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REPORT

# SCIENCE AND POVERTY

## An Interdisciplinary Assessment of the Impact of Agricultural Research

Ruth Meinzen-Dick, Michelle Adato, Lawrence Haddad, and Peter Hazell

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Ruth Meinzen-Dick
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Washington, D.C.
October 2004

ISBN 0-89629-528-1

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# Acknowledgements

This report synthesizes the results of a six-country, seven-case research project managed by IFPRI, with the country case studies led by the respective CGIAR centers identified in Table 1. Funding for the project was provided by the United Kingdom's Department for International Development (DFID); the Standing Panel on Impact Assessment (SPIA) of the CGIAR; the Australian Centre for International Agricultural Research (ACIAR); the Danish International Development Agency (DANIDA); the Government of the Netherlands; the International Fund for Agricultural Development (IFAD); and the Food and Agriculture Organization of the United Nations (FAO).

The authors thank Anthony Bebbington, Jere Behrman, and Robert Chambers for their contributions as members of the project's independent advisory committee and for their valuable comments on an earlier version of this report. They also thank Ruben Echeverria, Hans Gregersen, and Tim Kelley for their support and feedback on behalf of SPIA.

# Preface

Agricultural research has greatly increased the yields of important staple food crops, and for many people this has meant more food availability and trade opportunities. Yet many people in rural areas in developing countries still live in abject poverty. Therefore, policymakers, donors, and researchers are refocusing their priorities away from simply producing more food to making sure that agricultural research benefits the poor in particular.

How can we ensure that new agricultural technologies are appropriate for the different groups of people who most need assistance? Furthermore, how can we assess whether these new technologies actually reduce poverty? This report provides valuable answers by synthesizing lessons learned from seven case studies from around the developing world.

The studies show that measures of the direct impacts of new technologies on incomes and yields do not tell the whole story. Both economic and noneconomic factors (such as sources of vulnerability, gender roles, and the source of the disseminated technology) play an extremely important role in determining whether the poor adopt or benefit from a technology. In addition, social, cultural, and economic factors all influence whether the poor receive direct and indirect benefits from new technologies.

Therefore, it is crucial that impact assessments include a mix of disciplines and methods, and that researchers do not only focus on poverty-reducing impacts that are easy to measure. For the future, scientists and other decision makers designing new research programs need to understand all the social factors that will affect the uptake and impacts of technologies. They also need to understand poor people's strategies for managing risk and the importance and role of agriculture in their livelihood strategies.

The full results of this study (including results of the seven case studies cited), *Impacts of Agricultural Research on Poverty: Results of an IFPRI-Led Project of the CGIAR Science Council's Standing Panel on Impact Assessment*, edited by Michelle Adato and Ruth Meinzen-Dick, is available from IFPRI.

# Introduction

**Until recently, reducing poverty was a secondary goal of agricultural research. The primary focus was on increasing food supplies and reducing food prices, a strategy that successfully boosted the yields of important food staples. This was often good news for the poor, as increased productivity led to lower food prices and more jobs (both on and off the farm), cutting rural poverty significantly. However, benefits did not materialize for all poor people, and some indigent people were negatively impacted.**

Past efforts focused on boosting food production in irrigated and high-potential areas, but many poor people do not live in those areas, and those who do live there lack the assets (such as land, water, labor, and credit) needed to use new technologies. As a result, many of the poor could only benefit indirectly from technological change, and these benefits were often not sufficient to lift them out of poverty.

To benefit the poor, future research should target the areas where the largest numbers of poor people live and respond to their vulnerabilities and livelihood strategies. At the same time, more emphasis should be placed on improving the productivity of the crops that the poor consume most.

Any efforts in this direction will fail unless new technologies are appropriate to the conditions faced by the poor. Indeed, two major reviews of the literature on agricultural research and poverty reduction[1] conclude that it is not just the characteristics of a certain technology that determine whether it will benefit the poor. Underlying social, economic, and cultural conditions also play a crucial role.

We must understand how agricultural technologies influence—and are influenced by—different socioeconomic conditions, which include the diverse livelihood strategies used by the poor as well as the gender and power relationships that affect them. In addition, we must appreciate their vulnerability to factors such as weather, pests, diseases, labor shortages, credit squeezes, or economic shocks.

If research is going to focus more on poverty reduction, we also must strengthen our ability to identify and measure poverty. This means going beyond measures based on income or nutrition alone. Assessments need to include the effects of agricultural research on important dimensions of welfare (such as vulnerability, power, and access to institutions), which cannot easily be measured using standard indicators. Such impact assessments need to be based on integrated quantitative and qualitative research methods that generate solid data and should be used in combination with economic and social analyses.

# SEVEN CASE STUDIES
## The Big Picture

**To develop new approaches for assessing poverty impacts on multiple scales and to tease out the linkages between agricultural research and poverty, seven case studies were chosen. These built on work carried out by various research centers within the CGIAR (Consultative Group on International Agricultural Research).[2]**

The first five case studies (the "integrated"[3] case studies; Table 1) gave in-depth insights into the ways in which agricultural research directly affects the poor. To get the full picture, many different methods from the social sciences were used in an integrated social and economic analysis. Many types of data were collected from household and community surveys, focus-group discussions, in-depth household case studies, participant observation, and interviews with key informants.

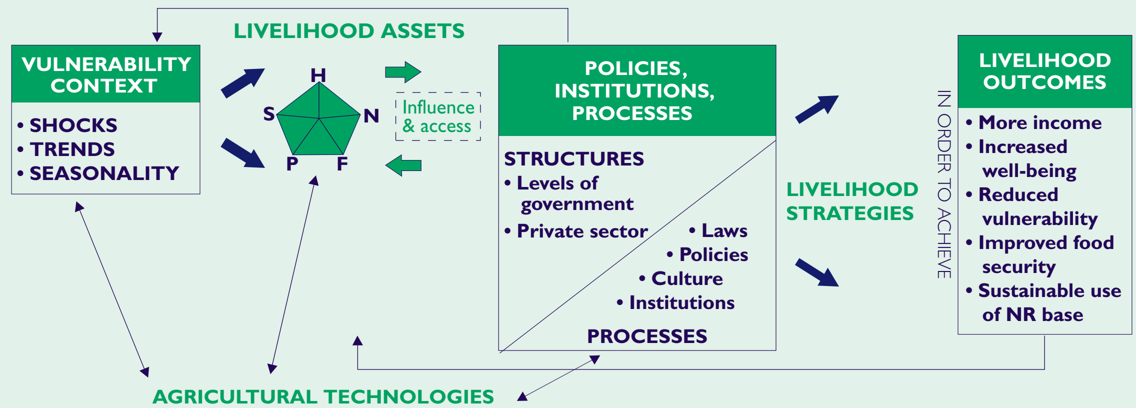
In an important strategy to see how those who adopted the technologies were affected and why some did not adopt or stopped using the

**Table 1 Five Integrated Case Studies Used to Assess the Impact of Agricultural Research on Poverty at the Household and Community Levels**

| CASE STUDY | COUNTRY | LEAD CGIAR CENTER | TECHNOLOGIES, BENEFICIARIES, AND TIME OF INTRODUCTION | DISSEMINATION |
|---|---|---|---|---|
| Modern rice varieties[4] | Bangladesh | International Rice Research Institute (IRRI) | 47 high-yielding varieties released since the 1980s | Formal: government extension services<br>Informal: farmer to farmer |
| Polyculture fish-ponds & improved vegetables[5] | Bangladesh | International Food Policy Research Institute (IFPRI) | Vegetables:[a] new varieties (plus credit & training) aimed at groups of poor women (1994)<br>Fishponds:[b] aimed at private pond owners (1988); group pond-leasing schemes aimed at groups of landless women (1993) | Nongovernmental organizations, women's groups, government (for private fishponds) |
| Soil fertility replenishment (SFR)[6] | Kenya | World Agroforestry Centre (ICRAF) | Improved fallows: scattering of tree/shrub seed in maize fields, with use of species that produce nitrogen and other nutrients, and that reduce weeds<br>Biomass transfer: application of leaves (and mulch) from a common roadside shrub to maize | Government extension services & nongovernmental organizations (via field days, seminars, demonstration plots, "adaptive research farmers," and farmers', women's, & church groups, etc.) |
| Modern maize varieties[7] | Zimbabwe | IFPRI | High-yielding varieties<br>First generation: adopted by smallholders (1980s)<br>Second generation: adopted mainly by commercial farmers (1990s)<br>Study conducted in resettlement areas | Private sector: "Seed Co" and government extension services advice: radio, field days, seminars, demonstration plots, and so forth. |
| "Creolized" maize varieties[8] | Mexico | Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT) | Improved, high-yielding maize varieties from CIMMYT, which farmers crossed with local landraces, to produce new creolized maize varieties | Improved varieties: seed and advice disseminated by government extension services and private sector |

**[a] Supported by the World Vegetable Center and the Bangladesh Agricultural Research Institute.**
**[b] Supported by WorldFish Centre with the Fisheries Research Institute and the Mymensingh Aquaculture Extension Project.**

**Figure 1 The sustainable livelihoods framework and how agricultural technologies interact with different components**




**SOURCE:** Adapted from Department for International Development, "Sustainable Livelihoods Guidance Sheets," London, DFID, 2001. www.livelihoods.org.
**NOTES:** Livelihood assets: H = human capital (e.g., farming knowledge, education, and available labor); N = natural capital (e.g., water, land, forests, and soil fertility); F = financial capital (e.g., credit, insurance, and savings); P = physical capital (e.g., tools, roads, and water pumps); S = social capital (e.g., neighbors and local farmer organizations).

technologies over time, four studies were conducted on households that did and did not adopt new technologies. This allowed researchers to be confident that any improvements were due to the technologies; establishing such causal links is a very important part of impact assessments.[9] To see whether different groups of rural people benefited more than others, both rich and poor people and men and women were asked about impacts of the new technologies.

To avoid falling into the same trap as in previous studies, researchers involved in these case studies made a deliberate effort to assess the impacts of technologies on the broader dimensions of poverty—rather than just using simple measures of income and nutrition. The studies were structured around the sustainable livelihoods (SL) framework[10] (Figure 1), which ensured that poor people's vulnerability and their assets (financial, physical, human, natural, and social capital) were taken into account. These studies also shed light on the policies, institutions, and processes that affect the poor and their adoption of new technologies.

Other factors not covered explicitly by the SL framework but that affect the uptake and benefits of new technology were also considered. These include culture (e.g., values, beliefs, tradition, identity, notions of status, and even preferences for taste and texture), power relationships (related to gender, class, and ethnicity), and history and experience (e.g., farmers' previous experiences with new technologies, credit, or extension services).

The final two case studies measured the impact that public investments in agricultural research and development (R&D) had on agricultural productivity, growth, and poverty in India and China. The researchers used official data (district level or higher) for recent decades in combination with econometric models. This approach allowed researchers to separate the impacts of agricultural R&D from those of other public investments. It also allowed them to pinpoint the economic pathways that linked agricultural R&D to a drop in poverty as measured by conventional income indicators.

To estimate just how much the CGIAR's agricultural research has contributed to increases in productivity and reductions in poverty, investigators in the China and India studies also traced the parentage of some key crop varieties. Both studies encompass a huge variety of individual technologies. Because the studies cover more than two billion people—and a significant share of crops produced by the developing world—they capture on a large scale the direct and indirect impacts of those many technologies on poverty.

# TECHNOLOGY ADOPTION
## Understanding Farmers' Decisions

**No agricultural technology will have an impact on poverty—either directly or indirectly—unless farmers adopt it. What makes farmers more likely to adopt a technology? What barriers exist to stop particular groups from benefiting directly from adopting technology?**

The case studies showed that three main factors affected technology adoption:

- vulnerability—whether the technologies were expected to increase or decrease people's vulnerability to loss of income, bad health, natural disasters, and other factors;
- assets—whether farmers had the assets necessary for technology adoption—especially if they were poor; and
- institutions—whether institutions (such as agricultural extension services, government policies, nongovernmental organizations [NGOs], the private sector, gender roles, markets for inputs and outputs, and so on) encouraged or discouraged adoption and represented the interests of poor people.

In each integrated case study, many different factors were shown to have affected the uptake of new technologies (Table 2). Their diverse—and often qualitative—nature shows that the decision to adopt does not easily fit into a conventional econometric model. Asset holdings are clearly important, but so are factors relating to vulnerability and institutions; the latter factors fit much less easily than the former into the quantitative regression analyses often used in impact assessments. Not taking such social and institutional factors into account means missing out on valuable lessons about the suitability of new technologies in the future. Thus, all these aspects should be considered in detail before embarking on any program to design new technologies to benefit the poor.

To encourage the adoption of new technologies, pro-poor agricultural researchers must look beyond simply boosting productivity. Stable yields, for example, may actually be more important to farmers than higher but more variable yields (as in the Mexican case study, Table 2), as they make people less vulnerable economically. Therefore, by breeding new crop varieties—such as those that are resistant to drought, flooding, and pests—agricultural researchers are now working to reduce farmers' vulnerability to climatic and biological shocks.

## Table 2 Factors Affecting Technology Adoption in the Five Integrated Case Studies: Assets, Institutions, and Vulnerability

| CASE STUDIES | ADOPTION |
|---|---|
| **Bangladesh:** modern rice varieties (MVs) | • **Assets:** the main asset required to adopt MVs was control over water.<br>• **Institutions:** a government policy that liberalized imports of small water pumps overcame the above asset-related constraint to adoption; pumps became more widely available and more affordable.<br>• **Vulnerability:** MVs changed the seasonal pattern of rice production, reducing the length of the "hungry season" before the first major harvest of the year. |
| **Bangladesh:** fishponds & vegetables | • **Vulnerability:** disease of fish and/or deliberate poisoning of ponds both could cause farmers to lose a season's investment in inputs and labor.<br>• **Assets:** a group approach was used (group fishponds) to try to overcome individuals' lack of assets, which was a constraint to adoption.<br>• **Vulnerability:** vegetable production reduced women's vulnerability to harassment as they did not need to go outside the homestead to undertake agricultural activities. |
| **Mexico:** "creolized" maize | • **Vulnerability:** farmers felt that trying new varieties of improved maize without first observing their performance would make them more vulnerable.<br>• **Vulnerability:** performance was less variable because traits were incorporated from landraces adapted to local conditions, which reduced vulnerability.<br>• **Institutions:** farmers had little trust in government seed and extension services, but they had a high level of trust in social networks, especially for obtaining seed. |
| **Zimbabwe:** high-yielding varieties (HYVs) of maize | • **Vulnerability:** having to rely on markets for improved seed was felt to increase vulnerability, as market varieties may be of a poor quality or too expensive to buy.<br>• **Assets:** men's access to financial assets and formal marketing institutions made them more likely than women to adopt HYVs. Women preferred open-pollinated varieties (as fertilizer need not be purchased), and seed was obtained through women's informal networks, which men do not control.<br>• **Vulnerability:** concerns were raised about accusations of witchcraft as a result of observing neighbors' fields or sharing information on yields and income.<br>• **Institutions:** seed companies forced farmers to buy new varieties by withdrawing the older ones they preferred. |
| **Kenya:** soil fertility replenish-ment (SFR) | • **Vulnerability:** households suffering from labor shortages because of acquired immune deficiency syndrome (AIDS) were unwilling to adopt labor-intensive SFR.<br>• **Assets:** SFR reduced concerns about "spoiling the soil."<br>• **Assets:** biomass transfer did not require much land ownership.<br>• **Assets:** education was not necessary to transfer the knowledge needed to adopt technologies (extension materials were aimed at those with low levels of literacy).<br>• **Institutions:** people had mixed experience with groups for technology adoption; there was some empowerment and greater social cohesion, but sometimes power relationships in the community that worked against the poor were reproduced in the groups. |

Developers of improvement programs also need to take into account institutional factors that relate to vulnerability (which they do not always do). Having to invest in a new technology by—for example, buying inputs—can make farmers more vulnerable, because their precious cash resources (as well as their food security) are at risk if their crops fail due to an unexpected drought or flood. This vulnerability will discourage farmers from adopting the technology. Therefore, they need new technologies that do not require investments in expensive inputs. Strengthening supporting institutions (such as those that give farmers access to effective crop insurance) will also encourage farmers to adopt beneficial technologies.

A lack of assets, such as land, education, or equipment (for example, water pumps), will also limit technology adoption. That means more attention needs to be paid to technologies that require few assets. For example, the modern rice varieties (MVs) used in the Bangladesh case study could be adopted on any size of landholding. Even tenant farmers can benefit from them as no long-term investments are needed.

Efforts also need to be made to lower the amount of land, education, or cash required to adopt a technology. For example, training materials that were understandable to those with low literacy meant that little education was needed to adopt soil fertility replenishment (SFR) technologies in Kenya.

Alternatively, substituting one asset for another can help the poor to adopt technologies. Labor, for example, can sometimes compensate for a lack of land. This was the case in Kenya, where farmers cut shrubs from roadsides or other public lands, mulched them, and spread them on their very small maize fields to replenish soil fertility. They did not need to devote their scarce land resources to growing shrubs for mulch. Pooling resources is another way forward and can allow even the landless to access opportunities otherwise beyond their reach. In Bangladesh, for example, landless women worked together to manage group fishponds.

Decisionmakers also need to recognize that technologies that build on assets that the poor already have are more likely to be adopted. Because poorer households in Bangladesh had more motivated (i.e., family) labor, the adoption rates of MVs—which have high labor requirements—were much higher for farmers with small holdings than for those with relatively large farms.

Cultural characteristics were also found to influence adoption in many different ways, such as by making new technologies more attractive or by limiting people's ability to take advantage of them. For example, in many places women cannot move freely outside the home. This was the case in Bangladesh, which meant that women did not usually come into contact with new technologies or dissemination efforts. Such cultural factors can have a very powerful influence. In Mexico, the desire to participate in religious festivals, which is important for social status, drives poor farmers to harvest their maize early and sell the grain before the price reaches its maximum. In this situation, new maize varieties that can be harvested at different times would benefit the poor. Preferences for certain tastes and textures also affect the varieties people will adopt.

Clearly, therefore, an understanding of local cultural practices and preferences is important if the poor are to benefit from agricultural research. These practices will affect who (e.g., women or men, elite or poor people) will adopt the new technologies. However, researchers also must bear in mind that culture changes over time and will often vary in response to the technologies introduced by the research itself.

# DISSEMINATION
## Why Methods Matter

**Dissemination pathways—how people learn about or obtain a technology—play a fundamental role in determining who adopts new technologies. A broad range of dissemination methods were used across the case studies (Table 1). However, there was no one "best" method of dissemination for all regions or even for all groups of farmers within one region. Each method was affected by local histories and social dynamics. Therefore, before deciding which methods are most appropriate, we must know about the local cultural and power relationships to understand how people interact and learn.**

Attitudes toward, and trust in, institutions are key factors in helping or hindering dissemination. In almost all cases, poor people had little confidence in public agencies and officials—including the extension services. In Mexico, for example, farmers had lost faith in the government after it provided poor quality seed and failed to deliver what it had promised. So, an understanding of historical experience is an important part of understanding adoption and impact.

Generally, the studies show that NGOs had a better reputation than governments among farmers. They tended to be better at targeting the poor and women—especially in Bangladesh and Kenya. However, NGO performance was highly variable in terms of competence, integrity, and operating style.

In all cases, farmers felt that when the private sector was involved in dissemination, companies were more concerned with the needs of larger, commercial, or "successful" farmers and were much less interested in fulfilling the needs of poor farmers. Decision makers need to take this perception into account when considering using the private sector to develop and disseminate technologies.

Local organizations were one innovative dissemination channel used in some of the locations studied. The use of groups was intended to make dissemination more efficient by reaching a number of farmers at once, building capacity by encouraging trained groups to train others, and empowering farmers through collective action.

While local organizations sometimes achieved these objectives, they also often reproduced local power relationships and other social dynamics. People who had power in the community also tended to have power in these groups. In some cases, groups excluded some poor people (for example by requiring people to have resources to join), created conflicts over resources, mismanaged funds, or failed to reach farmers outside the group.

Women's groups offer advantages to women who might not otherwise have the opportunity to engage in—and benefit from—collective activities. However, some women were reluctant to join groups because of time constraints or social pressures.

Group-based methods, like other development efforts involving community participation, can give huge payoffs that make them worth pursuing. When they work, they are extremely rewarding both for the participants and the disseminating institutions. But there are no shortcuts. Complications and drawbacks—and the time, effort, and vigilance needed to make groups inclusive and effective—should not be underestimated.

Of course, creating formal groups for dissemination is not the only way forward. Across the case studies, informal social networks were consistently shown to be important in helping the spread of technology. In many cases, they also gave farmers the opportunity to observe the performance of their neighbors' new varieties before trying them.

However, sometimes local beliefs meant that informal farmer-to-farmer dissemination was not effective. For example, in one region of Zimbabwe, people could not learn by observing their neighbors' fields because showing too much interest in your neighbors' fields can provoke accusations of witchcraft. This issue is not insignificant: 71 percent of the people questioned in the region believed that magic enhances agricultural skills. This highlights how important it is to conduct qualitative social science research before designing dissemination strategies. Of course, this will only be effective if strong relationships are built; people will only discuss sensitive topics (such as witchcraft) with researchers they trust. In the Zimbabwe, Kenya, and Mexico studies, for example, researchers lived in sample villages for three to six months, which gave them a clearer insight into the villagers' lives.

Use of model farmers or "adaptive research farmers" (as in Kenya) was also found to be important for testing the technologies and adapting them to local conditions before they were disseminated to other farmers. This system also introduced or exacerbated tensions in local social relationships: the farmers involved were resented for the attention they received from outsiders. This again underscores how important it is to use research to gain an understanding of local dynamics. Such problems might be avoided by, for example, bringing more farmers into the learning process at an earlier stage.

Valuable lessons can also be learned from observing farmers' own breeding experiments. The Mexico case provides a good example. Here, farmers were continuously crossing maize and developing new varieties with traits that were valuable to them, such as those that reduced farmers' vulnerability, allowed them to work with the assets they had, and met local preferences for taste and texture. To identify the traits that farmers want, breeders need to learn from these adaptive processes.

# NEW AGRICULTURAL TECHNOLOGIES
## Their Real Impacts on Poverty

**Agricultural research can help to alleviate poverty in many ways. Farm households that adopt the resulting technologies can benefit directly from higher yields and incomes, but benefits are not just felt by the adopting households. The indirect impacts of research (such as cheaper food and more jobs) can also improve the living standards of the wider population. Impacts can also be negative. All are important, and all should be included in assessments of impacts.**

Some direct impacts (such as changes in agricultural productivity and farm income) are relatively easy to measure quantitatively, which is probably why they have been the focus of most impact research.

Other direct effects (such as the increased empowerment of women within their households and increased knowledge) are much less easy to assess. These are "qualitative" impacts (Table 3). Because they are difficult to measure in any concrete (quantitative) way, they are rarely evaluated and often overlooked. However, qualitative impacts cannot be ignored: poverty is not just a matter of low incomes.

Agricultural technologies also have many, sometimes widespread, indirect impacts. Again, these can be both qualitative and quantitative. They can be seen at different levels, for example, at the community level (where women's groups formed through dissemination activities increase women's confidence and organizational capacity) and the national level (where greater agricultural growth drives general economic growth).

## DIRECT IMPACTS ON ADOPTING HOUSEHOLDS
### The Integrated Case Studies

*Bangladesh*—In terms of the impact of agricultural research on productivity, the MVs introduced in Bangladesh had the largest effect. In 2000, the yields of MVs were more than double those of traditional varieties. Although this was a huge jump in productivity, it did not translate into large gains in the annual income of adopting households (Table 4). Why not? The farms on which the new technology was used were small (only 0.67 hectares on average), and the price of rice was low—partly because the new agricultural technologies had boosted rice production.

**Table 3 The Four Types of Impact of Agricultural Technologies**

| | EXAMPLES OF IMPACTS | |
|---|---|---|
| **TYPE OF IMPACT** | **QUANTITATIVE** | **QUALITATIVE** |
| **Direct** | productivity, income | vulnerability, knowledge |
| **Indirect** | food price changes, wage rate changes, employment changes | community-wide changes in women's empowerment |

**Table 4 Direct, Quantitative Impacts of New Agricultural Technologies on Household Incomes in the Five Integrated Case Studies**

| CASE STUDY | INCREASE IN INCOME | PERCENTAGE OF ANNUAL HOUSEHOLD INCOME |
|---|---|---|
| **Bangladesh:** rice | $354/ha (per year) | 21 |
| **Bangladesh:** fishponds | | |
| Private | $76/ha (per 16 months) | 5 |
| Group | $156/ha (per 16 months) | Negligible |
| **Bangladesh:** vegetables | $36/ha (per month) | < 1 (but women controlled this income) |
| **Zimbabwe:** maize | $51/farm (per year) | 10 |
| **Kenya:** soil fertility replenishment | $26/farm (per year) for maize only | 5–10 |
| **Mexico:** maize | Better traits | Negligible |

The second Bangladesh case study considered both fish and vegetable production. Households adopting polyculture fishpond technologies sold three times as much fish per area of pond as those using traditional practices—again a great leap in productivity. Plus, cash profits for private fishponds averaged $223 per hectare: around $76 (or 50 percent) more than traditional fishponds (Table 4). However, as in the rice study, the effect on household income was much more modest; it takes a long time for fish to grow (16 months), and fishponds were a very small part of the households' livelihood strategies.

What is more, the benefits from using new technologies in private fishponds went mainly to men (who controlled them) and to better-off households that could afford to have fishponds in the first place. Group fishponds allowed landless women to participate, but only five of the nine group fishponds created operated as planned. In these five groups, each member received only $0.35 per month on average. So, although the poor can sometimes use social capital (collective action) to make up for a lack of land, the returns are not necessarily as good.

Introducing women to homestead cultivation through improved vegetable programs also had a fairly negligible effect on household incomes (1 percent on average). However, these programs increased vegetable growing among landless and land-poor households, giving per-hectare cash profits which averaged $72 per crop or $36 per month (Table 4). This was higher than the per-hectare profits obtained from MVs in that particular area, and the growing season was shorter.[11] Here the technology was prevented from having a more profound impact on household incomes by the fact that homestead plots were small and land-poor women could not expand the area planted with vegetables. However, there were added benefits, as any money gained was controlled by the women themselves.

*Zimbabwe*—In Zimbabwe, the introduction of a first generation of maize hybrids had a huge impact—doubling maize production between 1979 and 1985. Many smallholders adopted the hybrids and benefited from higher yields and incomes. However, the case study considered here was focused mainly on second-generation hybrids bred to be more resistant to drought and to the diseases that affect commercial farmers' crops. These do not seem to have increased smallholders' productivity as much as the first-generation hybrids. Adopters and nonadopters were compared through an analysis that controlled for confounding factors such as greater education, skills, and other assets. This showed that adopters benefited from a clear gain in income (Table 4).

*Kenya*—The Kenya study focused on the use of SFR techniques to increase maize yields. In terms of productivity, these techniques were very successful, as yields per hectare were much higher in fields where SFR was practiced than in those where neither SFR techniques nor fertilizers were used. Not only did the use of improved fallows and biomass transfer increase maize yields by 128 and 114 percent, respectively, they gave yields that were slightly greater than those gained when chemical fertilizers were used instead.

However, as with the other studies, household incomes did not increase by much (Table 4), partly because the farms adopting the technologies were small (less than one-half hectare). However, farmers gained extra benefits from SFR by applying their new knowledge to vegetable plots—where they got returns up to 10 times greater than those from maize plots.

*Mexico*—Assessing the productivity impact of creolized maize in Mexico was less straightforward. Farmers reported that yields of creolized varieties were higher than those of traditional varieties but lower than those of improved varieties that had not been creolized. They said that the differences between varieties were small when compared with yield differences between good and bad years and between favorable and unfavorable locations. However, yield data tell only part of the story in this case study. The farmers felt that the creolized varieties made them less vulnerable, which was an important benefit to them. The yields are less variable, and traits such as resistance to lodging (falling over prior to harvest) and to insect attack during storage make the creolized maize attractive to poor farmers.

Overall, farmers in Mexico did not see maize production as a major route out of poverty, but they felt that it contributed to their livelihood security by providing greater food security and cash income. They said: "We need it to live; without it we don't eat."

Generally, the agricultural technologies considered increased incomes but only by a small amount in each case—mainly because farms or ponds were small and crop prices were low. This does not mean they were ineffective: they still had an important impact on poverty and the welfare of farm households.

For many, increases in the stability of production were very important (e.g., creolized maize in Mexico). Even small gains in agricultural production were valued by poor households, not just for food security, but because the extra cash income gave them much-needed stability and allowed them to branch out into other activities both on and off the farm. In turn, this diversification reduced the vulnerability of the poor. In Zimbabwe, for example, the higher maize yields of better-off farmers enabled them to buy livestock, which helped them and their families cope in times of drought. Diversifying into off-farm activities also helped people to survive fluctuations in income and food supplies caused by bad weather and pests.

In other cases, the social effects of adoption offered some of the greatest benefits. Women cultivating improved vegetables in Bangladesh reported empowerment in dealing with traders and their husbands. Indeed, the study's analyses showed statistically significant empowerment effects in terms of freedom of movement, freedom from physical violence, and political knowledge and awareness. These improvements were specifically related to the adoption of the technology and did not just result from the adopting women being members of an NGO (which was also found to boost empowerment). The people in Bangladesh also shared, with friends and family, the extra vegetables and fish they produced. This helped to build social capital by strengthening ties among households—a vital asset, especially for the poor.

Social capital was also built up when technologies (such as SFR in Kenya and vegetable and fishpond technologies in Bangladesh) were disseminated using groups—but only when the technology was successful and groups functioned effectively. These groups gave women new confidence and created new organizational capacity. However, if things did not go well, the result was strain in the community and loss of social capital. This was a particular problem in Bangladesh when fishpond groups broke up and when NGOs or other organizations delivering the technology had technical problems or lost the trust of the community.

Other direct benefits resulted from people's adoption of knowledge-intensive practices. Adopters increased human capital, skills, and the knowledge that they could apply in other situations. For example, those successfully adopting improved fishponds in Bangladesh felt empowered and reported seeing themselves as scientists. In Kenya, new knowledge of SFR practices carried over into a better understanding of soil fertility on the whole farm.

## Indirect Benefits of Agricultural Technologies

In the integrated case studies, the clearest evidence of the indirect impacts of agricultural research was seen in the case of MVs in Bangladesh. This was probably because yield increases were large and because rice was grown very widely—on almost 75 percent of the country's farmland. As a result, there were large spillover effects on other households.

At the national level, MVs helped to increase food security greatly. Researchers estimated that if MVs had not been introduced and only traditional varieties were grown (i.e., the counterfactual scenario), rice production in 2000 would have been 13 million tons[12] lower than it was in reality. This large increase in production due to MVs could feed 59 million people in 2000—almost 45 percent of the population. As production increased, rice prices rose more slowly than inflation. Although modern rice farmers did not profit hugely from the new technology (Table 4), a great many households that relied upon buying rice to feed themselves certainly benefited from the less expensive food.

Demand for agricultural wage laborers also rose because MVs require more labor than traditional varieties. This created more jobs and boosted wages. Shifts also occurred from daily wage rates to piecework contracts for laborers and from sharecropping to fixed-rate tenancies. These allowed laborers and tenant farmers to earn more from rice. Poor men and women also placed a high value on the new agricultural labor relations that resulted from the high demand for labor. They felt that these situations gave them more dignity as they no longer had to do unpaid work for land owners to secure wage employment at harvest time. Instead, prospective employers had to call on people and ask them politely to come to work for them.

However, not all the indirect impacts of MVs were positive. Poor men and women were concerned that wild foods were disappearing. Wild green leafy vegetables, which had grown on common land or fallows, were being squeezed out by more intensive rice growing. In addition, the numbers of wild fish had fallen because of pesticide use.

Both Bangladesh case studies also highlighted large increases in nonagricultural employment. People found new opportunities to transport rice and sell fish fry—just two examples of employment generated by the new agricultural technologies. Other increases in employment also occurred as a result of rising prosperity, which was itself due, in part, to increases in agricultural productivity.

Another type of indirect impact is informal diffusion of technologies, which takes place when farmers adapt the technologies and pass them on to other farmers. The clearest example of this occurred in Mexico, where farmers crossed improved germ plasm with their own varieties; these new varieties then spread to many farmers who would not have bought the official "improved" varieties. Similarly, a few years after new vegetable varieties were disseminated in Bangladesh, there were few differences between the households that had originally adopted them and those that had not; the original package had been adapted in many different ways, and the seeds and necessary knowledge had spread quickly between neighbors.

A full summary of the direct and indirect impacts of the agricultural research considered by the five integrated case studies is given in Table 5.

**Table 5 The Direct and Indirect Effects of Agricultural Technology Adoption in the Five Micro Case Studies**

| CASE STUDIES | DIRECT EFFECTS | INDIRECT EFFECTS |
|---|---|---|
| **Bangladesh:** modern rice varieties (MVs) | • Large productivity increases due to the use of improved varieties. Income increases constrained by farm size and low price.<br>• Declining soil fertility. | • Low price of rice, which was important for net food purchasers.<br>• Increase in employment opportunities in agriculture.<br>• Improvement in working conditions in agriculture.<br>• Decrease in the availability of wild, green, leafy vegetables. |
| **Bangladesh:** fishponds & vegetables | • Improved productivity of fishpond and vegetable production.<br>• Small increases in the incomes of the poor because technologies constituted a small part of household livelihoods and some of the private fishpond owners were not poor to begin with.<br>• Increased empowerment of women, when technology was directed to them. | • Increased availability of vegetables in study sites.<br>• Social capital strengthened by some groups disseminating the technology but weakened when groups fell apart.<br>• Diffusion of vegetable technologies. |
| **Mexico:** "creolized" maize | • Yield increases due to improved varieties, but these were perceived to be more variable. Hence creolization was used as an intermediate solution (as it reduced variability in yields).<br>• Provision of a solid base from which to diversify (though maize was not perceived to be a route out of poverty).<br>• Increased ability to feed the family, especially in the case of the poorest farmers. | • Widespread diffusion and adaptation of improved maize via creolization. This combined the desirable traits of local landraces with the higher yields of improved varieties, increasing the predictability of their performance and reducing trade-offs that farmers face in choosing between varieties. |
| **Zimbabwe:** high-yielding varieties (HYVs) of maize | • Income gain of 10 percent, though gain was smaller for poorer farm households.<br>• Better-off farmers able to convert productivity-driven income gains to asset accumulation, increasing resilience to shocks. | • Networks built for information and technology demonstration for men. |
| **Kenya:** soil fertility replenishment (SFR) | • Doubling of maize productivity compared with no SFR; better results than with fertilizer and no SFR.<br>• Improved understanding of soil fertility issues on whole farm.<br>• Increased access to technology for women. | • Social capital strengthened as a result of some groups disseminating the technology, particularly women's groups; however, the use of "adaptive research farmers" created new social tensions. |

# NATIONAL-SCALE IMPACTS OF AGRICULTURAL RESEARCH

## India and China

The final two case studies measured the impact that public investments in agricultural R&D had on agricultural productivity, growth, and poverty in India and China. These macro-level case studies show that agricultural research had large impacts on both rural and urban poverty. Most important, the biggest poverty-reduction impacts were found in less-favored areas.[13]

Unlike the integrated studies, these two case studies did not take into account broader aspects of poverty (such as vulnerability, empowerment, or knowledge). These dimensions could not be measured at the national level in a meaningful way, nor could they be compared over long periods. Instead, official income-based poverty data for the past few decades were used with econometric models.

In both countries, a dramatic drop in rural poverty occurred during the Green Revolution era. Although around two-thirds of India's rural population was living below the poverty line in the early 1960s, by the late 1980s, this proportion had fallen to nearly one-third. In China, only around one-tenth of the rural population was living in poverty by 1984 as compared with one-third in 1970.[14]

What caused this drop in national poverty percentages? After controlling for many different factors—including a wide array of public policies and investments—analyses have shown that investment in agricultural research was one of the most important drivers of growth in agricultural productivity and rural poverty reduction.[15] However, the importance of different types of investment has changed over time in China and India. For example, investments in irrigation give much lower returns today than they did in the 1970s. Now, the highest returns and largest poverty impacts are achieved by investing in less-developed (or less-favored) areas that rely on rain-fed agriculture.

The models used in the China and India case studies show that additional investments in agricultural R&D will increase agricultural productivity (or agricultural GDP) more than any other form of public investment in rural areas. Investment in agricultural R&D is also predicted to be nearly as important with regard to poverty reduction. Only investment in education in China (Table 6) and in rural roads in India (Table 7) would have a greater impact on the number of people living in poverty.

**Table 6 Impacts of Additional Investments on Productivity (Agricultural GDP) and Rural Poverty in Three Regions of China (by rank)**

| | COASTAL | | CENTRAL | | WESTERN | |
|---|---|---|---|---|---|---|
| | PRODUCTIVITY | POVERTY | PRODUCTIVITY | POVERTY | PRODUCTIVITY | POVERTY |
| **Agricultural R&D** | 1 | 2 | 1 | 2 | 1 | 1 |
| **Irrigation** | 3 | 6 | 5 | 6 | 5 | 6 |
| **Roads** | 4 | 3 | 2 | 3 | 4 | 3 |
| **Education** | 2 | 1 | 3 | 1 | 2 | 2 |
| **Electricity** | 6 | 4 | 6 | 5 | 6 | 5 |
| **Telephone** | 5 | 5 | 4 | 4 | 3 | 4 |

SOURCE: S. Fan, L. Zhang, and X. Zhang, *Growth and Poverty in Rural China: The Role of Public Investment*, Research Report 125 (Washington, D.C.: International Food Policy Research Institute, 2002).

**Table 7 Impacts of Additional Investments on Productivity and Poverty in Rural India**

| | IMPACT ON PRODUCTIVITY | | REDUCTION IN NUMBER OF POOR | |
|---|---|---|---|---|
| | (PERCENTAGE) | (RANK) | (PER MILLION Rs) | (RANK) |
| **Agricultural R&D** | 6.0 | 1 | 84.5 | 2 |
| **Roads** | 2.4 | 2 | 123.8 | 1 |
| **Education** | 0.6 | 3 | 41.0 | 3 |
| **Irrigation** | 0.6 | 4 | 9.7 | 7 |
| **Power** | 0.1 | 8 | 3.8 | 8 |
| **Soil & water** | 0.4 | 6 | 22.6 | 5 |
| **Rural development** | 0.5 | 5 | 25.5 | 4 |
| **Health** | 0.4 | 7 | 17.8 | 6 |

SOURCE: S. Fan, P. Hazell, and S. Thorat, "Government Spending, Growth and Poverty in Rural India," *American Journal of Agricultural Economics* 82 (No. 4, 2000).
NOTES: 1 million rupees = approximately $22,000. NA = not available.

How does agricultural research translate into reductions in poverty? In both China and India, the most important pathway was found to be increased agricultural productivity. This led to direct on-farm benefits. However, it also contributed to lower food prices, higher wages, and greater employment in rural labor markets (both agricultural and nonagricultural). As an added benefit, cheaper food also reduced urban poverty, as the urban poor spend nearly one-half of their income on food.

Another set of analyses traced some of the benefits of the CGIAR's research to China from 1982 to 1989 and India from 1991 to 1999.[16] To this end, the parentages of rice varieties were traced in both countries. These data allowed researchers to calculate how much of the growth in productivity or production and the reduction in poverty described above could be attributed to the improved genetic materials provided by the CGIAR's International Rice Research Institute (IRRI).

The results indicate that rice improvement research has contributed tremendously to rice production in both countries. The annual benefits from total rice research (national plus IRRI) were about 20 percent of the annual value of national rice production in both countries during the 1980s and 1990s. These benefits were 10 times greater than the sums invested in the original research.

IRRI's research made important contributions to these gains. Even using a conservative attribution rule[17] for crediting the ancestors of plant varieties to IRRI, between 1.7 and 6.8 percent of the annual rice research benefits in China over the period 1991–2000 can be attributed to IRRI's research. The corresponding figures for India are higher, ranging from 18.1 to 56.4 percent of the annual benefits. In terms of its cash value, the amount of rice produced in India and China as a result of IRRI's breeding programs is such that, during the past decade, it would have covered the full costs of IRRI's global rice program more than 20 times over.

Rice research in India and China has helped large numbers of rural people escape poverty. The studies cited here conclude that in India about 4.6 million people moved out of poverty each year between 1991 and 1999 as a result of rice variety research; around one-third of that improvement was due to IRRI's work. In China the number of people who moved out of poverty as a result of rice research fell over the years, from around 5 million in 1991 to 1.5 million in

1999, of which only about 5 percent was attributable to IRRI's research.

For every $1 million IRRI invested in its global rice research program in 1999, more than 800 rural poor in China and more than 15,500 in India rose above the poverty line (and poverty benefits were generated in other countries too, of course). But most of these benefits are the results of research conducted before 1990. Since then, IRRI's investment in rice research has fallen and so has the rate at which rice yields have increased in trials.

# LESSONS LEARNED
# Assessing the Impacts of Research on Poverty

**Several lessons can be learned from all the case studies about the methods used to assess the impacts of new technologies on poverty.**

## 1. Impact Studies Need to Look Carefully at Causation.

To be confident that any reductions observed in poverty are due to the adoption of a new technology, we must establish causation. However, this cannot be done unless the differences between adopters and nonadopters are studied in detail—both before and after technologies are introduced. Therefore, it is critical that such studies are included in the design of any research program.

In theory, the clearest way to establish causation would be to select a uniform group of participants and randomly allocate the technology to one-half of them. This approach raises practical and ethical problems (a valuable technology should not be purposefully withheld from some group, nor would it be easy to stop that group from adopting if the technology proved beneficial to others). However, sometimes this type of approach can be applied ethically—for example when the technology has to be disseminated in phases for logistical or financial reasons.[18]

In an alternative to random allocation, researchers carefully choose a control group that they can study and compare over time with the group that has adopted the technology. This group must match, as closely as possible, the observable and unobservable characteristics displayed by the adopting households before they had access to the technology. This is fairly straightforward in the case of observable characteristics (e.g., income and asset levels) but more difficult in the case of unobservable characteristics such as agricultural skills. One way to overcome this problem is to use panel data (as was done in the Zimbabwe and both the Bangladesh cases studies), which allows the researcher to control for unobserved effects that remain relatively fixed over time at the household and community level.

Finally, controls can be achieved through econometric analysis if sufficient data are available on other intervening factors (e.g., other types of public investments in the China and India studies).

Evaluations should also try to capture the impacts of a technology on different social groups. For example, in the case studies reported here, separate focus group discussions and interviews were conducted with men and with women, as well as with those of differing income groups, to identify their beliefs about the impacts of the technology.

Finally, care must be taken to conduct surveys and other data collection as efficiently as possible, so that the whole study remains cost-effective.

## 2. Assessing a Full Portfolio of Impacts is Vital.

Direct and indirect impacts—both qualitative and quantitative—should always be assessed (see Table 5). If the studies had only focused on direct impacts, we would have overlooked the food price effects and the wage rate and employment effects that were observed because of changes in rice productivity in Bangladesh, India, and China. In addition, we would have missed both the positive and negative effects of the technologies on community-wide social capital in Kenya and Bangladesh.

If the studies had focused purely on quantitative measures, we would have been puzzled about why fishpond technologies had not been adopted more widely in Bangladesh (there were concerns about vulnerability). Similarly, we would have noted that wages rose in Bangladesh due to MVs, but we would have missed the improvement in people's employment conditions. That vegetable growing empowered women in Bangladesh would also have gone unnoticed, as would the fact that Kenyan farmers applied their newfound knowledge of soil fertility to all their crops and not just to maize.

With respect to the impacts assessed, the Mexico study highlighted some valuable points. It was recognized that productivity should not be the only measure of the success of a technology. The traits that farmers value are just as important as productivity, and breeders need to ensure that these traits are included in any new varieties developed and disseminated. Furthermore, even measures of yield are not straightforward because a simple measure of tons per hectare may not be used by farmers to judge a good yield. Farmers also think in terms of "yield by volume" (e.g., bags of grain per hectare) or "yield of dough to make tortillas."[19]

## 3. A Sustainable Livelihood Framework Is Valuable for Seeing the Big Picture.

Using the SL framework ensured that all research teams considered a wide range of issues related to vulnerability, assets, and institutions—helping to ensure that nothing was overlooked. This is important, because these issues are not normally included in conventional impact assessments. It was an effective means of communicating across disciplines and a useful way of thinking about the many interacting factors that influence people's livelihoods.

The use of the SL approach acknowledges the complexity of people's livelihoods and the processes that dictate whether interventions will be effective. However, the framework does not include some key concepts (such as culture, power, and experience) needed to explain people's attitudes toward a technology and to determine why they adopt it. To overcome this, the studies considered here integrated other concepts (from sociology, anthropology, and economics) when necessary.

## 4. Mixing Disciplines and Methods Is Essential.

The case studies confirmed that various social sciences (e.g., economics, sociology, and anthropology) are vital to assessments of impact. A full understanding of the complexities involved in the adoption of technologies and the impacts they have can only be achieved by mixing methods from these disciplines, such as panel surveys, qualitative interviews, focus groups, and ethnographic methods.

# Lessons for the Design of Future Agricultural Research

**What implications do the study findings have for institutions that develop and disseminate agricultural technologies? What should scientists, policymakers, and disseminators learn and change as a result of the insights and findings of this research?**

First, they need to understand that although agricultural research has benefited many rural and urban poor people indirectly by lowering food prices and increasing wages and employment in the nonagricultural sector, these benefits have not proved powerful enough to eradicate poverty on the scale required, and they may be weakening over time as food markets are liberalized (and hence prices are set by border prices) and the agricultural sector diminishes in importance relative to the nonagricultural sector. This means that greater attention is needed in the future to targeting agricultural research to generate more favorable direct benefits within rural areas for the poor. To this end, a number of key lessons emerge from the case studies.

## 1. Knowledge Is Needed to Design Research that Benefits Poor People.

Before research programs that aim to benefit the poor are put into action, the priorities of poor men and women must be understood. Plus, the potential outcomes and impacts of the research must be considered fully. The case studies highlight some important things that need to be known in advance to ensure that technologies are appropriate for, and beneficial to, the poor. These are listed below.

• *The priority the poor place on managing risk.* Any new technology will be less attractive to poor people if they believe it will increase their exposure to risk—especially when no insurance or recourse mechanisms exist. Even when a technology results in much higher average yields, poor farmers are unlikely to adopt it if it means that they will need to go into debt to purchase inputs or if they must depend on a market, a government program, or an NGO that they see as unreliable.

• *The social groups that will be targeted.* The uptake and impact of different technologies will be dictated by the social groups assessing and using them. Technologies that require few inputs and little cash will be particularly attractive to the poor, for example. However, technologies often have different impacts on women and men because they have different priorities and control different assets. Therefore, research to produce technologies that benefit the poor needs to pay particular attention to the norms that affect women and the assets and power available to them.

• *The traits that farmers value.* Farmers do not just value yield. They may also place a high value on, for example, particular tastes and textures as well as resistance to bad weather, pests, and diseases. Learning about farmers' priorities is a key aspect of ensuring positive impacts.

• *The amount of labor available in poor households.* Farmers in developing countries (especially poor farmers) do not always have a surplus of labor. Many poor agricultural producers face severe time constraints—particularly in environments where HIV/AIDS has killed or disabled much of the working population and people must care for the sick. Labor-saving technologies offer a way forward. Although they may reduce employment opportunities in some contexts, they will also allow many households to diversify their income-earning activities and free up time for the care of children or ill family members.

• *The importance and role of agriculture in livelihood strategies.* Technology should be tailored to fit people's livelihood strategies, and it should be targeted at areas where agriculture still plays a significant role in the lives of poor farmers.

• *The value of homestead production for women.* Women often cannot leave their homes, either because of cultural restrictions or because they have young children. Homestead production offers a practical opportunity for these women to improve their livelihoods.

The above insights are, to varying degrees, context specific. However, the payoffs from using them to target technologies effectively can be very high. Obtaining the valuable information needed to properly target research requires a cash outlay, but the costs are not prohibitive: each case study cost approximately $200,000. In fact, this is a small fraction of the investment that goes into the development of a technology. Time-efficient, cost-effective approaches and methods will enable scientists and other decision makers to learn about and appreciate poor people's conditions and priorities as well as to anticipate impacts and tailor research accordingly. The challenge now is to develop and adopt these approaches.

## 2. Dissemination Methods Are Important for Adoption.

The type of dissemination method used can play a crucial role in whether poor farmers adopt a technology. It can also influence both the direct and indirect impacts of that technology. As discussed above (under Dissemination), different social environments will dictate whether individual, group-based, or informal dissemination activities are most suitable. At an early stage in the research design process, thought needs to be given to which dissemination strategies will be used. This will ensure that the technology is likely to be adopted and that unintended negative effects are avoided.

## 3. New Partnerships Should Be Encouraged.

If agricultural research organizations (including those within the CGIAR) are to improve the livelihoods of poor people, they must create meaningful partnerships with a range of institutions that have a good understanding of local livelihood strategies. This will help them to tailor generic technologies to an enormous range of context-specific livelihood strategies. For research organizations, decisions about the region for attention or the crops to target are important. However, the choice of partners for developing and disseminating technologies can be even more important. Engaging the right partners should be considered an integral part of the research process.

Forming these partnerships will not be easy. National governments remain essential partners, but some maintain traditional top-down, male-dominated approaches, which will not be helpful. Capacity building can help address this. Government departments and national agricultural-research systems that have already moved to more farmer-centered, gender-sensitive, and participatory approaches (such as some of those in western Kenya) should also be sought as partners.

NGOs are also an important resource for dissemination because they are often closer to the ground and have different perspectives on local environments than do governmental agents. However, like governments, their performance is also variable, so their approaches and performance should be evaluated carefully.

# THE WAY FORWARD
## Institutional Learning and Change

**Finally, to increase the impact of agricultural research on poverty, research organizations need to embrace a culture of institutional learning and change (ILAC). This "can be fostered by a spirit of critical self-awareness among professionals and an open culture of reflective learning within organizations. In such an environment, errors and dead ends are recognized as opportunities for both individual and institutional learning that can lead to improved performance."[20] Within a culture of ILAC, research involves multiple stakeholders in a process that is more participatory, iterative, interactive, reflective, and adaptive than is conventional research.**

In the context of impact assessment, ILAC requires research organizations to regularly ask themselves questions such as:

- How could technology development and dissemination have been done differently?
- What were the barriers within the organization that prevented such alternative approaches from being used?
- How can these barriers be removed?
- What factors underlie successes, and how can these be capitalized upon in the future?

To be more effective, research managers must learn to be self-critical and to recognize the needs of their changing clientele. At the same time, they must be willing to acknowledge mistakes and failures so that they can learn from them.

An initiative to foster ILAC has been launched within the CGIAR system.[21] In addition, new poverty impact-assessment studies are being designed within an ILAC framework. The designers are drawing on the methods used in and the lessons learned from the case studies reported here.

# Notes

1. J. Kerr and S. Kolavalli, *Impact of Agricultural Research on Poverty Alleviation: Conceptual Framework with Illustrations from the Literature*, EPTD Discussion Paper 56 (Washington, D.C.: International Food Policy Research Institute, 1999); P. Hazell and L. Haddad, *Agricultural Research and Poverty Reduction*, Food, Agriculture and the Environment Discussion Paper 34 (Washington, D.C.: International Food Policy Research Institute, 2001).

2. Consultative Group on International Agricultural Research (http://www.cgiar.org).

3. The "integrated" case studies refer to the five that included integrated economic and social analysis as well as quantitative and qualitative research methods. Throughout this report, findings reported from studies are drawn from the following sources: For the Bangladesh rice study: M. Hossain, D. Lewis, M.L. Bose, and A. Chowdhury, *Rice Research, Technological Progress and Impacts on the Poor: The Bangladesh Case (Summary Report)*, EPTD Discussion Paper 110 (Washington, D.C.: International Food Policy Research Institute, 2003). For the Bangladesh fish and vegetables study: K. Hallman, D. Lewis, and S. Begum, *An Integrated Economic and Social Analysis to Assess the Impact of Vegetable and Fishpond Technologies on Poverty in Rural Bangladesh* (Washington, D.C.: International Food Policy Research Institute, 2003). For the Kenya study: F. Place, M. Adato, P. Hebinck, and M. Omosa, *The Impact of Agroforestry-based Soil Fertility Replenishment Practices on the Poor in Western Kenya, Final Report* (Washington, D.C.: World Agroforestry Centre (ICRAF) and International Food Policy Research Institute, 2003). For the Zimbabwe study: M.P. Bourdillon, P. Hebinck, and J. Hoddinott, *Assessing the Impact of HYV Maize in Resettlement Areas of Zimbabwe, Final Report* (Washington, D.C.: International Food Policy Research Institute, 2002). For the Mexico study: M. Bellon, M. Adato, J. Becerril, and D. Mindek, *The Impact of Improved Maize Germplasm on Poverty Alleviation: The Case of Tuxpeño-derived Material in Mexico. Final Report* (Washington, D.C.: Centro Internacional de Mejoramiento de Maíz y Trigo and International Food Policy Research Institute, 2003).

4. M. Hossain, D. Lewis, M.L. Bose, and A. Chowdhury, *Rice Research, Technological Progress and Impacts on the Poor: The Bangladesh Case (Summary Report)*, EPTD Discussion Paper 110 (Washington, D.C.: International Food Policy Research Institute, 2003).

5. K. Hallman, D. Lewis, and S. Begum, *An Integrated Economic and Social Analysis to Assess the Impact of Vegetable and Fishpond Technologies on Poverty in Rural Bangladesh* (Washington, D.C.: International Food Policy Research Institute, 2003).

6. F. Place, M. Adato, P. Hebinck, and M. Omosa, *The Impact of Agroforestry-based Soil Fertility Replenishment Practices on the Poor in Western Kenya, Final Report* (Washington, D.C.: World Agroforestry Centre (ICRAF) and International Food Policy Research Institute, 2003).

7. M.P. Bourdillon, P. Hebinck, and J. Hoddinott, *Assessing the Impact of HYV Maize in Resettlement Areas of Zimbabwe, Final Report* (Washington, D.C.: International Food Policy Research Institute, 2002).

8. M. Bellon, M. Adato, J. Becerril, and D. Mindek, *The Impact of Improved Maize Germplasm on Poverty Alleviation: The Case of Tuxpeño-derived Material in Mexico. Final Report* (Washington, D.C.: Centro Internacional de Mejoramiento de Maíz y Trigo and International Food Policy Research Institute, 2003).

9. Another method of establishing causation used in the case studies involved comparing what actually happened against the counterfactual (what would have happened without the research). This is important, as even without formal agricultural research the agricultural sector is not static: Farmers innovate, and changes in other sectors of the economy or society also affect agricultural productivity or have other impacts.

10. DFID (Department for International Development, UK), Sustainable Livelihoods Guidance Sheets (http://www.livelihoods.org).

11. IFPRI, Bangladesh Institute of Development Studies, Institution of Nutrition and Food Science, Data Analysis and Technical Assistance, and Research Department of Human Nutrition, "Commercial Vegetable and Polyculture Fish Production in Bangladesh: Their Impacts on Income, Household Resource Allocation, and Nutrition", Unpublished report (Washington, D.C.: International Food Policy Research Institute, 1998).

12. All tons mentioned in this report are metric tons.

13. Less-favored areas: areas that are challenged by difficult agroclimatic conditions, such as poor soil, low and unstable rainfall, steep slopes, and short growing seasons, and/or inadequate infrastructure and support services (roads, irrigation, markets, research and extension, credit, schools, and health centers). Definition from Hazell and Haddad, *Agricultural Research and Poverty Reduction*.

14. S. Fan, P. Hazell, and S. Thorat, *Linkages Between Government Spending, Growth and Poverty in Rural India*, Research Report 110 (Washington, D.C.: International Food Policy Research Institute, 1999); S. Fan, L. Zhang, and X. Zhang, *Growth and Poverty in Rural China: The Role of Public Investment*, Research Report 125 (Washington, D.C.: International Food Policy Research Institute, 2002).

15. This was true for the period 1970–1997 in the China study and 1970–1993 in the India study.

16. S. Fan, C. Chan-Kang, K. Qian, and K. Krishnaiah, *National and International Agricultural Research and Rural Poverty: The Case of Rice Research in India and China*. EPTD Discussion Paper 109 (Washington, D.C.: International Food Policy Research Institute, 2003).

17. The geometric rule: ibid.

18. For an example of this approach in the context of a social program, see E. Skoufias and B. McClafferty, *Is PROGRESA Working? Summary of the Results of an Evaluation by IFPRI*. FCND Discussion Paper 118 (Washington, D.C.: International Food Policy Research Institute, 2001).

19. Bellon et al., *The Impact of Improved Maize Germplasm on Poverty Alleviation*.

20. J. Watts, R. Mackay, D. Horton, A. Hall, B. Douthwaite, R. Chambers, and A. Acosta, *Institutional Learning and Change: An Introduction* (Washington D.C.: International Food Policy Research Institute, forthcoming).

21. Ibid.; D. Horton and R. McKay, *Institutional Learning and Change in the CGIAR*. Impact Assessment Discussion Paper (summary record of the workshop held at IFPRI, Washington D.C., February 2003) (Washington, D.C.: International Food Policy Research Institute, 2003).

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2033 K Street, NW
Washington, DC 20006-1002 USA
Telephone: +1-202-862-5600
Fax: +1-202-467-4439
Email: ifpri@cgiar.org

**www.ifpri.org**

## ABOUT THE AUTHORS

**Ruth Meinzen-Dick is a senior research fellow in IFPRI's Environment and Production Technology Division. Her research deals with water resource management, collective action, and property rights, and much of her fieldwork has been conducted in South Asia and Southern Africa. She heads the CGIAR's Collective Action and Property Rights initiative. She received her Ph.D. in development sociology from Cornell University.**

**Michelle Adato is a research fellow in IFPRI's Food Consumption and Nutrition Division. Her work focuses on social safety net and social protection programs, poverty dynamics, and institutions. She co-leads a research program on large-scale interventions to enhance human capital. She received her Ph.D. in development sociology from Cornell University.**

**Lawrence Haddad directed the Food Consumption and Nutrition Division at IFPRI from 1994 to 2004. He is now the director of the Institute of Development Studies, University of Sussex, United Kingdom. He has conducted and led policy research at the intersection of poverty, food security, and nutrition in many countries in Africa and Asia and has written on social capital, human rights, gender, agriculture, and social protection, among other issues. He received his Ph.D. in food research from Stanford University.**

**Peter Hazell is the director of the Development Strategy and Governance Division at IFPRI. He specializes in agricultural policy issues related to pro-poor and sustainable development in developing countries. He obtained his Ph.D. in agricultural economics from Cornell University.**

ISBN 0-89629-528-1
9 780896 295285 51000>