NOTES ON THE APPLICATION OF COST-BENEFIT ANALYSIS IN EVALUATING IMPACT FROM RESEARCH

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Prepared for Interagency
Workshop on Evaluation Methodology for Assessment
of Effects and Impact

IFAD, Rome

17-19 June 1985

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INTRODUCTION

The increased production and consumption of small grains, such as sorghum and millet, which are well adapted to the drier parts of the tropics, can help to alleviate food problems in those areas. The difficulty of dehulling these grains before grinding them into flour can be a bottleneck in the production-consumption process. In many parts of Africa, the traditional process of food preparation involves a series of stages : wetting the grain to soften and loosen the hulls, pounding with a wooden mortar and pestel to remove the hulls; drying, winnowing, and pounding the dehulled grains into flour. This job is usually done by women and children and can take several hours a day. With sorghum and millet, consumers are much less ready to eat flour made from grinding the entire grain, including the hull, than they are for maize. Hence a dehulling device is needed - if the process is to be mechanized - to relieve women and children of hard drudgery and to increase the consumption potential of sorghums and millets.

Beginning in 1971, the International Development Research Centre (IDRC) of Canada supported several small research projects on the dehulling and milling of small grains. These were mostly carried out in Africa, with a smaller number in Canada. From 1975 onwards, the IDRC supported research in Botswana through a local institution, the Rural Industries Innovation Centre (RIIC). In essence, the RIIC redesigned, developed and tested a scaled-down version of a dehuller that had been developed in earlier projects, mainly in Canada and Nigeria. By 1981, seventeen units were in commercial operation as part of grain-milling businesses in Botswana. The system established consisted of a dehuller that could operate on a batch or a continuous-flow basis; a fan and

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The views expressed in the paper are those of the author and not of IDRC.

cyclone for collecting the bran; a hammermill; and a water-cooled diesel engine to drive both machines. The systems either operated on a commercial or on a service basis, or both. Commercial operation involved purchase of grain by the mill and sale of the milled products. With a service operation, customers had their own sorghum milled in a batch, taking away the flour and bran and paying for the milling service. A consumer preference survey indicated that most rural people in Botswana - about three-quarters of the population - preferred to eat flour from sorghum which they grew themselves. The development of a batch service system thus became an aim of the RIIC research effort.

DEVELOPMENT IMPACT STUDY

In 1981, it was decided to conduct a short study of the Botswana case. The study* was of modest proportions, consisting of file review, interview of program staff, and four days in Botswana interviewing and collecting data from six of the mills.

Purpose

There were three main purposes:

(1) the need to document development effects arising from research work supported by IDRC;

(2) an experimental purpose - how to do this? how to try to measure "development"?

(3) a planning purpose - if it could be judged that there had been net social gains, could key ingredients be identified that would increase the chances of similar outcomes elsewhere?

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* Sorghum Milling in Botswana : A Development Impact Case Study. J. Hardie, Office of Planning and Evaluation, IDRC. January, 1982.

Type

It was an ex-post study as far as IDRC-support was concerned, although subsequently a small "trouble-shooting" project was funded.

By whom, for whom

It was carried out by a staff member of the Office of Planning and Evaluation in IDRC. The study was primarily for IDRC.

Beneficiaries

The primary beneficiaries of the original project were considered to be the **women and children** who were relieved of the daily necessity to spend several hours wetting, hand pounding, winnowing, drying and pounding grain (mostly sorghum).

Mill owners and their **employees** were also potential beneficiaries.

The **Botswana economy** as a whole also stood to gain, if certain conditions were fulfilled.

Potential **losers** should be mentioned here. They could include those whose livelihood was connected with providing the dehulling/milling service by traditional means, and those involved in the retail chain for competing products, such as imported maize flour. Such evidence as existed indicated that these effects were not significant and they were excluded from subsequent analysis.

Description of Study

The study was unplanned in the sense that it was not envisaged at the time of development of the dehuller research activity. There was no baseline survey done of any target group "before" or "without" the intervention. However a survey was carried out by RIIC itself in 1981 of the impact of the mills in four rural communities in Botswana.*

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* The Impact of Sorghum Mills on Four Rural Communities in Botswana. D. Narayan-Parker, RIIC, 1981.

The survey indicated that women spent about 2½ hours per day on food processing activities which were relieved by the milling service (103 out of 143 respondents). In addition, about 2 hours per day of childrens' labour was saved. To obtain a net saving, the time spent using the milling service had to be deducted. This was estimated at about 3½ hours per week or ½ hour per day average, giving a net saving of 4 hours per day per household.

The survey also provided some information on how this new found time was used. One way of estimating the benefits of service milling would be to put values on the different activities undertaken with the time saved. Empirical evidence to measure this would be extremely difficult to obtain and, it can be argued, is neither necessary nor desirable. The consumer is the best judge of the value of a good or service and this value can be measured by the consumer's **willingness to pay** (wtp). In this case the consumers had been willing to pay the going rate for the service itself (3t to 5t* per Kg of grain); transportation costs to and from the mill; and the cost of their time travelling to and waiting at the mill. It was therefore assumed that consumers valued their labour as worth at least the sum of those costs, otherwise they would have continued hand processing. Hence, at the level of the primary beneficiaries, the study concluded that in 1983 the equivalent of 15,000 families in the country would be realizing labour savings and valuing them highly enough to continue to pay the service milling costs.

The study did not examine closely the benefits accruing to mill owners, operators and employees. There were, however, strong indications of net positive benefits : the private owners interviewed expressed satisfaction with their investment; demand for the service was high; financial analysis suggested a reasonable return to capital and management; and a service mill provided about 3 jobs, excluding the owner/operator.

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* Botswana currency 1.0 Pula = 100 thebe (t), equivalent to CAD 1.41 in 1981.

With respect to the benefits to the Botswana economy as a whole, the study employed the principles of social cost-benefit analysis. A standard service mill unit was analysed using the actual rates of throughput and operating parameters being achieved. Benefits were valued in two components:

(a) the consumers' willingness to pay for the service;

(b) the better extraction of the mill as opposed to the traditional method.

It was argued that the grain processed by the mill would otherwise have been processed by hand. As argued above, the labour spent in this way was valued at least at 3 t per kg, since that was the price people were paying to avoid the traditional method. Also, there was less wastage with the mechanical system. Leaving aside spoilage from the wetting and drying involved in the hand method, the best estimate was for 0.70 kg of flour per 1.0 kg of grain from hand processing. The dehuller and hammer-mill were achieving average rates of 0.80 kg of flour per 1.0 kg of grain. Thus the consumer was also benefitting from an increased supply of food from the same amount of grain. With these assumptions, a service unit showed an Internal Rate of Return of 30 percent, and a Net Present Value at 12% of 27,000 Pula.

A standard commercially operated unit was also analysed and, finally, the aggregate effect of the total development to date was assessed, counting in the costs of the R&D effort in Botswana, promotion, administration, technical back-stopping and so on. Inevitably, some heroic assumptions and estimates had to be made in projecting these costs; however any tendency to underestimate was offset by confining the projection of benefits to those flowing from the 17 mills established and operating as of January, 1982. [Subsequently, 13 additional units have been set up, thus reducing the overall per unit "overhead" of administrative and technical costs.] The aggregate analysis indicated a Rate of Return of 20% and a Net Present Value of 725,000 Pula (at 12% discount). These results are summarized in Table 1.

Table 1 : COST-BENEFIT ANALYSIS RESULTS

	Internal Rate of Return	Net Present Value (12%)
		(Pula)*
Basic Assumptions[1]		
Service Mill Unit	30%	24,000
Commercial Mill Unit	26%	34,000
Sensitivity Analysis : shadow foreign exchange rate 1.25		
Service Mill Unit	18%	8,000
Commercial Mill Unit: local grain	79%	199,000
: imported grain	40%	85,000
Overall Analysis[2]		
Sorghum Milling R&D in Botswana	20%	725,000

* Botswana currency 1.0 Pula (= 100 thebe) = CAD 1.4 (1981).

1 Assuming that market prices equal economic values.
Capital Costs : Service mill unit 28,000 Pula (CAD 39,500)
Commercial mill unit 49,000 Pula (CAD 69,000)

2 Using the basic assumptions as in [1]; excluding R&D costs incurred outside Botswana; and only counting the 17 units installed up to 1981.

As Table 1 indicates, some sensitivity analyses were conducted for service and commercial units to test the results against the different foreign exchange implications of the two modes of operation. Service milling involved substituting a service that had **some** foreign exchange costs (machine-processing), for one that had **none** (hand-processing). However, in the absence of commercial milling, the only available flour at retail outlets was imported. Hence commercial operation involved substituting a product with **some** foreign exchange costs (flour from locally milled grain) for one with **100 percent** foreign exchange content (imported flour). Therefore, depending on the weight that Botswana wanted to place on reducing dependence on imports (saving foreign exchange), commercial milling had potential to play a more important role than service milling. Using a shadow foreign exchange rate of 1.25, showed commercial milling of either local or imported grain to be more beneficial to Botswana than service milling.

The study concluded with an attempt to itemize the determining factors of the process that had been analyzed and found to have a generally positive effect. No specific methodology was followed. Material and conclusions were drawn from all parts of the study and from observation and discussion. The planning purpose - in the sense of helping to replicate a similar positive experience elsewhere - could only be properly met by trying to identify the "key ingredients". In summary these were itemized as follows:

- the ground was fertile for the technology in that there was a **"demand pull"** in several respects:
  - the government was committed and supportive;
  - consumers had a strong preference for local sorghum flour;
  - women wanted an alternative to hand dehulling;
- conducive **policy steps** had been taken:
  - the producer price for sorghum was set high enough to encourage local production;
  - marketing and storage infrastructure was set up;
  - restrictions were placed on competing imports;
- adequate **technical capacity** was available, a significant part of which came from expatriate assistance, sustained over a number of years.
- the same **institution** (RIIC):
  - had the requisite capacity to research, field test **and produce** the dehuller;
  - had benefitted from long-term core support* enabling it to provide training, technical, marketing and administrative back-up to these activities;
  - had strong government links serving to maintain the focus of its efforts on areas of government concern.

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* The Friedrich Ebert Foundation provided core support for RIIC over a long period.

CRITIQUE AND CONCLUSIONS

A number of years have elapsed since the study was carried out. Apart from the standard emotion of dissatisfaction with the work, this brief review, together with further accumulated experience from other studies, has served to stimulate some thoughts on the application of cost-benefit analysis to assessing impacts arising from research.

1. Using cost-benefit analysis entails constructing models of "production functions", i.e. it necessitates a comprehensive understanding of what has happened and why.* What resources have been employed to produce the outputs and effects that are being counted as benefits? Also required is an understanding of the situation that would have prevailed if the project had not been implemented : the "without" project model. Only then can one derive a net benefit stream from valuation of the extra benefits that have been produced by implementing the project, and from valuation of the extra resources needed to obtain those extra benefits, both calculated from the difference between the "with" and "without" project models. The construction of "production function" models helps to derive a better understanding of the determining factors, at least in terms of resources. This is a useful first step in comprehending what makes for successful development, but it is limited. As the above case study illustrates, the institutional, political, policy and other factors that lie behind the provision and control of resources are as important to consider as the resources themselves. However, given that social cost-benefit analysis attempts to be comprehensive, it does provide a useful framework for systematic consideration of causal factors.

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* The term "production function" is used here in a very general sense using the same basic principles relating resources and products as employed in economics, without any pretensions to mathematical rigour. This paper looks at cost-benefit analysis applied ***ex post*** : what **has** happened? **Ex ante** cost-benefit analysis involves attempting to estimate what **will** happen and why.

2. Following the identification and quantification of costs and benefits, the next stage is valuation. This is really the distinguishing feature of the method, since it obliges detailed consideration of the costs and benefits to society as a whole, as opposed to private, monetary gains and losses. In so doing a more thorough understanding of "impact" is possible. This is not to imply that it will provide the definitive answer, (the practical application of the technique tends to lead the practititioner to the conclusion that unequivocal answers are rare in the measurement of social and economic progress). However it does help in putting the right questions, and proposing a set of conditional responses. To take the above case of the dehuller, the analysis concluded that if the alleviation of domestic drudgery for Botswana women is the primary goal, or - to express it in economic terms - if the opportunity cost of the labour of rural women and children is not zero and if the women are the best judges of what that value actually is, then the introduction of mechanical processing has resulted in net social gains. If however, saving foreign exchange is the primary goal and saving rural womens' labour has no weight, (or - again in economic terms - if the shadow price of the imported resources for mechanical milling is higher than the market price, and the shadow price of labour is set at zero) then the impact of service milling would be negative. It is argued that such conclusions are more valuable and responsible than those which attempt to claim a simple, unique answer to the question - has there been "impact"?

3. The final stage of cost-benefit analysis is calculating the choice criteria: rate of return and/or net present value. This is a simple arithmetic process and is insignificant in importance compared to the earlier stages. The calculation of a range of values to test the sensitivity of the analysis to changes in assumptions can be facilitated by having a computer do the arithmetic. However the calculations are of little value unless

the data collection for the construction of the "production functions", and the valuation of cost and benefits have been done thoroughly and conscientiously. There are few shortcuts in the effective application of this methodology.

4. Finally it can be argued that the **ex post** justification of past actions is a relatively weak rationale for impact evaluation, and can verge on the self-indulgent. The time and energy involved only really bear fruit if the results of the studies improve future decision-making, although it must be said that demonstration of impact has a role to play in maintaining the flow of resources to worthwhile endeavours. One of the pioneers of the application of cost-benefit analysis to the evaluation of agricultural research, Z. Griliches, has remarked:

> "What is the point of calculating the rate of return on one of the outstanding technological successes of the century (hybrid corn)? Obviously it will be high. What we would like to have is an estimate that would also include the cost of all the "dry holes" that were drilled before hybrid corn was struck."

This comment comes at the end of one of the seminal papers* on this subject and is not often quoted. This is unfortunate, since much of the subsequent literature is devoted to studies of marginal rates of return to agricultural research, as opposed to average rates, which would include the cost of the "dry holes". Such work has a role in supporting the notion that research is a good investment. However this is not especially helpful to research planning and management. Thus two points could be made in conclusion. One, given a limited supply of resources for **ex ante** research planning and evaluation, and for **ex post**

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* "Research Cost and Social Returns : Hybrid Corn and Related Innovations" Z. Griliches. Journal of Political Economy. Vol.66. 1958.

evaluation, the balance should be in favour of the former. Research can be likened to acupuncture : compared to the vast body of opportunities and problems, the resource needle of research is minute. Better to spend more time making sure the needle is stuck in the right place, and only analyse the results to the extent that it will improve the probabilities of getting it right the next time. Two, using cost-benefit analysis in impact assessment is very valuable for planning future options for the project or program under scrutiny; it is also of value in identifying and weighting the key ingredients and therefore for planning the successful replication of the project elsewhere; and it is of very limited value for research planning, in terms of providing choice criteria for resource allocation to different lines of research.

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