UKRAINE

ANNEX TO THE PUBLIC-PRIVATE PARTNERSHIP MANUAL

GUIDELINES FOR CONDUCTING COST-BENEFIT ANALYSIS OF INVESTMENT PROJECTS

WORLD BANK GROUP

UKaid from the British people

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TABLE OF CONTENTS

List of Boxes

List of Figures

List of Tables

Abbreviations

GHG	greenhouse gas
VAT	value added tax
SWM	solid waste management
ToR	Terms of Reference
ACI	average cost indicator
AHP	analytical hierarchy process
BRT	bus rapid transit
brownfield	PPP projects in the form of investments
CEI	cost-efficiency indicator
CBA	cost-benefit analysis
CEA	cost-efficiency analysis
CIF	cost, insurance, and freight
CPV	costs present value
EBIT	earnings before interest and taxes
EBITDA	earnings before interest, taxes, depreciation, and amortization
OM	operation and maintenance
EOCK	economic opportunity cost of capital
IG	interest groups
IRR	internal rate of return
NPV	net present value
FOB	free on board (export parity price)
GTC	generalized transport costs
greenfield	PPP projects in the form of investments created from scratch

IDA	International Development Association
MCA	multi-criteria analysis
NATA	new approach to appraisal
PPIAF	Public-Private Infrastructure Advisory Facility (a multidonor technical assistance facility financed by 17 multilateral and bilateral donors)
SDR	social discount rate
SRTP	social rate of time preference
UFW	unaccounted-for water
VOC	vehicle operational costs
VOT	value of time
WTP	willingness to pay
WTA	willingness to accept

Introduction

This document aims to guide the public authorities in preparing socioeconomic appraisal analyses of public investment projects and to improve the decision-making process for selecting high-quality projects that generate greater economic welfare.

The main audience for this document is project analysts looking for a set of practical, easy to use analytical tools grounded in economic theory. This manual will guide project analysts through a series of practical steps to implement a socioeconomic appraisal at the project level. This guideline was prepared based on experience and best practices applied in many countries that use cost-benefit analysis (CBA) as a decision-making instrument for public investment. It is not meant to provide an exhaustive theoretical foundation to CBA, but rather practical guidance for practitioners. In that sense, it presumes that the person undertaking the analysis has some knowledge about economic appraisal and its theoretical underpinnings.

The guideline is divided into seven chapters:

Chapter 1 provides an overview of the conceptual framework and introduces the motivation for looking at projects from a socioeconomic point of view. It presents the different types of socioeconomic assessments techniques: cost-benefit analysis (CBA), cost-efficiency analysis (CEA), and multicriteria analysis (MCA). It discusses how a socioeconomic assessment complements other approaches to analysis using different dimensions, including social and environmental impact analysis, economic impact assessment, fiscal analysis, and financial appraisal.

Chapter 2 presents the main questions that an analyst should answer as key steps to follow and the minimum information the analysis should collect to make an informed decision. The chapter proposes a seven-step process to run a CBA.

The following chapters apply the proposed process to five different types of infrastructure project, indicating the specificities of each type and the information needed to perform the analysis. The chapter also gives some insights into the difficulties and possible solutions that arise when applying cost-benefit analysis.

Chapter 3 discusses road infrastructure projects. The road network is the backbone of a country's transport infrastructure, connecting people to jobs, businesses, and education, and health services. Roads move the supply of goods and services around the world and allow people to interact and generate knowledge and solutions that foster long-term economic and social growth. Road infrastructure investment is essential to build safer, cleaner, more efficient and accessible transport systems.

Chapter 4 presents public transport projects. Rapid urbanization demands city planners meet the challenges of sustainable, cost-efficient, and inclusive public transport systems as a good alternative to motorization.

Chapter 5 discusses the CBA evaluation of a water project, an area that in many regions remains under the jurisdiction of municipal governments, which find it a challenge to guarantee their populations' access to this vital resource. The combined effects of growing populations, rising incomes, and expanding cities will see demand for water rising exponentially, while supply becomes more erratic and uncertain. Water is a scarce resource which it is important to learn to use through sustainable solutions.

Chapter 6 focuses on another major problem that municipalities must solve: how to deal with an uncontrolled and poorly performing solid waste management system. Waste is often openly burned or disposed of in unregulated dumps, practices that create serious health, safety, and environmental consequences. Managing waste properly is essential for building sustainable and livable cities, but it will require substantial investments.

Chapter 7 presents irrigation projects. Water is not only essential for human life, it is a vital factor for production—meaning that diminishing water supplies can translate into lower economic growth. In that sense, improving irrigation allows increases in productivity and creation of value for agricultural, fishing, and livestock activities, which contributes to improve farmers' incomes and reduce poverty.

Finally, the document includes appendices addressing the process of a multi-criteria analysis (Appendix 1) and the estimation and rationale of social discount rate (Appendix 2); proposing a template to standardize the presentation of information to authorities (Appendix 3); and offer some guidance to the authorities on elaborating Terms of Reference for contract consultants performing CBA (Appendix 4).

Chapter 1. General Principles of CBA

Importance and definition of CBA

Every economy is facing sharper shortages of resources. All governments around the world seek to use these resources more wisely following the three Es principles: Economy, Efficiency, and Effectiveness.

One of the tools to allocate scarce resources for a country's infinite needs is cost-benefit analysis (CBA). The main purpose of CBA is to improve decision making—to enable those responsible for decisions to choose projects with higher net benefits over those with lower net benefits and thereby maximize the effectiveness of investment.

CBA is a major project appraisal methodology that consists in identifying, quantifying, and monetizing the costs and benefits attributable to a project and, by discounting, determining the net benefits (or costs) in terms of a present value. It considers the difference between alternative options (such as do-something against do-minimum) and the cost and benefits of a project or policy intervention from the point of view of society as a whole; CBA's main objective is to generate economic welfare by improving the quality of investment.

The International Monetary Fund (2015) found that, in countries with efficient investment systems, a 1 percent of GDP increase in public investment could increase output by 0.6 percentage points of GDP, reaching better quality infrastructure, whereas in countries with less efficient investment systems the increase is only half that (0.3 percent).

Economic assessments methodologies

CBA is often used as a synonym for economic (or socioeconomic) assessment of investment projects; nevertheless, CBA is only one type of economic assessment. At least two other types of economic appraisal methodologies are commonly used: (1) cost-effectiveness analysis (CEA), and (2) multicriteria analysis (mca).

The objective of a CBA is to comparing benefits to costs. This is only possible if most of the benefits of a project can be reasonably measured in monetary terms. However, in a huge range of projects the valuation of the benefits is not an easy task; sometimes it is not even possible. In such cases, practitioners use CEA rather than CBA. CEA compares different alternatives to choose the alternative with the lowest cost per unit of output.

For instance, for a solid waste management system, it could be relatively easy to identify the benefits from having a proper system of waste collection and disposal versus the baseline scenario where waste collection is limited and disposal is in uncontrolled dumps. The most common benefits come from reduced negative externalities, such as visual blight; noise and odors; air, water, and soil contamination; and greenhouse gas (GHG) emissions.

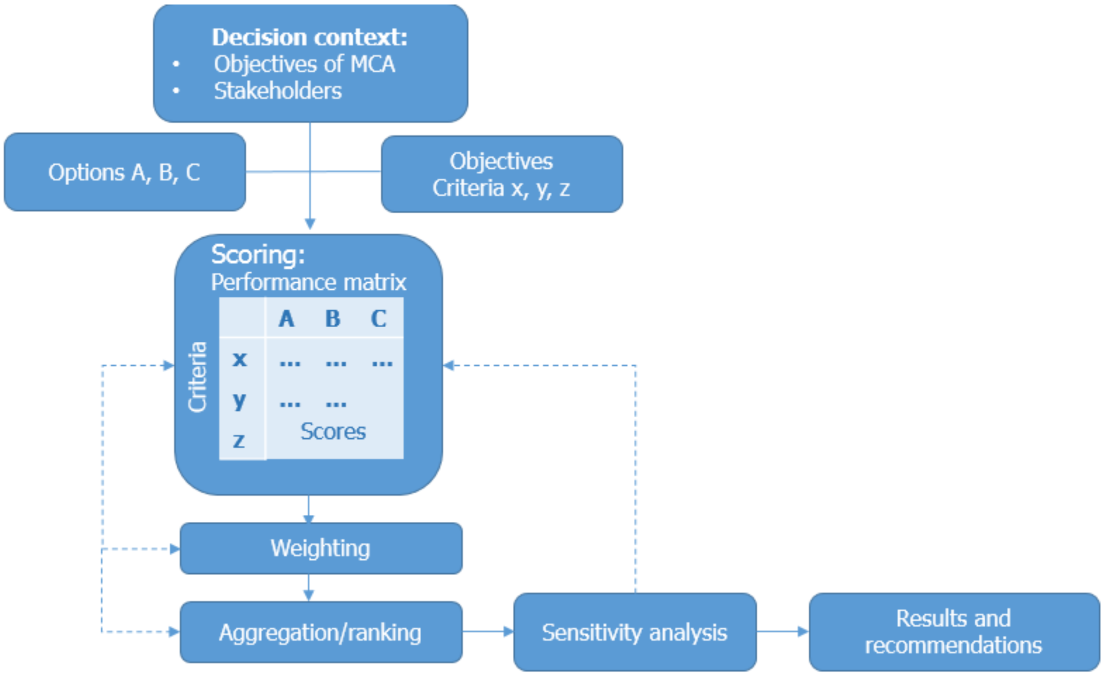
But attaching a monetary value to these benefits is not necessarily an easy task. In some cases, a proxy for benefits applies a contingent valuation methodology and asks the population about their willingness to pay to have an efficient solid waste management system. Nevertheless, as the study is costly, takes time, and only partially captures the benefits (for instance, the long-term environmental impacts), solid waste management systems are often appraised using CEA by comparing the life-cycle cost per ton of waste of different alternatives, such as a traditional sanitary landfill, waste transportation to transfer station before disposal to a sanitary landfill, and waste sorting, recycling, and composting before landfill disposal.

Another type of economic assessment to consider is the MCA, which can be used either as a substitute for CBA at an early stage of the project cycle to screen various alternatives and select a short list of options (sometimes a unique one) for subsequent detailed appraisal or as a complement to CBA when a project's impacts cannot be monetized.

MCA involves identifying monetary and non-monetary attributes, allocating of weights to each attribute reflecting their relative importance, and allocating scores to each option. The advantage of MCA over traditional techniques based on evaluation of costs and benefits, like CBA and CEA, is that it can include impacts that are not always adequately assessed by monetary techniques (environmental impacts, strategic goals, contribution to the regional economy, etc.).

A widely used and recommended sequence of MCA steps is demonstrated in the flow chart below.

Figure 1. The multicriteria process



- The first step for MCA is to set clear objectives and goals to be achieved by the analysis. Prior to moving to the analysis of options, the stakeholders must understand what exactly MCA can contribute to their decision-making process.
- The second step concerns the selection of options and criteria. Criteria are measurable objectives that help assess consequences of different options. They are formed on the basis of higher-level objectives. Identification of criteria may involve different approaches, including focused interest groups and inputs from representatives of decision-making teams and examination of secondary information sources.
- Prior to scoring different options against criteria, it may be reasonable to provide a qualitative characteristic of each option against each criterion and to spell out anticipated performance as high, medium, and low or with a different detail of disaggregation. Next, options need to be scored against each criterion on a chosen scale. Cardinal and ordinal scale can be used by the working group to score options.
- The next step is to assign weights to criteria and then apply these weights to the performance score of each alternative. The linear additive model for multicriteria analysis is widely used for many multicriteria evaluations. The inputs of the linear model include performance scores of alternatives and the weight of each criteria. Usually scores are considered as "known," but more effort is needed to determine weights. There are many approaches to weighting criteria, ranging from very simple to more sophisticated ones that require computer software to run the analysis. The most common approaches include ranking and rating (assessment of the overall importance of each criterion), pairwise comparison of trade-off preferences and defining ratios between pairs of criteria (the

analytical hierarchy process),[1] or a more flexible way of describing feasible range of weights rather than assigning precise value.

- In cases of high uncertainty of MCA, the robustness of results needs to be tested. Sensitivity analysis can be applied to check the stability of results in (a) changes to scores of options against criteria; and (b) changes in weights of criteria.
- Finally, present the MCA results, conclude, and formulate recommendations.

An example of an application of MCA is given in Box 1, and more information on MCA is provided in Appendix 1.

1. For AHP method, refer to Saati (1987).

Box 1. Multicriteria analysis

To meet an identified need of reducing traffic congestion in a city center, a government has identified three options: (1) Develop a rail-based mass transit system; (2) develop a dedicated bus solution; and (3) implement a cordon charge, payable by vehicles entering the city center.

The following table illustrates how these options could be assessed using MCA. The procuring authority has decided to include "environmental impacts" as additional criteria and has given weightings to the criteria to reflect their relative importance.

Table 1. Example of multicriteria analysis

Criteria	Weighting	Option 1 – Rail based Mass Transit		Option 2 – Bus Solution		Option 3 – Cordon Charge	
		Value / Description	Score	Value / Description	Score	Value / Description	Score
Capital cost	High (20 points)	$900m	2	$300m	14	$100m	18
Operating costs (per annum)	Medium (10 points)	$90m	1	$80m	2	$30m	7
Revenue generated	Medium (10 points)	$90m	10	$80m	8	$90m	5
Affordability	High (20 points)	Rail fare will be affordable for almost all users	18	Bus fare will be affordable for almost all users	18	Cordon charge will be unaffordable for those on lower incomes	5
Benefits (congestion reduction)	High (20 points)	50% reduction	20	30% reduction	12	20% reduction	8
Risks and uncertainties	Low (5 points)	Patronage is highly uncertain; significant construction risks	1	Patronage is somewhat uncertain	4	Driver behavior in response to the cordon charge is uncertain	3
Environmental Impacts	Low (5 points)	Minimal adverse impacts; significant reduction in car pollution	5	Some pollution from buses; reduction in car pollution	3	Reduction in car pollution	4
Total Score			57		69		50
Conclusion				Preferred Option			

Source: World Bank (2018).

CBA as part of the gateway process

Economic viability of a project is one of the dimensions analyzed at the different stages of the gateway process: when the project is identified, during the concept note development and PPP review, during the feasibility study preparation, and during contract implementation (as part of the contract monitoring and evaluation).

Economic analysis is considered as an important step at the preparation and structuring stage of the project where it is recommended to run a complete CBA analysis that eventually can be completed by an MCA for various project impacts that cannot be monetized.[2]

Nevertheless, economic analysis is even more useful when used early in the project cycle to identify poor projects and poor project components. If used at the end of the project cycle, economic analysis can only help determine whether to proceed with a project or not; at prefeasibility stage it also allows analysts to:

i. Compare options and find the best solution to the problem faced by the country;
ii. Analyze what could be the best version of the project in terms of location, scale, technology, and timing;
iii. Compare projects to select the most profitable ones for subsequent detailed appraisal.

At the prefeasibility stage, depending on the availability of data and the type of project, economic analysis would imply doing a CBA, CEA, or an MCA, but in any case, the objective is the same: comparing various alternatives and selecting a short list of options for detailed analysis at the feasibility stage.

At the structure finalization and tender design stage and at the tender management and transaction execution stage, it is recommended to review the CBA performed at the feasibility stage to see if the project remains profitable given the new information acquired through the tender process.

Finally, it is important during project construction and (even more) operation to monitor and evaluate ex-post the project to ensure it is delivering the anticipated outputs and outcomes and that the benefits are realized as expected.

CBA complementary to social and environmental impact assessment of projects

a) *Social assessment*

In most countries, CBA is done in efficiency terms, assuming the same weight to the welfare of all the different agents of the economy (consumers, producers, the government, rich and poor). In

2. As mentioned earlier, in some cases, CBA would not be possible, and the project would need to be appraised through CEA rather than using other alternatives at the feasibility stage.

some cases, however, CBA is performed according to a redistributive approach based on the use of social valuations functions allowing assignment of different weights to different agents or groups of agents, such as the poorest for instance (Dasgupta, Marglin, and Sen 1972; and Little and Mirrlees 1974).

But even if CBA adopts an efficiency approach that it is sufficient to measure the net impact of the project on the society, in many cases, identifying a project's winners and losers is useful.

A good project contributes to the country's economic output; hence, it has the potential to make everyone better off. Nevertheless, usually not everyone benefits from a project, and some may even lose. Groups that benefit from a project are not necessarily those who incur the costs. Identifying those who will gain, those who will pay, and those who will lose gives the analyst insight into the incentives that various stakeholders have to implement the project as designed and to support or oppose it.

Sometimes, projects intended to benefit society do not fully achieve their objectives, because they impose high costs on particular groups who then oppose the project. The analyst must look, therefore, not only at the project's net contribution to a country's welfare, but also at the distribution of its costs and benefits, for both equity and sustainability reasons. In that sense, CBA is a good complement to social assessments of projects whose objective is to understand the stakeholders of the project and their position toward it.

The following box gives an example of how CBA can be performed, either by measuring directly the net benefit of a project for the society as a whole or by disaggregating by groups of agents.

Box 2. Identification of winners and losers in a CBA

The project consists of the creation of a postgraduate and research program for the University of Mauritius and a polytechnic educational program. It implies construction and maintenance of new infrastructure as well as higher employment costs for new and upgraded existing faculty.

The following table summarizes the main costs and benefits.

Table 2: Summary of benefits and costs, net present values (1995 MURs thousands)

Costs and Benefits	Students	University of Mauritius and the Polytechnics	Government	Society
Benefits				
Incremental income	2,204,019	0	944,579	3,148,598
Costs				
Forgone income	(910,119)	0	(271,014)	(1,181,133)
Tuition and fees	(258,781)	258,781	0	0
Investment costs	0	(342,659)	(9,900)	(352,559)
Incremental recurrent costs	0	(143,992)	0	(143,992)
Transfers from government	0	486,651	(486,651)	0
Total costs	(1,168,899)	258,781	(767,565)	(1,677,684)
Net benefits	*1,035,119*	*258,781*	*177,015*	*1,470,915*

The project is socioeconomically profitable with a positive NPV for the society of MUR 1,470,915. For the students, the anticipated incremental income would pay for the tuition fees and the opportunity cost of their time (forgone income). The University of Mauritius and the Polytechnics would earn the tuition and fees as the government is funding the whole project. Notice that the project was clearly not self-financed. From a fiscal perspective, the government would pay for the investment costs and incremental operation and maintenance costs through the higher income taxes that it would receive due to the higher expected incomes of the students (net of the actual losses). Tuition and fees and transfers from government are at the end just transfers between agents and do not represent an effective cost of the project for the society.

b) *Environmental impact assessment*

An important difference between society's point of view and the private point of view concerns costs or benefits attributable to the project that are not reflected in its financial cash flows. When these costs and benefits can be measured in monetary terms, they should be integrated into the economic analysis. In particular, the effects of the project on the environment, both negative (costs) and positive (benefits), should be considered and, if possible, quantified and valued in monetary terms.

In that sense, the economic assessment of a project is complementary to the environmental impact assessment, which allows analysts to identify and quantify the positive and negative effects of a project on its environment as well as to define prevention and mitigation measures. What the economic analysis does is to take this information as an input and trying to monetarize the direct positive and negative environmental impacts or the costs of the prevention and mitigation measures to add these costs and benefits in the socioeconomic cash flows.

The conversion of a small fishery port to an industrial site resulted in lower catches. The monetary value of the reduction in catch was an economic externality attributable to the industrial development project and, hence, an economic cost of the project. The loss in production had an assessable market value that would be considered in the CBA (not without resting the lower costs of production also implied by the diminishing fishing activity).

CBA complementary to economic impact analysis

Economic impact analysis has the objective of measuring the impact of a project on important macroeconomic indicators like the gross domestic product, international or regional trade, or employment. Policy makers are usually very interested in the results of the economic impact analysis, which could be particularly relevant for "large" projects; nevertheless, economic impact analysis is different from CBA in the sense that the latter measures the net benefit whereas the former measures the activity generated by the project.

> *… [I]f a project involved digging a hole in the ground and filling it in again, then the expenditure on labour employed would be treated as a contribution to the economy and therefore as a benefit. The cost would be ignored.*
>
> *In contrast, a CBA would treat the expenditure on labour as a cost, recognising the fact that the labour is prevented from carrying out some other activity, i.e., recognising its "opportunity cost."* (New Zealand Government 2015, 54).

Both studies give different useful insights that are complementary.

CBA complementary to fiscal assessment

On paper, a project may contribute substantially to the economic welfare of a country (be socioeconomically profitable), but if the implementing agency lacks the funds to finance it, project implementation will suffer. It will also suffer if the funds that governments are supposed to provide (counterpart funds) are not provided on time or are not provided at all. Therefore, in addition to assessing a project's economic viability, it is necessary to look also at the project's fiscal impact. In particular, it is necessary to look at the annual cash flows to ensure that, even during its leanest years, the project will have the requisite funds to ensure its success. Furthermore, it is necessary to look at the project's recurrent costs and factor them into the annual budgets of the financing agency. It is often the case that brand new hospitals stand empty for lack of funds to pay for doctors, nurses, medicines, and utilities.

Given the importance of fiscal policy for overall macroeconomic stability, the fiscal impact of the project should always be analyzed. How and to what extent will the costs of the project be recovered from its beneficiaries? What changes in public expenditures and revenues will be attributable to the project? What will be the net effect for the central government and for local governments? Will the cost recovery arrangements (for instance a toll for a toll road) affect the quantities demanded of the services provided by the project? Are these effects being properly considered in designing the project? What will be the effect of cost recovery on the distribution of benefits? Will the cost recovery arrangements contribute to the efficient use of the output from the project and of resources generally? Is the non-recovered portion factored into the analysis of fiscal impact?

The fiscal assessment gives complementary information to the results of the CBA and is an important aspect of ensuring the feasibility of the project. Nevertheless, it differs from a CBA. A cost-benefit analysis would include all the costs of the project independently if the source of the financing is from the public sector at local or national level as well as from the private sector. Even if the existence of tariffs for the service provided does matter for the CBA as it impacts the demand, incomes received are usually considered as a transfer between consumers and the infrastructure's operator and not as a net benefit of the project. For instance, a toll road main socioeconomic benefit is reducing transport costs and not producing toll incomes. Nevertheless, the fact that the road allows generation of income would increase the probability that it would receive maintenance, allowing the economic benefits to be sustained through time.

CBA complementary to financial assessment

As we just discussed with the example of the toll road, CBA results could differ quite substantially from the financial analysis, for many reasons:

a) *Objective of the analysis*

Financial analysis focuses on monetary profits accruing to the project's entity comparing revenues, at market prices, obtained for operating the project and expenses, at market prices, necessary to execute, operate and maintain the project. Various financial indicators are used to evaluate the entity's ability to meet its financial obligations and to finance future investments. For example, financial analysis will need to include a balance sheet and a profit and loss statement, financial cost of capital, and calculation of key financial ratios including working ratio, operating ratio, debt service ratio, debt/equity ratio, EBIT, and EBITDA. The economic analysis, on the other hand, measures the project's effects on the efficiency of the whole economy considering the value for the society of the outputs produced by the project and the opportunity costs of all the resources needed to execute, operate, and maintain the project.

Various costs relevant for the financial analysis would not be considered as costs from the economic point of view, for example, depreciation, capital charges, interest, and financing costs. For economic analysis, the way the project is financed and by whom does not matter; the cost of an input should be recognized at the moment it is used or destroyed for the end of the project and valued depending on its best opportunity use.

b) *Fiscal corrections*

In economies where distortions are few, market prices provide a reasonably good approximation of the opportunity costs of inputs and outputs. In economies characterized by price distortions, however, market prices are a poor reflection of those costs and should be corrected. One of the important corrections is on taxes and subsidies. Taxes and subsidies should be considered as transfers from the taxpayers to the government or from the government to the subsidy recipient; nevertheless, they do not represent real costs and benefits for the project. That's the reason why the project's investment and operational costs are considered without value added taxes (VAT) in economic analysis or the price of water, gasoline, or electricity used in the production process of the goods and services provided by the project should be considered before subsidies, as it reflects the real cost of producing these inputs.

However, in correcting fiscal distortion, practitioners should be careful and be aware that, in some cases, taxes or subsidies are not just pure transfers and reflect real costs and benefits, for instance, local taxes that finance important services of the project, such as water treatment, waste collection, and disposal. In some other cases, taxes and subsidies are intended to correct some externalities of the project—electricity produced by renewable sources is subsidized due to its contribution in reducing global greenhouse gas (GHG) emissions. In that case, no double counting should occur including both the subsidy and the direct valuation of the GHG reduction at the same time (European Commission 2014).

c) *Social prices for tradable and nontradable goods and services*

To determine the social prices of project's inputs and outputs, it is useful to distinguish between tradable goods and services and nontradable ones. Tradable goods include those that are either imported or exported by the country or goods that the country could import or export under conditions of free trade but that it does not because of trade barriers such as import duties. A nontradable good or service, on the contrary, is one that by its very nature cannot be exported or imported. Land is a classic example of nontradable good.

In the case of nontradable goods and services, there is no doubt that the social price would be based on the domestic price, but in the case of tradable goods and services, often domestic market prices typically do not reflect their opportunity costs to the country. In many countries, import duties, for example, increase the price of domestic goods above the level that would prevail under conditions of free trade. If the domestic price of inputs is far higher than under conditions of free trade, a project that uses the protected input may have a low financial expected NPV. Likewise, if a project produces a good that enjoys protection, the project's financial NPV may be higher than under conditions of free trade. To approximate the opportunity costs to the country, the valuation of tradable inputs and outputs in economic analysis relies on border, rather than on domestic, market prices. The border price is the unit price of a traded good at the country's border.

If the country is a net exporter of the good in question, the appropriate border price is the free-on-board (FOB) price of exports—also known as the export parity price. If the country is a net importer, the appropriate border price is the cost insurance freight (CIF) price of imports plus internal transport costs—or the import parity price. For more information on this topic, refer to Belli et al. (2001, 45–49).

d) *Special shadow prices (exchange rate, wages, and discount rate)*

Other prices are usually corrected for economic assessment, in particular the exchange rate, wages, and the discount rate.

- *Social exchange rate:*

  The market exchange rates may not reflect the economic value in units of domestic currency of a unit of foreign exchange. Trade policies—for instance, import duties, quantitative restrictions, export subsidies, export taxes—distort not only individual prices of goods, but also the price of foreign exchange for the economy as a whole. Whenever serious trade distortions are present, border prices need to be converted into domestic currency equivalents using a shadow exchange rate, not the official or the market exchange rate. A shadow exchange rate is appropriate even if there are no balance-of-payments problems, or if the official exchange rate is allowed to adjust freely. The relevant question is whether trade distortions exist.

  A difference between an economic and a financial price is an indication of a rent, tax, or subsidy accruing to or being paid by someone other than the project entity. The difference between the economic price and the official or market price of foreign exchange exemplifies such cases. Take a country with a uniform import duty of 15 percent and no taxes or subsidies on exports. Now suppose that in this country the exchange rate is 5:1 with respect to U.S. dollars and is market determined. For every dollar of imports, every importer surrenders 5.75 units of domestic currency—5 units to purchase dollars plus 15 percent to pay for import duties. Exporters, by contrast, receive 5 units of domestic currency for every dollar of exports. The import duty introduces a distortion that drives a wedge between what importers pay to import one dollar's worth of goods and what exporters receive when they export one dollar's worth of goods. Because of this difference, the economic price of foreign exchange does not equal the market rate. Note that the financial and economic cost of foreign exchange need not be the same, even in a country with a market-determined exchange rate.

  In this country the economic cost of foreign exchange would be a weighted average of 5 and 5.75. The weights will depend on the relative shares of imports and exports in the country's external trade and on the elasticities of demand for exports and supply of imports. If the demand for imports is very elastic and the supply of exports is very inelastic, the economic cost of foreign exchange will be closer to 5.75 than to 5. Now, assume that the weights are 0.8 for imports and 0.2 for exports, and that the economic cost of foreign exchange is, therefore, 5.6. Such a value would imply that there is a premium on foreign exchange of 12 percent (5.6/5 = 1.12) over the market rate. A project that uses foreign exchange will cost the economy 5.6 units of domestic currency for every dollar of exports, yet importers will only pay 5 net of import duty.

For more information on the estimation of the social exchange rate, refer to the Technical Appendix of the World Bank report (2001), Lagman-Martin (2004), and Londero (2012).

In recent years, as many trade distortions have been removed and exchange rates are allowed to adjust more freely, it is often considered that the shadow exchange rate could equal the market exchange rate. In Chile, the shadow exchange rate correction factor is 1.01, very closed to 1 (Ministerio de Desarrollo Social, Chile, 2018).

- *Shadow wage:*

  In countries where the labor market functions smoothly, the actual wage is adequate for both financial and economic analysis. However, government interventions in the labor market, for example, minimum wage legislation, income taxes, and legal impediments to labor mobility, introduce distortions that make it necessary to use shadow wage rates to reflect the opportunity cost of labor used in a project.

  The shadow wage rate is basically the wage that workers receive in their previous activity. For skilled workers, who usually do not suffer from high unemployment rates, the shadow wage is the one that they receive in their previous activity, which if labor markets are functioning well, would be like the one offered for the project, meaning that no correction should be done to calculate the shadow wage rate. For unskilled workers, who have more precarious working conditions, it is the wage (income) that they get from unemployment or for informal sector or rural activities. And due to labor market distortions, this opportunity cost of unskilled labor is often lower than the wage rate paid for the project, the reason why some correction is needed to calculate the shadow wage rate.

  For more information on the estimation of the shadow wage, refer to the European Commission (2008, Annex D and 2014, Annex IV), Potts (2012), and Guillermo Peon and Harberger (2012).

- *Social discount rate:*

  Another important price for CBA is the shadow or social discount rate, which is used to calculate the net present value of a stream of benefits and costs occurring through time. In a perfect and undistorted capital market, the market rate of interest would reflect the cost of capital for a country. On the demand side, the market rate of interest would be equal to the marginal productivity of capital. On the supply side, it would be equal to the rate of time preference for consumption. And if the country is borrowing to the international market, the market rate inside the country would equate the international market rate. Nevertheless, there are many distortions in the capital market (taxes, imperfect information, market power, etc.) that explain how the social opportunity cost of capital differs from the private rate.

For instance, taxes drive a wedge between the private and the social discount rate. On the demand side, the private after-tax return is lower than the social return, that is, lower than the marginal productivity of capital in the private sector. On the supply side, also because of taxes, the marginal return to savers is lower than the social return, that is, lower than the rate of time preference for consumption.

The literature shows various alternatives for measuring the social discount rate that reflect different views on how public investment would impact the cost of private capital, domestic consumption, and international borrowing. It explains that the social discount rates adopted around the world differ significantly (see Table 3). Nevertheless, usually the social discount rate is correlated with the level of development of a country, with developing countries applying social discount rates among 8 percent to 15 percent and developed countries from 3 percent to 7 percent, according to the Asian Development Bank (2013).[3]

Table 3. Sample of indicatives SDR

Country	SDR	Country	SDR
Austria	4.1	Germany	3.1
Chile	6.0	Mexico	10.0
Canada	3.5	Netherland	3.1
Colombia	12.0	Peru	9.0
Czech Rep	5.7	Poland	5.3
Denmark	3.5	Slovakia	7.7
France	3.4	Sweden	4.1
Hungary	8.1	UK	3.5
India	5.2	US	3.7
Italy	3.3	World Bank[4]	6.0

Source: Campos, Serebrisky, and Suárez-Alemán (2016); Kossova, Kossova, and Sheluntcova (2014); and European Commission (2008).

For more information on methods for estimating the social discount rate, see Appendix 2.

In addition to the corrections needed for applying market prices to assess social prices, economic assessment also differs from private assessment by including more project impacts.

e) *Inclusion of all project impacts: direct, indirect, and externalities*

The financial analysis usually only includes the direct effect of the project on the market of the goods or services produced by the project. However, the economic assessment also includes indirect effects and externalities.

Indirect effects are the impacts of the project on other markets, particularly the markets of goods and services that are complements or substitute to the outputs produced or to the inputs used by

3. Chapter 3 of the Asian Development Bank's report on CBA gives a good survey on the social discount rate.
4. The World Bank discount rate is based on the opportunity cost of the funding used for development purposes.

the project. Indirect effects would only be relevant if there exist strong distortions in secondary markets.[5] For instance, if the construction of a toll road will decongest the existing road by deviating a portion of the vehicles, users of the existing road would benefit from reduced transport costs, which is an indirect benefit from the construction of the toll road. But when the existing road is perfectly fluid, there would be no gain from the new toll road to the existing one and the indirect benefit would be zero.

Externalities are costs and benefits that are generated by the project impacting or affecting other subjects without compensation, not only for the users or targeted population to which the project is aimed at but also to third parties. In general, an externality is said to exist when the production or consumption of a good or service by an economic agent has a direct effect on the welfare of other producers or consumers. Externalities may be positive or negative. A positive externality may reduce the costs of a production process of an unrelated economic agent, as when the bees of a bee grower pollinate a neighbor's apple orchard. They may also increase the enjoyment of another economic agent, as when musicians playing for their own pleasure delight those around them. A negative externality increases the production costs or reduces enjoyment for another economic agent. Traffic congestion and the numerous forms of environmental pollution, such as the pollution created by a manufacturing plant, are examples of negative externalities.

In the former example of the toll road, it is important to include various externalities that could be negative, like the higher transport costs the population would have to bear due to the necessary deviations in the normal road network during the project's construction, or they could be positive, like lower air pollution and GHG emissions from reduced gasoline consumption.

To include externalities, most of the time, specific studies are needed to identify, quantify, and monetize the project's impacts.

f) *Valuation of nonmarketed goods and services*

In many public investment projects, if not most of them, it could occur that there is not a market for the goods and services assessed (air quality, public parks, prisons, health and education services) or that the price is highly distorted (public museums and national parks, water treatment and waste management services, public transport). In that case, the valuation of goods and services cannot rely on the price observed in the market and corrected to obtain its social counterpart; some other methods must be applied that allow analysts to obtain the social value of nonmarketed goods and services. The main methods are presented in the following section of this report.

5. For more information on indirect effects, refer to the Netherlands CBA Guidelines (Romijn and Renes 2013).

g) *Complementarity between economic and financial assessments*

After presenting the main reasons why economic and financial assessments may differ, it is important to understand how these two analyses can complement each other and which decisions have to be taken depending on the fact that the project is financially and/or economically profitable.

Consider the following different possible scenarios:

- *Case 1: Project economically and privately profitable (with user incomes covering all the costs)*

  Many projects are privately and socially profitable; nevertheless, they would not be realized without the intervention of the government, which has to create the conditions for these investments to materialize and to compensate for some distortions in the market like transaction costs, imperfect information, market power, externalities, redistributive objectives, etc. This does not mean that the public sector is necessarily the one providing the goods and services for free. For example, many irrigation projects are socially but also privately profitable; however, due to limited access of farmers to the financial markets, their high level of risk aversion and the elevated transaction costs of organizing many small landowners, these projects would not be realized without government intervention, which does not mean either that the government must fund the whole project without the farmers contributing to it.

  At this stage, it is important to have a very good understanding about market failures, and analyze the winners and losers of the project, to design the best government policy.

  One possibility of government intervention is through the use of concessions or user-fee self-financed public-private partnerships (PPP), where the project is designed (potentially), financed, constructed, operated, and maintained by a private partner, which would be paid by the users once the project is operating and if the quality of the services complies with a series of performance indicators.

- *Case 2: Project economically but not privately profitable (with user incomes covering only part of the costs)*

  There exist many public investment projects that are economically profitable but not privately profitable. They receive some revenues from users (or other sources of incomes like advertisement), but the revenues are not sufficient to cover the project's CAPEX and OPEX. In the previous example of the toll road, it may be that the project is not privately profitable, but once the indirect benefit of decongestion of the existing road and positive externalities of pollution and GHG emissions reductions are considered, the project may be socially (economically) profitable.

In that case, the government may incentivize private investment. One way of doing that is using a PPP, funded by user fees and some form of government payments either up front or delayed.

- *Case 3: Project economically but not privately profitable (with cero user incomes)*

  Other projects may be socially profitable but will not receive any income from users (or very small amounts), which is the case of hospitals, schools, prisons, public parks, etc. In that situation, it does not mean that public provision would always be the best option. A PPP could also be an alternative way of providing the goods and services, but at the end the private partner would be paid by the government. To decide if public or private provision is the best option (as well as in cases 1 and 2), other types of consideration additional to CBA and private assessments are necessary to estimate if PPP provision is generating value for money.[6]

- *Case 4: Project privately but not economically profitable*

  Some projects are privately profitable but as they generate negative externalities they should not materialize, which means that the public sector must disincentivize the private sector initiative, usually by making the generator of the externality pay for it. For instance, mine activities could be privately profitable, but once the pollution of the soil and water generated by the mining activity is included, it is not socially desirable.

- *Case 5: Project economically and privately not profitable*

  Finally, this case is supposed to be the simplest one, as neither the public sector nor the private sector should be willing to go on with this project. However, judging by the poor quality of many public investments and the existence of so-called white elephants,[7] other motivations explain how low socially profitable projects are chosen and executed, even if they are not desirable from a social or from a private point of view.

Table 4. Financial and economic assessments complementarity

Project	Economically profitable ENPV>0	Not economically profitable ENPV<0
Privately profitable Incomes > costs FNPV>0	Case 1 Don't substitute the private sector. Give the conditions for private investment. Concession; user-fee self-financed PPP	Case 4 Disincentivize the private sector to invest.

6. For more information on the decision of public versus private provision, refer to the *Manual for Project Identification, Prioritization, Selection and Preparation: Phase 1* and *Manual for Feasibility Assessment: Phase 2.*
7. The term *white elephant* refer to a public project that is either abandoned without being concluded, completed but not used at all, or used for other purposes than the one initially planned.

Not privately profitable Incomes < Costs FNPV<0	Case 2 The government could incentivize private investment through PPP to create value for money (VfM). PPP (User-fees and government payments)	Case 5 The project is not convenient for neither society nor private sector
Not privately profitable Incomes = 0 FNPV<<0	Case 3 The government could incentivize private investment through PPP to create VfM. PPP with government payments	

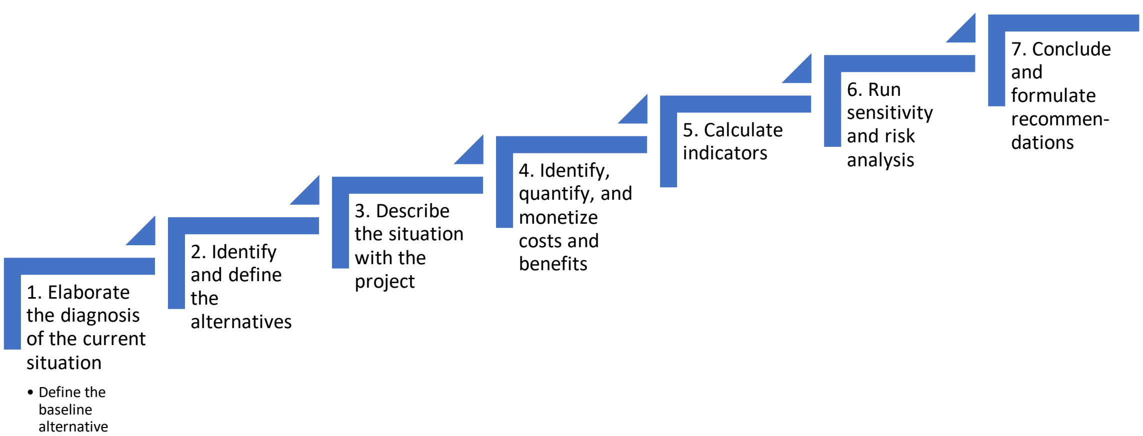
Chapter 2. Introduction to the cost-benefit analysis process

This guideline was prepared based on the experience of a number of countries that use cost-benefit analysis (CBA) as a decision-making instrument for public investment. The guideline aims to describe in detail the steps necessary to perform a CBA. The document first describes the steps to run a CBA and then addresses each step in more detail, describing important characteristics and features that must be considered when performing a CBA. Finally, by considering specific examples of projects for roads, public transport, water, waste management, and irrigation, the steps will be expanded and further explained in the following chapters.

General Overview

In general terms, a CBA can be performed by following seven steps: a diagnosis of the current situation; formulation of alternative solutions for solving the identified problem; description of the situation expected to arise with the implementation of the project; identification, quantification, and monetization of the costs and benefits of the selected alternative; calculation of basic indicators to inquire further the selected option; a sensitivity and risk analysis that stresses the main assumptions of this scenario; and the conclusion and delivery of the recommendations to the decision makers (see ***Error! Reference source not found.*** The following sections further explain each of these steps.

Figure 2. Steps in a CBA process



Step 1: Elaborate the diagnosis of the current situation and define the baseline alternative

The diagnostic commences with the analysis of the current situation. From a planning perspective, the characterization of the status quo is key to understanding what the problem is and to identifying the main components to be considered to solve a particular issue. For these purposes, one way to analyze a situation is by assessing the supply and demand of the good or service under analysis and their interaction.

a) *Supply*

The supply is the actual production capacity or the amount of goods and services currently available in the market. The supply is represented by how much of a good or service producers are willing to put forward for sell to a set of consumers. The analysis of the supply has to consider the amount and quality of the good or service being supplied, the innate characteristics of the production process (including the necessary inputs), and the legal and environmental aspects of the production process. Moreover, the following traits of the supply have to be thoroughly assessed:

i. Geographic location, to delimit the physical area where the goods or services will be provided. This information will allow the analyst to know the extension of the project and identify the potential beneficiaries.

ii. Physical characteristics of the existing infrastructure that should exhaustively summarize the dimensions, the present conditions of the service, and the current useful life.

iii. Operational capacity of the existing infrastructure, which defines the maximum capacity of good or service in the current conditions.

iv. Production costs for the provision of the good or service. Ideally, this determines the current supply curve that gives the amount of goods or services the producer is willing to supply at different price levels.

v. Operational and administrative processes, which could give feedback on how the good or service is currently provided, to identify areas of opportunity.

b) *Demand*

The demand is the amount of goods and services required to satisfy the needs of the target population. From an economic point of view, it is represented by the consumer´s willingness to pay for a specific good or service. As examples of demands, we can find, among others:

- The amount of water consumed by households
- The number of vehicles traveling on a highway

- The quantity of health services consumed by a population

When describing the demand, it is important to explain both the features that limit the amount consumed, as well as its historical behavior. Moreover, to fully characterize the demand, the analyst must obtain the following information:

i. *Target population, which will be established by delimiting the geographic area of the project.* Once this area is known, the reference population will be derived and thus the affected population (target population) will be determined. The concept refers to the people that are going to be direct consumers of the good or service and to the people that will be beneficiary of the infrastructure.
ii. *The amount consumed by unit of time, which is the amount of goods or services that the target population is currently consuming.* It could be disaggregated by segments of the population and it allows the analyst to understand the magnitude of the demand and subsequently compare it with the supply.
iii. *Consumption conditions that describe the different ways in which an individual consumes the good or service*. It must include the amounts consumed on each consumption channel and the prices for each one.
iv. *Prices and consumption levels, which describes the quantity of goods and services that the consumers are willing to consume given the price they have to pay for it.* This is also known as the price curve.

c) *Interaction between the supply and the demand*

The interaction between the supply and the demand (i.e., between producers and consumers) can be thought of as a collective negotiation, where the supply is the share that the producers are bringing to the market while the demand corresponds to the share of the product or service under analysis that the consumers want to buy. This underlined negotiation leads to the establishment of a specific quantity that is currently being traded at a certain price. In this sense, the interaction between the supply and the demand describes the market in the current situation, thus allowing an understanding of whether there is a problem that needs solving or whether there is the business opportunity that the government can take advantage of.

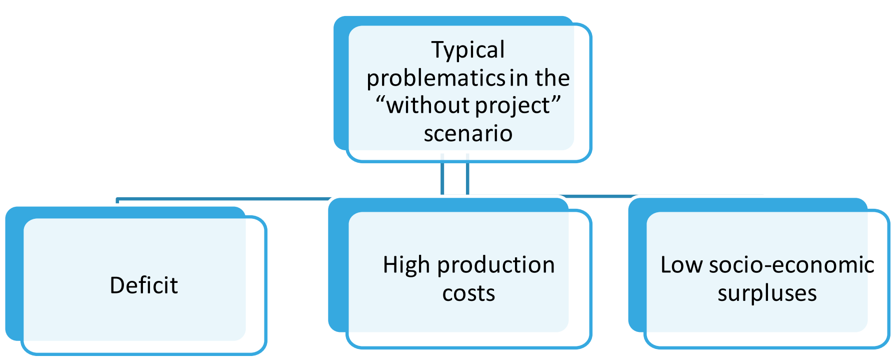
Based on the interaction between the supply and the demand, the analyst will usually identify the existence of one (or more) of the following problematics:

1. The interaction may show that the market has a deficit equilibrium. In this case, the installed capacity is not enough to meet the needs of the target population. It is important to fully ponder and explain the implications of having such a deficit. For instance, deficits can lead to economic inefficiencies like higher waiting times, higher travelling times, or higher morbidity. It is common to find a deficit equilibrium when assessing social infrastructure (i.e., hospitals, water provision services, educational infrastructure, etc.).

2. The interaction between supply and demand may show that the market is currently operating at higher-than-average costs of production. This problematic usually arises in two different situations. The first case is when there are high costs without congestion. An example could be a highway in bad condition that is not congested but that obliges the drivers to reach their destination at lower speeds. The second case is when there are higher than average costs from congestion. Considering the same example, now assume that there is a highway in bad condition that has a congestion problem. Both cases increase costs for the consumer; the second one increases them significantly higher than the first case. Higher than average costs are usually found when assessing economic infrastructure (i.e., transport projects, energy infrastructure, etc.).
3. In some cases, instead of a problem to fix there is a business opportunity available that could translate into lower prices for consumers, thus enabling higher consumption. This refers to the case where a resource could be potentially demanded by consumers but due to the present conditions of the supply it is not possible. It is important to highlight that business opportunities normally come from productive projects (i.e., touristic projects, irrigation projects, etc.).
4. The interaction between the supply and the demand shows a problem that is a combination of the last three. For instance, in case of a rural electrification program, without the project, some energy is produced and consumed by the households but at a very high production cost; furthermore, the installed capacity is not enough to cover the population's needs. In that case, problems 1 and 2 are combined.

Once the type of problem is defined, a quantification phase is next in line: the amount of deficit must be known; the higher costs need to be determined; and/or the socioeconomic surplus in case of a business opportunity must be derived (see Figure 3).

Figure 3. Main problematics in the "without project" scenario

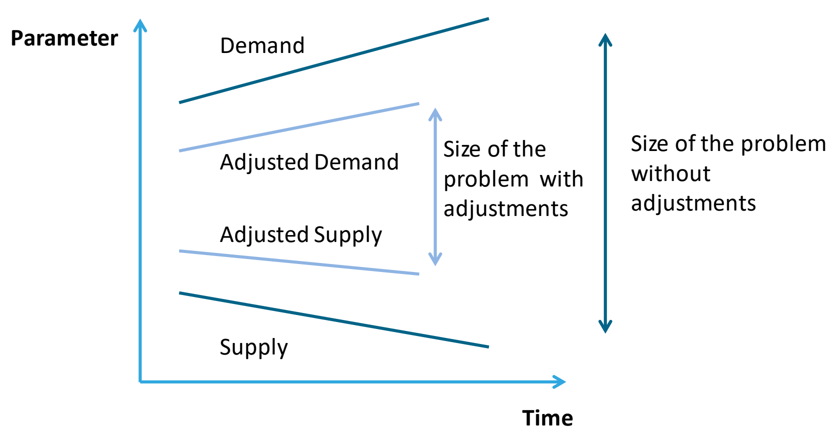


The current situation is represents the goods and services the market has and the interaction between the willingness to consume with the production capacity of such goods and services. Because the subsequent steps to run a CBA rely heavily on correctly identifying the problem, it is thus paramount to identify and holistically understand the problem of a deficit, a high-cost interaction between the supply and the demand or the fact that socioeconomic surpluses are low compared to what could be obtained with more or more efficient infrastructure.

d) *Baseline alternative*

Once the problem has been identified and before proceeding to identification of solution alternatives, it is important to acknowledge the extent to which the prevailing problem (or business opportunity) is due to administrative inefficiencies, carelessness in infrastructure maintenance, or lack of law enforcement. For instance, when it is identified that current long waiting times on public transport services are caused by poor scheduling of departures rather than the lack of vehicles or that high incidence of crashes is caused by the lack of signaling rather than the design of the road, it is then that the current situation must be "adjusted" to incorporate these minor corrections to avoid granting illegitimate benefits to any project. Incorporating these corrections is commonly known as the "do minimum" option, which will modify either the demand and/or the supply and produce a new interaction equilibrium known as the baseline or reference point, on which the project's benefits and costs will be calculated. If these "small" inefficiencies are not removed, there is a risk of assigning more benefits (or even costs) to the project, and this could lead to an incorrect decision. This is mainly because if no adjustments are considered, then the size of the problem would be larger. Figure 4 graphically depicts the expected effect of the do minimum option in terms of the size of the problem.

Figure 4. Supply and demand with and without adjustments



The key element that has to be analyzed is the impact of the "adjustments" over the supply and the demand in order to reassess its interaction and to reevaluate how the problem looks forecasted. Thus, it will be necessary to recalculate the following:

- Reevaluate the difference between the demand and the maximum capacity of the baseline's system when the problem is defined as a deficit.

- Reevaluate costs in the baseline situation in case the problem is one of high costs, both with and without congestion in the baseline.
- Reevaluate the socioeconomic surplus in the baseline when the problem is defined as an opportunity for the government to take on.
- Reevaluate costs and the potential deficit in the baseline if the problem is a combination of the three.

Another important step additional to the adjustment of the current situation is to define the baseline scenario, that is, to forecast how the situation will evolve through time. Analysts can use several methods to forecast the demand and supply of the "without project" situation, from a simple historical growth rate to probabilistic distribution models. However, use of one method or another will depend on the complexity of the situation to be described and the availability of information. Commonly, in cases with limited information, average growth rates or population growth rate are good parameters to perform the forecast needed, because sectors such as transport or consumption of public services (water, waste collection, electricity, public health, etc.), among others, respond to similar paths of growth as those that compound macroeconomic variables.

When there are no adjustments to make, it is assumed that the baseline is equal to the current situation, potentially adjusted.

Step 2: Identify and define the alternatives

Throughout a project's cycle, from its identification through its appraisal, considering alternative solutions is one of the most important steps in the evaluation process. Many important choices are made at an early stage when alternatives are rejected or retained for more detailed analysis. The need to compare mutually exclusive options is one of the main reasons for applying economic analysis from the early stages of the project cycle.

The particular problem a project is designed to solve may have many alternative solutions, some of which may be optimal from a technical point of view, but not necessarily optimal from an economic one. Furthermore, different alternatives may involve differences in important aspects, such as the scope of the components, the types of outputs and services, the production technology, the location, the starting date, and the sequencing of the components' implementation.

When the alternatives are identified, it is important to remember that projects are normally originated as a public interest in the form of problems to solve, needs to satisfy, and opportunities to take on. For project evaluation and appraisal purposes, the alternative solutions are the different courses of action that could be undertaken to solve or mitigate a certain problem. It is paramount to include every alternative that solves the identified problem.

Once formulated, the alternatives ought to be compared. For example, when dealing with solving the problem of congestion of an existing highway, the alternative solutions are: (1) expansion of the current lanes of the highway, (2) creation of a new highway with a different stroke line, or (3) identification of the bottlenecks and building a tunnel or bridge that decongests the relevant crossings.

The comparison of alternatives gets even more complex considering that, for each of the alternatives, other options have to be considered, for instance, the geographic location of the project, its size, the optimal moment for implementing the project, or which technology would be used. For instance, in the previous case of the highway, would the new highway have two or four lanes? Would it be constructed with asphalt or concrete pavement? What would be its optimal location?

Thus, the first step by dealing with the comparison of alternatives is to identify a first list of alternatives considering the objectives of (i) finding the best solution to the problem that has been defined by studying the current situation, and (ii) its best version.

For identifying alternatives, keep in mind that in all cases, three fundamental questions must be answered:

1. What market failure leads the private sector to produce more or less than the socially optimal quantity of this good or service?
2. What sort of government intervention is appropriate to ensure that the optimal quantity is produced?
3. Is the recommended government intervention likely to have the desired impact?

Once the alternatives have been listed, it is recommended to apply a simple qualitative multicriteria approach, that would assess the different feasibility aspects of each of these alternatives, to eliminate the alternatives that are either not feasible or are clearly dominated by others. For instance, legal, technical, environmental, economic, financial, strategic/political, commercial and social viability aspects may be assessed based on a scale assessing the level as low, medium, or high. The objective of applying this simple methodology would be to narrow down the list of alternatives by considering the restrictions each alternative pose for its execution.

Once the short list of alternatives has been defined, the surviving solutions must be fully evaluated through a detailed analysis of their costs and benefits, including their monetarization. At this stage it is important that the description and design of each alternative include at least the following elements:

- ✓ Set of investment components and their relative size
- ✓ Geographic location
- ✓ Technology
- ✓ Execution duration and program of activities
- ✓ Estimated investment, operation and maintenance costs
- ✓ Sources of financing

- ✓ Useful life
- ✓ Estimated capacity and expected production
- ✓ A summary on main legal, technical, environmental, strategic/political, commercial, and social feasibility aspects

The type of the alternative will indicate the best comparison method to use. Three different methodologies have been discussed in section 1 of this report: CBA, CEA, and MCA. In most cases, CBA would be the correct methodology to use, but in some cases the benefits would be identical between the two alternatives or it would be impossible to monetarize the project's benefits, and in that case, CEA would be the preferred method. A quantitative MCA[8] could also be a good option, when many important impacts of the alternatives cannot be directly monetized and the economic profitability of the project has to be balanced with other criteria.

So, in case of comparison of alternatives by CBA, for each of the alternatives on the short list it would be necessary to apply the following steps of the CBA process to calculate the CBA indicators of each alternative and then proceed to their comparison.

As it was explained in Chapter 1, most of this analysis would be expected to be done at the prefeasibility stage of the gateway process to select the best alternative before proceeding to a more detailed analysis. Nevertheless, for complex projects, it is quite common to allow more than one alternative to pass to the feasibility stage. In particular, it is quite common that some issues like the best location, size, and technologies are only studied in more detail at the feasibility stage.

Step 3: Describe the situation with the project

For each selected alternative, the next step in the CBA is to determine the effects of its implementation relative to the baseline scenario. The objective at this point is to determine how the new situation would look, assuming that the project gets implemented, and thus the description must include its location and the technical specificities and what the supply and demand could be, as well as the foreseeable interaction between the two. All in all, at this stage the analyst should be able to answer the following questions:

- How much does the project reduce the deficit identified in the baseline situation? Does the project generate new customers, such that more products and services will be consumed?
- Does the project reduce costs, and if so, how much?
- How much does the project increase socioeconomic surpluses?

8. In a quantitative MCA compared to a qualitative MCA, the weights assigned to each criterion are quantitative, and the definition of each scoring option for a given criterion is preferably quantitative too. Refer to Box 2 for an example of a quantitative MCA.

In short, the description must answer the question of how and to what extent the implementation of the project will solve the problem throughout its lifespan. This forecast will be compared to the baseline scenario, and the relative socioeconomic profitability of the project will be derived from its marginal effects over such baseline.

Step 4: Identify, quantify, and monetize costs and benefits

The next step in a CBA is to identify, quantify and monetize the costs and benefits generated by the project. These costs and benefits are the result of comparing the baseline to the situation with the project. As explained in the previous chapter, economic assessments include not only direct benefits and costs but also indirect ones and externalities. Based on this, the first step within the assessment process is to identify all the costs and benefits generated by the project. Then, each of these costs and benefits must be quantified in measurable units.

a) *Identify and quantify costs and benefits*

In terms of costs, the analyst must identify all those that happen with the project and do not exist without the project. First, there are investment costs, which are all the expenses needed to execute the physical infrastructure; second, there are the operating costs—fuels, electricity, property rent expenses, and employees´ salaries— necessary for the production of goods or services; and third, there are maintenance costs, which are expenses to ensure the proper functioning of infrastructure and equipment through time.

At this stage, it is important to consider that inputs have opportunity costs, as in the case of real estate acquired by donation. Analysts tend to believe that in the absence of resource expenditure, no cost should be considered; however, from an economic perspective all resources have an opportunity cost since they can be used either to perform the project or for an alternative purpose.

Furthermore, negative externalities have to be included as part of the relevant costs. For instance, during the execution stage some projects will have hassle costs. Building an additional lane in a road causes drivers to deviate from their regular schedules, translating into higher traveling cost (hassle costs) during the construction of the new lane.

For benefits, the easiest way to identify them is by focusing on the origin of the project identified at Step 1:

i. *Benefits from higher consumption:* This benefit takes place when the project increases the supply with the objective of reducing the deficit of a good/service in a given sector. The latter implies that more goods or services are consumed, and consumers benefit from doing so.

ii. *Benefits from spare resources or from lower production costs:* When a project reduces the cost of producing or makes the use of certain resources no longer necessary, society benefits from having those resources available for other purposes. For example, building a highway reduces the time spent by users who will have the option of spending the released time in consumption, production, or leisure activities.

iii. *Higher socio-economic surpluses:* The project, by creating new infrastructure or increasing the efficiency of the existing one, allows the development of some productive activities, increasing socioeconomic surpluses.

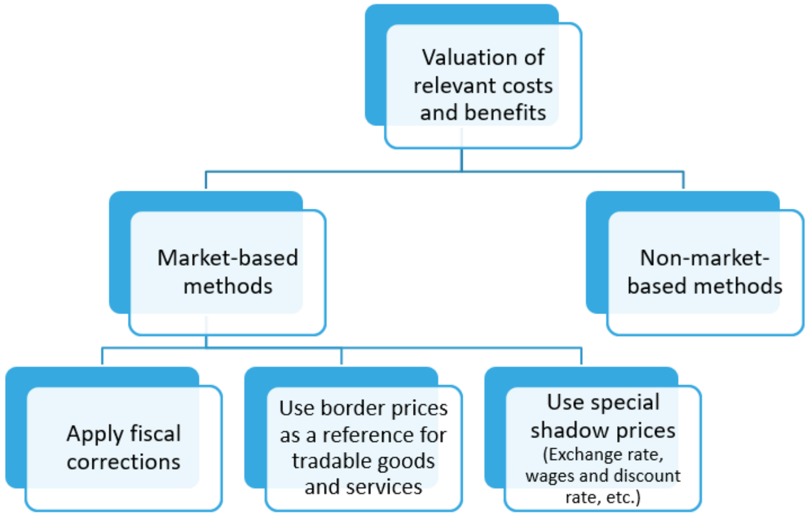
In the case of benefits, it is important to keep in mind the residual values that can be obtained in the last year of the evaluation horizon; for instance, real estate goods will continue to have value after the project reaches its lifespan.

In both cases, costs and benefits must be quantified in units of measurement such as total cubic meters of drinking water, square meters of liberated land, number of kilometers, etc. It is important to keep in mind that the quantification will depend on each case studied and the identified problem.

b) *Valuate costs and benefits*

Once the relevant costs and benefits have been identified and quantified, every unit has to be monetized. For this purpose, the economic theory provides a large number of methods (see Figure 5), the most common of which are based on market prices, but when performing a socioeconomic assessment, market prices must be corrected to calculate shadow prices, which represent the cost of using inputs and outputs for the society. An example of how to transform market prices into social prices is given inBox 3 Box 3. In absence of markets, economic theory provides alternative methods to estimate costs and benefits. Non-market-based valuation methods are explained in more detail in next section.

Figure 5. Costs and benefits valuation methods



i. Market-based methods

As explained in the previous chapter, it is necessary to convert market prices to their social counterpart, applying the following main corrections:

- Apply fiscal corrections.
- Use the border price as a reference for tradable goods and services.
- Use special shadow prices. A shadow price of a good or service is the economic opportunity cost to society of that good or service. Every time market prices do not consider the opportunity costs of both inputs and outputs the analyst needs to convert them to shadow prices through conversion factors, which are the factors for multiplying the market prices to make them shadow prices. It is normally the ratio between shadow prices and market prices.

Box 3. Example of adjustments of market prices to social prices

An appraiser analyzing a new road project needs to assess both financial feasibility and economic feasibility. The project is a toll road, and the technical team has provided the cost estimates for both CAPEX (US$100 million) and OPEX (US$15 million). Economists have determined the following adjustments:

- ✓ Adjust the price of certain equipment that must be imported and for which a specific duty is charged. This equipment represents 15 percent of the CAPEX investment and the duty imposed is equal to 10 percent of the final price.

  Therefore, an adjustment of 1,363,636.36 is required (see the table below for calculations).

- ✓ Adjust labor costs to shadow prices. An adjustment factor of 0.8 has been considered for construction labor costs (mostly civil works) and 0.9 for O&M labor costs, considering that weighted average salaries are overvalued considering the unemployment rate.

  Labor costs represent 40 percent of the construction costs (excluding equipment, i.e., 40 percent of US$85 million) and 30 percent of O&M costs.

  Therefore, an adjustment of US$6.8 million and US$450.000, respectively, should be applied, as shown in the following table.

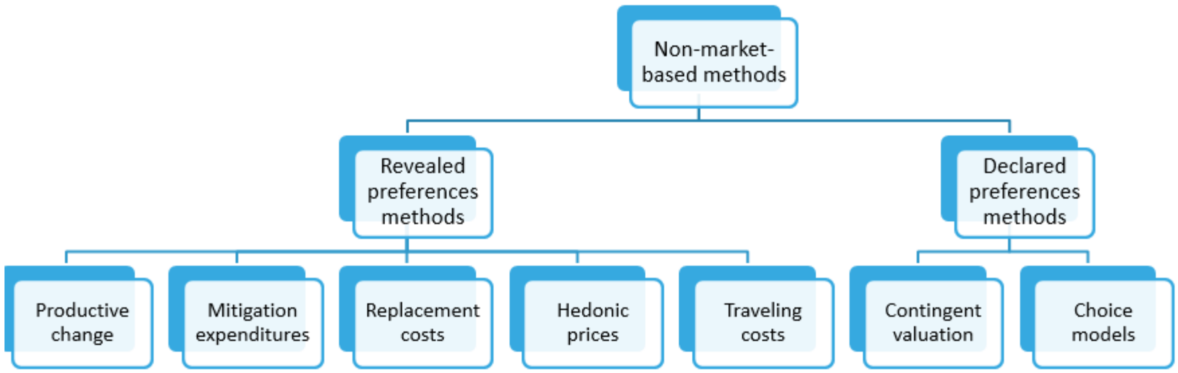
Table 5. Adjustment of market prices to social prices

	Costs estimates	Adjustment factor	Cost estimates (socioeconomic adjusted)
a) Construction costs	85 million US$	60%*1+40%*0,8	78.20 million
b) Equipment	15 million US$	1/(1+0,1)	13.64 million
Total CAPEX (a+b)	100 million US$		91.84 million
O&M projected costs/year	15 million US$ / year	70%*1+30%*0,9	14.55 Million

ii. *Non-market-based methods*

When the good or service under analysis does not have a specific market price (i.e., cultural or environmental goods), there are some non-market-based valuation methods that can help assess the costs and benefits of a project. These non-market-based methods are commonly known as either revealed preferences methods or declared preferences methods (see Figure 6).

Figure 6. Non-market-based valuation methods



<u>Revealed preferences methods</u>

Among the revealed preferences methods, five key techniques are commonly used, namely, productive change, mitigation expenditures, replacement costs, hedonic prices, and traveling costs. These methods assess the value of a good or service by observing consumers' actual behavior.

- *Productive change*

Productive change refers to a valuation that considers prices of a certain good or service (e.g., the price of an agricultural product) to value a non-market good or service (e.g., soil erosion). In this case, the non-market good (soil erosion) is an input to produce an agricultural product. Another example is the valuation of mangrove conservation in places like Guyana through the productivity change of fisheries' output. Most projects of environmental conservation use productivity change as a valuation method. For further detail on this method, refer to Asian Development Bank (2013, 177–78).

- *Mitigation expenditures*

The cost of mitigation expenditures is used as a proxy for the impact of a certain project. However, this method could potentially undervalue the effect. If the mitigation measure does not eliminate completely the external harm, then the method would underestimate the real cost of investing in the project. For example, visualize a waste treatment facility project nearby a complex of houses. The smell that the waste propels (assume the facility is outdoors) harms residents. Some may invest to mitigate the smell by insulating their homes; nonetheless, every time they go outside the mitigation measures are insufficient and the external harm is not eliminated. In this case, the method fails because the real cost for investing in the project is higher than what was originally paid for insulating each home. For further detail of this method, see New Zealand's *Guide to Social Benefit Analysis* (2015, 20–21) and Pearce, Atkinson, and Mourato (2006, 98–100).

- *Replacement costs*

The replacement costs are those needed to compensate for a loss generated by the project. For example, when a virgin beach is set to disappear because a chain of resorts wants to expand, the replacement costs for losing the beach must be valued to assess whether the proposed development proceeds. For further detail of this method, see New Zealand's *Guide to Social Benefit Analysis* (2015, 21).

- *Hedonic prices*

A hedonic price is the implicit or shadow price that can be derived from the disaggregation of the specific value of each component that integrates the good that is being analyzed. The method examines market prices to estimate indirectly the value of goods and services, such as clean air or quiet environments, for which no market exists. For example, differences in property values are used to estimate people's willingness to pay for scenic views or lower air pollution levels. Where public goods affect the prices of market goods (usually land values), the hedonic method assumes that variations in prices of the market goods, other things being equal, must be caused by observable characteristics of the public good. Protecting a forest upstream may have an impact on the value of agricultural lands downstream as improved water quality may increase crop productivity. For further detail of this method, please see Pearce, Atkinson, and Mourato (2006, 93–96).

- *Traveling costs*

Travelling costs method assumes that a consumer will spend an amount of monetary and time resources to go through an experience (i.e., cycling, fishing, etc.). The experience *per se* does not have a market price. Thus, travelling costs are an approximation to the costs that a consumer must pay to visit a certain place and have a particular experience. For further detail of this method, please see Pearce, Atkinson, and Mourato (2006, 96–98).

<u>Declared preferences methods</u>

Declared preferences methods aim at knowing, through surveys or inferential tools, the valuation that consumers and non-consumers have of a certain good or service regarding their existence or provision. The most common application of these methods is to valuate cultural heritage, environment conservation, and public health. Among these techniques, contingent valuation and choice models are the two main frameworks. These models allow the estimation of both use value and non-use value,[9] which are commonly present in historical buildings, archeological sites, or environmental assessment cases.

- *Contingent valuation*

9. Some people would assign a value to a good or service they would perhaps never use for different reasons: (i) option value: they may perhaps consume the good or service in the future; (ii) bequest value: they want to bequeath the goods and services to their descendants; and (iii) existence value: because they value just the fact that this good or service exists.

Contingent valuation uses surveys to identify the consumers' willingness to pay (WTP) for an improvement of the good or to avoid a negative change in it (make a maintenance of an historical building or avoid its demolition) or willingness to accept (WTA) a negative change or to avoid a positive change. For further detail of this method, please see Pearce, Atkinson, and Mourato (2006, 105–23).

- *Choice modelling*

Choice models (or attribute-based models) focus on the value that people assign to the different attributes that constitute a good or service. Through descriptive questionnaires built over a number of attributes and statistical models, the analyst is able to determine the WTP for a particular good or service. For further detail of this method please, see Pearce, Atkinson, and Mourato (2006, 125–38).

Once the valuation method or methods have been identified, the last step is to translate estimated units of measurement into monetary terms. It is paramount to use social prices that reflect the true value for society. Neither taxes nor subsidies should be included. Additionally, the valuation is performed using real prices, meaning those prices that consider the inflationary effects. Finally, it is important to make a checklist of all the costs and benefits generated by the project. This will help to reduce the probability of omitting relevant costs or benefits.

Step 5: Calculate indicators

Once the costs and benefits of a project have been valued, the next step is to calculate socioeconomic indicators that represent in a number whether the investment of public resources is convenient or not to be executed. These indicators provide decision makers with arguments to defend, discard, or order the different investment alternatives a government could have. There are a wide variety of indicators; however, the most commonly used are the following: (1) net present value, (2) internal return rate, (3) benefit-cost ratio, and (4) cost-efficiency and average cost indicators. The latter is not a CBA indicator; it is rather used in a CEA to select the most viable solution in terms of costs.

Note than in a CEA the process to follow for the analysis is very similar to that for a CBA; the only two differences are that usually the benefits will not be monetized running a CEA, and at least two alternatives have to be compared. In a CBA, at the end, the "with project" scenario is monetarily compared to the baseline scenario. In a CEA, the "with project" scenario cannot be compared monetarily to the baseline scenario; on the contrary, two different "with projects" scenarios are compared.

a) *Net present value*

The net present value of a stream of costs and benefits is a number that results from discounting the values of the stream at a given discount rate. It is equivalent to the number that results from the following expression:

$$NPV = \sum_{t=0}^{N-1} \frac{B_t - C_t}{(1+r)^t}$$

Here, the discount rate is r, the benefit in year t=i is Bi, the cost in year i is Ci, and N is the time horizon. The net present value of a stream is equivalent to the amount that would have to be invested today in order to obtain a return r for N years.

The decision rule is simple. Whenever the NPV is positive, the project is worth executing. On the other side, when the NPV is negative, it is not advisable to implement the project. In case the NPV is equal to zero, the conclusion must be that it is indifferent between executing the project and taking another project with an equal discounting rate.

b) *Internal return rate*

The internal rate of return of an income stream is that discount rate that makes the stream of net returns equal to a present value of zero. It is equivalent to the discount rate *r* that satisfies the following relationship:

$$\sum_{t=0}^{N-1} \frac{B_t - C_t}{(1+r)^t} = 0,$$

where B_t is the benefit stream and C_t is the cost stream. The internal rate of return shows the monetary yield of the resources invested in a specific period of time, commonly calculated in an annual basis.

The decision rule for the IRR is similar to the NPV. However, the IRR is for getting the discount rate that makes the stream of net returns equal to a present value of zero. The decision rule has to be made by comparing both the IRR with the current discount rate (r). If the IRR is larger than r, the project is profitable. If the IRR is lower than r, the project should not be carried out. When the IRR equals r, the conclusion is that it is indifferent between carrying out the project and doing another one with the same r.

c) *Benefit-cost ratio*

This indicator is particularly useful when the analyst seeks to portray the proposed investment in an intuitive manner. It shows the amount of benefit for each monetary unit invested in the project. In a sense, it provides information on how much benefit is ultimately generated by investing in the project. This ratio is the discounted amount of benefits over the discounted amount of costs.

$$\frac{B}{C} = \frac{PV(B)}{PV(C)}$$

Here, PV (B) is the present value of the benefits and PV (C) is the present value of the costs.

The decision rule on the benefit-cost ratio is the following: when the ratio is above 1, the project has larger benefits than costs and should be carried out; when the ratio is below 1, this means that the project has larger costs than benefits and should not be carried out; finally, when the ratio is equal to 1, it means that both benefits and costs are equal, and the indifference scenario is applied. It is worth noting that this indicator is appropriate for comparing alternatives where the benefits are measurable.

d) *Cost-efficiency and average cost indicators*

The objective of the cost-efficiency indicator is to distribute the cost's net present value of the project into a uniform series of annual values. This indicator is normally used to evaluate project alternatives that have the same benefits but different costs or useful lifespan. The formula for calculating the cost-efficiency indicator is the following:

$$CEI = CPV\left[\frac{r(1+r)^m}{(1+r)^m - 1}\right]$$

Here:

CEI = Cost-efficiency indicator

CPV = Cost's present value

r = Social discount rate

m = useful lifespan in years

The decision rule of the cost-efficiency indicator is to select the alternative that has the lower CEI, and it also works even if the lifespan of alternatives does not coincide.[10]

The average cost indicator is the average value of inputs needed to produce one unit of the product. It is obtained by dividing the costs present value (CPV) by the quantities present value (QPV). The indicator is the following:

$$Average\ Cost\ Indicator = \frac{CPV}{QPV}$$

The decision rule of the average cost is to compare it between alternatives and to select the one with the least value, meaning to select the alternative with the least average cost.

10. In cases where the lifespan of alternatives is also identical it would be sufficient to compare the two alternatives to use the cost's present value (CPV).

Step 6: Run sensitivity and risk analyses

The sensitivity and risk analysis are techniques to analyze the extent to which the profitability of the project may be modified when some relevant variables change. One of the main reasons why these analyses are run is because of what is theoretically called the *optimism bias*. Optimism bias is understood as a cognitive bias that leads a person into assigning a lower probability of occurrence to a negative scenario and assigning a higher probability of occurrence to a positive scenario. Therefore, this person feels confident that no negative aspect will occur and that every positive scenario is easily attainable. In socioeconomic evaluation, this optimism bias can translate into a sub-valuation of costs or an overvaluation of benefits. Either situation is undesirable for the project appraisal since the objective is to determine the real costs and benefits. Thus, both the sensitivity and the risk analyses are handy means of challenging the underlying assumptions of the project.

a) *Sensitivity analysis*

The sensitivity analysis is an analytical technique to systematically test the effects on a project's outcome if its basic assumptions change. This technique seeks to determine the impact in the project when independent variables are modified. The sensitivity analysis is mostly known as the "what if" analysis. A number of variables may be modified, some of which are: the investment costs, the operational or maintenance costs, and the amount of benefits, among others. Different types of sensitivity analysis are available: single-variable testing, switching value, scenario analysis, and Monte Carlo simulation.

- *Single-variable testing:*

Only one variable is changing and increasing or decreasing by a given percentage. The analyst must answer what if the operational costs increase by X percent and stress the operational cost assumptions. The way to measure it is by re-estimating the indicators such as NPV, IRR, and B/C and then see if the project profitability holds the change (see Table 6 for more detail on how a single-variable testing sensitivity analysis could be presented).

Table 6. Example of how to present single-variable testing sensitivity analysis results

Variable	Change	NPV (US$ million)	IRR	B/C
Construction costs	30%	10	15.5%	1.20
Operating costs	25%	15	17.2%	1.30
Yield per hectare	-15%	7	10.3%	1.05
Shadow exchange rate	-20%	-3	5.6%	0.85

- *Switching values:*

The idea behind the switching value sensitivity analysis is to determine the relative change of a given variable for the project not to be profitable any longer. For example, in Table 6, if construction costs increase by 48 percent, the project's NPV would be zero, and if they increase by more than 48 percent, the project's NPV would be negative. The switching value corresponds to the break-even point.

- *Scenario analysis:*

The previous analyses studied the impact of the variation of critical variables one by one; another possibility is to analyze how project profitability would change if a combination of variations occurs with certain probability. This process is based on the construction of scenarios with an associated probability of occurrence; a common structure considers the optimistic, base, and pessimistic scenarios. Doing this, helps the decision maker to have a much clearer picture of what could happen for different sets of assumptions.

Table 7. Example of how to present a scenario analysis

Scenario	Probability of occurrence	NPV US$ (million)	IRR	B/C
Optimistic	30%	30	35.5%	2.5
Base	40%	10	16.3%	1.3
Pessimistic	30%	-5	5.8%	0.75
	Expected NPV	11.5		

- *Monte Carlo simulation:*

Finally, a more sophisticated option for sensitivity analysis is using a Monte Carlo simulation, which analyzes the likely impact of the variation of critical variables (described by their distribution function) and their correlation on the project outcomes. The Monte Carlo simulation will help to assess not only the expected net present value of the project, but also the probability distribution of this indicator. For instance, one of the results of the Monte Carlo simulation could be to determine with which probability a project will present a positive NPV. A Monte Carlo simulation is a more complete sensitivity analysis that can help the analyst to assess whether the CBA results are robust to changes in many different combinations of the critical variables' values. For more information on the Monte Carlo simulation method, refer to *New Zealand CBA Guide* (2015, Appendix 1).

b) *Risk analysis*

The risk analysis is a technique that helps decision makers identify the potential causes that could negatively impact the project, in the sense of increasing the costs of execution and operation, delaying the execution of the project, or reducing its benefits. With this, project analysts can foresee what could happen if a particular risk materializes. Moreover, an advanced identification of possible problems allows project managers to anticipate any effect by proposing a mitigation plan. A common structure of a risk analysis is to list all the issues, explain why this is considered a possible risk, assign a probability of occurrence (many use a low, medium, and high scale) and a level of impact to the risk in order to classify the risk in a high, medium, or low risk category, and then define a management strategy: name a person in charge, identify possible mitigation measures, and design a possible solution if the risk materializes.

Step 7: Conclude and formulate recommendations

Once the CBA is performed and the seven steps of the analysis followed, it will possible to determine whether the project is convenient or not based on its socioeconomic profitability. In either case, the analysis will provide enough information either to recommend making the project smaller or waiting a certain amount of time to undertake it or to provide the necessary arguments to pursue the investments and carry on with the project.

Chapter 3. Roads projects

Roads projects provide the connections necessary for people to move from one place to another. The movement not only extends to people but to goods and services that government and businesses procure. The main purpose of roads projects is to lower generalized transport costs (GTC).[11] Roads projects are important because they connect people, often increase the supply of public goods, and allow people to interact and generate knowledge and solutions that foster long-term growth. Moreover, roads are the most frequent means of transport for goods produced by a country; they are the most important conveyance for people; and they are the way most goods and services reach distant communities. For example, rural roads can help reduce maternal deaths through timely access to childbirth-related care, boost girls' enrolment in school, and increase and diversify farmers' income by connecting them to markets.

Most frequently considered roads projects range from building a new road to amplifying or rehabilitating one existing road, including both urban and interurban projects. To explain how to produce a CBA for a roads project, this section will use as an example a highway rehabilitation project in Vietnam (see Box 4).

Box 4. Vietnam highway rehabilitation project

After decades of war and economic stagnation, Vietnam's deteriorated infrastructure threatens to hamper the country's economic recovery. It is estimated that the country needs to invest the equivalent of 3 percent of GDP per year over the next 10 to 15 years for the rehabilitation and modernization of the transport sector. The government has requested assistance from the International Development Association to rehabilitate the main highway network. The aims of the project are threefold: (a) to raise overall economic efficiency and support economic recovery by upgrading critical segments of the national highway network, (b) to transfer modern road technology to the relevant agencies through a program of technical assistance and training, and (c) to strengthen highway maintenance capacity by providing technical assistance and equipment.

The project has three main components: highway rehabilitation, improvements to ferry crossings, and technical assistance. The International Development Association (IDA) is financing US$158.5 million of the total project cost of US$176.0 million.

Source: World Bank (1993).

Step 1: Elaborate the diagnosis of the current situation and definition of the baseline alternative

Before conducting a CBA for a given road project, it is fundamental to elaborate the diagnosis of the state of affairs. Here, should be mentioned the geographical location of the problem, the characteristics of the road, and the network in which it is embedded, describing how other

11. The elements that integrate the GTC are: (1) people's value of time (VOT), and (2) the vehicle operational costs (VOC: fuel, tires replacement, etc.). Generally, these are divided between private vehicles (private cars, vans, etc.), urban transport vehicles, and freight transport. The unit measure is cost by kilometer (km) per type of vehicle.

highways, roads, and even rural roads feed the demand of the road under analysis. In this diagnosis the time it takes to go from point A to B must be evident for every means of transport and be segregated by tipping points during the day, when congestion is more likely.

The description of the current infrastructure conditions (i.e., analysis of the supply) must include all the factors necessary to explain the present service provision or the status of the infrastructure, such as:

- Road specifications (e.g., construction materials, slope stability, slope erosion, pavement alignment, flooding conditions, terrain altitude, proportion of time with an ascending slope, roughness index)
- Operational capacity (e.g., length in kilometers, size and number of lanes, etc.)
- Operational and maintaining costs
- Operational and administrative processes
- Remaining useful life

The demand will depend on a series of demographic dynamics, and it must be defined in terms of:

- Number of vehicles
- Types of vehicles
- Occupation rates of vehicles
- Disaggregation of the demand between long and short itineraries
- Levels of congestion (per hour, per day, per week)
- Seasonality of the demand (per month)
- Tariff system

In any case, however, a deep analysis must be executed that includes a regional disaggregation to identify whether the road is rural, which could provide information on the stationary behavior of the demand (only when there is produce good enough for market provision), or whether the road is mainly industrial, which answers mainly to GDP growth behavior.

> In the example of Vietnam, the current situation can be summarized as a problem of infrastructure deterioration. In the year 1992, Vietnam had about 70 million people. It was primarily an agricultural rural economy. Many regions throughout the country remained difficult to reach and suffered from inadequate access to markets and government support services. However, most places were reached by inexpensive water transport. In economic terms, Vietnam had its per capita income at about US$200.

The road network was 105,100 km with only 13,000 km of paved roads. In the period of 1990–1992, the total freight traffic increased 24 percent annually, measured by ton per kilometer. According to the UNPD and other local agencies, the annual total freight traffic was 185 ton-km per capita. Compared to similar countries, this figure remained low. Passenger traffic was at 262 passengers per kilometer per capita, which was higher than China at that time but still underperforming compared to similar economies.

Most freight transport was done by roads (58 percent), followed by inland waterways (28 percent), and maritime and rail, with 9 and 5 percent, respectively. With regard to passenger transport, most travel was done by road (75 percent). Transport was severely deteriorated as construction and maintenance remained poor after the wars. In 1990, transport equipment was not fully used (i.e., less than half of the road repair equipment was operating). After reform negotiations in 1989, the transport tariffs were adjusted to better reflect the cost of providing services.

The motor vehicle fleet was estimated at 219,000 motor vehicles registered by the end of 1990. Buses and trucks accounted for 14 and 66 percent, respectively. The average daily traffic varied substantially among and between regions. However, a number of congested regions were the norm rather than the exception (more so between Hanoi and the Ho Chi Minh City). In terms of road safety, Vietnam had high numbers of road accidents with fatality rates 10 times higher than in neighboring countries and some 40 times higher than in the more industrialized countries.

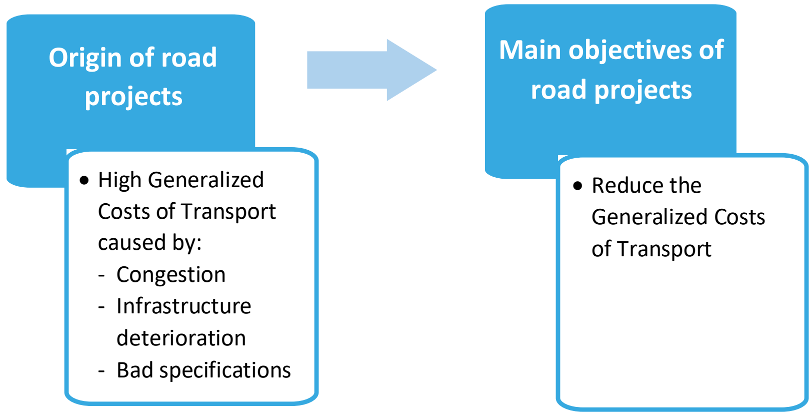
The interaction between supply and demand is the costs that people have to pay to transit, in terms of both money and time spent. The GTC provides a way to estimate these, calculated through the operational and maintenance costs of the vehicle and through the time people spend in the road going from point A to point B. In road projects, it is important to calculate the GTC because it internalizes the actual conditions of the infrastructure and the characteristics of the demand. Furthermore, when the analysis is on urban roads (highways), it has to be divided according to congestion levels, for instance between peak hours and non-peak hours, for greater precision on the calculated figures.

For roads projects, the most common identified issues at the interaction moment are:

1. High GTC due to overcrowded roads
2. High GTC due to insufficient maintenance or to the type of road material (dirt roads)
3. High GTC due to low specifications of the existing network

Figure 7 depicts the typical origin and the main objectives of road projects.

Figure 7. Origin and objectives of road projects



Right after the supply, demand and the interaction between them is understood; the problem the analyst faces is to identify the possible actions to carry forward or the "do-minimum" options that will allow her to estimate the baseline on which the costs and benefits of the project will be calculated. Among the most common proposed adjustments on road projects, it is possible to find:

- Improvement of the road material through patching activities.
- Improvement of horizontal signaling, which include the road lines painted on the pavement, the "reduce speed" signals, etc., and the vertical signaling, which include signals providing feedback to drivers on how the road is sketched.
- If the road is a concession to private entities, one "do-minimum" option is to increase the tariff charged in peak hours and decrease it during normal ones.
- Another adjustment is to improve the lay out of the road, perhaps by improving curvature, including a lane for passing (mainly for rural roads), and others.

At this stage, another important step to defining the baseline scenario is to forecast the supply and demand to analyze how the identified problem in the current situation will evolve. For roads project, generally the problem will get worst; as demand is expected to increase, annual GTC would follow. Strictly, the determinants to forecast demand and supply in roads projects must be analyzed project by project. Nevertheless, commonly in cases with limited information, average growth rates or population growth rate are good parameters to perform the forecast needed, because sectors such as transport and consumption of public services (water, waste collection, electricity, public health, etc.), among others, respond to similar paths of growth as those that compound macroeconomic variables.

Step 2: Identify and define the alternatives

The alternatives depend on the type of problem. A road project originate because the current one crosses rugged terrain, has higher degrees of elevation, was properly maintained, or has curves that slow the movement of people from point A to point B, thus increasing the GTC. It also may originate because the current road is overcrowded and congested during the day. Both types of issues may reduce the average speed of each means of transport. In the description of the current state of affairs, it must be evident which issue is the principal one. Once the problem has been well understood, it is possible to formulate alternatives that will provide a solution to this problem.

In road projects, it is often the case that the alternatives differ on their:

- Geographic location
- Size
- Technical issues like the type of pavement, etc.

Remember that for each alternative at this stage it is important that the description and design include at least the following elements:

- ✓ Set of investment components and their relative size
- ✓ Geographic location
- ✓ Technology
- ✓ Execution duration and program of activities
- ✓ Estimated investment, operation and maintenance costs
- ✓ Sources of financing
- ✓ Useful life
- ✓ Estimated capacity and expected production
- ✓ A summary on the main legal, technical, environmental, strategic/political, commercial, and social feasibility aspects.

Step 3: Describe the situation with the project

The description of the situation expected to arise with the implementation of the project has to include how the problem would look like once the project is operating. For example, if the problem is that the current speed of each means of transport is lower than on a comparable road, then if the project seeks to improve the roughness index by ameliorating the type of material used, a description could focus on how the average speed for each means of transport will increase, implying GTC will decrease.

Both supply and demand should be forecasted based on the characteristics or the projects' capacity. The narrative of this section has to describe the extent to which the problem is reduced, minimized, or eliminated. For example, if a project was set to reduce accidents, the percentage change in the accident rate could be an indicator that helps the analyst observe whether the project had the foreseen achievements.

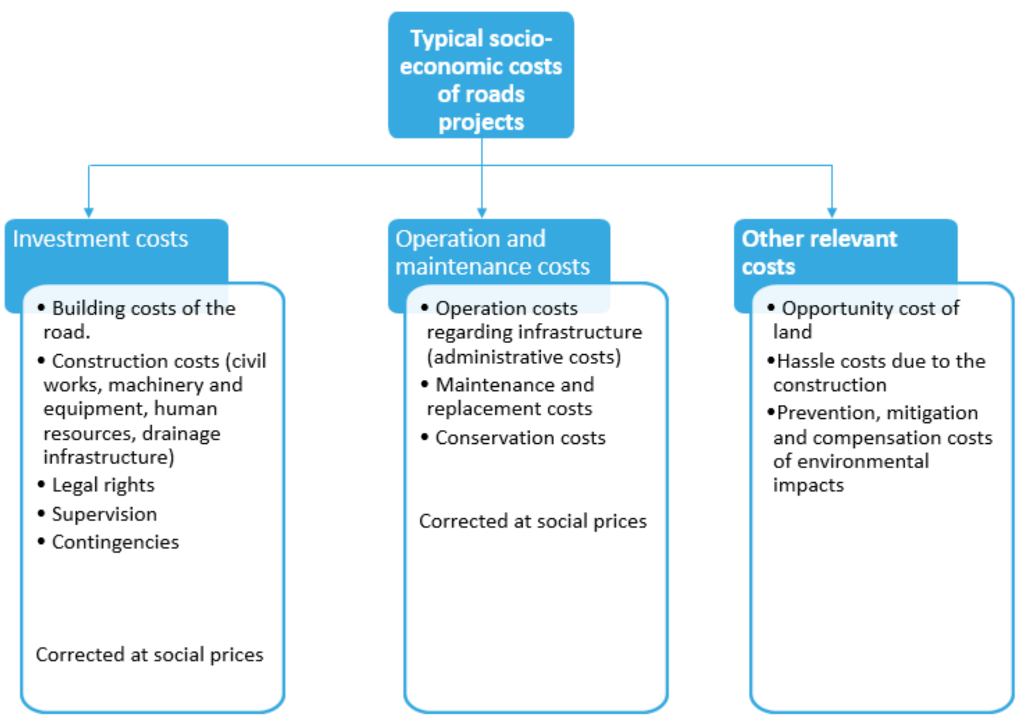
Step 4: Identify, quantify, and monetize costs and benefits

The next step is to identify, quantify, and monetize costs and benefits of the selected alternative. For in-depth analysis of the methodological approaches to identify, quantify, and value the costs and benefits of roads projects please refer to SHCP (2010), Department of Transport and Main Roads, Australia (2011), Asian Development Bank (2013, Chapter 7), and European Commission (2014, Chapter 3).

On the one hand, the cost flows must be quantified and monetized for the total duration of the project. The most relevant costs in road projects are:

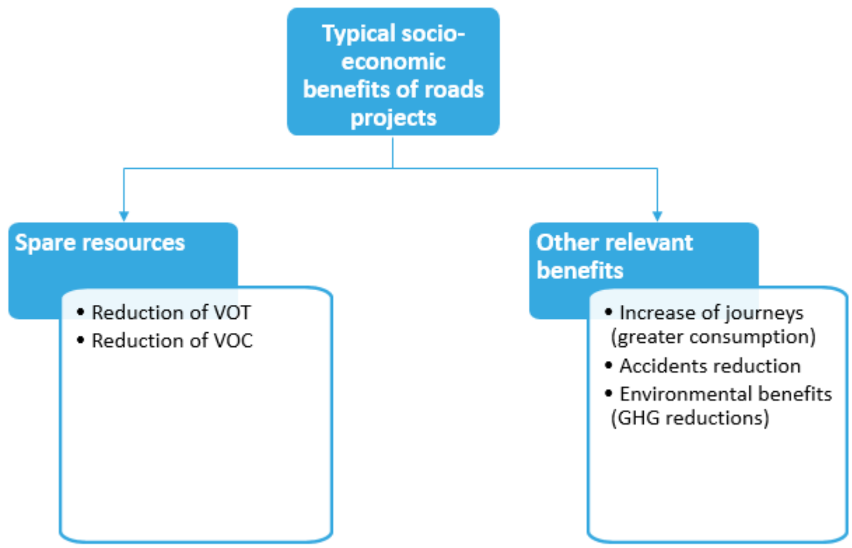
- *Investment costs:* building costs of the road, construction costs, civil works, drainage infrastructure, pavement, legal rights (i.e., rights of ways), machinery and equipment, workforce, supervision, and contingencies.
- *Operational and maintenance costs regarding infrastructure (potentially net of the ones incurred without project):* type of pavement, conservation costs, etc.
- *Opportunity cost of land*.
- *Hassle costs due to the construction:* quantification of the hassles generated by the project during its execution phase.
- *Environmental costs.*
- *Prevention, mitigation and compensation costs of environmental impacts.*

Figure 8. Typical socio-economic costs of road projects



The benefits related to road projects are given through a reduction of GTC and an increase in the number of journeys (induced demand), accidents reduced, and environmental benefits gained, summarized in Figure 9.

Figure 9. Typical socioeconomic benefits of road projects



Each one of these benefits must be monetized to be included in the socioeconomic flow of costs and benefits using the following methods.

- **Benefit due to the reduction of VOT (resources spared):**

  Many different methods exist to assign a value to transport time depending on the purpose of the trip, in particular working/nonworking.

1. Method for valuing working time savings

Approach to be adopted (data and resource dependent)	Method
Base (or minimum) approach (single value of work time savings)	Option 1: National average wage rate adjusted by observed adjustment factors to reflect additional employee-related costs (e.g., overheads for employer pension contributions) Option 2: 1.33 x wage rate (adjusted by shadow wage rate)[12]
Second best approach (by mode)	Adjusted from observed wage rate using observed adjustment factors (e.g., overheads and shadow wage rate)
More precise approach (by work sector)	Adjusted from observed wage rate using observed adjustment factors (e.g., overheads and shadow wage rate)

12. The concept of shadow wage rate is introduced in Chapter 1.

2. Method for valuing nonworking time savings

Approach to be adopted (data and resource dependent)	Method
Base (or minimum) approach (single value of nonwork time savings)	Adults: 0.3 x household income (per head) Children: 0.15 x household income
Second best approach (by mode, plus modifications for trip characteristics (e.g., walk, wait, journey quality))	Revealed and stated preference methods for values of time savings and modifiers; results adjusted to price base.
Ideal approach (by income group, socioeconomic group, journey purpose; plus modifications for trip characteristics (e.g., walk, wait, journey quality))	Revealed and stated preference methods for values of time savings and modifiers; results adjusted to price base.

3. Method for valuing walking and waiting time
   Some multiplier has to be applied as walking and waiting time is found to be costlier.
   1.5 x value for in-vehicle time

Consideration when calculating the VOT should also be given to:

- Relationship to wage rates for different workers (e.g., unskilled rural, skilled rural, white collar; working time only); relationship to income, socioeconomic group and journey purpose (nonworking time only); modifiers for walking and waiting time (nonworking time only); and modally specific values.
- For major projects that involve significant reductions in travel time but for which a fare or toll must be paid (e.g., new metros, toll roads, etc.) it will be essential to distinguish between different income groups (nonworking time) and industrial sector (working time); the value of time should grow in real times over the appraisal period; and it is essential to augment the economic appraisal with a poverty impact analysis.

- **Benefit due to the reduction of VOC (resources spare):**

  This benefit refers to the reduction of vehicle operational cost that will happen when congestion is reduced, speeds are closer to the optimal ones by type of vehicles, and the surface of a road is repaired. Having fewer potholes and a smoother pavement with better specifications, vehicles incurred lower cost while traveling through the road under analysis. Analysts must estimate how much cost reduction will take place because it is expected that a better road reduces the amount of fuel consumed, the frequency of taking vehicles for maintenance, and the amount spent for parts.

The are some options to estimate these benefits. On the one hand, specialized software such as The High Development and Management (HDM)[13] not only helps to estimate the VOCs but also to plan a schedule of investments in maintenance. On the other hand, it is possible to make this estimation by hand. First, the analyst must clearly identify the type of vehicles that circulate on the road. Second, she estimates a spare wear percentage of the main components of the vehicles (e.g., tires replacement, oil filters change, etc.) per a period of time and under the current situation (baseline) and with the project. And third, using market prices, the analyst must estimate the cost per km of each vehicle component considered. The use of any of the above options will depend on the availability of resources and the accuracy with which the estimate must be done.

- **Benefit due to an increase of journeys (greater consumption or induced demand):**

  Greater consumption of the infrastructure will normally happen whenever the project produces significant cost reductions. In order to assess the amount of this benefit, the analyst must estimate the number of new journeys that will take place as well as the consumers' willingness to pay for those trips.

  The most common cases where this benefit is observed usually relate to rural road rehabilitation, improvement, or enlargement. This happens mainly because the profitability of agricultural activities highly depends on the transportation costs of the crops, so when a project reduces them, it can detonate the economic margins of such activities, thus promoting a larger use of the road by farmers to transport their crops to market.

- **Accidents reduction:**

  Methods used to value the economic cost of an accident casualty can be categorized into six approaches:

13. This software can be found at https://www.piarc.org/en/knowledge-base/road-assets-management/HDM-4-Software/.

a. The "gross output" or human capital approach: In this method the cost of a fatal casualty is the loss of future output, equivalent to foregone earnings.

b. The "net output" approach: The cost of an accident is equivalent to the "gross output" figure minus the discounted value of the victim's consumption.

c. The life-insurance approach: The cost of an accident is directly related to what typical individuals are willing to pay for insuring their own lives.

d. The court award approach: With this approach, the sums awarded by the courts to the surviving dependents of those killed or injured are regarded as an indication of the cost that society associates with the road accident.

e. The "implicit public sector valuation" approach: With this method, an attempt is made to determine the costs and values implicitly placed on accident prevention in safety legislation or in public sector decisions taken either for or against investment programs that affect safety.

f. The "value of risk change" or "willingness to pay" approach: With this method, the value of a given improvement in safety (i.e., a reduction in risk) is defined in terms of the aggregate amount that people are willing to pay for it. That is, the value of a particular safety improvement is defined as the sum of all the amounts that people (affected by the improvement) would be willing to pay for the (usually very small) reductions in risk provided by that improvement.

- **Environmental benefits due to reduction of GHG emissions and other sources of pollution:**

By increasing speeds, road projects reduce the consumption of fuel, reducing GHG emissions and other sources of contamination, particularly air pollution.

To monetize air pollution, a strategy would be to measure the direct costs caused by contamination that would be saved in the "with project" scenario. Nevertheless, in most cases, the impact would not be so clearly identifiable; in that case, an option is to identify the variation in the quantity of a pollutant, for instance emissions of nitrogen oxides (NOx), and use previous studies to assign a price to it. For air pollution, refer to the National Emission Ceiling Directive published by the European Environment Agency (2016).

For the GHG reduction, the logic is the same. The first step is to estimate the reduction in the emissions of equivalent carbon dioxide (CO2) and then apply the shadow price of carbon. The World Bank has produced a guidance note on the calculation of the "Shadow Price of Carbon in Economic Analysis," released in November 2017, intended to help World Bank staff value carbon emissions in economic analysis of investment project financing. The guidance note presents recommended values for the shadow price of carbon, in US$ per 1 metric ton of CO2 equivalent, from 2017 to 2050 at constant prices, for low and high case scenarios. The Table 8 presents the recommended values in euros per metric ton of CO2 equivalent, assuming 1 euro equals US$0.85, for the low and high scenarios. An additional medium case scenario is presented in Table 8.

Table 8. Shadow price of carbon

	Euro constant prices per 1 metric ton of CO2		
		Scenario	
Year	Low	Medium	High
2017	31	48	64
2018	32	49	65
2019	33	50	66
2020	34	51	68
2021	35	52	70
2022	36	54	71
2023	37	55	73
2024	37	56	74
2025	38	57	76
2026	39	58	77
2027	40	60	80
2028	41	61	82
2029	42	62	83
2030	43	64	85
2031	43	65	87
2032	44	67	89
2033	45	68	91
2034	47	70	93
2035	48	71	95
2036	48	73	97
2037	49	74	99
2038	51	77	102
2039	52	78	104
2040	54	80	106
2041	54	82	109
2042	55	83	111
2043	57	85	114
2044	58	87	116
2045	60	89	119
2046	60	91	122
2047	62	93	124
2048	64	95	127
2049	65	97	130
2050	66	99	133
Annual growth (%)	**2.29%**	**2.26%**	**2.24%**

To define the CO2 emissions cost (euro/ton), the guidelines recommend the use of a CO2 cost scenario that gives more conservative economic evaluation results, e.g., for net CO2 savings over the evaluation period use the low CO2 cost scenario and for net CO2 increase over the evaluation period use the high CO2 cost scenario. Therefore, we have, for a case study that reduces CO2 emissions over the evaluation period that the CO2 emissions cost (euro/ton) in 2018 is equal to 32 euro per ton.

In the case of Vietnam, the costs were estimated at US$176.0 million, including contingencies, land acquisition, and resettlement. Table 9 provides a brief summary on each component.

Table 9. Costs of the road rehabilitation project in Vietnam

Component	
Road rehabilitation	88.5
Ferry operations	8.5
Equipment	10.3
Technical assistance	1.8
Implementation support and project preparation	5.6
Institutional development	2.0
Training	
Total base cost	**116.6**
Physical contingencies	15.7
Price contingencies	10.9
Resettlement and rehabilitation	28.9
Land acquisition	3.9
Total project cost	**176.0**

Source: World Bank (1993).

On the benefits estimation, the Table 10 provides the streams calculated for the Vietnam project divided by the northern and southern part of the country.

Table 10. Benefits estimation for the project in Vietnam[14]

Northern part of Vietnam

Year	Cost Without Project (Mil. US $)		Cost With Project (Mil. US $)		Benefit Streams (Mil. US $)			
	Maintenance (a)	Vehicle Operation (b)	Construction Maintenance (c)	Vehicle Operation (d)	Construction Cost Savings (a-c)	Vehicle Operation Cost Savings (b-d)	Net Cash Flow	Cumulative Net Present Value (Mil. US $)
1994	0.302	50.702	31.196	50.702	-30.894	0.000	-30.894	-20.261
1995	0.353	63.144	14.449	63.144	-14.096	0.000	-14.096	-37.980
1996	0.402	77.685	14.449	35.327	-14.047	42.358	28.311	-16.710
1997	0.439	94.613	0.140	41.508	0.291	53.105	53.395	19.760
1998	0.491	114.600	0.151	48.970	0.341	65.630	65.970	60.722
1999	0.528	130.278	0.155	58.003	0.373	80.275	80.648	106.246
2000	0.573	166.845	0.159	68.900	0.414	97.945	98.358	156.719
2001	0.614	200.352	0.163	82.227	0.450	110.125	118.575	212.036
2002	0.666	241.962	0.172	98.392	0.494	143.570	144.064	273.133
2003	0.725	290.664	0.185	117.899	0.540	172.765	173.305	339.950
2004	0.765	345.234	0.205	142.454	0.561	202.780	203.341	411.219
2005	0.813	407.161	0.218	173.366	0.565	233.794	234.389	405.903
							EIRR 77%	

14. In this case, only the VOC were considered; the VOT are not calculated.

Southern part of Vietnam

Year	Cost Without Project (Mil. US $)		Cost With Project (Mil. US $)		Benefit Streams (Mil. US $)			
	Maintenance (a)	Vehicle Operation (b)	Construction Maintenance (c)	Vehicle Operation (d)	Construction Cost Savings (a-c)	Vehicle Operation Cost Savings (b-d)	Net Cash Flow	Cumulative Net Present Value (Mil. US $)
1994	0.131	55.988	32.362	55.966	-32.231	0.000	-32.231	-29.946
1995	0.175	80.259	0.619	60.259	-8.444	0.000	-8.444	-21.852
1996	0.229	102.011	0.619	38.689	-8.390	63.322	54.931	19.419
1997	0.258	122.967	0.080	45.936	0.178	77.031	77.209	72.154
1998	0.283	145.543	0.081	54.800	0.202	90.743	90.945	128.624
1999	0.291	172.343	0.081	65.847	0.210	106.496	106.706	188.857
2000	0.304	203.345	0.081	79.725	0.222	123.620	123.842	252.407
2001	0.321	241.105	0.093	97.578	0.228	143.527	143.755	319.470
2002	0.347	285.931	0.099	120.739	0.240	165.192	165.440	389.633
2003	0.356	337.837	0.112	151.291	0.244	186.345	186.789	461.648
2004	0.385	400.122	0.127	193.216	0.258	206.905	207.164	534.258
2005	0.402	472.968	0.139	252.327	0.263	220.641	220.904	604.645
							EIRR 101%	

Source: World Bank (1993).

Step 5: Calculation of the indicators

Step 5 involves calculating the socioeconomic indicators to determine the convenience of the project. Keep in mind that there are four main indicators: (1) net present value, (2) internal return rate, (3) benefit-cost ratio, and (4) cost-efficiency and average cost indicators. In road projects, the first two are the most important indicators. When the NPV of the project is positive, the project is worth executing. On the other side, when the NPV of the project is negative, implementing the project is not advisable. In the case the NPV is equal to 0, the analyst must conclude that it is indifferent between executing the project and taking another project with the same discounting rate. The second indicator of IRR has a similar logic. However, the IRR shows the rate of a project for which the NPV is equal to 0. The decision has to be made by comparing both the IRR with the social discount rate (r). If the IRR>r, then the project must be made. If the contrary is the case (IRR<r) then the project should not be carried out. In the case the IRR=r, then the analyst is indifferent between doing the project and doing another project with the same r.

Step 6: Run sensitivity and risk analyses

Running sensitivity and risk analyses means to evaluate how the project will behave in case any of the sensitivity or risk scenarios materialize. All the underlined assumptions must be challenged when running a sensitivity and risk analysis. In roads projects, the most common risks are composition of the demand, supply trends, investment costs, number of years required for project completion, avoided costs of accidents, demographic trends, tariff collection capacity, land costs, delays in the construction, low-quality materials, financing challenges, people’s rejection of the project, etc. Most of these risks require mitigation measures foreseen by the analyst.

Regarding the sensibility analysis, in roads projects, the main sources of risk are the variability of costs and the variability on schedule times on one side and the variability of benefits and operational and maintenance costs on the other. These costs could be breached due to unforeseen situations, such as a change in the unitary prices, environmental considerations, unexpected constructions, expropriations, and input prices variabilities.

In the case of Vietnam, since IDA assisted and financed most of the operations in the project, the main risk associated was the lack of experience using their funds. The project considered these risks and attempted to mitigate them using training in workshops for people involved in project implementation and other relevant activities.

A series of sensitivity analyses were conducted for the road sections on Vietnam. These included construction cost increases, VOC benefit decreases, simultaneous cost increases and benefit decreases, and variations in traffic growth.

The main results (divided by North and South) were:

Table 11. Sensitivity analysis

	Base EIRR %	10% Cost Increase	10% Benefit Decrease	5% Traffic Growth
Highway				
North	77	72	72	57
South	>100	94	94	81

Source: World Bank (1993).

Step 7: Conclude and formulate recommendations

Finally, the analyst has to draw a number of conclusions and recommendations for the decision makers. Based on all the criteria of the CBA, the analyst has to determine if the project is to be implemented or not. Moreover, the analyst has to determine when this implementation is optimal as well as the optimal size of the project (number of lanes, etc.); what layout will maximize demand; what are the main organizational, legal, and environmental aspects; and the extent to which the "do-minimum" options should be factually implemented before investing in the project. The analyst thus puts forward all the information necessary to argue either that the project should be pursued or it is not viable.

Chapter 4. Public transport projects

Public transport projects aim at improving mobility of people and providing them with access to productive, touristic, and other relevant activities within medium and large cities. When public transport projects, mainly in urban contexts, experience difficulties, consequences are spread throughout households, businesses, and the community at large. The most frequent problems include health hazards, unsafe conditions, GHG emissions beyond the normal, reduced productivity and competitiveness, reduced access to economic opportunities, and an overall barrier to poverty alleviation.

Reversing a negative trend on public transport requires better urban planning and policy interventions that minimize the need for private automobiles through better options for public transport, cycling, or walking. To enhance the way that people travel every day to their destinations, most transport projects should aim at lowering travelling costs. To do this, transport projects often increase the capacity of the system (new bus routes, more metro stations, etc.) or reduce the waiting times by rescheduling the operation times of the transport. Any strategy pursued must be comprehensive and multimodal. It has to go beyond merely building facilities to understanding linkages with land use, human behavior, affordability, and the environment.

Public transport projects usually reveal many alternatives for solving the same problem. These involve various ways of exploiting the potential social benefits that these projects may entail (e.g., incentives to substitute public transit for automobile use to reduce GHG emissions and gain positive externalities from the reductions). Most common types of public transport projects are buses, bus rapid transit (BRT) systems, tramways, metros or subways, and trains. Additionally, the projects may involve either greenfield or brownfield investments.

The evaluation of transport projects requires comparing the situation with and without the project, as well as comparing it with the next best alternative. For instance, when facing the problem of overcrowding on urban buses and associated waiting times, one solution may be to increase supply by adding more buses; another is to shift demand by providing alternative modes of transport, such as a subway. For explaining how to produce a CBA for transport projects, this section will use the example of the Belo Horizonte Metropolitan Transport Decentralization in Brazil (see Box 5).

Box 5. Belo Horizonte Metropolitan Transport Decentralization

The main purpose of the Belo Horizonte Metropolitan Transport Decentralization Project was to develop an integrated urban transport system for the Belo Horizonte Metropolitan Region to reduce travel and waiting time.

In 1994, the Belo Horizonte Metropolitan Region, with 5,850 sq. km, had 3.5 million inhabitants spread unevenly over 18 municipalities. The annual population growth had averaged 2.5 percent in the previous five years. The region was considered the third most important economic region of Brazil. Each day, 3.2 million person-trips took place, of which 68 percent were by bus, 25 percent by private automobile, and the rest by rail, bicycle, or walking.

The network was radial, and all its main corridors intersected the beltway around the metropolitan region. Bus routes penetrated Belo Horizonte and adjoining municipalities through ten main corridors. The commercial speed of the buses in the segregated busways was around 25 km/hr, but it dropped to 9 km/hr in the central business district. At peak period, most highways were clogged with bumper-to-bumper buses. Bus services were generally low speed, unreliable, and infrequent at peak hours due to the congestion. The tariff system was regulated by local agencies and privately operated; no subsidy was paid to bus operators.

The first component of the proposed project focused on providing infrastructure and equipment to help build the rail extension (both for metro and busways), the transfer terminals, and a centralized road traffic signal control system. The second component focused on environmental and traffic safety. The third component focused on institutional and policy development to build the integral system further along the way.

Source: World Bank (1995a).

Step 1: Elaborate the diagnosis of the current situation and definition of the baseline alternative

To elaborate a diagnosis of the current situation, the analyst must first know the actual characteristics of the supply. This analysis must include all the different factors necessary to explain the current provision of the service or the status of the infrastructure, for example:

- Geographic location
- Number of vehicles for the provision of the service (buses, train convoys, trams, etc.)
- System capacity (maximum number of passengers per hour)
- Number of stations and routes
- Main source of transport power (fossil fuels or electricity)
- Current operation schedule (timetables, frequency, etc.)
- Length in kilometers and confinement features
- Operational and maintenance costs of the system disaggregated by transport mode
- Current operational and administrative processes (e.g., payment technology)

Regarding the demand side, the analyst must consider how many people use the current infrastructure. One useful metric is to estimate the number of persons that travel in both directions, on average, in one year. Some metrics, among others, are:

1) To determine the frequency with which the transport leaves the station
2) To determine the average number of people in each mode of transport (depending on the time of the day to identify peak hours)
3) To determine the average distance traveled
4) To determine the origin and destination of each passenger
5) To determine the time spent traveling from origin to destination
6) To describe the tariff system
7) To know the reasons for the trips
8) To deduct the income level and other demographic characteristics of the passengers

Some factors that could influence these are the demographic dynamics, climate conditions, and the type of tariff system set in place. It is worth noting that to accomplish a thorough demand analysis it is recommended to perform a demand study. Besides estimating the current demand for the mode of transport under analysis, it is also important to estimate in advance the demand for its substitute transport because, as it will be shown later, the majority of transport interventions affect other modes of transport. For instance, it is expected that car drivers or taxi users will decide to switch transport if subway lines or bus routes are extended.

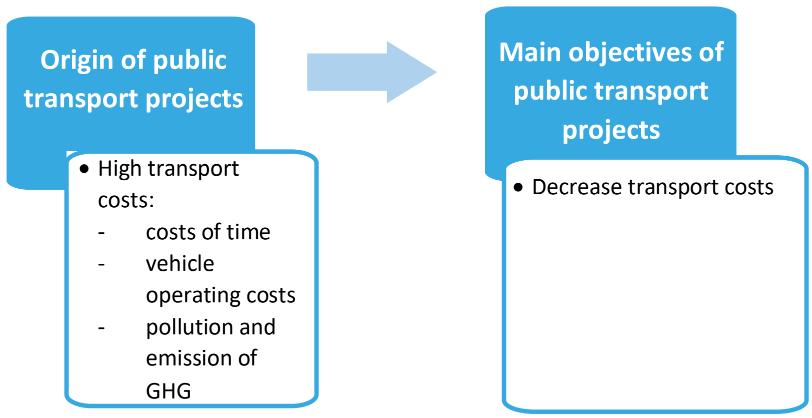
> In the example of Brazil, the current state of affairs was a decentralized system with no coordination between the responsible agencies. The supply of the urban transport in Belo Horizonte for buses, at the time, consisted of a single line of 16.1 km. The system was integrated by 74 bus lines in only one terminal, which generated about 60 percent of its demand at an integrated tariff. The demand, at the time, was 50,000 passengers per day, instead of the 250,000 originally planned. The low levels of demand were mainly because the original planned network was never completed. Another important factor for the demand was that the annual population growth was 2.6 percent on the 1989–1994 period.

Once the supply and demand characteristics are known, the interaction between the two will allow the analyst to understand the current state of affairs in terms of waiting and travel times, tariffs charged per trip, other trip costs, congestion hours, and others. Therefore, once the interaction is thoroughly described and understood, the analyst will be able to narrow down the specific problem and define it.

It is worth noting that most projects in the transport sector have multiple problems that governments are trying to solve. Besides having high travel time, it is possible that the current state of affairs presents high rates of accidents, economic inefficiencies, polluted air, etc. Moreover, the diagnosis has to consider every cost that the target population is paying for the increased travel and waiting times. For example, if people are spending on average three or four hours of their day going from point A to point B and back, then if point A is their home and point B is their work, most likely their productivity levels will be affected. Meaning that if the travelling costs are high, people will provide lower productivity levels that companies must internalize as well.

Nevertheless, it is possible to summarize the origin of the public transport projects and their objectives as it is defined in Figure 10.

Figure 10. Origin and objectives of public transport projects



Right after the supply, demand, and the interaction between them is understood, the problem itself will be, in most cases, evident. At this point, the analyst has to identify the possible actions that constitute the "do-minimum" option that will allow her to estimate the baseline situation relative to which the costs and benefits of the project will be calculated.

Among the most common proposed adjustments, it is possible to find:

- When the identified problem is an inefficiency of public transport then a "do-minimum" option could be to increase the number of bus maintenance tasks to decrease the number of malfunctions.
- Furthermore, if the problem has to do with system congestion, it is important to consider increasing user fares to ration the demand.
- In cases when the problem is related to accidents, a "do-minimum" option could include a strategy to communicate the ways in which users can avoid accidents. For example, when riding a bus or the metro it is not recommended to stand by the doors, thus increasing saliency of this safety measure will help reduce accident rates. Other "do-minimum" options for safety would be to improve signaling, modify access doors (making doors in the middle exits and doors at the extremes entrances), or add metal-and-glass sliding doors to avoid people jumping or falling on the rails.
- If the problem is related to environmental aspects of transit, a "do-minimum" option might promote the use of sustainable transport, such as bicycle or electric-powered transportation.

After the baseline is estimated, it will be necessary to forecast it throughout the project's evaluation horizon. For the forecast of the baseline alternative, the historical consumption readings, the population growth rate, the composition of consumers (industry, households, etc.), and the GDP growth rate are the main parameters used to estimate future changes in public transport demand. Concerning the supply side, this ultimately depends on maintenance facilities and on the number of trains or buses available.

Step 2: Identify and define the alternatives

The alternatives depend on the type of problem. On the one hand, when the problem is one of high waiting times, the alternative could be to increase the number of units transporting people. On the other hand, if the problem is connected with the number of accidents, resolution may relate to modification of the stroke line (current route). Furthermore, if the identified problem is one of quality, an alternative could be to improve the current transport by adding features people value, for instance, improved security in the public transport system.

Among the recurrent alternatives are:

- Stroke lines with different velocities
- Different types of materials used
- Different technologies employed
- Different sizes of the project (determine the optimal size)
- Different routes
- Different moments to start the building of the alternative (optimal moment for investing)

For each alternative it is also important to include depth of detail on the following aspects:

- ✓ Set of investment components and their relative size
- ✓ Life cycle
- ✓ Geographic location
- ✓ Execution duration
- ✓ Estimated investment, operation, and maintenance costs
- ✓ Sources of financing and social, environmental, technical, legal, strategic, and commercial restrictions

Step 3: Describe the situation with the project

The description of the situation expected to follow implementation of the project must assess how the problem would look once the project is operating. In particular, it is important to describe how the supply, the demand, and their interaction will change with the project's implementation.

The narrative of this section describes the extent to which the problem is reduced, minimized, or eliminated. For example, if this project seeks to reduce accidents, the percentage change could be one indicator that helps the analyst to observe whether the project had the expected achievements. Furthermore, it is important to acknowledge that most projects that aim at reducing costs will produce an additional benefit by increasing the consumption of the service they provide. This can happen precisely because the reduction in costs will increase the relative attractiveness of that specific transport mode.

> For the case of Brazil, remember that the project consisted of three components, including increasing the number of kilometers available; building four additional stations, two integration terminals, and a number of pedestrian walks; and providing stations with transfer terminals and access. Therefore, the narrative analyzed the problem and how it was reduced, minimized, or eliminated on each of the three components.

Step 4: Identify, quantify, and monetize costs and benefits

The next step is to identify, quantify, and monetize costs and benefits of the selected alternative. For in-depth analysis of the methodological approaches to identify, quantify, and value the costs and benefits of public transport projects please refer to the CEPEP (2009); National Planning Department, Colombia (2003); and European Commission (2014, Chapter 3).

On the one hand, the cost flows must be quantified and monetized for the total duration of the project. Some of these costs could be:

Investment costs:

- Building costs of the transport
- Construction costs (civil works, machinery and equipment, human resources, drainage infrastructure)
- Legal rights
- Reinvestments
- Urban adequacies
- Supervision
- Contingencies

Operation and maintenance costs:

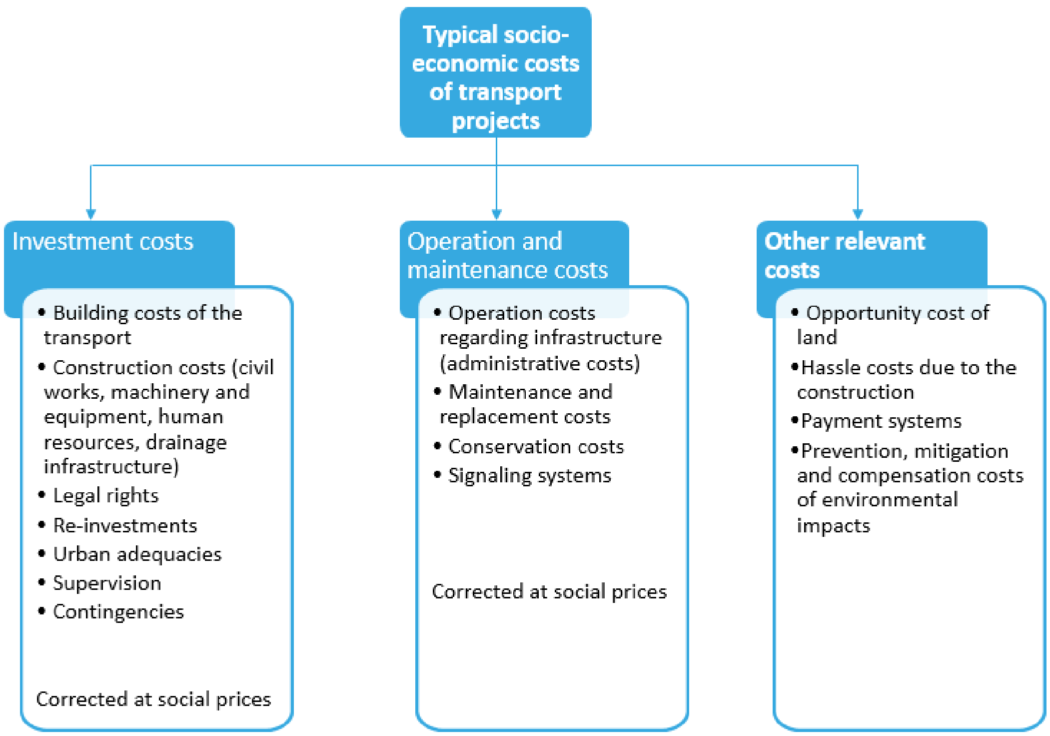
- Administrative costs
- Maintenance and replacement costs
- Signaling systems

Other relevant costs:

- Opportunity cost of land
- Hassle costs due to the construction
- Payment systems

- Prevention, mitigation and compensation costs of environmental impacts: The environment of a transport investment includes the surrounding objects and conditions as well as the circumstances of life in society in that area. This definition is broad, and the potential number of environmental impacts is therefore large. In addition, it is important to recognize that both positive and negative environmental impacts may arise from the same project. For example, the provision of extra road capacity, as part of an integrated transport strategy, may reduce air pollution by removing the incidences of standing traffic, but it may also increase severity and have safety implications for pedestrians and non-motorized traffic due to increased vehicle speeds.

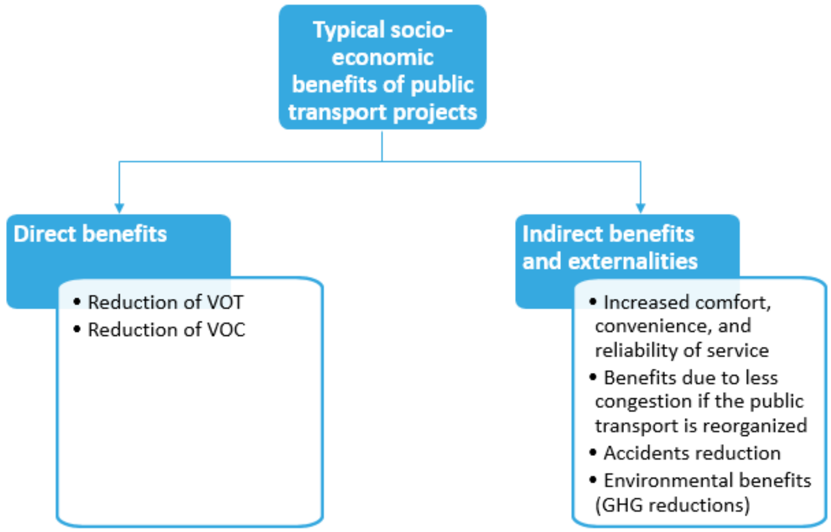
Figure 11. Typical socioeconomic costs of public transport projects



On the other hand, the most common direct and indirect benefits of public transport projects include:

- Savings in vehicle operating costs
- Time savings
- Reduction in the frequency and severity of accidents
- Increased comfort, convenience, and reliability of service
- Benefits due to less congestion if the public transport is reorganized
- Environmental improvement (reduced GHG and pollution)

Figure 12. Typical socioeconomic benefits of public transport projects



As happens on roads project, when estimating the benefits of transport project, the analyst must consider time savings. Any transport project that saves time produces important measurable benefits. In many cases, the value of time saved is reflected in demand for faster service and the price that consumers are willing to pay for it. The value that consumers attach to time saved must be derived indirectly. In general, time savings can be analyzed through the value of people's working time saved and the value of people's nonworking time saved. The first refers to the time employed transporting during working hours, which is time not used at work. Working time saved, then, is working time that can be used to produce goods and services, and its value is the wage rate plus any other costs associated with employment, such as social security taxes. The second refers to the time saved in trips undertaken for nonworking purposes. Because there is no explicit market for time spent at leisure (i.e., no observable price), the value of nonworking time must be inferred. In principle, willingness to pay for savings of leisure time should be lower than willingness to pay for savings of work time, because the wage rate includes payment both for the effort and the scarce skills embodied in the work activity. Moreover, the willingness to pay for leisure time may vary by journey and timing, both because time may be valued differently at different times of the day, and because the travel activity may have some positive utility. For example, a person on an emergency trip to a hospital would value time saved very highly (see Chapter 3, Step 4, for further details on how to assess the benefits of transportation projects).

As shown in Table 12, the total annual value of time savings for the Brazil example was US$37,581 thousands. Most benefits came through working time saved (business) in the bus mode of transport; the value of time per hour in US dollars for business is also the highest compared to commuting and others in the same mode of transport. In transport projects, the best way to estimate time savings is by dividing the demand into commuting, business, and other uses.

Table 12. Benefits estimation (time savings) of the Belo Horizonte Metropolitan transport project

Mode of transport	Hours of travel time per day			Value of time (US$ per hour)	Annual value of time savings (US$ thousands)
	Without project	With project	Net savings		
Metro (subway)					
Commuting	13,045	48,296	-35,251	0.24	-2,741
Business	4,635	17,147	-12,512	1.99	-8,067
Other	4,417	16,364	-11,946	0.24	-929
Bus					
Commuting	764,340	647,487	116,853	0.31	11,737
Business	271,350	229,862	41,488	2.50	33,605
Other	258,919	219,334	39,585	0.31	3,976
Total					37,581

Source: World Bank (1995a).

In the case of Brazil, direct benefits estimated in the economic evaluation were:

1) Travel time savings came mainly from existing metro and rail passengers who saved time in their trips by taking advantage of the extended transport facilities (i.e., extended metro lines and busways).

A computer program (the Mantra System Microcomputer Program) was used to estimate time savings stemming from diverted demand, but not from the additional trips generated (generated demand), thus resulting in an underestimation of benefits. Travel time savings were measured by the difference between the total number of morning peak passenger hours spent without the project and those spent with the project. These peak-hour estimates were converted to annual values and then multiplied by the assumed value of time. The net change in travel time across the four modes was the overall measure of travel time savings.

From surveys on wage levels and the income distribution of users, the value of time saved was estimated at 17.5 percent of average hourly wage, disaggregated by transport mode and trip purpose. A 20 percent value was tested as part of the sensitivity analysis and it was assumed that the number of operating days per year was 324.

2) Operating cost savings for the non-rail modes derive principally from the improved commercial and traffic speeds, which were achieved by buses and cars, respectively.
3) Road maintenance cost savings derived from the possibility of delaying periodic maintenance mainly because of reduced bus traffic on the corridors under consideration.

Step 5: Calculate indicators

The next step is to calculate the socioeconomic indicators and decide whether the project is worth pursuing or not. The relevant indicators for these projects are: (1) net present value, (2) internal return rate, and (3) benefit-cost ratio.

Net present value is defined as the present value of the benefits minus the present value of the costs. When the NPV of the project is positive, the project is worth executing. The internal rate of return is another indicator useful for determining if the project is socioeconomically profitable or not. If the IRR of a given project is larger than the social discount rate (or what the country can get on average by investing in another project), this project is worthwhile investing. If the IRR is lower than the social discount rate, investing in other projects is more profitable. The benefit-cost ratio also indicates whether it is economically viable to pursue the project; nevertheless, it is also relevant to know how much the service will cost per user and to calculate the average cost of the project.

Step 6: Run sensitivity and risk analyses

In public transport projects, the main sources of risk are the variability of costs and the variability of schedule times on one side and the variability of benefits and operational and maintenance costs on the other.

Running sensitivity and risk analysis evaluates how the project will behave if any of these scenarios occur. All underlined assumptions must be challenged when running a sensitivity and risk analysis.

The most common assumptions are trend of public transport consumption, supply trends, investment costs, number of years required for project completion, willingness to pay for public transport consumption, avoided costs of accidents, demographic trends, tariff collection capacity, land costs, delays in the construction, low-quality materials, financing challenges, people’s rejection of the project, etc.

Sensitivity and risk analyses may be run on how the benefits and costs could change. For example, for the sensitivity analysis, variables affecting benefits are changes in the value of time, operating cost savings changes, differences in the growth rate, or incremental traffic modifications. Variables that potentially affect the cost side are changes in construction or operational costs.

Step 7: Conclude and formulate recommendations

Finally, the conclusions and recommendations will be derived from the CBA. Based on all the criteria, the analyst will provide further recommendations on whether the project should be implemented, and if so when. Moreover, also based on the CBA, the analyst will pass along recommendations on the optimal design of the project and provide all the necessary information on how well the project withstands the challenges of the assumptions. All in all, the analysis will deliver to the decision makers the information necessary concerning the socioeconomic convenience of implementing the project.

Chapter 5. Water provision projects

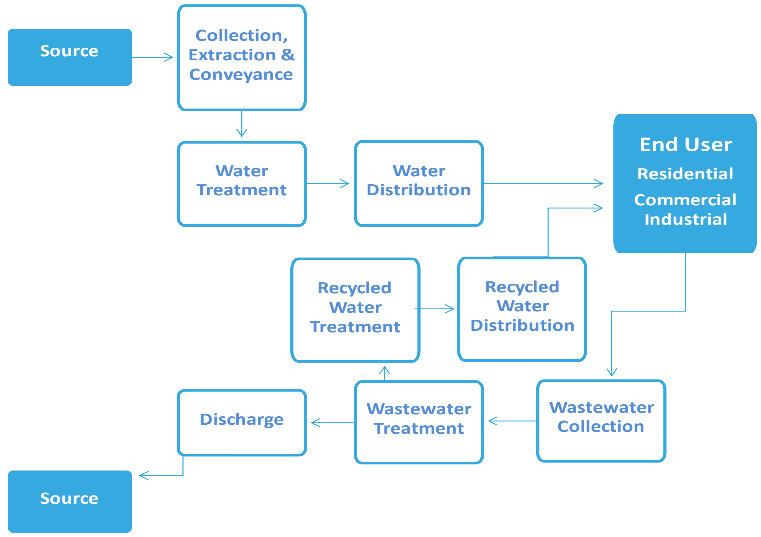
Water is a nonrenewable resource that has multiple uses, including industrial, domestic, and agricultural. Projects related to water infrastructure are key to attaining a sustainable management of this scarce resource and to forming sustainable strategies for coping with extreme climate conditions and pollution.

Water is not a normal resource given its indispensable characteristic for human life. However, supply of water depends on the availability of this resource. Throughout history, water as an economic problem occurs due to the scarcity of the resource and its necessity for satisfying human needs. Technological advances, mainly in engineering, have provided technical responses that have been optimal, timely, and efficient. The conundrum for public policy officials is to select from a vast quantity of projects the ones that optimize the scarce resources, both natural and economic, and maximize the economic and social impacts.

The impact that water projects have on a country's economic and social outlook range from improvements in health to economic growth. Water projects enable the population of a country to carry on with daily activities that translate into better living conditions. Water availability and management have an impact on whether cities are healthy places to live, whether industries thrive, and whether poor villages withstand the impacts of floods or droughts on agriculture. Therefore, guaranteeing water availability, water security, and water quality are essential for every nation.

On any given water project, the evaluation consists in identifying, quantifying, and valuing social costs and benefits related to construction, operation, and maintenance of the required infrastructure. Water projects mainly encompass (1) water supply and sanitation; (2) water treatment and pollution control; (3) environmental remediation, protection, and risk prevention; (4) irrigation; and (5) energy transformation. Even though these water projects intertwine, each one has different logics of intervention. For instance, as can be seen from Figure 14, an urban water cycle comprehends most of the type of interventions usual in water projects.

Figure 13. Urban water cycle



Source: Adapted from Western Resource Advocates[15]

Given the vast array of possible projects related to water provision, sanitation, and treatment, this section will limit its scope by focusing on projects of potable water provision. To explain how to produce a CBA for this sort of project, an example of an urban water and sanitation project in Senegal for the year 2015 will be considered (see

Box 6).

Box 6. Urban Water and Sanitation Project in Senegal (2015)

Senegal is a Sub-Saharan African country with a population of 13.5 million inhabitants, 45 percent of whom live in urban areas. In recent years, Senegal has adopted a National Economic and Social Development Strategy that seeks to achieve economic growth and governance framework improvements. The strategy's main focus is to achieve a quantum leap in the living conditions of the people, minimizing social inequalities while preserving the resource base and fostering the emergence of viable regions. Specifically, on water and sanitation, the government set out the strategy to achieve the water and sanitation Millennium Development Goals by 2015.

Even if access to water connections is relatively high in the country (98 percent in urban areas and 84.1 percent in rural areas), Senegal faces a number of challenges. For instance, emergence of water shortages has now been an issue, mainly in the Dakar area, due to the development of a new economic hub by the airport. The demand for water has been growing faster than expected, triggering supply deficits of 20,000 cubic meters (m^3) per day that is likely to worsen to 60,000 m^3 per day by 2020 if nothing is done. An additional challenge is the gap between water and sanitation services. Outside the Dakar area, the gap between the two is particularly wide. The rate of access to improved sanitation amounts to 78 percent in Dakar and 44 percent in other urban centers. A remaining challenge regards tariff policy shortcomings that could deter financial

15. https://coyotegulch.blog/2014/11/12/wra-a-new-paradigm-for-water-management-managing-a-cycle-of-water-energy-and-resources/.

viability. The proposed project was essentially set to improve the quality of water services in Dakar and Petite Côte areas with external financial support from the International Development Association (IDA). The objective of the project was to improve access to water and sanitation services in selected urban areas in a financially sustainable manner. About 590,000 people were to benefit from the proposed project either by gaining access to safe drinking water, by improving sanitation services, or by reducing water shortages. More specifically, the project proposed to focus on the following areas: (i) help finance an interim investment program to quickly address difficulties arising from water shortages in the Dakar region, improve water services in Petite Côte, and increase access to services throughout the country; (ii) help increase access to urban sanitation services outside of Dakar; and (iii) support sector institutions and reforms.

The project consisted of three components: (1) water supply (US$48.9 million); (2) sanitation (US$ 16.8 million); and (3) institutional strengthening and project management (US$4.3 million). The first component sought to increase water availability by developing underground resources, by rehabilitating water infrastructure, by increasing access to safe water in selected urban centers, and by carrying out technical studies for water supply systems. The second component encompassed provision of sanitation facilities in urban centers, increasing access to sewerage services, supporting the country in the areas of supervision and communication, and carrying out technical studies for developing sanitation systems in selected zones. The third and last component sought to strengthen the monitoring capacity of groundwater systems and to support the country in areas of coordination, supervision, financial management, communication, and outreach. Hence, the total cost of the project was of US$70.0 million.

Source: World Bank (2015).

Step 1: Elaborate the diagnosis of the current situation and definition of the baseline alternative

To elaborate a diagnosis of the current situation, the analyst must describe the characteristics of the current supply and demand. The description of the current state of affairs must include the factors that influence both supply and demand for water, such as:

- Geographic and climate characteristics (type of ground, hydrology, weather, etc.)
- Water availability trends
- Demographic, economic, and living conditions (number of inhabitants, living facilities, density within the households, level of income, dominant economic activities)
- Number of households and their average water consumption levels
- Demographic dynamics
- Agricultural water consumption trends
- Industrial water consumption trends
- Sources of water
- Characteristics of the existing water system (physical conditions, operational capacity and actual operational level, remaining useful life, distribution net length, physiochemical characteristics, pollution levels, sanitary control results, etc.)

- Type of tariff system

Analyzing the supply will help determine the water problem in the area. It will gather and organize the information necessary to determine the actual level of supply in the area the project seeks to cover. It should gather the hydrological supply in terms of the available amount of water and its quality. In other words, it must identify the current water services provision that can give further information on the conditions of the system, its operational and maintenance costs, and its operational and administrative processes. It is essential to determine the sources of water, the degree of exploitation, and the deterioration level of the facilities as well as of the natural resource.

The demand must describe the characteristics of the area in which the project will occur. It will provide the consumption levels by each sector—industrial, domestic and commercial—as well as the consumption forecast for each. When addressing potable water, the consumption forecast may be done assuming that actual consumption patterns will remain. If different consumption patterns are foreseen, the analysis could be carried out as a parallel scenario. The analysis of demand must identify the implied costs the demand pays. For example, the cost for hauling water differs from that of having a tap inside a home. Each cost must be identified, analyzed, quantified, and valued so the analyst can include them in the social cost of the demanded good.

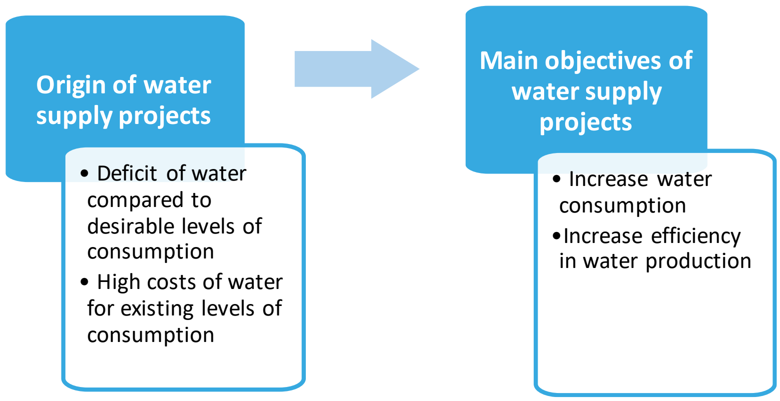
> In the case of Senegal, the supply and demand analysis for access to safe water has two parts. First, the supply faces shortages in its most extreme case. In addition, in some parts of the country supply may be underrepresented or even nonexistent (mostly in rural settings). Second, the demand has been consistently increasing for urban areas, pressing the supply toward shortages.
>
> This analysis is worse for sanitation services. For instance, the supply of sanitation services is highest in urban areas, whereas it remains extremely low in rural ones. On the demand side, the demand for access to sanitation services is still high for either urban or rural areas.

Once the supply and demand are known, the interaction between the two will allow the analyst to know the current situation and to understand the problem at hand. To perform this analysis between supply and demand, the analyst must consider the population forecasts, the historical levels of consumption, the amount of water sources, etc., to forecast at a later stage the relevant factors that will have direct or indirect impact on the project's outcome. Furthermore, in order to determine the interaction between supply and demand it is necessary to build the consumption levels for each consumer at the given prices.

The interaction between the supply and demand leads the analyst toward understanding whether the problem involves a supply deficit or high costs. For example, if the supply of water is insufficient for household consumption, the analyst has to pose a supply deficit scenario for the interaction. Many causes may lead to this situation: a leakage from the water pipelines, low pressure levels, insufficient infrastructure, nonexistent facilities, etc. Another context may be that a particular user faces a high-cost problem. It is usually the case that in developing regions women have to walk long distances to freshwater basins and then haul the water back to their homes, sometimes walking for hours each day. In this case, the analyst may define the interaction as a high-cost problem for a set of consumers.

In summary, the interaction between supply and demand by definition differs in any given context. The analyst's main objective is to characterize the differences and accurately identify the applicable issue. Nevertheless, the most common origin of water provision projects is summarized in Figure 14.

Figure 14. Origin and objectives of water supply projects



In the case of Senegal, both issues seem to be pressing since legislation on both shortages and high subsidies was needed to guarantee financial viability.

The state of affairs in Senegal could be summarized as challenging for both access to safe water and access to sanitation services. The main challenges are (1) emergence of water shortages; (2) gaps between water and sanitation services; (3) tariff policy shortcomings and financial viability; and (4) the need to reform the current system. (See Box 6.)

Moreover, and despite all its challenges, the Senegal urban water sector ranks among the top performers when compared to Mali, Burkina Faso, and Niger (See Table 13).

Table 13. Operating performance indicators (2013)

Indicator	Senegal	Mali	Burkina Faso	Niger
Access to piped water	98%	68%	84%	74%
Household connections ratio	89%	47%	61%	46%
Unaccounted-for Water (UFW) (%)	20%	28%	18%	15%
Bill collection ratio, private sector (%)	97%	93%	97%	96%
No. Of staff per 1,000 connections	2.1	5.1	3.6	4.8
Staff costs/Total revenues (%)	20%	22%	21%	21%
Compliance with bacteriological standards (% of samples)	99%	99%	100%	99%

Source: World Bank (2015).

Once supply, demand, and the interaction between them is understood, the problem itself will in most cases be evident. Now the analyst must identify the possible actions to carry forward or the "do-minimum" options that will allow her to estimate the baseline on which the costs and benefits of the project will be calculated. Among the most common proposed adjustments are the following:

- When the identified problem is a deficit of fresh water, a common adjustment to the current situation can be to service the pipeline to reduce water losses or to implement a new tariff system to properly reflect the marginal social cost of providing water to different consumers (industry, agriculture, and households).
- When the problem is the quality of the water, a possible adjustment is to enforce the current law. Sometimes many problems are caused by the lack of law enforcement, and it is at this point that the analyst must show whether the country has a problem of this nature. For example, industries must be made to comply with laws requiring them to purify wastewater before discharging it into a water source, such as a river.
- When the problem is excessive water consumption, a solution is to install water meters that will allow revised tariffs and required payments according to the level of consumption.
- Another solution would be to provide users with feedback about their consumption levels in comparison to that of their neighbors. Providing information on social norms has been used in other domains, such as energy provision (for more information see Allcott 2011).

In forecasting the baseline, the historical consumption readings, seasons, the population growth rate, the composition of consumers (industry, households, etc.), and the GDP growth rate are the main parameters used to estimate future changes in the water demand. In the case of water supply, its evolution mainly depends on rain flows and water source capacity.

Step 2: Identify and define the alternatives

Every alternative must be mentioned, as well as the reasons why it is no longer a feasible alternative (for example, there may be a legal or environmental unfeasibility). At this step, once the feasible alternatives remain, the analyst has to compare why they were considered and to briefly summarize the main characteristics of each. It is useful to summarize at least the following information for each alternative:

- Capacity installed (m^3/s)
- Brief technical description
- Total investment amount ($)
- Operational fixed cost ($/year)
- Operational variable cost ($/year)
- Maintenance cost ($/year)
- Useful life

An investment water project should be compared against other feasible options that could potentially achieve the same objectives. In addition, in water projects the alternatives could be compared using both strategic and technical alternatives. The first contrasts the alternatives by differences in approach. For example, one alternative might be to extend the current facilities, while another might be to build a new facility from scratch. The second approach contrasts the alternatives by different technical possibilities. Options might include different routes for aqueducts, contrasting building techniques, or purifying technologies. Certainly, the alternatives may differ as well in other domains, for example, the source of fresh water or the size of the project.

If the problem is access to safe water, a particular project alternative might mention the following aspects:

- ✓ Set of investment components and their relative size
- ✓ Life cycle
- ✓ Geographic location
- ✓ Execution duration
- ✓ Estimated investment, operation and maintenance costs
- ✓ Sources of financing
- ✓ Social, environmental, technical, legal, strategic, and commercial restrictions

Step 3: Describe the situation with the project

The description of the situation expected to arise following project implementation must include how the state of the problem once the project is operating.

In describing the situation with the project, the analyst must explain what would happen with supply and demand and the consequent effect on their interaction. For example, if a project seeks to provide tap water at a distant town, both supply and demand would be increased for the households connected to the pipeline. The interaction in this case would, most likely, differ from the situation without the project, because the project reduced the costs significantly for people who had been hauling water. Moreover, it is also likely that the price they pay (in monetary terms) for the service will be subsidized, although this situation could translate into further financial pressures for the government. The analyst must describe how all these variables will look with the project.

In addition, the narrative for this section must describe the extent to which the problem is reduced, minimized, or eliminated. For example, in the project to provide access to a fresh source of water, an improvement of health indexes would be expected. Likewise, the description could include whether people attend health institutions at a lessened rate due to water-related diseases. Finally, a complementary description could be the number of days workers report themselves sick. The three indicators provide a complementary view of the expected situation if the project is undertaken successfully.

In the case of Senegal, the project included the following main components:

- The project aimed to benefit 590,000 people by enhancing safe water access and sanitation access and by eliminating water shortages.

- The project sought to help reduce gender inequalities by reducing the burden of water hauling, reducing the stress associated with water shortages, and providing safe household sanitation facilities as well as adequate and convenient solutions for wastewater disposal.

Moreover, by analyzing each component, Senegal's expected situation with the project was as follows:

1. The first component will improve the quality of water services by eliminating the current water shortages through the development of groundwater resources. The development of these resources will make water volumes equivalent to 23,100 m^3 per day, available first to Dakar consumers, pending completion of long-term supply schemes in 2021, and then to Petite Côte consumers. The development of groundwater resources in Mbour will provide an additional volume equivalent to 7,700 m^3 per day to existing water customers in Petite Côte.
2. The sanitation component will help improve access to safe water and improve sanitation outside of Dakar. The development of access to water services will be prioritized through the construction of 20,000 social connections for the populations in low-income neighborhoods, as household connections provide more water at a reasonable cost. The construction of sanitation facilities in selected areas will enable more than 6,300 households to obtain access to improved sanitation.
3. The third component will support the government in preparing and implementing the next round of reforms in the urban water and sanitation sector, including a different tariff scheme.

Step 4: Identify, quantify, and monetize costs and benefits

The next step is to identify, quantify, and monetize costs and benefits of the selected alternative. For in-depth analysis of the methodological approaches to identify, quantify, and value the costs and benefits of water projects, please refer to the Mexican National Commission of Water's 2015 publication, CONAGUA (2015), and to European Commission (2014, Chapter 4).

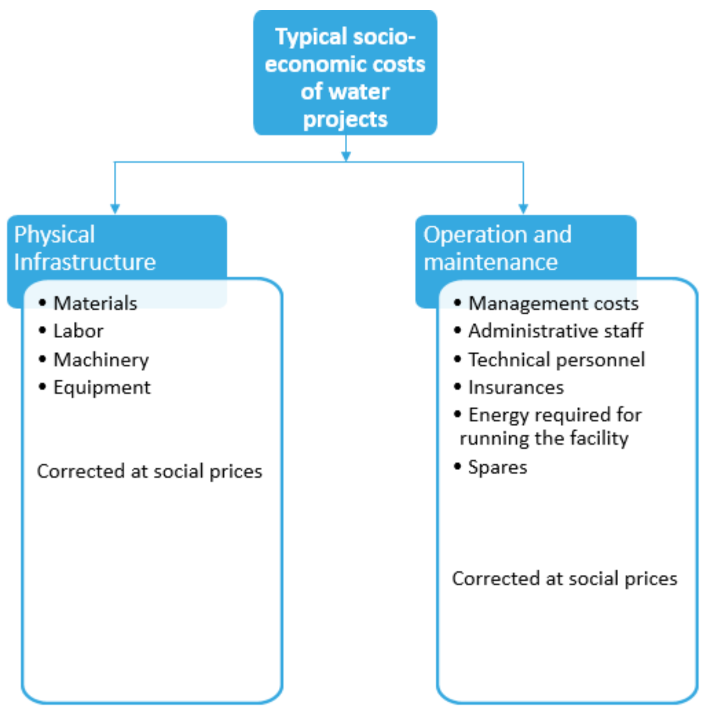
On the one hand, cost flows must be quantified and monetized for the total duration of the project. Some of these costs could be for the qualified labor force needed to pursue the project, the technology proposed, and the equipment and other costs necessary to build, operate, and maintain the alternative facilities. Typical costs for water projects include, but are not limited to the following:

- *Physical infrastructure:* materials, labor, machinery, equipment
- *Operations and maintenance:* management costs, administrative staff, technical personnel, insurances, energy required for running the facility, parts.
- *Reinvestment costs of equipment that will need to be replaced throughout the lifecycle*

Moreover, costs are usually divided between variable and fixed. Clear and concise assumptions written down in the analysis are a requisite to quantify and monetize costs both of the alternative and of the forecasted baseline. All in all, the costs are represented by the investments and re-investments required to implement the project. It is worth noting that all operation and maintenance costs are exclusive to the new infrastructure or exclusive for the increment from the current situation to the situation with the project. Usually, the total costs incurred by the operating facility are not relevant.

The benefits may vary by project, but it is usually the case that water supply projects generate (i) greater consumption of potable water or water in general (measured as the value that consumers place on the additional water consumption); (ii) resources liberation (lower costs of consumption, i.e., water hauling); (iii) avoiding health risks; (iv) maintaining water coverage; (v) improved image and smell; (vi) savings in installation and maintenance costs; (vii) lower pollution levels; (viii) higher yields of agricultural produce; (ix) higher water availability; (x) development of new industries; among others.

Figure 15. Typical socioeconomic costs of water supply projects

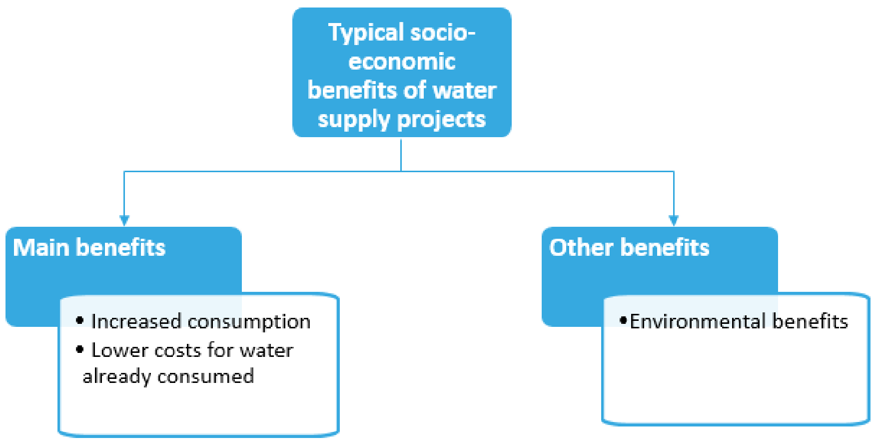


Projects having to do with increasing system coverage may supply these or other benefits:

- Time and cost savings for households that previously had to search for water in locations far from their homes or had to purchase water at high prices (with high production costs) —i.e., water hauling prominently performed by women.

- Improved water consumption, allowing improvements in the population's health and living standards.
- Improved quality and reliability of water (i.e., elimination of water shortages).
- Preservation of ecosystems and improved levels of GHG emissions.

Figure 16. Typical socioeconomic benefits of water supply projects



In the Senegal case under analysis, the main costs and benefits found were as follows:

Costs

The investment costs included:

- Water supply component: US$48.9 million
- Sanitation component: US$16.8 million
- Institutional strengthening and project management component: US$4.3 million

Operating costs included: (1) staff salaries; (2) travel expenditures and other travel-related allowances; (3) equipment rental and maintenance; (4) vehicle maintenance and repair; and (5) utilities and communication expenses.

Benefits

The benefits were due to the increased production and transport capacities helping to eliminate water deficits in impacted areas and generating additional water consumption. These benefits could be monetized throughout increased water revenues from existing users, incremental water revenues from new connections, and consumer surpluses accruing to beneficiaries.

Step 5: Calculate indicators

This step is to calculate the socioeconomic indicators to determine the convenience of the project. In water projects, the main profitability indicators are (1) the net present value, (2) the internal return rate, and (3) the benefit-cost ratio.

> In Senegal's case, the economic internal rate of return on the water-related activities was estimated at 14.4 percent, and their net present value (NPV) using a discount rate of 10 percent was estimated at US$14.6 million.

Step 6: Run sensitivity and risk analyses

To run sensitivity and risk analyses it is first best to know the sources of risk. In water projects the main sources of risk are the variability of costs and the variability of schedule times on one side, and the variability of benefits and operational and maintenance costs on the other. These costs could be breached due to unforeseen situations, such as a change in the unitary prices, environmental considerations, unexpected construction, expropriations, swift urban changes, and input prices variabilities. Bear in mind that running a sensitivity and risk analysis involves evaluating how the project will behave if any of these scenarios materialize. Probabilistic and deterministic approaches are complementary. For the deterministic approach, it is usually the case that the analyst must understand what happens when a particular variable is changed. For example, the analyst must answer questions such as, What happens when the operational and maintenance costs change in +/-30 percentage points? What happens if the investment cost changes in +/-20 percentage points? And so on. To have a probabilistic approach is to estimate with different probabilities how the scenario could be modified and made unsustainable. All the underlined assumptions must be challenged when running a sensitivity and risk analysis. The most common assumptions are trend of unit water consumption, production trend, investment costs, years required for project completion, willingness to pay for water consumption, avoided costs of illness, demographic trends, tariff collection levels and trends, land costs, reliability of identified water sources, and so on.

> In the case of Senegal, the overall results were particularly sensitive to the variation of the water demand (the switching value of this variable amounts to 23.1 percent). However, a weak demand response to project activities was unlikely, given the current water deficits in the project area.
>
> The overall risk for the project was considered as moderate. The project implementation agencies had years of experience and were well-versed in implementing this type of operation, and the technologies to be deployed were fully mastered by all actors.
>
> More specifically, the results of the sensitivity analysis were:

- Baseline scenario: IRR 14.4 percent; NPV US$ M 14.6
- Investment cost increase: 20 percent (IRR: 11.8 percent; NPV US$7.1m)
- Operation and maintenance cost increase: 20 percent (IRR: 13.7 percent; NPV US$12.1m)
- Overall demand decrease: 20 percent (IRR 10.6 percent; NPV US$2.0m)
- Production reduced: 20 percent after five years (IRR 13.6 percent; NPV US$11.4m)

Step 7: Conclude and formulate recommendations

The analyst will conclude and recommend to the decision makers whether the project is worth pursuing. In water projects, it could be the case that a number of projects are very similar. It is therefore paramount that the analyst provides a thorough set of recommendations on which project to pursue and why. Of course, as for any other project, the analyst must also include recommendations on optimal size (number of households to cover) and design, on the optimal timing, and on all the main aspects of the CBA.

Chapter 6. Solid waste management projects

Around the world, waste generation rates are rising. In 2012, the worlds' cities generated 1.3 billion tons of solid waste per year, amounting to a footprint of 1.2 kilograms per person per day. With rapid population growth and urbanization, municipal waste generation is expected to rise to 2.2 billion tons by 2025.

Furthermore, in many countries, waste is often openly burned or disposed of in unregulated dumps. These practices create serious health, safety, and environmental consequences. Poorly managed waste serves as a breeding ground for disease vectors and contributes to global climate change through methane generation.

Managing waste properly is essential for building sustainable and livable cities, but it remains a challenge for many developing countries and cities. Effective waste management is expensive, often comprising 20 to 50 percent of municipal budgets. Operating this essential municipal service requires integrated systems that are efficient, sustainable, and socially supported.

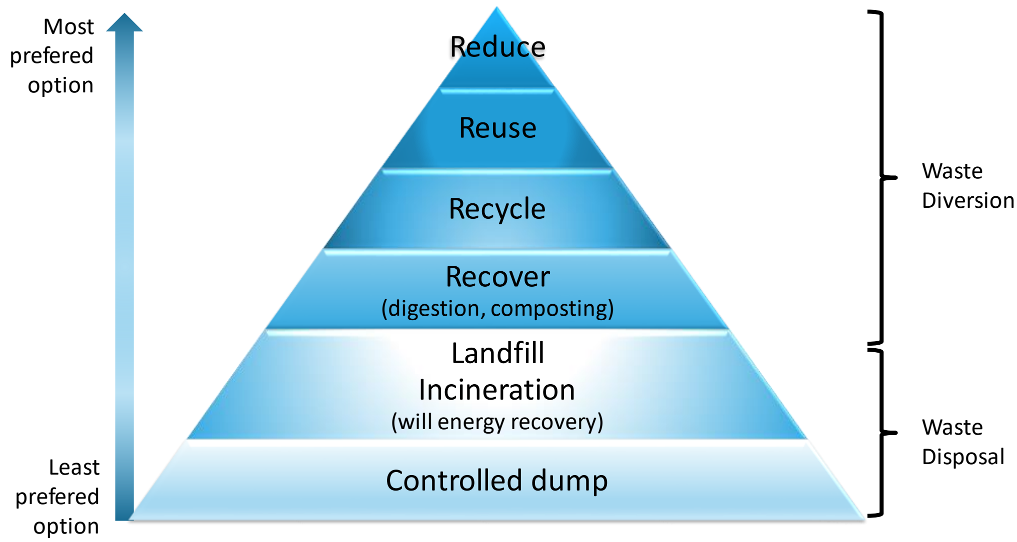
Integrated waste management systems could lead to many different infrastructure projects depending first on the generators and type of waste: municipal solid waste, including residential, institutional, commercial, and municipal waste; industrial waste; medical waste; or agricultural waste. In addition, hazardous waste requires specialized treatment.

Integrated waste management systems also imply taking actions at different stages of the waste management process:

- Choosing the optimal equipment and routes for waste collection from generators to transporters.
- Deciding about the optimal level of separation needed to foster waste reuse and recycling.
- Minimizing the costs of transportation from collection points to the treatment facility, for instance, by building waste transfer stations.
- Deciding about the type of treatment to give to the refuse: incineration, composting, anaerobic digestion plants, or others.
- Designing secure disposal facilities.

Historically, waste was considered as pure cost, with substantial amounts of money spent to collect, transport, and dispose of it. In recent years, this vision has evolved, and waste has started to be seen as a potential resource or input that should be reduced, reused, recycled, and recovered—the four Rs—according to the hierarchy shown in Figure 17.

Figure 17. Waste hierarchy



Source: Hoornberg and Bhada-Tata (2012, Figure 14).

At the level of waste treatment and disposal, it is also possible to identify various technologies depending on waste composition and on whether valorization processes are adopted.

According to the United Nations University (2014, Table 1), the most common technologies are the following:

- Landfilling with landfill gas flaring or with landfill gas recovering and use for electricity and/or heat production.
- Incineration with no energy recovery or with energy recovered as electricity or as heat and power.
- Composting the organic fraction of waste for beneficial or agricultural use.
- Anaerobic digestion of the organic fraction of waste to produce compost or electricity in biogas plants or fuel.
- Recycling particular materials (metal, glass, plastics, paper, wood, etc.).

How the infrastructure project should be socioeconomically appraised strictly depends on the characteristics of each project, nevertheless some common features would be stressed in the present methodology focusing on waste treatment and disposal. The example presented in Box 7 will be used to illustrate the present methodology.

Box 7: Solid waste/environmental management project, Lebanon

In 1993 the World Bank authorized a loan of US$175.0 million for the Lebanese Emergency Reconstruction and Rehabilitation Project. US$55 million were assigned for solid waste management to a project with a total cost of US$135.00 million. The main objective of the project was to complete the rehabilitation of the country's municipal solid-waste collection and disposal systems and introduce a separate system for hospital waste.

The proposed project includes four major components:

i. Refuse collection facilities to improve methods of waste collection: 5,200 containers and 180 compactor trucks.

ii. Waste disposal facilities to eliminate unsanitary and improper dumping of solid waste.

This component includes the construction of 15 new landfills, three compost plants (one in Saida and one in Zahle with a capacity of 200 tons each of waste per day, and a third one with a capacity of 240 tons a day in the Amrousiyeh Complex in Beirut). It also included closing and rehabilitating old dumps.

iii. Separate collection and disposal of hospital waste, including an incinerator for hospital waste in Beirut.

iv. Technical assistance and the preparation of a coastal zone management plan for more orderly planning and development of the Lebanese coastal zone.

Source: World Bank (1995b).

Step 1: Elaborate the diagnosis of the current situation and define the baseline alternative

The first step of an economic assessment always consists in obtaining a very good understanding of the current state of affairs giving rise to the project. To define the current situation correctly, it is recommended to analyze the supply and demand of the goods or services the project is intended to produce and their interaction.

In the case of waste management, it is common to find that a small percentage of waste is collected and disposed of properly in controlled landfills or receives other appropriate treatment. But this situation also implies that waste is being disposed of at roadsides, at open dumps, on vacant land, and at uncontrolled dump sites or just being burned. As will be discussed in more details later, these practices generate many costs to the population and to the environment; for this reason, countries traditionally adopt as an objective proper management of 100 percent of the waste generated, implying achieving higher levels of waste separation and collection, minimizing transport costs, closing uncontrolled dumps, and increasing the infrastructure for waste treatment and/or controlled disposal.

Given this situation, to define the supply for waste management projects, the following information is useful:

- Description of the existing infrastructure for waste collection, transport and disposal, eventually treatment: method used, equipment, capacity.
- Geographic location of the existing infrastructure, in particular of uncontrolled disposal sites and on the existing landfills.
- Equipment and infrastructure useful lifetime for existing landfills. Some projects might originate because an existing landfill is reaching its total capacity and must be closed.
- Operational capacity of the existing infrastructure: tons of waste collected, transported, and disposed of per day, etc.
- Operational and administrative processes. In these projects, it is important to know how the service is provided to identify areas of opportunity. For instance, identification of the collection routes and days of collection, number of employees, existence of controls and security in the disposal sites, etc.
- Current waste collection, transport, and disposal annual costs.

As a summary, the analysis of the supply should allow determination of the current capacity of the system to collect, transport, and treat and/or dispose of waste in adequate conditions.

From the demand side, the main objective is determining the quantity of waste generated by the population that has to be collected, transported, treated and/or disposed of under adequate conditions; nevertheless, more information could be useful, such as the quality or composition of waste. As a minimum to describe waste management demand, the following information should be presented:

- Current and past waste generation per capita for different types of generators
- Current waste composition (organic, paper, plastic, glass, metal, others) ideally by type of generators
- Socioeconomic conditions and geographic distribution of the generators
- Existence of potential markets for reuse, recycling, and compost

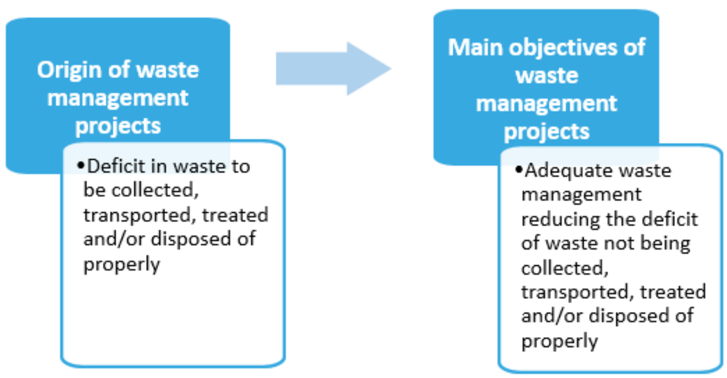
By showing the interaction of supply and demand, deficits in the current situation can be identified, including whether the capacity of the existing waste management system is not enough to collect, transport, treat and/or dispose of waste generated in adequate conditions. This deficit has huge consequences and will generate many costs for the population and for the environment:

- Unpleasant appearance, noise, and odors due to waste disposal in public spaces and closeness of uncontrolled disposal sites

- Air, water, and soil pollution due to air uncontrolled emissions and leachate infiltrations, causing health and environmental risks
- Greenhouse gas (GHG) emissions, mainly methane (CH4), contributing to the climate change phenomenon.[16]

Once the current situation is carefully described and the problem well understood, it is relatively straightforward to define the objectives of the potential projects. In the case of waste management projects, particularly waste treatment and disposal, the objectives will focus on solving the deficit identified and increase the capacity to collect, transport, and treat and/or dispose of waste in adequate conditions, as summarized in Figure 18.

Figure 18. Origin and objectives of waste management projects



As an example, in the case of Lebanon, the solid waste management (SWM) project aimed to contribute to closing a gap between the current situation and government objectives. Due to the war, solid waste services had deteriorated, generating problems such as pollution of water sources and distribution systems; discharge of waste directly into the sea and into irrigation canals; scattered piles of haphazardly dumped solid waste throughout the country; mixed waste from hospital facilities and households; and air pollution caused by solid waste burning. In response to this situation, the government embarked on a solid waste management program with the following objectives: (i) providing SWM services to all the urban communities of Lebanon in an environmentally sound manner; (ii) preventing further environmental degradation resulting from uncontrolled dumping of wastes and initiating a program to address the environmental problems associated with existing dump sites; (iii) replacing damaged and antiquated collection equipment and extending waste collection services to new communities; (iv) repairing and rehabilitating existing disposal facilities; (v) establishing and operating suitable sanitary landfills in all Cazas; (vi) utilizing the private sector in

16. "GHG emissions from MSW [municipal solid waste] have emerged as a major concern as post-consumer waste is estimated to account for almost 5% (1,460 mtCO2e) of total global greenhouse gas emissions" (Hoornberg and Bhada-Tata 2012, 29).

rendering waste collection and disposal services; and (vii) ensuring sustainability of services through cost recovery.

Once the problem faced in the current situation has been well understood and a baseline scenario defined, one important task will be to identify the “do-minimum” actions for improving the current situation. For instance, in the case under analysis, some communication campaigns may raise awareness among the population on the risks of uncontrolled waste disposal and burning as well as the necessity to reduce waste generation, for instance by avoiding the use of disposable plastic bags. Even if these actions will not solve the problem observed in the current situation, they may help reducing its size and impacts.

Another important task at this stage is to forecast how supply and demand will evolve without the project throughout the project’s evaluation horizon. In the case of waste management projects, the problem of deficit is expecting to get worst through time. Indeed, in most countries, the demand of waste to be managed is expected to grow mainly due to (i) population growth, (ii) urbanization trends, and (iii) increases in income levels and standards of living.

Step 2: Identify and define the alternatives

The next step consists of identifying and comparing alternatives to give the best possible solution to the current situation.

Traditionally in the case of waste management, several alternatives can be compared to determine:

- *The dimension of the project(s):* Is it better to have one regional landfill or many municipal ones?
- *The location of the project(s):* Location is always a problem due to social opposition to having a waste management facility close to one’s place and the necessary precautions to take to reduce environmental impacts.
- *The technology to use:* (i) At a more strategic level, what is the best option for waste treatment and disposal? A sanitary landfill, waste incinerator, or compost plant for organic waste and a smaller landfill for inorganic waste? Or (ii) at a more specific level, what is the best technology for flue-gas cleaning in a waste-to-energy facility?
- *The recycling and valorization processes:* Should paper be separated and recycled? Should landfill gas be recovered and used for electricity and/or heat production?
- *For operational processes:* Which kind of collection system would be the best option, home-to-home or communal bins?

According to Chapter 2, one way to proceed to compare alternatives is the following:

i. First, list all possible alternatives of solution.

ii. Eliminate some of them based on a first qualitative multicriteria analysis considering the degree of legal, technical, environmental, social, strategical/political, commercial, economic, and financial viability of each alternative.

iii. Then, for the shorter list of alternatives, engage in a more quantitative analysis comparing each option.

At this stage, it is important for each of the preferred alternatives to specify at least the following elements:

- ✓ Set of investment components and their relative size
- ✓ Geographic location
- ✓ Technology
- ✓ Execution duration and program of activities
- ✓ Estimated investment, operation and maintenance costs
- ✓ Sources of financing
- ✓ Useful lifetime
- ✓ Estimated capacity and expected production
- ✓ A summary on the main legal, technical, environmental, strategic/political, commercial, and social feasibility aspects.

Step 3: Describe the situation with the project

The key aspect for economic assessment is to compare the baseline scenario defined at Step 1 with the situation with the project. For that, it is necessary to understand how the baseline scenario would be impacted by the implementation of the project.

In the case of waste management projects, the project will contribute to reduce the deficit between the baseline scenario and the government objectives in terms of sustainable waste management, which would improve the living conditions of the population and their environment.

The time horizon for a waste management project is usually around 25 to 30 years,[17] which means that the "with project" scenario must be analyzed over this time horizon. In particular, regarding the size of the project, special attention must be given to the impact on waste generation and composition forecasts.

17. Of course, it could be different if the project only implies waste collection or transport equipment repositioning; in that case the time horizon would depend on the useful life of the new equipment.

Step 4: Identify, quantify, and monetize costs and benefits

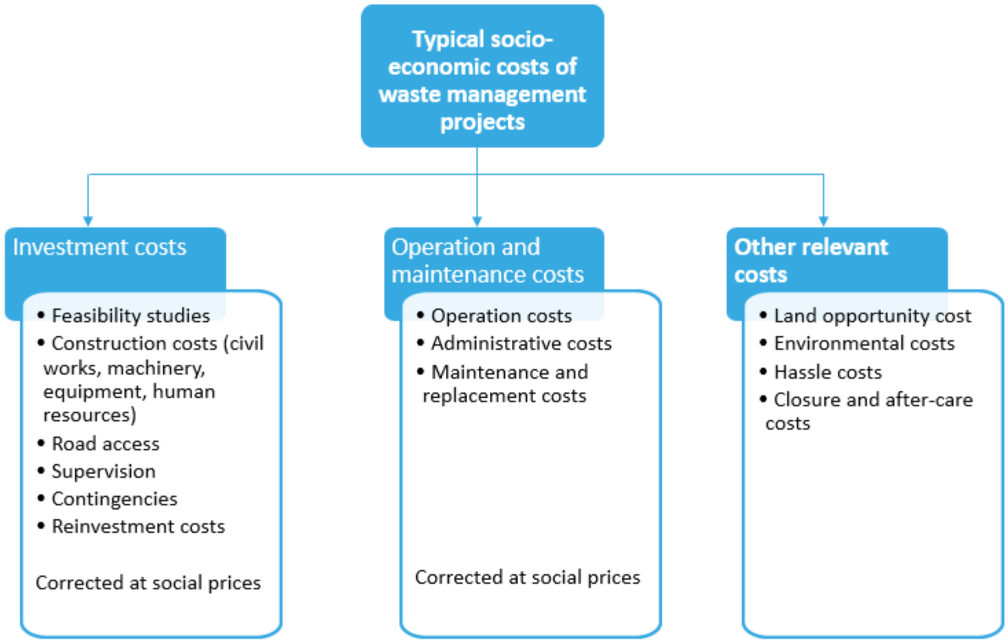
Once the "without" and "with" scenarios are well defined, identification of the relevant costs and benefits for a given project can be done relatively straightforwardly by comparing the two situations.

The typical costs included in economic assessments of waste management projects are the following (see also Figure 19):

- *Feasibility studies costs:* all the costs incurred at the preparation and tender stage of the project should be included.
- *Construction costs (civil works, machinery, equipment, human resources):* The opportunity cost of all the inputs necessary to the construction/rehabilitation of the infrastructure should be considered.
- *Access road costs:* Roads are needed for access to the waste management facility.
- *Supervision costs:* Supervision is a necessary activity the cost of must also be included.
- *Contingencies:* Regularly some percentage of the CAPEX (10 to 15 percent) is included in socioeconomic assessment studies to cover some contingencies.
- *Reinvestment costs throughout the time horizon:* Costs must account, for instance, for opening a new cell.
- *Operation costs of the waste management system:* Energy, fuels, materials, transportation costs, human resources, etc., will be needed to operate the system.
- *Administrative costs:* These are costs incurred by the waste management operators to run the businesses.
- *Maintenance and reposition costs:* These costs help preserve the capacity of the existing infrastructure and equipment.
- *Land opportunity cost:* Even if the land used for the construction of the facility was already owned by the public sector, its opportunity cost must be included in the flow of costs.
- *Hassle costs during the construction of the project.*
- *Environmental costs:* For waste management projects, careful environmental impact assessments must be performed that help define environmental management plans during the construction and operation of the project. Therefore, the cost of the prevention and mitigation measures defined in the plan as well as the cost to monitor and enforce compliance with the plan must be included into the analysis. Some remaining impacts would not necessarily be included, such as the negative externality for neighbors getting a waste management facility constructed closed to their property; in that case, hedonic price methods can be used to anticipate how the price of surrounding properties will decrease.

- *Closure costs and after-care costs:* These are (i) costs generated by the closure of uncontrolled disposal sites once the new project is operating, and (ii) costs for closing down the project at the end of its useful lifetime.

Figure 19. Typical socioeconomic costs of waste management projects



Once the relevant costs have been identified, remember to proceed to the necessary corrections to adjust financial prices to economic values, mainly for tradable and nontradable goods and services, unskilled labor, and energy.

In the case of the Lebanese waste management program, the costs were divided into four components:

1. Civil works (US$25.0 million): including land acquisition, development of new sites, closure of old dumps and buildings and workshops.
2. Goods and equipment (US$23.6 million): including compactor trucks, containers, landfill equipment, and special equipment.
3. Disposal plants (US$60.0 million): including the compost plant in Saida, 200 T/day; the compost plant in Zahle, 200 T/day; the Amrousiyeh compost plant; and the hospital waste incinerator.
4. Technical assistance (US$11.0 million): including a coastal zone management plan, engineering services, technical assistance, and training.

To this basic cost, US$15.4 million were included into the budget for physical and price contingencies, for a total cost for the project of US$135.0 million.

On the benefits side, of the different methodologies for waste management projects identified, authorities such as CEPEP (2008), the Asian Development Bank (2013), the European Investment Bank (2013), the Ministerio de Desarrollo Social, Chile (2013a and 2013b), and the European Commission (2014) agree on the main benefits to consider in a socioeconomic assessment, although they differ substantially in the way they monetarize these benefits.

By comparing the baseline scenario and the "with project" scenario, the following benefits are identified.

i. Reduction of unpleasant visuals, noise, and odors.

ii. Reduction of air, water, and soil pollution, improving living standards and decreasing health risks.

iii. Costs savings due to lower production of substitutes to waste-based outputs (compost, recycled products, waste-based electricity and heat or biofuel), which are produced in the "without project" situation. For instance, a waste to energy plant replaces electricity produced without the project with alternative technologies like thermic plants (coal), which are costlier and exhibit higher marginal costs of production.

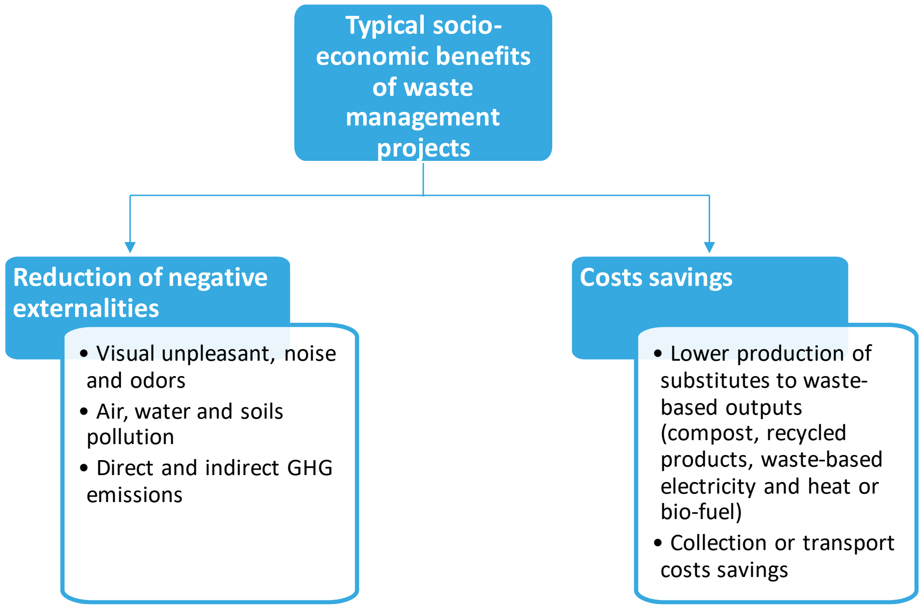
iv. Other costs savings incurred in the "without project" situation, like the cost people must bear to self-eliminate waste or the costs of inefficient transport with low capacity and aging vehicles.

v. Reduction of GHG emissions: direct ones are due to the capture and flaring of biogas or its conversion into energy, and indirect ones are due to the production of substitutes to the waste-based outputs, implying GHG emissions. By replacing coal-based electricity with waste-based electricity, GHG emissions are reduced.

At this stage it is important to calculate the benefit of the difference between the GHG emissions and costs without the project and with the project.

Figure 20 presents a summary of the typical benefits of waste management projects.

Figure 20: Typical socioeconomic benefits of waste management projects



Once the benefits have been identified and quantified, they should be monetized, which is traditionally not an easy task for waste management projects, which is why the existing methodologies on waste management projects diverge over how it should be done.

The first option, adopted by the European Commission (2014), is to monetarize the benefits one by one using different valuation methods.

For the reduction of unpleasant visuals, noise, and odors, a hedonic price method is recommended, which measures the impact of the negative externality on the price of properties affected by the externality versus other similar properties not affected. A project that reduces waste disposal in public space and uncontrolled disposal sites will increase the price of surroundings properties.

For the reduction in air, water, and soil pollution, the strategy used is to measure the direct costs caused by contamination that would be saved in the "with project" scenario. For some projects, the impact will be clearly identified; for instance, in the case of aquifer pollution, municipalities would be forced to find other sources of water, incurring higher costs. Nevertheless, in most cases, the impact would not be so clearly identified; if so, an option is to identify the variation in the quantity of pollutants, for instance, emissions of nitrogen oxides (NOx), and use previous studies to assign a price to this particular pollutant. For air pollution, refer to the National Emission Ceiling Directive published by the European Environment Agency (2016).

For the evaluation of cost savings due to lower production of substitutes to waste-based outputs, the valuation method would depend on the available information. Strictly speaking, if information is available, production costs should be computed with and without the project; nevertheless, if it is not, the benefit may be measured using the market price (using fiscal corrections) and calculating expected revenues from selling compost, recycled products, energy, or biofuel.

Collection and transport costs will be related to time and operational cost savings similar to that traditionally used for transport projects. Refer to Chapter 2 for more information on how they can be computed.

Finally, GHG emission cost reduction is calculated based on the net emissions avoided (measured in CO2-equivalent tons per year),[18] considering both direct and indirect emissions and applying the social price of carbon to this quantity. Refer to Table 8 for more information on the shadow price of carbon recommended by the World Bank.

Another approach used for monetarizing the benefits of waste management projects is based on the idea that these projects increase the consumption of improved waste management services valued by the population. Waste management benefits can thus be measured using the willingness of the population to pay for this service. In that case, the contingent valuation method presented in Chapter 2 can be used to calculate the inhabitants' willingness to pay. This approach has been adopted by the Asian Development Bank, which gives more information about how to apply it (2013, Chapter 6).[19]

Finally, in some cases, the benefits of waste management projects are considered so difficult to monetarize that the countries are adopting a cost-efficiency approach (CEA) rather than a cost-benefit one (CBA). This is the case in the methodologies used by CEPEP (2008), Chile (2013a), and the EIB (2013).

By using a cost-efficiency approach, the question of interest is not whether the project is profitable, meaning that the "with project" scenario is better than the "without project" one, the main concern of the CBA, but rather to study which alternative is the least costly way to answer the problem identified in the baseline scenario. To compare the different alternatives, all of the life-cycle costs should be considered: investment, operation and maintenance, reinvestment, and closure costs. Some easy to monetize benefits can also be included in the analysis, such as that related to waste-based outputs production. Because of their relevance, many analyses include GHG emissions reductions. In that case, the costs flow is calculated net of these benefits.

Step 5: Calculate indicators

If a CBA approach is adopted for the socioeconomic assessment of the waste management project, the most relevant indicators are the net present value (NPV) and the internal return rate (IRR), which are presented in Chapter 2 of this guideline. Both indicators measure whether the benefits

18. For more information on how to compute GHG emissions avoided, refer to the publication of the United Nation University (2014).

19. Usually, other benefits than the one measured through the willingness to pay would be added, particularly those related to waste-based outputs production.

generated by the operation of the project are enough to cover the costs to build, operate, and maintain it. Note that for comparing two alternatives assessed by CBA, the benefit-cost ratio (BCR) will be a better indicator than comparing NPVs.

If a CEA is performed, as most of the benefits have not been monetized, another type of indicator will be used. If all the alternatives have the same useful lifetime and the same capacity, it will be enough to compare the costs present value (CPV) (net of some monetized benefits) of each alternative and then select the one with lower CPV. But for waste management projects, most of the time alternatives have different useful lifetimes and capacities. If so, it is recommended to use the average cost indicator (ACI), as introduced in Chapter 2.

$$Average\ Cost\ Indicator = \frac{CPV}{QPV}$$

Here,

CPV = Costs present value

QPV = Quantity present value

Again, the alternative selected is the one presenting the lower ACI.

In the case of the Lebanese waste management program, the benefits were not monetized, so alternatives were compared using a CEA.

For the choice of the disposal technology, the annualized total cost per ton of three different alternatives was compared: sanitary landfill, composting, and incineration plant. Note that the revenues of compost are not directly included in this analysis.

Table 14. Solid waste/environmental management project, Lebanese Republic Comparison of waste disposal alternatives

	LANDFILL	COMPOSTING	INCINERATION
Capacity (tons per day)	100	300	400
Annual throughput at 90% capacity (tons per year)	32850	98550	131400
Total investment cost ($Mn)	1.5-3.0	16	45
Annual costs			
Amortization 10%/20 yrs (US$/ton)	5-10	20	40
Operation and maintenance (US$/ton)	10-15	15-20	25-35
Total annual amortization and operating costs (US$/ton)	**15-25**	**35-40**	**65-75**

Source: World Bank (1995b,79).

Step 6: Run sensitivity and risk analysis

Before concluding the socioeconomic assessment, it is important to run a sensitivity analysis. For waste management projects, some critical variables, aside from the investment and O&M cost, are the evolution of waste generation and composition and the changes in prices and quantities of waste-based outputs, GHG emissions, and pollution emissions, among others.

At this stage it also important to understand the main risks that the project will face, which could end up increasing the cost of the project, slowing down its implementation, and reducing its socioeconomic benefits. Some of the typical risks of waste management projects are presented in Table 15.

Table 15. Typical risks of waste management projects

Stage	Risk
Regulatory	• Changes of environmental requirements and regulatory instruments (i.e., introduction of landfill taxes, bans on landfilling)
Demand	• Waste generation lower than predicted • Waste flow control/delivery insufficient
Design	• Inadequate surveys and investigation • Choice of unsuitable technology • Inadequate design cost estimates
Administrative	• Building or other permits • Utility approvals
Land acquisition	• Land costs higher than predicted • Procedural delays
Procurement	• Procedural delays
Construction	• Project cost overruns • Delay in construction schedule • Contractor related (bankruptcy, lack of resources)
Operational	• Waste composition other than predicted or having unexpectedly large variations • Maintenance and repair costs higher than predicted, accumulation of technical breakdowns • Process outputs fail to meet quality targets • Failure to meet limits of emissions produced by the facility (to air and/or water)
Financial	• Tariff increases slower than predicted • Tariff collection lower than predicted
Other	• Public opposition

Source: Reproduced from European Commission (2014,Table 4.8).

Step 7: Conclude and formulate recommendations

Finally, based on the previous indicators and the sensitivity analysis, a decision must be made. For waste management projects, the decision will not be so much whether to proceed with the project, rather it will relate more to selecting the best alternative to adopt to achieve cost-efficient, effective, integrated, and sustainable waste management systems, increase the living standards of the population, and reduce environmental costs.

Chapter 7. Irrigation projects

Improving irrigation is essential to increase water availability. Water is not only essential for human life, it is also vital for production—meaning that diminishing water supplies can translate into lower economic growth.

In that sense, improving irrigation allows increases in productivity and the creation of value for agricultural, fishing, and livestock activities, improving farmers' incomes and creating opportunities for job creation, therefore, promoting social and economic development in rural areas—which may, furthermore, reduce inequalities, as rural areas usually present higher poverty rates than urban areas.

Nevertheless, due to increasing water scarcity all over the world in the face of continuously growing demand—the World Bank estimated that in 2016 nearly 1.6 billion people lived in countries with physical water scarcity, a figure that may double in just two decades—investment in irrigation infrastructure has switched from projects aimed at increasing water intake to projects aimed at rationalizing water use. Projects to strengthen the resilience of irrigation schemes to water scarcity and climate change by reducing water losses and increasing water efficiency are likely to present the highest socioeconomic profitability.

To measure socioeconomic profitability and identify and select irrigation projects able to generate more socioeconomic value for the country, this section aims to point out the most important elements of a CBA for irrigation projects.

Strictly speaking, the economic assessment will depend on the specific features of irrigation project, which might include:

- Creation of new infrastructure (greenfield) versus projects aiming at improving existing facilities (brownfield)
- Different sources of the water (river diversion projects, groundwater projects, large reservoirs)
- Different uses of the water (agricultural, fishing, livestock, or other activity)
- Different sized projects (for instance, big projects usually have more indirect impacts on other markets as they can end up modifying prices)
- The type of infrastructure: off-farm infrastructure only (water intakes, canals and construction of water regulation reservoirs) and/or on-farm infrastructure (local systems of field channels and irrigation plots).

The main principles of CBA are similar, however, and can easily be adapted for any particular project.

For ease of the presentation, the rest of this chapter will concentrate on irrigation projects for agriculture, taking as an example the first phase of the Shire Valley Transformation Program for Malawi (see Box 8).

Box 8: Shire Valley Transformation Program (SVTP), Malawi

In 2017 the World Bank authorized a loan of US$160.00 million to a total cost project of US$234.59 to contribute to the productivity and production of irrigated crops in a predominantly drought and flood prone area of Malawi, the Shire Valley.

The proposed project includes five major components:

Component 1: Irrigation service provision
This component will finance the works, goods and services necessary to develop bulk irrigation and drainage infrastructure in the SVIP Phase 1 area. This includes preparation of detailed designs and construction supervision and quality assurance, construction of the physical bulk water conveyance and main distribution system, major drainage, and service and access roads. Provisions will be made for the SVIP Phase 2 area in terms of canal dimensions, right of way, and preparatory studies. Component 1 will also include actions to support the establishment of a professional management, operation, and maintenance system for the scheme. These activities will also enhance absorptive as well as adaptive capacities against future climate change risks and contribute to more sustainable water resource management and stable agriculture production.

Component 2: Land tenure and natural resources management support
Aims at supporting farmer organization within a comprehensive land use plan; supporting land tenure strengthening and consolidation; as well as natural resources management.

Component 3: Agriculture development and commercialization
Finances on-farm investments in irrigation and drainage, land leveling, and commercial farm development.

Component 4: Project management and coordination

Component 5: Project preparation advance repayment

Source: World Bank (2017a).

Step 1: Elaborate the diagnosis of the current situation and define the baseline alternative

The first step of an economic assessment always consists in obtaining a very good understanding of the current status that leads to the project.

To define correctly the current situation, it is recommended to analyze the supply and demand of the good or services the project is producing and their interaction. One of the particularities of irrigation projects is that this analysis must be performed in the water market as well as in the agricultural market. Indeed, the value of additional water provided by the project will not be measured directly in the water market,[20] but rather it will be measured indirectly through its impact on agricultural activities, applying the productivity change method mentioned in Chapter 2.

In the case of the water market, it could be useful to give the following information:

- Historic rainfall statistics of the area
- The location and type of potential irrigation water source and its capacity
- A complete description of the existing irrigation system, if any, including its location, capacity, technology used, and remaining useful life, and identifying which parcels of land are equipped and which are not
- The operation and maintenance costs of the existing irrigation system
- The reposition cost of the previous infrastructure

Also useful would be a description of the alternative downstream water uses, as they could be impacted by the project's implementation by receiving less water than previously.

In the case of the agricultural market, providing the following information is recommended:

- location and extension of the producing parcels
- existing crops and yield statistics
- annual production levels
- statistics on prices by crop
- current production costs

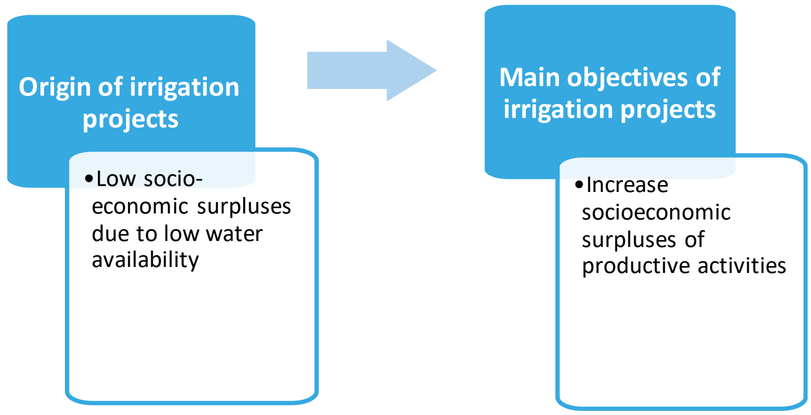
The previously listed information must be sufficient to compute the socioeconomic surpluses in the current situation (i.e., revenues minus production costs).

In the case of irrigation projects, farmers usually face a deficit of water, causing low crop productivity and low production levels; for this reason, socioeconomic surpluses without the project are relatively low (compared to what could be obtained with the project).

Once the origin of the project is well understood, its main objective is relatively straightforward to define, as it will be to solve the previous problem and improve the previous situation. Irrigation projects are indeed classified as productive projects and respond to the motivation of taking advantage of an opportunity to improve socioeconomic surpluses in the economy (see Figure 21).

20. Usually there is no market for water for agricultural use; water rights are distributed among farmers according to their hectares, and although they may pay a water fee, it is a highly regulated and subsidized price that does not represent the farmer's willingness to pay for extra water and so cannot be used to give a socioeconomic value to higher water availability once the project is implemented.

Figure 21. Origin and objectives of irrigation projects



In the case of the SVTP, the origin of the project is effectively presented as an opportunity to grasp. The Shire Valley contains the highest incidence (above 80 percent) of extreme poverty in Malawi (Integrated Household Survey 2013). Droughts and floods are increasingly frequent and pose a persistent threat of famine. Natural resources, such as forests, biodiversity, and fisheries are under severe threat and the loss and degradation of these resources threaten to exacerbate vulnerability, reduce resilience to climate shocks, and diminish the provision of environmental services in the watershed. In terms of agricultural production and value chains, there are currently limited economic activities taking place due to lack of water. Yet, the agronomic potential is enormous, with generally fertile soils, as demonstrated by the high sugar yields achieved in the area under commercial irrigation in the large-scale Illovo estate and by its out-growers. There is also a young and abundant workforce, and there are positive experiences with smallholder out-growers and strong support for agricultural intensification. The least and most productive agriculture systems in Malawi have coexisted in the Shire Valley, and the challenge for the government has been to unlock the development potential of this area. The long-term presence of the private sector (primarily commercial sugar estates) and good market linkages—its proximity to Malawi's commercial hub Blantyre and Tete and the Nacala railroad in Mozambique—make Shire Valley a highly attractive development area.

Before proceeding to the identification of the alternatives to solve the problem, it is important to define what is called the baseline scenario, and for that purpose, it is central to identify what the "do-minimum" option would be for improving the current situation. For instance, in the case under analysis, farmers could benefit from some training in the use of fertilizers and pesticides, which can slightly increase yields and thus socioeconomic surpluses.

Another important task at this stage is to forecast how supply and demand will evolve without the project throughout the project's evaluation horizon. In the case of irrigation projects, water availability could possibly decrease due to a higher inefficiency of the irrigation canals and the obsolescence of the existing infrastructure, causing decreasing socioeconomic surpluses throughout the project's useful life.

Step 2: Identify and define the alternatives

This next step consists in identifying and comparing alternatives to find the best possible solution to the current situation.

One obvious alternative for irrigation projects is to choose the best technological option, for instance between improved gravity irrigation, drip irrigation systems, and pressurized systems. The choice will depend on many different factors, including costs, type of crops, and even farmers' preferences.

Scope, size, and capacity of the project will indicate other design features of alternative solutions. What will be the capacity of the new irrigation project? Which hectares will be equipped? Will the complete irrigation infrastructure be modernized or only part of it? Will priority be given to modernizing the common off-farm infrastructure or to implementing new on-farm irrigation systems? To maximize the profitability of the project it is necessary to answer these questions carefully.

Step 3: Describe the situation with the project

The key for CBA analysis is to compare the baseline scenario defined at Step 1 with the situation with the project. For that it is necessary to understand how the baseline scenario would be impacted by the project's implementation.

In irrigation projects, it is not necessarily easy to define the situation with the project. Hussain and Bhattarai in their report for the International Water Management Institute (2004) mentioned that in most cases project profitability is overestimated ex-ante and that ex-post many projects exhibit a much smaller profitability than expected. One reasons is that the "with project" scenario is often overly optimistic.

By improving the irrigation infrastructure, farmers would benefit from a higher water availability, which would allow them to:

i. incorporate new irrigated areas,
ii. increase the yields of their traditional crops, *or*
iii. change crops for higher value ones, *or*
iv. a combination of the three previous cases.

Although in many ex-ante assessments, farmers would be expected to maximize the profitability of the water available, post-completion assessments demonstrate that, in most cases, farmers adopt quite conservative behavior, merely intensifying irrigation of their current crops and thus reducing substantially the benefits that could be obtained through the project.

At this stage, it is important for policy makers to fully understand the reasons behind the previous statement to take important measures for optimizing the project's impact and insuring its long-term sustainability. Some key success factors for irrigation projects are the following:

- Stakeholders' collaboration in the project, particularly in the definition of what the "with project" scenario will be.
- Long-term support to water users' organizations and farmers for technical, financial, and administrative capacity building, allowing them to successfully manage the improved irrigation systems on their own.
- A strong sense among users of their ownership of irrigation subprojects, an essential factor in guaranteeing the long-term sustainability and effective use of improved irrigation schemes (both collective and on-farm).
- Formalized water rights and more efficient water allocation, guaranteeing to farmers willing to take risks and contribute to the financing of the new irrigation systems that their water rights would not be expropriated.
- Adequate cost recovery from water users to ensure adequate implementation of O&M plans.
- Adequate design and quality construction of irrigation infrastructure.
- Access to markets to ensure that irrigation development goes beyond subsistence farming, with farmers switching to higher value crops.

Another important feature in properly defining the scenario with project is understanding how the situation will evolve through time in comparison to the "without project" situation. Two main factors will be useful in determining the speed of progress achieved through the project:

- First, it would depend on the farmers' adoption process. Not all farmers would modernize their irrigation infrastructure at the same time. Some will start first, and others will follow.
- Second, some maturation time is needed before reaching the optimized yields, for instance in case of adoption of new crops.

These two factors explain why net benefits in the case of irrigation projects traditionally increase in the first years of the project's assessment horizon.

Phase 1 of the SVTP develops about 11,535 ha new irrigation areas and improves the performance of the existing 10,745 ha irrigated sugarcane production at Illovo estate and its associated cane out-grower schemes by converting the existing pump-based irrigation system to a gravity-based irrigation system.

This would allow the introduction of new crops compared to the baseline scenario. In order to determine which crops to introduce, a gross margin analysis was carried out to assess the viability of the crops considered suitable, from an agronomic perspective, for growing in the lower Shire Valley. Nine crops were selected from the list of 22 crops evaluated (see Table 16). The crops selected were those best suited to the agronomic conditions of the Shire Valley, have reasonably high gross margins, have readily available markets, either in Malawi or in the region, and are easily handled, transported, and stored without elaborate transformation or investment in processing facilities beyond those that already exist in the SVTP area.

Table 16. Gross margin estimates and ranking of suitable crops, SVTP

No	Crop	Average yield (kg/ha)	Av. Price (US$/kg)	Gross margin (US$/ha)	Include/exclude from cropping program
1	Tomatoes	45,000	0.28	7,683.17	May be introduced gradually after investments in processing technology
2	Sweet corn	50,000	0.15	6,493.35	**To be introduced** gradually after investments in packing, storage, freight facilities
3	Green mealies	45,000	0.16	6,449.76	**To be introduced** gradually after investments in packing, storage, freight facilities
4	Sugar cane	120,300	0.07	3,320.62	**Included**
5	Cassava (wet)	30,000	0.10	3,002.31	Excluded; needs storage and processing facilities
6	Baby corn	11000	0.30	1,983.65	**To be introduced** gradually after investments in packing, storage, freight facilities
7	Rice (polished)	2,500	0.75	1,871.19	Excluded; no suitable rotation crop, high water requirement
8	Beans (dry)	2,500	1.04	1,657.97	**Included**
9	Pigeon peas	2,500	0.75	1,500.50	**Included;** for rotation purposes and to meet the national aspirations
10	Cassava (dry)	10,000	0.15	1,316.19	Excluded; needs processing and storage facilities
11	Cotton	4,000	0.45	1,223.43	**Included**
12	Chilies	1,500	0.97	2,234.8	May be introduced gradually after investments in processing technology
13	Rice (unpolished)	3,500	0.45	826.41	Excluded; no suitable rotation crop, high water requirement
14	Groundnuts (shelled)	2,500	0.75	752.72	Excluded; not suited to the soils of the area
15	Soya beans	3,100	0.28	337.85	**Included**
16	Maize (seed, irrigated)	3,500	0.37	264.01	Excluded; viability of seed
17	Maize (grain, irrigated)	5,000	0.24	196.64	**Included;** food security, political and social reasons
18	Sorghum	5,000	0.18	166.20	Excluded; markets
19	Groundnuts (unshelled)	4,170	0.30	166.01	Excluded; not suited to the soils of the area
20	Wheat	4,000	0.27	108.69	Excluded; yield, quality
21	Cow peas	2,000	0.21	97.16	Excluded; marketing not clear
22	Sesame	1,100	0.27	64.16	Excluded; marketing not clear

Source: World Bank (2017b).

Step 4: Identify, quantify, and monetize costs and benefits

Once the without and with scenarios are well defined, identification of the relevant costs and benefits for a given project is done relatively straightforwardly by comparing the two situations.

The typical costs included in CBA of irrigation projects follow (see also Figure 22).

- *Feasibility studies:* All the costs incurred at the preparation and tender stage of the project should be included.
- *Construction (civil works, equipment, human resources):* The opportunity cost of all the inputs necessary to the construction/rehabilitation of the infrastructure should be considered.
- *Supervision:* Supervision is a necessary activity the cost of which should be included.
- *Contingencies:* Regularly some percentage of the CAPEX (10 to 15 percent) is included in CBA studies to cover some contingencies.
- *Operation costs of the irrigation system:* One of the most important operating costs is the energy cost necessary for the irrigation system to operate.
- *Administrative costs:* Costs incurred by the water users' organizations and farmers to run their businesses.

  Note that conventionally the production costs of agricultural goods are already included in the benefits as they are calculated based on surpluses, incomes minus the costs; nevertheless, if it is not the case, and only incomes are included in the benefits, production costs should be considered in the costs.
- *Opportunity cost of land:* For the sake of construction, some parcels may not be cultivated, generating a socioeconomic loss that should be considered. In some projects, the loss of land may even be permanent, for instance in the case of a dam that would inundate some upstream land. [21]
- *Prevention, mitigation and compensation costs of environmental impacts:* Irrigation projects may have some adverse environmental impacts, fostering deforestation, ground salinization, and use of chemical pesticides and fertilizers. In some projects, the impacts could rather be positive, by reducing environmental externalities. In all cases, it is necessary to run a good-quality environmental impact assessment of the project to define appropriate prevention, mitigation and/or compensation measures, which costs should be included in the analysis.[22]
- *Prevention and mitigation costs of natural disasters:* Agriculture is an economic activity that could be highly affected by natural disasters, meaning the probability of their occurrence and impacts must be analyzed, and potential mitigation measures must be included into the project.

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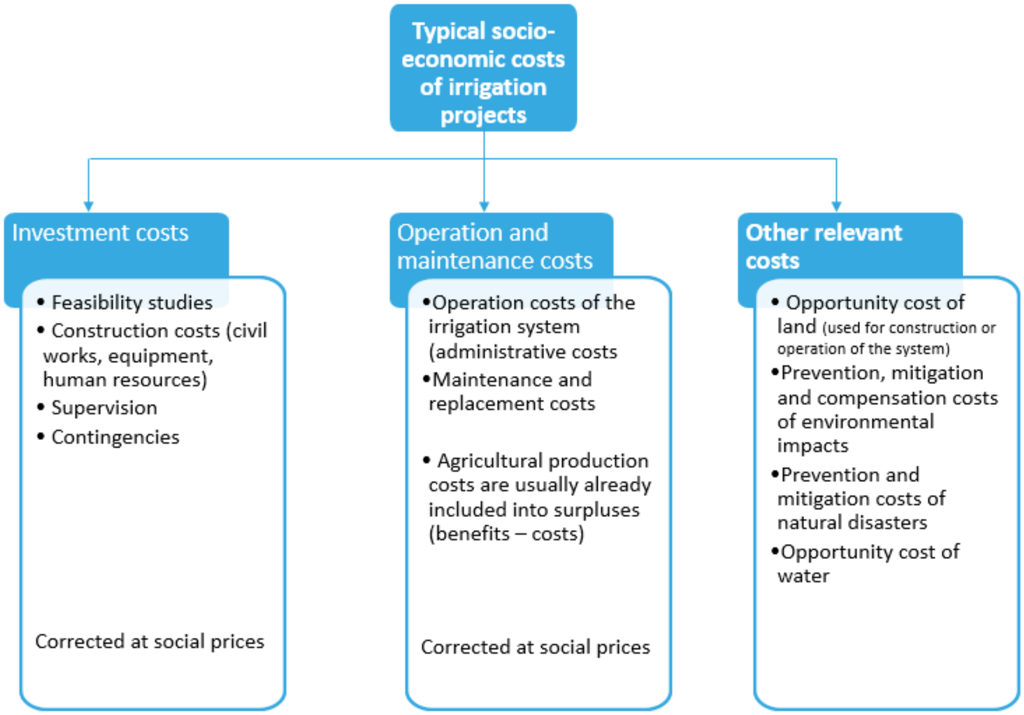
21. At this stage it is important to understand that the opportunity cost of all the cultivated land impacted by the project should not be included among the costs to avoid double counting. Traditionally, the benefits are calculated comparing the surpluses with and without the project, so the opportunity cost of the land is already included in the benefits.
22. For further information on the environmental impacts of irrigation projects, refer to Hussain and Bhattarai (2004), pp. 14–15, and to pp. 31–35 of Silva and Pagiola (2003).

- *Opportunity cost of water:* For example, for projects increasing the water intakes, it is important to consider that this water may have downstream uses and thus a potential opportunity cost that should not be neglected in the analysis.

Figure 22. Typical socioeconomic costs of irrigation projects



Once the relevant costs have been identified, remember to proceed to the necessary corrections to adjust financial prices to economic values, mainly for tradable and nontradable goods and services, unskilled labor, and energy.

On the benefits side, the different methodologies that have been identified for irrigation projects (see, for example, Gittinger (1982), Olivares and Wieland (1987), Mideplan, Costa Rica (2012), Ministerio de Agricultura, Peru (2016), and Ministerio de Desarrollo Social, Chile (2016)) agree that the main benefit is an increase in socioeconomic surpluses coming from three main sources:

i. *Increase in the agricultural area actually irrigated.* Agricultural benefits will stem from an increase in the area irrigated resulting from increased water intakes or increased water use efficiency (mainly from improvements in canal lining and the adoption of improved on-farm irrigation technologies).

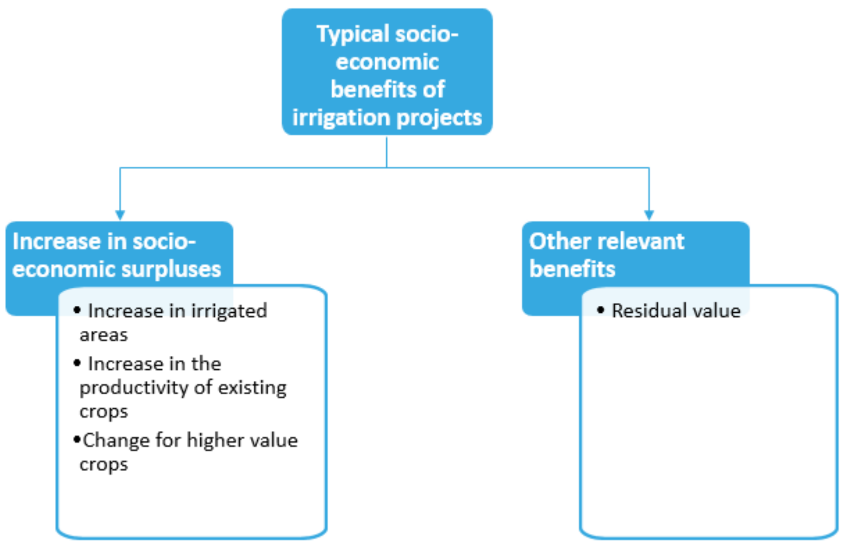
ii. *Increases in yields.* Improved irrigation involves a quantity of water available to the crops closer to the optimum at the most critical stages of the plant development cycle and a better uniformity in crop water distribution.

iii. *Change in land use.* In addition, agricultural benefits will stem from a change in land use, through a shift from lower-value crops to higher-value crops or forage for livestock production.

An extra benefit that could be added in some projects is the residual value of the infrastructure at the end of the project's evaluation horizon, which is traditionally of 15 to 20 years for irrigation projects, while some components of irrigation systems have much longer useful life, like pump stations or water pipes. There are different ways of computing the residual value, but the most common ones are as a perpetuity[23] of the last net benefit or as a proportion of the CAPEX.

The following figure presents a summary of the typical benefits of irrigation projects.

Figure 23. Typical socioeconomic benefits of irrigation projects



Depending on the particular project, some additional benefits may be relevant, as in the case of the SVTP.

In the case of the SVTP, the following benefits were included in the socioeconomic analysis:

- Increased net income from irrigated crop production, due to the introduction of new irrigated areas (11,535 ha) and new crops, as well as the increase in the yield of the traditional crop, sugar cane, by about 10 percent.

23. A perpetuity is a net present value of an infinite stream of benefits and costs. Assuming that the project would generate the net benefit of the last period constantly at the end of the project's evaluation horizon (T), the perpetuity would be calculated by dividing the last net benefit by the social discount rate and will be considered in the flow at date T. It is likely to overestimate the residual value of the project as it does not include reinvestments and higher maintenance costs.

- Increased net income from livestock production, as it is envisaged that a 100-cowherd unit will be established at ten of the fifteen 500 ha cooperative farms included in the Phase 1 of the SVTP.
- Increased net income from aquaculture production, due to the introduction of a fish farm.
- Avoided flood damage loss, which implies an estimated damage or loss probability curve combining an assessment of the hazard, in terms of the probability of future floods to be averted, and a vulnerability assessment in terms of the damage that would be caused by those floods and therefore the economic saving to be gained by their reduction.
- Increased access to improved domestic water supply, monetarized using the value of time saved by the population (particularly women) by not having to fetch water from the Shire River anymore.
- Power savings benefits: 15 MW allocated to pumping for agriculture purposes may be freed-up, which would save the corresponding generation cost estimated in the region to US$240/MWh.
- Benefits of natural resources management, due to reduced land degradation and soil loss, sustainable supply of biofuels for communities, increased nature-based tourism, and reductions in GHG emissions.

One of the common mistakes in identifying and valuing benefits for irrigations projects is double-counting, as Harberger pointed out in 2009:

> We very often see the double counting of benefits on many different types of projects, but I think that one so-called project report that I once reviewed in India probably holds the record. In that report, benefits were claimed: (a) equal to the value of the water, (2) plus the increase in the value of the land that took place as a consequence of the project, (3) plus the increase in the value of crops produced on that land, and (4) plus the wages bill paid for the extra employment that emerged as a result of the project. As I said, I had seen cases of double counting of benefits quite often, but this was a case of triple, and even quadruple counting!! (Harberger 2009, 1).

The reason why the water, the land, and the workforce have value is because they are inputs for the agricultural activity that generates socioeconomic surpluses, so in all four cases the same benefit is captured, ending up overestimating substantially the project's benefits.

In particular, one of the alternative ways of measuring the benefits of an irrigation project is by its impact on the land value in the logic of the hedonic prices method.[24] In a competitive market, the value difference between an irrigated versus a rain-fed parcel would be equal to the present value of the flow of net benefits from additional production obtained with higher water availability. This

24. Refer to Chapter 2 for more information on this valuation method.

valuation method is a good alternative to the productivity change method for which socioeconomic surpluses must be computed with and without the project. Refer to Harberger (2009) for a practical example of a CBA using the land value difference approach. Among CBA practitioners, a common practice is to compare the results obtained by the two methods to ensure that the benefits of irrigation projects are not overestimated.

Step 5: Calculate indicators

For irrigation projects, the most important indicators are the net present value (NPV) and the economic internal rate of return (EIRR), presented in Chapter 2 of this report, which allow measuring the project's benefits to society as higher than the costs society incurs in implementing, operating, and maintaining the project.

The benefit-cost ratio (BCR) can also be a useful indicator for comparing irrigation projects of different sizes.

> In the case of the SVTP, a CBA was carried out over a period of 40 years. Its main results indicate a net present value (NPV) of US$435.02 million and an economic internal rate of return (EIRR) of 20.34 percent, well above the opportunity cost of capital, estimated at 6 percent.

Step 6: Run sensitivity and risk analysis

Before concluding the CBA, it is important to check, by running sensitivity analysis, that these results are robust to some changes in the most critical variables for the project's profitability. For irrigation projects, some critical variables in addition to the investment cost are the agricultural output prices, the adoption rate of on-farm irrigation modernization projects by the farmers, the adoption rate of changes to higher value crops, and the amount of new irrigated parcels, among others.

> In the case of the SVTP, three main factors were considered in the sensitivity analysis: (i) cropping pattern or choice of crop mix, (ii) degree of realization of the planned new net irrigated area, and (iii) cropping intensity (against the target intensity of 190 to 200 percent).

At this stage it also important to understand the main risks that the project will face, which could end up increasing the cost of the project, slowing down its implementation, and reducing its socioeconomic incomes. This analysis would allow analysts to define some mitigation measures, the cost of which should be included in the CBA.

Some of the specific risks of irrigation projects include the following:

- *Instability of agricultural output prices:* Prices of many agricultural goods are highly volatile, and farmers cannot easily adapt their production plans.

- *Poor management of irrigation systems:* In particular, if farmers or water users' organizations do not have a clear ownership on the irrigation systems, management of irrigation systems can be poor in quality and maintenance is not guaranteed.
- *Water resource availability:* Water demand is increasing, and water supply is sometimes decreasing, which reduces water availability for irrigation.
- *Environmental impact*: Irrigation projects can generate environmental risks that must be studied carefully.
- *Natural disasters:* Agriculture is one of the economic activities most affected by natural disasters.
- *Availability of funds to finance the projects:* Part of irrigation projects is usually financed by farmers, who often have difficulties bringing their share of the financing, slowing down implementation of the projects.
- *Institutional coordination:* The project's implementation depends on the coordination of many actors, which is often difficult to get.
- *Social unrest:* Irrigation projects usually only benefit some of the farmers of a given region, creating tensions between farmers.

Step 7: Conclude and formulate recommendations

Finally, based on the indicators of the CBA and the sensitivity and risk analysis, some conclusions and recommendations can be formulated. These will favor one of three options: abandoning the project, postponing its implementation, or proceeding with due consideration of several factors that will be critical to its success.

Remember at this stage that the project that has been assessed is not necessarily the only possible alternative to be considered. A complete socioeconomic assessment should compare the results obtained with this project with results obtained from assessment of additional alternatives to define which is the best possible solution to the problem identified in the current situation.

For instance, in the case of irrigation projects, recommendations will need to be given on the optimal size of the project or the optimal irrigation technology.

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Appendix 1. Multicriteria analysis

The objective of Appendix 1 is to provide more details on each of the steps for performing an MCA, as shown in Figure 1, along with some applications to the transport sector.

Decision context and options for appraisal

The key to MCA is to set clear objectives and goals for the analysis. Before moving to the analysis of options, the stakeholders need to understand what exactly MCA will contribute to their decision-making process. The analysis can be set up in different ways to serve different purpose. MCA is very flexible with respect to who can participate in the definition of criteria and weights:

- All members of the decision-making body or of each involved organization/department
- Public works departments (PWD), to rate options independently
- Panels of experts asked to make judgments; different panels can judge different criteria
- Decision-making bodies thrashing out solutions on the consensus model
- Stakeholders
- Different groups rating options using different criteria

The MCA can be used to:

- Identify a single most-preferred option
- Prioritize options or come up with a new option
- Short list a limited number of options for subsequent detailed appraisal through other frameworks, such as CBA
- Distinguish acceptable from unacceptable options
- Help stakeholders understand available opportunities to move forward
- Identify gaps in information to support full-fledged analysis of available options
- Prioritize allocation of resources, e.g., as part of programming

The analysis can start at different stages of the decision-making process, e.g., to complement CBA when some criteria cannot be monetized, or at earlier stages for screening and preselection of options for further evaluation. MCA may show that some alternatives are unacceptable and help define inadequacies. It also may encourage participants to think about new options or modify existing ones.

Identification of the criteria

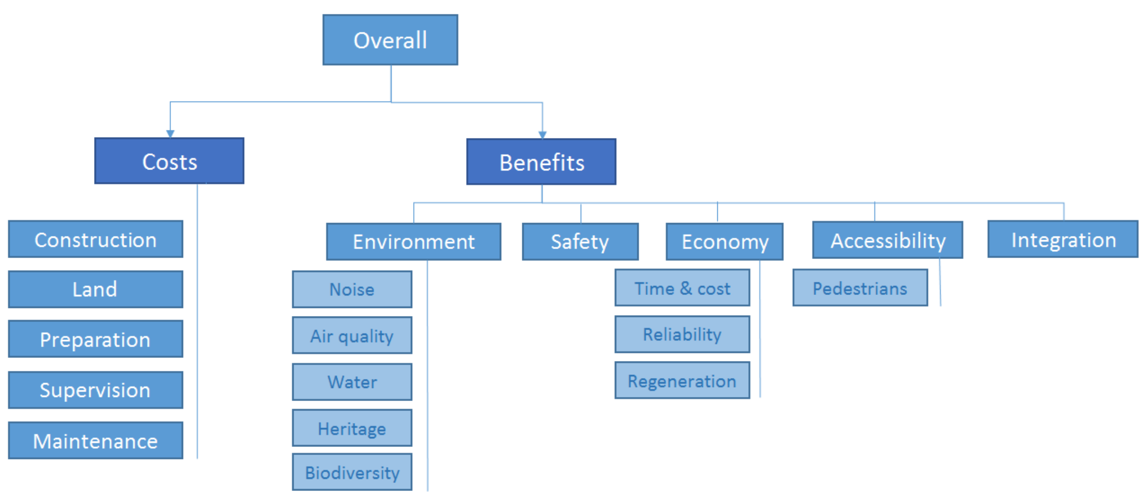
Criteria are measurable objectives that help assess consequences of different options. They are formed on the basis of higher-level objectives. Identification of criteria may involve different approaches, including contributions from focused interest groups, input from representatives of decision-making teams, and examinations of secondary information sources.

Often, criteria can be defined in very broad terms, making evaluation of options against these criteria difficult. For example, the criterion "environment" may be too vague in context and will need to be divided into subcriteria for more precise evaluation of options on relevant environmental aspects. For example, NATA (New Approach to Appraisal) adopted in the UK25 for roads suggests that evaluation would follow a set of high-level objectives that are then further broken down into subobjectives, or criteria:

- To protect and enhance the built and natural environment
- To improve safety
- To contribute to an efficient economy and support sustainable economic growth
- To promote accessibility
- To promote the integration of all forms of transport and land use planning, leading to a better, more efficient transport systems

Organizing the selected criteria around higher-level objectives helps in scoring options and analyzing the results against the high-level objectives. Figure 244 provides an example of a value tree showing how criteria are presented in relation to higher objectives.

Figure 24. The aggregation of criteria in MCA



Source: Department for Communities and Local Government: London (2009).

25. NATA was introduced by the UK government in 1997 to look at different criteria of road projects and take them into account while prioritizing alternatives.

When criteria are selected, they must be assessed against the general principles laid out in Table 17:

Table 17. Selection of criteria

Principle	Questions
Completeness	Any major category of performance missed? Are all criteria that are necessary to compare the options' performance included in the matrix? Do the criteria reflect all objectives linked to this MCA?
Redundancy	Are there criteria which are unnecessary? While some of the criteria may seem to be unimportant, it is important to include all relevant criteria even when options are likely to perform equally. Omission of common attributes can distort scores and show relatively unbalanced comparisons.
Operationality	Options are assessed against criteria by different experts, so they need to be judgmental. Sometimes it is useful to break a criterion down into a further subcriterion that would reflect specific aspects of performance more explicit.
Mutual independence of preferences	This is particularly important and affect the choice of an MCA method. Simpler MCA techniques that are recommended for PWD to start with require that evaluation of options against criteria is independent of each other. In other words, check if you can assign scores for the options on one criterion without knowing how options perform on the other criteria. If the answer is NO, then more complex MCA methods need to be used. In this case, the two criteria that are not mutually independent of each can be combined into one criterion that would reflect the common value.
Double counting	When criteria are scored in MCA, double counting should not be allowed in MCA as it will result in overweighting of some criteria in the final score.
Size	Long lists of criteria will require excessive efforts in regard to data inputs and analytical work. The performance matrix needs to be reasonable in size.
Overtime impacts	If a target completion date is an important factor and is a threat to some options, it can be included as a separate criterion. Time can also be included in the definition of criteria. Some options can perform short-term effects, while consequences of other options are long-term and repeated. This needs to be reflected in the scores if time dimension is important in regard to impacts.

Source: Department for Communities and Local Government: London (2009).

Performance and scoring

Prior to scoring different options against criteria, it may be reasonable to provide a qualitative characteristic of each option against each criterion and spell out anticipated performance as high, medium, or low, or with a different detail of desegregation. Next, options need to be scored against each criterion on a chosen scale. Cardinal and ordinal scale can be used by the working group to score options. Cardinal scale means that if option X performs twice as well as option Y, then option X will be given a score that is twice as much as for option Y. Ordinal scale is used for simple comparison of options but without indication how much better one option performs than another. The use of the cardinal scale is preferred as it provides better comparison of options against each other. Scales can be defined in different ways, for example, from 0 to 20, or 0 to 100, or as described in Table 18. The chosen scale should be kept constant for all criteria for mathematical consistency. The meaning of maximum and minimum should be understood by all group members and documented.

Table 18. Example of an approach to scoring options (PPIAF)

No.	Criteria	High Score (10 to 8)	Moderate Score (7 to 4)	Low Score (3 to 0)
1	Financial feasibility /fiscal support	Likely viable: >20%, and no fiscal support	Likely Viable: between 14-20%, and no fiscal support	Not viable <14%; and high fiscal support
2	Readiness and risk	Few major issues/risks and project ready	Identified risks can be largely mitigated and the project can be made ready	Many risks, few can be mitigated sufficiently and project not ready
3	Economic feasibility: socioeconomic benefits	EIRR>15%; major macro impact	EIRR 12%-15%; Moderate macro impact	EIRR <12%; minor macro impact
4	Regional development / integration/contribution to GDP	Impact on low GDP provinces and/or high poverty alleviation potential	Impact on low-medium gross regional domestic product provinces and/or medium poverty alleviation potential	Impact on high gross regional domestic product provinces and/or low poverty alleviation potential
5	Sector network role importance in sector plan	Forms integral part of the sector plan	Included in the sector plan	Ad hoc project but not in conflict with sector plan
6	National security/ national integration	Strengthens national security/integration	Medium impact	Low impact
7	Land acquisition	All/most land acquired (e.g., over 80%)	Some land acquired (25%-80%)	None or little land acquired (<25%)

8	a. Likely environmental impacts b. Involuntary resettlement	Few issues: a. Low impact b. Few people affected	Some issues: a. Mid impact b. Mid affected	Many issues a. Severe impact b. Many people affected
9	Impact on export earnings	Major overseas trade and/or tourism impact:	Limited overseas trade or tourism impact	Little overseas trade or tourism impact
10	Safety	High safety focus	Moderate safety focus	Low safety focus
11	Project Cost	> 100m US dollars	100m US dollars - 50m US dollars	< 50m US dollars
12	Demand growth %/ traffic volume or the demand/capacity ratio	a. >15% pa b. >20 thousand vehicles per day c. >1.2	a. 15%-5% pa b. 10-20 thousand vehicles per day c. 1.2-0.8	a. <5% pa b. <10 thousand vehicles per day c. <0.8

Table 19 presents an example where three different interest groups of stakeholders, using criteria describe above, respond to the criteria with a score between 0-10 for two alternative projects (i.e., Alt 1 and Alt 2). The scores do not address how the scores from each member within each interest group are aggregated. Actually, each interest group can collect information using different techniques for instance through a workshop similar to the one used for risk analysis.

Table 19. MCA: Two alternative projects and three stakeholder groups

No	Criterion	Group 1: PWD		Group 2: USERS		Group 3: NGOs	
		Alt 1 score	Alt 2 score	Alt 1 score	Alt 2 score	Alt 1 score	Alt 2 score
1	Financial feasibility / fiscal support	8	9	7	5	6	8
2	Readiness and risk	6	4	5	7	5	7
3	Economic feasibility: socioeconomic benefits	6	8	5	3	6	7
4	Regional development / integration / contribution to GDP	3	1	4	6	4	1
5	Sector network role importance in sector plan	4	6	5	3	4	2
6	National security / national integration	3	1	3	5	3	2
7	Land acquisition	8	10	6	4	6	6

8	a. Likely environmental impacts b. Involuntary resettlement	5	7	6	6	5	3
9	Impact on export earnings	3	5	4	2	4	4
10	Safety	5	7	5	6	7	4
11	Project cost	6	8	7	5	6	5
12	Demand growth % / traffic volume or the demand/capacity ratio	6	4	5	7	6	7

Weighting and aggregation

A widely used approach for comparing the performance between two alternatives is to assign weights to criteria and then apply these weights to the performance score of each alternative. The linear additive model for multicriteria analysis is widely used for many multicriteria evaluations. The inputs of the linear model include performance scores of alternatives and weights of each criteria. Usually scores are considered "known," but more effort is needed to determine weights. The model can be also applied with fixed scores and variable weights, or fixed weights and variable scores, for example upper and lower bounds. A more detailed description of how weights can be determined is presented below.

The overall approach of the linear additive model is expressed by the following formula:

$$Si = \sum_{i=1}^{n} (w_i * s_{ij}) = w_1 * s_{i1} + w_2 * s_{i2} + \ldots + w_n * s_{in}$$

Here, Si – the overall score of option i

w_i – weight of criterion i

s_{i1} – scoring of option i against criterion 1

The challenge of the linear additive model relates to the difficulty to assign weights to criteria based on their relative importance in the decision-making process. The many approaches to weighting criteria range from very simple to highly sophisticated (requiring computer software to run the analysis). The most common approaches include ranking and rating (assessment of overall importance of each criterion), pairwise comparison of trade-off preferences, and defining ratios between pairs of criteria (analytical hierarchy process),[26] or a more flexible way of describing feasible ranges of weights rather than assigning precise values.

Approach 1: Rating and ranking

26. For the AHP method, refer to Saati 1987.

The problem with the scores described in Table 18 is that each interest group may have different preferences for the criteria. For instance, for PWD, the financial feasibility may be an important factor but of less of no importance for users. This makes it necessary to rate and rank the different criteria and produce an aggregate vector of criteria that can be used in the linear approach described above.

Each interested groups (IG) are asked to rank the importance of each criterion in relation to a common high-level objective. Each IG is asked to give each criterion a score, or percentage score, between 0 and 100, adding up to 100. They are also asked to rate each criterion using a magnitude of importance as described in Table 20, where the scores are from 1 to 9. The following scale is used for ***ranking*** (for convenience, the importance of criteria can first be described in words and then assigned a value referring to the scale).

Table 20. Scale for ranking criteria

1	3	5	7	9
Weakly important	Less important	Moderately important	More important	Extremely important

Source: Center for International Forestry Research (1999).

Therefore, each group ranks the twelve criteria to the sum of 100, but it also ranks each criterion from 1 to 9. For example, using the same three-group example used above, each group presents weights the different criteria according to their subjective preferences, as shown in Table 21.

Table 21. Prioritization of criteria in MCA

	Criterion	Group 1: PWD			Group 2: USERS			Group 3: NGOs		
		Ranking of criteria	Meaning of ranking	Rating of criteria, %	Ranking of criteria	Meaning of ranking	Rating of criteria, %	Ranking of criteria	Meaning of ranking	Rating of criteria, %
1	Financial feasibility / fiscal support	8	More to extremely important	15	1	Weakly important	2	2	Weak to moderately important	2
2	Readiness and risk	4	Less to moderately important	5	2	Weak to moderately important	3	2	Weak to moderately important	2
3	Economic feasibility: socioeconomic benefits	7	More important	12	5	Moderately important	6	9	Extremely important	17
4	Regional development / integration / contribution to GDP	8	More to extremely important	15	7	More important	13	6	Moderately to more important	8
5	Sector network role importance in sector plan	9	Extremely important	16	5	Moderately important	6	5	Moderately important	6
6	National security/ national integration	6	Moderately to more important	10	6	Moderately to More important	12	5	Moderately important	6
7	Land acquisition	2	Weak to Moderately Important	2	8	More to extremely important	14	8	More to extremely important	15
8	a. Likely environmental impacts b. Involuntary resettlement	3	Less Important	4	8	More to extremely important	14	9	Extremely important	17
9	Impact on export earnings	3	Less Important	4	4	Less to moderately Important	7	4	Less to moderately important	5
10	Safety	4	Less to moderately important	5	9	Extremely important	17	7	More important	13
11	Project Cost	5	Moderately important	6	3	Less important	4	4	Less to moderately important	5
12	Demand growth % / Traffic volume; demand/capacity ratio	5	Moderately important	6	1	Weakly important	2	3	Less important	4
				100			100			100

The next step is the aggregation of criteria into a vector of twelve criteria that will serve as weights in the linear approach. The criteria, as mentioned, receive values from 0 to 100 based on their importance in the evaluation process, while the sum of all values for 12 criteria adds up to 100. Further, these weights are normalized and averaged to come to a single weighted score for each criterion (as shown in Table 22).

Table 22. Aggregation of criteria

No.	Criterion	Estimation of combined weights for criteria				
		Sum of ranking votes	Sum of rating votes	Relative ranking weight	Relative rating weight	Combined weight for criterion
1	Financial feasibility / fiscal support	11.00	19.00	5.88	6.33	6.11
2	Readiness and risk	8.00	10.00	4.28	3.33	3.81
3	Economic feasibility: socioeconomic benefits	21.00	35.00	11.23	11.67	11.45
4	Regional development / integration / contribution to GDP	21.00	36.00	11.23	12.00	11.61
5	Sector network role importance in sector plan	19.00	28.00	10.16	9.33	9.75
6	National security / national integration	17.00	28.00	9.09	9.33	9.21
7	Land acquisition	18.00	31.00	9.63	10.33	9.98
8	a. Likely environmental impacts b. Involuntary resettlement	20.00	35.00	10.70	11.67	11.18
9	Impact on export earnings	11.00	16.00	5.88	5.33	5.61
10	Safety	20.00	35.00	10.70	11.67	11.18
11	Project cost	12.00	15.00	6.42	5.00	5.71
12	Demand growth % / traffic volume or the demand/capacity ratio	9.00	12.00	4.81	4.00	4.41
	TOTAL:	187	300	100.00	100.00	100.00

Based on average scores assigned by 3 different groups of stakeholders to each criterion for Alternative 1 and Alternative 2 and the combined weight for each criterion, weighted average scores for project options are calculated by multiplying average scores by respective weight of criterion. The sum of weighted average scores for each alternative option represents performance of a certain alternative and can be used for comparison with other project alternatives. In this example, the Alternative 1 project is the preferred option.

Table 23. Multicriteria analysis results

No.	Criterion	Estimation of average weighted scores for Alternatives 1 and 2			
		Alt 1 average score	Alt 2 average score	Alt 1 weighted average score	Alt 2 weighted average score
1	Financial feasibility / fiscal support	7.00	7.33	42.75	44.79
2	Readiness and risk	5.33	6.00	20.30	22.83
3	Economic feasibility: socioeconomic benefits	5.67	6.00	64.87	68.69
4	Regional development / integration / contribution to GDP	3.67	2.67	42.59	30.97
5	Sector network role importance in sector plan	4.33	3.67	42.24	35.74
6	National security / national integration	3.00	2.67	27.64	24.57
7	Land acquisition	6.67	6.67	66.53	66.53
8	a. Likely environmental impacts b. Involuntary resettlement	5.33	5.33	59.63	59.63
9	Impact on export earnings	3.67	3.67	20.56	20.56
10	Safety	5.67	5.67	63.36	63.36
11	Project cost	6.33	6.00	36.15	34.25
12	Demand Growth % / traffic volume or the demand/capacity ratio	5.67	6.00	24.97	26.44
	TOTAL weighted score:			**511.59**	**498.36**

Approach 2: Pairwise comparisons

Analytical hierarchy process (AHP) is a widely used MCA approach based on converting relative importance of criteria into a set of weights. Stakeholders define relationships between pairs of criteria that indicate rates of trading one criteria against the other. The question "How important is attribute X compared to Y?" can be used to set a ratio. If trade-off ratios are difficult to establish, ranges of ratios, or a *feasibility range,* can be defined for two criteria in a form of inequalities. This approach will be demonstrated further under the flexible approach example.

Department for Communities and Local Government' MCA manual (2009) offers the following approach to establish relationships between pairs of criteria.

How important is X relative to Y	Preference index assigned
Equally important	1
Moderately more important	2
Strongly more important	5
Very strongly more important	7
Overwhelmingly more important	9

Results of pairwise comparisons can be presented in the matrix form.

	X	Y	Z
X	1	5	9
Y	1/5	1	3
Z	1/9	1/3	1

If stakeholders decide that Y is strongly more important than X, then the value 5 would be assigned to Y relative to X, and reciprocally 1/5 to X relative to Y (see the matrix). It should be noted that this method does not guarantee consistency of relationships between pairs. Finding "optimal" weights for X, Y, and Z that would fit relationships in a matrix could be done by a special AHP computer package. Although with a small error, it can be also done manually following the logic below:

- Calculate the geometric mean of each row in the matrix,
- Total the geometric means, and
- Normalize each of the geometric means by the total.

CRITERIA	GEOMETRIC MEAN	NORMALIZED WEIGHT
X	$(1*5*9)^{1/3}$ = 3.5568	0.751
Y	$(1/5*1*3)^{1/3}$ = 0.8434	0.178
Z	$(1/9*1/3*1)^{1/3}$ = 0.3333	0.070
TOTAL	4.7335	=1.00

Sensitivity analysis

In cases of high uncertainty of MCA, the robustness of results must be tested. Sensitivity analysis can be applied to check the stability of results in (a) changes to scores of options against criteria;

and (b) changes in weights of criteria. The question is how rankings of proposed options would change with certain levels of uncertainty in regard to weights and scores. If ranking of options does not change significantly while assigning random distribution of weights or scores within the uncertainty range to the criteria, one can assume that the results of the MCA are robust.

Weighting of criteria and scoring are subjective processes that require a consensus among stakeholders. Often, stakeholders differ in their opinions on the importance and value of criteria and the performance of each option. Sensitivity analysis can help test for different combinations of scores and accommodate debated issues among stakeholders. It also may facilitate looking into areas of improvement for selected project alternatives.

Sensitivity testing can include:

- **Variations in option scores**: In this sensitivity analysis the score variation should fit the uncertainty range for scores defined, for example, by a percentage or a minimum and maximum threshold, by which the score may vary. This is defined by the group of stakeholders and can account for differences in opinions regarding scores assigned for different options. If possible, the overall score/rank of options is recalculated a number of times, assigning random values satisfying the uncertainty range. The result of this exercise is a table of frequencies or probabilities (of scores/ranks calculated) for each option.
- **Variations in weights of criteria:** Sensitivity of rankings can be also checked against different weights in criteria. One way is to check for variations in overall scores of options calculated with different weights assigned separately for each criterion. This analysis can be run as a Monte Carlo simulation, assigning random weights to criteria. Some options may demonstrate the highest probability of staying at the top or bottom of the ranking. The analysis also will show trends in the overall scores of options, any reversal in ranking of options with respect to changes in the value of criteria, and the most critical criteria that impact ranking.

To summarize, the objective of sensitivity analysis is to check the robustness of MCA results and identify the most critical factors contributing to the results. Sensitivity analysis reveals the level of uncertainty and stability of ranking and points out the areas within options that might be considered for improvement. Please see the Box 9 for illustrative purposes.

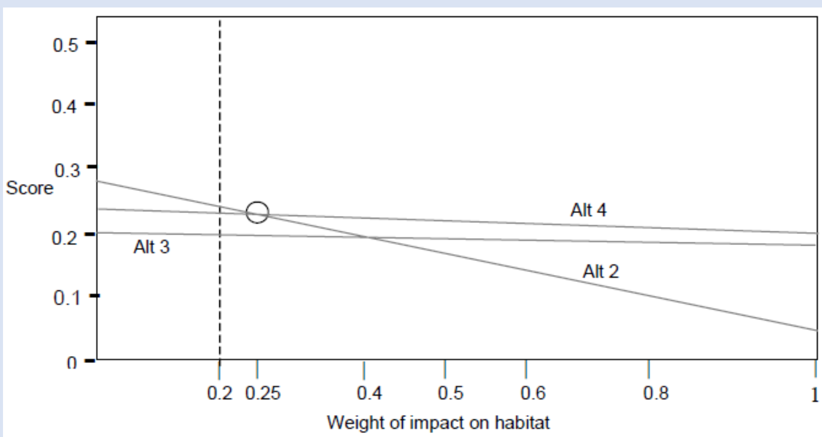
Box 9. Sensitivity analysis for an MCA

In the study of three different alignment options for a road in the Province of Trento, Northern Italy, selected tested criteria included five environmental attributes: vegetation, habitat, land production, landscape, and geomorphology. After weighting and aggregation of scores for road alternatives was completed, sensitivity analysis was performed for changes in the impact scores. For this, 1,000 random numbers were generated for each impact score, within a 20 percent uncertainty range for scores, after which overall scores were computed for each alternative and 1,000 ranking options generated.

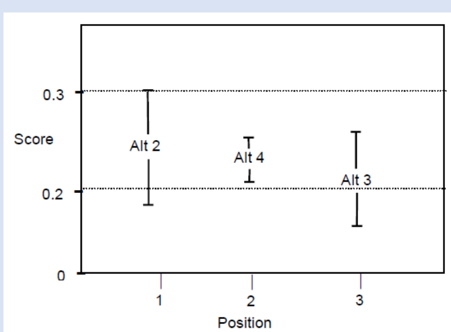
From the picture table, it can be seen that option 4 takes the first rank 76 percent of cases, option 2 performs worse in 70 percent of cases, and alternative 3 outperforms option 2 in many cases.

	1st	2nd	3rd	4th	5th
Alt 4	760	230	10	0	0
Alt 3	200	500	300	0	0
Alt 2	40	270	700	0	0

Another type of analysis targeted changes in the weights assigned to each criterion. The figure below shows the outcome for changes in the weight of "habitat" criteria. It underlines that a reversal in the ranking takes place when the value for habitat is more than 0.25. When the weights for habitat increase, alternative 2 overall scores become worse, as this alternative is not "strong" on this criterion. Alternative 4 is less sensitive to habitat and more stable in respect to changes. However, the original weight was 0.2, and reversal in ranking occurred with a 20 percent variance.



The summary of the sensitivity analysis is demonstrated on the figure below. It shows that alternative 2 performs better compared to alternative 4; however, it is more sensitive to changes, while alternative 4 is more stable in its overall scoring.



Source: Geneletti (2005).

Appendix 2. Social discount rate

Appendix 2 presents the main methods used to estimate the social discount rate (SDR).

The literature offers several alternatives to estimate the SDR. Below we offer a brief review of the following: (1) the weighted cost of capital approach; (2) the social rate of time preference (SRTP) method; (3) the marginal productivity of capital in the private sector method; and (4) a method that uses an accounting or "sliding" discount rate.

- Weighted cost of capital

The weighted cost of capital method assumes that the discount rate for capital investments should be the economic opportunity cost of funds obtained from the capital markets. This rate—initially proposed by Arnold C. Harberger (1972, and 1997) and subsequently expanded and improved by other authors—is a weighted average of the marginal productivity of capital in the private sector and the rate of time preference for consumption or the interest rate on savings.

The decision to fund a public project will displace private investments and consumption. The weights for estimating SDR, as explained in more detail below, will come from the expected displacement of investments in one case or the postponed consumption in the other, evaluated at their respective economic prices. A key advantage of the weighted cost method is the use of market information to estimate prices for the marginal gross-of-tax returns for investors as well as net-of-tax savings rates for consumers or suppliers of capital, both domestic and foreign. The basic equations underlying this method are summarized in Box.

The weighted cost of capital approach offers certain advantages over alternative methods, particularly with regard to clarity and robustness of the results. It is a comprehensive approach that considers the impact of financing public projects on both domestic private investment and consumption, while other approaches tend to focus either on one variable or the other. Unlike alternative methodologies, the weighted cost of capital estimation is based on observed market evidence. For instance, this approach relies on domestic prices such that economic values are compatible with the values in financial flows and budget analysis. Furthermore, it favors the comparability of results across sectors in the economy, hence promoting transparency. Based on these characteristics, the weighted cost of capital methodology has been widely favored by governments and multilateral agencies (including the World Bank). As demonstrated by Burgess (2008), the weighted cost of capital approach tends to offer a higher probability of optimal investment choices than other methodologies. For further discussion on the merits of this approach, see Rajaram et al. (2010).

Box 10. Weighted cost of capital approach to estimate the social discount rate

The economic opportunity cost of capital (EOCK) is the weighted average of the share of displaced investments (ω^d) priced at the gross of tax return (π) and share of induced savings ($\omega^s = 1 - \omega^d$) at the rate of time preference for consumption (r).

$$EOCK = \omega^d \pi + \omega^s r$$

For several types of investors and savers, the weighted returns can be expressed as follows:

$$\omega^d \pi = \sum_{j=1}^{n} \omega_j^d \pi_j = \frac{-\sum_{j=1}^{n} \eta_j^d (I_j / S) \pi_j}{\sum_{i=1}^{m} \varepsilon_i^s (S_i / S) - \sum_{j=1}^{n} \eta_j^d (I_j / S)}$$ and

$$\omega^s r = \sum_{i=1}^{m} \omega_i^s r_i = \frac{\sum_{i=1}^{m} \varepsilon_i^s (S_i / S) r_i}{\sum_{i=1}^{m} \varepsilon_i^s (S_i / S) - \sum_{j=1}^{n} \eta_j^d (I_j / S)}$$ and $\sum_{j=1}^{n} \omega_j^d + \sum_{i}^{m} \omega_i^s = 1$

The weight of demand for displaced investments of type j (ω_j^d) is the price elasticity of demand for investments (η_j^d) times the investment share over total savings (I_j/S) for each type of investment. This weight is applied to the gross of tax return (πj) of the type j investment. Similarly, for the weight of supply of savings out of postponed consumption from type i (ω_i^s) is the price elasticity of supply of savings (ε_i^s) times the savings share over total savings for each group (i), times the net of tax returns (ri).

Another version of the weighted cost of capital approach includes a third source of funds to finance public investment (additional to domestic savings and the displacement of private investment), which is foreign borrowing. By increasing the demand for funds, public investment tends to increase the national interest rate, which attracts foreign savings and increase the country's foreign debt, generating a rise of borrowing costs on new and existing debt contracted at floating interest rates. In this case, the SDR is estimated using a weighted average of the marginal productivity of private capital, the net return on domestic savings, and the marginal cost of foreign borrowing.[27]

- Social rate of time preference

The social rate of time preference (SRTP) measures the preference for giving up consumption in favor of savings. A method originally proposed by Marglin (1963), Feldstein (1964), and Dasgupta,

27. For an example of an estimation of the SDR using this approach in Mexico, refer to Rodriguez (2013).

Marglin, and Sen (1972), the SRTP-based discount rate has become the approach preferred by some European countries (e.g., the United Kingdom) and European multilateral agencies. Often centrally prescribed rather than measured in the capital markets, the SRTP method still generates debate when compared to the weighted cost of capital approach.

The SRTP method could be comparable with the EOCK by valuing investment costs at the shadow price of investment measured in units of consumption. Conceptually, the SRTP must be used in discounting consumption benefits and costs measured in units of foregone consumption. Hence, to make the SRTP comparable to the weighted cost of capital method, investment costs should be valued at the shadow price of investment, which measures the foregone consumption arising from the investment. For a long-lived investment, if investment is financed out of a weighted average of foregone investment and consumption, then the shadow price of investment (S) is the present value of the foregone stream of consumption, or a weighted average of the consumption foregone on investment valued at consumption units (π/r) and the share from consumption valued at unity (S = $\omega^d \, \pi/r + \omega^s$ = EOCK/r). Clearly, the shadow price of investment rises with the investment share and the gap between π (cost of foregone investments) and r (SRTP or cost of foregone consumption).[28] Relying on the shadow price of investment when using the SRTP method will yield similar conclusions to those reached when using the EOCK.

The SRTP tends to be significantly lower than the rate obtained when using the weighted cost of capital method. In capital market terms, the SRTP can be equated to the rate of time preference for consumption (r), and hence, if the cost of foregone investments (π) exceeds r, then the EOCK exceeds the SRTP.

- Marginal productivity of capital

The marginal productivity of capital in the private sector approach is based on the principle that the government will always seek to maximize the returns for the economy. Under this rationale, all public sector projects would use the rate equal to the marginal productivity of capital in the private sector (Hirshleifer, DeHaven, and Milliman 1960). If private sector returns are higher than those generated by the public sector, more funds should then be made available to the private sector to maximize the returns on economic resources. Little and Mirrlees (1969, 1974) developed a cost-benefit method that values costs and benefits in terms of border or world prices in foreign exchange units.[29]

The marginal productivity of capital in the private sector method advocates the use of a discount rate based on the cost of foregone investments (or π). This approach to setting the discount rate is appropriate in closed economies with unresponsive private savings. Under these conditions, the

28. In countries with substantial taxes on capital (corporate, property, and personal income taxes), a large distortion can exist between π and r, such that the shadow price of investment (EOCK/r) can be around 1.5 to 2, making the adjustment to the appraisal significant.

29. An attractive approach to dealing with the value of traded goods, the Little and Mirrlees methodology requires all nontraded goods and labor to be converted to their foreign exchange equivalent, and all distortions are expressed in foreign exchange units.

weighted average EOCK could be approximated by the cost of foregone investments π as ωd approaches unity. In the context of more open economies with increasingly integrated capital markets, this extreme assumption is no longer appropriate. One possible advantage of this method is the comparability of projects across borders, as they are measured using international monetary units. Some international organizations and UN agencies have used this method in the past.

The discount rate based on the marginal productivity of capital in the private sector approach is higher than the weighted EOCK. An unnecessarily higher discount rate for public sector projects, as π is by definition higher than the weighted EOCK, can result in the elimination of worthwhile investments in the public sector, leading to real economic losses.

- Accounting or sliding discount rate

Finally, the accounting or sliding discount rate employs a rationing approach that allows public sector projects to be funded, in descending order, as long as available resources are available in the public sector budget. Originally proposed by Little and Mirrlees (1969, 1974) and by Squire and van der Tak (1975), this method recommends the use of an accounting discount rate, which is compared to the marginal returns from public sector projects, within the available budget constraints for the public sector. The accounting discount rate employs a rationing device to fund public sector projects in descending order, on the condition that the marginal project (e.g., the one with the lowest economic internal rate of return or lowest net present value) is accepted subject to available resources in the public sector budget. The accounting discount rate is adjusted upward or downward depending on the proposed projects, their returns using this discount rate, and the available budget.

From an economic standpoint, the accounting discount rate approach is not optimal. An accepted economic discount rate (as a true opportunity cost to the economy) ensures that only projects deemed to contribute to the economy at that rate should be adopted. Excess funds, if any, should then be used to lower the public sector debt and/or to fund private sector projects through the private capital markets. By contrast, an accounting discount rate only selects projects appropriately if the selected discount rate is equal to or higher than the EOCK. When enough funds are available, the sliding rate advocates the approval of public sector projects that yield lower returns than those approved with the weighted EOCK, ultimately generating economic losses.

For an example on how to apply the weighted cost of capital approach explained earlier to estimate the SDR, refer to Coppola, Fernholtz, and Glenday (2014) for a case in Mexico.

Appendix 3. Standardized content of a CBA

As introduced in Chapter 1 and described in detail in Chapter 2, the elaboration of a cost-benefit analysis should follow the seven steps outlined in the following sections.

Step 1: A diagnosis of the current situation and definition of the baseline alternative

In this step, the analyst must present the problem happening in the current situation. Based on demand and supply characterization, this part of the process must provide strong arguments that support the problem identified and that will be the base for analyzing whether the solution (the project) will be a convenient option from a socioeconomic approach. Once the problem or a business opportunity is defined, it is important to identify any adjustment that could improve the current situation (baseline situation).

The main elements to be presented in Step 1 are the following:

- A description of the existing supply
- An analysis of the historic and current demand
- The interaction between supply and demand and identification of the problematic faced in the current state of affair
- The identification of adjustments to the current state of affair
- The forecast of the adjusted state of affair

Step 2: Identify and define the alternatives

Once the problem is framed, this step involves describing and comparing the different solutions identified by the analyst. The main goal here is to select the feasible solution that will most help to reduce the problem identified.

Usually, the main elements of Step 2 are:

- Identify alternatives to the problematic identified at Step 1.
- Compare the alternatives based on their feasibility levels to select a short list of feasible alternatives.
- Describe in more detail each remaining alternative to be assessed through CBA or CEA.

Step 3: Describe the situation with the project

In this step, the solution (the proposed project) has to be clearly defined and detailed. It is important to forecast its implications in relation to the demand and supply.

Step 3 will contain:

- A description of the supply in the "with project" scenario
- A description of the demand in the "with project" scenario
- The interaction of supply and demand in the "with project" scenario and the analysis on the impact of the project on the problemat identified in the baseline scenario

Step 4: Identify, quantify, and monetize cost and benefits

Comparing the baseline and the situation with the project, the analyst must identify and quantify all the costs and benefits related with the execution of the project. Then the analyst must determine which valuation method best suits the type of cost or benefit. The range of methods and techniques presented in Chapter 2 can be used as a benchmark.

Main elements in Step 4 are:

- Identification, quantification, and monetarization of the costs of the project
- Identification, quantification, and monetarization of the benefits of the project

Step 5: Calculate indicators

Based on the costs and benefits generated by the project, this section must show the profitability indicators that will be used to decide whether to execute the project under analysis.

Step 5 will contain as a minimum:

- A table of the net socioeconomic flow of the project
- Computations of the relevant indicators

Step 6: Run sensitivity and risk analysis

This step is dedicated to managing somewhat the variability present in any assessment. It is impossible to fully arm the estimations against variations in the different factors involved, so it is highly recommended that a sensitivity and risk analysis be run to acknowledge the magnitude of effect certain changes could make in the project's viability and to make a contingent plan if these variations occur.

The main elements of Step 6 are:

- A deterministic and/or probabilistic sensitivity analysis
- A risk analysis identifying prevention and mitigation measures

Step 7: Conclude and formulate recommendations

Finally, it is important to include a section stating the main findings of the study. These will be the base for deciding on the execution of the project. Also, any recommendations or suggestions should be included here to provide the decision maker with as much information as possible.

Step 7, the final stage of the analysis, should therefore present the following:

- The conclusion based on the previous results
- Formulations of various recommendations related to the optimal geographic location, size, timing for investment, technology, and degree of prioritization of the project

Appendix 4. Guidelines for elaborating Terms of Reference for contract consultants performing CBA

This appendix describes possible the Terms of Reference (ToR) for consultants performing CBA.

A. Background and main objective of the study

The opening section of the ToR typically introduces the overall program or project to be assessed, ideally answering the following questions:

- What is the project to be assessed?
- Why is it an important project? What are the objectives and intended outcomes of the project to be evaluated?
- What is the context and history of the project?
- Who is involved in developing the project?

Usually, the main objective of the study will be an elaboration of a socioeconomic assessment of the project or program, which could be a cost-benefit analysis (CBA), a cost-efficiency analysis (CEA), and/or a multicriteria analysis (MCA), depending on the type of project and the level of the study, prefeasibility or feasibility.[30]

B. Specific objectives and scope of work

At this stage it is important to specify the objectives and structure of the study. For instance, as it was presented in Chapter 2, the study should contain a chapter diagnosing the current situation; identifying and comparing alternative solutions; describing the situation with the project; identifying, quantifying, and monetizing costs and benefits; calculating indicators; analyzing risks and sensitivity; and formulating conclusions and recommendations based on the results of the assessment.

It is also important to be precise on whether the study must present at least some of the basic elements listed in Appendix 3.

Additional elements may be added to the precise scope of work. For instance, the ToR should specify if the consultant will be expected to run complementary studies in addition to those already performed, such as complementary demand studies, more precise technical studies, or environmental and/or social studies.

30. The consultants could also be asked to define the relevant type of analysis.

C. Deliverables / specific outputs expected from consultants and schedule

The outputs and reporting requirements expected for the evaluation should be specified, along with the required or proposed timeline for the study.

Usually for socioeconomic assessments, the consultants elaborate at least three types of deliverables:

- A Word document presenting the main elements of the socioeconomic assessment
- An Excel file (without protected cells) containing all the information and calculations presented in the previous document
- Various appendices providing more details on or support for the information included in the socioeconomic assessment

Note that in many cases, in particular for complex projects, it could be useful to ask for intermediate deliverables in advance of requiring the complete assessment. For instance, it is possible to ask for a first draft containing the diagnosis of the current situation and an identification of the costs and benefits of the project. At this stage, consultants will find it very helpful to get some feedback from the contracting entity.

In addition to the list of deliverables, it is important for the contractor or the client to define dates for each deliverable.

Usually, as part of its offer, consultants should be asked for a detailed work schedule specifying the activities to be performed for each deliverable and the dates of delivery.

It is also important that the contracting entity commit time to giving comments and feedback on the deliverables.

D. Specific inputs to be provided to the consultants

Socioeconomic assessments usually rely on information obtained from other studies, like technical, environmental, or demand studies. For this reason, it is important that the ToR provide precise information on what is available and will be provided to the consultants once the contract is signed.

E. Suggested team and qualifications

To attract the strongest candidates for conducting the study, the ToR should specify as clearly as possible the desired profile for the evaluator or team. Relevant and useful details include:

- If firms, individuals, or both may apply
- The minimum level of general experience required from the firm and the professionals working on the assignment

- The minimum level of specific experience required from the firm and the professionals working on the assignment

Performing a socioeconomic assessment generally requires a team with technical as well as economic skills. As part of its offer, therefore, consultants should be asked to present a biographical data on each member of the team, as well as information on the organization of the team and the level of efforts and activities to be performed by each member.

F. Budget and payment

Consultants will be asked to present their economic offer, which will be compared to those of the other candidates.

A calendar of payments should also be defined for the duration of the project, in proportion to the total amount of the contract.

G. Criteria for comparing offers

Depending on the project, different criteria can be used to assign the contract, but usually the final choice would mostly depend on the following:

- The quality of the proposal in terms of methodology and the work schedule to attain the objectives of the study
- The quality of the team and its experience and skills
- The amount of the economic offer

Ideally, the ToR should specify how each criterion will be scored and what weights are assigned to each criterion when computing the final score.

H. Special terms and conditions or specific criteria

Finally, the ToR may set out specific information and important guiding principles or values that should guide the study. These can include concepts such as transparency, cost-effectiveness, collaboration with beneficiaries, confidentiality of data, and so on.