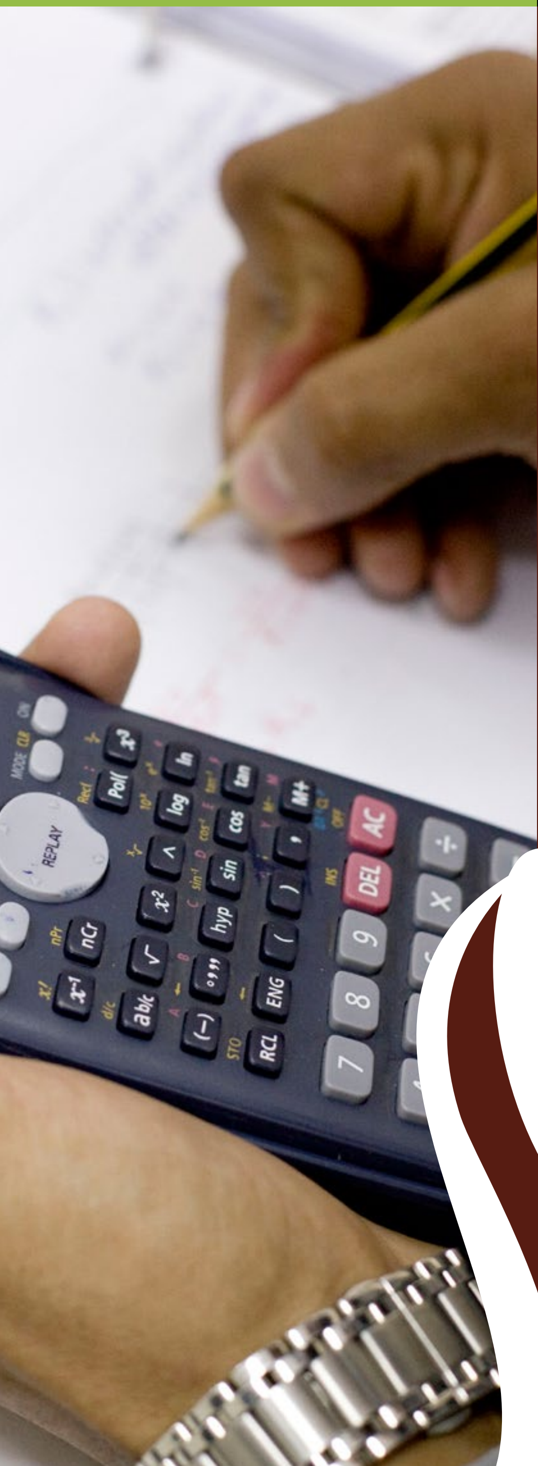
THE ECONOMICS OF
LAND DEGRADATION

ELD CAMPUS
Module:
Cost-benefit analysis



www.eld-initiative.org
#ELDsolutions

Main author:
Emmanuelle Quillérou

Compiled by:
Silke Schwedes

Reviewed and edited by:
Richard Thomas

The content of this document was prepared based on materials of ELD's massive open online class 2014: "Principles of economic analysis and valuation for sustainable management of land".
United Nations University, Institute for Water, Environment and Health (UNU-INWEH),
prepared by Emmanuelle Quillérou, reviewed by Richard Thomas, edited by Naomi Stewart

Photography:
GIZ/Markus Kirchgessner (front and back cover), GIZ (pg. 9);
GIZ/Catalina Altagracia Ayala Avelar (pg. 22); Klaus Ackermann (pg. 24)

Visual concept: MediaCompany, Bonn Office
Layout: kippconcept gmbh, Bonn
Bonn, September 2019

For further information and feedback please contact:
ELD Secretariat
Mark Schauer
c/o Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
Friedrich-Ebert-Allee 36
53113 Bonn, Germany
E info@eld-initiative.org
I www.eld-initative.org

Suggested citation:

ELD Initiative (2019). ELD Campus.
Module: Cost-benefit analysis.

Available from www.eld-initiative.org

Module:
Cost-benefit analysis

September 2019

www.eld-initiative.org
#ELDsolutions

Abbreviations

BCR	Benefit-to-cost-ratio
CBA	Cost-benefit analysis
CIF	Cost, insurance, freight
CSF	Conservation Strategy Fund
ELD	Economics of land degradation
FOB	Free on board
IRR	Internal rate of return
NGO	Non-governmental organisation
NPV	Net present value
SER	Shadow exchange rate

Table of contents

Module: Cost-benefit analysis

This module was developed based on materials prepared for the ELD's Massive Open Online Course 2014 by the United Nations University Institute for Water, Environment and Health (UNU-INWEH) (Quillérou, Emmanuelle. 2014). The materials for this specific module have been prepared, in turn, using distance learning and face-to-face teaching and learning material course materials from the Imperial College London (Smith, Lawrence E.D. 2006).

It is suggested to view, in parallel to studying this module, all **self-learning videos on cost-benefit analysis** produced by the Conservation Strategy Fund, which can be accessed either on the CSF's website or on YouTube:

https://www.conservation-strategy.org/en/csf-econ-video-lessons?term_node_tid_depth=380
https://www.youtube.com/user/numbers4nature

The following videos are available:

1. Intro to Cost-Benefit Analysis
2. Cost-Benefit Scenarios
3. Cost-Benefit Perspectives
4. Cost-Benefit Real vs Nom
5. Cost-Benefit Discounting
6. Cost-Benefit Time Horizons
7. Cost-Benefit Net Present Value
8. Cost-Benefit Internal Rate of Return
9. Benefit Cost Ratio and Payback
10. Cost-Benefit Parameters for a Financial Analysis
11. Cash Flows for a Financial Analysis
12. Conducting an Economic Analysis
13. Sensitivity Analysis
14. Risk Analysis

The logic and basic elements of a cost-benefit analysis and the importance of a sound context analysis

Cost-benefit analysis (CBA) is a form of analysis derived from accounting. Policy-makers and project managers use CBA to assess whether an action, planned change or project is worth undertaking. A project is worth undertaking if the net benefits derived from it are greater than the costs, and in comparison to doing business as usual.

Whereas a **financial cost-benefit analysis** builds on actual (financial) money flows, an **economic cost-benefit analysis** integrates the viewpoint of society as a whole. Economic costs-benefit analysis is sometimes called social cost-benefit analysis, although a true social cost benefit analysis would include a form of weighting to account for relative wealth.

What is a cost-benefit analysis?

A cost-benefit analysis is the process of quantifying costs and benefits of a decision, program, or project (over a certain period), and those of its alternatives (within the same period), in order to have a single basis for comparison and evaluation. Though employed mainly for financial analysis, a CBA is not limited to monetary considerations only. It often includes environmental and social costs and benefits that can be reasonably quantified in monetary terms.

Adapted from:
http://www.businessdictionary.com/definition/cost-benefit-analysis-CBA.html

Key steps in performing a cost-benefit analysis include:

1. Definition of the target group to be guided or informed;
2. Definition of parameters of the analysis:
   - the timeframe for analysis and categories of benefits and costs must be defined in advance;
   - A discount rate is also needed to be able to express the costs and benefits at the same point in time;
   - Indicators (e.g., net present value, internal rate of return, and benefit-to-cost ratio) have to be chosen to assess whether the action is financially (or economically) worth undertaking;
3. Estimating economic benefits and costs under alternative scenarios (e.g., business-as-usual, changes in land use, change in land management practices);
4. Comparing net benefits of action to net benefits from business-as-usual to estimate the 'added value' of the proposed change compared to what is already being done;
5. Computing indicators of viability to assess whether a switch to the proposed alternative is justified under an financial or economic perspective; and
6. Undertaking a sensitivity analysis to include some degree of uncertainty and assess potential impact over recommendations derived from the CBA.

Source: Adapted from Snell 2011

Basic elements of a CBA are:

- A common time horizon
- Several scenarios
- Revenues (or benefits, money coming in)
- Costs (money spent)
- Net balance calculation (revenues minus costs)
- An appropriate discount rate and discounting formula for conversion of values into a common present value
- Economic indicators of viability

The cost section can be divided into upfront investment costs (often incurred in year 1) and ongoing costs for operation and maintenance. If the project or investment is realised to improve an existing production system, one would focus on the additional revenues and the additional costs the changes will bring (table 1). Uncertainty in CBA parameters is simulated using a sensitivity analysis, which assesses how results respond to possible changes and by how much.

FIGURE 1

Elements of a cost-benefit analysis

Source: Conservation Strategy Fund

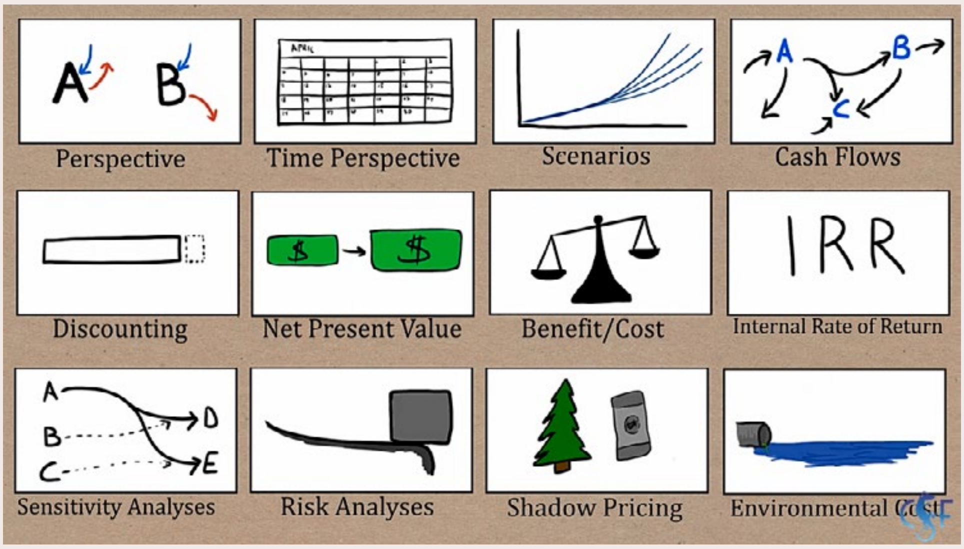


TABLE 1

Structure of a CBA

	Year 1	2	3	4
Additional revenues (+) with proposed change		$$$	$$$	$$$$
Additional Costs (-) with proposed change	$$$	$$	$$	$
Net revenue (balance)				
Discount rate (%)				
Discounted additional revenue				
Discounted additional costs				
Discounted additional net revenue				
Economic indicators to assess viability:				
Net present value (= sum of all discounted additional net revenue)				
Internal rate of return (%)				
Benefits-costs ratio (discounted)				

Costs and revenues or benefits of the project are to be identified as clearly and precisely as possible. They can be broken down into as many categories as appropriate, taking care that they do not overlap. They can be calculated from individual prices and quantities.

Context analysis

It is important to understand the context in which the assessment leading to a CBA is taking place. The circumstances need to be identified very carefully and thoroughly. CBA does not demonstrate anything. The analyst, by the way he/she sets up a CBA, can have total control over CBA results. CBA's main contribution is that it is a tool that can help facilitate the thought process around possible solutions to a problem. A good understanding of the study context is essential to build a cost-benefit analysis that matches real-life conditions and derive salient results to inform decision-making. Failing to do so invariably leads to inaccurate and/or misleading outcomes with policy-makers and project managers taking the wrong decisions. As well as a waste of financial and human resources, consequences of these ill-informed decisions can be disastrous, especially for vulnerable populations.

Study context can be identified by **reviewing available literature** (academic, grey, etc.) as well as by mobilising stakeholders. Both approaches are complementary to derive as accurate and as complete a picture of the on-the-ground situation.

The stakeholders often include local communities, local or national government bodies, non-governmental organisations (NGOs), and donors. Participation of local stakeholders into the cost-benefit analysis process can be used to help identify who should be considered as impacted by the project and with what scale/scope. Including the right people from the start help raise awareness about the project. This is also helpful to calibrate the CBA so as to more closely match real-life conditions and derive results that lead to appropriate decisions (see also module "communication, outreach and policy impact").

Another benefit of a CBA approach is linked to the embedded quantification of monetary flows. This can help assess whether there are any potential short-term financial barriers to action, and how much they represent. This can help inform financial engineering, with consideration of different forms of funding and redistribution between different (types of) stakeholders.

It is also very important to consider on what time-scale the change (project) occurs in order to give an appropriate timeframe to the cost-benefit analysis. Again, this can be fostered by stakeholder participation for greater assessment accuracy. The constraints faced by stakeholders, the area of interest and the chosen timeframe impact the amounts and variation of costs and benefits across stakeholders, space and time. These constraints should also be identified as part of the context to better frame the cost-benefit analysis and potential associated risks. Cost-benefit analysis can also be undertaken separately for each stakeholder or group of stakeholders if deemed necessary.

02 "With project" and "without project" scenarios

Since economic cost-benefit analysis is the focus, and unless otherwise specified, the term benefit is used from now on to refer to monetary estimates of benefits derived. 'With project' refers to the proposed change to be introduced (often in the form of a project), and 'without project' refers to business-as-usual.

The net benefit derived from the project is computed as follows:

With project net benefits = With project benefits – With project costs

Even if doing business-as-usual, benefits and costs vary from one year to the next. The likely pattern of variation in costs and benefits (or in prices and quantities) needs to be identified.

Similar to the with project scenario, the without project (or business-as-usual) net benefit can be computed as follows:

Without project net benefits = Without project benefits – Without project costs

A cost-benefit analysis compares the net benefit derived from implementing the project to the without project net benefits for each stakeholder (or each stakeholder group).

The incremental net benefit is derived as follows:

Incremental net benefit = With project net benefits – Without project net benefits

The idea is that the project is worth undertaking if the incremental net benefit is positive, i.e. if the net benefits are greater for the with project scenario than for the without project scenario. This requires knowledge of the economic values for the costs and benefits and their timing as detailed in the following sections.

Costs and benefits related to land use

Benefits and costs can be estimated from unit quantities and prices. Table 2 below shows examples of quantities and unit prices that can be used to estimate costs and benefits for a range of land uses. For example, the benefits associated with agriculture are yields multiplied by the number of hectares cropped yields multiplied by the price per ton of crop. For a national park, benefits correspond to the number of visitors yields multiplied by the entry fee charged per visitor. The benefits derived from carbon storage are the number of tonnes of carbon stored multiplied by the price per tonne of carbon.

Costs can be decomposed into variable costs and fixed costs. Variable costs vary with the quantity

TABLE 2

Examples of quantities and prices to estimate costs and benefits for different land uses
Source: adapted from Quillérou 2014

Type of land use	Agriculture	National park or conservation area	Carbon storage
Benefits			
Quantities	Crop yield (tonnes/ha) multiplied by area cropped (ha); Number of animals (kg of meat)	Number of visitors (country nationals, foreign tourists …)	Number of tonnes of carbon stored
Prices (per quantity unit)	Market price for crops; Market price for animals; Market price for meat	Entry fee per visitor; willingness to pay per visit (if no entry fee is charged)	Carbon market price
Costs			
Quantities	Quantity of agricultural inputs (fertiliser, water, seeds, animal feed and fodder, fuel and machinery, family labour, hired labour …)	Number of park employees (park rangers, welcome centre …) multiplied by work days kWh of electricity used	Number of trees planted
Prices (per unit quantity)	Market price per unit agricultural input; labour wage	Labour wage Price of kWh	Price per tree seedling

used for production (the higher the quantity used, the higher the cost). This is the case for labour, fuel, inputs such as fertilisers etc. Fixed costs do not vary with the level of utilisation (e.g., insurance, building depreciation, subscriptions to the electric grid).

The gross margin and net income can then be computed for a given year as follows:

Gross Margin = Benefits – Variable costs

Net income = Gross Margin – Fixed costs

CHAPTER

03

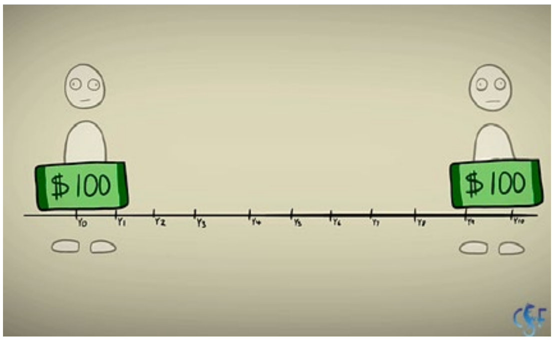
Time preference and discounting (social discount rate or factor)

People often show a preference for receiving money now rather than later, which shows there is a time preference for the present. It is the same principle behind earning interest on savings in a bank account: the bank pays extra for leaving money in the account to compensate the account holder for not spending it today.

FIGURE 2

Time preference

Source: Conservation Strategy Fund



Costs and benefits typically incur at different times of a project. These are not directly comparable because of inflation and time preferences. Preferences do not change significantly over the timeframe of the project (an assumption that needs to hold up to real-life). To undertake a cost-benefit analysis, all costs and benefits need to be comparable in how they are measured (price system), their currency as well as in time. They therefore have to be expressed in a common price system (or referential), a common monetary unit, and a common time reference point.

Real prices can be derived from observed nominal prices by correcting for inflation. To assess whether a project is worth investing in, the incremental net benefits need to be made comparable in time before they can be summed up. **Discounting is the technique used to express economic or financial values at one chosen point in time by estimating their 'time-equivalent'.** Costs and benefits occurring in the future are discounted to obtain the value they would have if they were occurring today (their equivalent in today's terms). **Such discounted value is called present value.**

What is discounting?

Discounting means multiplying an amount by a discount factor to compute its present value (the 'discounted value').

Adapted from: *http://www.businessdictionary.com/definition/discounting.html*

In CBA, the social discount rate is given by the answer to the question: at what rate should society be compensated in the future for giving up a unit of consumption today such that overall well-being is preserved (OECD 2018)?

The current value of future benefits and costs is computed as follows:

Present Value = Discount Factor * Value

The discount factor always includes a **discount rate**. The discount factor directly reflects on time preferences. Several formulae exist for the discount factor, based on different assumptions on how the discount rate impacts values over time.

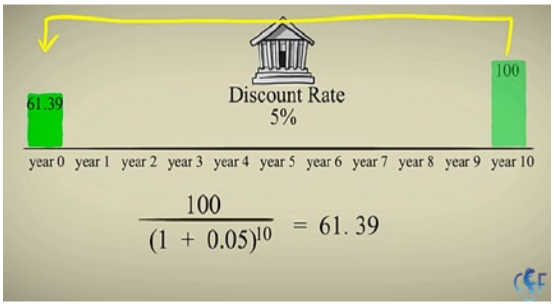
One of the most common formulae of the discount factor is:

$$\text{Discount Factor} = 1/(1+r)\wedge(t-1) = \frac{1}{(1+r)^{t-1}}$$

where r is the discount rate (social discount rate in an economic analysis) and t is the year (assuming year 1 is the year taken as time reference). When applying the formula, the discount factor is multiplied by the value that needs to be discounted (see figure 3).

FIGURE 3

Discounting (with year 0 as time reference. 100 USD are discounted at a rate of 5 %)
Source: Conservation Strategy Fund



The further in the future the cost and/or benefit occurs, the less it is worth today, because of time preferences. Also, the higher the rate of discount (r), the less the future is worth compared to the present. A simple way of remembering this is that **the higher the rate of discount is, the quicker an amount of money loses value in time**.

Economists call the preference for the present (i.e. "getting the money today") a positive time preference. People are said to have a zero time-preference when they are indifferent between getting the money in the present or in the future. If they prefer getting money in the future rather than the present, they are said to have a negative time preference. These terms correspond to the sign of the discount rate used (e.g. positive time preference for a positive discount rate). Table 3 provides a computation example.

Because of the timing of costs and benefits, **the choice of a discount rate is not neutral and can influence the decision to undertake a project or not**. A project that starts with high costs and have benefits later is less likely to be undertaken when a higher discount rate is used (giving a lower weight to later benefits than a smaller discount rate). This typically characterises environmental improvements. On the contrary, a project that starts with high benefits and have costs later (e.g.

TABLE 3

Example of timing of benefits and computation of their present value
Source: Quillérou 2014

	Year 1 (present)	Year 2	Year 3	Year 4
Benefit	100	140	200	200
Discount rate	10 %	10 %	10 %	10 %
Discount factor	$\frac{1}{(1+10\,\%)^{1-1}}$ = 1	$\frac{1}{(1+10\,\%)^{2-1}}$ = 0,9091	$\frac{1}{(1+10\,\%)3-1}$ = 0,8264	$\frac{1}{(1+10\,\%)^{4-1}}$ = 0,7531
Present value = Discount factor * Benefit	100	127	165	150

a nuclear power plant) is more likely to be undertaken for a high discount rate and less for a lower discount rate.

Choosing the appropriate rate of discount can be challenging. The rate varies across space, time and groups and is generally higher in younger and/or less developed countries. The chosen rate of interest often reflects current generation's time preferences and ignores future generation's time preferences. Future generations are not yet here to signal their time preference and their influence tends to be ignored when choosing a discount rate. The more the present time has value to current generations (i.e. the higher the discount rate) the more weight is given to present generations compared to future generations.

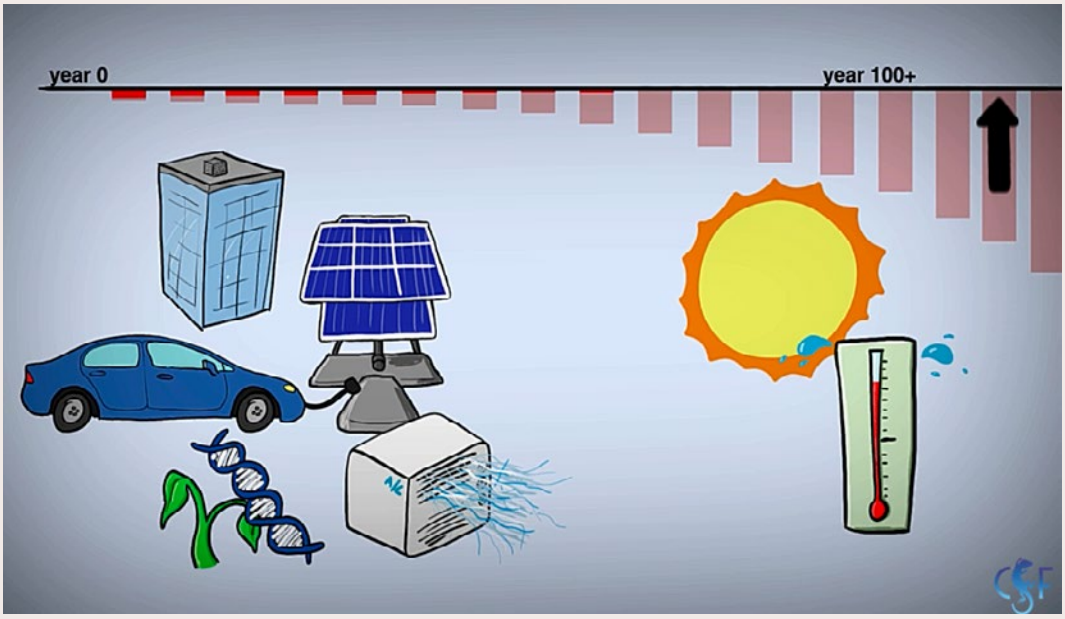
By design, a lower discount rate assumes more intergenerational equality than a higher rate. The Stern Review on the Economics of Climate Change caused controversy at the time of its release (2006), because it considered a 1.4% rate of discount. Such discount rate is a relatively low value under current practices, and gives almost equal weight to both today and tomorrow's generations.

The social discount rate should, in theory, be determined based on current and future preferences of society as a whole for the present, but also reflecting on current and future preferences for intergenerational equity. A good cost-benefit analysis should include a discussion on the consequences the chosen rate of discount rate has for future generations. As a result of this time preference, strong identification of when benefits and costs arise is important to derive valid conclusions from a cost-benefit analysis. The **discount rate is a choice that needs to be justified and the consequences of this choice must be discussed**.

The OECD, in its 2018 book on CBA and the environment comments as follows: "Discounting is both a critical and pervasive issue in CBA, and this is nowhere more so than in environmental applications. On the one hand, this is a technical matter

FIGURE 4

Low discount rates show a high interest for the future
Source: Conservation Strategy Fund



arising from the standard assumption in CBA that the social or shadow price of a unit of consumption in the future is lower than the price of a unit of consumption today. The discount rate simply measures the rate of change of the shadow price. This simplicity is, of course, a matter of extent. While the theory of social discounting shows clearly how the social discount rate should be defined, in practice numerous questions arise especially when considering actions with implications for generations in the far distant future, intergenerational projects and policies. Not only do the assumptions underpinning conventional discounting become problematic, but also the ethical underpinnings of discounting become extremely important and influential" (OECD 2018).

Discounting is still a debated issue in the scientific literature, between normative and positive approaches. The publication by Grollier 2012 on the economics of discounting can help inform how to set up an appropriate discount rate (see further reading materials).

Since 2016, discount rates applied in ex ante policy assessments have varied between 1 and 8% in the context of industrialised countries (OECD 2018, p. 416). Snell (2011, Appendix E p205) mentions 8–15% as the usual range of applied discount rates, most in the 10–12% range. A sound discussion of the chosen discount rate as well as the use and discussion of additional rates could be an option to include a range of perspectives and to discuss potentially different results. For instance, 10% could be used as the 'typical' development bank rate to establish a CBA basis. Cross-checking the conclusions from the economic indicators hold for 1% (developed country perspective for environmental projects) and 20% (poor populations in low income countries), or even increasing the discount rate to 50% and 100%, could help assess whether differing time preferences between actors could cause a project to fail.

What are shadow prices?

In simple terms, a shadow price is a price hiding in the shadow of a market price. Market prices do not always measure preferences accurately, because of market distortions or market failures.

A shadow price reflects the opportunity cost of an activity or project to a society, computed where the actual price is not known or, if known, does not reflect the real sacrifice made.

Source: http://www.businessdictionary.com/definition/shadow-price.html

What are opportunity costs?

A benefit, profit, or value of something that must be given up to acquire or achieve something else. Since every resource (land, money, time, etc.) can be put to alternative uses, every action, choice, or decision has an associated opportunity cost.

Opportunity costs are fundamental costs in economics, and are used in computing cost benefit analysis of a project. Such costs, however, are not recorded in the account books, but are recognized in decision making by computing the cash outlays and their resulting profit or loss.

Source: http://www.businessdictionary.com/definition/opportunity-cost.html

The (social) opportunity costs of capital corresponds to the rate of interest that would be earned by placing the money in a bank account rather than spending it now.

Source: Quillérou 2014

04 Economic indicators to conclude on a project worth

Several indicators have been developed to assess whether a project is worth implementing. Three indicators used for assessment are detailed here: the net present value (NPV), the internal rate of return (IRR) and the benefit-to-cost ratio (BCR).

Net present value

The net present value or net present worth is computed after all economic values have been obtained and/or estimated. The net benefit for the with-project scenario is computed by subtracting the costs from the benefits for all years. The same is then done for the without-project scenario. The net incremental benefit corresponds to the extra benefit derived from the project and is computed by subtracting the "without project net benefit" from the "with project net benefit".

The discounted value of the incremental net benefit is then computed taking year 1 (or year 0) as the year of reference and a specific discount rate. **The NPV is the sum of the present value across all years.** When computed from incremental net benefits, it gives an indication of whether the project will add to business as usual. These computations are illustrated in table 4.

The project is considered worth undertaking for a NPV greater than 0 (positive) and not worth undertaking for a NPV less than 0 (negative). The NPV can be used in a financial or an economic cost-benefit analysis. This indicator does not allow comparisons across alternative projects, especially if they mobilise different resources. It only allows to make a decision on whether a given project is worth undertaking or not. For instance, for a project with a NPV of 100 and a project with a NPV of 1, both projects are worth undertaking. However, the project with the lowest NPV might be of more value to society as a whole. This is because NPV values are not comparable for projects with different timeframes, scale and scope. The internal rate of return can be a better indicator for comparison between alternative projects (although the validity of such a comparison is also contested).

What is a net present value (NPV)?

NPV reflects the difference between the present value of the future cash flows from an investment and the amount of investment. Present value of the expected cash flows is computed by discounting them at the required rate of return.

For example, an investment of $1,000 today at 10 % will yield $1,100 in cash flow at the end of the year; therefore, the present value of $1,100 at the desired rate of return (10 %) is $1,000. The amount of investment ($1,000 in this example) is deducted from the expected cash flow to arrive at the net present value, which here is zero ($1,000 – $1,000). A zero net present value means the project repays original investment plus the required rate of return.

A positive net present value means a better return, and a negative net present value means a worse return, than the return from zero net present value. It is one of the two discounted cash flow techniques (the other is internal rate of return) used in comparative appraisal of investment proposals, where the flow of income varies over time.

Source: http://www.businessdictionary.com/definition/net-present-value-NPV.html

TABLE 4

Example of timing of benefits and the computation of the net present value
Source: Quillérou 2014

With project

	Year 1 (reference)	Year 2	Year 3	Year 4
Benefit	100	140	200	200
Cost	300	150	0	0
Net benefit	- 200	- 10	200	200

Without project (business-as-usual)

	Year 1 (reference)	Year 2	Year 3	Year 4
Benefit	100	90	90	90
Cost	80	80	80	80
Net benefit	20	10	10	10

Incremental net benefit = net benefit (with project) minus net benefit (without project)	- 220	- 20	190	190
Present value of incremental net benefit (at 10 % discount rate)	- 220	- 18	157	143
Economic net present value (at 10 % discount rate)	= - 220 – 18 + 157 + 143 = 62			

Internal rate of return

The Internal Rate of Return (IRR) is the discount rate at which the net present value equals zero. In other words, it corresponds to the maximum interest rate that can be earned from investing resources in a project. It is not just a return on capital investment but a return on all types of resources invested in a project (capital but also labour and natural resources). The internal rate of return is therefore conceptually different from an interest rate on capital investments. The project is accepted for an IRR equal to or greater than the opportunity cost of capital. The opportunity cost of capital is the interest rate that can be earned from investing the same resources in the next best alternative project. It is often assumed equal to the rate of return on capital investments.

The IRR is derived through interpolation, by changing the discount rate until at least one positive and one negative NPV are obtained. Going back to the previous example (table 4), NPV = 62 (monetary units) at a 10% discount rate. If the discount rate increases to 25%, the NPV becomes -17. The IRR can be computed using the following formula:

$$\textbf{IRR = lower discount rate + difference between rates} * \frac{\textbf{NPV at lower rate}}{\textit{sum NPV}} \textbf{ NPV (signs ignored)}$$

In the above example, IRR = 10% + (25% - 10%) * 62 / (62 + 17) = 21.8%. This means that the project would lead to an internal rate of return of 21.8%. This is higher than the interest rates paid by banks on savings (opportunity cost of capital), so the project is worth undertaking. The IRR value is prone to measurement error, but its accuracy can be improved by changing the discount rates until obtaining a positive and a negative NPV that are both close to zero. It is important to note that the internal rate of return does not always have a unique value, in which case the IRR values cannot be used to decide on whether a project is worth.

What is an internal rate of return (IRR)?

One of the two discounted cash flow techniques (the other is net present value or NPV) used in comparative appraisal of investment proposals where the flow of income varies over time. IRR is the average annual return earned through the life of an investment and is computed in several ways. Depending on the method used, it can either be the effective rate of interest on a deposit or loan, or the discount rate that reduces to zero the net present value of a stream of income inflows and outflows. If the IRR is higher than the desired rate of return on investment, then the project is a desirable one.

However, it is a mechanical method (computed usually with a spreadsheet formula) and not a consistent principle. It can give wrong or misleading answers, especially where two mutually exclusive projects are to be appraised.

Source:
http://www.businessdictionary.com/definition/internal-rate-of-return-IRR.html

Benefit-to-cost ratio (or cost-benefit ratio)

The benefit-to-cost ratio (BCR) is the first indicator that has been historically adopted by project managers to assess projects. It is the ratio obtained by dividing the present value of the benefit stream by the present value of the cost stream. Present values are derived using the opportunity cost of capital as the discount rate. A project is accepted if the BCR is greater than or equal to 1, meaning benefits are greater than costs.

What is a benefit-to-cost-ratio (BCR), also called cost-benefit ratio?

Comparison of the present value of an investment decision or project with its initial cost. A ratio of greater than one indicates that the project is a viable one.

Source:
http://www.businessdictionary.com/definition/cost-benefit-ratio.html

Building from table 4, the relevant values can be computed and are summarised in table 5. The BCR is 170% for an opportunity cost of capital of 10% and the project is therefore considered worthwhile.

TABLE 5

Example of timing of benefits and the computation of the cost-to-benefit ratio
Source: Quillérou 2014

With project

	Year 1 (reference)	Year 2	Year 3	Year 4
Benefit	100	140	200	200
Cost	300	150	0	0
Net benefit	- 200	- 10	200	200

Without project

	Year 1 (reference)	Year 2	Year 3	Year 4
Benefit	100	90	90	90
Cost	80	80	80	80

Incremental benefit	100 - 100 = 0	50	110	110
Present value of incremental benefit (at 10 % discount rate)	0	45	91	83
Incremental cost	300 - 80 = 220	70	- 80	- 80
Present value of incremental cost (at 10 % discount rate)	220	64	- 66	- 60
Benefit-to-cost ratio	= (0 + 45 + 91 + 83) / (220 + 64 - 66 - 60) = 170%			

Evaluation of a project using several indicators of a project worth

All three indicators are complementary and when possible should be computed to assess a project's worth. Each of them is criticised in one way or another, and none of them is enough to compare across project alternatives. As for any other indicator, it is not their value that matters, but rather how this value compares to a set threshold (0 in the case of NPV, opportunity cost of capital for IRR and 1 for BCR). Binary decisions are made from these indicators, regardless of their exact values: accept or reject project (for a specific set up). In the example used above, all three indicators lead to conclude that the project is worth undertaking. However, these indicators do not necessarily always lead to the same conclusion, in which case a further formal discussion on whether the project is worth undertaking needs to be included with the cost-benefit analysis.

All indicators can be computed in a financial setting (i.e. when costs and benefits correspond to actual money flow in the economy) as well as in an economic setting (where costs and benefits correspond to the values allocated by society as a whole, which may or may not match observable market prices). In the case of a financial analysis, the economic indicators of a project's worth can be referred to as "financial indicators".

05 Derivation of economic costs and benefits from financial values

A financial analysis is based on the financial costs and benefits to participants (individuals, firms, organisations) whereas an economic analysis is based on the costs and benefits to society as a whole. Financial costs and benefits are observed through market prices, user fees or the like. In case of ELD studies, the interest is in both economic and financial values: financial because they are related to the world stakeholders are operating in, and economic because of the wider aspects under consideration with consequences for society as a whole.

Economic values are referred to as **shadow prices** (see box in section 3), as they are “in the shadow” of the financial values that can be observed in real-life. Economic values correspond to opportunity costs and/or willingness to pay for the goods and services considered from the point of view of society as a whole. In simpler terms, shadow prices reflect the true value allocated by society on something.

One of the easiest ways to undertake an economic cost-benefit analysis is to first perform a financial analysis and then adjust each financial value to derive its economic equivalent. Adjustments between financial and economic values are needed because of market price distortions that arise when markets are not perfectly competitive. The type of adjustment varies with:

(i) the type of value being considered (transfer payments, traded good, non-traded tradable good, non-traded non-tradable goods);
(ii) the reference system adopted for measuring the costs and benefits (world or domestic price system); and
(iii) the currency (domestic or foreign) in which benefits and costs are expressed.

The adjustment process outlined below leads to the shadow values required for an economic cost-benefit analysis.

In simple terms, economic values can be derived or estimated from financial values in three steps:

- Step 1 – Adjust for transfer payments (taxes and subsidies);
- Step 2 – Adjust for price distortions in traded goods;
- Step 3 – Adjust for price distortions in non-traded goods (tradables and non-tradables).

Step 1 – Adjust for transfer payments (taxes and subsidies)

Step 1 consists in removing transfer payments from the financial values, i.e. payments that corresponds to a redistribution of wealth within society. This is a step undertaken for values expressed in the domestic price system only. They change the financial incentives faced by an individual, which is why they are factored in financial analysis. They do not change the wealth of society as a whole (taken as closed system), hence why they are removed in economic analysis. Taxes and subsidies are typical examples of this kind of redistribution. This also applies to user fees that are transferred from a user to a provider within a given society.

What are transfer payments?

One-way payment of money for which no money, good, or service is received in exchange. Governments use such payments as means of income redistribution by giving out money under social welfare programs such as social security, old age or disability pensions, student grants, unemployment compensation, etc. Subsidies paid to exporters, farmers, manufacturers, however, are not considered transfer payments. Transfer payments are excluded in computing gross national product.

Source: http://www.businessdictionary.com/definition/transfer-payment.html

Step 2 – Adjust for price distortions in traded goods

Step 2 consists in adjusting the financial price values to remove market imperfections and distortions introduced by policies such as minimum wage or land market regulations.

There are two different aspects that need to be checked upon to ensure that economic values are measured and expressed in a consistent way: the point of reference and the currency. Shadow prices are derived using the same point of reference for measuring their values, e.g. using a world or a domestic price system. Changing the point of reference used for measuring prices can change their value (values are relative to the referential chosen for measuring them).

In the world price system, the opportunity costs to the country of traded goods are assumed to correspond to border prices. These opportunity costs are valued using incoterms (international trade terms) such as the CIF (cost, insurance, freight) for imports and the FOB (free on board) for exports.

In the domestic price system, economic values correspond to what society is willing to pay for goods and services. For both price systems, economic values can be expressed either in a foreign currency or the domestic currency. When values are expressed in different currencies, the shadow exchange rate (SER) is used for conversion of values into one single currency for consistency.

Step 3 – Adjust for price distortions in non-traded goods (tradables and non-tradables)

Step 3 consists in adjusting the values of tradable but non-traded goods (i.e. goods that can theoretically be traded but are not traded in practice) in the world price system. This can be done by using a conversion factor when financial prices are considered good estimates of opportunity costs. The conversion factor is the ratio of the shadow price to the domestic market price. It is called standard conversion factor when an average ratio is used. Non-tradable goods need to be valued using specific economic valuation methods in order to estimate their opportunity costs. In the domestic price system, the values of non-traded and non-tradable goods are estimated based on their opportunity costs. Table 6 summarises the adjustments to be made depending on the price system used.

The actual transformation is a bit more complex than detailed above but the above shall an idea of how to adapt a financial cost-benefit analysis into an economic cost-benefit analysis.

Because an economic cost-benefit analysis adopts the perspective as society as whole, it can be used to assess the desirability of a project from this perspective. It does not, however, reflect on incentives faced by individual stakeholders or stakeholder groups and **should thus be complemented by a financial cost-benefit analysis** for a thorough assessment of the proposed project.

TABLE 6

Adjustments to derive shadow prices from financial prices (simplified)
Source: Smith 2006

		Price system	
		World	**Domestic**
Shadow prices	Traded goods	CIF (cost, insurance, freight) FOB (free on board)	Delete taxes and subsidies Shadow Exchange Rate
Shadow prices	Non-traded goods	Conversion Factor Standard Conversion Factor Opportunity Cost	Opportunity Cost Correct for price distortions

Once transfer payments have been removed and shadow economic values of costs and benefits estimated, the economic indicators – i.e. the net present value, the internal rate of return and the benefit-to-cost ratio – already used for the financial analysis can be derived again, from the perspective of society as a whole this time round.

The values of indicators derived from economic analysis often do not match those of the financial analysis, and may sometimes lead to contradicting conclusions. Ultimately, the decision to undertake the project or not when indicators are contradictory between financial and economic analyses will depend on how much priority is given to actual financial flows over values to society as a whole. It may be socially acceptable to go ahead with a development project that leads to small losses for society as a whole (negative NPV in the economic analysis) but that allows poor stakeholders to benefit from it (positive NPV in the financial analysis). Or it may not. This discussion depends on the specific context of the study, social and political acceptability of different options under review.

Uncertainty and sensitivity analysis

Because cost-benefit analysis can always be set up to give the results we want, it is important to lay out assumptions behind the analysis, describe how such assumptions match real-life conditions and behaviours, and discuss the results derived from the analysis and indicators very thoroughly. It is very easy to overlook some less desirable aspects that may arise in real-life, but that may act as strong barriers to effective action.

One of the limitations of cost-benefit analysis is that it often relies on average or 'typical' values for quantities, prices, costs and benefits. This means that the analysis and the economic indicators derived from it provide a good idea of whether the project is worth undertaking on average. This approach fails to consider the viability of the project under extreme events such as droughts, floods, food crises, or financial crises. This is important as high variability may constitute a choking factor for the project and impair its adoption. Extreme weather events are becoming more frequent as a consequence of climate change and their impact at the local level can often no longer be dismissed as marginal.

To assess project viability under extreme events, a sensitivity analysis can be conducted. A sensitivity analysis aims to assess consequences on the project's worth for risks arising from the project itself or external forces. **The question behind sensitivity analysis is: do the conclusions derived from the economic indicators for average conditions hold under extreme events?** A good sensitivity analysis helps assess the resilience of the consequences of project implementation and its social consequences. This is particularly critical to assess whether livelihoods of already fragile populations can be sustained even under extreme events or not.

What is a sensitivity analysis?

Simulation analysis in which key quantitative assumptions and computations (underlying a decision, estimate, or project) are changed systematically to assess their effect on the final outcome. Employed commonly in evaluation of the overall risk or in identification of critical factors, it attempts to predict alternative outcomes of the same course of action. In comparison, contingency analysis uses qualitative assumptions to paint different scenarios. Also called what-if analysis.

Source:
http://www.businessdictionary.com/definition/sensitivity-analysis.html

A simple way of conducting a sensitivity analysis is to identify the main quantities and/or prices that are likely to change, e.g. because of droughts, floods, changes in inputs or fluctuations in commodity prices on the world market. This can be done in consultation with the relevant stakeholders and/or based on local or international expert opinion. The average values originally used in the cost-benefit analysis are changed to the new "extreme" values and the economic indicators of a project's worth are recalculated to assess whether the project remains economically worth implementing.

If the project is worth doing on average but not under extreme events, a policy-maker might can take one of two possible decisions: forget about the project or mitigate the impact of extreme events by providing some form of safety net (e.g., insurance scheme, subsidies) for when these extreme events occur, especially for projects targeting fragile populations. This decision depends on wider political considerations and needs to be discussed with the relevant stakeholders to figure out what the best applicable solution is.

Alternatively, the values of quantities and prices of inputs (raw materials, labour, minimum wage, discount rate, etc.) can be changed to obtain "switching values" – the values for which the project becomes economically undesirable (e.g. the input value which leads to NPV = 0). One value and/or a bundle of values at a time can be changed. There is need to estimate whether the values under which the project becomes economically undesirable are likely to arise or not, in light of previous and future biophysical and economic patterns and by discussions with local and national stakeholders and experts. Depending on the results and consultation with stakeholders, the sensitivity analysis is done and/or the need for the project to introduce safety net mechanisms can be discussed.

Financial or economic assessment should be supplemented by a social analysis and an environmental analysis to assess the consequences of the project on the different populations (ethnicities, villages, etc.) as well as on the environment (pollution, natural resource availability, etc.). These are essential to assess accurately the success and resilience of the project considered for implementation.

In conclusion: CBA is a tool that allows great leeway in how it is set up so as to explore different options for project set up, identify barriers to adoption. Its quality relies on the analyst competence to set it up and ground it in real-life as well as to discuss CBA set up, numerical results and implications. Numerical results can give a false impression of extreme accuracy, while the analysis relies on orders of magnitude rather than exact numbers in the first place. CBA is a tool that can be used to help inform decisions – or discussions in decision-making processes – but which results cannot be taken at face-value without proper discussion weighing different implications.

List of references

Snell, Michael. 2011. Cost-benefit analysis. A practical guide. London, UK

Quillérou, Emmanuelle. 2014. 'The Economics of Land Degradation. Principles of economic analysis and valuation for sustainable management of land'. Materials prepared for the ELD's Massive Open Online Course 2014 by the United Nations University Institute for Water, Environment and Health (UNU-INWEH)

OECD, 2018. Cost-Benefit Analysis and the Environment: Further Developments and Policy Use, OECD Publishing, Paris. *http://dx.doi.org/10.1787/9789264085169-en*

Smith, Lawrence E.D. 2006. Project planning and management, Course C34, Imperial College London. Original version 2001, Reprinted 2006. Distance learning and face-to-face teaching and learning material.

Further reading

(these books are unfortunately not available for free online, but need to be purchased):

Snell, Michael. 2011. Cost-benefit analysis. A practical guide. London, UK

Gollier, Christian. 2012: Pricing the Planet's Future. The Economics of Discounting in an Uncertain World. Princeton University Press: *https://press.princeton.edu/titles/9894.html*

Curry, Steve and Weiss, John. 1993: Project analysis in developing countries

Potts, David 2002: Project planning and analysis for development

Belli, Pedro et al. 2001: Economic Analysis of Investment Operations World Bank Institute. WBI Development Studies

OECD, 2018. Cost-Benefit Analysis and the Environment: Further Developments and Policy Use, OECD Publishing, Paris. *http://dx.doi.org/10.1787/9789264085169-en*

List of figures

List of tables

For further information and feedback please contact:

ELD Secretariat
Mark Schauer
c/o Deutsche Gesellschaft
für Internationale Zusammenarbeit (GIZ) GmbH
Friedrich-Ebert-Allee 36
53113 Bonn
Germany
E info@eld-initiative.org
I www.eld-initiative.org

This document was published with the support of the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ)

Photography: Front and back cover © Christina Ketter / GIZ
Design: kippconcept gmbh, Bonn
Bonn, September 2019

www.eld-initiative.org
#ELDsolutions