27]	Quantity of carbon emitted into atmosphere related to using fuel for pumping.	KgC
Climate change – Soil quality	Cultivation – land use change	IPCC tier 1 guidelines[28] to assess carbon of land use/cover	Soil carbon values, based on standardised soil carbon values	tC/ha
Climate change	Cultivation	IPCC tier 1 guidelines[29] on standardised values of methane emissions from rice cultivation	Methane (CH_4) emissions resulting from rice cultivation	tCO_{2e}/ha; tCH_4/ha
Air pollution	Fertiliser	EPA figures on air pollution (ammonia emissions) related to fertiliser use[30]	Ammonia (NH_3) emissions resulting from fertiliser application	kg N-NH_3/ha/yr
Air pollution	Fertiliser	Literature based estimates for N_2O emissions[31] from fertiliser application	Nitrous oxide (N_2O) emissions resulting from fertiliser application	kgN-N_2O/ha/yr
Wild species diversity	Pesticides	TERRPLANT model[32] to assess the risk for biodiversity to water pollution.	Risk for biodiversity of exposure to pesticides through water pollution by pesticide use.	Risk quo tients

Advantages	Limitations	Data - activities (metrics)	Data - external context	Examples
Readily available metrics; CO_2-equivalents can be valued directly.		Quantity of fuel/energy used (or literature-based estimate), type of energy.		CS6
Readily available metrics; CO_2-equivalents can be valued directly.	Literature based figures for C emissions are not site-specific.	Type of pumps, well depth. (If for pumping irrigation water)		SABMiller
Readily available metrics; CO_2-equivalents can be valued directly.	Not based on site-specific carbon content of soils.	Land use after conversion, area converted (ha)	Land use before conversion	CS7
Readily available metrics	Not based on site-specific ecological conditions (ecosystem type, soil type).	Cultivated area (ha); water regime; manure application.		CS2
Simple factor.	Output cannot be linked directly to human welfare; figures are based on Californian agriculture.	Amount of fertiliser used in kgN/ha/yr; (soil pH).		CS5
Simple factor	Reflect total losses, not only fertiliser application; method does not take soil, rainfall or application method into account.	Total mineral fertiliser input		CS5
Simple model based on typical farm and efficient application.	Output cannot be linked directly to human welfare impact; method does not take ecological site-characteristics into account	Pesticide input (chemical name, application method, form, solubility, rate); crop.		CS5

5.1.2 Data requirements

The data requirements for the different models specified in Table 6 need to be compared with the data availability. This also shows which additional data may have to be collected.

Data needs and requirements:

Data are preferably:

- spatially explicit, given the context specific characteristics of environmental changes and their values;
- collected at or close to the site with the purpose of environmental management;
- collected recently;
- collected on an annual basis and at time intervals relevant to the assessment.

What data are necessary?

This depends on the impact and activities of interest.

Relevant generic farm level data related to activities, inputs and outputs that are required for many analyses include:

- Location of farm;
- Area under cultivation (field length, slope);
- Planting and harvesting records (crops planted, annual/seasonal yields per crop, crop rotation, cropping pattern);
- Water sources (groundwater or surface water, depth of wells), proximity to fresh water bodies;
- Water use (quantity used in litres/day, irrigation schedule, crops irrigated);
- Water quality (measures at regular intervals to assess run-off);
- Fertiliser use (type, quantity applied, application method, intervals between applications);
- Pesticide use (type, quantity applied, application method, intervals between applications);
- Tillage practices (method, frequency);
- Fuel use (type and quantity per type).

Other external environmental data that are often needed for various assessments:

- Climatic data (temperature, rainfall, wind);
- Soil data (type, quality, texture, carbon content);
- Habitat types (pre land conversion at the site and its surrounding area).

Data sources:

Data can be obtained from various sources:

- On-site, company-level data: e.g. from existing environmental monitoring programs, farm level surveys.
  - procurement information on energy, pesticides and fertilisers;
  - financial records of fuel and water payments;
- Local sector-level knowledge from experts: e.g. agricultural extension officers, environmental experts, agronomists, etc. (see SABMiller case study);
- Regional or national level databases, including census data, other publicly available databases, sector level data (e.g. agricultural organisations);
- Globally available databases, such as FAO, WRI, UNEP, etc;
- Literature based estimates from existing studies.

When measured correctly, on-site data collected by the company (e.g. by operations or environmental manager) is preferred to other data which are often coarser or less relevant to the firm. However, when supply chains are long and the company interested in the externality assessment purchases its product from suppliers, site-level data from suppliers may be hard to obtain **(Figure 12)**. Reliable data collection requires investments (but this may be justified if it creates value for internal and external stakeholders and relates to the corporate strategy).

For the purpose of externality assessment, if no farm-level data is available but new data collection at the farm-level would improve the reliability of the assessment, the sustainability manager has to decide if the budget covers data collection activities. Otherwise, other data sources may provide proxies for farm-level data.

Data collection methods: it depends on the data required which data collection method is most appropriate. Biophysical farm-level data may be obtained from field measurements. Agricultural practices may require farm-level surveys. Group discussions and consultations with experts can be an efficient way of rapid data inventory and/or collection at a local-sector level.

If such data are not available, regional or national data can be used. Databases can often be queried online. Literature based estimates from academic sources, sector agencies, etc. can also often be found online, although in some cases hardcopy reports may have to be requested from the relevant institutions.

Figure 12: When supply chains are long it may be harder to get farm-level data

Decision 7-8:
What data is available, what data will have to be collected? Where or how (from which source) will data be collected?

The SABMiller case study data collection

SABMiller decided, after an initial assessment based on regional data, that a more accurate externality assessment would merit the collection of more precise farm-level data.

The improved assessment made use of knowledge of agricultural extension officers to discuss cropping schemes, crop and seed choices, irrigation and tillage practices, fertiliser and pesticide use, groundwater availability, well characteristics, etc.

5.1.3 Quantification examples

Once the model(s) is chosen and the data are ready to use, the model has to be applied to the data.

Output 3:
A biophysical quantification for each externality for each scenario.

Output 4:
A description of the method(s) and data, and the assumptions and limitations of the method(s) and the results.

Table 7 gives an overview of the different quantification examples provided in the Practical Guide.

Activity	Env. Impact	Case study	page
Water use for irrigation	Water quantity: groundwater depletion	SABMiller	49
Fertiliser use	Water quality: nitrogen and phosphate	SABMiller	50
Fertiliser use	Climate change: N_2O emissions	SABMiller	51
Fuel use / irrigation	Climate change: CO_2 emissions	SABMiller	52
Fertiliser use	Water quality: nitrogen	CS5	53
Pesticide use	Water quality: pyrethroid	CS5	54
Fertiliser use	Climate change: CO_2 emissions	CS6	54
Fuel/electricity use	Climate change: CO_2 emissions	CS6	55
Land conversion	Climate change: CO_2 emissions	CS7	56
Cultivation	Climate change: methane emissions	CS2	57
Fertiliser use	Air pollution: ammonia emissions	CS5	58
Fertiliser use	Air pollution: nitrous oxide (N_2O)	CS5	58
Pesticide use	Wild species diversity	CS5	59

Table 7 Examples of quantification

The SABMiller case study

Activity: Water use for irrigation

Impact: water quantity: groundwater depletion which limits agricultural production
Method: CROPWAT is a computer-based model for the calculation of crop water requirements. This can be extended with methods developed in Hoekstra et al. (2011)[14] for the Water Footprint Network Standards. In absence of accurate farm level data on irrigation use, CROPWAT[13] with local crop coefficients and cropping information provides a relatively robust estimate of water use.

Data: Information on the crops grown, area planted, length of growth period and cropping pattern was obtained from the farm extension worker survey. The CROPWAT software has standard climate (temperature, sunshine, humidity, windspeed, rainfall) and some crop data (rooting depth, critical depletion fraction, yield response, crop height). Local crop coefficients (Kc) for three stages in the growth period, as well as information on the length of these stages, from the literature were used – this is necessary to adjust the water requirements to local crop characteristics and climate conditions. Soil data from the World Harmonised Soil Database was used, in combination with CROPWAT software data.

Quantification: Water consumption is mainly determined by evapotranspiration (evaporation and plant transpiration). CROPWAT uses standard settings to calculate evapotranspiration and then adjust this based on user input on local crop evapotranspiration values (ETc in mm/growing period) and crop coefficients (Kc). In this case, the calculation was based on the 'irrigation schedule (IrrS) option' and default settings in the software ('irrigate at critical depletion' and 'refill soil to field capacity', assuming optimal irrigation, i.e. avoiding water stress.

Based on the data input, the software produces the actual crop evapotranspiration (ETa), which can be split into evapotranspiration met by irrigation (ETBlue) and met by rainfall (ETGreen). For Barley, the estimated irrigation water extraction (CWUBlue) is 4,230 m^3/ha (0.42 million liter/ha).
Part of the rainfall and irrigation water is not used and is assumed to return to the ground water through deep percolation ('rain recharge'). This is subtracted from the irrigation water extraction. Total net extraction is therefore approximately 4,120 m^3/ha.

Crop	Eta	ETBlue	ETGreen	CWUBlue	Rain recharge	Net groundwater loss
	mm/growing period				m^3/ha	
Barley	448	423	25	4230	110	4120

Limitations: The assumption made here of optimal irrigation may not apply to the local farm practices. However, if local data are available, then the actual time, frequency and depth of irrigation can be used in the CROPWAT model to estimate water use under non-optimal conditions.

The SABMiller case study

Activity: Fertiliser use

Impact: Water quality

Method: Hoekstra et al. (2011)[14] for the Water Footprint Network Standards methods estimate grey water consumption by quantifying the dilution water volumes required to dilute waste such that water quality standards are met.

Data: Nitrogen and phosphate application (in kg/ha/yr); water pollution standards.

Quantification: Hoekstra et al. (2011)[14] assume that the quantity of nitrogen reaching flowing water bodies is 10% of the applied fertilisation rate (in kg/ha/yr). A loss of 1% was assumed for phosphate[18]. Information on pollution standards is hard to find and differs widely across countries; this study uses limits of 50 $mgNO_3/l$ and 1mgP/l based on EU standards[19]. The UREA and DAP application per ha is multiplied by the nutrient loss conversion factors to calculate runoff and leachate values for N and P. For Barley, this implies an estimated runoff and leachate of 19.3kg N/ha, and 0.79 kgP/ha.

Barley	Application (kg/ha)	Amount of N (kg/ha)	Conversion factor (N)	N runoff+ leachate (kg/ha)	Amount of P (kg/ha)	Conversion factor (P)	P runoff + leachate (kg/ha)
Urea	90	41	0.1	4.1			
DAP	100	18	0.1	1.8	46	0.01	0.46
manure	22,239	133	0.1	13.3	33	0.01	0.33
Total				**19.3**			**0.79**

DAP is 18% nitrogen and 46% Phosphorous; Farm yard manure is assumed to contain 6% nitrogen and 3.5% Phosphate P_2O_5.

To estimate grey water consumption, N has to be converted to nitrate (NO_3) first. Total grey water consumption is the maximum value of water consumption values for different pollutants (in this case N and P). Total grey water use for barley is therefore 1708 m^3/ha.

Total N from fertilisers (kg/ha)	Total NO3 from fertilisers	Grey water consumption NO3 (m^3/ha)	Total P runoff and leachate (kg/ha)	Grey water consumption P (m^3/ha)	Grey water consumption (critical)(m^3/ha)
19.3	85.4	1708.0	0.8	794.7	1708.0

Limitations: no country specific data on nitrogen runoff and leachate was available. The estimate of grey water use does not reflect actual water use and has no immediate link to human welfare impacts.

The SABMiller case study

Activity: Fertiliser use

Impact: Climate change impacts related to N_2O emissions

Method: Literature based emission factors from IPCC tier 1 guidelines[23].

Data: Fertiliser use (in kg/ha) per fertiliser type was collected through extension worker survey (or information on the amount of fertiliser used per crop, and the area (ha) per crop). Information may be available from national statistics.

The N content varies among fertilisers[33]: Urea 46%; DAP 18%.
IPCC conversion factors[23]:

- for flooded rice (0.003 N_2O_N /kgN, uncertainty range 0.000-0.006)
- for other crops (0.01 N_2O_N /kgN, uncertainty range 0.003-0.03).

Quantification: The type of fertilisers used included synthetic nitrogen fertilisers (Urea, DAP), applied organic fertilisers, urine and dung from animals, crop residues and mineralisation of soil organic matter. The following steps must be taken for quantification:

1. Determine the amount of nitrogen applied per hectare (N/ha). The input of fertiliser per ha is expressed in terms of its nitrogen input per ha using the nitrogen content of the fertiliser type.

2. Use the conversion factors to assess the N emissions: The conversion factors reflect how much of the applied nitrogen is emitted as N_2O into the air through volatilisation. They can be used to determine nitrous oxide emissions based on mineral fertiliser, organic amendments and crop residues and mineralisation. To estimate the nitrogen emissions, multiply the N input (in kgN/ha) by the conversion factor, to get to the emitted quantity of volatile N (in kgN_2O_N/ha).

3. Convert into N_2O (the greenhouse gas): Express the kgN_2O_N/ha in terms of kgN_2O/ha by multiplying by 44/28. The emissions can now be expressed in CO_2 equivalents (Global Warming Potential) by multiplying by 310 (N_2O is a much stronger GHG than CO_2)[18]. Based on a total of 3.03 kg N_2O/ha, the CO_2e emissions related to N volatilisation of fertiliser are 939 kg CO_2e/ha.

Fertilise	Fertiliser application (kg/ha)	Amount of nitrogen (kg/ha)	Conversion factor	N_20_N emissions (kg/ha)	N_20 emissions (kg/ha)	N_20 emissions (kg/ha) uncertainty	CO_2 Equivalent (kg/ha)
Urea	90	41.4 (46%)	0.01	0.414	0.65055	0.195 - 1.95	201.67
DAP	100	18 (18%)	0.01	0.18	0.28285	0.085 - 0.85	87.68
Farm manure	22,239	133.43 (6%)	0.01	1.334	2.09678	0.629 – 6.29	650.00
Total							**939.35**

Limitations: The tier 1 IPCC guidelines are standardised factors that do not account for country specific factors, including management, climate, soil or land use.

The SABMiller case study

Activity: Fuel use for irrigation

Impact: Climate change

Method: Literature based factors of carbon emissions from electricity.

Data required: Quantity of groundwater pumped up per well, depth of well, energy used.

Quantification: the CROPWAT model and Consumptive Water Use estimates provide information about the quantity of groundwater used. Based on groundwater level and rate of reduction from data of the Central Groundwater Board (2007) for Jaipur, an assumption was made that well depth was 40m.

All wells were assumed to be electric. Carbon emissions in this study were estimated for lifting 1000m^3 of water 1m at 3.873kgC with electric pumps)[27]. These estimates take transmission losses (5%) and pump efficiency (30%) into account. Conversion from C to CO_2 is based on a factor 44/12.

Crop	Well depth (m)	Ground water pumped (m^3)	Emissions to pump 1000m^3 1m (kg)	C produced (kg/ ha CO_2_C)	CO_2 (kg/ ha)
Barley	40	4230	3.873	655	2403

Limitations: the analysis was not based on farm-level data on fuel use, energy type, or pump efficiency. This may be of concern as fuel use is the major contributor to CO_2 emissions per ha in this case study.

CS5: maize cultivation in France and Germany

Activity: Fertiliser application

Impact: Water quality: N leaching into groundwater

Method: N leaching model

Data: soil type/texture (percolation rate and clay content)[20], average N-application (here based on the European Commission 2010 maximum allowable N fertilisation rate) depending on fertiliser type and input amount.

Quantification: Levels of N leaching into groundwater resources depend on several conditions, including soil PH, soil texture, crop rotations, N fertiliser applied (type, timing, amount), weather conditions and soil cultivation (type and timing). A simplified model of N leaching[20,21] is based on the following equation:

$$L = \exp(1.136 - 0.0628 * Clay + 0.00565 * N + Crop) * P^{0.416}$$

L: leaching of Nitrogen
Clay: clay content percentage in the 0-25cm depth
N: average nitrogen input in manure, fertiliser and fixation, in kgN/ha/yr
P: percolation in mm/year
Crop: parameter related to summer crop and following winter crop.

France and Germany have different soil conditions: France has sandy soils and Germany has loamy soils, resulting in the following N leaching outputs:

Parameter		Germany	France
Clay	% clay in 0-25 cm depth	14.2	5
N	Average N application (kg/ha/y)	170	170
P	Percolation (mm/yr)	345	465
Crop	Crop estimate	0 (unknown)	0
L	**Nitrogen leaching (kg N/ha/yr)**	**37.93**	**76.52**

Limitations: Limited site-specific data was available on N application, cropping, soils, etc. The analysis does not take crop rotation (crop estimate) into account. The leaching of N into groundwater provides a biophysical estimate of the impact but has no immediate meaning in terms of human welfare impacts unless more information about groundwater use and pollution levels, safe standards, etc. is considered.

CS5: maize cultivation in France and Germany

Activity: Pesticide application

Impact: Water quality

Method: GENEEC2[22]

Data: Pesticide type and product information (active ingredient, solubility, organic carbon normalised soil/carbon equilibrium partition coefficient); farm-level data (dose rate (kg/ha), number of applications and interval of applications, spraying method); soil aerobic half-life, photolysis half-life and aerobic aquatic metabolic half-life[34].

Quantification: The GENEEC model quantifies the impacts of pesticides leached into surface waters on aquatic organisms and the environment.

Company data show that insecticide application (pyrethroid) in Germany is 4.24 pounds/acre, compared with 47.76 pounds/acre in France.

The GENEEC2 results for the application of pyrethroid in Germany show that peak levels in surface water amount to 46.02 µg/l and reduce to 3.13 µg/l after 90 days. Results for France are higher, with peak values at 56.0 µg/l reducing to 35.27 µg/l after 90 days.

Limitations: GENEEC results are based on an average farm and estimates the impact on a standardised water body. It does not take local ecological characteristics into account. The results are difficult to link directly to impacts on human welfare.

CS6: maize cultivation in the USA

Activity: Fertiliser application

Impact: Climate change (CO_2 emissions)

Method: Literature based estimates[24] of CO_2 emissions produced in inorganic nitrogen fertiliser production (based on life cycle assessment)

Data: N application in kg/ha/yr.

Quantification: The average emission factor is 2.8 $kgCO_2$/kgN of fertiliser applied. This results in a total CO_2 emission of 0.45 tCO_2/ha/yr, based on the application of 161 kgN/ha/yr.

Limitations: The estimates are not based on farm-level data. The emission factor is based on a Life Cycle Assessment of nitrogen fertiliser, and therefore reflects emissions from fertiliser production (i.e. it looks at the commodity chain of inputs, which falls beyond the scope of other assessments presented in the Practical Guide).

CS6: maize cultivation in the Midwest, USA

Activity: Fuel and electricity use (for tractors, heating and drying crops)

Impact: Climate change

Method: Literature based factors of direct and indirect emissions from energy use[25]

Data: Fuel use (diesel, gasoline, LPG, natural gas) and electricity use (Economic Research Service (ERS) of the United States Department of Agriculture, 2000) per state per farm.

Quantification: CO_2 emissions from on-site fuel combustion are relatively insensitive to the combustion process and hence depend on the fuel carbon content. Using average energy use data from ERS, and emissions factors from the US EIA, the CO_2 emissions per ha can be calculated. The results show that emissions per hectare from the use of diesel oil are highest.

Energy source	Energy use (ERS)	Emission factor	CO_2 emissions
Diesel oil	6.1 gallons/acre	0.0741 tCO_2/GJ	0.16 tCO_2/ha
Motor Gasoline	1.8 gallons/acre	0.0693 tCO_2/GJ	0.02 tCO_2/ha
Natural Gas Liquids	5.0 gallons/acre	0.0642 tCO_2/GJ	0.08 tCO_2/ha
Natural gas	328.1 cubic ft/acre	0.0561 tCO_2/GJ	0.05 tCO_2/ha
Electricity	32.3 kWh/acre	0.676 tCO_2/MWh	0.05 tCO_2/ha
Total			

CS7: soy production in Brazil

Business case: A company has bought areas 30 years and 10 years ago that was used as a cattle farm before and converted the land to grow soy at two locations in Brazil. One of the locations used to be a transition area (from cerrado to forest), the other cerrado (tropical savannah). This assessment however considers the conversion of natural habitat to cropland used for growing soy at two locations in Brazil, so it is not a true representation of the company's actions. One of the locations used to be forest, the other cerrado (tropical savannah).

NOTE: It should be noted that the company bought the land from cattle ranches long after the natural habitats had been converted to grazing land. Therefore this analysis does not represent the values from the change of cattle to soy land use change that are associated with the company. This study is used here to show how IPCC tier 1 indicators can be applied, but the results do not reflect the true actions of the company.

Activity: Cultivation (land conversion)

Impact: Climate change (carbon losses from soils and vegetation)

Method: IPCC tier 1 indicators[35] on land-use and carbon storage can be used to estimate the change in stored carbon resulting from land conversion from natural habitat to soy cropland (i.e. compare the business case and counterfactual).

Data: Land use before and after conversion, area converted.

Quantification: The average carbon stocks for different land uses are taken from IPCC (2000)[35].

Land-use	Vegetation biomass (t/ha)	Soil (t/ha)	Total (t/ha)
Cerrado	29	117	147
Tropical forest	120	123	243
Soy	2	80	82

Using these values and company data on the area converted, the carbon losses can be quantified:

	Cerrado to soy	Forrest to soy
Area (ha)	3,456	30,746
Change in CO_2e (tonnes)	821,786	18,201,510

Limitations: The quantities are approximate; as such estimates for native habitat types are variable depending on local soil and vegetation types[35,36]. Similarly, the soil carbon stored in soils used for soy production has been shown to vary with the frequency of cropping cycles[37] and tillage systems[38] which are not taken into account in IPCC tier 1 indicators.

CS2: rice production in Punjab, India

Business case: A company is purchasing milk from local farmers. To increase milk production, farmers will have to increase fodder production at the expense of paddy rice production. The company wants to assess the externalities of this change.

Activity: Rice cultivation

Impact: Climate change (methane emissions)

Method: IPCC indicators[29] with information from local agricultural studies.

Data: Area cultivated, rice growing time in study area, type of fertiliser used, flooding/water pattern, organic amendments.

Quantification: IPCC guidelines provide standard emission factors of methane/ha/day, which can be adjusted for: the flooding pattern and fertiliser application using 'scaling factors'.

The default emission factor is adjusted for the fact that pre-season flooding is banned in the study area. Another adjustment is applied for the application of organic fertiliser. According to a local survey, 8.227 tonnes/ha is applied, which has a conversion factor of 0.14 in terms of its effect relative to organic fertiliser applied shortly before cultivation. The scaling factor is therefore $(8.227 * 0.14)^{0.59} = 1.086$.

Factor	Abbrev.	
Default emission factor	Efc	1.30 kg CH_4/ha/day
Scaling factor for water regime during cultivation: continuous flooding	SFw	1
Scaling factor to account for difference in water regime in pre-season before cultivation	SFp	0.68
Scaling factor for organic amendment	SFo	1.086

The adjusted emission factor is a multiplication of the default factor and the scaling factors:

EFi= EFc * SFw* SFp * SFo = 0.96 kg CH_4/ha/day.

The annual methane emissions depend on the length of the growing time in the study area, which is 129 days. Therefore the overall annual emissions are 123.95 CH_4/ha. Methane is a potent greenhouse gas, with a warming potential of 21 (compared with 1 for CO_2). The methane emissions in CO_2 equivalents are therefore 123.95 * 21 = 2602.95 CO_2e/ha/yr.

Limitations: The approach does not take site-specific conditions such as ecosystem type and soil type into account.

CS5: maize cultivation in France and Germany

Metric: fertiliser application

Impact: air pollution related to ammonia (NH_3) emissions

Method: Literature based factor (EPA conference paper)

Data: average N-application (from European Commission 2010 maximum allowable N fertilisation rate).

Quantification: Volatilisation of N leads to air pollution in the form of ammonia emissions (NH_3). An EPA study on ammonia emissions in California found that emissions factors ranged from 0.1% – 6.6% gN-NH_3/m^2 of the applied nitrogen. Assuming an inorganic nitrogen fertilisation rate of 170 kgN/ha/yr (EC maximum allowance), NH_3 emissions are estimated to result in between 0.17 and 11.22 kgN-NH_3/ha/yr.

Limitations: For the assessment little information at the farm-level was available (fertiliser application rate, crop rotation). Assumptions based on sector averages and EU standards were made instead.

CS5: maize cultivation in France and Germany

Activity: fertiliser application

Impact: air pollution related to nitrous oxide (N_2O) emissions

Method: literature-based factor[30]

Data: average N application (from European Commission 2010 maximum allowable N fertilisation rate)

Quantification: Volatilisation of N leads to air pollution in the form of nitrous oxide (N_2O) emissions. A study by Conrad et al. (1983)[30] estimated that the total loss of fertiliser nitrogen in the form of N_2O ranged from 0.001% to 0.94% of total mineral fertiliser input, resulting in estimates ranging from 0.0017 to 1.59 kgN-N_2O/ha/yr based on an application rate of 170 kgN/ha/yr (EC maximum allowance).

Limitations: These simple factors do not take into account the variation in N_2O emissions from fertiliser related to soil temperature, rainfall, soil moisture, and actual fertiliser application (type and quantity).

CS5: maize cultivation in France and Germany

Activity: pesticide application

Impact: wild species diversity (plants in dry and semi-aquatic areas adjacent to the farm)

Method: TERRPLANT[32]

Data: pesticide type and product information, application rate; incorporation, runoff and drift fraction from the literature[39].

Quantification: Various parameters are usually specified on the product label. These parameters go into the TERRPLANT model.

Company data show that insecticide application in Germany is 4.24 pounds/acre, compared with 47.76 pounds/acre in France.

The results for the application of pyrethroid in Germany and France show that the risk quotients for plant species are below 0.1, which suggests that under the assumptions made, there is no exposure risk known. Interpretation of risk factors is described on the TERRPLANT website. They can be compared with the level of concern of the US environmental agency.

Limitations: The risk quotients have no direct relationship to human welfare impacts (only indirect). Further modelling or additional assumptions will be necessary to link the output of TERRPLANT to human welfare.

5.2 Step 2: Relate environmental change to human welfare impacts

This step aims to describe the link between the environmental impacts (the outputs of the biophysical models) to the associated changes in human welfare. To express the impacts of environmental change on human welfare in monetary terms, more information is needed about how people (stakeholders outside the company) use resources and how many people are affected.

Questions:
Who is affected by the environmental impacts?
How many people are affected?
How does the company's natural resource use affect the resource use by others over time and space?
What is the (monetary, non-monetary) value that people attach to the resource?

- Does the welfare impact relate to market products or non-marketed goods?
- Do people use the natural resources directly for consumption or indirectly for recreation?
- Do people mainly appreciate the existence (i.e. non-use)? Is the environmental impact related to unique features?
- How often do people use the good?

Process: This step requires discussions with natural scientists and social scientists and/or economists. The sustainability manager has to ensure that the needs of stakeholders that are of particular relevance to the company's strategy are considered. Discussions should address how the model results can be linked to valuation models. If no direct link can be made to economic models, further biophysical modelling may be required. It is important to consider the set of values related to the business case as well as the counterfactual scenario.

Expertise: The involvement of the biophysical analysts and environmental economists and sociol scientists is needed to related the environmental impacts to human welfare impacts in such a way that local resource uses and culture are accounted for.

Output: The output of this step is a qualitative description of how the biophysical/ environmental impacts quantified in Step 1 result in a change to particular components of human welfare.

5.2.1 What value do environmental impacts have?

The key is that externalities arise because other people are affected by the environmental impacts that the operational activities generate, either positively or negatively. The human welfare impacts reflect the value that people attach to the resources that they can(not) use because the company has (used) provided them.

The monetary values of externalities are classified into so-called 'use values' and 'non-use values'. Use values relate to direct consumption of natural resources (e.g. water, timber, wild food), non-consumptive use (e.g. recreation), or indirect uses (e.g. pest control). Non-use values reflect the welfare that people attach to the existence of the environment, for themselves or for future generations.

- See also the reports: Corporate Environmental Valuation[11], Water valuation: Building the Business Case[40], and Eco4Biz - Ecosystem services and biodiversity tools to support business decision-making[41].

Some of the environmental impacts may relate to environmental goods and services for which markets exist, such as crop losses due to water unavailability. But the main issue is that for many externalities, no suitable markets exist. Use of water is often not taxed or priced at all, or prices or taxes do not reflect the full social impact of water resource depletion and do not reduce total water offtake to sustainable levels.

Table 2 relates environmental changes to human welfare impacts – it explains why environmental impacts matter to people. In **Figure 9**, the items in the orange rectangles are associated with human welfare and can be monetised. Therefore, in order to understand externalities, biophysical models that produce outputs directly related to these environmental changes are most useful.

Understanding the link between environmental change (biophysical) and human welfare impacts is crucial. The relevance of these impacts is site-specific and depend on local uses of the natural capital. Moreover, **the number of people affected** is important (and this information will be used in the valuation step, except for climate change impacts). These people may be located near the site, but in case of water-related impacts the stakeholders may be located downstream, or in case of airborne impacts downwind.

5.2.2 Non-monetary indicators of human welfare impacts

E.Valu.A.Te focuses on economic valuation of environmental externalities. Monetary estimates may be helpful to make trade-offs between different environmental impacts, especially where these go into different directions when operations are changed, or when the users of the results are not familiar with biophysical units and find monetary units more meaningful.

The externality assessment can also be useful when the impact on human welfare is not expressed in monetary terms, but in other units. There are different situations in which monetising the impact may not be possible or most relevant:

- **Equity and poverty conditions** may be more important than total values: the impact on poor people is especially relevant for businesses operating in developing countries. Companies may report on the number of people that can(not) access clean drinking water or experience a change in food security or fuel availability as a result of the environmental impacts, for example.
- **Some welfare impacts may be harder to value**, such as impacts on human health. In such cases companies may aim to quantify the number of people that may experience a change in their health and the severity of the health impact, or even the number of lives lost.
- **It may not be possible to quantify all environmental impacts** in biophysical units, but a qualitative description of the possible environmental impacts and related human welfare impacts helps to consider the consequences of operational activities and changing strategies;
- **Stakeholders** for whom the externality assessment results are intended may be more interested in non-monetary descriptions of the human welfare impacts.


Figure 13: Some impacts on human welfare are meaningfully described in non-monetary term, such as the number of people with safe access to food, or wild species diversity in case of endangered species

Decision 9:
What are the human welfare impacts resulting from the operational activities and environmental impacts?

Output 5:
Qualitative description of how the environmental impacts quantified earlier result in a change to human welfare and the number of people affected.

The SABMiller case study human welfare impacts
Water extraction from groundwater resources results in lower water availability, which may result in higher pumping costs and costs to replace dried wells. Carbon emissions related to soil carbon changes and fertiliser use result in climate change effects. Carbon reductions under the program of change would benefit the global population. Fertiliser use may also reduce water quality which affects the local population in the same watershed.

5.3 Step 3: Valuing environmental changes

Objective: The next step is for those companies that want to have monetary estimates of their externalities. The main objective of valuation is to express different environmental impacts of business operations in the same unit, which allows for direct comparison and trade-offs. The value of externalities depends on the impact that the use of natural resources by a company has on the welfare of other stakeholders of that resources.

Questions:

What are the main human welfare impacts? (See Step 2)

What factors may influence the value of the impact?

- Is the resource impact related to frequent use?
- Is the demand for the resource high, or supply low (is the resource scarce)?
- Are there any substitute goods that people may use?

Who are the people affected by the environmental impact?

- How many people are affected?
- What is their socio-economic background?

How can the impacts of the environmental changes be valued in monetary terms?

- Which methods are appropriate to value the human welfare impacts?
- What is the level of accuracy needed?

Process: The economic analysis requires time to collect suitable socio-economic data on the affected population and valuation evidence and apply this to the business case and counterfactual scenario. Discussions with the natural scientists of the modelling step may be necessary to ensure that the economic and biophysical assessments are appropriately linked. The sustainability manager has to ensure that the results are suitable and evaluate the quality of the economic assessment.

Expertise: The expertise of an environmental economist will often be needed if externalities other than climate change impacts are assessed.

Output: The output of this step is a monetary value attached to each of the environmental impacts assessed, representing the welfare change experienced by the affected population due to the on-site operations of the company during the agricultural growing phase.

Figure 14: Translating impact into money

5.3.1 Some methodological issues in the valuation step

- **Also value the counterfactual scenario**

The net impact of the company is the difference between the business case and the counterfactual. Valuation addresses changes in welfare resulting from a different way in which natural resources are used. Values reflect the change in welfare (positive or negative) related to higher or lower levels of emissions, water use, as a result of different business operations. This means that not only the business case scenario, but also the environmental changes in the counterfactual scenario have to be assessed.

- **Avoid double counting**

Figure 9 and **Table 2** show that the environmental impacts with human benefits are linked in many cases. For example, better water quality may lead to benefits associated with recreation in environmental settings, human health when used as drinking water, it supports wild species diversity which humans enjoy watching and prefer to exist, and it supports the production of crops, wild food, bio-energy and other materials.

One important error in valuation is to double count impacts. For example, when the impact of climate change is firstly valued by using the social cost of carbon, and next by the costs of flooding associated with climate-related sea level rise, these values should not be added up. The social cost of carbon already includes sea level rise impacts on human welfare, and including both values would overestimate the externality values. Another example is when valuation studies assess the benefits of multiple human welfare impacts and capture these benefits in one 'composite' value estimate, e.g. a study that provides a composite value that reflects all associated benefits of improved water quality, or the costs of improving water quality of a water treatment plant. Such composite values cannot be added up to the results of a study that looks specifically at recreational benefits of water quality improvements. When such values are added up, the benefits are 'double counted' and overestimated. The red arrows in **Figure 9** show the links between various welfare components. Where there are links between welfare components (orange rectangles), any double counting issues should be checked.

- **Site-specific and spatially explicit valuation**

Values of externalities often vary across space. For example, people living close to a river are usually willing to pay more for its quality than others living further away. The proximity of the population, as well as the availability of alternatives/substitutes, are key factors in externality price setting. Therefore, benefit transfer approach should aim to be spatially explicit. The exception is carbon **(Section 5.3.5)**

5.3.2 Valuation techniques

Various methods are available for the valuation of final ecosystem services. Overviews of these methods, including their advantages and disadvantages, are provided (among others) in Bateman et al. (2002)[42], Freeman III (2003)[43], Turner et al. (2010)[44] and. A short summary is included in **Table 8.**

The Guide to Corporate Ecosystems Valuation[11] has a background document (B: Selection and Application of ecosystem valuation techniques for CEV, see Table 2) that explains these methods, their costs and skills required, along with their advantages and disadvantages.

In general, it depends on the type of environmental and human welfare impact aspect that has to be valued. Particular impacts require specific methods. All methods have advantages and disadvantages and sometimes method choice is a matter of preference. It is important to consider the preference of the user and higher-level management to ensure that the valuation results are considered useful and credible by the relevant internal and external stakeholders.

There are 3 options for valuation:

- Relatively simple and cheap approaches include cost-based estimates and market prices as the data may be readily available, but their limitations are important and have to be considered **(Table 8)**.
- It is possible to commission a new study, but this may be time and money intensive, and would need inputs from environmental economics experts.
- Alternatively, existing valuation studies may be used in so-called benefit transfer analysis **(Section 5.3.3/5.3.4)**. Carbon valuation is straightforward and the Practical Guide provides ready-to-use value estimates in **Section 5.3.5**. Given the importance of water in agricultural production, additional guidance for the valuation of groundwater extraction is provided in **Section 5.3.5.**

Table 8 Valuation methods[44]

Method	Short description	Human welfare
Travel cost method	Indirect method: estimate demand (willingness to pay) using travel costs to visit site	Recreational benefits settings & wild specie
Hedonic pricing method	Indirect method: estimate willingness to pay using property price changes that can be related to changes in the environment	Value of living near e settings or quality as property prices, e.g. p water or air quality, e
Contingent valuation	Direct survey-based method. Hypothetical questions to obtain willingness to pay (accept) to obtain more (less) of an environmental good/benefit	All welfare categorie species, human hea values
Choice experiments	Direct survey-based method,. Hypothetical questions to obtain willingness to pay (accept) to obtain more (less) of an environmental	All welfare categorie and human health, r
Net Factor income, productivity method	Assign value as revenue of an associated product net of costs of other inputs	Resources (water, lar grow crops and othe
Production function (dose-response)	Trace impact of physical environmental change on human welfare	Pollination, water us quality impacts on h
Market prices	Direct method based on market prices for traded environmental goods	Crops, timber, fish ar water quantity (if pri change (lower boun
Replacement cost	Costs of replacing the function with an alternative (manmade) technology or restoration of the ecosystem	Water quality (treatm pollination, pest and
Defensive expenditure method, avoided damage costs	Costs and expenditures incurred in avoiding damages of reduced environmental functionality	Storm and flood defe air quality impacts or and disease control, c

	Advantages	Limitations
of environmental es diversity	Based on data of observed behaviour; results are relatively easily interpretable	Data intensive; site-specific results; only recreational values
nvironment reflected in proximity to forest, tc.	Based on actual behaviour in property markets; results are relatively easily interpretable	High data requirements; data may be insufficient to estimate impact of environment on prices; model needs to account for all factors affecting prices
es, incl. wild lth, non-use	Flexible; can be used for wide range of benefits, including future situations and non-use values	Based on stated behaviour, sensitive to bias, and less reliable for goods that people are not familiar with resource & data intensive
es, incl. wild species non-use values	Flexible; can be used for wide range of benefits, including future situations; can be used to assess value of various components of the environmental good	Based on stated behaviour, sensitive to bias, and less reliable for goods that people are not familiar with. Resource & data intensive
nd, soil) used to er products	Relatively straight forward when inputs are clearly related to outputs; limited data requirements	Only applicable to resources that are inputs into production; changes in resource may affect market price of final good
e for irrigation, air human health.	Explicit cause-effect modelling	Data and cause-effect relationship are often unavailable; only use-values
nd other products, iced), climate d value)	Transparent method when goods are traded regularly	Assumes "perfect" markets (no subsidies or other market distortions); only possible for traded goods; prices do not reflect externalities (lower bound value estimate)
ent), flood defences, disease control.	Cost data may be easier to acquire and may be more familiar	Second-best approach; value of benefits may be larger than the cost of supply; not suitable for cost benefit analysis; technology may not be perfect substitute
ence, erosion control, human health, pest climate change	Cost data may be easier to acquire and may be more familiar	Second-best approach; typically lower bound estimate of benefits (assumes society is willing to pay at least that amount); not suitable for cost benefit analysis; only use-values

5.3.3 Benefit transfer analysis for valuing externalities

Benefit transfer approaches may come in useful when primary valuation studies are prohibitively time and money intensive. **Benefit transfer** studies use estimates of monetary values from existing studies (estimated for a 'study site') to value ecosystem services at another site (the new 'policy/business site'). The main advantage of benefit transfer is the time and cost savings of doing primary data collection and analysis. It is a relatively simple and straightforward approach to valuation. The limitations are that benefit transfers can result in large errors when the quality of the existing study was low or when the study site and business site are very different.

There are **four benefit transfer approaches:**

1. Mean value transfer: uses the mean value for the study site to estimate benefits at the business site without any adjustments. Suitable when sites and human populations (culture, income, resource use) are very similar.

2. Adjusted value transfer: uses the mean value for the study site but adjusts these for differences in characteristics between the study site and business site, usually for differences in income. Suitable when it is possible to adjust for income differences and sites are otherwise similar;

3. Value function transfer: uses the value function (economic model) of the study site to estimate values for the business site. It uses the model parameters of the study site with secondary data at the business site for the explanatory variables in the model (e.g. from national census) in the calculation of the benefits. Suitable when the value function includes the variables that capture differences between the sites or populations and secondary data for explanatory variables are available at the business site;

4. Meta-analytical value transfer: uses meta-analysis studies of existing valuation studies. Meta-analysis valuation studies bring together multiple valuation studies on the same topic (e.g. same habitat type, natural resource or welfare impact) and develop a value function based on regression analysis. For example, TEEB[47] looks at the value per hectare of different habitats. Habitat focused meta-analysis typically bundle different ecosystem services (e.g. recreation, water provision) into one value indicator for that habitat type. Such studies may give a rough indication for the main externalities and their magnitude, but usually cannot provide sufficiently accurate values to decide about trade-offs between financial and environmental gains at local scales, or to compare relatively small production sites.

5.3.4 Benefit transfer step-by-step

Figure 15 describes the steps taken in a benefit transfer exercise. Note that separate value estimates may have to be derived for each of the environmental impacts in both the business case and counterfactual scenarios.

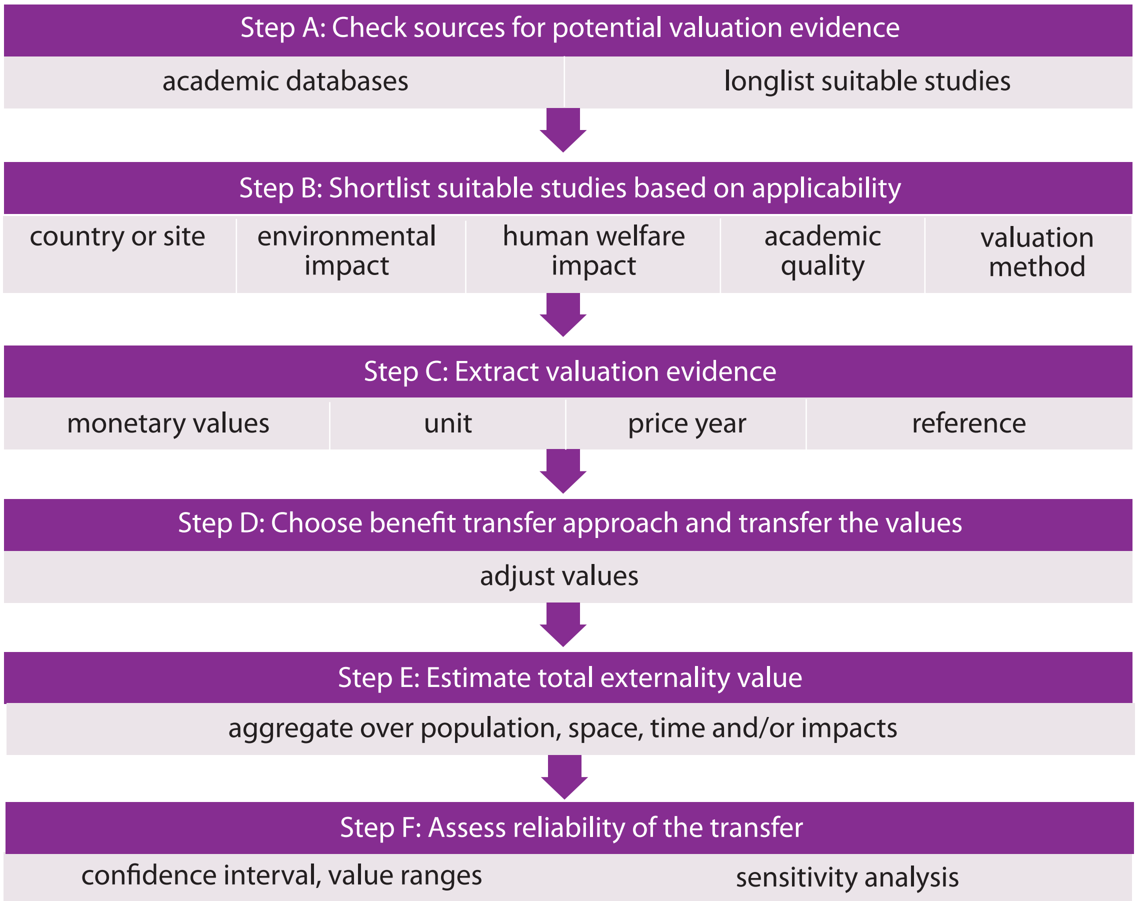


Figure 15: Stepwise approach to benefit transfer

Step A: Check sources for potential valuation evidence

For benefit transfer to be possible there must be monetary valuation evidence available. So the first step in a benefit transfer exercise is to check possible sources for potential evidence, and identify a list of potentially suitable studies. In some countries, governments prescribe the use of value estimates, e.g. the use of DECC prices for carbon in policy proposals in the UK.

Valuation data sources

Academic studies can be found in google scholar, where a search command consisting of the following terms should provide suitable evidence:

[study region or country], [environmental impact], [environmental metric], 'environmental valuation'

The Ecosystem Services Partnership (ESP) has collated a large dataset with 1310 values (Aug 2013) freely available here.

The ESP website also gives an overview of other valuation data bases here

For some academic journals, access is restricted. However, the quality and reliability of peer-reviewed papers is likely to be higher and lead to more robust results than other, non-reviewed papers.

Decision 12:
Which search criteria will be used to find relevant existing valuation studies for each of the environmental impacts?

Output 7:
Collection of relevant existing valuation studies for each of the environmental impacts.

Step B: Shortlist suitable original valuation studies

Next, a study shortlist of suitable original valuation studies has to be developed. The quality (reliability and validity) of benefit transfer results depends on the comparability of the sites, their context (ecological, social, economic) and the business case, as well as the reliability and validity of the original valuation study.

Shortlisting can be guided by answering the following questions:

- Does the original valuation study value the environmental impact that is relevant to the business case? Are the impacts sufficiently similar in direction (+/-), magnitude (in biophysical terms), spatial and temporal scale?
- Is the human welfare impact (in biophysical terms) in the original study sufficiently similar to the change under the business case scenario?
- Is the original valuation study performed in the same country or area within large countries as the business case?
- Does the study-site of the original valuation study have similar ecological characteristics and resource limits (incl. scarcity)? For example, if in the original study the availability of substitutes was high, but it is low in the business case, benefit transfer may result in an underestimation of the value of externalities, and vice versa.
- Is the original study conducted at a site with similar population characteristics (socio-demographics, resource use, welfare, proximity)?
- Can the output (unit) of the biophysical assessment be linked to the economic evidence?

The next set of questions addresses the quality of the original valuation study and allows for a refinement of the shortlist:

- Is the original valuation study published in the academic literature?
- For guidance on the quality of valuation studies, see SEPA[46]
- Does the original valuation study use a method appropriate for the externality of interest **(see Section 4.3)**?
- Is the original valuation study performed sufficiently recent? As a rule of thumb: less than 10 years ago– using very old studies for benefit transfer should be avoided if possible.
- Are the data collection methods and sample representativeness sound?
- Are the results analysed reliably and are the outcomes valid; are they consistent with economic theory? For example, do the results show that people with higher incomes are willing to pay more to protect existing environmental quality, or are people willing to pay more for higher levels of environmental quality?

If the answer to all questions above is positive, the study is likely to be suitable for benefit transfer. If not, the study is either not suitable, or values have to be adjusted somehow and/or the results of transfer have to be interpreted with the necessary precaution. It is recommended to seek guidance from an environmental economist for this step.

Decision 13:
What are the most suitable existing valuation studies for benefit transfer? Why have these been selected?

Step C: Extract valuation evidence from the selected studies

After potentially suitable studies have been shortlisted, the valuation evidence they provide has to be extracted and described shortly (values or value function, price year of values, reference, main advantages and limitations).

Output 8:
Shortlist and a short description of valuation studies that will be used for benefit transfer.

Step D: Select a benefit transfer approach and transfer the values

A decision has to be made on the value transfer approach: mean value transfer, adjusted value transfer, function value transfer, or meta-analytical transfer (See **Section 5.3.3).**

- If value function transfer is considered to be most appropriate, secondary data from the business site have to be collected for the variables in the value function.

Decision 14:
Which benefit transfer approach will be used?

Further adjustments may include – these should be reported and justified:

- Adjustment for differences in purchasing power (using PPP-conversion factors) if the original study has been performed in another country (instead of the income adjustment
- Adjustment for inflation to ensure that the values are expressed in current monetary values (instead of prices of the year in which the valuation study was executed);
- Adjustment for the size of the study area. This is difficult unless the original study includes the size as an explanatory factor in the value function. Assuming constant values per ha may result in errors, when values are expected to decline with size (see also **Step E** on Aggregation).
- Adjustment for the size of the affected population. When the original study only provides a total value for all people affected and the population affected in the business case is different, some assumption may have to be made to adjust for differences in the size of the affected population (see also **Step E** on Aggregation).

Instead of adjustments for area and population size, or substitutes, sensitivity analysis can be used or the limitations of the benefit transfer results have to be reported.

Decision 15:
Are further adjustments necessary?

Step E: Aggregation

Aggregation of values implies the summation of externality values over space (area affected), time (duration of scenario), affected population and/or externalities.

- **Over the population:** When the economic values are expressed in values per person or household, this value has to be multiplied by the total number of people that are affected by the environmental impact. For example, if the value of lower groundwater availability per farmer is USD 40 per year and there are 4000 farmers dependent on this groundwater resource, the aggregate value is USD 160,000 (ignoring further impacts on neighbouring areas or other water resources).

- **Over space:** When the economic values are expressed in values per hectare, this value has to be aggregated over the total area that is affected by the business activities. For example, if the soil carbon values of the habitat before conversion by the business are worth USD 80/ha and only USD 20/ha after conversion (under agricultural use), and the business has converted 8000 ha to farmland, then the net impact is USD 480,000. For some externalities, such as recreation, however, the price per ha may decrease with increasing area size (the higher the supply, the lower the price).

- **Over time:** some environmental impacts only manifest themselves over time: resource stocks only become critically depleted after a number of years of operation, population growth leads to a higher number of affected people, or business operations increase/decrease their resource/land use over time. In such cases, the scenario analysis should have a temporal dimension and cover the relevant temporal scale. In cost benefit analysis, the costs and benefits have to be discounted when multiple years are considered – the net present value is affected by the distribution of values over time **(See Section 5.4).**

- **Over externalities:** In case of multiple externalities, the values for each externality have to be summed for each scenario. At this point, it is recommended to check if any double counting errors **(see Section 5.3.1)** have been made.

Decision 15:
Is aggregation required? If so, how will the monetary estimates be aggregated?

Output 9:
A monetary value for each of the environmental impacts by applying benefit transfer and any adjustments, and aggregation as necessary.

Step F: Assess the reliability of the benefit transfer results

The questions listed in **Step C** also provide a list of quality checks for interpreting and evaluating the results of a benefit transfer study. Where the answer to one of the questions is negative, the results must either be appropriately adjusted or another valuation study must be used. **Section 5.5** describes approaches to sensitivity analysis.'

Output 10:
Description of assumptions and limitations of the valuation.

5.3.5 Valuing carbon and groundwater quantity

Carbon valuation

Emitted greenhouse gases have a uniform global price, because it does not matter for climate change where the gases are emitted. For CO_2 and other greenhouse gases, various estimates for the price per tonne of CO_2 equivalent are available in the literature, based on different valuation methods, discount rates, climate change models and assumptions.

In general, it is recommended to compare the results based on different price estimates to show a range of carbon values **(Table 9).**

- Estimates based on studies of the **social cost of carbon** (SCC) reflect the social cost of climate change, including damage costs from flooding and health risks, both financial and non-financial. It is estimated as the net present value of climate change impact (damages) across the globe over the next 100 years of one additional tonne of carbon emitted into the atmosphere today. Like for any other method, the SCC studies have resulted in a wide range of estimates, from a few dollars per tonne of carbon to a few hundred dollars. Tol (2010)[49] provides a meta-analysis (i.e. a review of published literature on the SCC) which suggests that the median price of peer-reviewed SCC studies is approximately 80 USD/tC (21.80 USD/tCO_2).
- Some governments, including the UK and US, prescribe prices that have to be used in policy projects. For instance, the UK DECC rates are based on **marginal abatement cost studies**, which look at the costs of reducing emissions, without looking at negative impacts on health and mortality.
- **Market prices**, including the ETS prices. Carbon markets are typically immature and not comprehensive. Therefore, market prices are unlikely to reflect the 'true' cost of carbon.

Table 9: Carbon prices in USD/tCO_2 in 2011 prices

Carbon	Reference	Method	Notes
2.18	Pearce (2003)[50]	Social cost of carbon	Lower bound estimate
21.80	Tol (2010)[49]	Social cost of carbon	Median value based on meta-analysis of many published SCC studies
85.56	Stern (2007)[51]	Social cost of carbon	High estimate
87.02	DECC (2009)[52]	Marginal abatement costs	Second-best method. Government price. Used for UK policy.
22.78	Bell and Callan (2011)[53]	Social cost of carbon (US-based)	Government price. Used for US policy.
14.30	ETS[54]	Market prices	Imperfect market (not all sectors included, not all externalities reflected in price).

Decision 10-11:
Which carbon price will be used and which price range will be reported?

Output 5:
Monetary valuation of the climate change related impacts.

SABMiller carbon valuation
SABMiller decided to use a carbon price of 75 USD/tCO_2.

CS6: maize production in the USA

Environmental impact/activity: CO_2 emissions from nitrogen fertiliser application
Welfare impacts: climate change

Valuation method: market prices

Quantification: The application of inorganic nitrogen fertilisers results in 0.39t CO_2/ha. At a market price (ETS) of 8 EUR, the resulting externality is valued at 3.6 EUR/ha.

Limitations: The market price at European markets has no direct relevance to emissions in the USA. The market is incomplete, imperfect and greatly affected by European climate regulations. Prices therefore do not reflect the social welfare changes associated with an additional tonne of carbon emitted. There are also considerable methodological uncertainties associated with the biophysical quantification in this case.

CS7: soy production in Brazil

Environmental impact/ activity: CO_2 emissions from land conversion from natural habitat to soy cropland.

Welfare impacts: climate change

Valuation method: meta-analysis of marginal abatement costs

NOTE: It should be noted that the company bought the land from cattle ranches long after the natural habitats had been converted to grazing land. Therefore this analysis does not represent the values from the change of cattle to soy land use change that are associated with the company. This study is used here to show how a meta-analysis can be applied, but the results do not reflect the true actions of the company.

Quantification: To value the CO_2 emissions from land-use change (from cerrado or forest to soy), two prices are used: an estimated social cost of carbon in 2010 of 27 USD/tCO_2, and the median cost per tonne of CO_2 from a meta-analysis on marginal carbon abatement costs of 16 USD/tCO_2. The difference between the two locations is mainly driven by the difference in farm area, but also by the difference in carbon storage between forests and cerrado. The externality cost when converting 3,456 ha cerrado to soy cultivation is 13-22 million USD (3.8-6.4 thousand USD/ha), whilst 30,749 ha of forest conversion to soy cultivation generates carbon externalities valued at 298-491 million USD (9.7 – 16.0 thousand USD/ha).

Values	cerrado to soy	forest to soy
Area (ha)	3,456	30,746
Change in tCO_2e (kilotonnes)	822	18,202
Marginal damage cost (million USD; 2010)	22	491
Marginal abatement cost (million USD; 2010)	13	298

Limitations: Soil carbon values vary with frequency of cropping cycles, tillage systems, local soil and vegetation types.

Valuing water quantity

The value of water quantity, especially in cases where resources are close to depletion levels and used unsustainably, can be assessed by looking at the opportunity costs. The opportunity costs refer to the value of a resource (water) in its best alternative use – which is the cost that society stands to lose when a company uses the water instead. The total opportunity costs include: the direct costs of water abstraction (labour, equipment, fuel, etc) adjusted for subsidies and taxes, external costs of water use in terms of the welfare losses or gains imposed on other people (e.g. crop losses – the net present value of), and finally a scarcity premium ('user-cost'). This scarcity premium reflects that exploitation may lead to future water unavailability. It can be based on the rate of exploitation relative to the water stock, the cost of substitutes now and in the future, and current and future demand for water. It may also incorporate higher costs of future water use, such as increased pumping costs.

The SABMiller water valuation approach:

Environmental impact/activity: Groundwater depletion due to irrigation water abstraction

Welfare impact: Increased pumping costs, dried up shallow wells.
Valuation method: benefit transfer: adjusted mean value approach.

Quantification: Irrigation by farmers requires electricity for pumping up groundwater. The total water use of each farmer that grows barley for SABMiller is 13,797 m^3/yr. The new barley variety uses less water so less electricity. The groundwater table is assumed to be at 40m. It takes $9.534*10^{-3}$ kWh to lift 1m^3 of water by 1m, so 40m takes 0.381 kWh. The electricity price is 5.45 rupees/kWh. Therefore, a farmer spends 477.5 USD/yr on electricity costs (1 USD =60 rupees). By reducing water use, an SABMiller farmer can save 0.0346 USD/m^3. Since electricity prices in India are subsidised and consumers pay only 75% of the real cost of production, the real cost of the electricity savings is 0.0433 USD/m^3.

The total water use reductions are very small compared with the total water use by all farmers in the Jaipur district. Therefore, the water use reductions have little effect on the overall groundwater table, but are not ignored here. The replacement costs per dried up well are estimated at 1500 USD. Shared between all farms, the water use reduction was associated with costs savings of 0.00138 USD/m^3 due to a smaller number of shallow wells lost.

The total externality value is estimated at 0.00447 USD/m^3.

CS4: wheat production in Argentina

Environmental impact/ activity: Land conversion from natural habitat to agricultural fields for wheat production

Welfare impacts: Reduced level of benefits provided by natural habitat values

Valuation method: Benefit transfer: adjusted mean value approach

Adjustment: Factor to estimate difference between benefits provision by natural habitats and cultivated land to estimate the net loss of benefits (difference between the counterfactual natural habitat scenario and the business case scenario) (e.g. Power, 2010[57]).

Quantification: Converting natural habitat to agricultural land results in a loss of benefits provided by natural habitats. Using values from Costanza et al. (1997)[58] and assuming that this loss is 10-20%, land conversion of wheat production in Argentina is likely to have lowest human welfare impacts when converting grasslands, such as the Pampas (18-36 USD/ha/yr), whereas highest externalities may be expected when for example areas in the Pantanal wetlands are converted to agricultural land (573-1145 USD/ha/yr). This difference in caused by the fact that grasslands are less valuable than wetlands according to the original valuation study.

Limitations: The values provided in Costanza et al. (1997)[58] have been criticised for a number of reasons and are currently being updated. The results should be interpreted as a very crude estimate of the potential welfare losses associated with land conversion in these Argentinean biomes.

5.4

Step 4: Compare scenarios

In **Section 3**, the need for scenario analysis has been described. Looking at differences over time or situations gives insight into the externalities that the company is responsible (and even liable) for. For example, water quality can be affected by many (f)actors and the water quality level at the farm-site may not reflect the impact of the company. Changes water quality at the site as well as further downstream as a result of changes in farming practices of the business are of interest for externality assessment.

Questions: What is the net impact of the business? What is the net value of the externalities?

Expertise: The natural scientists and economists who have quantified the externalities must be involved to evaluate the outcome of both scenarios. The sustainability manager must be involved to see if the results are useful, credible and appropriate for the business context. Local experts may be involved to ensure realism of the scenarios.

Process: First, the storylines of the scenarios have to be put into numeric, quantified changes. Then, the natural scientists and economists must quantify the externalities under both scenarios. This involves checking that the assumptions driving the scenarios are appropriately included in the modelling. The results must be reported along with the relevant assumptions and limitations.

Output: Scenario results showing the net impact in biophysical and economic units of the counterfactual and business case, and a description of the limitations and assumptions.

Temporal scale: Environmental impacts, business practices, affected populations, etc. can change over time. Scenarios can therefore incorporate impacts that have different monetary and/or biophysical values across years. In such cases, rather than comparing externality values per year, the calculation of net present values over the scenario time period have to be calculated. This involves discounting – the procedure for discounting environmental valuation results is the same as for other financial results and will not be described here. Because of intergenerational equity considerations, lower discount rates can be considered for environmental externalities than for other capital assets.

Output 11:
Comparison of the results of the scenarios.

Output 12:
Assessment of the net impacts in biophysical and economic units.

The SABMiller scenario analysis[a]

The company wanted to assess the environmental externalities of increasing the production of barley, typically grown in the dry season and therefore irrigated, to understand the sustainability of promoting barley in the region. The quantification of the counterfactual was based on district level data on yield and production area per crop, whilst the business case scenario was based on interviews with farmer extension workers.

In the counterfactual scenario, the traditional production of mustard, gram and wheat by small-scale farmers is expected to continue. In the business case, more land would be allocated to barley production. Yield of barley would increase (+55%) as a result of the extension services provided by the company and better quality seeds that use less water and result in higher yields. In addition, the extension services result in a lower (more efficient) application of fertiliser to barley. The company will also provide a 5% price premium above the market rate.

Scenario	Proportion of crop area (%)				Barley yield change (%)	Barley price change (%)
	Barley	Wheat	Gram	Mustard		
Counterfactual	15	36	14	35		Current
Business case	35	30	10	25	+55	Current+5

The quantification of greenhouse gas emissions from fertiliser and energy and water use from groundwater resources results in the biophysical estimates of environmental impacts per hectare. Barley uses more rainwater and requires less irrigation, which also leads to a reduction in pumping-related CO_2 emissions. Moreover, barley requires less fertiliser per hectare and therefore produces lower N_2O (greenhouse gas) emissions.

	Counterfactual		Business case	
Crop	CO_2e (kg/yr)	Irrigation water (m^3/yr)	CO_2e (kg/yr)	Irrigation water (m^3/yr)
Barley	1423	1730	3275	4038
Wheat	4375	5806	3646	4838
Mustard	3631	4802	2594	3430
Gram	1456	1858	1040	1327
Total	**10885**	**14197**	**10555**	**13633**

As the comparison between the counterfactual and business case scenarios shows, the externalities are lower in the business case. The difference in environmental impacts between the counterfactual and the business case can be valued using the prices per impact described earlier. The net value of externalities is estimated at 50 USD per farmer producing barley for SABMiller.

	Difference in biophysical units	Price per unit	Net externality value
CO2 emissions	-330 $kgCO_2e$	75 USD/tCO_2e	24.8 USD
Irrigation water	-563 m^3	0.0447 USD/m^3	25.2 USD
Total			**50 USD**

Over all farmers that the company works with in Jaipur, 6000 in total, the reduction in externalities that could be achieved in the business case are 300,000 USD/year.

[a]The full report presents two additional scenarios and provides more detail on the effects of production yields and costs and farm income and profits. It also includes the quantification of green and blue water.

5.5 Step 5: Interpret results and perform sensitivity analysis

When interpreting the results of the biophysical and economic assessment, the main question is how reliable the results are. Therefore, the scope, limitations and assumptions that have to be made in the assessment should be considered. These may have to do with the availability of data at the farm-level or for particular externalities of interest, the assumptions that where made to employ available models and data, uncertainties in existing methods and values, etc.

Questions:

What are the uncertainties and caveats underlying the results of the assessment?

What is the scope of the assessment; which impacts have (not) been accounted for?

How sensitive are the results to different assumptions and changes in key parameters?

How do these affect the interpretation of the results?

Expertise: The natural scientists, economists and/or social scientists involved in the quantification of the externalities should be involved. Depending on the level of accuracy needed and the importance of the assessment, further external reviewers may be asked to get involved.

Process: The experts involved in the quantification of biophysical and economic impacts have to reflect on the results, and see how uncertainties may propagate through combining results. They have to produce a sensitivity analysis alongside the main results. The sustainability manager has to ensure that the sensitivity analysis addresses externalities that are of strategic interest.

Output: A discussion of the key assumptions and limitations that were recorded throughout the externality assessment process, and a sensitivity analysis in which these assumptions are tested, to support the interpretation of the results of the externality assessment.

Scope and limitations

- The methods and approaches to externality assessment in the Practical Guide relate to the growing process only.
- Often, farm-level data on environmental impacts and human welfare values are not available, and the assessment will be based on transfers of biophysical, ecological and economic estimates of studies performed at different sites.
- Lack of reliable site-specific data and the use of transferred values increases the uncertainty range of the results.
- It is often not be possible to assess all externalities due to a lack of data, methods or expertise.
- This is of most concern when the most substantial externalities cannot be included.
- Less well-informed assessments will have larger error margins.
- The methods put forward in the Practical Guide all have disadvantages and limitations and employ a number of simplifying assumptions that affect the outcomes.
- There are considerable gaps in the scientific knowledge regarding the environmental impacts of agricultural practices and the associated impacts on human welfare.

Output 13:
Discussion of the key assumptions and limitations and their effects on the results.

Sensitivity analysis

It is best practice to present the results of both the biophysical and the economic assessment with a confidence interval or as a range of values, or provide a sensitivity analysis:

- Relevant information on value ranges or uncertainty intervals can be extracted from the original study and applied to the business case and/or counterfactual;
- Results from different original studies can be used to see if that changes the results of the assessment such that different conclusions must be drawn, for example;
  - different crop coefficients, such as in a CROPWAT water analysis;
  - different carbon values.
- The parameters for key externalities can be varied.
- The underlying assumptions of the analysis of the biophysical and economic values can be changed and the subsequent results compared, for example;
  - For the biophysical assessment:
    - Different modelling approaches, such as different models in CROPWAT (see SABMiller case study report)
  - For the monetisation:
    - different assumptions about the affected population or area;
    - different assumptions about the characteristics of the population or area;
    - externalities can be in- or excluded depending on the assessment accuracy;
    - different benefit transfer approaches; and
    - different time horizons or discount rates for scenario net present values.

A sensitivity analysis also provides insight in the strategic relevance of costs and benefits of business operations in relation to the long-term sustainability of the business.

Output 14:
Sensitivity analysis: results and interpretation.

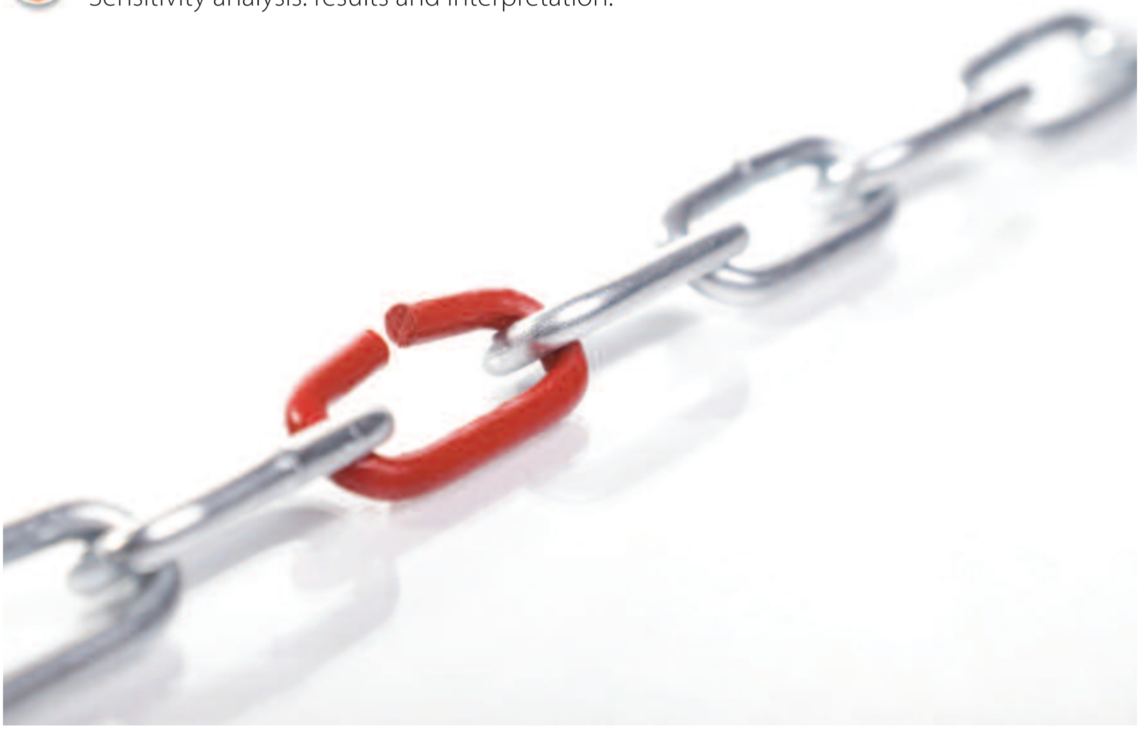


Figure 16: Reliability: test the weakest link of the assessment!

The SABMiller discussion of results:
In the interpretation of the results of the assessment, the following issues should be considered:

- the impacts on biodiversity and corresponding wild species diversity and other benefits are not included due to a lack of data on pesticide use and biodiversity measures at the site;
- the impacts on water quality are not monetised because the biophysical model outputs are not meaningful in terms of actual welfare changes;
- the scenario analysis ignores potential impacts of climate change, and a shift in rainfall patterns, which may increase barley production in the future;
- the water use assessment assumes optimal 100% irrigation of all land and crops, which may bias water abstraction from groundwater either upwards or downwards – no farm-level data on liters of water abstracted and irrigation practices is available;
- the economic values associated with water use were based on a range of assumptions on well depth, number of wells dried up, ground water levels, etc.

To assess the uncertainty, the assessment:

- includes uncertainty ranges for N_2O emissions from fertilisers from the original study;
- compares two different methods of assessing ground water use;
- compares the results of CROPWAT results on groundwater use using different crop coefficients from the literature;
- compares different business case scenarios where some of the assumptions are changed.

The assessors also discuss that the groundwater resources in Jaipur are close to being depleted:

- Although groundwater abstraction is lower in the business case scenario, the reductions are insufficient to meet sustainable abstraction levels and depletion will continue albeit at a slower rate. The operational risk may be reduced but is not eliminated under the business case.
- Although farmer profits may increase in the business case, when ground level resources are depleted and wells fall dry poorer farmers may be affected proportionally more. Since poverty and food security issues are a key consideration, there is still a reputational risk associated with water use in Jaipur. Even though the impact of the farmers that the company buys products from is marginal, the company is a very visible consumer of groundwater.

6 How to use the results?

After the assessment has been completed, the sustainability manager has to decide what to do with the results. Relevant questions include:

- What do the results mean (and not mean) for the corporate strategy?
- Are there actions that can be undertaken to improve the performance? What can be done to address these externalities?
- What can be done to improve the results and their accuracy?

6.1 Key findings from the case studies

- The main externalities of cereal production relate to negative impacts on groundwater supply, water quality, climate change, air quality, soil quality and wild species diversity. Their ranking (importance, monetary value) depends on the environmental, social and economic conditions at the site. Some of these externalities have localised impacts (groundwater supply, water quality, air quality, soil degradation), while others are more diffuse and impact at a wider scale (climate change).
- For localised externalities, the impact on human welfare depends on the proximity of populations to sources. The monetary value of localised externalities will often be higher in densely populated areas, and smaller in uninhabited areas.

Evaluating externalities is the first step to identify opportunities to reduce them.

6.2 What can be done to address these externalities?

Some case study findings:

The SABMiller findings:
The findings show that SABMiller can reduce their environmental impact whilst improving supplier (farmer) income at the same time. By moving from mustard and wheat to barley, the environmental impact of agriculture is lower because of lower groundwater use and greenhouse gas emissions. At the same time, farmers' income may improve when costs of irrigation pumping reduce and the company pays a small premium above current market prices.

CS4: Wheat production in Argentina is likely to have lowest impacts in areas that were previously grasslands, such as the Pampas (18-36 USD/ha/yr), whereas highest externalities may be expected when (for example) areas in the Pantanal wetlands are converted to agricultural land (573-1145 USD/ha/yr). This difference is based on relatively limited current evidence, which suggests that grasslands typically are associated with lower human welfare than wetlands. The general point here is that, to reduce environmental externalities, companies should aim at sourcing/procuring from areas where the impacted ecosystem is of least value to society (in terms of 'opportunity costs').

CS2: In India, groundwater scarcity is likely to make rice production problematic in the future. Reducing rice production will help to reduce greenhouse gas emissions and water use, but has severe negative implications for farmers' income. The case study shows that replacing rice production by higher value dairy cattle and fodder production may create both lower environmental externalities compared to the current situation, as well as have a positive economic impact by increasing farmer income.

6.3

Showing leadership

Externality assessment supports companies in measuring their achievements of their strategic sustainability goals:

No net loss: The International Finance Corporation demands from their clients that their operations result in 'no net loss' of biodiversity and conservation, and a 'net gain' in critical habitats. They can mitigate their impacts by biodiversity offsets – conservation efforts that compensate adverse biodiversity impacts from business activities.

Net positive: Leading companies aim not only to do less bad, but rather to put back more resources than they take. Aiming to achieve a net positive impact requires new thinking about the way of doing business. So far, businesses adopting a net positive strategy have focused on one or two key externalities; Rio Tinto focuses on Biodiversity, BT focuses on carbon, and Kingfisher on timber and energy. The future challenge is to include all externalities into the measurement of net positive impact achievements.

The results of environmental externality assessments may be used in different ways. Evidence of relatively low impact from operational activities at one site may help to get a license to operate elsewhere, and form an important step in the regulatory process. Companies may be able to use good environmental performance results to market their products and appeal to sustainability minded consumers. Building the evidence base on externality assessment in the private sector may also be used to call for changes in policies and regulations to promote sustainable production methods. Companies aware of their externalities will have a strategic advantage when such policies are imposed.

6.4 What can companies do to improve the results of the assessment?

Lessons learned from the case studies include:

You can't manage what you don't measure:

- Reliable and valid assessments of externalities require data collection by companies on operational activities in the growing phase and impacts on the environment. The Practical Guide provides lists of data that should be documented on activities, as well as the ecological and socio-economic context.

- In long supply chains, it may be difficult to obtain information on environmental performance in the growing phase of crop production. Sustainability Managers will have to build an effective dialogue with suppliers to be able to assess the externalities.

Reliable and valid assessments require multi-disciplinary teams

- Impacts need to be assessed in terms of impacts on human welfare, and this requires expertise about different types of habitats and the importance and economic values of environmental impacts

- Although there remain high levels of uncertainty in the underpinning natural, economic and social sciences associated with the environment and the links to human welfare, this does not preclude the possibility of some broad estimates of value, although these must be treated with caution.

Externality values vary across space: business externalities are context-dependent

- Economic values are inherently spatial. Assuming fixed monetary values for environmental externalities violates basic economic principles, such as the roles of scarcity and market demand.

- Similarly, ecosystems vary across the world in the level of ecosystem services they provide, and therefore the impact of corporate actions on ecosystems and their services is location-dependent.

- The total impact and value of environmental changes depends on the total number of people that are affected, and their characteristics and preferences.

- Single value estimates are easier to communicate, but they are not helpful for making management decisions such as, should a company source its cereals from country A or B, or region X or Y?

The biophysical assessment (without valuation) supports corporate sustainability and provides useful management information.

- Linking activities to environmental impacts and human welfare changes provides insight into the various externalities of the business, and for instance provides information about the operational risk and supply chain stability in the future.

- The use of biophysical indicators of resource use (relative to biophysical limits or regulatory/community standards) can be used for risk assessment. Regular monitoring of resources use allows for managing environmental impacts, so that timely measures can be considered.

7 Glossary

Benefit transfer	Benefit transfer studies use estimates of monetary values from existing studies (estimated for a 'study site') to value ecosystem services at another site (the new 'policy/business site').
Business case	The scenario that describes the operational activities and related environmental impacts for which the company wants to assess the externalities.
Counterfactual	The counterfactual scenario describes a plausible alternative state of the site and its environmental conditions that would result if the company did not operate as described under the business case.
Environmental context	The state of the environment and external conditions at and around the site where the operational activities take place, such as the type of habitat, climatic conditions, biodiversity, water quality and quantity conditions, soil conditions.
Environmental Impact	Biophysical change in ecosystem (here: as a result of an operational activity)
Externality	E.Valu.A.Te defines (business) externalities as: Costs (benefits) resulting from (business) activities that are not accounted for in market prices or otherwise compensated, borne by parties who did not choose to incur those costs (benefits).
Human welfare impact	Impact (here: of a change in the environment) on human welfare and wellbeing, including freedom of choice, health, food, water and fuel security, etc.
Socio-economic context	The social and economic conditions at and around the site where the operational activities take place, such as population size and growth, income and wealth levels, natural resource use, cultural values towards the environment, policy and regulatory frameworks, infrastructure.

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