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# Ex Ante Economic Analysis in AKIS Projects

## Methods and Guidelines for Good Practice

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## Preface

A 1996 World Bank OED review of agricultural research projects emphasized the importance of Borrowers' use of economic analysis as an input to prioritizing research. This led to discussions on the use of economic analysis as a basis for Bank project investments in research and extension projects and the conclusion that a review of options and good practice in this area would be useful to AKIS TTLs. Gesa Horstkotte-Wesseler prepared an initial concept paper which was reviewed and revised with input from other Bank staff in a series of discussion meetings. This paper summarizes these discussions and is intended as a contribution to the exchange of ideas and experience within the Agriculture Knowledge and Information Systems Thematic Team. The paper concludes that while economic analysis of World Bank projects for AKIS system capacity building per se is often not warranted, increased attention to and use of economic analysis within research and extension programs is useful and to be encouraged.

"AKIS Good Practice Notes" are to disseminate views, experience, and ideas, which may assist World Bank Team Leaders, national counterparts from Borrower countries, and other partners with preparation and implementation of projects to strengthen agricultural research, extension, and education programs. They attempt to disseminate lessons from innovative experiences in World Bank projects and elsewhere and make this information readily available for comment and use by project teams.

AKIS is the Agricultural Knowledge and Information Systems Thematic Team, composed of World Bank staff working in or interested in research, extension, and education programs. The overall team objective is to enhance the effectiveness of Bank support to agricultural knowledge and information system development and thus contribute to the Bank's objectives of alleviating poverty, ensuring food security, and improving sustainable management of natural resources. The AKIS team emphasizes policy, institutional, and management issues associated with agricultural research, extension and education, recognizing that other thematic teams will focus on technical issues. The Team mission is to "promote the development of sustainable and productive agricultural research, extension, and education systems in Bank client countries."

This "AKIS Good Practice Note" was prepared by Gesa Horstkotte-Wesseler, Mywish Maredia, Derek Byerlee, and Gary Alex, based on inputs from Jock Anderson, Marie-Hélène Collion, Madhur Gautam, J. Price Gittinger, Robert D. Hunt, Jaakko Kangasniemi, Matthew McMahon, Ridley Nelson, David Nielson, Michel Petit, Trayambkeshwar P.N. Sinha, Chandrashekhar Ranade, Dina Umali-Deininger, and Willem Zijp.

*David Nielson*  
Chairman

## *Abbreviations*

IRR	Internal rate of return
M&E	Monitoring and evaluation
NARO	National agricultural research organization
NARS	National agricultural research system
NPV	Net present value
OED	(The World Bank's) Operations Evaluation Department
R&E	Research and extension



## *Summary and Key Recommendations*

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**T**his note outlines an approach to economic analysis in agricultural research and extension (R&E) projects financed under World Bank loans and credits. Because Bank-funded R&E projects allocate considerable resources to institutional development, it makes little sense to attempt an economic analysis for such projects per se. Furthermore, although it is conceivable and often desirable to undertake ex ante economic analysis of direct investments in agricultural research programs, the time and resources available during project preparation usually preclude a comprehensive, high-quality analysis. This note provides guidelines for alternative approaches, recommending steps to take during project preparation and implementation.

In designing and conducting an economic analysis, the emphasis should be on building capacity within national agricultural R&E systems. Rather than purely serving the needs of World Bank or bilateral donors, economic analysis of R&E should become an integral part of management processes within national systems for project evaluation, priority setting, and impact assessment. Accordingly, this paper makes the following recommendations:

- Agricultural research investments should be evaluated at the level of research programs for important commodities or production systems (such as maize, beef, or irrigated rice). Evaluators should consider all programs, even those with non-World Bank funding. At the level of individual research projects within a research program, however, economic analysis is not recommended. The analysis of research expenditure impacts will almost always have to take extension expenditures into account.
- Agricultural extension investments (again including those with non-World Bank funding) are often best evaluated using rough measures of cost-effectiveness or unit costs (such as costs per farmer reached or hectare affected). The evaluation of extension impacts separately from research impacts is justifiable if recommended technologies have been available for some time but have not been adopted.
- Alternatively, break-even analyses can be conducted for extension programs to show the minimum impact needed to justify proposed expenditures. Break-even analyses might also be used for research programs or for Bank-financed projects as a whole.
- During project preparation, economic analyses should focus on (1) retrospective technology adoption and impact studies to demonstrate that the current technology system has been productive in some areas; and (2) prospective technology case studies to demonstrate that R&E investments can produce substantial economic benefits. These analyses can be based on existing studies and information or—preferably, at least for the prospective studies—on field-oriented case studies. Break-even analyses and overall assessments of profitability can help in evaluating whether proposed investments are justified.
- During project implementation, the main emphasis should be on establishing systems that incorporate economic analysis on an ongoing basis into R&E evaluation, planning, and priority setting. This requires improving R&E management within national systems. Training, support for socioeco-

economic programs, partnership building, and stakeholder participation are needed to ensure effective economic analysis within program management systems. More attention should also be paid to collecting baseline information and designing performance indicators (issues that are treated in separate guidelines).

- Evaluators within the national agricultural research system should conduct the economic analyses whenever possible in order to build local capacity and foster local ownership of the results. The role of the World Bank or other external parties should be limited to providing support.
- All economic analyses should use, as an

underlying model, the economic surplus method or a simplification thereof, such as a cost–benefit analysis. The specific type of analysis chosen should be determined by the data and analytical capacity available within the national system.

Economic analysis of agricultural R&E should not be designed to calculate a single summary measure (which is normally subject to a wide range of assumptions). Instead, the mainstreaming of economic analysis should provide a framework for research managers and scientists to think about the impact of their actions in terms of costs and benefits, thereby leading to a more efficient allocation of scarce resources.

## *Introduction and Background*

For projects funded through World Bank loans and credits, economic analysis has many dimensions. It can include the assessment of economic, fiscal, social, and environmental impacts; the relationship of the project to broader development objectives of the sector and country; the rationale for public-sector involvement; and the contribution to poverty reduction. This note focuses on a single dimension—assessing how investments in agricultural research and extension (R&E) affect agricultural productivity and growth in the agriculture sector. A comprehensive treatment of the other dimensions would require developing separate guidelines.

For most Bank-funded projects, preparation includes a mandatory economic analysis of the expected returns on investments. In the past, agricultural R&E projects were exempt from this requirement because their benefits are difficult to quantify and their rates of return worldwide were widely acknowledged to be high.

Today, in many fields of agricultural research, the “easy gains” have already been made. It no longer seems obvious that investments in agricultural R&E can sustain continued high rates of return. Indeed, the pervasive funding crisis and the poor performance of many national agricultural R&E systems have placed the efficiency of agricultural R&E investments in doubt. Moreover, thanks to recent advances in the methodology of economic analysis, most aspects of agricultural R&E are now measurable. These factors have prompted calls for a “fairer” treatment of agricultural R&E in the World Bank’s project cycle.

In 1997, in a key report on agricultural R&E (see box 1), the World Bank’s Operations Evaluation Department (OED) recommended integrating economic analysis into the priority-setting and project preparation/appraisal processes for national agricultural research systems (NARSs) and into the ex ante and ex post evalu-



**Box 1. OED Recommendations on Agricultural R&E**

In 1997, the OED published a report under the title, *Agricultural Extension and Research: Achievements and Problems in National Systems* (Purcell and Anderson 1997). The report includes these recommendations:

**Research:**

- Economic analysis should be integrated into project preparation for NARSs and into the ex ante and ex post evaluation processes of World Bank-supported research programs. “[E]conomic analysis (normally using an economic surplus model or a simplified derivative) should be fostered in borrowers’ processes for prioritizing research. By the same logic, economic analysis should be used by the Bank in ex ante and ex post evaluation of supported research programs” (p. 278).
- Instead of analyzing the full economic rate of return on investments, the Bank should build NARS capacity to conduct economic analysis. “[The Bank’s] focus should not be on estimating the economic return on the projects it supports. [...] Rather, the Bank should focus on institutionalizing the capacity within NARSs to use eco-

nomics analysis, especially in setting program priorities” (p. 12).

- To build the capability for economic analysis of research within NARSs, “an ex ante economic assessment of programs within a borrower’s research agenda should be completed during the project preparation/appraisal process” (p. 279). However, “to be consistent with ownership and capacity-building objectives, the scale and comprehensiveness of ex ante analysis will depend upon the availability of economic expertise within NARSs” (p. 279).

**Extension:**

- For agricultural extension projects, ex ante economic analysis is not always necessary. Because of the difficulties of linking cause and effect, “the expenditure of a large amount of scarce resources on extensive surveys to quantify extension impact and economic benefits is of dubious value for many countries” (p. 197).
- Instead, “the Bank should place much greater emphasis during implementation on assessing the effectiveness of the extension process in meeting the program objectives in the targeted farming systems—accelerating the rate of adoption of relevant technology in a cost-effective manner” (p. 270).

ation processes for Bank-supported research programs. Accordingly, the importance of economic analysis is growing in Bank-funded agricultural R&E projects. Some Bank managers now encourage or even require economic analysis in agricultural research projects, both to justify the investment and to prioritize programs and projects funded by the Bank.

Clear guidelines are needed to help World Bank operational staff perform economic analysis of agricultural R&E projects. This note is designed to clarify some of the issues involved and to provide guidelines for good practice in analyzing the potential impact of R&E investments on agricultural productivity and on growth in the agriculture sector.

## Overview and Economic Analysis

**What Is Economic Analysis of Agricultural R&E?**

Economic analysis of agricultural R&E uses economic principles and models to evaluate agri-

cultural R&E activities, either before they are undertaken (ex ante evaluation) or after they are completed (ex post evaluation). In either case, the main purpose of economic analysis is to help

select and design R&E activities that contribute to the welfare of a country. Ex post analysis is done to justify R&E budgets and to identify areas with likely future research payoffs. Ex ante analysis is designed to help set priorities, allocate resources, and decide whether or not to proceed with a specific R&E program.

Economic analysis is only one part of the overall analysis of a World Bank-funded project. It takes for granted that the project is technically sound, socially acceptable, and financially viable for all participants; that institutional arrangements will be effective during implementation (Belli and others 1998); and that environmental and natural resource impacts are acceptable (although these can sometimes be costed and included in more complex economic analyses).

In the early phases of project preparation, economic analysis should help answer several questions of strategic importance, such as: What will happen if the project is undertaken? What if it is not? Is the project the best alternative for achieving the objective? Do some components of the project perform better than others? Should the public or the private sector undertake the project? And who are the gainers and losers?

For investments with benefits that are measurable in monetary terms, the appropriate yardstick for judging whether the investment is acceptable is its expected net present value (NPV). The NPV is the sum of all costs and benefits over the life of the investment, discounted at the opportunity cost of capital. The expected NPV takes account of the entire range of possible NPVs by weighting all possible project outcomes with their corresponding relative frequencies or probabilities.

A related yardstick for determining whether an investment is acceptable is the project's internal rate of return (IRR). The IRR is the interest rate at which the NPV equals zero—that is, at which the investments break even. To be acceptable on economic grounds, an investment must meet one of two conditions:

1. The expected NPV of the investment must be (a) zero or positive, and (b) higher than

or equal to the expected NPV of mutually acceptable investment alternatives; or

2. the IRR must be greater than the opportunity cost of capital.

Projects can be ranked using either NPV or IRR. However, NPV is preferred because it can be normalized in a way that takes into account the size of the research investment. Although the IRR is not always a satisfactory measure (for example, when comparing and ranking mutually exclusive project alternatives), it is widely understood and may be used for the purpose of presenting the results of economic analysis.

For investments with benefits that are difficult to measure in monetary terms (for example, reductions in soil erosion), physical indicators of achievement in relation to costs (such as cost-effectiveness and unit costs) are appropriate measures for determining the acceptability of the investment. In all cases, however, the economic analysis should give a persuasive rationale for why the benefits of the project are expected to outweigh its costs—that is, why the net development impact of the project investment is expected to be positive.

### Special Problems

The main goal of investments in agricultural R&E is to increase the efficiency of agricultural production. Important secondary goals are to provide equity and to enhance security. In other words, successful investments in agricultural R&E increase total income, improve income distribution, and reduce income variability. The trick is to measure these benefits and to link them to specific investments in agricultural R&E. That poses several problems.

Measurement of research benefits is complicated because (1) benefits are spread geographically and vertically in markets for goods and services, (2) research can affect product quality, (3) some research is not commodity oriented, (4) some research (such as social science) is aimed at modifying institutions, (5) some research generates externalities, and (6) research

can be relatively basic without immediate application (Alston and others 1995). World Bank lending for agricultural R&E increasingly includes institutional development and capacity building, natural resources management, integrated farming systems, and social sciences research, all of which produce benefits that are difficult to quantify.

Time lags pose additional problems in measuring research benefits (see box 2). Research takes a long time to affect production and then affects production for a long time (20–30 years). The analyst usually estimates the length and shape of time lags arbitrarily, because there are no proven theories on how to structure time lags in an economic analysis model. Erroneous time lag structures can result, biasing the estimates of rates of return on research investment.

Another problem is the inherent uncertainty in predicting the outcomes and impact of research. Uncertain parameters include the impact and adoption of research results; the natural, economic, and political environments in which agricultural commodities are produced; the time it takes to find solutions to research problems, which can easily exceed the timeframe of a typical World Bank project cycle; and the factors that influence farmers' decisions to adopt new technologies, such as market conditions, domestic agricultural policies, and the effectiveness of agricultural infrastructure in linking local prices to border prices. These uncertainties present

considerable analytical challenges in determining the potential returns from research investments.

Many of the same uncertainties apply to extension as to research. Uncertainties include the relevance of available technologies and extension "messages" to producer needs; the impact of technologies at different locations and on different farm situations; and technology adoption patterns and lag times under different economic, social, technical, and other conditions. Variations in the available technology, in the efficiency of the extension system, and in the receptivity of farmers all render the impact of extension highly uncertain.

Another complication is that many extension programs address a broad range of commodities and production and management activities. This makes it difficult to estimate and aggregate costs and benefits. On the cost side, extension expenditures are not easily allocated to specific crops, farming systems, or recommendations; on the benefit side, separating the project from nonproject impacts is challenging. For example, productivity increments for a group of farmers might result from any of various extension providers or other sources of information; from new technologies, which in turn might be due to research by the NARS, by international agricultural research centers, or by the private sector; from infrastructural improvements; or from institutional innovations. In a

#### **Box 2. Time Lags in Realizing Benefits from Agricultural R&E**

Investments in agricultural R&E can take decades to realize any benefits. Such time lags are critical in analyzing economic returns. The shape and length of the time lag distribution in the early years of a project, important in calculating research benefits, vary among research programs and among technological options within programs (Alston and others 1995). Three related lag components need to be estimated: the research lag (the time between a research expenditure and the release of new technologies); the adoption or

uptake phase; and the depreciation phase (the time it takes for research knowledge to become obsolete).

As a rule of thumb, the time lag for extension is three years, for adaptive research six years, for applied research fifteen years, and for strategic research twenty-five years. Of course, lag times might be longer in rain-fed and less commercial agricultural systems and shorter in more commercialized areas. For extension projects, the main benefit comes from speeding up a technology adoption that will likely occur anyway, only at a slower rate. If adoption without project investment will occur ten years later, then the annual net project benefits ten years later would be zero.

dynamic world with many players, where technology is not the only factor that is changing, it is difficult to measure the impact of a project's activities.

Benefits from investments in agricultural education are even more difficult to estimate. Education and training support programs in

R&E and many other sectors. Quantifying benefits from those programs is challenging enough; to go further by attempting to allocate benefits to specific program components (such as staff training), and then to estimate the value of those components, poses nearly insurmountable obstacles.

## *Methods for Assessing Agricultural R&E Projects*

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Several different economic methods can be used to evaluate investments in agricultural R&E projects. Methods range in complexity from simple checklist and scoring models to complex mathematical programming and simulation models. Annex 1 lists data requirements for various methods.

No single approach is best for every situation. Evaluators should choose the method or combination of methods best suited to the type of data available; to the resources, skills, and time available; and to the economic importance of the decision. Annex 2 outlines the available references, manuals, computer programs, Web sites, and other resources for assessing agricultural R&E and for planning and priority setting in NARSs.

### **Economic Surplus Approach**

The most widely used methods in project evaluation are based on measures of economic surplus. This evaluation methodology is preferred because economic surplus concepts underlie the conventional economic rationale for government intervention in providing agricultural research through the public sector (Alston and others 1995). The economic surplus approach estimates returns on investment (generally, a weighted

average rate of return over time) by (1) calculating the change in consumer and producer surpluses that results from technological change brought about through research, and (2) using estimated economic surplus together with research costs to estimate the NPV or IRR.

The theory underlying the economic surplus approach is based on the material benefits to society from technological change. The adoption of new technology reduces the unit cost of production, shifting the supply curve to the right and increasing consumer and producer surpluses. Consumers gain from the new technology because they can consume more at a lower price, and producers gain because their unit costs of production fall. The distribution of benefits between producers and consumers depends on the elasticities of the demand and supply curves and on the magnitude and nature of the supply shift. The combined total benefit to consumers and producers, measured in monetary units, is the change in economic surplus. The basic formula for estimating the change in economic surplus in year  $t$  ( $\Delta ES_t$ ) is:

$$\Delta ES_t = K_t P_t Q_t \left( 1 + \frac{0.5 K_t \varepsilon \eta}{\varepsilon + \eta} \right)$$

where  $P_t$  is the price of a commodity affected by research in year  $t$ ,  $Q_t$  is the quantity of production

in year  $t$  of the commodity affected by research,  $e$  is the elasticity of supply,  $\eta$  is the elasticity of demand, and  $K_t$  is the proportionate downward shift in the supply curve in year  $t$  due to research. The most critical parameter, the variable  $K$ , is calculated as the net change in the cost of production due to new technology (which is sometimes approximated by the yield increment due to the new technology), weighted by the rate of adoption of the new technology in year  $t$ .

The economic surplus approach has been widely used to calculate benefit–cost ratios, IRRs, and NPVs for benefits generated from agricultural research. The method is best used by those with at least some training in economics. Ex ante analysis of future benefits requires information on expected values of production, expected yield increases, reduction of unit costs and/or the maintenance effects of research, probabilities of research success, adoption rates, research and adoption lags, and the appropriate discount rate for converting future benefits and costs into present values or for comparing them against an IRR.

### **Cost–Benefit Analysis: A Simplified Economic Surplus Approach**

Depending on the type of data available and the purpose of economic analysis, the economic surplus approach is often simplified by calculating research benefits in year  $t$  as the product of  $K_t \cdot P_t \cdot Q_t$ . The cost–benefit analysis assumes that demand and supply elasticities are polar—that is, that demand is infinitely elastic and supply is completely inelastic, or vice versa. If the purpose of the economic analysis is to measure only the total economic surplus and not its distribution between consumers and producers, then this simplified approach gives reasonable estimates of the economic benefits.

### **Efficiency Index: A Simplified Cost–Benefit Analysis**

Another simplification often made in ex ante analysis is to calculate a net efficiency index (or

an efficiency score) for a research program or individual project. The index is used to rank a given project in relation to other research projects. For project  $i$ , the net efficiency index  $I_i$  is calculated as:

$$I_i = \left( \frac{K_i^{\max} \cdot P_i \cdot Q_i}{C_i} \right)$$

where  $K_i^{\max}$  is computed for the maximum adoption rate,  $C_i$  is the research cost of the project,  $P_i$  is the price of the commodity affected by project  $i$ , and  $Q_i$  is the quantity of production of the commodity affected by project  $i$ . The value of the net efficiency index by itself should not be used to economically justify a project, but only as a scoring measure to rank and prioritize research projects based on the economic efficiency criterion.

### **Cost-Effectiveness Analysis**

The methods described above are appropriate for R&E activities where benefits are measurable in monetary terms and where output has a market price that is relatively easy to assess. However, the principal benefits of many activities, especially in extension, are not easily quantified in monetary terms. For such activities, a straightforward cost–benefit assessment to get economic rates of return can be very demanding, if not impossible.

An appropriate method to use for projects where the principal benefits are not easily quantified in monetary terms is the cost-effectiveness analysis. In this analysis, the benefits are measured in nonmonetary units (such as the number of farmers receiving services or the number of trainees) and compared to the cost of the project to arrive at the cost-effectiveness ratio (or cost per unit of output). If the benefits consist of improvements in several areas (such as in farmer education, technology adoption by farmers, and information dissemination), then the various benefit areas are weighted and reduced to a single measure in a “weighted cost-effectiveness analysis.”

Cost-effectiveness analysis is always comparative. It is used to compare different ways of achieving the same objective. Cost-effectiveness analysis can determine the alternative that will accomplish the same output at lowest cost, or the alternative that generates the highest output with a given level of inputs.

### **Break-Even Analysis**

If benefits from an R&E activity are unknown or difficult to estimate *ex ante*, a break-even (or threshold) analysis can be conducted as a first step towards quantification. Using this approach, an analyst determines the minimum benefits that an R&E activity should generate to justify its costs. This method permits *ex ante* analysis of a project when only its costs are clearly known. However, it is based on guesswork by the analyst as to the likelihood of achieving the minimum necessary benefits, and it says nothing about the distributional impacts of the activity.

### **Risk Assessment**

Agricultural R&E are inherently risky. Because the economic analysis of R&E activities is based on uncertain future events, the measurement of costs and benefits inevitably involves explicit or implicit probability judgments (Belli and others 1998).

Tools for assessing risk include sensitivity analysis. Using this tool, the analyst identifies the variables that most influence a project's net benefits, such as aggregate costs and benefits, critical cost and benefit items, and the effects of delays. Then the analyst quantifies the extent of their influence. The preferred approach to sensitivity analysis is based on the switching value of a variable—the value at which the project's NPV becomes zero (or the IRR equals the discount rate). Switching values are usually given in terms of the percentage change in the value of the variable needed to turn the project's NPV to zero. The switching values of the more important variables may be presented in order of declining sensitivity. For variables that are expected to vary together (such as price and quantity sold), the analyst should examine the sensitivity of the outcome to changes in combinations of those variables (such as in total revenues).

The major shortcoming of sensitivity analysis is its failure to account for the probabilities of future outcomes. Using more elaborate approaches to risk assessment, such as simulation techniques, analysts can assign probabilities to a range of outcomes for important variables. However, with the data commonly available for agricultural R&E, these probabilities are usually highly subjective. Simulation exercises are therefore not recommended.

## *Guidelines for Good Practice*

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Given the OED recommendations and the growing emphasis on quantitative evaluation by World Bank management, economic analysis will increasingly be required for Bank-funded agricultural R&E projects. However, a summary

economic analysis purely for a World Bank loan or credit would be of little value. Bank-funded agricultural R&E projects are no longer limited to supporting specific technologies in extension or well-defined programs in research. Instead,

many projects now focus on institutional restructuring, capacity building, and farmer empowerment, areas where benefits are difficult to quantify in the short to medium term. It therefore makes little sense to attempt a full economic analysis of a World Bank project per se. The most important role for economic analysis today is in priority setting, planning, evaluation, and impact assessment for agricultural R&E within a national system. The emphasis should be on building capacity for economic analysis within the national system.

From this central conclusion, several principles follow:

- Both ex post and ex ante economic analyses of direct expenditures for agricultural R&E operations are feasible and often desirable under the particular circumstances of a borrowing country. Therefore, ex ante analysis should become an integral part of the planning and priority-setting process in agricultural R&E, and ex post analysis should become a regular part of evaluating R&E activities. These analyses should be integrated into the country's ongoing programs, not performed specifically for World Bank projects.
- Investments that directly support agricultural research should be evaluated at the level of research programs for important commodities or production systems (such as maize, beef, or irrigated rice). Evaluators should consider all programs, even those with non-World Bank funding. The analysis of research expenditure impacts will almost always have to take extension expenditures into account.
- For R&E projects that are designed to increase productivity, relatively simple cost-benefit or economic surplus methods can be used to estimate NPV and IRR as a basis for investment decisions. Costs should include all direct costs for the activity; management overheads; and, for research activities, extension costs. Such simple analyses are most appropriate for extension and adaptive research, less relevant to applied research, and very speculative for basic and strategic research.
- For individual projects within a research program, economic analysis is not recommended because (1) the benefits from such fine-tuning might not justify the cost, (2) measurement problems rise as the degree of data disaggregation increases, and (3) micromanaging creative endeavors such as research can be counterproductive. Detailed allocation decisions are probably best guided by well-structured incentive systems and farmer demands (Alston and others 1995).
- For agricultural education and for extension activities that do not focus on productivity enhancement or specific commodities, expenditures are best evaluated through rough measures of cost-effectiveness or unit costs (such as costs per farmer reached or hectare affected).
- A break-even analysis showing the minimum impact needed to justify an investment is often useful in evaluating a proposed loan in terms of risk and viability. Extension impacts may be evaluated separately from research impacts if the recommended technologies have been available for some time without having been adopted.
- To build local capacity and foster local ownership of the analytical process (including its results), evaluators within the NARS should conduct the economic analyses whenever possible, with the World Bank or other external parties providing support.
- Some technology adoption occurs even without agricultural R&E investments. Therefore, especially for extension programs, investment decisions should be based on a comparison of outcomes with and without investment.
- Economic analysis should be based on the full duration of a project's impact, not the

duration of a specific Bank-funded project. The analyst should choose a timeframe from the beginning of project activities (such as the start of extension activities or of a breeding program) to the end of the period when benefits are likely to accrue.

- For any particular country, the uncertainties

of ex ante analysis can be reduced by building on ex post studies to define key parameters of agricultural technology generation and dissemination, such as adoption rates. All available information should be used to make the case that future investments in agricultural R&E will be profitable.

## *Activities During Project Preparation*

During project preparation, the limits on available time and resources will usually preclude a comprehensive, high-quality economic analysis. However, the analysis should indicate the overall magnitude of expenditures and the historic rates of return on R&E investments in the particular setting. Good practices during project preparation include:

- *A summary of previous studies:* As a first step, the analyst should summarize previous studies (both ex post and ex ante) on the impact of agricultural R&E in the particular country and/or setting. To help indicate future impacts, the analyst might include a synopsis of the international experience (see

box 3). The analyst should also indicate whether there are reasons to expect that future returns might differ from past experience.

- *Retrospective studies on technology adoption and impact:* The analyst should conduct studies on the adoption and impact of previous technologies to show results from the current technology system and to assess the impacts expected from past R&E efforts, based on early adoption and on-farm verification trials. For research projects, such studies should concentrate on major commodities (such as maize, beans, or cassava); for extension, they should focus on key tech-

### **Box 3. Worldwide Experience with Returns on Agricultural R&E Investments**

Many ex post analyses have shown that agricultural R&E investments yield high rates of return. A comprehensive 1998 report by the International Food Policy Research Institute (Alston and others 1999) reviewed 294 studies of returns on investments in agricultural research and development (including extension). After eliminating extremes, the report found that the remaining 1,760 estimates indicated an average return of 73 percent per year, confirming the conventional view that returns on investments in agricultural research and development are relatively high.

The report found that returns averaged 88 percent on investments in research alone, 79 percent on extension alone, and 45 percent on R&E combined. The lower estimate for R&E combined might be because the corresponding studies captured more of the total costs of the technology innovation process. The report found no evidence of a decline in rates of return in recent years and little consistent difference among regions. Rates of return were similar across all research categories except for natural resources research, where lower rates of return were mainly due to longer production cycles.



nologies (such as integrated pest management). To maintain objectivity and credibility, the analyst should avoid selecting only success stories (for step-by-step guidelines, see annex 3).

- *Case studies on prospective technologies:* The analyst should conduct field-based case studies, for selected crops and regions, on the technologies that could be developed during the project (for step-by-step guidelines, see annex 4). These studies should begin as early as possible to help in project planning and priority setting and to establish a core team in the national system with experience in applying the proposed methods.
- *A break-even analysis:* The information available during project preparation will rarely suffice for a rigorous ex ante assessment. However, the analyst should determine the threshold magnitudes of productivity gains that would be needed to justify total project allocations. These figures should be compared to historic figures from similar situations to assess their probability. (For national programs, an estimate of the minimum growth of agricultural gross domestic product needed to justify proposed expenditures might help determine whether an investment is realistic under the particular circumstances. The design of this type of analysis is still under discussion.)

## Activities During Project Implementation

During project implementation, the main emphasis should be on establishing a system that incorporates economic analysis on an ongoing basis into R&E evaluation, planning, and priority setting. This requires improving R&E management within the national systems. It also implies the need to pay more attention to collecting baseline information and designing performance indicators (issues addressed in other guidelines).

Capacity building for improved R&E management touches on a broad range of issues:

- *Increased support for socioeconomics programs:* In many developing countries, the national agricultural research organizations (NAROs) neglect the socioeconomics discipline. To be able to conduct economic analysis for agricultural R&E investments, NAROs should provide more staffing, training, and support for their socioeconomics programs.
- *Partnership building:* While its socioeconomic capacity is still limited, the NARO should build partnerships to obtain the analytical capabilities needed for impact assessments and evaluation studies. Potential partners include institutions in the same country (such as agricultural universities and economic research institutes) and other countries (such as international agricultural research centers). All partnerships should be designed to increase the NARO's own capacity for economic analysis.
- *Shifts in donor support:* To encourage analysts within the national systems to conduct economic analyses for R&E investments, donor support for priority setting should shift from master planning by donor consultants to institutional capacity building within the NARS.
- *Training for NARS staff:* To encourage thinking in terms of costs and benefits, all research

scientists and extension workers within the NARS should have basic training in the fundamental concepts of economic analysis. In addition, those who will conduct the economic analyses should have a thorough training in methodology. Staff training should start during project preparation, when ex post analyses of past R&E efforts and field-based case studies of prospective technologies are prepared.

- *Stakeholder participation:* The project should involve major stakeholders (such as farmer groups and nongovernmental organizations) as full partners in priority setting and impact evaluation to increase the quality of

information used and to help build political support for the strategy as well as for the R&E system.

- *Monitoring and evaluation (M&E):* M&E should be implemented in a highly decentralized manner, with R&E staff participating in data collection and reporting on progress and impact indicators. A small central unit is needed to promote M&E, develop standards, provide training, and consolidate reports (Byerlee and Alex 1998). Comprehensive monitoring plans with indicators and targets should be developed during project preparation and then updated routinely throughout the life of the project.

## *Special Considerations for Competitive Grants Programs*

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Competitive grants programs for agricultural research are proliferating, yet no body of good practices is generally accepted for the use of economic analysis in the operations of these programs, let alone in measuring their performance (Alex 1998). The competitive grants programs in some countries (such as Australia) have required that all projects submitted for funding include an ex ante cost-benefit analysis. Critics make the following points:

- For many projects (for example, in basic research or natural resources research), a cost-benefit analysis is inappropriate because the quantity or value of outputs is difficult to estimate.
- Cost-benefit analyses yield low-quality re-

sults because the time and skill needed for good estimates are not available for all submitted projects. The low-quality results in turn undermine the credibility of competitive grants programs in the eyes of both researchers and research funders.

However, the critics do agree that researchers should be explicit in their proposals about the area targeted by the proposed research, the estimated number of farmers to be reached, and the expected change in yields or costs per hectare resulting from the research. Dividing the costs of the proposed project by any of these indicators provides an impact estimate (a measure of cost-effectiveness) potentially useful to both researchers and proposal evaluators.

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## *Annex 1: Data Required for Economic Analysis of Agricultural R&E*

Economic Surplus Approach	
<p><i>Advantage:</i> Benefits from research can be disaggregated among different groups of producers and consumers.</p> <p><i>Disadvantage:</i> Highest data requirements (including the need to establish price elasticities of supply and demand for each identified group of consumers and producers).</p>	
<i>Research-Related Data Required</i>	<i>Market-Related Data Required</i>
<ul style="list-style-type: none"> <li>• Key technologies generated by each selected research program over the period of the analysis.</li> <li>• Proportionate yield change due to new technologies.</li> <li>• Proportionate change in variable input costs per hectare, if any, to achieve the expected yield change.</li> <li>• Probability of research success.</li> <li>• <i>Research lag:</i> observed or expected time from the beginning of research activities to the release of a new technology.</li> <li>• <i>Development and adoption lag:</i> observed or expected time between the release of new technology and first adoption by farmers.</li> <li>• <i>Adoption path:</i> observed or expected time between first adoption and full adoption (for simplicity, a linear adoption path is often assumed).</li> <li>• <i>Adoption ceiling:</i> maximum number of farmers likely to adopt the new technology or maximum number of production units expected to be affected by the new technology.</li> <li>• Period of time that the new technology will generate full benefits.</li> <li>• <i>Depreciation factor:</i> the rate at which the benefits of new technology will depreciate after the period of full benefits.</li> <li>• Annual total research expenditures for each selected research program (including overheads and non-World Bank funds), from the beginning of research activities to the time of new technology release.</li> <li>• Annual extension expenditures that can be related to new technology (difficult—a frequently used pragmatic approach is to allocate total extension expenditures among crops by relative area planted).</li> </ul>	<ul style="list-style-type: none"> <li>• Quantities produced and consumed.</li> <li>• Prices received and paid.</li> <li>• Price elasticities of supply and demand for each identified group of producers and consumers.</li> <li>• Exogenous output growth rate: anticipated proportionate change in output not due to research in each year (growth rate of area + growth rate of yield not due to research).</li> <li>• Discount rate.</li> <li>• For an ex ante analysis, three to four years of price and quantity data (as a benchmark).</li> <li>• For an ex post analysis, detailed data on prices and quantities for a single commodity aggregate of interest on an annual basis, for all past years for which benefits are assessed.</li> <li>• For traded commodities— <ul style="list-style-type: none"> <li>– Prices and quantities of exports and imports, and</li> <li>– Exchange rates.</li> </ul> </li> <li>• For more refined analyses— <ul style="list-style-type: none"> <li>– Rates of population and income growth, and</li> <li>– Information on government policies and any other relevant market interventions.</li> </ul> </li> </ul>

(continued on next page)

*Annex 1 (continued)*

<b>Cost–Benefit Analysis</b> <i>(simplified economic surplus approach with extreme assumptions about elasticities)</i>	
<p><i>Advantages:</i> Lower data requirements (demand and supply elasticities are assumed to be polar, eliminating the need for estimates); lower analytical skills required.</p> <p><i>Disadvantage:</i> Ignores all regional and international price effects due to research, as well as any distributional effects.</p>	
<i>Research-Related Data Required</i>	<i>Market-Related Data Required</i>
Same as for economic surplus approach.	Same as for economic surplus approach, except no need to estimate price elasticities for supply and demand.
<b>Efficiency Index</b>	
<p><i>Advantage:</i> Lowest data requirements.</p> <p><i>Disadvantages:</i> Insufficient alone to economically justify a project (usefulness limited to ranking and prioritizing research projects); ignores differences in the timing of benefits and their accrual over many years.</p>	
<i>Research-Related Data Required</i>	<i>Market-Related Data Required</i>
<ul style="list-style-type: none"> <li>• Anticipated proportional yield increase or reduction per unit cost that would follow from a successful program with fully adopted results.</li> <li>• Estimated probability of success.</li> <li>• Proportion of farmers likely to eventually adopt the technology.</li> <li>• Research costs.</li> </ul>	<ul style="list-style-type: none"> <li>• Benchmark quantity of production for each commodity.</li> <li>• Benchmark price for each commodity.</li> </ul>

## Annex 1 (continued)

<b>Cost-Effectiveness Analysis</b> <i>("simplified" cost benefit analysis when benefits are difficult to quantify in monetary terms)</i>	
<p><i>Advantages:</i> enables economic analysis of programs that either do not have a readily accessible market price or are not easily measurable in monetary terms.</p> <p><i>Disadvantages:</i> can only be used to compare alternative programs that try to achieve a given result. Not applicable to programs with different outcomes.</p>	
<i>Research-Related Data Required</i>	<i>Market-Related Data Required</i>
<ul style="list-style-type: none"> <li>• Annual total research expenditures for each selected research program (including overheads and non-World Bank funds), from the beginning of research activities to the time of new technology release.</li> <li>• Annual extension expenditures that can be related to new technology (difficult—a frequently used pragmatic approach is to allocate total extension expenditures among crops by relative area planted).</li> <li>• Benefits measured in some nonmonetary unit (such as number of vaccines delivered).</li> </ul>	None.
<b>Break-Even Analysis</b> <i>(calculating the minimum benefits necessary to justify project costs)</i>	
<p><i>Advantage:</i> Lower data requirements, especially for research programs where the size of the benefits is unknown.</p> <p><i>Disadvantages:</i> Little information on the likelihood of achieving the minimum benefits; no consideration of distributional impacts.</p>	
<i>Research-Related Data Required</i>	<i>Market-Related Data Required</i>
Same as for cost-benefit analysis, except that cost reduction/output gain and/or rate of adoption need to be calculated.	Same as for cost-benefit analysis.

## *Annex 2: Resources for Economic Analysis of Agricultural R&E*

<i>Resource</i>	<i>Description</i>
<i>References</i>	
Alex (1998)	Reviews approaches to research performance and impact assessment; makes recommendations for a practical yet rigorous approach to impact assessment.
Alston and others (1995)	Presents the principles and practice of ex post and ex ante economic analysis methods and their use in research priority setting. Reviews, synthesizes, and assesses a wide range of approaches using a unifying conceptual framework.
Belli and others (1998)	Provides a comprehensive overview of methods, techniques, and tools of economic analysis of investment projects in the areas of education, health, and transportation.
Gittinger (1982)	Provides guidelines for the economic analysis of agricultural projects. Long used in World Bank training courses.
Horton and others (1993)	Synthesizes literature and experience on principles, processes, and methods of research M&E.
<i>Manuals</i>	
Collion and Kissi (1995)	Outlines an approach to research program planning by objective, based on a series of steps that include cost-benefit analysis as an approach to priority setting.
Janssen and Kissi (1997)	Outlines a practical approach to integrating productivity concerns into natural resource management. Introduces a methodology for prioritizing research projects based on economic considerations.
Masters and others (1996)	Summarizes tools for conducting persuasive impact studies that quantify the economic benefits and costs of research. Three spreadsheet-based computer exercises and an accompanying diskette help apply the methods described.
Orlando (1991)	Describes the financial, economic, and social analysis of public-sector investment projects.
USAID (1987)	Provides guidance on economic analysis for various projects, including agricultural research and development.

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## Annex 2 (continued)

Resource	Description
<i>Software</i>	
Dream© - Dynamic Research EvaluAtion for Management	Facilitates the application of the economic surplus model under a variety of market situations. Developed by the International Service for National Agricultural Research, this menu-driven computer program is available on the International Food Policy Research Institute Web site (see below under <i>Web Sites</i> ). [For more information, contact Stanley Wood at <a href="mailto:s.wood@cgnet.com">s.wood@cgnet.com</a> ]
Masters and others (1996) MODEXC—Modelo de Análisis de Excedentes Económicos	See above under <i>Manuals</i> . Helps calculate the NPV, IRR, and benefit–cost ratio for investments in agricultural research for both ex ante and ex post economic analysis of technical change under different market scenarios. This spreadsheet-based model is available in Spanish on the International Center for Tropical Agriculture Web site (see below under <i>Web Sites</i> ).
<i>Web Sites</i>	
Site: International Center for Tropical Agriculture Page: The Impact of Agricultural Research	<a href="http://www.ciat.cgiar.org/projects/bar_bp1.htm">http://www.ciat.cgiar.org/projects/bar_bp1.htm</a> Features abstracts on the impact of agricultural research, data bases, trends, and a download version of MODEXC (see above under <i>Software</i> ).
Site: International Food Policy Research Page: Dynamic Research EvaluAtion for Management	<a href="http://www.cgiar.org/ifpri/dream.htm">http://www.cgiar.org/ifpri/dream.htm</a> Provides a description and free download of the Dynamic Research EvaluAtion for Management program (see above under <i>Software</i> ).
Site: International Service for National Agricultural Research Page: Information and Discussion Forum on Priority Setting in Agricultural Research	<a href="http://www.cgiar.org/isnar/Fora/Priority/index.htm">http://www.cgiar.org/isnar/Fora/Priority/index.htm</a> Describes the process, steps, and methods of priority setting for research.
Site: The World Bank Page: Agricultural Knowledge and Information Systems	<a href="http://essd.worldbank.org/essd/rdv/rdvhome.nsf/AKISHolder?OpenView">http://essd.worldbank.org/essd/rdv/rdvhome.nsf/AKISHolder?OpenView</a> Provides good practice examples, case studies, and useful links on planning and priority setting, as well as on M&E of agricultural R&E.

### *Annex 3: How to Conduct Retrospective Technology Impact Studies*

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During project preparation, retrospective technology impact studies should be conducted for different types of technologies generated by the NARS to document that the current technology system has been productive in some areas and to justify continued support for the system. The studies should be based on already available information, with additional input from program scientists and other experts. Step-by-step guidelines for conducting these studies follow.

- Select appropriate research programs for economic analysis based on strategic considerations, such as the importance of a commodity in the agricultural gross domestic product or to certain groups of consumers or producers, the impact of planting an area to different crops, or the tendency of a commodity to lag behind regional averages. Clearly state the selection criteria to help avoid the temptation of selecting only success stories. Aim for a mix of crop management, livestock, natural resource management, and commodity varietal development research programs. Try to conduct an economic analysis for every selected program. (If not possible during project preparation, try to finish during project implementation.)
- Depending on objectives, data availability, and analyst skills, select a method for the analysis (for the data requirements associated with each approach, see annex 1).
- For each selected research program, define a timeframe for study (not necessarily linked to the timeframe of the World Bank-funded project). The timeframe can begin on the start date of current research activities (such as the start date for a current breeding program) and should extend for as long as benefits are likely to accrue from research products (thus, even a retrospective impact study might have an ex ante element). However, the analysis should emphasize recent impacts and might even focus on early adoption as the most relevant factor in assessing recent impacts.
- Define the appropriate level in the production/marketing/consumption system for applying the analysis (that is, farm level versus wholesale level—for traded goods, the wholesale level is more appropriate, and world market prices should be used).
- Identify costs and benefits for outcomes both with and without the research program.
- Compute summary measures such as the (expected) NPV and the (expected) IRR for the research program.
- To justify investments in agricultural research, compare the NPV of the various research programs to alternative investment opportunities and to the opportunity cost of capital. To justify the allocation of resources among research programs or to set research priorities, take additional factors (such as objectives and constraints of the system) into account.
- Conduct a sensitivity analysis to determine whether the results stand up to changes in the parameters. Present switching values to show which parameters have the greatest impact on the results.

## *Annex 4: How to Conduct Prospective Technology Case Studies*

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Project preparation should include a series of case studies to assess technology prospects. Studies should be based on important commodities or production systems (such as maize, beef, bananas, or rice/wheat/dairying). They may be summarized from available documentation on current or recent projects operating in the same general environment as the proposed project, supplemented by field studies using rapid rural appraisal or other informal information-gathering techniques at the district or community level. Case studies often require teams of at least three analysts—a research specialist for the commodity or production system, a socioeconomist, and an extension specialist familiar with the area. Each study normally requires two to three weeks. Step-by-step guidelines follow.

**Step 1:** Estimate potential for transferring existing technology.

- Describe current production systems and problems, and estimate current production and income for a typical producer.
- Inventory available technologies that could be immediately transferred and are appropriate for target farmers.
- Based on prior examples and experience, estimate the likely adoption path for technologies introduced with support from the project extension program.
- Based on on-farm experimental data, estimate the likely economic benefit from adoption.

[Note: Case studies can provide substantial information that is both relevant to social, institutional, technical, and financial analyses of R&E

programs and useful in planning extension approaches.]

**Step 2:** For the same commodities and geographic areas as in step 1, estimate potential for research.

- Based on available knowledge, identify major limitations on productivity.
- Identify potential technologies that could be developed during the project period to overcome key constraints.
- Based on experience, estimate the probability that the research will succeed.
- Based on prior examples and experience, estimate the likely adoption path for the technologies developed through the research program under the project.

**Step 3:** Conduct economic analyses based on steps 1 and 2.

- Estimate the costs of a typical extension program needed to diffuse the available technologies. Compare the costs to the benefits estimated in step 1 and compute an NPV or IRR for the program.
- Estimate the costs of a typical research program to develop the technologies identified in step 2. Because the research program is likely to benefit farmers beyond the immediate area of study, scale up the estimated benefits of the technologies to include the total farm population that is likely to benefit from the research. Compare these benefits to the cost of the research and compute an NPV or IRR for the program.