EFORWOOD
Tools for Sustainability Impact Assessment

Protocol for performing Cost-Benefit Analysis (CBA) and Cost-Efficiency Analysis (CEA) in EFORWOOD

Irina Prokofieva and Bo Jellesmark Thorsen

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Preface

This report is a deliverable from the EU FP6 Integrated Project EFORWOOD – Tools for Sustainability Impact Assessment of the Forestry-Wood Chain. The main objective of EFORWOOD was to develop a tool for Sustainability Impact Assessment (SIA) of Forestry-Wood Chains (FWC) at various scales of geographic area and time perspective. A FWC is determined by economic, ecological, technical, political and social factors, and consists of a number of interconnected processes, from forest regeneration to the end-of-life scenarios of wood-based products. EFORWOOD produced, as an output, a tool, which allows for analysis of sustainability impacts of existing and future FWCs.

The European Forest Institute (EFI) kindly offered the EFORWOOD project consortium to publish relevant deliverables from the project in EFI Technical Reports. The reports published here are project deliverables/results produced over time during the fifty-two months (2005–2010) project period. The reports have not always been subject to a thorough review process and many of them are in the process of, or will be reworked into journal articles, etc. for publication elsewhere. Some of them are just published as a "front-page", the reason being that they might contain restricted information. In case you are interested in one of these reports you may contact the corresponding organisation highlighted on the cover page.

Uppsala in November 2010

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Protocol for performing Cost-Benefit Analysis (CBA) and Cost-Efficiency Analysis (CEA) in EFORWOOD

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Summary

In this internal deliverable, the main stages of cost-benefit and cost-efficiency analyses (CBA and CEA) are reviewed. These techniques are used for the evaluation of the sustainability impact of global, European or local changes on the Forest Wood Chains (FWCs).

A particular attention is paid to the application of these techniques to the needs of EFORWOOD project. Implications for data collection and design of TOSIA-E are highlighted.

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1 Introduction

The objective of the EFORWOOD project is to develop a quantitative decision support tool (ToSIA) for sustainability impact assessment of the European Forest Wood Chain (FWC). The tool will permit the analysis of the sustainability impact of a wide variety of global, national and local changes (e.g. climate change, globalisation, urbanisation, technological innovations) on the FWC from economic, social and environmental perspectives. The evaluation of the sustainability impact is the central task of the WP1.5. The evaluation will be performed using three complementary approaches, which are cost-benefit, cost-efficiency and multi-criteria analyses.

1.1 Purpose of this report

This report provides a thorough overview of the main stages of the cost-benefit and cost-efficiency analyses paying particular attention to the applicability of the method for the needs of EFORWOOD project. Project deliverable PD1.5.1 on externalities has prepared ground for the incorporation of external effects into the cost-benefit and cost-efficiency analyses. The procedure of using multi-criteria analysis is described in detail in the project deliverable PD1.5.2.

Evaluation methods will form an essential part of a TOSIA+E version. The project deliverable PD1.4.4 defines an interface between the evaluation module and the TOSIA software, and discusses in detail how the cost-benefit analysis will be dealt with in TOSIA. Since TOSIA is performing calculations which are similar to those used in CBA, it is planned that the functionality of some aspects of CBA will be implemented inside TOSIA. Due to this fact, the current deliverable omits the discussion of the software development, as it is already described in the PD1.4.4. As a consequence, the title of the present report has been modified accordingly. The current report focuses exclusively on the description of the cost-benefit and cost-efficiency analyses and the implications they have for data collection and the design of TOSIA+E.

1.2 General concepts and application

Cost-benefit analysis (CBA) is a technique for the assessment of the relative desirability of competing alternatives (projects[1] or policy measures). In the context of the EFORWOOD project, CBA as well as a closely related cost-efficiency analysis (CEA) are used to evaluate the overall sustainability impact of different policy measures on the forestry wood chains (FWC). The assessment involves the comparison of the status quo situation (*base case*) to one or more *alternatives* considering the incremental differences between the base case and the alternatives. For example, if one is interested in evaluating the impact that an introduction of a carbon tax would have on particular forest wood chain, the base case (without the tax) would be compared to the alternative scenario (with the tax). The analysis would focus on the incremental costs and benefits, that is, the differences between their values in the situations with and without the tax.

[1] In this document, we will use the words “project” and “policy” to refer to the analysed competing alternatives.

The CBA compares the costs and benefits measured in monetary terms, whereas in the CEA the benefits are measured in physical terms. The choice of the appropriate method of analysis depends on the problem at hand and is discussed in more detail in the following chapters.

Cost-benefit as well as cost-efficiency analysis can be conducted from different perspectives (Figure 1). *Private CBA* considers the costs and benefits of the analysed project which are imposed onto or accrue to a private agent (e.g. individual or firm). That is, all expenditures incurred under the project and revenues resulting from it are taken into account. This approach is also often called financial appraisal. *Social CBA* in turn attempts to assess the overall impact of a project on improving the welfare of the society as a whole, rather than of the agent that implements the project. Social analysis differs from the private analysis in terms of both (i) the breadth of the identification and evaluation of inputs and outputs, and (ii) the measure of costs and benefits. Social CBA considers the costs and benefits which accrue to the society as a whole. Social costs and benefits usually differ from the private ones because of the existing market imperfections, which may take the form of

- imperfect competition in the market (e.g. monopoly power),
- government intervention in the market (e.g. taxes, subsidies, price regulation),
- externalities and public goods.[2]

Ideally, social CBA should take into account all the impacts of the analysed project, including the ones that are difficult to measure (e.g. usually related to environmental externalities).

In the framework of the EFORWOOD project, the social perspective on the cost-benefit and cost-efficiency analyses will be taken as the benchmark.

1.3 Structure of the report

In the second chapter of this deliverable we describe the most important stages of cost-benefit analysis. Due to the similarities between CBA and CEA, most of these stages are also applicable to the CEA. The third chapter briefly presents the cost-efficiency analysis and identifies the main differences between the two methods. A simple CBA, described in chapter four, is performed on a demonstration case to exemplify use of cost-benefit analysis. The final chapter summarises the main assumptions used in the CBA and CEA.

[2] See PD1.5.1. on the concept of externality and its importance for the EFORWOOD project. PD1.5.1. is available at http://212.17.41.155/Eforwood/uploads/Deliverable_1_5_1_Final.doc.

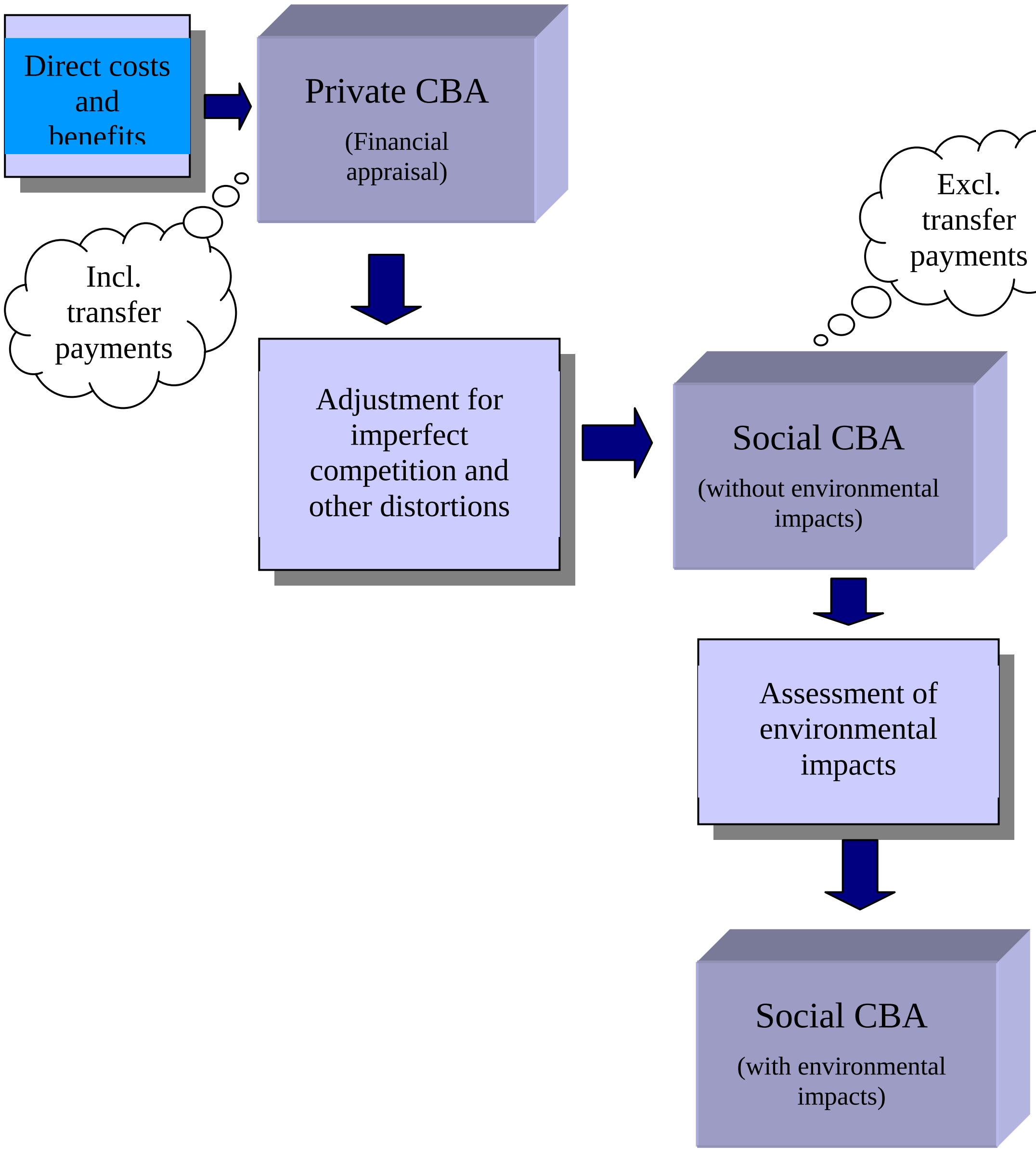

Figure 1. Different perspectives on the cost-benefit analysis.

2 Stages of a cost-benefit analysis

This chapter describes the most important stages of the CBA and CEA (as applicable). These stages are:

1. Project or policy definition
2. Identification of relevant project impacts
3. Physical quantification of relevant impacts
4. Monetary valuation of relevant impacts
5. Discounting of cost and benefit flows
6. Calculating the CBA indicators
7. Performing sensitivity analysis

In what follows, these stages are discussed in more detail.

2.1 Project or policy definition

The first stage of the CBA should define a common framework for comparing the effects of the alternatives against the base case. This common framework can be established by completing the following steps:

2.1.1 Describe the project or policy to be evaluated

A first step in establishing a framework for the analysis is to describe the project or policy in sufficient detail in order to be able to determine the relevant benefits and costs. The description should clearly state what is the issue at hand, which problem(s) – if any – the project seeks to mitigate, what goal(s) does it address, what – if anything – will be done, where, when, how and by whom. The nature of the problem or goal will determine its intended benefits and recipients. The unintended effects and the affected parties should also be identified, even if these effects may be left out of the cost-benefit analysis.

In the EFORWOOD context, this means that once, e.g. a relevant policy or technology scenario has been chosen for analysis, it is necessary to identify and determine all the stages and processes, and when relevant also spatial location and point in time, in the FWC where a change is brought about by this scenario.

2.1.2 Define the purpose of the analysis and the appropriate level of detail

The next step is to define the purpose of the cost-benefit analysis. Will the analysis be used to determine if the project should be undertaken? Will it be used to determine which of a group of projects should be selected or which should have highest priority? Identifying the purpose of the analysis helps to define the level of detail appropriate for the study.

The level of detail also depends on the available data and the budget allocated for the CBA. It is important to verify that the available data suits the purposes of the analysis and provides the appropriate level of detail, which should be consistent throughout analysis (the same for the base case and alternatives) and commensurate with the available budget.

The important discussion of on which aggregation level the TOSIA will provide results and analyses is to some extend still ongoing in EFORWOOD. Referring to the DOW (2005), however, the purpose of constructing the Tool for Sustainability Impact Assessment (TOSIA) is to improve the knowledge base for policy and decision makers, to enable their ability to pass on good and sound decisions and policies concerning policies affecting the FWC. This suggests that the aggregations and hence the analyses undertaken in EFORWOOD, including CBA, will be undertaken at a fairly aggregate level (e.g. regional or industry level).

2.1.3 Define the base case, the proposed alternatives and the study area

Once the purpose of the analysis is determined, the base case and the alternatives should be defined. The base case is the situation that will prevail if the project is not undertaken or if the policy is not implemented. The base case should be a realistic representation of current and expected future conditions.

The proposed alternatives correspond to specific actions that can be undertaken. When evaluating policy impacts, policy measures leading to different outcomes correspond to distinct alternatives. This means that actions that have little or no impact on different components of the analysed process need not be considered as separate alternatives from the perspective of CBA. The alternatives should be specified in as much detail as possible in order to correctly identify the relevant costs, benefits and impacts. All the alternatives must be developed and analyzed at the same level of detail.

An appropriate study area should be chosen so that the majority of the effects of the project are included. Likewise, the scope of the study (e.g. sector-specific, regional, national, international, etc.) should be identified in order to include all the relevant impacts of the project.

In the framework of EFORWOOD, the alternatives may be of different types:

- alternative processes and combinations thereof within or representing a given FWC; recognising that not all processes can be scaled freely or is relevant in all cases or
- alternative outcomes due to changes in the future conditions. According to DOW (2005), the future conditions may be provisionally grouped in three categories:
    - *Global changes*, that is, changes external to the EU, such as world market and exchange rates changes, climate change, etc.;
    - *EU-level changes*, that is changes in EU policies, energy prices or shifting consumer preferences;
    - *Internal FWC changes*, that is, changes in forest management, technological development and innovation, etc.

In the first case, the objective of the CBA is to compare alternative processes within a given FWC in order to identify the one that is the most beneficial for the society. This approach requires a detailed specification of the underlying processes within the FWC. In particular, it is necessary to determine if a given well-performing process can in fact be scaled to a higher use, or if this changes the process or if it is infeasible for other reasons, e.g. the technology may not be available in all cases (no train tracks close by, no harbour etc.). In the second case, the objective of the CBA is to evaluate the impact of future changes on the specific processes within a given FWC or on the FWC as a whole. In this situation, a base case (FWC without the change) is compared to an alternative scenario (FWC with the change). The crucial issue is to clearly define consistent future scenarios under which the FWCs will be evaluated.

The work on the definition and specification of scenarios is still ongoing in the EFORWOOD. The results will be reported in the Deliverables PD1.4.7 and D1.4.7.

2.1.4 Define the time frame

The time horizon starts with the first project expenditures, and extends through the useful life of the project or its most long-lived alternative, or some future time at which meaningful estimates of effects are no longer possible. The costs and benefits are compared and evaluated for this time horizon. The general principles for selecting the time horizon are:

- The time horizon should be long enough to capture the majority of costs and benefits;
- The time horizon should be consistent with that used for other analyses being undertaken for the project;
- The time horizon should be consistent for all alternatives;
- All benefits and costs occurring or accruing over this time horizon should be included in the analysis.

The choice of time horizon should be addressed carefully as it affects the calculation of the main indicators of the cost-benefit analysis.

In EFORWOOD, the current FWC is analysed in such a way that all processes in different stages of the chain occur simultaneously, that is, they run in parallel. TOSIA integrates in each time period the indicator values across all the FWC-processes modelled.

Nevertheless, time is an important factor in evaluating scenarios and alternative developments in EFORWOOD. Some stages of the FWC are likely to respond faster to changes in external factors than others; e.g. the industry's use of input factors will change faster in response to changes in relative factor prices, than will e.g. the tree-species composition in the forest. The impact of scenarios will be assessed after 10 and 20 years, respectively. Some sort of interpolation may perhaps be relevant for years in between. In addition, different parts of the FWC may need to consider also medium to long-term impacts of scenarios, in particular the parts covered in M2, because forest management changes will only slowly have an effect on relevant sustainability indicators. To take impacts beyond the 20-year time horizon into account in EFORWOOD, the module will define indicators for future states of the resources, for example forest biodiversity indicators or timber resources after 50 years. Similarly, in M5 there may be a need to include some wood-product related indicators close to the end of the lifetime of the products.

2.2 Identification of relevant project impacts

Once the project or policy is defined, the next step is to identify the impacts of its implementation. Both tangible and intangible impacts should be recognized. First, the resources used in the implementation of the project should be specified (e.g. labour, raw materials, etc.). Second, the effects of the project on market prices and output levels of the marketed goods in focus, the local employment levels, market prices of related goods, as well as the impacts on the surrounding environment should be identified.

Most projects are regarded as marginal in the sense that they do not have any effect upon the prices of project inputs and outputs. However, large projects may have considerable impacts on the regional, national or international economy and therefore, additional factors must be taken into account in the analysis.

The positive impacts – called *benefits* – refer to the increases in the quantity or quality of goods or services that generate positive utility or a reduction in the price at which they are supplied. The negative impacts – called *costs* – stand for any decreases in the quality or quantity of such goods or services, or increases in their price. The negative impacts also include the usage of resources (inputs in production) in the project, since they cannot be simultaneously used in any other project. When the benefits and costs are valued in monetary units, the resulting net benefits from the project will reflect the summation of the changes in the net income of the society as a whole from undertaking the project compared with the decision of not undertaking the project.

The cost-benefit and cost-efficiency analyses are based on incremental benefits and costs. An important concept in this respect is *additionality*, which refers to the net impacts of the project (Hanley and Spash, 1993). This means that the costs of the project that are relevant for the assessment are those that would be incurred if the project were undertaken, but that would not be incurred otherwise. The *opportunity cost* of the project measures the best alternative option forgone as a result of undertaking the project. Similarly, the benefit of the project is the extra amount of a good (e.g. money, time, etc.) that would be gained if the project were undertaken rather than not undertaken. (Sugden and Williams, 1978)

Costs and benefits can be monetary or non-monetary, qualitative or quantitative, marketed or non-marketed.

Table 1. Examples of marketed or non-marketed benefits.

	Benefits		**Costs**	
	Quantitative	**Qualitative**	**Quantitative**	**Qualitative**
Monetary	Operating cost reductions	---	Electricity costs, rents, maintenance costs	---
Non-monetary	Reduction in the travel time Improvement in the tree composition	Improvement in the water quality Improved health	Increase in the travel time	Worsening of air quality Reduced access

2.2.1 Scope of the analysis

For the reason of tractability, we will adopt a partial equilibrium model[3] in order to limit the scope of the relevant impacts of the project. Any project and any policy change produces a whole set of effects, which spread out to affect the whole economy. It is obvious that the cost-

[3] A partial equilibrium framework assumes that the prices in the analysed sector (e.g. forestry) are independent of the demand and supply conditions (and of the changes in these conditions) in other sectors (e.g. energy).

benefit analysis cannot take explicit and detailed account of all of such a chain of effects. Therefore, and in accordance with the DOW (2005)[4], the scope of the project impacts should be contained within the established system boundaries. This limitation implies that the CBA and CEA in EFORWOOD will not in general include the study of the indirect economic impacts of the analyzed project on the economy as a whole, including jobs in other sectors and other impacts of policy changes. Furthermore, it will not in general include minor environmental impacts or the impacts for which adequate measures (either physical or monetary) are not available.

Because TOSIA is not in itself an equilibrium model, EFORWOOD will also apply a trade model to secure that scenarios are evaluated and constructed in a way that product flows reflect at all time steps a demand-supply equilibrium. The model chosen is a modified version of the EFI-GTM-model, for more details see the project deliverable PD1.3.1[5].

2.2.2 Environmental impacts

Whenever the implementation of a certain project has an impact on environment representing positive or negative externalities[6], these external effects must be taken into consideration in the process of project evaluation. Typical environmental effects are associated with air quality, climate changes, water quality, soil and groundwater quality, biodiversity and landscape degradation and other natural risks. The changes in the quality or quantity of environmental goods and services produce changes in social benefits associated with their consumption, which should be accounted for in the CBA and CEA. Not including environmental impacts in the CBA and CEA leads to an over- or underestimation of social benefits of the project.

Whenever environmental externalities are difficult to quantify, a list of them should be included in the CBA in order to offer the decision-maker a wider perspective on the project's impacts. In this situation, the methods of multi-criteria analysis[7] are most helpful for decision-making.

For environmental impacts, uncertainty in outcomes can be expected. See Box 1 for a more detailed discussion of this issue.

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[4] "In EFORWOOD, a partial equilibrium model for forestry and forest industries will be used to analyse how changes in one production process (or a specific group of processes), for example as a result of the impact of policy implementation, in the FWC can change – through changes in demand and supply – the chain before and after the process concerned, and how this will affect other chains. This model will also be used to analyse global aspects of FWCs by looking at mutual influences on levels of sustainability of inherent inter-dependencies between European and regions outside Europe." (DOW, 2005)

[5] PD1.3.1. is available at http://212.17.41.155/Eforwood/uploads/D1-3-1ModelStructure_071206.pdf.

[6] An externality is defined as an unintended action caused by an economic agent that influences the utility of another agent (external) without being fully or directly reflected by market prices (Merlo and Croitoru, 2005). For more on the concept of externalities, see PD 1.5.1. at http://212.17.41.155/Eforwood/uploads/Deliverable_1_5_1_Final.doc.

[7] For more on the concept and methods of multi-criteria analysis, see PD1.5.2 at http://212.17.41.155/Eforwood/uploads/PD152_final.pdf.

Box 1. Uncertainty and risk

In order to conduct a sound cost-benefit analysis, all relevant impacts of the project within established boundaries should be taken into account. However, this is not always possible due to the presence of uncertainty. There are three types of situations, which give rise to uncertainty in the analysis.

Consider an example of the environmental costs of a new pollutant entering a river. Three situations regarding the costs are possible:
1. The analyst may be unsure what physical impacts the pollutant will have; this implies that not all states of the world, $s_1, \ldots s_n$, are known.
2. The analyst may be able to identify all possible impacts $s_1, \ldots s_n$, but is not able to identify the probability distribution of these states of the world.
3. All possible states of the world and their probability distribution may be known.

In the latter case, instead of uncertainty, the term *risk* is usually used. When the probability distribution for all the states of the world is known, the expected value can be computed and integrated in the CBA.

In the first two cases, the CBA must rely on the sensitivity analysis, which estimates net benefits of the project under different, known states of the world.

Source: Hanley et al. (2001).

2.2.3 Distribution of project impacts

The impacts of a proposed project may be unevenly distributed across different individuals and sectors of the population, as well as across different geographical regions affected by the project. If distributional effects are to be considered in cost-benefit analysis, the costs and benefits to different groups of agents must be determined in order to identify the winners and the losers of the proposed project. Ideally, the net benefit should be quantified. For example, if the project involves welfare transfer from agent A to agent B, it is considered a benefit if the welfare gains to B exceeds the welfare losses to A.

There are several ways in which the distribution of project impacts can be analysed. Firstly, the effects may be allocated among different project participants (suppliers, consumers, owners, lenders, workers, producers, rest of society). Secondly, the project effects may be allocated across geographical regions (nationals vs. foreigners, Europeans vs. non-Europeans). Thirdly, the project effects may be allocated between the public and the private sectors. And finally, the effects can be allocated among participants with different income levels (poor vs. rich). In case distributional aspects are to be considered in an evaluation, it is important to determine which distributional effects to study.

It must be noticed that determining the distribution of costs and benefits across different groups can be complicated and time-consuming, because the impacts of the projects are often redistributed in unintended and unexpected ways. For example, a subsidy for the production of a good usually increases the income of its suppliers, but it can also benefit consumers through lower prices and reduce the income of suppliers of substitute or competing goods. In addition, a subsidy may also raise the value of specialised resources used in the production of the subsidised good. As the subsidy is incorporated in asset values, its distributional effects can change.

2.3 Physical quantification and monetary valuation of relevant impacts

This stage involves determining the physical amounts of cost and benefit flows for a project (e.g. in man-years of labour, tons of CO_2, etc.), and identifying when in time they will occur. All the calculations made at this stage are performed under varying levels of uncertainty (see Box 1).

In order for physical measures of impacts to be comparable, they must be valued in common units (e.g. euros). The CBA values all the costs and the benefits in monetary units, whereas the CEA values the benefits in physical units and only the costs of are expressed in monetary units. The general principle of monetary valuation in CBA is to value impacts in terms of their marginal social cost or marginal social benefit. The marginal social cost measures the opportunity cost of producing a good, while the marginal social benefit represents the marginal willingness to pay (WTP) of the consumers for that good. Market prices, under certain conditions, can contain correct information about the social costs and social benefits. However, in many cases prices do not adequately reflect the true value of a good to society. Market power, externalities, taxes or subsidies can distort market prices. Whenever such distortions occur, *shadow prices* are used as estimates of marginal social costs and benefits to reflect true value of a good.

In some instances, market prices do not exist for relevant impacts. This is the case of many environmental externalities, such as landscape quality, air quality or biodiversity. In this case valuation techniques[8] must be used in order to estimate the willingness to pay for changes in the quantity of these externalities. The WTP estimates are considered as a special case of shadow pricing. (Hanley et al., 2001)

It should be remembered that only the costs and benefits, which are relevant for the analysis should be included. In some cases this may include comparing the advantages and disadvantages of including some unquantifiable project impacts. Clearly, if the amount of effort or resources required to quantify a particular cost or benefit outweighs the advantages of including it, then this cost or benefit should not be quantified. Instead, a qualitative assessment of the impact should be made using other available techniques (e.g. multi-criteria analysis).

Summarizing, once the physical measures of impact and their flow over time are determined, the tasks to be performed at this stage are:

(i) to predict prices for value flows extending into the future *(inflation);*

(ii) to correct market prices where necessary *(shadow prices);*

(iii) to calculate prices where none exist *(valuation techniques).*

[8] See PD1.5.1. on the brief review of the valuation techniques. PD1.5.1. is available at http://212.17.41.155/Eforwood/uploads/Deliverable_1_5_1_Final.doc.

2.3.1 Inflation

Inflation is the loss in the value of money over time, or in other words, the increase in prices over time. CBA generally controls for inflation using estimates of future costs and benefits that are expressed in terms of some base year's prices. These are referred to as *constant* or *real* prices (as opposed to *nominal* or *current* prices) from which the overall effect of a general price inflation has been removed. Where current prices are adjusted for general inflation, it is assumed that inflation will affect the prices of the inputs and outputs to the same extent, such that prices retain the same general relationship to each other. Using constant prices ensures that the future costs and benefits of the evaluated alternatives are estimated in the same units as the costs and benefits measured at the time the decision about the project is made.

Nominal and real values must not be combined in the same analysis. Logical consistency requires that an analysis be conducted either in constant monetary units or in terms of nominal values. This may require converting some nominal values to real values, or vice versa.

Example
Consider a project that produces the earnings given in the second column on the Table 2. Year 0 is the first year of operation. The inflation is expected to remain constant at 5% per year. For any year, the real value of benefits in year 0 currency is $B_t(1+\pi)^{-t}$, where B_t is the benefit occurred in the year t (since year 0) and π is the annual inflation rate.

Table 2. Nominal and real benefits (inflation rate 5%).

Year	Value of benefit in nominal terms (MEUR)	Value of benefit in real terms (MEUR)
0	200	200
1	400	381
2	580	526
3	950	821

If constant prices are used, corrections must be entered for changes in the *relative* prices when these changes are significant. For example, suppose that the wages for the skilful workers are expected to increase by 7 percent per year, while the overall level of inflation is 3 percent per annum. Then, the real increase in price of skilful labour is (1+0.07)/(1+0.03)-1=0.0388, that is, it increases 3.88 percent per year.

In general, however, it is assumed that the price of a good or a service will remain constant in real terms unless there is a strong reason to believe that its price will change relative to all other prices in the economy. Such a strong reason may of course be embedded in a scenario, e.g. a scenario affecting the prices of energy.

2.3.2 Shadow prices

Shadow prices are the estimates of the marginal social costs and marginal social benefits. Shadow prices are used among other cases when (i) imperfect competition prevails in the market; or (ii) the market is regulated via taxes, subsidies or minimum prices.

In the framework of EFORWOOD, we will assume perfect market competition whenever possible, which means that the market prices (net of taxes) will be considered good indicators of opportunity costs.

2.3.3 Special categories of costs

Sunk costs

Sunk costs are defined as money that has been spent or irrevocably committed before the start of the project. In other words, sunk costs are those costs that would exist both with and without the project, and therefore, are not additional costs for achieving project benefits.

Sunk costs are not included in social CBA because there is no opportunity cost involved, and because the only relevant costs to be considered are those occurring in the present and future. Although past actions can certainly influence the magnitudes of costs and benefits for future alternative actions, those past commitments must not be permitted to otherwise influence the decision.

System costs

If a project is part of a larger system (umbrella project), then the expected benefits may not accrue unless some matching investments are made. For example, the benefits of a power generation plant rely on investments in transmission and distribution of energy. The project boundary must include the total system investment required to achieve the benefits, and correspondingly, the total system benefits.

The discussion on the system boundaries is still ongoing in EFORWOOD. The treatment of system costs for the purposes of cost-benefit analysis will be defined in accordance to the outcome of this discussion.

Transfer payments

Transfer payments are usually excluded from the social CBA, because there are no economic gains associated to them. They represent transactions where money moves around without anything of economic value being created or consumed. The benefits of those who receive such transfers are matched by the costs borne by those who pay for it. For example, interest costs, indirect taxes and social security payments (the latter ones associated with wages and salaries) are all examples of pure transfer payments.

If the social perspective on the CBA is adopted, we seek to identify net differences among alternatives as they impact the overall society. In such cases, the transfers are irrelevant to the decision at hand and are therefore excluded from the analysis.

Note that in some circumstances taxes and subsidies should be included in the prices of inputs or outputs. This occurs whenever the tax (subsidy) is directed at correcting for an externality, and thus, including the tax (subsidy) in the price is aimed at identifying the shadow price of the resource. For example, if the government is correcting for an externality by applying a tax or a subsidy to reduce or to increase production, for example, where a tax is levied on project output that is equivalent to the costs of waste processing undertaken by a government agency, the economic cost of the input should also include the tax element. Note that if, for these reasons, the tax or subsidies are included in the analysis, the analyst should take care not to undertake double-counting by also including e.g. economic valuation estimates of the external benefit or cost reflected in the subsidy or tax.

In some cases, transfers are not without costs for society. If public subsidies are financed by public funds raised through the use of distortionary taxes, then the simple use of public funds comes at a welfare cost, a so-called deadweight loss caused by a non-optimal allocation of resources elsewhere in the economy.

It is important to note that if the private perspective on the CBA is used, then the transfer payments should be properly counted as costs and benefits.

Depreciation

Depreciation is an accounting allowance that recognises that physical assets wear out or become obsolete by spreading purchase costs over the useful life of the assets. Depreciation allowances do not have a direct economic effect and should therefore be excluded from the social CBA. Moreover, including both purchase costs of the asset and depreciation allowances for its replacement would result in double counting.

When the time frame of the project matches the economic life of the asset, the residual value would be zero and accumulated depreciation should be sufficient to replace the asset. When the asset needs to be replaced during the period of the analysis, the replacement investment should be included in the period it occurs.

It is important to keep in mind that regular maintenance cost is not the same as depreciation; maintenance is a real use of economic resources and should therefore be counted as a proper cost.

2.3.4 Marginal vs. average costs and benefits

For resources to be allocated to their best possible use (allocative efficiency), it is important that marginal[9], not average, benefits and costs be used in CBA. In practice, this means that only incremental costs and benefits should be included. For example, overhead costs should not be included unless there is an incremental change in overhead costs resulting from the evaluated alternative.

When only average operating costs are available and the cost-benefit analysis is based on these figures, it is important to keep in mind that the results are distorted.

2.3.5 Deadweight losses

A deadweight loss is the net cost to the society attributable to a move away from an economy’s competitive equilibrium usually resulting from the imposition of a tax or regulation. For example, imposing a tax on a particular good or service causes some consumers to purchase less of that good or service than they would in the absence of the tax. This deadweight loss is the loss of welfare resulting from the tax-induced behavioural change. It is a transfer from the taxpayer to nobody.

[9] Marginal costs (benefits) are the additional costs (benefits) that result from the production of an additional unit of good or service. Average costs (benefits) are total costs (benefits) divided by total production.

In practice, deadweight losses are very difficult to quantify. Usually, the decision on weather or not to include deadweight losses in the analysis is done on case-by-case bases. As a general rule, deadweight losses should be included if they are of a sufficient size relative to the overall costs and benefits of the project. In any case and irrespective of their significance, deadweight losses should be identified and explained to decision-makers.

In the framework of EFORWOOD project, we will assume perfect market competition (that is, no distortions) in most of the cases.

2.4 Discounting of costs and benefits

Once all the relevant costs and benefits are expressed in monetary terms, it is necessary to convert them into a common metric, their *present value*. This is process is called *discounting* and it is based on the fact that the individuals have *time preferences* between consumption in different periods. According to this assumption, an individual is not necessarily indifferent between receiving 100€ today and receiving the same 100€ in ten years time. This is true even if there is no inflation, because 100€ today can be used productively in the consequent ten years, producing a value greater than the initial 100€. The rate at which an individual is willing to exchange the present consumption for the future consumption is called the *discount rate.* The higher is the discount rate, the greater preference is given to the present consumption.

2.4.1 Present value calculation

The present value of a cost or a benefit X received in time t given the discount rate d is calculated as follows:

$$PV(X) = X(1+d)^{-t} = \frac{X}{(1+d)^t}.$$

For example, if the discount rate is 4%, a benefit of 10.000€ received in 10 years is:

$$\frac{10000}{(1+0.04)^{10}} = 7440.9\text{€}.$$

Discounting can be done in two ways:

i. by computing the net value of benefits minus costs for each time period (e.g. each year), and discounting each of these annual net benefit flows through the lifespan of the project; or
ii. by calculating discounted values for each element of the project (costs and benefits), and then summing the discounted elements.

Both approaches should give identical answers.

2.4.2 Choice of the discount rate

The discount rate used in the CBA is *the social discount rate* (see Box 2), which attempts to reflect the social view on how future benefits and costs should be valued against present ones. This discount rate usually differs from the discount rate used in the financial appraisal of the projects (private CBA), because of the imperfections in the capital markets.

Box 2. Social discount rate

The theoretical literature distinguishes several different approaches for interpreting and choosing the value of the social discount rate. While it is not our aim to summarize here the academic debate on this topic, a brief introduction of the main concepts used in the estimation of the social discount rate may be in place.

Social time preference rate (STPR)

STPR measures the society's preferences between consumption in one period and consumption in another. The approximated formula for the social time preference rate, r, based on Ramsey (1928) is:

$$r = ng + p,$$

where p is the rate of pure intertemporal preference (utility discount rate), n is the elasticity of marginal utility of consumption, and g is the growth rate of per capita real consumption. In most EU countries the rate of pure intertemporal preference is about 1%, the growth rate is around 2% and the elasticity of marginal utility of consumption is between 1 and 2 (EC, 2002). This implies that the social time preference rate is in the range of 3%-5%.

Opportunity cost of capital

The opportunity cost of measures the value of the input in the best possible alternative use. When capital is invested in a particular project, the opportunity cost of capital accounts for the loss of income from an alternative project. The empirical estimation of the relevant opportunity cost of capital depends on the project, country and time. According to some authors, the social discount rate is lower than the market return on capital due to taxation (Hanley and Spash, 1993). Others propose that the marginal public investment should have the same return as the private one (EC, 2002). EC suggests the rate of 5% as the lower end of the opportunity cost of capital for private investors (EC, 2002).

Source: EC, 2002; Hanley and Spash, 1993

Theoretical literature and international practice show a wide range of approaches in choosing the value of the social discount rate to be adopted. A common solution is to use the market rate of interest as a social discount rate. Government's long-term borrowing rate and the pre-tax rate of return to private capital are often used as proxies for the social discount rate (Nas, 1996).

In its current project appraisal guide, the European Commission suggests using a 5% social discount rate in the case of EU member states (EC, 2002). This is a compromise figure based on the market interest rate, cost of capital and social time preference considerations (see Box 2). World Bank and EBRD adopt 10% economic rate of return (EC, 2002), which is usually considered as a high cut-off rate and is usually justified by considering development oriented cases.

The choice of discount rate has a critical impact on the analysis. The reason is that with discount rates, the more distant the costs and the closer the benefits are in time, the better a project will be evaluated. And this effect gets more and more pronounced with higher discount rates. Figure 2 demonstrates the impact of a discount rate on present value estimates. When evaluating alternative projects, a *sensitivity analysis* using a range of discount rates is typically used to determine the importance of the discount rate in the relative performance of the projects.

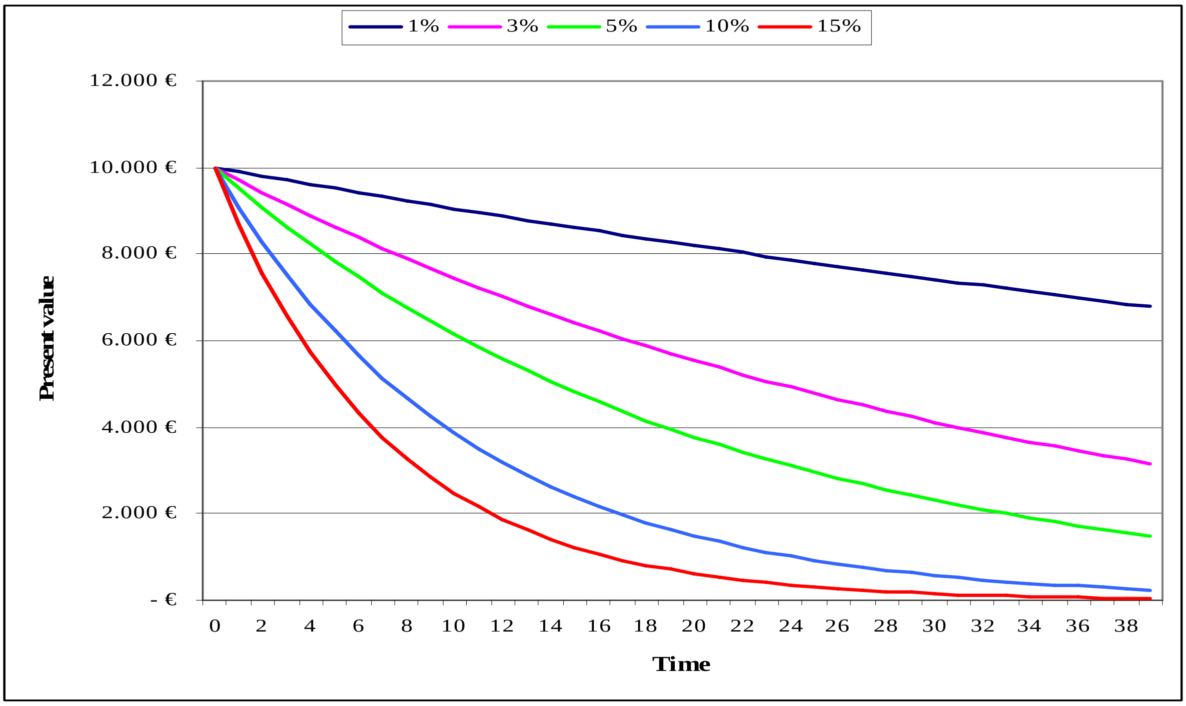

Figure 2. The present value of 10.000 € received at different points in time (by years) with different discount rates.

It is very important for the discount rate to be consistent with the treatment of inflation. If future costs and benefits follow the common practice of being expressed in terms of real (constant) monetary units, then discount rate should be the real interest rate which excludes the effect of inflation.. If future costs and benefits are expressed in terms of inflated (nominal) monetary units, then the discount rate to be used should be the nominal interest rate.

If the market (nominal) interest rate is i_n and the inflation rate is π, then the real rate of interest i_r is given by:

$$i_r = \frac{1+i_n}{1+\pi} - 1.$$

Nominal historical values can be converted into real values using a price index: in this case, the most general measure of price changes available (e.g. Retail Price Index) should be used, rather than a project-specific index. (Hanley and Spash, 1993)

2.5 Calculating the CBA performance indicators

The main performance indicators for the cost-benefit analysis are:

- the net present value (NPV)

- the internal rate of return (IRR)
- the benefit-cost ratio (BCR)
- the payback period.

The most appropriate performance indicator (or criteria) to use in project appraisal usually depends on the circumstances. In this sub-chapter we explain how these indicators should be used in the evaluation of different alternatives.

2.5.1 Net present value (NPV)

The net present value of the project is defined as:

$$NPV(S) = \sum_{t=0}^{T} \frac{S_t}{(1+d)^t} = \sum_{t=0}^{T} \frac{B_t}{(1+d)^t} - \sum_{t=0}^{T} \frac{C_t}{(1+d)^t},$$

where S_t is the net benefit of the project at time *t*, *d* is the discount rate and *T* is the time frame (the last year of the project). The net benefit of the project is the difference between the benefits (B_t) and costs (C_t) associated with the studied alternative.

The net present value is a simple indicator which is useful both for identifying beneficial projects and for selecting the best project out of several alternatives. A project is accepted whenever $NPV > 0$, because its benefits outweigh the costs. The greater is the *NPV*, the more desirable is the project. Therefore, alternative projects can be ranked on the basis of their net present values.

When dealing with *investment projects*, in which early costs are followed by later returns, the negative values in the first years are weighted more heavily than the positive ones in the last years. The opposite happens when a *disinvestment project* is in question. This implies that the choice of the time frame (*T*) and the discount rate (*d*) are crucial for the determination of the *NPV*.

2.5.2 Internal rate of return (IRR)

The internal rate of return is defined as the critical value of the interest rate at which the project has a net present value of zero, in other words, when all costs are equal to all benefits when discounted by that rate. That is,

$$IRR : NPV(S) = \sum_{t=0}^{T} \frac{S_t}{(1+IRR)^t} = 0 .$$

IRR is usually expressed as a percentage. The calculation of the IRR does not require the identification of the discount rate. However, it should be remembered that any project that has relatively large positive net flows in early stages will generate a relatively large IRR. Thus, IRR tends to favour short-term investments (Klemperer, 1996).

When dealing with *investment projects*, the interpretation of the IRR is straightforward. The project is acceptable if and only if the IRR is greater than the actual value of the interest rate. For the *disinvestment projects* – projects where early returns are followed by later costs – the interpretation of IRR is different. In this case IRR is interpreted as the lowest value of the interest rate that would justify undertaking the project. Thus, the project should be undertaken if IRR is lower than the true value of the interest rate.

IRR is based on the assumption that the cost-benefit flows are reinvested at the internal rate of return. When examining mutually exclusive projects, IRR may yield results that are inconsistent with the ranking based on the NPV criterion. In addition, IRR is not an appropriate criterion to be used when capital rationing exists[10].

Example

Consider a comparison between the investment projects A-D (Table 3). When no capital rationing exists, all projects would be selected, because each of them has a positive NPV. However, if a capital budget is limited to 7.000.000€, the projects selected depend on the criterion used. According to NPV criterion, project D should be chosen as it increases the social wealth by 800.000€. The IRR criterion, however, would pick projects A,B and C. Observe, however, that these projects increase the social welfare by 500.000€, which is less than the NPV of the project D. Thus, project D should be preferred in this situation.

Table 3. Project selection under capital rationing.

Project	Investment	NPV	IRR/Year
A	1.000.000 €	50.000 €	20%
B	2.000.000 €	150.000 €	18%
C	4.000.000 €	300.000 €	16%
D	7.000.000 €	800.000 €	15%

2.5.3 Benefit-cost ratio (BCR)

The benefit-cost ratio is the relation between the discounted benefits and the discounted costs:

$$BCR = \sum_{t=0}^{T} \frac{B_t}{(1+d)^t} \Big/ \sum_{t=0}^{T} \frac{C_t}{(1+d)^t} .$$

If $BCR > 1$, then the discounted benefits outweigh the discounted costs, and hence, the project results in the net gains for society. The higher is the ratio, the greater are the benefits relative to the costs. Note, however, that the benefit-cost ratio is insensitive to the magnitude of net benefits and, therefore, may favour projects with smaller costs and benefits over those with higher net benefits.

Example

Consider two projects: project A with the discounted benefits $B_A=100$ and discounted costs $C_A=50$; and project B with the discounted benefits $B_B=300$ and costs $C_B=200$. The BCR of the project A is *2*, whereas of the project B is *1.5*, which could advocate for the implementation of project A instead of project B. The net benefits of the project A, *100-50=50* are, however, lower than the net benefits of the project B, *300-200=100*.

[10] Capital rationing refers to the situation when a fixed capital budget exists and cannot be exceeded.

2.5.4 Payback period

Payback period indicates how long does it take for the accumulated benefits to exceed the accumulated costs. In order to determine the payback period, the costs and benefits should be discounted, and then the accumulated costs and accumulated benefits should be calculated for each year. The first year in which the accumulated benefits exceed the accumulated costs is the called the payback period.

2.6 Performing sensitivity analysis

Sensitivity analysis is a method for examining how the outcome of the cost-benefit analysis changes with variations in inputs, assumptions or the setup of the analysis. Typically, the sensitivity analysis should be performed when the following parameters change (Hanley and Spash, 1993):

- the discount rate
- physical quantities and qualities of inputs and outputs
- shadow prices of these inputs and outputs
- project life span.

The purpose of the sensitivity analysis is to determine critical variables and parameters of the model, that is, those to which the NPV outcome is most sensitive.

Sensitivity analysis can be performed either on a *variable-by-variable* basis or by changing groups of variables at the same time using *scenario analysis*. Below we present a brief overview on how these analyses can be used in the CBA, as well as discuss the advantages and disadvantages of sensitivity analysis.

2.6.1 Variable-by-variable analysis

This approach attempts to isolate the effect of a change in one variable on the performance indicators of the cost-benefit analysis (e.g. NPV, BCR, etc.). It is performed in four steps.

1. All important factors affecting the cost-benefit flows should be listed.
2. For each factor, a range of possible values should be defined. For example, the estimates for each factor could be prepared under “best-case (optimistic)”, “most likely”, or “worst-case (pessimistic)” scenarios. In practice, these values are usually based on past experience with similar project evaluations or expert opinion. Moreover, the range is sometimes expressed as one or two standard deviations from a mean (or an expected value).
3. For each value of each factor the relevant performance indicators should be calculating holding the values of all the other factors unchanged.
4. The resulting performance indicators should be examined to determine the degree of overall variation and which factor or factors is/are most responsible for variation in the estimates.

2.6.2 Scenario analysis

Scenario analysis relies on the assumption that factors affecting cost-benefit flows do not operate independently of one another as is assumed in the *variable-by-variable* approach. In scenario analysis, the potential future states of the world are divided into *best, worst* and *most likely* scenarios. The best case scenario is based on the lowest estimate for costs and the most optimistic estimates for benefits. The worst case scenario is based upon the most pessimistic estimates of costs and benefits.

2.6.3 Advantages and disadvantages of sensitivity analysis

Sensitivity analysis has several advantages. First, it is relatively easy to compute the necessary information required for each approach. Moreover, in many cases the analysis can be based on the range of values around the most likely case, without the need to undertake a great deal of work. Second, sensitivity analysis provides additional information for the decision-making. Particularly, it provides an insight on the impact and importance of uncertainty for the CBA. Finally, the potential interaction of factors is revealed when scenario analysis is employed.

Among the disadvantages, the first is related to the accuracy of information upon which the values that correspond to variations in key factors are determined. The methods determining pessimistic, optimistic and most likely estimates are in many cases ad hoc. Second, the lack of a systematic method for determining the appropriate combination of factors used to define given scenarios limits the reliability of sensitivity analysis. Finally, while the variable-by-variable approach fails to account for factor interaction, the scenario approach usually only includes a small number of potential scenarios.

2.7 Critical issues in the CBA and major problem areas

2.7.1 Comparing projects with different life spans

Whenever the goal of the cost-benefit analysis is to compare projects with different life spans, the calculation of the CBA performance indicators may lead to incorrect decisions. Two techniques have been developed to deal with this problem: (1) the replacement chain method, and (2) the equivalent annual annuity method. Both of these methods transform the performance indicator into a common metric for projects with different life spans.

<u>Replacement chain method</u>
This method requires that a common life span be found for the projects under consideration. For example, for the projects A (3 years) and B (5 years), the common life span would be 15 years, the least common multiple. This method requires the assumption that the project could be replaced indefinitely. In the example case, the cost-benefit flow should be repeated 5 times for the project A, and 3 times for the project B, after which the relevant performance indicator (e.g. net present value) can be calculated. An alternative method often used in forestry is to repeat the project cycles to infinity (since this is a common multiple for any project cycles). The general way of calculating this is:

$$NPV_{\infty} = \frac{NPV_T}{1-(1+d)^T},$$

where the sub indices denote the length of the project cycle.

<u>Equivalent annuity method</u>
This method begins with the calculation of the net present value of each project under consideration. This value is then converted to an *annuity* given the number of years in the project's life span. An annuity is a cash flow of an equal amount received at fixed intervals, for example, annually. That is, given the number of years and the discount rate, there is an

amount which if paid at regular intervals for the same period, would equal the net present value. The annuity can be calculated as follows:

$$Annuity = NPV \Big/ \sum_{t=1}^{T} \frac{1}{(1+d)^t}$$

The project with the highest annuity is selected.

2.7.2 Opportunity cost of land

Some of the alternatives considered in EFORWOOD may involve the use of land. Even when land has no financial (accounting) cost, its economic cost should be estimated and included in the cost-benefit analysis. The demand price for land does not always accurately reflect the true economic value of land, mainly because the supply cannot be expanded and land can be held for speculative, as well as productive, purposes or to meet immediate needs. The value of land is best determined through its opportunity cost. The opportunity cost is defined as the cost of an alternative that must be forgone in order to pursue a certain action, or, otherwise, the benefits one could have received by taking the best alternative action. The opportunity cost of land can thus be measured by the benefits that the best alternative use of land would have brought about.

In a relatively competitive land rental market, land rent is usually a good estimate of the opportunity cost. In rural areas, the opportunity cost of land could be measured by the net agricultural output foregone measured at economic prices. In urban areas, alternative land uses include housing, offices, commercial and industrial activities, and recreational uses. The extent of land use change for each type of activity can be calculated and valued accordingly, considering the lost production at economic prices for industrial and commercial activities, the cost savings through relocation of other activities, and the willingness to pay for recreational and other public amenities.

One possibility of including the value of land in the cost-benefit analysis is to use the price of land at the beginning of the project (this would appear as a cost) and at the end of the project (this would appear as a benefit). Another alternative is to use the concept of the annual rent, in which case the value of land is considered a cost.

3 Cost-efficiency analysis (CEA)

Cost-efficiency analysis measures the cost of achieving a particular benefit. In this case, the costs (discounted) are measured in monetary terms whereas the benefits can be measured in physical terms. CEA is appropriate whenever it is unnecessary or impractical to consider the monetary value of the benefits provided by the alternatives under consideration. This is the case whenever

- each alternative has the same annual benefits expressed in monetary terms;
- each alternative has the same annual effects, but the monetary value cannot be assigned to the benefits.

Cost-efficiency analysis provides an answer on how to spend a given amount of money obtaining the greatest benefit from the resources available, or how to achieve a given benefit at the lowest cost. For example, cost-efficiency analysis would be of a great help to identify which of the given alternative measures brings down the CO_2 emissions to a required level at the lowest cost.

The decision of whether CEA or CBA should be used in the framework of EFORWOOD project largely depends on the purpose of analysis and the type of questions that will be asked. CBA is a more general evaluation method used primarily to identify the alternatives which increase social welfare, whereas CEA focuses on the comparison of the relative effectiveness of alternative projects in achieving a given objective. Moreover, when the non-marketed benefits are considered (such as, for example, landscape beauty or the reduction of pollution), CEA allows for more flexibility as the benefits do not have to be valued in monetary terms, which is always a controversial issue.

4 A demonstration case of CBA

In this chapter we present a very simple example to demonstrate the application of CBA and CEA to project evaluation. This example is partially drawn from Mendes (2004).

Suppose that the purpose of the analysis is to analyse the social desirability of a project to plant trees on an area of land currently used for agricultural purposes.

Table 4 presents the costs and the benefits of planting maritime pine (partially based on Mendes (2004)).

The operating costs are considered to include capital, labour and raw materials, and it is assumed that market prices of all of these are reasonable indicators of marginal social cost.

The cost of land is calculated on the bases of the discounted sum of future rents that can be earned on land over the project period, plus some element of real appreciation in land prices (a speculative element). Land prices in this example reflect expected rents from agriculture, which depend upon profits to be made from farming. Suppose that 25% of farm profits on similar land are accounted for by payments from government. This 25% should be excluded from the market price, since it represents a pure transfer payment. We suppose that the resulting cost of land is 500 €/ha.

The benefits are computed on the basis of timber prices, which are stumpage prices.

Table 4. Costs and benefits from afforestation. Source: Mendes, 2004 (partially).

Year	Operation	Costs (EUR/ha)	Benefits (EUR/ha)
0	The cost of land	500 €	
	Planting (1562 plants/ha)	800 €	
1	Restocking	200 €	
3	Brush control	250 €	
8	Brush control	225 €	
10	Stand cleaning (removal of dead and bad quality plants, reducing stand density to 1000-1200 trees/ha)	400 €	
13	Brush control	225 €	
15	Pruning of the best trees (300-500 trees/ha)	350 €	
18	Brush control	225 €	
20	Thinning from below (removal of 20-40% of the trees)		49 m3 ob x 35,72 €/m3 ob = 1750 €
25	Brush control	225 €	
30	Thinning from below (removal of 20-30% of the trees)		76 m3 ob x 44,39 €/m3 ob = 3374 €
35	Brush control	225 €	
40	Thinning from below (removal of 20-30% of the trees)		46 m3 ob x 44,39 €/m3 ob = 2042 €
45	Final harvest (clear cut of 300-500 trees/ha)		240 m4 ob x 44,39 €/m3 ob = 10654 €

The next table presents the conversion of these cost and benefit items into annual net benefit flows (Table 5). For each year, the costs and benefits are summed to obtain the net benefit (or cost) of the project (second column of Table 5). In column 3, the discount factor for a discount rate of 5% is calculated. This factor is given by $[(1+d)^{-t}]$, where t is the time period during which the net benefit occurs, and d is the discount rate ($d=0.05$). The discounted net benefit flows are shown in column 4, which are obtained by multiplying the net benefit values by the discount factor (column 2 multiplied by column 3). Summing these values of the discounted net benefits gives the net present value of 323.34 € at the discount rate of 5%. Since NPV of the project is positive, it demonstrates that the project should be accepted.

Table 5. Discounting of costs and benefits.

Year	Net benefit	Discount factor	Discounted net benefit
0	- 1.300 €	1,0000	- 1.300,00 €
1	- 200 €	0,9524	- 190,48 €
3	- 250 €	0,8638	- 215,96 €
8	- 225 €	0,6768	- 152,29 €
10	- 400 €	0,6139	- 245,57 €
13	- 225 €	0,5303	- 119,32 €
15	- 350 €	0,4810	- 168,36 €
18	- 225 €	0,4155	- 93,49 €
20	1.750 €	0,3769	659,56 €
25	- 225 €	0,2953	- 66,44 €
30	3.374 €	0,2314	780,67 €
35	- 225 €	0,1813	- 40,79 €
40	2.042 €	0,1420	290,06 €
45	10.654 €	0,1113	1.185,75 €
			323,34 €

The impact of the discount rate The net present value of the project at the discount rate of 2% is 5251.58 €, whereas at the rate of 7% the net present value is negative, -835.50 €. The internal rate if return of the project turns out to be 5.42%. At this discount rate the NPV of the project is nil.

Environmental impacts In the previous calculation the benefits of non-wood forest products, recreation, game, protection of soil, water and landscape quality were not considered. If the positive environmental impacts outweigh the negative ones, the net present value at 5% discount rate will be higher than previously calculated. The precise increase of the net present value will depend on the magnitude of the environmental effects (on their economic value).

Limitations to be considered Observe that the land is not resold at the end of year 45. If the land is continuously replanted, meaning that the project is repeated in time, the opportunity cost of land should measure the returns over a perpetual rotation.

5 Conclusions

In the following table we summarise the main assumptions of the cost-benefit analysis.

Table 6. Main assumptions of the cost-benefit analysis.

Issue	Initial assumptions	Possible variations
Regional limits of analysis	EU economy	National economy (for regional case studies) International economy if dealing with international trade or impacts outside the EU
Scope of analysis	Partial equilibrium analysis: considers the impacts from the perspective of a single sector (forestry)	General equilibrium analysis: considers the impacts on all the sectors of the economy
Time frame	20 years	Up to 50 years
Capital costs and interest costs	Excluded, because represent pure transfers	Excluded
Depreciation	Excluded, because already counted in the purchase costs	Excluded
Intangibles	Included if can be reliably measured	Excluded, and evaluated by multi-criteria analysis, if cannot be reliably measured
Taxes	All prices and costs should be measured net of taxes	Adjustments may be made if competing alternatives contain differences in the treatment of taxation
Transfer payments	Excluded, if do not result in changes in social welfare	Included in private CBA analysis
Discount rate	5% per annum	Alternative discount rates for the sensitivity analysis
Inflation	Excluded, as constant prices are used	Included if the current prices are used
Market competition	Perfect competition is assumed whenever market distortions are not significant, therefore the prices are considered to be good estimates of the marginal cost	
Opportunity cost of land	Land rent as an estimate of opportunity cost	

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