Republic of Iraq

Ministry of Water Resources

General Directorate for Water Resources Management

Strategy for Water and Land Resources in Iraq

Guidance Note Series

Introduction to Cost Benefit Analysis

GN 09

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This document is one of a series of occasional guidance notes published by the Ministry of Water Resources addressing issues relevant to strategic planning for the sustainable use of the water and land resources of Iraq.

The guidance note introduces cost benefit analysis for engineers and planners who lack a formal training in economics.

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1 INTRODUCTION

1.1 A set of tools for guiding decisions

1.1.1 We all make decisions every day. Consciously or not, before deciding on a course of action we often ask ourselves 'is it worth it?'. When we do that we are using cost-benefit analysis. Having formulated a possible course of action (a project) we assess the cost it will incur and the benefits it will bring, balance the one against the other, perhaps consider other influences, and then decide: 'is the benefit worth the cost?'. So cost-benefit analysis (CBA) is above all a set of tools for guiding decisions.

1.1.2 To use CBA quantitatively for the guidance of a decision there are a few basic steps in every case

1. Define the decision, normally between a possible course of action and its alternative
2. Fix, at least tentatively, the decision criteria
3. Estimate the cost of taking that course of action
4. Estimate the benefits that it would bring
5. Weight up the costs and benefits by means of some quantitative indicator
6. Consider uncertainty and the range of possible outcomes
7. Apply the criteria
8. Consider the CBA alongside other relevant decision guides like environmental aspects
9. Make the decision

1.1.3 Although CBA is a tool for guiding decisions it is seldom the only guide to a particular decision. Most decisions are made on several criteria, some of which may be unacknowledged and never explicitly presented. Examples are:

- Regional policy (a political desire to develop some regions)
- Social policy (a political desire to favour some groups of people like disadvantaged minorities)
- Environmental criteria

- Self interest
- Habit
- Risk aversion.

1.2 A common unit of measurement

1.2.1 In order to ask 'is the benefit worth the cost?' in any quantitative way we need to have the cost and the benefit expressed in some sort of common unit of measurement. Since costs are most easily and normally measured in terms of money it is usual, although not essential, to use money as the common unit of measurement.

1.2.2 In many kinds of CBA the unit is not really money because some kind of economic or social pricing has been used rather than ordinary financial or market prices, but the unit is still called by the name of a currency; this can cause confusion so careful labelling and explanation should always be provided.

1.2.3 When the various costs and benefits are of different kinds the processes for putting the two into a common unit of measurement are called valuation methods. When the costs and benefits occur at different times the relative value of resources at different moments has to be taken into account by discounting.

1.3 Main stages of a cost-benefit analysis

1.3.1 To provide a framework for later discussion the main activities in a CBA are listed below (for an economic analysis).

- Define the decisions that are to be guided. When the analysis concerns a project it must be precisely defined which can usually best be done by defining its purpose and then the with-project and without-project situations.
- Define the group of people whose point of view is to be applied
- Decide the criteria and parameters such as:
    - Project life, or period to be used for analysis
    - Discount rate
    - Categories of benefits and costs (some things can be treated as either positive benefits or as negative costs)
    - Adjustments: shadow pricing, omission of transfer payments etc

- Calculate the economic benefits attributable solely to the decision or the project for each year of its life, ie the incremental benefit (the benefits of the with-project situation minus any benefits that would arise in the without-project situation).
- Calculate the economic costs:
    - Initial (capital) costs
    - Recurrent (annual) cost
    - Replacement costs, eg replace pumps in years 16, 31 etc; in each case incremental cost is the with-project cost minus without-project cost for each year of the project life.
- Formulate the net benefit stream
    - List the benefits and costs year by year for the whole analysis period
    - Calculate the net benefit (benefit minus cost) for each year
- Carry out the arithmetical economic analysis ie discount the benefit and cost (or net benefit) streams and calculate indicators
- Carry out sensitivity tests
- Assess other benefits or costs that have been excluded from the CBA
- Report the whole analysis.

2 QUANTIFYING AND VALUING COSTS AND BENEFITS

2.1 With- and without-project situations

2.1.1 The key to correct and complete identification of costs and benefits is the definition of the with- and without-project situations. These are projections into the future with all the usual difficulties and uncertainties of estimating and forecasting.

2.1.2 The without-project situation, sometimes equivalent to the do-nothing scenario, is not usually the same as a continuation of the present situation.

2.1.3 Part of the work of defining the with-project and without-project situation is to consider whether a project's outputs add to total production of the relevant goods, or substitute for (displace) goods that would have been produced or provided anyway. If the latter is true the effects on the other providers of the goods may need to be considered too.

2.1.4 CBA takes three forms according to the point of view being examined.

2.1.5 A person, a commercial organisation or a state organisation operating on quasi-commercial lines may be interested in the financial benefits compared with the financial cost – which comes from the budget they hold.

2.1.6 However, when deciding on national projects, the efficiency of resource use is more important than the financial impact on a particular organisation.

2.1.7 Where account is to be taken of achieving certain social goals, social CBA is employed. In this, some costs and/or benefits are given a weighting to increase or decrease their impact on the CBA calculations, in accordance with criteria established prior to the CBA. In summary:

Whose point of view	Type of analysis	Main criterion
Commercial organisation	Financial analysis	Money
Whole economy	Economic analysis	Efficiency
Region		
Nation		
'society'	Social analysis	Equity
Whole human race		

2.1.8 In an economic CBA any cost borne by a member of the nation should be included even if there is no money payment made, as in the case of family

labour, and also any benefit enjoyed for which nothing is paid. Since no money changes hands these items would not be included in a financial CBA.

2.2 Shadow pricing

2.2.1 In an economic CBA there may be costs and benefits to include that have no market and thus there is no financial price, while others may have prices which, because of say market distortions, do not reflect their true value to the defined group of people on whose behalf the project is being analysed. Special valuation techniques must be used, referred to as shadow pricing.

2.2.2 The usual method is to start with financial prices and apply a factor which converts a value in financial prices into a value in economic prices. The factor being the shadow price factor (SPF). The SPF may give a higher economic price or a lower economic price than the financial price.

2.2.3 When goods or services appearing in a CBA as costs or benefits are traded in a relatively free market with few distortions, the market prices are a relatively good guide to willingness to pay and are usually used in an economic CBA unchanged (SPF=1). When they are not so traded, the economic price can either be estimated directly by finding out what people would be willing to pay if there were an effective market, or by taking the distorted real market price and adjusting it by shadow pricing.

2.2.4 The opportunity cost of something is what we have to forego or give up in order to obtain it. For example, in a rural area the use of unskilled labour on road-building is related to its seasonal use in agriculture. At harvest-time the opportunity cost to the nation of using an unskilled labourer for a day on the road is the value of the forgone work he might have been doing in the fields, quite a high value. However, the loss of his normal activity in the quiet season to spend a day working on the road might be if little or no value. The SPF could then be adjusted seasonally from say 1 at peak times like harvest down to 0.3 for slack times.

3 RESOURCES AND TIME

3.1 Time preference

3.1.1 Humans have a time preference. When considering using resources or enjoying benefits, we are not indifferent to timing. Most of us prefer jam today to jam tomorrow.

3.1.2 A benefit in the future is valued less than a benefit now. Equally a future cost is of less concern than a cost borne now.

3.1.3 The cost or benefit now is called the Present Value (PV) and now is considered to be year zero. At some time in the future, year 'n' the same cost or benefit has a Future Value (FV), so that there is a stream of costs or benefits over time each with a different FV. The formula is:

3.1.4 $PV/FV_{Year\ n} = 1 / (1 + r)^n$ where 'r' is the time preference or discount rate

3.2 Discounting

3.2.1 Discounting is the arithmetical process of converting value statements referring to one moment in time to their equivalent value statements referring to another moment in time. Excel spreadsheet functions will do the calculation for you.

3.2.2 Discounting deals with the time value of resources or effects of any kind. Usually it is applied to money or to an economic or social value that is expressed in monetary units by some valuation technique. It can however be applied to anything whose value needs to be assessed at different times. For instance it is common to discount the annual volumes of water delivered by a water supply scheme so as to produce a discounted total volume which can be compared with a discounted total cost in a cost-effectiveness analysis.

3.2.3 The outcome of a CBA may depend on the choice of discount rate. This rate is not related to inflation rates; it is however related to the balance between consumption and saving/investment. Selecting a discount rate is therefore a specialised task; however, as the rate should only change slowly with time it is normally possibly to use a rate recommended by the national central bank (or equivalent organisation). On some internationally financed projects a specific discount rate will be required for the analysis.

3.3 Indicators and their calculation

3.3.1 Discounting can be used to calculate indicators which describe the relative merit or desirability of projects or options being studied. The most basic are the Net Present Value (NPV) and the benefit-cost ratio (B/C).

3.3.2 The starting point for both is to list the costs and the benefits by year and to discount both series. This gives the total discounted costs C and the total discounted benefits B. Then NPV is the difference between them, B – C, and the benefit-cost ratio is the ratio between them, B/C.

3.3.3 Discounted costs and benefits many years in the future become very small – especially at high discount rates. The length of time used should be the design life of the project, typically 25-30 years but sometimes 50 years or so.

3.3.4 The internal rate of return (IRR) is the discount rate at which the NPV is equal to zero and the B/C ratio is equal to one.

3.3.5 Because the NPV and B/C values depend on the discount rate it must e stated when they are quoted, eg 'the NPV is $10 million at a discount rate of 9%'.

3.4 Choice of indicator

3.4.1 If the analysis is to be used to decide whether or not to implement a certain project an indicator is normally compared with a pre-determined threshold value which determines whether a course of action is acceptable or not. This is normally a test discount rate.

3.4.2 To choose between projects that are mutually exclusive for technical reasons the criterion should be maximum NPV with an appropriate discount rate. Maximising any other indicator may lead to a wrong decision especially when the competing projects vary widely in size.

3.4.3 When ranking projects that are competing for a limited resource (usually funding) the B/C should be used, with the projects ranked in descending order of B/C ratios.

3.5 Sensitivity tests

3.5.1 Sensitivity tests are ideal for investigating and reporting on uncertainty due to the inherent difficulty of estimating and forecasting with limited information.

4 WORKED EXAMPLE

Calculation of Internal Rate of Return and Net Present Value ($ million)

Year	Without project (WO)			With project (WP)						Marginal values (WP - WO)	
	Agricultural benefits	Pump O&M	Total benefits	Capital	Drain O&M	Agricultural benefits	Downriver benefits	Total benefits	Net Benefit	Total costs	Total benefits
1	31.55	1.22	30.33	9.62		31.55		21.93	-8.40	8.40	0.00
2	34.37	1.22	33.15	13.39		34.37		20.98	-12.17	12.17	0.00
3	38.59	1.22	37.37	9.62	0.46	39.59		29.51	-7.86	8.86	1.01
4	41.40	1.22	40.18	9.62	0.46	43.51		33.43	-6.75	8.86	2.11
5	42.81	1.22	41.59	9.62	0.46	47.43		37.35	-4.24	8.86	4.62
6	44.22	0.83	43.39		1.57	51.35	1.03	50.81	7.41	0.75	8.16
7	45.63	0.83	44.80		1.57	60.50	1.03	59.95	15.15	0.75	15.90
8	45.65	0.83	44.82		1.57	61.42	1.03	60.87	16.05	0.75	16.80
9	45.67	0.83	44.84		1.57	62.34	1.03	61.79	16.95	0.75	17.69
10	45.69	0.83	44.86		1.57	63.26	1.03	62.71	17.85	0.75	18.59
11	45.71	0.83	44.88		1.57	64.17	1.03	63.63	18.74	0.75	19.49
16	45.82	0.83	44.99	4.81	1.57	68.77	1.03	63.41	18.42	5.56	23.97
17	45.84	0.83	45.01	4.81	1.57	69.69	1.03	64.33	19.32	5.56	24.87
18	45.86	0.83	45.03	4.81	1.57	70.60	1.03	65.25	20.21	5.56	25.77
19	45.88	0.83	45.05		1.57	71.52	1.03	70.97	25.92	0.75	26.67
30	45.95	0.83	45.12		1.57	74.28	1.03	73.73	28.61	0.75	29.36

Discount rate 10%.

Illustration of a series of sensitivity tests against the baseline (derived above).

			EIRR	NPV at 10%	B/C ratio	Total costs (NPV)	Total benefits (NPV)
Baseline case			**24%**	**75.3**	**2.64**	**45.85**	**121.12**
Switching value - capital costs	**+**	**167%**			**1.00**		
Switching value - net benefits	**-**	**62%**			**1.00**		
Switching value - with project benefits	**-**	**15%**			**1.00**		
Switching value - without project benefits	**+**	**19%**			**1.00**		
Sensitivity analysis		**Assume**					
Non saline soil crop yields	**-**	**50%**	**14%**	**11.8**	**1.26**		
Capital cost	**+**	**50%**	**17%**	**53.4**	**1.78**		
Capital cost	**-**	**50%**	**40%**	**98.7**	**5.25**		
Drain O&M cost	**+**	**100%**	**22%**	**66.2**	**2.19**		
No pump costs saved			**23%**	**74.7**	**2.58**		
No downriver benefits			**23%**	**70.2**	**2.53**		