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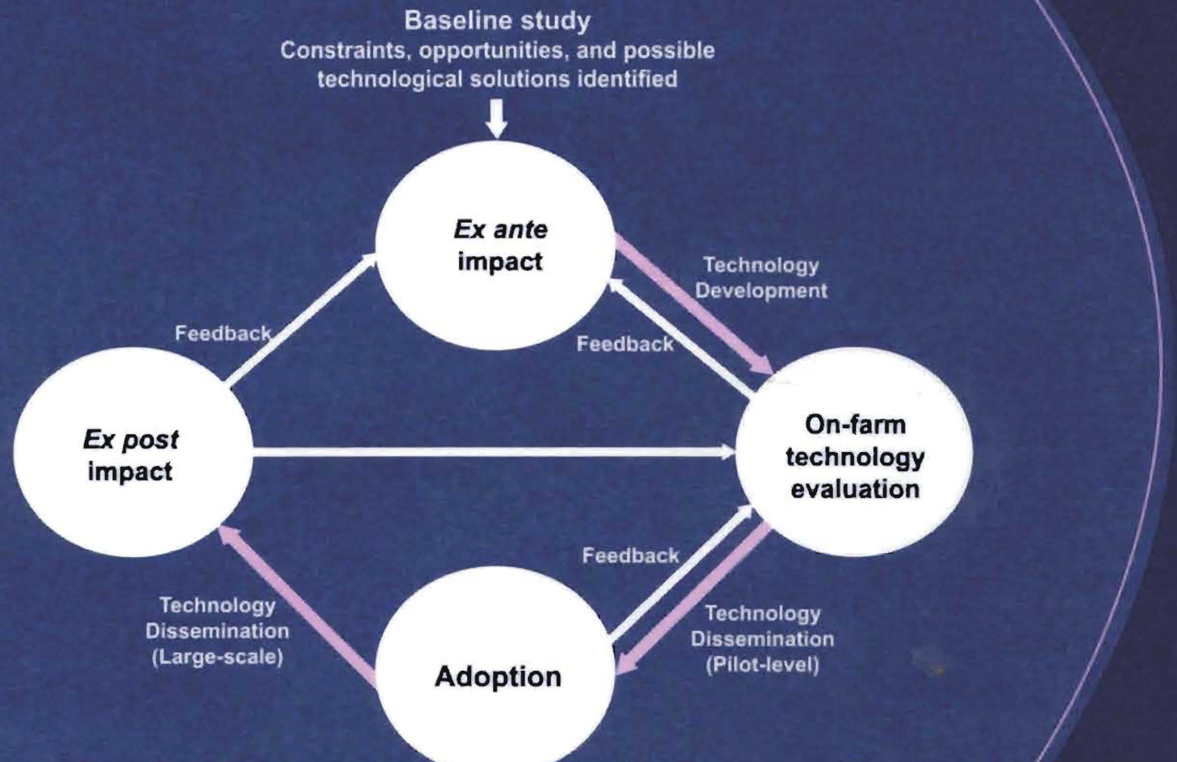
A framework for conceptualizing impact assessment and promoting impact culture in agricultural research



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Abstract

Assessing the impact of agricultural research can assist with setting priorities, providing feedback to the research programs, and demonstrating actual benefits of the products of agricultural research. Towards this end, many national and international agricultural research centers have institutionalized impact assessment. However, a number of conceptual and operational difficulties remain that limit the scope and depth of impact assessment work. The objective of this document is to develop a framework for conceptualizing and promoting impact assessment in agricultural research. First, the linkages between agricultural research and rural livelihoods and the implications for evaluating the impact of agricultural technologies are illustrated, using the sustainable rural livelihood framework. Secondly, a strategy for institutionalizing an appropriate data system is proposed to make impact assessment an integral part of the agricultural research process. To operationalize the data system, data sheets for each stage of the impact assessment process are developed to guide researchers in gathering relevant and adequate information relating to each agricultural technology. Implementation of data systems requires biophysical and social scientists to work jointly towards generating and maintaining data for impact assessment.

Key words: Agricultural Research Centers; agricultural technology; data system; impact culture; sustainable livelihoods framework.

Introduction

Impact assessment of public agricultural research has always been viewed as an important activity to ensure accountability, maintain credibility, and improve internal decision-making processes and the capacity to learn from past experience. Impact assessment is a critical component of agricultural research in that it helps to define priorities of research and facilitate resource allocation among programs, guide researchers and those involved in technology transfer to have a better understanding of the way new technologies are assimilated and diffused into farming communities, and show evidence that clients benefit from the research products (Manyong et al. 2001).

The focus and methods of impact assessment have evolved over time in response to donor interest and research mandates. From a rather narrow emphasis on the adoption of new crop varieties in the 1970s, the focus of impact assessment activities expanded to estimating rates of return to research investments in the 1980s and to examining a wider range of impacts, including environmental benefits and costs and the distribution of benefits and costs across different socioeconomic groups in the late 1980s and 1990s. The focus has generally been on measuring the actual impacts of investments made in agricultural research, mainly in terms of the rates of return to research investments.

In view of declining funds for agricultural research and the need for stronger accountability in recent years, there is now a much greater demand not only for demonstrating the actual impacts of research but also for maximizing impacts through targeting research benefits to poor people. Despite the fact that the generation and dissemination of agricultural technologies requires sustained investments in research and extension, publicly funded agricultural research and extension budgets in developing countries have been declining in recent years. There has been increasing pressure to direct agricultural research towards the needs of small-scale farmers and the rural poor. Emphasis has more recently been given to sharpening the focus of international agricultural research based on its poverty alleviation impacts. More important in this regard has been the need to assess the potential impacts of agricultural research on poverty alleviation with a view to setting priorities of research (Kerr and Kolavalli 1999; Alwang and Siegel 2003).

Impact studies have, however, faced both conceptual and empirical challenges, partly due to the complexities of the relationships between agricultural technology and the various dimensions of poverty, with research having both direct and indirect effects on poverty alleviation (Kerr and Kolavalli 1999; de

Janvry and Sadoulet 2002). As the goals of agricultural technology development change from increasing food production to the broader aims of reducing poverty, both technology development and studies of its impact become more complex. Qualitative and quantitative information and qualitative and quantitative methods are needed to assess the impact of research on the poor. The context in which new technologies are released and adopted should also be examined for a better understanding of the impact of agricultural research on broader definitions of poverty and social outcomes.

Clearly, there is a need for greater institutionalization of impact assessment and impact culture with a better understanding of the complexities of the links between agricultural technology and rural livelihoods. Biophysical and social scientists as well as research managers need to have a shared understanding of the needs and demands of impact assessment in the context of poverty alleviation. The objective of this document is thus to develop a livelihood-based framework of impact assessment that can help scientists and managers to have a common vision of the needs and demands of impact assessment for them to jointly design and implement impact assessment, thereby building a favorable impact culture.

Conceptualizing the livelihood impacts of agricultural technology

Impact studies have faced both conceptual and empirical challenges, partly due to the complexities of the relationships between agricultural technology and rural livelihoods. As the goals of agricultural technology development change from increasing food production to the broader aims of reducing poverty, both technology development and studies of its impact become more complex. Yet, examining the impacts and impact pathways of different types of agricultural technologies is essential to guide future research in ways that will make the greatest contribution to poverty reduction. The sustainable rural livelihoods framework (SRLF) has been adapted and used in assessing the impact of new agricultural technologies on livelihoods (Kerr and Kolavalli 1999; Adato and Meinzen-Dick 2002).

The SRLF is a particular form of livelihoods analysis used by a growing number of research and applied development organizations, including the Department for International Development (DFID) of the United Kingdom (one of its most ardent supporters), the United Nations Development Program (UNDP), as well as nongovernmental organizations (NGOs) such as CARE and Oxfam (DFID 1997; Ashley and Carney 1999). It is primarily a conceptual framework for analyzing the causes of poverty, people's access to resources and their diverse livelihoods activities, and the relationship between relevant factors at micro, intermediate, and macro levels. The SRLF draws on a number of theoretical and conceptual approaches to development thinking; in this sense it is a holistic and synthetic framework rather than an entirely new set of concepts. What the framework does is to provide a method for thinking about the multiple and interactive influences on livelihoods without overlooking important explanatory factors. In this respect, it provides a "checklist" (Ashley and Carney 1999) of issues to be considered in designing research initiatives or program evaluations. Everything on the checklist cannot be included in one study, so prioritization is necessary. The framework has the advantage of allowing researchers to understand the parameters of the "big picture," and then to narrow the scope of the study to what can have the greatest impact or what is most relevant to the important stakeholders (including the researchers). The framework may guide researchers to consider and prioritize less visible factors and local priorities that may or may not revolve around production and consumption or even physical or financial resources, but could instead relate to education, safety, or legal rights. The SRLF brings in many considerations that are often not included in an impact study dealing with agricultural technologies. At the same time, it may not be obvious how agricultural research and technologies might fit into this framework (Adato and Meinzen-Dick 2002). Adapting the SRLF for the assessment of the impact of agricultural technologies on rural livelihoods is, therefore, always important.

In impact assessment, the assets upon which people build their livelihoods are of particular interest. This includes a wider range of assets than are usually considered. Rather than looking only at land or other classic wealth indicators, the SRLF suggests consideration of an asset portfolio of five different types of assets.

1. Natural capital: land, water, forests, marine resources, air quality, erosion protection, and biodiversity.
2. Physical capital: transportation, roads, buildings, shelter, water supply and sanitation, energy, technology, communications, or other household assets.
3. Financial capital: savings (cash as well as liquid assets), credit (formal and informal), as well as inflows (state transfers and remittances).
4. Human capital: education, skills, knowledge, health, nutrition, and labor power.

5. Social capital: networks that increase trust, ability to work together, access to opportunities, reciprocity; informal safety nets; and membership in organizations (DFID 1997).

Agricultural technology is the product of agricultural research. It includes modern crop varieties, crop and resource management (CRM), plant health management (PHM), and postharvest (PH). Rural people pursue different livelihood strategies by combining their assets and agricultural technology to achieve their goals, and these are referred to as livelihood outcomes. These encompass many of the types of impact of interest for the study of the impact of agricultural technologies on rural livelihoods. The SRLF needs to be adapted to explicitly account for the interactions between livelihood assets and agricultural technology. Furthermore, there is a need to account for the role of research-for-development in shaping policies, institutions, and processes, instead of research success being fully conditioned by these factors. Such a framework helps to conceptualize how such an approach could not only enhance technology adoption, but also demonstrate development impact that would not have been possible with the simple dissemination of particular technologies.

Impact on agricultural productivity and on rural incomes has been an important contribution of the CGIAR centers since their inception. Apart from directly shaping policies and institutions, the impact of agricultural research-for-development itself may influence agricultural policy when successful research-for-development practices, which obviously have elements of appropriate policies and institutions as part of the "package", are taken up and applied at a larger scale. Agricultural policy, however, affects the level of agricultural research impact through its effects on incentives for technology adoption. A promising strategy to minimize the influence of unfavorable policies and institutions is to broaden the scope of research to include aspects of development using the technologies as a means. A framework representing these interactions among agricultural research, policy, and livelihoods is needed for a more complete understanding of the impact of new agricultural technologies on rural livelihoods and on poverty alleviation.

The fact that livelihood outcomes strengthen the five livelihood assets means that researchers can adopt a simple framework to assess the impact of agricultural technologies on rural livelihoods. For example, livelihood outcomes associated with income changes represent changes in financial capital and if this has been mediated through a new agricultural technology, it represents the impact of the technology on the financial capital of rural people. Outcomes associated with positive changes in the natural resource base represent impacts on natural

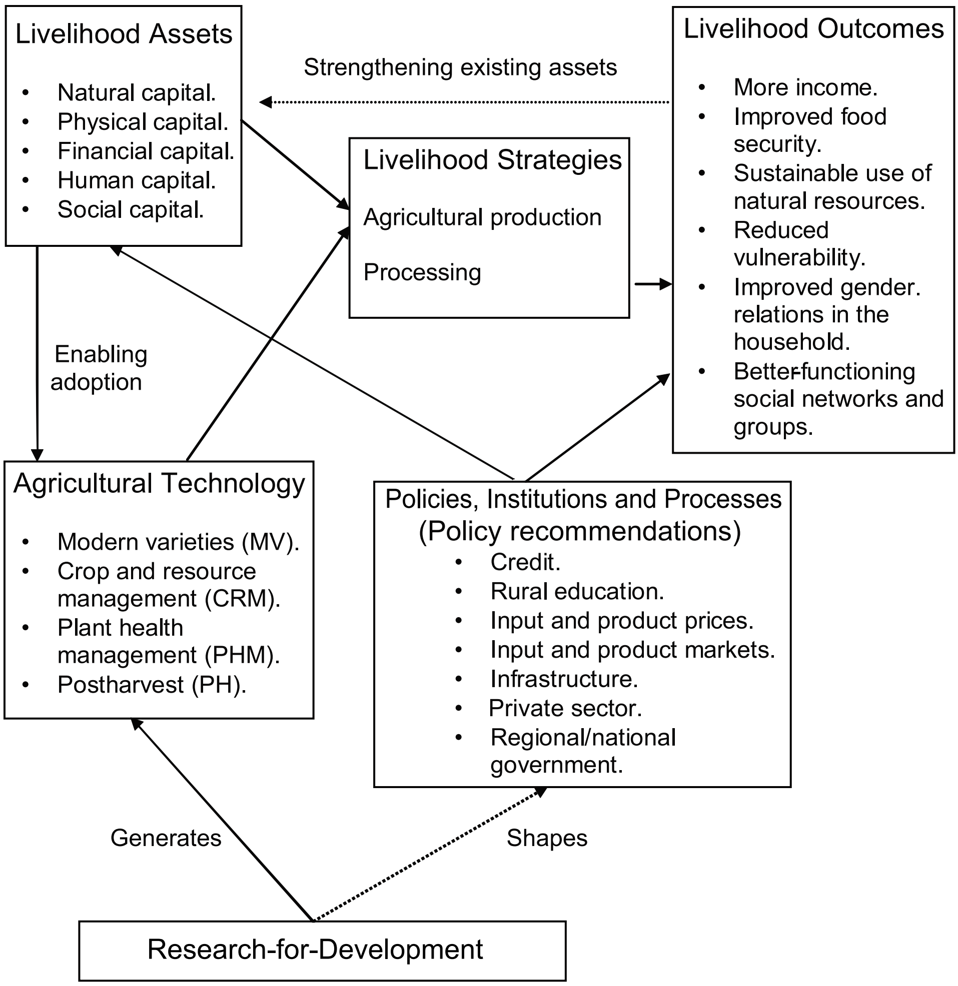

Figure 1. A sustainable livelihoods framework with agricultural technology.
Source: Adapted from DFID 2001.

capital; outcomes associated with changes in the education and health status of children and women represent impacts on human capital; outcomes associated with changes in intrahousehold gender relations, social networks, and collective action represent impacts on social capital; and outcomes associated with changes in village services and/or household facilities represent impacts on physical capital. Furthermore, the influence of capital assets on technology adoption is another important aspect that needs to be explored. This requires an integrated adoption and impact framework that looks into the two-way relationships between technology adoption and livelihood assets. Figure 1 gives a conceptual framework to help researchers to understand these relationships. Although the assets–technology adoption–assets relationships are simple to describe, verifying the importance of these relationships requires an innovative methodology that accounts for the complexity of the interactions.

This conceptual framework illustrates the important interactions among agricultural technology, assets, policies and institutions, and rural livelihoods. These interactions have implications for research on the adoption and impact of agricultural technologies. Livelihood assets and agricultural technology are combined to pursue an agricultural production-based livelihood, and this yields several livelihood outcomes— more income, improved food security, sustainable use of natural resources, reduced vulnerability, improved gender relations in the household, and better-functioning groups in the community. Assets, technology, and livelihood strategies are conditioned by policies and institutions, as these influence the initial endowment of assets, the rate and speed of adoption of technology, and the actual livelihood strategy (i.e., agricultural production).

Assets have both a direct and an indirect impact on livelihood outcomes, such as income and food security, and these again strengthen existing levels of assets. The direct impact of assets on livelihood outcomes is their mere employment in the agricultural production process, with more assets leading to more income and food security. The indirect impact of assets is the impact through the adoption of new technology, with more assets stock, such as land and livestock, enabling greater adoption of technology and hence leading to more income and food security. The implication of this for the impact assessment of agricultural technologies is that researchers need to account for initial asset endowments to isolate the impact of new technology on rural livelihoods. This means that technology adoption is endogenous and cannot independently have an impact on livelihoods.

Complexity of the agricultural technology–poverty alleviation links

Technological change is believed to lead to poverty alleviation through positive effects on consumers' food prices, producers' incomes, and laborers' wage incomes (Winkelmann 1998). Higher productivity, better natural resource management, and poverty alleviation are mutually reinforcing and lead to the achievement of a sustainable food system. However, many households have complex livelihood strategies that cross the simple boundaries of being farmers, or laborers, or consumers. They may engage in all three of these activities, farming a small plot and selling some of the product, earning wages as laborers on someone else's farm, and purchasing agricultural products on the market. For such households, the effects of changes in output, prices and wages may have complex effects.

Consider a situation where an increase in agricultural productivity has four positive impacts: (1) producers have higher output, (2) laborers receive higher wages and more employment, (3) prices fall so consumers pay less for food, and (4) economic growth raises overall sales and employment opportunities. However, the four impacts will have competing effects on households that are simultaneously producers, wage earners, and consumers. For example, lower food prices mean less income earned through sales but less expenditure through purchases. If a farm household sells part of its production but also purchases food, then whether it benefits from lower prices will depend on whether it is a net seller or net purchaser of food. If the household hires labor in for some operations but hires labor out at other times, then the effect of rising wages on its welfare will depend on whether it is a net buyer or a net seller of labor services. In this hypothetical scenario, technical change causes the marginal products of land and labor to rise; labor demand rises per unit of land but falls per unit of product. Note that for most of the household categories, the net effect of changing outputs and prices is ambiguous. This means that the theoretical net effect of the changes is uncertain, because the various positive and negative effects counteract each other (Kerr and Kolavalli 1999).

For example, for the net seller of food/net buyer of labor, increased agricultural productivity may be so great that it outweighs the higher use of labor, the higher wages, and the lower output price. But the opposite outcome could equally apply and the actual outcome will vary case by case. Similarly, in this hypothetical scenario, the landless worker who sells labor and buys food benefits unambiguously from technical change. However, it would be just as easy to construct a case in which the net effect was ambiguous or negative, such as if wages rose but the number of days of employment decreased. In any case, this example shows the complexity of the impact of increased productivity on different categories of households.

In view of the complexities of the research–poverty linkages and the limited scope for targeting research benefits to the poor, Byerlee (2000) argues that enhancing the efficiency and effectiveness of research systems in promoting broad-based technical change should be emphasized more than major efforts to target poverty directly. The scope for targeting poverty is limited, mainly due to the direct as well as the indirect effects of agricultural technology on poverty. However, de Janvry and Sadoulet (2002), using a general equilibrium model to assess the relative role of the direct and indirect poverty alleviation impacts of agricultural technologies in Asia, Latin America, and Africa, found that, in sub-Saharan Africa (SSA), the direct poverty alleviation impacts of agricultural technology are more important than the indirect effects. Therefore, there is arguably a good case for a poverty-based approach to assessing the impact of agricultural research.

The products of agricultural research and the scope of impact studies

Varietal technologies

Improved genetic material embodied in seeds is the most fundamental and perhaps most familiar type of agricultural research output. "Improved" may refer to any of several desirable characteristics: higher potential grain yield, responsiveness to other inputs such as fertilizer and/or irrigation, greater tolerance to stresses such as droughts, pests or diseases, a shorter duration (length of the growing season), longer storage capability after harvest, higher nutrient content, better taste, and higher fodder quantity or quality (Anderson 1997). In practice, most research on modern varieties has focused on raising yields, reducing susceptibility to various stresses, and reducing the length of the growing season. Most impact studies have addressed commodity-specific research and, within that category, there has been an overwhelming emphasis on varietal technologies.

Nonvarietal technologies

Many of the products of research are not embodied in tangible inputs, such as seeds, but are provided as information, in the form of a recommendation. Some examples of these improvements are better information on the most suitable inputs, improved management techniques such as methods and levels of application of inputs, and improved cultural practices. Farmers obtain new information through explanations on field days, recommendations in extension bulletins, intermediary contacts, and fellow farmers (Baidu-Forson 1996). CRM and PHM research may account for half of all crop research (Traxler and Byerlee 1992). It aims to develop new techniques to manage natural resources and material inputs in a way that raises production. This can involve identifying optimal combinations and quantities of inputs or developing better management practices that do not involve material inputs, such as improved timing of operations and crop rotations (Baidu-Forson 1996). Integrated pest management practices are another category of nonvarietal technologies dealing with the management of insect pests through techniques, such as crop rotations and biological control.

Adoption of CRM and PHM technologies is often difficult to track, complicates attribution to research, and raises thorny problems of valuation. CRM and PHM are generally more complex innovations than improved varieties, and methods for impact assessment are less well developed and study results are fewer. Little impact assessment has been carried out on the impact of CRM technologies although this type of research accounts for about one-half of all crop research in developing countries (IAEG 1999; Pachico 1998; 2001). Information from CRM and PHM experiments is usually summarized in the form of production recommendations with defined rate, timing, and methods for using inputs, as well as the conditions under which these recommendations apply (Baidu-Forson 1996). The value of improved input management information depends on the interaction of input response with location-specific climatic and field conditions (e.g., integrated pest management or phosphorus maintenance doses conditional on soil test information) (Perrin 1985; Blackmer and Morris 1992).

It is especially difficult to measure the benefits of improved information from research compared to what would have occurred in the absence of the program. The effects of research must be separated from other sources of information, including farmers' learning-by-doing and private sector suppliers. Often this is approximated by the yield and cost differences between adopters and nonadopters of a management practice—that is, the area between the "with" and "without" adoption curves (Baidu-Forson 1996; Joshi and Bantilan 1998). Traxler and Byerlee (1992) provide a framework for assessing benefits in such situations. First, identify research areas for which an improved management practice has been supplied as a new recommendation (i.e., new information) issued to farmers. Secondly, determine which practices the farmers have modified in a manner consistent with the new recommendation. Thirdly, determine whether a revised recommendation has caused the change in farmers' practice. Fourthly, measure the impact of each research-induced change in CRM or PHM on economic surplus. Fifthly, sum the economic surplus across practices and compare the benefits stream to the costs of research and extension. A refinement of the above approach is to track changes in farmers' subjective beliefs about payoffs to a practice in response to improved information provided by research (Feder and Slade 1984; Pingali and Carlson 1985).

Even more complex is the issue of assessing the impact of a policy recommendation. What would be the impact of the removal of subsidies on external inputs, setting new standards on the commercialization of an agricultural product, the structural adjustment program on the African economies, or the application of new World Trade Organization regulations on the agricultural sector of a country? The "before and after" approach in impact assessment could be applied. As for CRM, the effects of research on policy information must be separated from other sources of information.

Impact assessment as a process

Impact assessment of agricultural research is a continuous process (Manyong et al. 2001). Impact assessment, being a process, is better conceptualized as a cycle involving different types of impact studies at the different stages. Impact studies essentially have the same process as technology development itself. Based on the technology development process, therefore, four stages of impact assessment would constitute the impact cycle. These include impact for priority setting (i.e., *ex ante* impact), on-farm technology evaluation, adoption, and *ex post* impact. The different types of impact studies are not mutually exclusive; they rather serve distinct and at the same time complementary functions in the technology development and dissemination process.

Ex ante *impact assessment*

Ex ante impact assessment is undertaken before the project or program is initiated as an aid in priority setting, based on the potential impacts of alternative research portfolios on aggregate net benefits or on poverty alleviation. *Ex ante* impact studies are conducted to estimate the expected returns from current alternative research efforts. Assessment of future impact includes measures of productivity impacts, distribution of economic benefits, and effects on environmental quality. Assessing expected impact is a two-stage process (Pachico 2001): (1) scenarios are generated with the conditions expected in the future without the proposed research; and (2) the impact of potential research innovations is estimated. Considerable uncertainties exist in the generation of future scenarios as well as in the projections of expert knowledge of the potential payoffs from research and the probabilities of success (Alston et al. 1995). In practice, *ex ante* impact studies have been conducted for just a single technology development program based on information obtained from on-farm trials and thus have little or no priority setting motivation (e.g., Kristjanson et al. 2002). Such studies provide valuable information on the potential impact of the technology developed and help to make the case for continued efforts and investments in technology promotion. However, their application is limited by the fact that major investments in the research have already been made and hence there is little scope for resource reallocation at that stage.

Greater emphasis has now been given to the assessment of the potential poverty alleviation impact of agricultural research with a view to research priority setting (Alwang and Siegel 2003).

On-farm technology evaluation

After research priorities have been set, researchers embark on technology development. This could involve the on-station development of new crop varieties, crop and natural resource management practices, or pest management practices. These technologies will then undergo on-farm testing with the farmers. Some technology development activities may involve only on-farm evaluation of technologies already available. On-farm testing is useful for evaluating technologies in a wider range of conditions than is available on-station. They are carried out to test, with farmers and on their plots, the acceptability and profitability of the technology developed or technologies already available before they are promoted at a larger scale.

On-farm trials are important for obtaining realistic input–output data for cost–benefit analysis. Cost–benefit analyses conducted on experiments on-station differ from those conducted on-farm because (1) yield response is often biased upward, (2) estimates of labor used by station laborers on small plots are unrepresentative of the farming community, and (3) operations often differ, e.g., when tractors instead of oxen or hoes are used for preparing land. And finally, on-farm testing provides important diagnostic information about farmers' problems. Even if diagnostic surveys and appraisals have already been conducted, researchers can still learn a great deal about farmers' problems, preferences, and livelihood strategies from interacting with them in on-farm trials. Trials have important advantages over surveys in that they are based on what farmers do, rather than on what they say. Studies carried out during on-farm technology generation help researchers to better understand the early adoption processes involving the integration of farmers' indigenous knowledge into the scientific knowledge of researchers.

Adoption

Adoption studies are carried out to monitor the level and pathways of adoption and the impact of proven technologies on farm-level productivity during the technology promotion stage. These studies measure the extent of use of the technology, the performance of the technology (productivity changes, advantages, and disadvantages), changes in farm management induced by the new technology, and characteristics of the diffusion process. The essential information includes the following (IAEG 1999; Manyong et al. 2001; Pachico 2001; Bantilan and Dar 2001): (1) levels and speed of adoption, and reasons for nonadoption of technology; (2) farmers' perceptions of desirable traits or features of the technology options; (3) farm-level productivity and income gains due to the alleviation of biotic and abiotic constraints; (4) impact on the welfare of the farm household, for example, in terms of the intrahousehold distribution of income, nutrition, and health; and (5) infrastructural, institutional, and policy constraints hindering technology adoption.

Farmers' perceptions of important constraints, desirable cultivar traits, and management practices are very useful. First, they help in identifying binding constraints and research opportunities. Secondly, they provide an empirical basis for estimating expected ceiling levels of adoption. Technologies introduced in an environment characterized by significant constraints to adoption cannot be expected to have high levels of adoption ceilings unless these constraints are addressed. Thirdly, research options which directly address users' needs are most likely to be adopted. Adoption studies are usually conducted as case studies, which are chosen on the basis of scientists' views on the importance and potential of different technologies, research cost, funding availability, and some balance among different research lines.

Ex post *impact assessment*

Ex post impact assessment is conducted after a technology has been widely adopted by farmers in the target areas. *Ex post* impact assessment develops the confidence of scientists, research managers, and stakeholders and makes the case for enhanced research support (Bantilan and Dar 2001). In addition, information obtained during the process of impact evaluation feeds back into research prioritization. Figure 2 illustrates the impact assessment process. Impact assessment begins with a priority setting task using *ex ante* impact analysis that estimates the potential impacts of alternative research portfolios on poverty alleviation or aggregate net benefits. This is based on data generated from a baseline survey, expert knowledge (e.g., from biophysical scientists and research managers), and information from previous adoption and impact studies. Baseline data allow researchers to establish the current levels of poverty; information from biophysical scientists and research managers helps to predict likely changes in yields, costs, and other needed parameters; and information from previous adoption and impact studies is used to identify alternative technologies that would address the major production constraints while at the same time taking into consideration farmers' preferences and farming conditions.

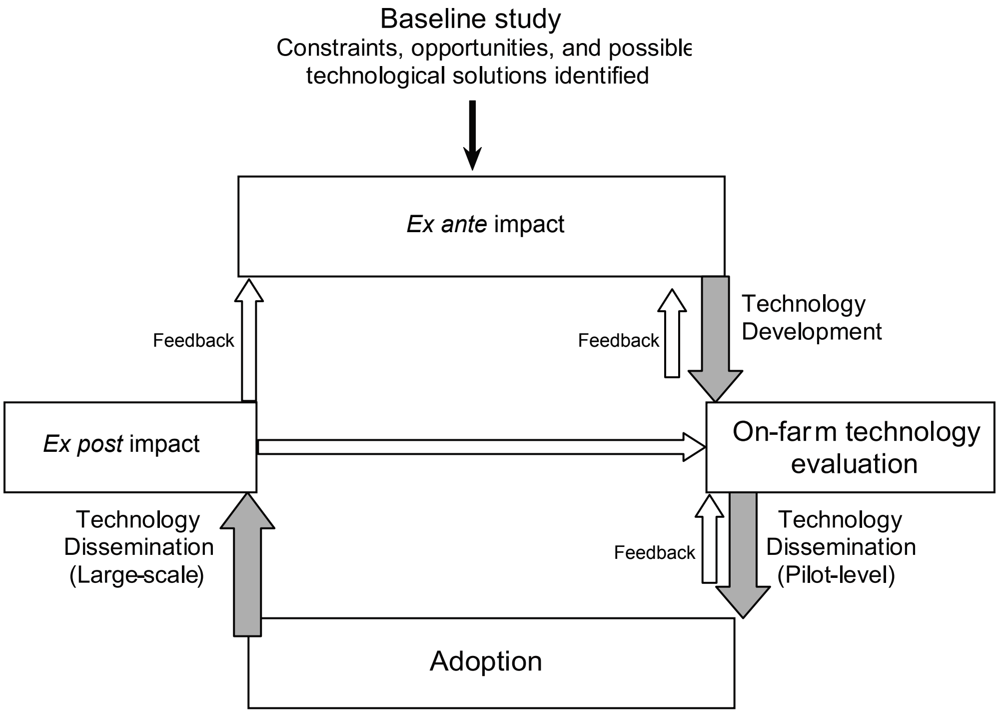

Figure 2. The impact assessment process.
Source: Own formulation.

Priority setting is followed by (on-station) technology development and on-farm evaluation that are carried out to identify an appropriate technology under farmers' conditions and based on their priorities and preferences. Appropriate technologies are then promoted or scaled-up and out, starting from the initial trial-hosting villages to other villages, districts, provinces, and regions. As technology dissemination is underway, adoption studies become very important to document the process and levels of adoption and changes in productivity and cropping pattern. These are usually conducted as case studies on adoption and impact. Finally, *ex post* studies on adoption and impact are carried out following large-scale dissemination of the technology. In practice, however, case studies on adoption and impact, such as those conducted in the technology demonstration villages, are considered as *ex post* impact studies. While this does not have any practical implications for methods and results, it may be important to make a clear conceptual distinction between the two. The impact assessment process becomes complete when adoption and impact information obtained from *ex post* impact studies is fed back to *ex ante* impact studies and the process continues, as technology development itself is continuous.

A data system for impact assessment in agricultural research

Impact assessment is a data-intensive activity. Collecting appropriate data is perhaps the most time-consuming and costly component of conducting impact assessment. Research programs usually balance data needs between the ideal (and costly) and the practical, and must draw data from various sources. If impact assessment is to become an integral part of the research process in agricultural research, it is important that an appropriate data system be institutionalized within the research system. Institutionalizing a data system also ensures that the information generated by research is available in a systematic and timely manner and is retained for future use as the staff and the Institute change and evolve.

A key issue is the role of baseline and panel surveys to provide data on benchmark-related household variables as the basis for adoption and impact. Many types of impacts can only be adequately assessed if relevant baseline data exist (especially for disembodied research products), and regular surveys, preferably of the same households, are undertaken over-time to monitor changes in farmers' practices. Having a panel of the same households allows regular monitoring of the changes in key farm practices and productivity indicators related to the most important types of research outputs. The sample should be representative of an important subset of the mandate area. The data collection system requires a clear definition of the key parameters, sample size, frequency of data collection, and benchmark sites. Collection of such data should become an integral part of agricultural research.

Research product-based data

An explicit focus on assessing the potential as well as the actual poverty alleviation impacts of agricultural research has been emphasized in recent years. The complexity of the technology–poverty links and lack of data and appropriate methods have limited analysis of the poverty alleviation impacts of agricultural research. An appropriate conceptualization of the livelihood impacts of improved technology and a greater impact culture are important to jointly generate and maintain adequate data relating to all agricultural technology development.

One of the issues to be considered in collecting and organizing data for impact assessment is how such data should be organized. Because impact assessment relates to a given agricultural technology that is to be developed, or a technology that is being tested, or has been promoted in a given area, data need to be organized for each such technology. That is, data should be research product-based, regardless of disciplines involved or the project(s)/program(s) generating the technology. In fact, project and program evaluations will still be based on the evaluation of the products in terms of relevance, acceptability, and impact on livelihoods. This means that research product-based impact assessment is the building block of impact assessment at all levels (i.e., project, program, and institutional levels). Data are needed on a range of variables disaggregated by research product, including MV, CRM, and PHM technologies and policy recommendations.

It should be noted, however, that varietal technologies could involve improved CRM technologies when they are promoted as a package. For example, the International Institute of Tropical Agriculture has developed an improved cowpea technology package composed of improved variety seed, a cropping pattern (two rows of cereals × four rows of cowpea), and appropriate applications of fertilizer and insecticides (Singh and Ajeigbe 2002). That is, the technology package has both the varietal and nonvarietal (i.e., CRM) technologies. Given that the development of the improved variety has been the major focus of the research, such technologies could reasonably be categorized as varietal technologies. This also has the advantage of more easily identifying the technology and assessing its impact after it has been widely disseminated. Similarly, technology packages consisting of both improved varieties and CRM or PHM technologies, but with the CRM or PHM as the major focus of the technology development process, could be categorized as CRM or PHM technologies. In such packages, the varietal technology would already be available and would not be developed.

The nature of the data (i.e., type and source of data) to be organized for a given agricultural technology depends on the stage of the technology development and dissemination process and the objective of the envisaged impact assessment. As there are four types of impact assessment in the impact assessment process discussed in the preceding section, there should be four categories of data. However, differences could be only in terms of, for example, the source of data (e.g., farmers participating in technology evaluation, sample of farmers in adopting villages, sample of farmers in the larger target area) and not in terms of type of data.

Ex ante *impact data*

Ex ante impact studies are mainly needed for priority setting purposes. Emphasis has shifted away from aggregate benefit-based priority setting to an explicit focus on the poverty alleviation impacts of agricultural research.

Assessment of the potential impacts of alternative agricultural research schemes on poverty alleviation has been proposed as an approach to priority setting in view of declining research budgets and growing concern about worsening poverty, especially in SSA. It is acknowledged that the poverty alleviation impacts of agricultural technologies are often not quantifiable and depend on a number of factors. For instance, cropping patterns might change following the introduction of a new variety; changes in these patterns are difficult to predict. If increased productivity stimulates the demand for labor and the poor tend to be the suppliers of off-farm labor, then indirect labor market effects, such as increased employment and higher wages, may exceed the direct effects of productivity gains on the farm incomes of the poor. Moreover, agricultural productivity growth can stimulate broader development of the rural economy, which also contributes to poverty alleviation. As noted earlier, however, the direct poverty alleviation impacts of agricultural technology are more important than the indirect effects in SSA.

For poverty-based impact assessment, a structured database needs to be established from various sources. First, a survey of nationally representative sample rural households will generate data needed to compute the baseline poverty levels. These include off-farm income, land allocation to various crops, crop-specific uses of labor, animal power, fertilizer and pesticides, total production by crop, input and product prices by crop, and levels and intensities of adoption of a similar technology (e.g., a second generation variety that replaces a previously introduced improved variety due to declining yields after some years). It should be acknowledged that this is a gradual process whereby nationally representative data for most countries in SSA will be added to the database only as they become available. Secondly, expert knowledge (e.g., researchers, research managers, etc.) will be elicited to predict crop-specific yield changes associated with each new research program. Specifically, this relates to yield losses without improved technology (i.e., for resistant crop variety development, natural resource conservation, etc.), expected yield gains, expected requirements per unit of land, of inputs such as labor, animal power, fertilizer, and pesticides. Moreover, as yield gains (and losses) are expected to vary across agroecological zones (e.g., high and low potential), information relating to yield gains may have to be obtained for each zone.

With household-level data, income growth associated with crop-specific yield changes can be aggregated to create measures of change in poverty. In a household income determination framework, the data will be used to re-compute household income and hence poverty indices associated with each technology.

This will give an insight into the poverty-reducing effects of each technology and allow an objective prioritization of research programs.

On-farm technology evaluation data

On-farm trials provide a good opportunity for the assessment of the profitability and acceptability of the improved technology. That is, the potential adoption of the technology can be analyzed using information obtained from the on-farm trials and this makes the case for the promotion of the technology. The data used for previous *ex ante* impact assessment for priority setting, some of which are based on expert knowledge rather than actual observation (e.g., yield changes), could also be updated using on-farm trial data. This would be used for future priority setting as well as reassessment of the potential poverty alleviation impact of the current technology to provide further grounds for additional investments in the agreed research portfolio.

Impact assessment at this stage requires adequate data to be collected on critical variables relating to both the traditional and the improved technology. The assessment of profitability requires data on yields, labor, animal power, organic and inorganic fertilizer, pesticides, and the unit prices of all the inputs used and the output produced. Data should cover both the farmers' practice and all technologies tested. Realistic data can be obtained only if farmers manage the trials to their own standards. Thus, profitability objectives require trials in which researchers have considerable input in the design but farmers are responsible for implementation. The objectives of assessing feasibility and acceptability require data on farmers' assessments and adaptations of the technology.

Adoption data

Lack of adequate data and documentation of the adoption process itself usually limits the monitoring of progress towards the research targets or milestones. A strong data system will greatly help to monitor progress towards the research targets and to finally validate initial technology adoption and impact targets. Each agricultural research center needs to devise strategies to set up farm-household and farm-plot panels, where a representative sample of households and their farms are regularly monitored and all the relevant data are collected. The panel should preferably be in the important mandate areas where most technology adoption occurs to capture much of the dynamics of technology adoption and poverty. This will help in establishing a database, including data on farm and household characteristics, cropping pattern, and the adoption of new technologies – why and since when, sources of improved seed and information on improved crop and natural resource management practices, postharvest details, pest and disease problems, characteristics/traits of the technology leading to adoption, and constraints to adoption. Analyzing this information from selected locations will give an idea of the dominant cultivars in the locations and the reasons for adoption/nonadoption of these cultivars, which can be fed back to researchers. The panel data to be collected from the households should also be geo-referenced using global positioning technology to allow future researchers, and future generations of researchers, to return accurately to the same fields and farms to update the information.

Ex post *impact data*

This relates to data needed to assess the impact of an agricultural technology after it has been widely disseminated and used (i.e., target areas). A combination of the adoption data generated from the panel households after a technology has been widely adopted and of data on livelihood outcomes will allow an appropriate assessment of the actual poverty alleviation impact of the technology. In a study of the impact of agricultural research on poverty alleviation, the outcome in question is poverty or poverty alleviation. However, poverty is difficult to define, let alone measure. The livelihood outcomes in Figure 1 are good indicators of poverty alleviation. A variety of concrete indicators can be derived from the conceptual framework and the necessary information can be collected accordingly. (1) The technology's effects on income levels of adopters of the technology. (2) The technology's effects on food security indicators, such as daily per capita food consumption. (3) The technology's effects on food and nutrition indicators, such as weight-for-height, weight-for-age, height-for-age, particularly for the most vulnerable people, such as infants and pregnant and lactating women. (4) Whether the technology has contributed in terms of smoothing household consumption and income streams, thereby reducing the vulnerability of the households. This is important because, if income is distributed evenly over-time, it will reduce the risk of the households falling into poverty during lean seasons or lean years. (5) Whether the technology has led to a sustainable use of natural resources in terms of, for example, increased soil fertility and of the environment in terms of reduced pesticide use. (6) Whether the technology has improved intrahousehold gender relations for a better intrahousehold distribution of benefits. (6) Whether the technology has strengthened social networks and the functioning of local organizations.

It should be noted that it is not every technology that brings about all the above changes. The magnitude and types of impacts of a technology depend on the type of the technology itself (i.e., MV, CRM, PHM, PH, policy or a combination of two or more of these), the time since initial adoption, socioeconomic setting, and the objective with which the technology was developed. Nevertheless, being aware of the possible impacts of a given technology helps researchers to examine the wide-ranging poverty impacts of agricultural technologies. The indicators help researchers to overcome the complexities associated with defining and measuring poverty.

It is acknowledged that, in the long term, there would be second-order effects of the technology on different types of households, regardless of adoption status. These are mainly in the form of reduced food prices for net buyers of food and increased labor demand and the subsequent wage increases for net suppliers of off-farm labor. Impacts on the different households depend on a variety of factors and the magnitudes are difficult to predict in view of the complexity of the technology–poverty links. Therefore, it is more appropriate to address the direct impact of agricultural technology on poverty alleviation as measured in terms of the different livelihood outcomes.

Guidance sheets for impact data

An important step towards operationalizing data systems is to develop data sheets to guide researchers in gathering relevant and adequate data in the process of technology development and dissemination. Guidance sheets serve as useful operational tools to facilitate the collection of agricultural technology-based data, described in the preceding section, relating to the four stages of the impact assessment process. Data should relate to each agricultural technology, including MV, CRM, PHM, and PH technologies and policy recommendations. In this way, instead of highly scattered and inadequate data that may be available with researchers, standardized and adequate data can be made available and maintained for impact assessment. Four basic guidance sheets, relating to each of the types of impact assessment, are proposed (see Annex 1–4).

Implementation strategy

Biophysical and social scientists should work together towards generating and maintaining impact assessment data. Social scientists should take the lead in designing and conducting surveys of sample households in case-study areas to study adoption as well as in the larger target area for *ex post* impact assessment. Whether surveys of nationally representative sample households to generate data for *ex ante* impact assessment should be conducted by a research center depends on budgets, the availability of such data, and the ease with which these could be obtained from the responsible offices or ministries in the various countries. Data for *ex ante* impact assessment and priority setting (see Annex 1) can be elicited from researchers (national and international). The data for on-farm evaluation can be collected from all farmers participating in on-farm evaluation. Social scientists, in collaboration with the biophysical scientists, should design appropriate questionnaires to facilitate the collection of on-farm evaluation data. Biophysical scientists can keep good records of the appropriate information as they carry out the on-farm experiments with farmers. This approach is believed to facilitate the process of building an impact culture and institutionalizing impact assessment in agricultural research centers.

Conclusion

Since agricultural research is one of many competing investment alternatives, governments and donor agencies are demanding stronger and clearer evidence of the poverty alleviation impacts of their investments in agricultural research. Moreover, scientists and research managers within the research institutions need information on the adoption and impact of agricultural technologies to provide feedback to their research programs. Through a better understanding of how agricultural technologies influence the livelihoods of farmers, impact assessment can assist with (1) setting agricultural research priorities and allocating research resources across programs, and (2) demonstrating actual impacts of the products of agricultural research on rural livelihoods.

A rural livelihood-based conceptual framework of the impact of agricultural research is developed to help researchers to better understand the technology–livelihood links and the implications for impact assessment. Impact assessment is conceptualized as a process involving *ex ante* impact for priority setting, on-farm technology evaluation to identify appropriate technologies with farmers, adoption to document the diffusion process during the promotion of the technology and monitor progress towards the stated project goals, and *ex post* impact to assess the impact of the technology after it has been widely disseminated in the target region.

A strategy for institutionalizing an appropriate data system is proposed to make impact assessment an integral part of the research process at an agricultural research center. This ensures that the information generated by research is available in a systematic and timely manner and is retained for future use as the staff and the Institute change and evolve. To operationalize the data system, data sheets for each stage of the impact assessment process are developed that can guide researchers in gathering relevant and adequate data relating to each agricultural technology, including MV, CRM, PHM, and PH. In this way, instead of highly scattered and inadequate data that may be available with researchers, standardized and adequate data can be made available and maintained for impact assessment. Implementation of data systems requires that biophysical and social scientists work together towards generating and maintaining impact assessment data. Social scientists should take the lead in designing and conducting sample surveys, whereas biophysical scientists gather relevant data as they carry out the on-farm experiments with farmers through direct observations of practices and discussions with participating farmers. The success of this joint approach in establishing a data system depends largely on the common understanding and commitment of biophysical and social scientists.

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Annex 1. *Ex ante* impact data sheet

Description of variable/parameter	Data /Data source
Type of technology to be developed (MV, CRM, PHM)	Example: MV
Description of the technology to be developed	Example: Drought resistant maize
Current average on-farm yield with old technology (kg/ha)	Researchers' estimates
Expected on-farm yield with new technology (kg/ha)	Researchers' estimates
Current average labor use with old technology (days/ha)	Researchers' estimates
Expected average labor use with new technology (days/ha)	Researchers' estimates
Current average inorganic fertilizer use with old technology (kg/ha)	Researchers' estimates
Expected inorganic fertilizer use with new technology (kg/ha)	Researchers' estimates
Current average animal power use with old technology (days/ha)	Researchers' estimates
Expected animal power use with new technology (days/ha)	Researchers' estimates
Current average pesticide use with old technology (kg/ha)	Researchers' estimates
Expected pesticide use with new technology (kg/ha)	Researchers' estimates
Research lags (between start of research and release of technology)	Researchers' estimates
Adoption lags (years between release and beginning of adoption)	Previous adoption studies; researchers' estimates
Ceiling adoption (maximum % of farmers adopting technology)	Previous adoption studies; researchers' estimates
Current land allocation to crops	Nationally representative sample surveys of agricultural households, agricultural census
Crop-specific input uses and production	Nationally representative sample surveys of agricultural households, extension services
Adoption and intensity of use of a related improved technology	Nationally representative sample surveys of agricultural households, extension services
Input–output prices	Nationally representative market surveys or survey of nearby markets
Off-farm incomes and transfers (e.g., remittances)	Nationally representative sample surveys of agricultural households

Annex 2. On-farm evaluation data sheet

Description of variable/parameter	Data/Data source
Type of technology being evaluated (MV, CRM, PHM)	Example: MV
Description of the technology being evaluated	Example: Drought resistant maize
Yields with old technology (kg/ha)	Survey of all control plots
Yields with new technology (kg/ha)	Survey of all treatment plots
Family labor used with old technology (days/ha)	Survey of all control plots
Hired labor used with new technology (days/ha)	Survey of all treatment plots
Inorganic fertilizer used with old technology (kg/ha)	Survey of all control plots
Inorganic fertilizer used with new technology (kg/ha)	Survey of all treatment plots
Animal power used with old technology (days/ha)	Survey of all control plots
Animal power used with new technology (days/ha)	Survey of all treatment plots
Pesticide used with old technology (kg/ha)	Survey of all control plots
Pesticide used with new technology (kg/ha)	Survey of all treatment plots
Land allocation to crops	Surveys of all participating farmers
Crop-specific input uses and production	Surveys of all participating farmers
Adoption of other improved technologies	Surveys of all participating farmers
Input–output prices	Survey of nearby markets
Farm and household characteristics	Surveys of all participating farmers
Technology characteristics and farmers' preferences	Surveys of all participating farmers
Production constraints	Surveys of all participating farmers

Annex 3. Adoption data sheet

Description of variable/parameter	Data /Data source
Type of technology being promoted (MV, CRM, PHM)	Example: MV
Description of the technology being promoted	Example: Drought resistant maize
Yields with old technology (kg/ha)	Survey of sample farmers (case study)
Yields with new technology (kg/ha)	Survey of sample farmers (case study)
Input use/ha with old technology*	Survey of sample farmers (case study)
Input use/ha with new technology*	Survey of sample farmers (case study)
Source of seed (MV) or information (CRM, PHM)	Survey of sample farmers (case study)
Household-level land allocation to crops	Survey of sample farmers (case study)
Household-level land under improved technology	Survey of sample farmers (case study)
Household-level crop-specific input uses and production	Survey of sample farmers (case study)
Adoption of other improved technologies	Survey of sample farmers (case study)
Input–output prices	Survey of nearby markets
Farm and household characteristics	Survey of sample farmers (case study)
Livelihood capital assets	Survey of sample farmers (case study)
Off-farm incomes and transfers	Survey of sample farmers (case study)
Support services (credit, extension, input supply)	Survey of sample farmers (case study)
Agroclimatic conditions	Village or district level secondary data
Constraints to adoption of technology	Survey of sample farmers (case study)
Technology characteristics and farmers' preferences	Survey of sample farmers (case study)
Household food consumption	Survey of sample farmers (case study)
Intrahousehold gender relations	Survey of sample farmers (case study)
Intrahousehold distribution of benefits	Survey of sample farmers (case study)
Social networks and groups	Survey of sample farmers and villages (case study)
Vulnerability (e.g., stability of incomes)	Survey of sample farmers (case study)
The diffusion process	Observation and documentation

Note: Inputs include family and hired labor, inorganic fertilizer, pesticides, and animal power.

Annex 4. *Ex post* impact data sheet

Description of variable/parameter	Data/Data source
Type of the technology disseminated (MV, CRM, PHM)	Example: Modern variety
Description of the technology disseminated	Example: Drought-resistant maize
Land area under new technology in target region (ha)	Statistical offices, FAO, NARS estimates
Total production under new technology	Statistical offices, FAO, NARS estimates
Yields with old technology (kg/ha)	Comprehensive sample survey in target region
Yields with old technology (kg/ha)	Comprehensive sample survey in target region
Input use/ha with old technology*	Comprehensive sample survey in target region
Input use/ha with new technology*	Comprehensive sample survey in target region
Source of seed (MV) or information (CRM, PHM)	Comprehensive sample survey in target region
Land allocation to crops	Comprehensive sample survey in target region, or agricultural census data
Land under improved technology	Comprehensive sample survey in target region or agricultural census data
Crop-specific input uses and production	Comprehensive sample survey in target region
Adoption of other improved technologies	Comprehensive sample survey in target region
Input–output prices	Market survey in the region
Livelihood capital assets	Comprehensive sample survey in target region
Livelihood strategies	Comprehensive sample survey in target region
Off-farm incomes and transfers	Comprehensive sample survey in target region
Farm and household characteristics	Comprehensive sample survey in target region
Support services (credit, extension, input supply)	Sample survey in target region or agricultural census
Agroclimatic conditions	Village or district-level secondary data
Constraints to adoption of technology	Comprehensive sample survey in target region
Technology characteristics and farmers' preferences	Comprehensive sample survey in target region
Household food consumption	Comprehensive sample survey in target region
Intrahousehold gender relations	Comprehensive sample survey in target region
Intrahousehold distribution of benefits	Comprehensive sample survey in target region
Nutrition status of women and children	Anthropometry measurements from comprehensive sample survey in target region
Social networks and groups	Comprehensive village and household survey in target region
Vulnerability (e.g., stability of incomes)	Comprehensive sample survey in target region
Natural resource base (e.g., changes in soil fertility status or afforestation)	Comprehensive sample survey in target region or agricultural census data

Note: Inputs include family and hired labor, inorganic fertilizer, pesticides, and animal power.

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IMPACT

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