MEASURING DEVELOPMENT EFFECTS
OF
AGRICULTURAL RESEARCH IN THE THIRD WORLD:
CASE STUDY METHODOLOGIES

by

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

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INTRODUCTION

Agricultural researchers are more fortunate than scientists working in more esoteric areas of investigation. In terms of their contribution to the public good, agriculturalists can relatively easily show direct links between their efforts and goods and services that are essential to life. One category of researchers, mostly agricultural economists, tries to go further and to justify agricultural research through its contribution to development. Even in the poorest countries of the world, in which the absolute lack of food of adequate quality is most evident, economists are concerned about the variation in returns from different avenues of agricultural research. Returns are measured by indicators chosen to reflect some appropriate measure of development. The studies are often justified by two reasonable propositions. One, it is necessary to demonstrate a good pay-off to agricultural research in order to give some account of what has been spent and to attract sustained and possibly increased investment, particularly from the public sector. Two, with inadequate resources to do all the things that need to be done, it is important to develop criteria in order to be able to choose the best set of activities. Unfortunately, the immediate products of agricultural research are not marketable in a common currency. The work of the plant pathologist cannot be easily expressed in money terms and compared with that of the animal breeder. It is therefore necessary to go further down the line and to try to measure their
work in terms of its contribution to development. These speculative calculations can then help to improve agricultural research investment decisions.

Another valid reason for studying the development effects arising from research is derived from curiosity, the core of scientific enquiry. More specifically, any researcher thinking about the link between his or her work and development will also be curious about how to operate in such a way as to maximize the probability of useful outcomes in developmental terms. Similarly, managers and decision-makers at national and international levels wish to improve their understanding of the agricultural "research for development" (R for D) process in order to extract the greatest benefit from current and future investments.

Whatever the reasoning behind these studies, there are certain inescapable aspects of the R for D process that influence strongly the choice of methodology used for them, the validity of results and their overall cost-effectiveness. These aspects of the process are not new, but seem sometimes to be overlooked in discussion of the benefits from agricultural research. The diagram in Figure 1 is used as a simple framework to present them.
Figure 1: The "research for development" (R for D) process.
(a) The conduct of research produces a variety of outputs

The lower segment of Figure 1 encompasses the use of research resources to produce output. The agricultural research output most commonly considered is probably the improved crop variety – a tangible item of biological technology. Also common are items of hardware used in the production or post-production processes, such as seeders or crop driers. Of course any item of biological technology or hardware is useless without the associated "soft" knowledge of how and in what conditions to use it. Another legitimate research output is purely soft knowledge: either about how to do something with existing technology, e.g. knowledge about time of planting and plant spacing for optimum yield; or about the probable effects of a policy change (pricing or credit) on development objectives. The conduct of agricultural research can also produce knowledge about more effective methodologies and approaches to research; and it often produces better qualified human resources, either through formal or on-the-job training. These outputs can be considered to be intermediate goods on the road to the production of useful biological technology, hardware and soft knowledge. However, they are sometimes introduced to discussions of research "impacts" when those discussions are intended to focus on the development effects arising from the adoption of knowledge outputs. This paper will confine itself to "impacts" in the sense of development effects, without denying the
importance of intermediate research outputs such as better research methods or trained people.

(b) The zone of influence of research is smaller than the zone of concern.

Figure 1 is an over-simplification of a process that involves many more steps in between the use of resources to produce outputs and the use of those outputs to contribute to development effects. As just noted, a research activity can lead to an improved methodology, which in turn can generate useful knowledge. If the knowledge is in the form of an improved crop variety, it may be considered as the final output of the research process. Following this, there are the complexities of moving from breeder's to foundation to certified seed and getting the technology into the hands of the growers. At some point along the line, (and the point may vary, hence the frontier is hazy) the process moves beyond the influence of the formal research community. Although, as indicated by the diagram, the entire R for D process is the zone of concern of researchers, their zone of influence is more limited. Thus researchers feel pressure to justify their work in terms of development, without having any influence over many of the factors that cause it to happen.
(c) The R for D process is uncertain.

Research is by definition concerned with seeking, with exploring the uncertain. The objective may be to produce resistance to a specific disease or pest, but the attempt may fail, or it may take a lot longer than expected. Thus the probabilities attached to the use of research resources for the production of specified outputs are less than one. Also, the process of disseminating the output in its original form to the target users and beneficiaries carries its share of constraints and uncertainty. Finally, use of the research output to produce an overall net positive effect on development, including the desired equity goals, is less certain still. Regardless of the relative sizes of the sequential probabilities, their cumulative effect is such that the chances of any discrete set of research resources, allocated to a specific objective, ultimately leading to a net development gain (assuming that this could be measured and proven) can be quite small.

(d) Agricultural research alone does not cause development.

Another implication of the fact that the zone of influence of research is smaller than its zone of concern is the need for other factors and knowledge to be applied in conjunction with the research output in order for a development effect to be realised. The use of the research output by those for whom it was intended may be a necessary condition, but it is not sufficient. Taking the example of purely "soft" knowledge, let it be assumed that a significant number
of producers are persuaded to adopt time of planting and crop density recommendations. Neither they (nor perhaps consumers) will benefit unless the marketing systems and price structures for the extra production are in place and appropriate. This feature of the R for D process gives rise to the most common and serious difficulties with studies on research "impact": those of establishing cause and effect, and of attributing benefits among the various possible contributing factors. Assuming that an increase in producer income has been quantified, was it caused by price, climate, better seed, better management, or luck? Which portion of the extra income can be attributed to better seed as opposed to a "better" pricing policy, both of which may be the products of agricultural research?

Some Case Study Experience

Against the background of these realities of the R for D process, the experience of the International Development Research Centre (IDRC) of Canada with eight "impact" studies is examined. The studies do not constitute a set: they are not uniform with respect to timing or approach. They do not claim to be case studies in the stricter sense of the term and the lessons that can be drawn are therefore more anecdotal than analytical. The features of the studies that are most relevant to the theme of this paper are summarized in Table 1.
### TABLE 1: MAIN FEATURES OF STUDIES OF DEVELOPMENT EFFECTS ARISING FROM AGRICULTURAL RESEARCH PROJECTS IN THE THIRD WORLD

<table>
<thead>
<tr>
<th>PROJECT</th>
<th>AQUACULTURE (INDIA)</th>
<th>CROPPING SYSTEMS (INDONESIA)</th>
<th>FUELWOOD (MALAWI)</th>
<th>SEED POTATO STORAGE (PERU)</th>
<th>ANIMAL PROD. SYSTEMS (C. AMERICA)</th>
<th>SWEET POTATOES (PHILIPPINES)</th>
<th>BY-PRODUCTS (BALI)</th>
<th>SORGHUM (BOTSWANA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Research</td>
<td>experimental development</td>
<td>cropping systems</td>
<td>experimental <strong>former-back-to</strong></td>
<td>farming systems</td>
<td>crop breeding</td>
<td>applied</td>
<td>experimental development</td>
<td></td>
</tr>
<tr>
<td>Cost* (CAD'000)</td>
<td>324</td>
<td>516</td>
<td>203</td>
<td>300</td>
<td>967</td>
<td>450</td>
<td>150</td>
<td>205</td>
</tr>
<tr>
<td>Study Method</td>
<td>national consultants team (9)</td>
<td>national and expatriate consultants</td>
<td>CIP** researchers</td>
<td>national consultant</td>
<td>national project team</td>
<td>national consultants</td>
<td>national project team</td>
<td>IDRC staff member</td>
</tr>
<tr>
<td>Survey of producers</td>
<td>secondary survey</td>
<td>farm survey of trial sites</td>
<td>farmer survey</td>
<td>secondary survey of farm visits</td>
<td>secondary survey of farmers' trials</td>
<td>field survey by sample</td>
<td>field survey by sample</td>
<td>field survey by sample</td>
</tr>
<tr>
<td>Methodology</td>
<td>1. Appropriate indicators</td>
<td>yields, area in production, total output</td>
<td>area in production, total output</td>
<td>growth in woodlots, establishment</td>
<td>number of adopters, herd size, total milk output</td>
<td>number of adopters, area planted, consumer price</td>
<td>number of adopters, tons of grain milled</td>
<td>number of adopters, tons of grain milled</td>
</tr>
<tr>
<td></td>
<td>Before/After</td>
<td>+</td>
<td>+</td>
<td></td>
<td>+</td>
<td></td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>2. Cost and Returns</td>
<td>net incomes, traditional/ improved</td>
<td>sales benefits</td>
<td>as seen by farmers</td>
<td>farm models, benefits</td>
<td>as seen by farmers</td>
<td>net incomes, traditional/ improved</td>
<td>rate of return for model</td>
<td></td>
</tr>
<tr>
<td></td>
<td>WITH/WITHOUT</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>3. Cost-Benefit Analysis</td>
<td><strong>macro analysis including research costs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* IDRC contribution only. ** Spanish acronym for "International Potato Centre".
The research investments that were the subjects of scrutiny were all projects carried out by research institutions in developing countries. They were "projects" in the sense of aiming at specific objectives for a limited time period, usually one or two phases of about 3 years each. However this does not mean that they did not follow on from and fit into broader research programs. This is reflected by the fact that the principal researchers were all permanent staff members of the institutions and not brought in from the outside. However, the research investments were relatively small, ranging from CAD 150,000 to CAD 900,000 in terms of the IDRC contribution, and the follow-up studies were correspondingly "micro" : once-off, short duration exercises costing between CAD 5,000 to 10,000.

The distinction is made between the "study method" and the "methodology". The former term refers to the general approach taken - who conducted the studies, their short duration, their reliance on secondary data, supplemented by rapid field surveys; the latter refers more narrowly to the indicators chosen and the analytical techniques used. The two are intimately related, but are addressed separately.

The experience with these small studies is reviewed with respect to three possible broad purposes for doing them:
(i) in order to account for money spent and to provide evidence that research is a desirable investment, thereby attracting future financing
   - referred to as the funding purpose;

(ii) in order to be able to compare the relative pay-off to different lines of research, thereby assisting with resource allocation choices
    - referred to as the planning purpose;

(iii) in order to improve understanding of the R for D process, thereby contributing to the greater effectiveness of current research programs and projects or their future replicates
     - referred to as the management purpose.

**Study Methods**

For the most part the studies shared both the funding and the management purposes: all of them set out to demonstrate some form of development pay-off, and most of them attempted to analyse the process and the determinants of those benefits. The main features of the studies to emphasize are (a) the use of national evaluators and (b) of what might be described as rapid development assessment techniques. Consistent with the IDRC's belief in the importance of
indigenous research capacity, six of the studies were conducted by researchers from the countries or regions concerned. All of them involved simply following up a number of years after project completion to find out and measure what had happened in development terms, and to describe how it had happened. Depending on the circumstances and the availability of information, data was collected by a variety of means, including sample surveys, questionnaire interviews, and field visits.

(a) National Evaluators
There are a number of advantages to this approach. It is cheaper than sending out Canadian consultants: remuneration rates are lower and travel costs are considerably reduced. [N.B. It is easier to secure this advantage if the organization is decentralized, so that locally-based staff can help with the selection and recruitment of local consultants.] The investigations, especially any field surveys and interviews, are more likely to be sensitive to cultural factors that otherwise might inhibit the collection of information, or might need to be taken into account in interpreting what is provided. Clearly language is an important part of this feature. The study of the spread of improved sweet potato varieties in the Philippines was carried out by interviewing selected key informants, including 11 storage project cooperators and 23 growers. The report notes that:
"One team member's ability to speak both Cebuano and Waray proved to be an advantage in many sites where these dialects are the medium of communication. This enabled us to strike a certain level of rapport with our respondents which was critical in ferreting out sensitive information such as their reactions to the recommended root crop technologies."

(Escalada, p.23)

With respect to any of the three broad purposes of conducting this kind of ex post evaluation, another advantage of using local personnel is that it contributes to building and sustaining an indigenous research capacity. At an IDRC-sponsored workshop of managers of national agricultural research systems from all parts of the Third World, it was recognized that "... national organizations have the primary responsibility for program management, including evaluation." (Daniels, p.10). Like any kind of research, if evaluations are always carried out by external consultants, most of the accumulated experience and information is exported when the consultants go home. It is important for countries to build up their own body of experience in this area, particularly to serve the planning and management purposes. Paradoxically, the funding purpose can sometimes be better met by using expatriate resources. Regardless of the level of training and experience available locally,
there are instances when the "prophet is without honour in his own country" and decision-makers may be more persuaded by the results of studies carried out by what is perceived to be more prestigious and objective expertise.

(b) Rapid Development Assessment
None of the studies was planned at the time the original research projects were initiated. This meant that no benchmark data was available, unless it had been collected as part of the project, as was the case in the systems research projects in Indonesia and Central America (see Table 1). There was heavy reliance on existing data, field surveys and interviews with producers. Compared to more elaborate efforts, the studies might therefore be generally described as the ex post equivalents of rapid rural appraisal. This approach was appropriate to the subject matter, since none of the projects concerned large investments aiming at major breakthroughs on an international scale. Big breakthroughs are the exception that prove the rule that development is mostly composed of a lot of small slow advances here and there, (often unfortunately held back or eliminated by natural or man-made events). Thus the study method was commensurate with the subject matter: short and tightly focussed.

In these circumstances, the experience with these studies and with others that the IDRC has supported has led to the conclusion that
diminishing marginal returns tend to set in earlier than might be supposed. That is, be it for the funding, planning or management purpose, most information that is available can be obtained quite quickly at little cost; and thereafter, additional time and effort will produce benefits of decreasing value and may quickly pass the point of being profitable.

From the point of view of the IDRC as the client for whom the studies were being done, one of the costs of using local consultants can be less control over the final product. It is necessary for client and consultant to spend some time at the outset going over the terms of reference in detail to ensure that the focus is clear. For example, in some of the studies, insufficient attention was paid to gathering information on spread effects beyond the boundaries of the original projects, particularly those of an experimental development nature. This could have been avoided by investing more time on planning the studies and monitoring them in the early stages.

Methodologies
The "snapshot" nature of the studies, their short duration and low cost did not generate data that warranted the application of sophisticated methodologies. As Table 1 shows, there was heavy reliance on what are being called (i) "appropriate indicators" and
(ii) "costs and returns" for the purposes of this paper. Cost-benefit analysis (iii) was used in one case.

(i) **Appropriate indicators** simply means tailoring the information to the nature of the research output. The aim was to collect evidence of any effects on development associated with the use of research outputs. The evidence depended on the kind of project and the timing. For example, the Fuelwood and Polewood research involved establishing trial plots at 73 sites throughout Malawi to test potentially suitable species. Even after 5 years it was possible to make preliminary judgements about which species had the best potential. However, it was clearly not possible to obtain any evidence of economic benefits from the use of the knowledge gained. This will have to wait until the chosen species have been planted and harvested. However, there was evidence that "development" was happening, due largely to the participatory nature of the research. Information was collected on harvesting and sales of wood that were already taking place in the trial plots, and on woodlots that had been established using the identified best species. These species had been used extensively on National Tree Planting Day. Thus the long term nature of forestry research determined what was feasible to collect in the short term. In contrast, the Seed Potato Storage project produced knowledge that could be applied and produce benefits immediately. Growers adopting the diffused light storage technology
could provide information on the benefits they had obtained, such as early emergence, resistance to insect attack and higher yield.

In all cases, information about adoption is a basic indicator. "Impact" analysis remains in the realm of the speculative if it does not include evidence of somebody actually using the products of a research process. Data on items such as area under production of composite fish culture or improved cropping systems, number of farmers growing improved varieties, and number of entrepreneurs using a new sorghum dehulling and milling system were collected as a first order priority. (It should be added that the obvious nature of such indicators does not mean that they are readily available or simple to collect.) If resource or other constraints mean that it is difficult to collect much more than adoption indicators, the passage of time can help lend conviction to any claims about the research having made a useful contribution to development. For example, it was found that seven years after adoption, farmers in Indonesia were still using the improved cropping system technology. It is easier to conclude that these growers were realising a net benefit from the new practices than if they had been revisited only two years after adoption. As far as their own costs and benefits are concerned, farm families are the real experts and do not usually persist over long periods with unprofitable new ventures.
(ii) **Costs and Returns** In four of the eight studies, data on costs and returns to individual business units were collected. Comparisons could be made of net incomes accruing to adopters and non-adopters at the same points in time, i.e. "with" and "without" the use of the research output in question. These cases provide more convincing evidence of the occurrence of a positive development effect, at least as far as the individual units are concerned, than those that only give "before and after" comparisons. Where time series data are not available, snapshot studies are better to have "with and without" rather than "before and after" information. Few farmers in the Third World are able to provide information on their net income position in the past, prior to adopting a particular technology, and even if they can, it is difficult to sort out how much of the change is due to the adoption. It is usually argued that this weakness is more severe than comparing the net incomes at the same time of farm firms that are claimed to be alike in all respects except the adoption (with) or non-adoption (without) of a technology. Again, if the luxury of time is available, persistence with adoption can be equated with being better off "with" than "without" the research output in question. However this is only a reasonable assumption in the case of an easily disposable item, such as a crop variety, as opposed to one that involves capital investment, such as a sorghum mill, to which the entrepreneur may be committed in order to repay a loan.
The costs and returns methodology should be generously interpreted to include items that are difficult to quantify. The adopters' perception of benefits may not be reflected in net income calculations, especially not on a short term snapshot basis. For example, taste and cooking quality proved to be important factors to sweet potato growers in the Philippines; and seed tubers stored in diffused light remain suitable for planting for longer periods, providing extra flexibility and reduced risk to Peruvian growers.

(iii) Cost-Benefit Analysis. The methodological approaches outlined above may provide valid evidence that a research output is being used and that net benefits are being experienced by those who are using it. However, they do not necessarily prove that the original research investment was a good one or that society as a whole is better off. To take an extreme example, the costs of breeding a new crop variety, multiplying it up and extending it to farmers can amount to millions of dollars over 10 to 20 years. A large number of growers have to be realizing significant benefits above what they would be obtaining in the absence of the "improved" variety before society can feel comfortable that the money was well spent. The production of evidence of "impact" in terms of increased net incomes to "x" farm families, without reference to the costs of achieving those increases, does not answer this larger question.
Using a simplified Cost-benefit analysis, one of the studies attempted to find out whether the R&D investment in a sorghum dehuller in Botswana, together with its adoption in 17 small businesses, had been socially profitable. The answer was positive, but the process of conducting the analysis was probably of more value than the final numerical answer. The main observations to be made about this experience are as follows.

Cost-benefit analysis is a very data-hungry methodology. It requires a wide range of information, e.g. on past research costs, "with" and "without" production levels, and on prices and values of goods and services. Since the calculation often involves projecting streams of incremental costs and benefits into the future, a sound empirical basis for forecasting is also needed. Such a range of data is rarely readily available and can be expensive to collect. Sensitivity analysis can cater for lack of confidence in the data to a certain extent. For small research investments with what appears to be commensurate pay-off, the costs of data collection may be considered prohibitive.

Application of the technique entails constructing models of what might be described as "production functions", i.e. comprehensive pictures of what has happened over time in causal relationships between resources and outputs. Adjustments to take account of the possible divergences between monetary or market prices and social
values are also needed. Among other things this means awareness and analysis of public policies and public policy issues. This comprehensiveness is both the difficulty and the virtue of the methodology. Properly applied, it demands the scrutiny of a particular economic event in its broader economic and social context, and in so doing makes the analysis more complicated and time-consuming. The detailed consideration required in constructing the with and without production functions, and in attempting to put real social values on costs and benefits, can together yield valuable insights into the workings of the R for D process. The methodology therefore serves well the management purpose. The final product – a rate of return of "x" percent – may be of use to the funding purpose also, but may be of less significance than the lessons learned about how to conduct R for D more effectively. For this purpose, the way the study is carried out, who is involved in it and how it is communicated become critical factors.

The conscientious applicant of cost-benefit analysis, trying to start at the bottom of the R for D zone of concern and trace a chain of events up into the development arena and to measure the overall social value emanating from the production and use of a research output, is faced with a quandary. Assuming that he or she is able to identify and cost out the research resources that were more or less directly devoted to the production of the output concerned, there
remains the awareness of the existence of often large indirect research costs, such as fixed overhead and library services, and of those research programs which do not bear fruit in terms of tangible development effects. Two obvious examples are basic research that provides the foundation of knowledge on which more applied efforts can be built; and research that contributes to knowledge - and development - by finding out that something does not work. Who pays for these? For the most part, calculations of rates of return to research lay such questions aside and confine themselves to direct research costs. Ironically, one of the pioneers of the application of cost-benefit analysis to the evaluation of agricultural research, Z. Griliches, remarked:

"Does it really make sense to calculate the rate of return on a successful "oil well." 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."

(Griliches, p.426)
This comment comes at the end of one of the seminal papers on this subject and is not quoted as often as Griliches' finding that the rate of return to corn research was between 35 and 40 percent. This is unfortunate, since much of the subsequent literature is devoted to similar studies of successful oil wells, as opposed to estimates which would include the cost of the "dry holes". Persuading decision makers that agricultural research is a good investment because of occasional high rates of return is comparable to encouraging the pensioner to put his savings in the stock market on the grounds that some people make a lot of money. Intellectual honesty would insist that he should also be told that a lot of people make some money, and some people lose a lot. Similarly, perhaps the agricultural economics profession would be doing a greater service in the long run by working more on average rates of return and communicating more forcefully the realities of the R for D process (ref. Figure 1): that research produces a range of useful outputs, not just specific technologies; that its zone of influence is limited and other factors need to be added to research output for it to have a positive development effect; that research is to do with uncertainty, therefore some "dry holes" are inevitable and it is as important to know what does not work as what does.
CONCLUSIONS

(1) The value of approaches and methodologies for assessing the "impact" of agricultural research depends on the purpose being sought.

For the **funding purpose**, once-off case studies measuring appropriate indicators can be useful, but cost and returns analysis is better, and cost-benefit analysis better still. The use of local consultants may carry less weight with funding sources than outside expertise.

For the **planning purpose**, "impact" assessment of past research investment is of little value. Such evaluation is more useful for indicating how to do R for D (see below) than for guiding research resource allocation decisions. In this respect, **ex ante** cost-benefit analysis is perhaps not exploited to the extent that it should be.

For the **management purpose**, the kind of studies described in this paper can be valuable. Analysis of the R for D process that gave rise to the development effects was specifically built in to most of them. Cost-benefit analysis is the most useful for this purpose since it requires a holistic examination of all inputs and outputs in the broad social and economic context.
(2) Process is as important as product. The practice of using local personnel helps to build up indigenous skills and understanding of the R for D process. The benefits of the studies are further enhanced if the clients and users are involved in their design and implementation.

(3) Once-off case studies are cheap and techniques such as "appropriate indicators" and "costs and returns" are easy to communicate.

(4) Once-off studies carry the obvious risk of gathering information at an unrepresentative time, when the effects of the research output under examination are either masked or exaggerated to an abnormal degree. Time series data tracking the development effects over a number of years would alleviate this problem, and would also permit more thorough examination of the R for D process, including the often neglected role of the adopter as adapter, innovator and researcher.

(5) "Appropriate indicators" and "costs and returns" do not compare overall benefits with R and D costs. Cost-benefit analysis attempts to determine whether or not a research investment
resulted in a net gain to society. For this reason it is worth attempting even though it is data hungry and complex.

(6) The scope of application of cost-benefit analysis should be broadened. Instead of focussing on the glamorous rates of return to special cases, it could be used to communicate better the complexities and realities of the R for D process (ref. Figure 1) and to include consideration of the full range of necessary research costs, not just those directly linked to success stories.
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