Cost Benefit Analysis I: Introduction - Key Concepts

1. Cost Benefit Analysis (CBA)

To calculate the profitability of an enterprise or a project, a ***cost-benefit analysis (CBA)*** is often used**.** CBA is a widely used financial and economic appraisal tool for projects. It is particularly useful when a choice has to be made out of several projects (selection), and when the project involves a stream of benefits and costs over time, covering more than one year (from several to dozens of years (usually 20 years is taken as a maximum).

In the agricultural sector, CBA is used also for agricultural projects or large estates, examples being irrigation projects and estates with perennial crops and corresponding processing facilities, e.g. palm oil. The basic idea here is to find out if the investment in construction and yearly maintenance and operational costs of the irrigation scheme is justified in terms of a higher agricultural production and agricultural incomes (benefits).

Cost Benefit is a standardized tool, but can take several forms, and is usually complemented with other types of analysis. An overview is provided in Table 1.

Table 1 Tools for financial and economic appraisal

Main type	Technique	Main issues
Financial	Cash flow analysis (CFA)	Throughout the project period is sufficient money available to cover outlays (*liquidity, sustainability*)?
		To what extent should beneficiaries pay for services (*cost recovery*)?
		Are funds available to cover investments (*financing plan*)?
	Financial Cost-Benefit Analysis	Over the lifetime of a project, do revenues justify investments to private investors (*profitability*)?
	Financial Cost-Effectiveness Analysis (CEA)	Which alternative gives the highest revenues per unit of costs (or the lowest costs per unit of revenue)?
	Financial Statements	Is the organisation that will ultimately incorporate a project in its activities financially in a healthy condition?
Economic	Analysis of context	What economic problem the project is intended to address?
		Are external economic conditions favourable to the project?
	Economic Cost-Benefit Analysis	Over the lifetime of the project, do benefits justify the use of scarce resources to society (*profitability*)?
	Economic Cost-Effectiveness Analysis	Which alternative gives the highest benefits to society per unit of costs (or the lowest costs per unit of benefits)?
Social	Social Cost-Benefit Analysis	How is the profitability of a project to society affected if normative views on income distribution are incorporated?
Mixed	Multi-criteria analysis (MCA)	What is the relative performance of project alternatives given their scores on financial, economic and other criteria?
	Logical Framework	Are the objectives, activities, inputs and outputs of the project, and external assumptions mutually consistent?

The first step in any CBA is to define and delineate the purpose of analysis, or to define the "project". A project can be described as an activity in which resources are being combined to achieve one or more goals. Resources can include labour, capital, know-how, natural resources etc. Conserving a natural area can also be considered a project. A farm can also be called a project.

Project promoters often favour comprehensive or integrated projects. For instance, a proposed rural development project may comprise activities such as provision of seed and fertiliser, agricultural extension services, construction of irrigation works, credit schemes, support to trade unions, and improvement of basic needs provision. Should CBA focus on the complete set of activities, or on separate activities?

In the CBA philosophy, it is only useful to design integrated projects if overall objectives cannot be achieved without the implementation of all interdependent activities. If this is the case, CBA may focus on the overall project and not all the individual components of the project by themselves. However, in conducting CBA each component should be appraised separately, and their contribution to the overall project be made clear. This may result in a rethinking of project design and a more modest integrated project that achieves similar overall results.

A CBA can be made before the project starts (called: *ex-ante*) or after the project is completed (called: *ex-post*). A statement is usually needed on the economic feasibility of a project; therefore, most CBA's will be *ex-ante*.

2. "With Project" and "Without Project" Situation

Project proposals are often submitted to aid agencies, who then approve or reject them. Often, alternatives to the proposed project are not explicitly taken into account. The CBA, however, always compares the situation with and the situation without the project. This is needed, because in CBA only the *effects* that may be attributed exclusively to the project should be considered. In the CBA way of thinking *effects* are defined as changes that take the form of additional costs and additional benefits.

The "without project" is usually referred to as the "without-case", or "base-case", or "zero-case". It will be made clear, that the distinction between the "with project" and "without project" is not the same as the "before-project" and "after-project" situations.

Consequently, in the CBA approach, two basics questions are raised:

1. What would happen if the project were not implemented? This fundamental question is often not raised, let alone answered. But a project is only justifiable if a country, a region, or a group is better off with the project than without it. A benchmark for consideration of a project is, therefore, the "without-case".

2. If the project is implemented (the "with-case"), could this be done in different ways? CBA stresses a search for alternatives to minimise the risk of ignoring more attractive opportunities. In early appraisal stages especially the question should be addressed whether the project proposed is really the best solution to a problem of a particular group or the society in general.

This basic principle will be illustrated by the following example of a road project.
A proposed project involves the rehabilitation of a road linking a regional town to the main capital. At present 1000 cars use this road daily. Three consultants were asked to estimate the benefits of road improvement. After project completion, they all agreed that 1400 cars would use the road daily. However, their estimates of the project benefits (i.e. additional daily traffic) were all different, namely 400, 100 and 800 cars. The outcomes varied from a 10% to 80% increase. The consultants give the following justifications for their estimates:

- Consultant 1: the benefit is 400 because this is the increase in daily traffic.
- Consultant 2: the benefit is 100 because even if the road is not rehabilitated, traffic will increase to 1300, because of autonomous economic growth in the region and drivers will still use the road, even when it is in a bad condition.
- Consultant 3: the benefit is 800 because without the project traffic would decline to 600 cars daily, because few drivers are willing to use the road when it continues to deteriorate further.

Consultant 1 sins against the CBA principle that *effects* should be estimated through *incremental analysis*. To see which changes in traffic may be attributed to the project, Consultant 1 should have investigated the difference between the expected situation if the project is implemented (the *with-case*) and what would have happened without the project (*without-case*). In fact, the focus was incorrectly on the difference between the traffic before (present, pre-project) and after the project. This approach is only correct if the project is the only factor influencing traffic. And this is not the case, so Consultant 1 is wrong.

Whereas both Consultant 2 and Consultant 3 apply the with-without principle soundly, they differ on traffic forecasting and consequently arrive at widely different estimates on the *without-case* and thus the project benefits. One of them or both of them may be wrong, depending on the quality of their traffic forecasts.

3. Costs and Benefits

3.1 Project effects

Costs can be described as the intended or unintended negative *effects* of a project; investments are also part of costs. Benefits can be described as the intended or unintended positive effects of a project. It is important to remember that costs and benefits can, therefore, be intended and expected or unintended and unforeseen. Many CBAs only take into account the intended costs and benefits, and unintended costs and benefits or external effects are not included. If this is the case the analysis only show part of the picture and may lead to wrong decisions.

3.2 External effects (externalities)

External effects or *externalities* play an important role in CBA. They refer to welfare changes in society attributable to the project, for which the project does not pay or receive financial compensation (i.e. there is no balancing outlay or receipt item). The project causes changes in its environment and others experience the consequences, either favourable (positive externalities) or detrimental (negative externalities). For example, in building a factory, the pollution of a river through wastewater (i.e. an unintended cost) does not show up in the CBA of that factory. Positive external effects may occur, for example related to training and health. If a child is effectively immunized against a transmittable disease, the direct benefit is that the child will stay healthy. Positive externalities arise because that child will not pass on the disease to others, with favourable impacts on productivity levels and health sector budgets.

3.3 Financial flows

The profitability of a project covers only cash-inflows and cash-outflows attributable to activities of the project. Therefore, CBA does not incorporate *depreciation*, as depreciation does not involve a *cash* payment or *cash* outlay. The argumentation is that the use of capital goods (such as machines and cars) is already fully reflected in two cash flows, namely investments and operation and maintenance costs. To include depreciation would simply imply double-counting.

Taxes may either be excluded (profitability before tax) or included (profitability after tax).

Cash flows related to funding (credit) are not taken into account. In this way, the profitability reflects the efficiency of the project itself, which than can be compared with alternative uses of the investment. This can be explained from two angles:

Firstly, take the example of a farmer, who is considering using his *own capital funds* to buy a tractor. He will pose a fundamental question in incremental analysis: will the tractor be more profitable than another investment (*the without case*)? In other words, what are his opportunity costs of capital? An alternative is to hire a tractor, and deposit the majority of the money at the bank and earn a certain level of interest. If the tractor is less profitable, it makes more sense to open an interest-bearing account.

Secondly, assume that the same farmer has to *borrow money* to start the project. The decision criterion for this entrepreneur will be whether the effect of the tractor on his income is large enough to meet his debt service obligations. In other words, the yield on his investment ("the project") should be higher than the (borrowing) bank rate.

3.4 Prices and inflation

In many countries, inflation is an important economic issue. However, In CBA usually the decision is taken not to take inflation into account for the reason that both benefits and costs will rise proportionally. In this case, one can take constant prices, picking a certain year (e.g. "2003 constant prices"). Alternatively, one can choose to take into account inflation and use current prices. This is more difficult, especially when it is difficult to predict what the inflation will be in the coming years.

3.5 Exchange rates

In many countries the exchange rate does not reflect the real price of the local currency, and is overvalued against international currencies, such as the US dollar or Euro. Equally, unexpected changes in the exchange rate may occur frequently, with important consequences for the economic actors. However, it is difficult to predict how devaluation or revaluation will develop in the future. Fluctuations in the exchange rate are, therefore, similar as inflation, usually ignored.

3.6 Cost Effectiveness Analysis (CEA)

Costs and benefits are not always tangible or cannot be expressed (easily, straightforward, non-arbitrary) in monetary terms. This limits the usefulness of a CBA. Benefits are often more difficult to assess than costs. For example, the benefits of a forest are more difficult to assess than the costs for maintaining that forest, or the value of reduced child mortality resulting from iron supplements is also hard to assess. In these cases, it may be more useful to conduct a "Cost Effectiveness Analysis" (CEA), which compares the costs of various alternatives that will satisfy a certain objective.

CEA is used to select the alternative with the lowest monetary costs per unit of physical benefits. In other words, CEA is confined to calculating the total discounted costs for each alternative.

Application of CEA requires that two important assumptions be met:

a) The expected outlays for each alternative for investments, recurrent costs and any other cost element (including external effects) are available in monetary (shadow-priced) terms;

b) The benefits are quantitatively and qualitatively equal for all alternatives.

4. Financial and Economic Analysis

There are two major forms of conducting CBA: financial or economic.

A financial CBA is made from the perspective of a person, group or unit directly involved in the project: a farm, for example. Only expenses that will be made by the farm and benefits that will accrue to the farm (i.e. not including the externalities) are taken into account in a financial analysis; this makes a financial CBA much simpler to calculate.

An economic CBA takes the broader perspective of society. This has various implications for calculating costs and benefits. First of all, all costs and benefits are taken into account, including externalities: costs and benefits that are attributable to the project but are borne or enjoyed by third parties not involved in the project. Secondly, in calculating prices, it is not the market price of a cost or benefit is used but the so-called real price, or its value to society. These prices are also called “shadow prices” or “opportunity costs”.

Economic CBA is especially important in environmental projects, because it focuses on the *value* of the environment to society. It can often occur that the financial analysis turns out to be unprofitable, but the economic analysis turns out to be profitable. For example, a forest that is conserved without logging can be unprofitable for the owner; the forest has to be maintained but does not generate any direct revenues. But to the society as a whole, the benefits enjoyed by the forest – water provision, tourism, wildlife, biodiversity, scenic beauty, etc - may outweigh the costs. Similarly, maintaining soil fertility may not be profitable for an individual farm or group of farms, but for the whole community or area, it can be beneficial.

An economic CBA may give researchers a bargaining tool to convince policy makers to invest in environmentally sound practices. Nevertheless, a positive economic analysis does not mean individual farms are profitable – so the practices involved may not be very attractive for the farmers to adopt, and may require subsidies from society to encourage the farmer to invest in such environmentally sound practices that lead to benefits that accrue to society and not just the farmer.

5. Discounting

Another basic characteristic of CBA is discounting. This is important as costs and benefit flows do not occur at the same time, and it makes a big difference when, after having made an investment (=costs), one has to wait a long time before benefits are generated. The principle is explained below.

The value of US$ 100 now is not the same as US$ 100 in one years’ time. If someone gave you the option: take the US$ 100 in cash now, or wait one year and then take it, what would you prefer? Generally, people would rather have something right away than wait for it. They are only willing to wait for something, if a bigger reward is promised. So, you might opt for US$ 130 in one years’ time instead of US$ 100 now. This is the consumption side of time preference.

There is also an investment side of time preference. The US$ 100 can be invested and in one years’ time a profit might be expected. The rate of time preference, or discount rate, is often equated to the interest rate. But a discount rate can also be picked, for instance on the basis of a certain expected or required rate of return. Many economists use discount rates from 8% - 12%.

All costs and benefits are “brought back” to the starting time. With the rates of 8-12%, a timeline of 25 years is usually applied. After this, the discounted costs and benefits have become so small that they become insignificant. For example, a sum of US$1000 discounted with 8% over 30 years has shrunk to U$ 99.40.

6. Net Present Value (NPV) and Internal Rate of Return (IRR)

The Net Present Value (NPV) and the Internal Rate of Return (IRR) are the most commonly used decision criteria of CBA. Less used is the Benefit-Cost Ratio (BCR). They are used equally for financial and economic CBA.

The sum of all discounted costs and benefits is called the Net Present Value (NPV). This sum reflects how much the project will earn. If the NPV is negative, clearly the costs outweigh the benefits and the project is not economically feasible.

Another way of analysing the costs and benefits of a project is calculating its Internal Rate of Return (IRR). The IRR is the rate with which the discounted costs equal the discounted benefits, that is it would be just break-even at that particular rate. The IRR can then be compared with a base line or standard rate, for example the current interest rate, or a certain minimum rate, and if the IRR is higher the project would be profitable.

The benefit-cost ratio BCR is similar to the NPV. Whereas the NPV is the *difference* between all costs and benefits, the BCR is the *ratio* of (discounted) costs and benefits. It is assumed initially that benefits are gross benefits, and costs are gross costs, which means that all costs (investments and recurrent costs) are added together. For a project to be selected, the BCR should exceed 1. The BCR is used least often, as there are no strict guidelines on how to treat recurrent costs: some analysts prefer to include them in the cost denominator, whereas others deduct them from the benefits. So the outcome depends on the approach followed. Although when systematically applied in all cases the problem is small, the NPV and IRR are preferred for their unequivocal outcomes.

Without the aid of computers, IRR calculations are cumbersome. Trial-and-error is used to determine NPVs for various interest rates; the interest rate at which the NPV becomes zero is the IRR. Pocket calculators and computers have made life much easier by producing an IRR for a set of cash flows and a start-level for the interest rate.

The *IRR* is the most popular profitability indicator, because it is a *relative* measure that allows a direct comparison between investments and market interest rates (yield). Nevertheless, there are two constraints on its use. Firstly, the use of the IRR in the case of *mutually exclusive projects* may lead to incorrect recommendations. Mutually exclusive projects occur if implementation of one project makes the other project impossible. For instance, if a site is used for a factory, it cannot be used for agriculture. The IRR may then suggest that the factory project is chosen, whereas the agriculture project would be preferable at a given discount rate. Secondly, the IRR cannot be used to *rank* project alternatives. If the IRR of alternative A is 15% and 20% for alternative B, the IRR does not prove that alternative B is better and should be selected. If the discount rate is 10%, *both* should be implemented.

The *NPV* is an *absolute* profitability indicator and, like the IRR, should not be used to *rank* project alternatives. A small, very profitable project may have a lower NPV than a large, marginally profitable project. The NPV simply shows whether a project should be selected or not. The advantage of the NPV is that it is also applicable in the case of mutually exclusive projects, when the IRR should not be applied.

A concrete example of the application of these decision criteria is presented in the annex to this concepts note.

7. Assumptions and sensitivity analysis

The outcomes of CBA in terms of NPV or IRR are meaningless, if the underlying *assumptions* are not soundly based. Discussions on financial and economic CBA studies should therefore primarily focus on assumptions, such as:

- Is the "right" world market price of that machine being used?
- Is it reasonable to assume that a processing plant reaches full capacity after three years?
- On what basis are operation and maintenance costs of a drinking water project set at 1 million Tanzanian Shilling a year?
- Is the "correct" discount rate being applied?

As uncertainty is often involved, and opinions may differ on the "right" prices or other assumptions regarding *effects*, many CBA studies include a *sensitivity analysis*.

Two approaches may be applied. The first option is to determine NPVs for different assumptions regarding costs and benefits (including prices and timing). An example of sensitivity is provided on the questions raised above:

- If the world market price of the machine is US$ 15,000 instead of US$ 10,000, then NPV declines from 235 to 56;
- If the processing plant reaches full capacity after five years instead of three years, then the NPV would be -50 instead of +80;
- If operation and maintenance costs are 20% higher, then the NPV is +5 instead of +20;
- If the discount rate is set at 7% instead of 14%, then the project is feasible instead of unfeasible.

Alternatively, *switching values* can be determined. These are the specific values of costs, benefits and timing that cause the project to switch from feasible to non-feasible. Switching values provide information on the cost and benefit items, for which the overall result is most sensitive. For instance, it may be found that - starting from initial assumptions - a 10% increase in investment costs would be needed to decrease the NPV from 234 to 0. An increase of 5% in the price of raw milk will mean that the processing plant no longer makes a profit. On the benefit side, a drop of 10% in the price of the final product would have the same result.

8. References and acknowledgements

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Annex: concrete example of application of decision criteria

To determine whether a project is profitable, financial cost-benefit analysis (CBA) may use one of the following decision rules:

- The *net present value* (NPV) should be positive;
- The *benefit-cost ratio* (BCR) should exceed 1;
- The *internal rate of return* (IRR) should exceed the interest rate.

These three rules are basically similar, and all state that a project fulfils the requirement that it is more profitable than a borrowing or lending interest rate (the *opportunity costs of capital*). The interest rate hence plays a crucial role, and is referred to as the *discount rate* or the *cut-off rate*.

We will show the use of these criteria by way of a simple example, see Table 1.

Table 1. Example cash flows of a 4-year project.

Year	0	1	2	3	4
Investments	-500				
Recurrent cost		-50	-50	-50	-50
Revenues		200	200	200	250
Net cash flow	-500	150	150	150	200

Should this project be approved? Someone unfamiliar with discounting would say yes, because after an initial investment of $ 500 the project earns a total of $ 650. If discounting is omitted, however, the principle of incremental analysis is ignored, particularly the time value of money. To obtain the net present value (NPV), all future cash flows are discounted to year 0. Using discount tables (or using calculators) with a 10% interest rate, the discounted or present values are obtained, see Table 2.

Table 2 Discounted or present values of the 4-four project

Year	0	1	2	3	4
Discount factor	1	0.909	0.826	0.751	0.683
Discounted investments	-500				
Discounted recurrent costs		-46	-41	-37	-34
Discounted revenues		182	165	150	171
Discounted net cash flow	-500	136	124	113	137

1. Net Present Value (NPV)

The cash flows are now comparable, and the NPV can be determined as the sum of the discounted cash flows:

NPV = -500 + 136 + 124 + 113 + 137

= 10

The NPV is positive, although the margin is small, and the project is financially profitable.

The general NPV formula is as follows:

$$NPV = \sum_{t=0}^{T} \frac{X_t}{(1+i)^t} = X_0 + \frac{X_1}{(1+i)} + \frac{X_2}{(1+i)^2} + \ldots + \frac{X_T}{(1+i)^T} \quad (1)$$

2. Benefit-cost ratio

The BCR would be calculated as follows:

BCR = discounted benefits/discounted costs

= (182 + 165 + 150 + 171)/(500 + 46 + 41 + 37 + 34)

= 1.02

The BCR exceeds (marginally) 1, hence the project is (marginally) profitable.

The general BCR formula is:

$$BCR = \frac{\sum_{t=0}^{T} \frac{B_t}{(1+i)^t}}{\sum_{t=0}^{T} \frac{C_t}{(1+i)^t}} 2$$

3. Internal rate of return

The IRR in the above example results in about 11%. The project is (marginally) profitable, because the IRR exceeds the interest rate of 10%.

The formula used to determine the IRR is the same as the NPV formula, but where the NPV is given (0) and the interest rate is to be determined:

if $NPV = \sum_{t=0}^{T} \frac{X_t}{(1+i)^t} 3 = 0$, then i = IRR