Annex 1 (Reference Chapter 1) - Application of cost-benefit analysis to storage projects

Introduction

In this publication, it is not possible to provide a full description of the techniques of CostBenefit Analysis (CBA), for which purpose the reader is referred to suitable texts such as those by Gittinger (1982), Irwin (1978) or the Overseas Development Administration (1988).

CBA is used for choosing between different options, by comparing the net benefits of each option, that is the total benefits minus the total costs. To simplify calculations, only the differences in costs and benefits need to be compared. Indeed in many cases one is comparing projects which provide identical services and therefore benefits; in such cases it is only necessary to compare the difference in the costs between the options compared.

Before carrying out a CBA, it must first be decided whether the analysis is to be economic, i.e. from the point of view of the country as a whole, or financial, i.e. from the point of view of the individual operator, company or organisation which makes the investment. The economic analysis tells one whether the project is worth supporting as a matter of public policy; the financial analysis whether the project is sufficiently profitable to interest the operator(s) concerned. According to which type of analysis one is conducting different approaches are needed in the valuation of costs and benefits. Often one must analyse the project from both viewpoints.

In this Annex it will be shown how CBA was applied by the Natural Resources Institute in two cases, involving respectively large-scale and small-scale storage.

Application of CBA in a large-scale storage project; bag versus bulk handling in Pakistan

The reader is referred to Chapter 1 for the background and main findings of the study, which was carried out by Coulter (1991).

In this case an economic analysis was required, to determine whether public sector food handling agencies were justified in adopting bulk handling and storage. In order to measure the costs and benefits of different options the following factors had to be accounted for:

(i) Capital costs, including the cost of land, buildings, plant and machinery, and working capital with which to operate them. The decision to invest in a new technology involves committing capital and time which might otherwise have been used for other purposes. The income foregone is assigned a value, called the opportunity cost. The opportunity cost is valued at the return which the capital would have earned if invested in the most profitable alternative use.

While this concept of opportunity cost is attractive, in practice it can be difficult to quantify. Often economists use the cost of borrowing, and in economic analyses this is the cost to the country of obtaining international loans at commercial rates, net of expected inflation in the currency concerned (inflation is not a cost in real economic terms). Rates ranging from 5% to 12% have been applied in different studies. Conventionally major aid donors often use a 10% rate, and this practice was followed in the Pakistan case.

In order to compare technologies with different useful lives the fall in the value of the capital investment over time (its depreciation) must be accounted for. It is also necessary to account for variation in the capacity utilization of different technologies.

There are different ways of allowing for capital costs in CBA, but one of the most useful and that adopted in the Pakistan case was to express the capital costs in terms of the annualised cost of using the technology, given its initial cost and its useful life. This is done using an annuity factor, which takes account of both depreciation and the opportunity cost of capital tied up in the investment. It can be obtained from a standard table of annuity factors (e.g. Gittinger, 1982 p.435). It allows for a direct comparison of technologies with different initial costs and different life spans. The following example shows how this can be done.

A miller has an alternative of investing (a) 100,000 in plant and equipment with useful life of ten years, or (b) 120,000 in plant lasting 15 years. He expects to mill 20,000 tonnes of wheat per annum. His cost of capital is 15%.

The annuity factor for a ten year investment is 5.019, and for a fifteen year investment

The annualised cost of: investment (a) is 100,000/5.019 = 19,924 investment (b) is 120,000/5.847 = 20,523

The cost per tonne of wheat milled: for investment (a) = 19,924/20,000 = 1 00

for investment (b) = 20,523/20,000 = 1.03

Conclusion: The annualised cost of investment (b) is marginally higher.

(ii) Other fixed costs. Fixed costs are costs which do not vary with the level of utilization, and will be incurred each year even if the technology is not used. Capital costs are likely to be the most important fixed cost, and others include maintenance, supervision, security, rent, information systems, managerial overheads and so on. In practice it can be difficult to decide whether a particular cost, such as store management, is a fixed or a variable cost. Some costs, such as electricity from a national grid, can include both a fixed and a variable charge.

For large millers or Government corporations, who are able to invest in major storage structures and equipment, fixed costs are likely to be high. In the Pakistan case, it was found that capital costs and maintenance were the two most important cost factors to be considered when comparing long-term storage options. Indeed they were much more important than the cost of bags and labour (both of which are saved by mechanical handling), and the prospective reduction in storage losses.

(iii) Losses. Great care is needed in quantifying losses, avoiding heroic and unreliable estimates of the kind noted in Chapter 1. It is also important to compare like with like, e.g. an improved bulk system with an improved bag system, not an improved bulk system with a poorly managed bag system which exists at present. In some countries estimates of current levels of losses are available from survey data, but often there are no such data, in which case it may be advisable to test the CBA with different values, as described below under sensitivity analysis. When carrying out economic analyses, quantitative loss can be valued as follows: for a country which is a net importer of the grain concerned, it is the cost of restoring the loss through imports; in an exporting country, it is the net export revenue foregone. Qualitative losses can be valued as the difference between the realisable value of the stock in its original and deteriorated form. In financial analyses, the loss value is simply the net financial loss to the operator.

(iv) Other variable costs. Variable costs vary with usage of the technology. They depend on the amount of grain in store, the length of time of storage, the amount of grain which is handled or milled, and include losses (which we have discussed above), bags, handling labour, storage insecticide, fuel, electricity to operate equipment, and queuing costs. Care is needed in estimating the cost of bags in a particular operation, as they are generally reused, and when deteriorated, can be sold on to other users e.g. for carrying potatoes. The following approach is suggested: Bag costing 0.18, with resale value 0.06 Number of times handled before resale - 20 Cost per time handled -0.12/20 = 0.006 Handling required in storage operation - fill in field and load on truck, unload and stack at middleman's premises, unstack and load on truck, unload and stack at storage centre, unstack and loan on truck, unload and empty at mill. Total times handled = 6 times Cost of sack to operation = 6 x 0.006 = 0.036

A cost may also be attributed to the capital tied up in the bags, as in the case of a capital asset.

Queuing costs are the costs incurred by truckers who have to wait for their grain to be received and unloaded at a grain store, depot or mill. In comparing bag and bulk options they may be important, because bag handling systems may be characterised by long queues of trucks waiting for labour to unload them; mechanical handling may speed up handling and turn-around time, and allow the trucker or shipper to use his assets more economically.

In the Pakistan study, this saving was put forward as a reason for converting long-term storage facilities to bulk handling. In practice it was found that most of the queuing which characterised the existing bag-handling system was due to the official inadequate labour rates and systems for labour contracting. It was estimated that the queues could be cleared by doubling the rates. To allow for this, the study costed handling labour used in bag handling options at a shadow rate twice the value of rates actually paid. The practical impact of this change on overall grain handling and storage costs was minimal, indicating that the appropriate solution to the queuing problem was indeed better contracting systems and labour rates.

These different costs were estimated and added up for each scenario and each option considered, on a per tonne basis. The results obtained for one scenario, the building of brand new long-term storage facilities, are shown in Chapter 1, Table

1.1. The table allows a simple comparison of the cost per tonne for each option considered. Notwithstanding possible errors in some of the assumptions used in this analysis, the table illustrates the power of CBA in comparing alternatives.

Application of CBA to storage by small farmers

The reader is referred to Chapter 1 for the background and main findings of this study, which was carried out by Boxall and Bickersteth (1991). The objective of the exercise was to assess whether recommended changes in storage practices were profitable for farmers, that is to say the analysis was of a financial, not an economic kind.

A number of assumptions were made concerning capital costs, the opportunity cost of capital, labour costs, and the losses suffered under different technologies. It was assumed that all stores would be used to maximum capacity throughout their useful lives.

Decisions on an appropriate opportunity cost of capital are most difficult in this kind of analysis, as one has to ask: What is the opportunity cost of capital to the farmer? Is it (a) the cost of borrowing on informal markets, which may be as much as 10% per month? Is it (b) the cost of bank credit at between 27% and 33% per annum (less inflation which is not a true cost of capital)? Or should (c) a somewhat higher rate than this be used to provide a risk premium which the farmer needs to induce him to invest his own equity capital in the venture?

Faced with such decisions, economists generally use simple rules of thumb, and in this case the analyst used two alternative discount rates 10% and 20%. Net of inflation the range between these two rates reflect a compromise between criteria (b) and (c). However given the general scarcity of capital in rural areas of Africa the 20% rate is probably closer to the farmer's true opportunity cost of capital.

The results of the analysis are shown in Chapter 1 (Table 1.2) as a break even point, which shows, under each option, the price to which maize must rise for the farmer's investment to pay for itself.

Some other approaches to CBA

Both of the above cases involved comparing the costs of two technologies for carrying out the same activity. Revenue (or benefits) was not computed because it is the same for all options. In other cases one has to appraise the case for a new activity, involving consideration not only of the costs but also the revenue or benefits derived from the activity. Where grain is being stored longer than before the opportunity cost of capital tied up in this grain must be computed.

Often the benefits of increased storage of grain will not accrue to the operating company or marketing board concerned but will accrue to the country as a whole through increased production of crops in response to better producer prices. Here the increased output may be valued as benefits, while the cost of fertiliser, labour etc. to produce this extra output may be counted as costs.

In such cases the results are often appraised using a simple ratio of benefits to costs, the cost-benefit ratio, or by computing the pay-back period, the net present value (NPV) or the internal rate of return (IRR). Break even analysis can be used in other ways than that shown above, for example by measuring the amount of time a product has to remain in store for a particular technology to become profitable. One advantage of break even analysis is that it can be used in situations where there is doubt, or where a choice needs to be made, about the value of one particular variable.

Pitfalls and Limitations of CBA

(i) False assumptions in the calculation of costs and benefits

We have already mentioned the danger of inaccurate loss estimates. Another common way in which benefits can be overestimated is by assuming higher or more stable capacity utilization than in fact occurs. For example, the capacity utilization of a dryer will depend on the amount of rain at harvest. If sun drying is feasible it is generally more costeffective than using mechanical dryers, since no capital investment is required, although the labour requirements may be higher. In the case of new stores, capacity utilization depends on the size of harvest and market price at harvest, and may vary widely from year to year.

(ii) Data requirements

Cost-benefit analysis is quite demanding in terms of the data requirements. Even where the capital and variable costs of different options are relatively easy to obtain, it can be difficult to arrive at accurate estimates of the value of losses, or to find relevant price data for rural areas.

If estimates of losses are available, they are often expressed in terms which are difficult to convert to market values. Losses are commonly expressed in terms of percentage weight. loss, but the market value will also depend on losses in quality, and may depend on where the weight loss has occurred. Weight loss in the germ of grain kept for seed may mean a total loss if germination can no longer occur, while weight loss in the husk of grains which are subsequently milled may have little effect on the income obtained.

Even where data on past losses or prices are available these are not always a good guide to future events. This leads us to the third problem with CBA.

(iii) Dealing with uncertainty

There are a number of ways of accounting for the uncertainty of future benefits using CBA. One of the simplest is to do a sensitivity analysis. If a particular piece of data is uncertain, then the net benefits are calculated using different estimates for the unknown value and results are compared. For example, if losses under different systems are not known then different values for losses are used, to cover the range of likely possibilities. If there is little difference in the net benefits derived then the accuracy of the particular piece of data is not very important for selecting the preferred technology. But if small changes in the estimate lead to large changes in the net benefits then it is advisable to try to improve on the estimates before any recommendations concerning the technology are made.

Another method of dealing with uncertainty about future events is to use a pay-off matrix In this case the possibility of a range of future events is accounted for explicitly, and the outcomes of using the technology under each of the possible scenarios is calculated. It is then up to the potential user to assess the likelihood of any particular event occurring, and therefore, the risk involved in using a particular technology. If an estimate can be made of the probability of different events then the 'expected outcome' of each technology can be calculated.

An example of a pay-off matrix, using hypothetical figures for net benefits per ton of grain, using different drying technologies, is given below:

	Wet Harvest	Dry Harvest
Sun dry	$300	$1500
Mechanical dryer	$600	$ 600

In this example, a miller investing in a mechanical dryer would gain in a wet harvest but lose in a dry harvest, compared with the sun drying alternative, and assuming the same level of utilization in wet and dry years. The dryer is less profitable than sun drying in a dry year because of the higher capital costs. The lower net income from sun drying in a wet harvest results from higher losses or lower sale price for wetter grain.

In order to decide whether to invest in the dryer it is necessary to know how many years, over the life of the dryer, are likely to be wet years. If the dryer lasts 10 years, and the probability of a wet harvest is 30% in any one year then the calculation would be as follows:

(600 X 0.3)+(600 X 0.7) = $600

and for sun drying: (300 X 0.3) + (1500 X 0.7) = $1,140

Pay off matrices are particularly good for tailoring decision making, or recommendations regarding different technologies, to individual circumstances. Each individual can assess the probabilities of different events, and the level of risk they are prepared to take. For example, the miller might have a minimum income requirement of at least $500 dollars in any one year in order to repay debts. In this case a technology which offers high pay off in good years, but gives an income of less than $500 in bad years will be rejected.

(iv) Failure to predict farmer behaviour

It is commonly found that technologies which do well on CBA are nevertheless not taken up by farmers.

An important reason is that the costs and benefits used in the calculation often do not reflect the actual costs incurred by the user, or the benefits which are available to the user (Compton, 1992). For example, the cost of local materials may be undervalued. Even where wood, mud and other materials are not

marketed, they may be in short supply, or there may be local systems of ownership and distribution which impose scarcity or some kind of cost on the user. Families may value unpaid labour at less than the opportunity cost assumed by the analyst.

Benefits in terms of technical improvements will only be enjoyed as benefits if they are reflected in market prices. For example, increased milling yields or reduced mycotoxin levels from dryers will be of no benefit to farmers until these factors are reflected in the prices they receive.

Incentives to adopt new technologies also depend on who will bear the costs and who will enjoy the benefits. For example, if women are required to shell maize for storage, while men gain from the increased income, there may be disagreements within the farm household as to the desirability of the new storage methods (Compton 1992).

Clearly, a good understanding of the local economy, farming system, storage practices and division of labour are required if the results of CBA are to be useful in predicting the uptake of different technologies.

Another problem with CBA is that it often doesn't reflect the farmer's reasoning process. Small farmers make choices about farm investments with incomplete knowledge of future events. They are often 'risk-averse' and therefore choose options with steady average returns even when these are low compared with the potential gain from risky alternatives. The risks involved in adopting the same technology may be very different for a small farmer for whom grain crops provide the main source of income than for a wealthy farmer, who has other sources of income and can afford to incur losses on grain cultivation from time to time.

Potential users generally have a very wide range of criteria for selecting different technologies which cannot be adequately represented in a CBA, including such factors as the taste of the consumed product, the avoidance of neighbours' jealousy, or theft, or the ease of removing grain from a store. However due account of these phenomena can be taken by carrying out a proper demand assessment, using the approaches outlined earlier.

References

Boxall R.A. and Bickersteth J.S. (1991). Liberalisation of cereals marketing in Sub-Saharan Africa: Implementation Issues. Report-no. 3: Ghana - a Case Study. Chatham: NRI.

Compton, J.A.F. (1992). Reducing Losses in Small Farm Grain Storage in the Tropics. Chatham: NRI.

Gittinger J.P. (1982). Economic Analysis of Agricultural Projects. Baltimore: John Hopkins University Press, 505 pp.

Irwin, G. (1978). Modern Cost-Benefit methods. Basingstoke, UK: Macmillan Publishers Ltd., 257 pp.

Overseas Development Administration (1988). Appraisal of Projects in Developing Countries; a Guide for Economists. London: Her Majesty's Stationery Office, 238 pp.

Annex 2 (Reference Chapter 5) - Organizations involved in research on biomass residue combustion

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Annex 3 (Reference Chapter 4) - Example of calculating the costs of operating processing machinery

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This example is given only to indicate how the calculations are carried out. It cannot be transposed as such to concrete case studies. Assuming that:

a farmers' organization has purchased a rice thresher through a local agricultural credit office;

they plan to work on their own farms, but also possibly for farmers out of the

organization;

they need to determine the operating cost of the machine.

(i) Assumptiom

Purchase conditions in Fcfa

- Purchase price 1,600,000

including the price of the machine,

commissioning costs, cost of the loan, etc.

- Personal contribution 320,000

- Bank loan: * amount 1,280,000

*** annual rate of interest 15%**

*** maturity 5 years**

*** constant annuities 381,844**

TOTAL INTEREST 629,220

The machine has not been insured and no shelter has been specially built for it.

Technical Specifications

- Diesel engine horsepower 8hp

- Fuel cost 210 Fcfa/l

- Lubricant mean cost 800 Fcfa/l

- Output per hour 500kg

- 2 operators 3,000 Fcfa

The other workers required for feeding the machine, bagging and winnowing operations are paid by the customer.

- Repair costs over the useful life, i.e. 0.5 as coefficient 800,000 Fcfa

- Useful life 5 years

- Working time per day 6 hours

For a labour presence of 8 hours (maintenance and transport of the machine from stock to stock)

- Paddy mean yield St per ha

- Sundries: machine transport, bags, etc... 2,000 Fcfa/day Because custom services are paid a percentage of the crop, marketing costs are included.

(ii) Annual performances

- Work time * in days 110 per year

*** in hours 660 per year**

- Fuel consumption: 0.121/hp/h x 8 hp x 660 hr/year 6341 per year

(iii) Annual costs

Fixed costs

The interest rate of the bank is applied to the personal contribution (i.e. 320,000 Fcfa actually paid by the purchaser), the remaining sum being borrowed.

When refunding a loan with constant annuities, interest amounts decrease each year. To make the calculation easier, 1/5th of interest is used here as annual financial charges.

As the annual use (fur) is lower than the ratio of the useful life in hours (Hr) to years of depreciation (N), amortization is considered as a fixed cost(A): A = Purchase price/N

- Interest on capital: 320,000 x 15 / 2 24,000 Fcfa

- Amortization: 1,600,000 / 5 320,000 Fcfa

- Financial charges: 630,000 / 5 126,000 Fcfa

TOTAL FIXED COSTS 470,000 Fcfa

Variable costs

- Fuels: 634 L x 210 Fcfa/L 133,140 Fcfa

- Lubricants: 634 L x 2,5 x 800 Fcfa/L/100 12,700 Fcfa

- Repairs: 1,600,000 x 0,7 x 660 hr/year x 5 years / 3500 hr = 105,600 Fcfa

- Labour cost: 3,000 Fcfa/d x 110 d/year 330,000 Fcfa

- Sundries: 2,000 Fcfa/d x 110 d/year 220,000 Fcfa

TOTAL VARIABLE COSTS 801,440 Fcfa

That is a gross total of 1,271,440 Fcfa per year, or 1,896 Fcfa per hour. For an efficiency of 5000kg per ha, the operating cost can therefore be estimated at 18,960 Fcfa per ha.

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Annex 4 (Reference Chapter 6) - Fumigable warehouses

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Conventional and traditional warehouses have frequently been fumigated, either by sealing gaps in the structure (Webley and Harris, 1979)' or by enveloping the entire building under gas-proof sheeting. However, such operations are never simple and are often fraught with difficulties. Bulk grain storage facilities are usually constructed with fumigation in mind and, unless they are structurally faulty, are sufficiently gas-tight for this purpose.

The fumigable warehouse briefly described here was developed in the sahelian zone of west Africa (Hayward, 1981), and is intended for long-term storage of reserve stocks of grain.

Much of what is written in Chapter 6 about the location, design and determination of size of standard warehouses applies equally to fumigable warehouses. Only the differences relating to sealing of the warehouses are highlighted in this Annex.

Walls: Constructed of hollow concrete blocks, these are rendered smooth with cement plaster and then covered on the inside with a special plastic paint.

Roof: The spaces between the aluminium roof sheets and the girders along the tops of the side walls are plugged with shaped wood pieces soaked with wood preservative and bitumen. A liberal coating of bitumen is then painted on and around the plugs.

Ventilators: These are fitted externally with tight fitting flanged metal covers, which can be locked and sealed with gas-proof sealing tape.

Doors: The hinged metal doors are tight-fitting, and have flanges overlapping the frame set in the wall so that the gap all round is not greater than 2 mm. When the doors are closed for a fumigation this gap is closed completely with gas-proof sealing tape.

Annex 5 - GASGA Members

GASGA Members

GASGA Members (continued)

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