FEED THE FUTURE
The U.S. Government's Global Hunger & Food Security Initiative

# Feed the Future Learning Agenda Literature Review: Improving Research and Development

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USAID
FROM THE AMERICAN PEOPLE

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# LIST OF ACRONYMS

| | |
|---|---|
| ACIAR | Australian Center for International Agricultural Research |
| AIS | Agricultural innovation systems |
| AKIS | Agricultural knowledge and information systems |
| AMA | Assets and Market Access |
| BFS | Bureau for Food Security |
| BIFAD | Board for International Food and Agricultural Development |
| C3P | Crop Crisis Control Project |
| CGIAR | Consultative Group on International Agricultural Research |
| CGS | Competitive grant scheme |
| CIAT | Centro Internacional de Agricultura Tropical |
| CIP | International Potato Center |
| CRS | Catholic Relief Services |
| CRSP | Collaborative Research Support Program |
| ERR | Economic rate of return |
| FARA | Forum for Agricultural Research in Africa |
| FIRCA | Fonds Interprofessionnel pour la Recherche et le Conseil Agricole |
| FONTAGRO | Fondo Regional de Tecnología Agropecuaria |
| GMO | Genetically Modified Organism |
| ICRISAT | International Crops Research Institute for the Semi-Arid Tropics |
| IFPRI | International Food Policy Research Institute |
| IITA | International Institute of Tropical Agriculture |
| ILRI | International Livestock Research Institute |
| INCAGRO | Investigacion y Competitividad para el Agro Peruano |
| INIA | Instituto Nacional de Investigacion Agropecuaria (Uruguay) |
| IP | Innovation platform |
| IPR | Intellectual property right |
| IRRI | International Rice Research Institute |
| IWMI | International Water Management Institute |
| LSMS | Living Standards Measurement Study |

| | |
|---|---|
| M&E | Monitoring and evaluation |
| MATP | Maendeleo Agricultural Technology Fund |
| MDG | Millennium Development Goal |
| NAIP | National Agricultural Innovation Project |
| NARS | National agricultural research systems |
| NGO | Non-governmental organization |
| NPV | Net present value |
| NRM | Natural resources management |
| POR | Policy oriented research |
| PPB | Participatory plant breeding |
| PPP | Public-private partnership |
| PROLINNOVA | Promoting Local Innovation in Ecologically Oriented Agriculture and NRM |
| R&D | Research and development |
| RCT | Randomized controlled trial |
| SPIA | Standing Panel on Impact Assessment |
| USAID | United States Agency for International Development |

# MAIN FINDINGS AND CONCLUSIONS

To ensure that impact evaluations being undertaken for the U.S. Government's Feed the Future initiative are well-conceived, build on existing evidence, and fill critical evidence gaps, the Bureau for Food Security (BFS) of the United States Agency for International Development (USAID) is providing resources for a comprehensive assessment of existing evidence and gaps in knowledge for each of six themes covered by the Feed the Future Learning Agenda. Concerned staff of USAID in headquarters and country missions and staff of USAID's implementing partners are expected to be the primary users.

The stated aim of Feed the Future is to tackle the root causes of global hunger and poverty through inclusive agriculture sector growth and improved nutritional status. This paper summarizes available evidence that relates to key questions for the Feed the Future Learning Agenda theme on improving research and development (R&D).

The paper examines available evidence on the impact of investing in agricultural R&D as a means of fostering agricultural growth, reducing poverty and enhancing food security and nutrition. It also highlights areas where evidence gaps on impacts of investing in R&D are most visible.

The two key questions addressed are:

1. What partnership mechanisms are most productive, efficient, effective and sustainable for carrying out agricultural research to positively benefit resource-poor farmers and food security?

2. Which R&D programs have had an impact on the policy or enabling environment?

After reviewing evidence and gaps relating to these two questions, other major evidence gaps on impacts of investing in agricultural R&D are briefly discussed.

Productive, efficient, effective, and sustainable partnership mechanisms. Despite a burgeoning literature on partnerships and on innovation systems more generally, there has been very little in-depth evaluation of the extent to which they are achieving their expressed objectives. It is also clear that appropriate partnerships need to be designed to fit the specific institutional landscape and the objectives of the R&D. Thus, no definitive response on which partnership is "best" can be provided.

Only two studies were identified that evaluated the impacts of a specific partnership arrangement against an explicit counterfactual. Both evaluated multistakeholder innovation platforms. One study assessed impacts on location-specific problems at the community level and the other assessed impacts on specific value chain constraints. The evidence from these studies was broadly positive although costs were not considered and challenges of scaling up these highly participatory approaches have to be addressed.

Other impact studies provide evidence of successful R&D in which specific partnerships appear to have been central to this success. The review indicates that partnerships with a good evidence base on impacts are (i) those between the Consultative Group on International Agricultural Research (CGIAR) and National Agricultural Research Systems (NARS), (ii) some of the Innovation Labs for Collaborative Research that partner U.S. universities and developing country research and development organizations, and (iii) partnerships between Australian agricultural research organizations and NARS that have been funded by Australian Center for International Agricultural Research (ACIAR). Even so, the evidence base for these partnerships

could be enriched by evaluation of a wider range of technologies and by deeper evaluation of impacts on poverty reduction, food security, nutrition and sustainability.

For other partnerships, the evidence base is generally modest to weak (Annex 1). Partnerships with farmers and their organizations seem to be generally effective in improving the demand orientation of research. For partnerships with the private sector and non-governmental organizations (NGOs), as well as partnerships in funding R&D, there are few impact evaluations although there are plausible stories of impacts. These findings of weak evidence but plausible impacts also apply to innovation funds that have proliferated in recent years as a way of incentivizing partnerships. The bulk of the evidence indicates that most partnerships have been less effective in reaching resource-poor farmers than better-resourced farmers.

Going forward, there is a case for evaluating new and innovative partnership arrangements before scaling up, using randomized controlled trial (RCT) and mixed methods to enhance rigor and improve learning. Meanwhile, institutionalization of regular impact evaluation studies of USAID funded R&D would create a database that could be analyzed for successes and failures in partnerships. More qualitative case studies of partnerships followed over time could greatly add to the learning agenda at a relatively low cost. A further major gap that needs to be addressed by impact evaluations relates to the transaction costs of partnerships and the cost effectiveness of different ways of managing them, especially in reaching resource-poor farmers.

Impact of R&D programs on policy. Only a handful of impact evaluation studies have been carried out for policy oriented research (POR), although these have greatly expanded our understanding of how POR can influence policies and affect welfare. They have highlighted the importance of networks of influence, messaging (dissemination), the importance of context and windows of opportunity, and the key role of participatory processes of designing and implementing POR in close interaction with policy-makers, in realizing impacts.

However, it is clear that impact evaluation of POR is still in its infancy. There is a lack of robust methods, especially for defining a counterfactual and attributing policy changes to POR. Future efforts to evaluate impacts of POR should combine in-depth quantitative studies of POR on welfare where appropriate, with a wider range of qualitative case studies of the influence of policy research. Almost all evidence to date is from international or donor organizations and a new round of evaluations of POR impacts should include national institutions involved in POR. At the same time, international organizations such as the Standing Panel on Impact Assessment (SPIA) of CGIAR and the International Food Policy Research Institute (IFPRI), the lead CGIAR center for POR, should help move the methodology frontier forward, since the development of more robust methods remains the biggest challenge in providing more evidence-based evaluations of POR impacts.

Other priority gaps. The overwhelming majority of studies to date have focused on estimating impacts in terms of economic returns on investment, leaving a big gap in evidence relating to how improved R&D can meet the goals of Feed the Future—poverty reduction, food security and nutrition, and sustainability. This will require a greater investment in systematic collection of national-level household panel data, including detailed adoption data. Partnerships with other organizations such as the World Bank's rural Living Standards Measurement Study (LSMS) and its modeling work, and CGIAR's SPIA to develop methods could be pursued.

As USAID re-engages in capacity building for NARS, a critical issue will be to develop impact evaluation methods relevant to these investments. More and better impact evaluation by NARS would also go a long way to building databases for wider impact evaluation.

Finally, Feed the Future will need to develop more appropriate intermediate outcome measures to monitor its investments in improving R&D. Current measures such as the number of hectares with adopted new technologies risk biasing investments toward research with very short-term payoffs that could have negative implications for investment in more strategic research with much higher payoffs over the longer term. A sensible approach that recognizes the uniqueness of R&D investments would avoid common indicators and develop specific milestones for each R&D investment. These could be complemented by early adoption and impact evaluations around five to seven years after the research has been initiated to build a database on impacts. Over time, a growing portfolio of such impact evaluations would allow periodic meta-evaluations of the overall impacts of investments in R&D.

In the end, a judicious balance of methods will be needed to fill evidence gaps in evaluating impacts of improving R&D systems. This review shows that relatively low cost case studies and participatory approaches that are well grounded in a theory of change can provide valuable feedback on what works where. At the same time, carefully selected and designed in-depth studies based on RCT methods or time-series household data and preferably conducted by independent evaluators can greatly increase the credibility of the evidence base for investing in R&D. The evidence to date strongly supports such investments as a high payoff activity for development partners in the future.

# I. ABOUT THE LEARNING AGENDA

The objective of this paper is to summarize available evidence on key questions for the Feed the Future Learning Agenda theme on improved R&D and document expert opinion on gaps in the scientific literature for this theme that are in most urgent need of attention.

Feed the Future is an initiative of the U.S. Government, undertaken in response to the commitment of global leaders at the G8 Summit in L'Aquila, Italy in July 2009, to "act with the scale and urgency needed to achieve sustainable global food security." Feed the Future aims to tackle the root causes of global hunger and poverty through inclusive agriculture sector growth and improved nutritional status, especially of women and children. Feed the Future aims to achieve these objectives through several intermediate results detailed in the Feed the Future Results Framework: sustainably increasing agricultural productivity, expanding markets and trade, promoting increased public and private investment in agriculture and nutrition, supporting vulnerable communities and households to increase resilience, increasing access to diverse and quality foods, promoting improved nutrition-related behaviors, and improving use of maternal and child health and nutrition services. The Feed the Future approach focuses on smallholder farmers, especially women.

An important objective of the Feed the Future monitoring and evaluation (M&E) component is to generate evidence to address unanswered questions in the development literature pertaining to the causal linkages in the Feed the Future Results Framework. In line with USAID's new Evaluation Policy launched in January 2011, Feed the Future's M&E approach emphasizes generating, learning from, and sharing evidence and results that can inform future programming and investments, increasing the chance that future investments will yield even better results than in the past.

To organize this work, USAID's BFS led the development of a Feed the Future Learning Agenda in the first half of 2011, composed of a set of key evaluation questions related to the causal linkages in the Feed the Future Results Framework. These questions were designed to be

answered using evidence-based hypothesis-testing, primarily through impact evaluations but also through performance evaluations, economic analysis, and policy analysis. In June 2011, a meeting was held with key experts from implementing partners and other stakeholders—U.S. Government agencies, universities, research centers, NGOs, think tanks, the private sector, and others—to review and validate the key questions and the thematic groupings into which they had been organized to form the Feed the Future Learning Agenda. These stakeholders also provided preliminary design ideas for impact evaluations to be conducted to address these questions.

To ensure that Feed the Future impact evaluations are well-conceived, build on existing evidence, and fill critical evidence gaps, BFS is providing resources for a comprehensive assessment of existing evidence and gaps in knowledge within the framework of the Feed the Future FEEDBACK project. This assessment includes annotated bibliographies and literature review papers organized around the six themes of the Learning Agenda:

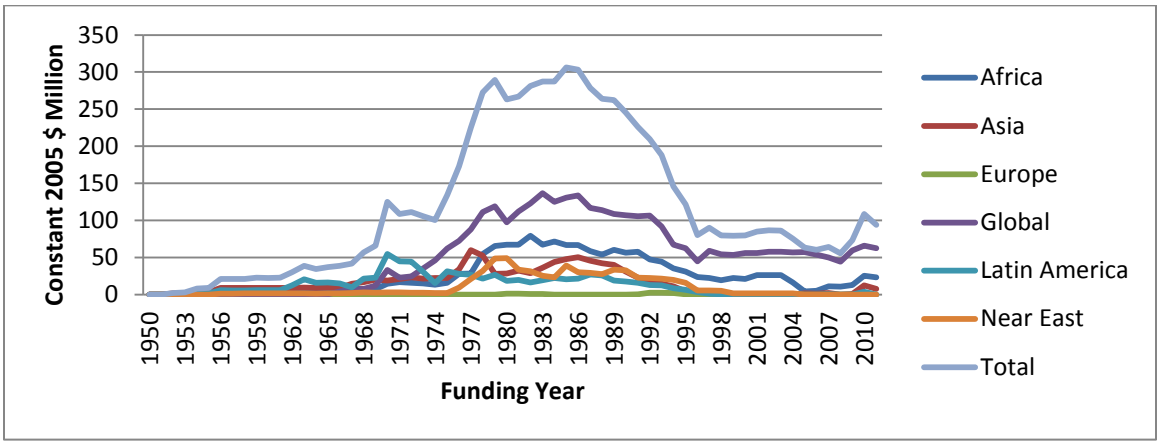
1. Improved Agricultural Productivity;
2. Improved Research and Development;
3. Expanded Markets, Value Chains, and Increased Investment;
4. Improved Nutrition and Dietary Quality;
5. Improved Gender Integration and Women's Empowerment; and
6. Improved Resilience of Vulnerable Populations.

Annotated bibliographies for each of the Learning Agenda themes have already been prepared. Literature review papers for each theme, including this one, present expert analyses of the current state of the scientific evidence for the key questions related to each theme and offer additional guidance on the gaps remaining to be filled by the impact evaluations. At a later stage, the assessment will also include activities aimed at articulating and demonstrating how new evaluations and studies conducted under the auspices of the Feed the Future M&E program contribute to filling the gaps in the body of evidence identified in this and the other five expert papers on the Learning Agenda themes.

# II. ABOUT THE THEME: IMPROVING RESEARCH AND DEVELOPMENT

USAID has a long history of investment in agricultural R&D, including CGIAR, the U.S. University Innovation Labs for Collaborative Research (formerly known as Collaborative Research Support Programs [CRSPs]), and NARS. Investment, especially in NARS, fell sharply from about 1985, but in recent years, USAID has re-engaged in agricultural R&D (Figure 1). In particular, at the request of USAID, Anderson, Roseboom, and Weidemann Associates, Inc. (2013) have recently laid out a framework for re-engagement in NARS.

Figure 1. Estimated USAID Funding for Agricultural Research, 1950-2010




Source: Data from Alex (2012).

Alston, Marra, Pardey, and Wyatt (1998)—the standard reference on the benefits of investment in agricultural R&D—provides conclusive evidence that such investments have high economic payoffs across a wide range of institutional, economic, and agro-climatic settings. There is also much literature to suggest that agricultural R&D is especially effective in reducing poverty. Across a range of countries, Fan (2008) found that per dollar invested, R&D was more pro-poor than any other type of public investment analyzed. Note that much of the poverty impact of investing in R&D is mediated through lower prices of food staples to poor consumers in addition to raising productivity and incomes of resource-poor farmers. There is much less evidence on the impacts of investing in R&D on food security and nutrition at the household and individual level, and on environmental sustainability.

In looking at the two key questions reviewed below, it is important to note at the outset that standards of evidence on impacts vary widely. In recent years, there has been much greater attention to defining a counterfactual explicitly, and to ensuring statistical rigor in estimating intervention (treatment) effects. Most studies before about 2005 and many recent studies do not meet these standards. Application of rigorous standards and selection of only peer-reviewed studies would have reduced the evidence base for this review to a handful of studies (see Annex 1). However, less rigorous studies such as adoption studies and case studies, mostly qualitative, often published in the "gray literature" provide many valuable insights related to the questions for this review and have been cited. Still, some so-called impact evaluations that were relevant were deemed too weak from a methodological view to be included in the evidence base.

Two other cautions are also noted. First, it is much easier to evaluate investments in a specific program such as a crop research program aimed at developing and diffusing productivity-enhancing technologies than to evaluate investments aimed to broadly improve R&D capacity over the long run. The paucity of impact studies on the latter especially limited the evidence base for Question 1.

Second, in evaluating investments in R&D, there is considerable tension between the evaluation functions of learning and accountability given that very long time lags are often required to achieve payoffs to research. Many of the impact evaluations in the past have focused on the accountability function measuring payoffs to research investments that were made a decade or more before the impact study. Such studies are, however, limited in contributing to the learning function. Given the objectives of the Feed the Future Learning Agenda, this review has

purposefully tried to include evaluations that are carried out at an early stage in the research-to-impact cycle to provide feedback to research decision-makers.

# III. KEY QUESTIONS FOR THE THEME

## 1. Partnerships to Reach Resource-Poor Farmers

What partnership mechanisms are most productive, efficient, effective, and sustainable for carrying out agricultural research to positively benefit resource-poor farmers and food security?

### *Evidence*

#### Introduction

There is a rich literature on partnerships in agricultural research, which has been extensively reviewed by Horton, Prain, and Thiele (2009). In the context of international agricultural research for development, Horton et al. define partnership as "a sustained multi-organizational relationship with mutually agreed objectives and an exchange or sharing of resources or knowledge for the purpose of generating research outputs (new knowledge or technology) or fostering innovation (use of new ideas or technology) for practical ends." This definition embraces a wide diversity of partnerships that are often complex and multilateral. It is the working definition used in this review.

The basic rationale for research organizations to enter into partnership is to combine assets and skills in ways that create synergies and enhance the potential size and probability of impacts on the ground on food security, poverty reduction, and sustainability. Thiele et al. (2011) further characterize objectives of partnerships as to: learn and jointly innovate, broker innovations, improve coordination, reduce costs, and advocate policy changes. Successful partnerships build trust, enhance understanding, define roles, and engage in joint action (Thiele et al., 2011).

The need for and potential payoffs to partnerships have increased with the complexity of science, the growing multidisciplinarity of agricultural problems, the broader institutional landscape in which R&D organizations operate, the increasing number of developmental goals (enshrined in the Millennium Development Goals (MDGs)), and pressure from R&D funders to deliver wider impacts in more cost-effective ways (Anderson et al., 2013; Hall, 2012).

Even just considering bilateral arrangements introduces a wide range of possible partnerships. In this review, a simple typology is used, consisting of (i) partnerships among public R&D organizations, (ii) public-private partnerships, (iii) partnerships with farmers and their organizations, and (iv) partnerships with NGOs. Even within a given type of partnership there is much potential diversity. Partnerships may be for funding of R&D; accessing scientific knowledge and tools; or delivering new technologies to farmers, especially resource-poor farmers. Further, since many partnerships are multilateral and involve several types of partners, the classification of partnerships for the review is subjective, based on what seems to be the dominant partnership type.

In recent years, much, if not most R&D is organized through multistakeholder partnerships within an innovation systems framework. As posed by Posthumus, Martin, and Chancellor (2013), "Well-connected actors have a greater innovation capacity as they can combine skills and knowledge from different sources to address problems and opportunities." Anderson et al. (2013) in their recent review for USAID on re-engaging with NARS, highlight this shift to innovation systems, largely in terms of the strengthening of interactions of a broad set of actors in ways that foster an enabling environment for innovation—institutional and managerial, as well as technological (Table 1). In practice, some of the more rigorous impact evaluations have looked at these types of multistakeholder partnerships or platforms, and the evidence review begins with those.

Table 1. Defining features of the NARS, AKIS, and AIS

| Defining feature | National agricultural research systems (NARS) | Agricultural knowledge and information systems (AKIS) | Agricultural innovation systems (AIS) |
|---|---|---|---|
| Primary actors | Research organizations | Research, extension and education organizations | Potentially all actors in the public and private sectors involved in the creation, diffusion, adaptation, and use of agricultural knowledge |
| Outcome | Technology invention and technology transfer | Technology adoption and innovation in agricultural production | Different types of innovation – technological as well as institutional |
| Organizing principle | Using science to create new technologies | Accessing agricultural knowledge | New uses of knowledge for social and economic change |
| Mechanism for innovation | Technology transfer | Knowledge and information exchange | Interaction and innovation among stakeholders |
| Role of policy | Resource allocation, priority setting | Linking research, extension and education | Enabling innovation |
| Nature of capacity strengthening | Infrastructure and human resource development | Communication between actors in rural areas | Strengthening interactions between all actors; creating an enabling environment |

Source: Anderson et al. (2013).

Four other considerations framed the review and selection of the impact evidence presented. First, appropriate institutional arrangements for effecting innovation are highly context specific depending on the type of technology, type of farmers, and the wider institutional context. Thus, the response to the question, "*What partnership mechanisms are most productive, efficient, effective, and sustainable?*" will nearly always be "It all depends." An appropriate framework for responding to the question is the "best fit" approach put forward by Birner et al. (2009) that recognizes that institutional arrangements have to be adapted to the local context. In practice, a range of different partnership mechanisms is likely to be needed even within countries, depending on local context.

Second, there is an important distinction between evaluating impacts of partnerships per se versus evaluating impacts of R&D in which a specific partnership has been central to achieving those impacts. In the first case, which is rare in the literature, a new or innovative partnership in R&D is evaluated against an explicit counterfactual institutional arrangement that represents the conventional approach. In the second case, impacts of successful R&D cannot be attributed

directly to the partnership, although a well-articulated theory of change can greatly increase the plausibility that the partnership arrangement was critical to achieving impacts.

Third, as recognized by the innovation systems framework, innovation may, and often does, occur independently of formal R&D. However, since this review is focused on improving R&D systems, the selection of impact evaluations is based on cases in which the R&D organization was a significant participant in the innovation partnerships. This excludes much work for example on innovation in value chains. A companion paper by Campbell (2013) reviews evidence related to value chain approaches.

Finally, the focus of this review is on reaching resource-poor farmers. Many studies have documented successful partnerships for innovation in commercial agriculture with medium and large-scale farmers. An example is the highly successful adoption of zero tillage in Argentina, through a partnership led by farmer organizations and including the NARS and the private sector (Ekboir & Parellada, 2002). However, since these partnership arrangements may not be transferrable to resource-poor farmers, these studies are excluded.

### Multistakeholder innovation platforms and value chains

Quite recently, multistakeholder innovation platforms (IPs) have become a popular approach to bringing partners together to foster innovation. IPs generally include R&D organizations, advisory services (often non-governmental), input suppliers, financial organizations, and downstream processing and marketing firms (Hall, 2012). Some innovation platforms are quite decentralized, focusing on innovation at the local level, building on local priorities and opportunities across a range of products. Other platforms are built around value chains for a specific product, and may operate at a higher level of aggregation, sometimes nationally. In each case, there has been at least one serious attempt to evaluate impacts of the IP approach against conventional approaches.

The African Challenge Program led by the Forum for Agricultural Research in Africa (FARA) and funded by a multidonor consortium (including USAID) was specifically designed to test the efficacy of the innovation platform approach relative to conventional approaches. Initiated in 2008, some 36 IPs were established in three regions of sub-Saharan Africa targeting a total of 5,400 households. The novelty of this program was that a quasi-randomized approach was used to select villages with IPs and control villages, either with no extension services, or more conventional "linear" systems.[1] An external evaluation by Pamuk, Bulte, Adekunle, and Diagne (2012) found that by 2011, the IPs reduced poverty modestly (around 15 percent) but did not appear to improve household food consumption. Further, the results were not robust across IPs, with some apparently successful and others not (Pamuk, Bulte, & Adekunle, forthcoming). Not surprisingly, the level of initial social capital in a village was positively associated with the success of an IP. Lynam, Harmsen, and Sachdeva (2010) also conducted a qualitative evaluation of the program and like the quantitative impact evaluation concluded that the IPs have much potential but that more time is needed to evaluate progress.[2]

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[1] Although the intention was to implement a fully randomized control trial, this was not possible due to resource constraints (Lynam et al., 2010).

[2] A strongly positive internal evaluation was recently published by Adekunle, Fatunbi, Agumya, Kwesiga, and Jones (2013) who report increases in incomes by 2011 of $1364 (232 percent), a benefit-cost ratio of 44:1 and a pro-poor distribution of benefits. However, these results are questionable given that they are based on Propensity Score Matching, a method that has been strongly criticized for potential biases (de Janvry, Dustan, & Sadoulet, 2011).

Second, a multistakeholder platform built around the potato value chain in Ecuador has been comprehensively evaluated by Cavatassi et al. (2011). The IP aimed to introduce institutional innovations to reduce the transactions costs of smallholders participating in high-value markets with demanding standards, such as potatoes for restaurants, fast foods and processing. As in Africa, the IPs facilitated by the International Potato Center (CIP) brought together a wide range of stakeholders over the five-year period under evaluation, 2003-2007. Cavatassi et al. (2011) carefully pose a counterfactual and use a range of tools such as selection of control villages that are "ground truthed," instrumental variable regressions, and Propensity Score Matching, to isolate the treatment effects of the IP intervention. They conclude that the IPs doubled gross income, partly through a one-third increase in yields, and partly through 30 percent higher prices relative to conventional marketing approaches. As in the African Challenge Program, the performance of the IPs varied, and initial social capital appeared to be an important determinant of success.

Although there are two rigorous evaluations of the benefits of IPs reviewed above, neither has looked at costs. A further step is required to analyze the cost-effectiveness of IPs versus other approaches (Thiele et al., 2011). Likewise, in both cases it is too early to evaluate sustainability once external subsidies are removed and the lead international institution withdraws. Challenges to scaling up these highly decentralized and participatory approaches will also need to be addressed.

Many other multistakeholder partnerships to foster innovation have claimed success, although aside from those described above the impact evidence is generally weak. This is in part because comprehensive impact evaluations of the type discussed above are costly. In a companion review as a part of this series, Campbell (2013) concludes that there is a paucity of rigorous impact evaluation of these approaches despite the huge interest in value chain approaches. Research organizations also have little or no role in much of the value chain work, illustrating the need for much wider conceptualizing of the innovation process. Still, plausible case study evidence suggest that multistakeholder partnerships with strong R&D participation have been quite successful in enabling small-scale farmers to create new export value chains, e.g., white bean exports from Ethiopia (Ferris, Paschall, Seville, Dadi, & Kumssa, 2012), groundnuts exports from Malawi (Adekunle et al., 2012), and honey exports from the Dominican Republic (Henriquez & Li Pun, 2013). Although these studies did not employ rigorous evaluation methods, the results clearly identified impact pathways from R&D to export expansion.

### International partnerships among public R&D organizations

Public R&D organizations enter into partnerships, often internationally, to gain synergies among different types of research. CGIAR Research Programs have a mandate to conduct strategic research that generates spillovers across countries while advanced research organizations in developed or emerging economies have strong capacity in upstream research areas. At the same time, NARS in small- and medium-sized poor countries often have strong local presence and delivery mechanism, but lack resources and market size to capture economies of scale in research. In these situations, both upstream R&D organizations and NARS gain synergies from partnerships to tap spill-ins of knowledge and technology to achieve impacts on the ground (Byerlee & Traxler, 2001). Evidence of impacts of four major partnerships of this type are reviewed below. In these examples, the NARS are broadly defined to include universities, NGOs, and the private sector, but the major players in each case are the public sector R&D organizations and universities.

By far the largest number of formal impact evaluations have focused on partnerships that emphasize crop varietal development and involve CGIAR centers and national research systems, mostly public but sometimes also private.[3] Impacts have been evaluated at global level (Evenson & Gollin, 2003) and regionally (Alene et al., 2011) for all food staples as well as for individual staples at a global or regional level (Byerlee & Traxler, 1995; Alene et al., 2009; Renkow & Byerlee, 2010). Overwhelmingly, these studies show high returns to the investment in R&D as well as positive impacts on poverty reduction ((Fan, Chan-Kang, Qian, and Krishnaiah, 2005; Hazell, 2010), although more so for poor consumers and less for poor farmers in marginal areas. For example, Evenson and Gollin (2003) found that without CGIAR investment in crop varietal improvement from 1965-2000: (a) world food production would have been 4–5 percent lower; (b) world grain prices would have been 18–21 percent higher; (c) area planted to food crops would have been expanded by 11–13 million hectares in developing countries; (d) per capita food consumption in developing countries would have been 5 percent lower on average, and up to 7 percent lower in the poorest regions; and (e) some 13–15 million additional children would have been malnourished. While the rigor of these studies is being challenged by advances in methods (de Janvry, Dustan, & Sadoulet, 2011), there is little doubt that the joint investment and ongoing CGIAR-NARS Partnership for crop varietal improvement has been and continues to be a huge success.

The Feed the Future Innovation Labs for Collaborative Research, supported by USAID (formerly known as the Collaborative Research Support Programs) represent another type of international partnership, largely among public research organizations. An Innovation Lab is managed by a lead U.S. university in partnership with other U.S. universities and with research organizations, universities and other partners in developing countries. The partnerships aim to tap scientific capacity in U.S. Land and Sea Grant Universities (primarily) to solve problems relating to global and national food security. This partnership approach has a track record of over 30 years with 10 Innovation Labs currently covering a variety of research themes. A recent review conducted by the Board for International Food and Agricultural Development (BIFAD) noted a number of Innovation Labs that have demonstrated significant measured impacts—including Integrated Pest Management, Sorghum and Millet, Legumes, Peanut, and Global Livestock Innovation Labs—through dissemination of new and improved varieties and ecologically-sensitive pest management strategies (Jones et al., 2012). For example, since 1991, national programs of Costa Rica, El Salvador, Honduras, Nicaragua and Ecuador in collaboration with the Legumes Innovation Lab and the Centro Internacional de Agricultura Tropical (CIAT) have released some 90 improved bean varieties that have been widely adopted by resource-poor farmers on two-thirds of the bean area in the Central American countries and half the area in Ecuador. Reyes (2011) estimated the net present value (NPV) of benefits at $362 million, with an internal rate of return on investment in bean research of 33 percent. In other cases, Innovation Labs have made significant contributions in the form of institutional innovations and policy changes, such as the BASIS Assets and Market Access (AMA) research program which refined the design of weather index-based insurance schemes to mitigate risks to small holders (Carter, Long, & Boucher, 2011).

Third, ACIAR aims to reduce food insecurity, improve livelihoods and increase sustainability by tapping Australia's recognized scientific capacity to develop solutions to agricultural problems in developing countries. Collaboration with researchers in partner countries is integral to the development and delivery of ACIAR research programs. During 2011-2012, approximately $72 million of the Centre's research budget of $108 million was allocated to bilateral country research projects in more than 40 countries in Asia and Africa. The Center has a culture of

[3] USAID is one the major supporters of the CGIAR System.

impact evaluation with projects selected randomly for impact evaluation soon after their completion. For 90 projects that have been evaluated in detail, total benefits were estimated at $12.6 billion for a total investment of approximately $234 million in 2008 dollar present value terms (Harding, Jiang, & Pearce, 2009). Of the total benefits $11.4 billion accrue to developing countries and $1.2 billion to Australia.

Finally, growing capacities in the large emerging economies with dynamic R&D systems, such as Brazil, China, and India, represent an underused resource for South-South cooperation that small developing countries can tap, with modest levels of funding. New collaborative arrangements among developing countries are making this possible. Fondo Regional de Tecnología Agropecuaria (FONTAGRO), the Regional Fund for Agricultural Technology for Latin America and the Caribbean, is one example. A consortium of 13 countries, created in 1998, FONTAGRO allocates grants competitively to partnerships within the region, aiming to achieve economies of scale across countries.[4] A recent evaluation identified 15 projects with positive impacts on the ground (Henriquez & Li Pun, 2013). One of these illustrates how a partnership between honey bee producer organizations and scientists in the Dominican Republic and their counterparts in Argentina was associated with a doubling of yields and a 277 percent increase in production, much of it exported. A related model is the Latin American Fund for Irrigated Rice, which includes members from public and private sectors and from producer organizations in 13 countries to finance rice improvement research, again with apparently positive impacts (Binenbaum, 2008). Very recently, several donors have supported the establishment of the Brazil-Africa Agricultural Innovation Marketplace to foster the transfer of Brazilian expertise in tropical agriculture to Africa. While such partnerships are increasing rapidly, the evidence base on impacts remains limited.

One feature of the impacts reported above for international partnerships is their concentration on crop varietal improvement and pest management. Although CGIAR, ACIAR and the Innovation Labs invest considerably in other areas of R&D, especially natural resources management (NRM), often in partnerships with NARS, evidence of impacts on the ground is still relatively weak. Some studies such as Waibel and Zilberman (2007) and Rejesus, Martin, and Gypmantasiri (2013) have estimated significant impacts of CGIAR-NARS partnerships in NRM research but of an order of magnitude less than for varietal improvement and pest management. The greater difficulty of tracking changes in NRM, methodological challenges in attribution, the greater location specificity of much NRM research, and the need for complementary investments in policies and institutions explain this evidence gap (Renkow & Byerlee, 2010; Mayne & Stern, 2013).

### Public-private partnerships

With increasing emphasis on private sector development, there has been a flurry of activity on public-private partnerships (PPP) in agricultural research (Byerlee & Echeverría, 2002; Spielman, Hartwich, & von Grebmer, 2010). PPPs build on the complementary assets of the public sector (genetic resources, networks, public good orientation) and private sector (market orientation, access to capital, and proprietary technologies) to realize synergies and wider impacts of investment in R&D (Table 2).

Such partnerships have different purposes that may be broadly classified into (i) partnerships to access proprietary technologies for the benefit of the poor, (ii) partnerships to commercialize technologies, (iii) partnerships to develop a new product, and (iv) partnerships to generate

[4] See website at http://www.fontagro.org.

revenues for public organizations. The challenge in all cases is how to engage the private-for-profit sector to support resource-poor farmers. In general, partnerships aimed at revenue generation for public R&D organizations are unlikely to be pro-poor and in any event, only a small number of such partnerships are successful (Fischer & Byerlee, 2002).

Although there is a rich literature on PPPs there are very few rigorous impact studies (Spielman et al., 2010). Naseem, Spielman, and Omamo (2010) note the difficulties in evaluating impacts of PPPs such as controlling for variations in PPP design, the valuation of in-kind costs such as intellectual property, and the relatively young age of most PPPs. However, there are a number of examples that have been subjected to qualitative evaluations.

CGIAR has entered into an increasing number of PPPs with multinational seed companies and others with the aim of accessing proprietary knowledge for the benefit of the poor. These PPPs have become necessary as the private sector has dominated biotechnology research and a small number of firms now hold the great majority of biological patents for agriculture (Fuglie, Heisey, King, & Schimmelpfennig, 2012).

Table 2. Assets of public and private sectors in agro-biotechnology research

| Institution/firm | Scientific and knowledge assets | Other assets |
|---|---|---|
| Multinational research firms (life-science firms) | Genes, gene constructs, tools, related information resources<br>Biotechnology research capacity | Access to international markets and marketing networks<br>Access to international capital markets<br>Economies of market size<br>Intellectual property right (IPR) skills |
| International agricultural research centers (CGIAR) | Germplasm collections and informational resources<br>Conventional breeding programs and infrastructure<br>Applied/adaptive research capacity | Access to regional/global research networks<br>Access to bilateral/multilateral donor funding<br>Generally strong reputation for integrity |
| National agricultural research institutes in medium-size countries | Local/national knowledge and materials<br>Conventional breeding programs and infrastructure<br>Applied/adaptive research capacity | Seed delivery and dissemination programs and infrastructure<br>Generally strong reputations for integrity |
| Local firms | Local/national knowledge and materials<br>Applied/adaptive research capacity | Seed distribution and marketing infrastructure |

*Source*: Adapted from Byerlee and Fischer (2002), and Spielman and von Grebmer (2004). For simplicity, advanced research institutes and other players in the global research system are excluded from this table.

Although a number of mechanisms are being used (Byerlee & Fischer, 2002) most negotiate IPRs within a framework of segmented markets that allows free use of the technologies for resource-poor farmers defined by region and/or income level. Examples are Vitamin A enriched Golden Rice and Water Efficient Maize for Africa. These partnerships were initiated with high expectations, but to date impacts have been negligible mostly due to high transactions costs of regulatory approval for transgenic products. Even non-Genetically Modified Organism (GMO) products such as herbicide coating for maize seed developed by a PPP to combat *striga* weed in Kenya have had low adoption rates to date (Mignouna et al., 2008). Beyond CGIAR, brokers such as the African Agricultural Technology Fund are using similar approaches to access

proprietary knowledge for the benefit of African farmers and consumers but although many promising products are in the pipeline, there is still no evidence of impact (Mignouna et al., 2008). These types of PPPs, including those by NARS have been characterized by some as supply driven and not responding to needs of resource-poor farmers (Muraguri, 2010; Ayele, Chataway, & Wield, 2006). In all cases, transactions costs on IPRs have also been high (Spielman et al., 2010).

Diffusion-oriented PPPs aimed at commercialization of publicly developed technologies have had much more success. They have generally worked best for hybrid seed that carries inbuilt IPR protection. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) established a Hybrid Parents Research Consortium to commercialize its plant breeding products. Pray and Nagarajan (2009) observe widespread adoption and yield gains of 23 percent for millet as a result of this partnership. Sixty percent of millet area (6 million hectares) is now sown to private hybrids based on public programs, much of it in very marginal dry areas characterized by high levels of poverty. The program was estimated to provide an annual benefit of $50 million with an internal rate of return on investment of 50 percent. Although information on the type of beneficiary is not available, sorghum and millet farmers are generally among the poorest in India due to their marginal production environment.

Commercialization programs can also work with open pollinated crops. Tripp and Pal (2001) highlight growing PPPs between public research organizations and the rice seed industry in Andra Pradesh, India, even though rice is a self-pollinated crop. Seed sales almost doubled in the late 1990s, with all of the increase in the private sector, made of many small companies.

Similarly, the Rice-Wheat Consortium in India and Pakistan worked closely with private farm machinery manufacturers to develop and popularize a zero-tillage drill that was adopted by an estimated 620,000 farmers (Erenstein, 2009). This program generated benefits of $94 million and a 57 percent return on the R&D investment, although benefits were largely in richer irrigated areas of India and Pakistan.

Diffusion-oriented PPPs do not always deliver as expected. The International Livestock Research Institute (ILRI) entered into an innovative partnership to deploy a vaccine for East Coast Fever for cattle in Kenya. Although the partnership was dissolved after vaccine testing did not generate the desired response, valuable lessons were gained on how to organize and manage such partnerships (Spielman, 2009; Smith, 2005). Other PPPs such as for sorghum varieties for brewing in Uganda, and diffusion of the genetically improved farm tilapia in the Philippines, have achieved their diffusion objectives but the major beneficiaries have been larger producers (Akullo, Maat, & Wals, 2011; Ponzoni, Khaw, & Yee, 2010).

Finally, many PPPs are oriented toward adding value through development of a commercial product based on a research prototype (Hartwich & Tola, 2007). Most of these are in the processing sector and are often built around agribusiness incubators. Some of these have been spectacularly successful such as the Fundacion Chile in establishing a salmon industry that now leads the world, but few seem to have been focused on resource-poor farmers and firms.

One example that has been evaluated is cassava in Nigeria, where a large program responding to a presidential initiative designed and commercialized a range of cassava processing equipment through partnerships with local manufacturers. Rusike et al. (2012) found a positive impact of the program on adoption of processing methods and improved varieties, but no discernible impact on household food consumption of cassava producers. Similarly, the Centro Internacional de Agricultura Tropica (CIAT) in Colombia designed equipment for dried cassava chips for animal feed that led to the building of 37 private processing plants that by 1993 produced 35,000 tons of dried cassava, with an estimated value of $6.2 million (World Bank,

2007). In another case, a PPP introduced by the International Potato Center (CIP) in Peru to process indigenous potato varieties into snacks has grown into a new industry benefiting thousands of poor farmers in the highlands (Devaux et al., 2009).

Overall, PPPs have been a mixed success to date. As expected they work best for more commercially-oriented farmers although much depends on the trait, crop and technologies in terms of potential to reach resource-poor farmers (Spielman et al., 2010). PPPs designed to gain access to proprietary science for the public good have not yet met expectations. Regardless of the objective, successful PPPs have to overcome challenges of different business cultures, incentives, and capacities, as well as the negotiation of IPRs often from unequal power bases and capacities.

### Partnerships with farmers and their organizations

There has been a long tradition of increasing involvement of farmers in the research process to enhance the probability that resulting technologies will be adopted. Such partnerships in recent years have emphasized demand-oriented research by empowering farmers to make key decisions in the research process.

Evaluation of these approaches is most advanced in participatory plant breeding (PPB) research, where farmers define traits and select breeding lines grown in their fields for commercial use. In very poor rainfed rice-growing areas of South Asia that the Green Revolution bypassed, participatory plant breeding has resulted in strong early adoption of farmer-selected varieties with 40 percent higher yields in farmers' fields (Walker, 2006). Conroy et al., (2009) reviewed progress for two varieties developed through PPB and estimated nearly three million adopters. Importantly, they estimated that the varieties improved household rice self-sufficiency by 17 percent and that adopters were overwhelmingly poor.

In Latin America, Ashby, Hareau, Thiele, and Quiros (2009) found that PPB accelerates breeding and improves acceptability of resulting varieties in poor areas. A recent impact study (Reyes, 2011) is the first to compare conventional breeding and PPB, focusing on beans grown by resource-poor farmers in Honduras. The PPB program involving the NARS and an NGO achieved yield gains that were much lower than for conventional breeding but adoption of PPB varieties was much higher (31 percent versus 4 percent), due to their superior traits other than yields. Although the PPB program was much less costly than the conventional program, rates of return were barely positive given the small number of communities covered. The cost-effectiveness of the approach for wider use needs to be evaluated, and legislation for seed and plant varietal rights has to be adapted to accommodate the nonuniformity of varieties developed by the approach.

Participatory action research with farmers has also been evaluated for NRM technologies, notably aquaculture in Malawi, where NGOs helped scale up the adoption of fish ponds to 7,000 adopters (Dey et al., 2007). In Thailand and Vietnam, improved crop and natural resource management practices developed through participatory research were widely adopted, with annual benefits of $2.5 million and an economic rate of return (ERR) of more than 40 percent (Dalton, Lilja, Johnson, & Howeler, 2007).

A further step in farmer partnerships is to develop formal partnerships with farmer organizations for design and implementation of research. Wennink and Heemskerk (2006) summarize case studies and good practice for these types of partnerships in Africa, although no impact evaluations are provided. Spielman, Ragasa, and Rajalahti (2012) describe the Agricultural Services and Producer Organization Project in Senegal where farmer organizations help set

research priorities and screen proposals for adaptive research. Evaluation of the first phase suggested modest increases in adoption and farmer incomes.

Farmers are further empowered when they co-finance R&D. In Cote d'Ivoire, Fonds Interprofessionnel pour la Recherche et le Conseil Agricole (FIRCA) is a fund established by a federation of producer organizations that collects levies on cash crops. FIRCA funds the bulk of research and extension in Cote d'Ivoire with apparent success (Byerlee, 2011). An evaluation for farmer funding of research was recently carried out for the Instituto Nacional de Investigacion Agropecuaria (Uruguay) (INIA), the NARS of Uruguay. Established in 1990, INIA is funded jointly by the government and by farmers through a levy on output, with farmers and government having equal representation on the governing board. A recent evaluation of INIA estimated a benefit–cost ratio for investment in public research of 16:1 to 20:1, and found generally positive social and environmental impacts as well. However, impacts were larger for larger commercial farmers although small-scale horticulture producers also benefited (Bervejillo, Alston, & Tumber, 2012).

A meta-review of impacts of innovation funds by Ton et al. (2013) finds strong supporting evidence that "participation of local farmer organizations in decision-making about research funds is effective in directing the research to critical constraints in onfarm agricultural innovation." However, they also note that there is only weak evidence that participation of higher-level farmer organizations in decision-making about research grants is effective in scaling up and scaling out onfarm agricultural innovation processes.

### Partnerships with non-governmental organizations

NGOs are highly diverse and defy easy generalizations about impacts of partnerships. Some NGOs are major research organizations in their own right, but most focus on grass roots development activities, especially in poor and marginal areas. Partnerships by research organizations with the latter type of NGO are increasingly common, given NGOs' field presence, their commitment to bettering the lives of the poor, and their skills in mobilizing farmer and community networks. Further, they often have strengths in natural resource management and nutrition that strongly complement the assets of scientific organizations. A review of several examples of CGIAR-NGO partnerships is found in Smith and Chataway (2009). However, impact evaluations of such partnerships are scarce, partly because until recently, "impact culture" was weak in NGOs. Methods of measuring impact are also necessarily less rigorous because projects are generally small in relation to the costs of using formal impact evaluation methods.

Still, a growing number of studies provide plausible stories of considerable success of partnerships with NGOs in reaching resource poor farmers. FARM Africa has tried to document impacts of its Maendeleo Agricultural Technology Fund (MATP). This fund provides grants averaging around $50,000 to scale up technology adoption, mostly to other NGOs, many of whom are working in partnership with research organizations. Irwin Grayson Associates (2008) reviewed impacts of 33 such projects, estimating that some 100,000 farmers had been reached with "income gains" of 500 percent. While income gains of this magnitude are considered very high (and possibly implausible), case studies of individual projects financed by MATP for indigenous vegetables in East Africa (Muhanji, Roothaert, Webo, & Stanley, 2011) and indigenous poultry in Uganda (Roothaert, Ssalongo, & Fulgensio., 2011) do indicate considerable success in themes that are not generally emphasized by mainstream research organizations.

In another approach, Promoting Local Innovation in Ecologically Oriented Agriculture and NRM (PROLINNOVA) provides micro-grants averaging around $100 directly to farmer groups through its Local Innovation Support Fund for experimentation with new technologies in nine African countries (Waters-Bayer & Bayer, 2005). With a focus on natural resources management, and linking with research and extension, the program claims to be particularly successful in reaching the poorest, especially women, and has also had some success in influencing priorities of formal R&D.

Catholic Relief Services (CRS) is one of the world's largest NGOs involved in agricultural programs. One of their most successful projects, Crop Crisis Control Project (C3P) involved diffusion of disease-resistant varieties and planting materials for cassava and planting materials and management practices for bananas, after the outbreak of new and devastating diseases on those crops in the Great Lakes area of East Africa. An evaluation by Eden-Green, Akoroda, Bhattacharyya, and Oruko (2008) estimated that working through local NGOs, C3P benefited over half a million cassava farmers and about 60,000 banana producers. This project worked in contractual partnerships with Bioversity International and the International Institute of Tropical Agriculture (IITA), but in a reversal of the usual approach, CRS was the lead agency.

Some international research organizations frequently partner with NGOs in poor and remote regions. The Australian Center for International Agricultural Research (ACIAR) has documented impacts of working with World Vision on technology diffusion in such regions of Southeast Asia. High economic benefits were recorded for rainfed rice in Savannakhet province of Laos, where more than 20,000 farmers were reached with improved varieties and management practices, although another project on fruit in Northern Thailand was not successful (Harris, 2011a, 2011b). Likewise, the International Rice Research Institute (IRRI) provided grants to NGOs reaching 18,000 rice farmers in Bangladesh (Magor, Salahuggin, Hague, Biswas, & Bannerman, 2007). World Agroforestry Center partnered with a number of NGOs in Kenya to diffuse fodder trees to 200,000 farmers with a net annual benefit of $3.8 million (Wambugu, Place, & Franzel, 2011).

Finally, the evidence suggests that NGOs have often targeted the poorest and most marginal farmers, including women, with some success. However, NGOs also often target technologies that minimize use of external inputs, under the assumption that such technologies would be pro-poor. In an important book of case studies of such programs, Tripp (2006) found that while adoption by small farmers was often significant, the bulk of the evidence indicated that low input technologies were most widely adopted by better-resourced farmers.

### Incentivizing partnerships and their impacts through funding mechanisms

Competitive grant schemes (CGS) have been established in many countries, supported by the World Bank and other donors in part as a way to provide incentives for partnerships that will enhance research effectiveness. Focusing initially on Latin America, these programs aim at making research more demand-driven through encouraging greater stakeholder participation in defining research priorities, enhancing cross-institutional collaboration through joint proposals, and mobilizing additional funding through co-financing arrangements (World Bank, 2006).

The Independent Evaluation Group of the World Bank in a review of these programs in Latin America found that although CGS increased the rigor and transparency of selection of research projects, there was little evidence that this led to higher quality and more cost-effective research nor to increased agricultural productivity and incomes of farmers (World Bank, 2009).

Although projects were more client-responsive, outreach to the poorest groups was problematic and involvement of the private sector was below expectation.

The major exception to these findings is Investigacion y Competitividad para el Agro Peruano (INCAGRO), a decentralized innovation fund in Peru, established in 1999 with World Bank support that carried out an impact evaluation of its grant program in 2009 (Avila, Filho, & Alonso, 2010; Preissing, 2012). Findings indicated a one-third increase in adoption by farmers participating in grants, increased employment, and a positive contribution to the development of human and social capital and development of local institutions such as advisory services. The program had an overall return of 24 to 36 percent on an investment of $53 million as well as positive environmental benefits such as reduced use of pesticides and adoption of conservation practices (Avila et al., 2010). However, benefits were concentrated in wealthier regions and among larger and better-educated farmers.

In India, the National Agricultural Innovation Project (NAIP) has been rated a success in providing competitive grants to bring partners from the public and private sectors together to foster innovation in particular value chains (Mudahar, 2012). NAIP has just sponsored an innovation marketplace with private firms that resulted in 80 licenses to commercially develop new products. However, impacts on the ground will require more time to be realized.

As mentioned above, Ton et al. (2013) recently conducted an extensive meta-review of impacts of competitive innovation funds. They were able to locate only 20 impact evaluations and another 42 that included some form of qualitative evaluation. They found strong evidence that CGS stimulate value adding innovation processes by smallholders, especially where they build on initial social capital. However, few studies explicitly considered counterfactuals and there was only weak support that CGS improved livelihoods. They also noted that the grants required wider support through complementary services to enable impacts. Even so, the study generally supported the relevance and effectiveness of CGS in relation to conventional approaches to research and extension. As with many of the partnerships considered in this review, Ton et al. (2013) conclude that CGS make positive contributions to human and social capital that may have larger and longer lasting impacts than the specific products of the research grants. In short, while the evidence base is still weak, CGS has a plausible rationale.

Prizes to reward research outcomes, such as the extent of adoption of a technology, have also been proposed as a way to incentivize the demand-orientation of research organizations. Masters and Delbecq (2008) have proposed prizes for agricultural research and a multidonor initiative—the AgResults for Innovation in Research and Delivery—has established a funding mechanism to test the approach. However, there is as yet no evidence that this approach will be more cost effective in reaching resource poor farmers than existing alternatives.

### *Evidence gaps*

In recent years, partnerships by R&D organizations have often been seen as an end in themselves rather than as a way to improve the efficiency, effectiveness and sustainability of research. From a conceptual standpoint, R&D partnerships make good sense for improving R&D systems because they enhance access to modern science, foster spill-ins of knowledge and technology from abroad, enhance the demand and market orientation of R&D, and increase the probability and scope of technology adoption. Partnerships are also integral to the recent emphasis on broader innovation systems going beyond reliance on traditional R&D systems as the sole source of innovation. However, despite a burgeoning literature on partnerships and on

innovation systems more generally, there has been very little rigorous evaluation of the extent to which they are achieving their expressed objectives.

This review indicates that the only partnerships with a solid evidence base are CGIAR partnerships with NARS, some of the Innovation Labs for Collaborative Research being implemented jointly by U.S. universities and research organizations in developing countries with funding from USAID, and the ACIAR partnerships with developing country NARS broadly defined to include universities, the private sector and NGOs. In these cases, there is strong evidence of large economic impacts, with significant benefits for resource poor farmers. Even so, the evidence base could be enriched by impact evaluation of a wider range of technologies, beyond varietal improvement, and by deeper evaluations of impacts on poverty reduction, food security, nutrition, and sustainability, as discussed later in Section IV.

For other partnerships the evidence base is modest to weak. Better impact information is available on partnerships with farmers and their organizations and these seem to have been generally effective in improving the demand orientation of research, although not always in ways that ensure that resource-poor farmers are major beneficiaries. For partnerships with the private sector and NGOs, as well as partnerships in funding R&D, there are few impact evaluations. This is partly because the methods for evaluating impacts are challenging, and when impact studies are carried out, they lack rigor.

A critical question for the development community is how much to invest in impact evaluation of alternative partnership arrangements per se versus increasing investment in impact evaluation more generally and paying particular attention to the type of partnership arrangements that underpin successful investment in R&D and the lessons learned about partnerships from less successful cases. In general, this review suggests the second approach, given the difficulty of designing impact evaluations of specific partnership arrangements, including the choice of a counterfactual. However, when new institutional approaches are being widely implemented that depart sharply from conventional approaches, such as the multistakeholder innovation platforms in recent years, there is a case for in-depth evaluation of these new partnership arrangements. The two impact evaluations of innovation platforms reviewed demonstrate that rigorous approaches can be applied when sufficient resources are made available.

In recent years, many have argued for using RCT designs to introduce an intervention, such as an innovative partnership, and to track household adoption and income over time against a control. There is considerable scope to scale up RCT evaluation in cases where the partnership and the control (counterfactual) treatment can be clearly defined. However, innovation systems are by definition interactive and learning so design needs to incorporate flexibility for the intervention (and control) to evolve over time. Additional challenges are the potentially high cost of conducting such trials and the external validity in applying the results of apparently successful interventions to a wider scale (Lynam et al., 2010). The potential role and limitations of RCT methods are discussed further in de Janvry et al. (2011) and Barrett and Carter (2010).

At the other end of the rigor spectrum, case studies of partnerships can deliver valuable qualitative evaluations at much lower cost and in a more timely manner. Such approaches may not meet standards of rigor for accountability but they are valuable for learning and feedback, especially if program design is based on an explicit theory of change (i.e., impact pathways). One weakness of the case studies reviewed has been their one-off nature, leaving a big gap in this review on the long-term sustainability of partnerships. This gap could be remedied through repeat evaluations at regular intervals.

In practice, a mix of evaluation approaches, both qualitative and quantitative, may be optimal (Bamberger, 2012). This approach is best illustrated in this review by the Cavatassi et al. (2011)

evaluation of value chain platforms in Ecuador. Further effort along these lines appears to be a fruitful area for enhancing evidence on impacts of partnerships. Because of costs, these evaluations need to be carefully selected to maximize learning and knowledge generation.

A final major gap in impact evaluations relates to the cost of partnerships. Although some studies have included resource contributions by partners in estimating ERRs, none has tried to quantify transaction costs of partnerships. With the move toward more complex partnerships, most agree that such transactions costs are significant and need to be more carefully documented. Further, there is little comparative analysis of the cost effectiveness of different ways of managing partnerships, especially in reaching resource-poor farmers.

# 2. Impacts of Research on Policies

Which R&D programs have had an impact on the policy or enabling environment?

### *Evidence*

#### Introduction

Evaluating the impacts of policy oriented research (POR) is a relatively new venture, and one that is seemingly confined to a handful of international donors and organizations. The basic framework for POR was laid out in a conference in 2001 reported in Pardey and Smith (2004). In the past five years, there have been at least four major reviews of impacts of POR, and this review draws heavily on their findings (Raitzer & Ryan, 2008; Walker, Ryan, & Kelley, 2010; Lindner, 2011; Masset, Mulmi, & Summer, 2011). Note that these reviews by three different organizations—CGIAR, ACIAR and the Institute of Development Studies)—largely cover the same set of studies.

POR here is defined as research aimed to result in new or improved policies, regulations, or institutions (or their management) that enhance economic, social, and environmental welfare (Raitzer & Ryan, 2008). POR achieves this by providing input into a political process that results in a decision or decisions to change a particular policy, regulation, or institutional arrangement. POR may focus directly on public decision-makers but may sometimes provide advice to private decision-makers aimed at improving social welfare.

POR studies are generally classified as supply-led (starting from the POR and working through the impact pathway) or demand-led (starting from a specific change in policy and analyzing the influences on that policy change). The impact pathway from POR is through dissemination (messaging), influence on policy decisions, implementation of those decisions, and the resulting changes in welfare. However, the policy-making process is messy so that impact pathways are rarely linear, generally complex, and often indirect (Figure 2). Impacts are very context specific, often defined by "windows of opportunity" in the political process brought about by new leadership or a sharp change in economic fortunes, such as a fiscal crisis.

All agree that attribution is the biggest challenge to impact evaluation of POR since a specific POR is only one of many sources of input into a policy decision. Analysts have usually assessed influence through interviews and surveys with key informants including the decision-makers

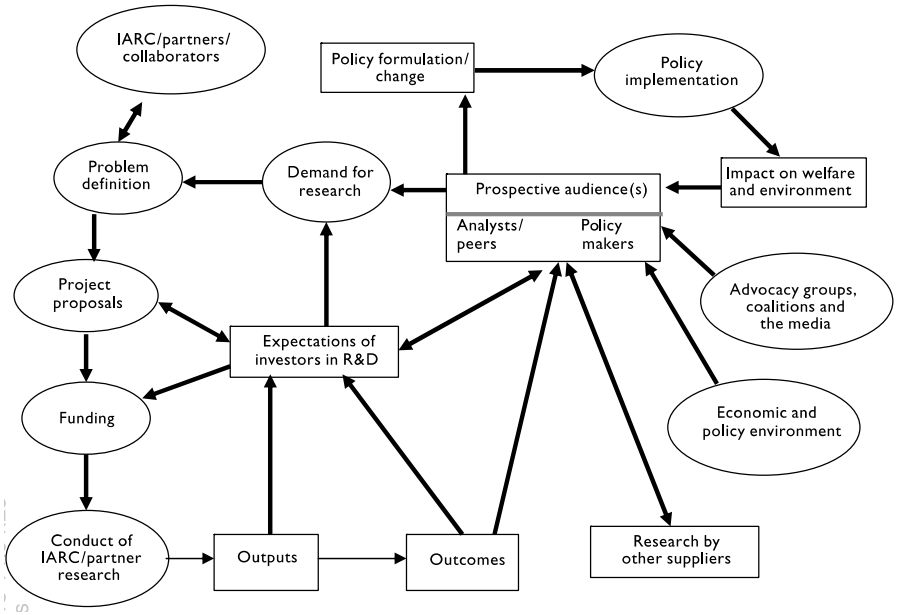
themselves. Sometimes citations can help trace a pathway to decision-makers. Analysts also commonly adopt "conservative" assumptions, in the hope that any bias in the benefits estimation would be downward. Even so, this approach misses benefits from maintaining policies that would have been changed in welfare-reducing ways in the absence of POR (Pardey & Smith, 2004).

Similarly, the specification of the appropriate counterfactual—what would have occurred in the absence of the research that was conducted—is a difficult challenge for evaluating POR impacts. In some cases, the counterfactual may be later and/or slower implementation of the same policy decisions as occurred with the POR (Ryan, 2002). There is little if any obvious guidance available in the impact evaluation literature to assist in choosing a counterfactual.

The welfare effects of a policy change are usually handled through an economic modeling exercise against the assumed counterfactual. This seems to be well accepted although the estimates are obviously only as good as the models.

Additional special complications have been highlighted in evaluating impacts of POR. These include the "poisoned well" problem (Pardey & Smith, 2004), where POR is induced by rent seeking behavior that leads to welfare reducing policies—for example, POR promoted by producer organizations that leads to increased tariff protection of farm products and higher prices to poor consumers.

Figure 2. Diagrammatic depiction of complexity of impact pathways for POR




**NOTE:** The rectangles represent nodes where evaluation efforts would primarily focus. The ovals are the actions or influences. IARC is International Agricultural Research Center which is the assumed source of the POR in this example.

Source: Raitzer and Ryan, 2008.

Two organizations, CGIAR and ACIAR, have conducted a set of impact evaluations of POR. IFPRI, one center within CGIAR, has since 2008 largely conducted qualitative studies of influence rather than quantifying impacts.

## CGIAR impact studies

SPIA, CGIAR's Standing Panel for Impact Assessment, sponsored a series of POR impact studies from 2005-2010 (Raitzer & Ryan, 2008; Walker et al., 2010). SPIA noted that CGIAR expenditures on POR had grown substantially over time, from 10 percent of the CGIAR budget in 1992 to 16.5 percent in 2005. At the same time, the World Bank's 2003 meta-evaluation of CGIAR found a striking lack of credible studies analyzing impacts of the large historical investments in POR estimated to be about $800 million from 1971-2004 (World Bank, 2003). To fill this gap, SPIA identified and reviewed 24 *ex post* assessments of CGIAR POR projects (SPIA, 2006). The studies spanned a range of policy domains: trade and market policies, property rights, plant genetic resources, and gender. These provided substantial qualitative evidence on how and why POR and the recommendations it generates find their way into real-world policy formulation and implementation. But most studies stopped well short of quantifying impacts on CGIAR core missions of food security, poverty reduction, and environmental sustainability.

The dearth of empirical impact evaluations was attributed to the very difficult challenges facing analysts of POR, both in the quantification of ideas and knowledge—the fundamental products of POR—and their attribution to specific producers of that knowledge. Only three of these 24 studies yielded quantitative estimates of economic impacts, all from IFPRI. Babu (2000) evaluated food policy reforms in Bangladesh, the abolition of Rural Rationing Program and implementation of Food for Education Program. Ryan (2002) evaluated impacts of policy reforms for rice trade in Vietnam, particularly a reduction in the export tax, following recommendations of IFPRI research. Both studies estimated that the IFPRI POR delivered benefits in the tens of millions of dollars ($27-$166 million for Bangladesh and $45 million for Vietnam) for a relatively small investment in POR.

In 2007, seven POR impact evaluations were commissioned by SPIA to augment available studies from IFPRI. These studies reviewed a wide range of policy interventions—forestry, fertilizer, conditional cash transfers, milk marketing, and pesticide policy. The estimated net benefits of each of these policy research projects were in the tens or hundreds of millions of dollars in net present value – substantial, but an order of magnitude lower than those attributed to CGIAR successes in the biophysical sciences, especially crop germplasm improvement. Walker, et al. (2010) note that impressively high returns on specific POR projects to a large degree reflected modest budgets for POR projects, relatively short gestation periods, and a compressed diffusion process. Only a small share of all POR would need to be successful to pay the cost of all POR in CGIAR.

All of the 2007 impact studies listed were country studies conducted within a particular, country-specific policy environment. Most produced knowledge potentially relevant to policy domains in other countries. However, documentation of such spillovers is quite difficult, particularly given the sporadic, "right time, right place" nature of policy changes. Only two studies – Behrman's 2010 analysis of IFPRI's contribution to Mexico's conditional cash transfers program and Ryan's 2002 analysis of IFPRI's contribution to policy change in Vietnam's rice sector – quantified these spillovers, both finding that the value of these spillovers alone exceeded the projects' costs (Behrman, 2010; Ryan, 2002).

Since 2007, it has been hard to find full impact evaluations of POR in CGIAR. Shah, Bhatt, Shah, and Talati (2008) provide a good analysis of the impact of the change in electricity management in Gujarat state of India to reduce subsidies to tube wells, control groundwater overdraft, and improve supplies to the nonfarm sector. This policy change appears to have been a major success story in terms of economic and sustainability benefits although it harmed marginal

farmers. The proposed policy reform was attributed to the International Water Management Institute (IWMI) (Shah et al., 2008), although neither the attribution to POR nor the counterfactual are substantiated.

It is also worth noting that some POR is now using RCT methods to rigorously evaluate specific interventions to improve value chain performance. For example, Saenger, Qaim, Torero, and Viceisza (2013) look at ways to monitor quality of milk production in contract dairy farming in Vietnam. Other research of this type is underway at IFPRI, the Poverty Action Laboratory at Massachusetts Institute of Technology, and the AMA Innovation Lab led by the University of California at Davis.

### ACIAR impact studies

POR accounts for about 5 percent of all research projects funded by ACIAR. Several POR projects have been selected by ACIAR for impact evaluation, most recently on a random sampling basis.

The ACIAR evaluations represent extremes in terms of potential impacts. Two of the studies, Lindner (2011) and Mullen (2010) review POR related to price and trade policy reforms in Indonesia and China, respectively. The impacts of these "big picture" reforms were estimated in the billions of dollars. However, it was very difficult to attribute these changes to ACIAR-supported POR, although only a tiny share of the benefits would pay for the ACIAR investments.

On the other hand, several evaluations looked at very specific policy and institutional changes at the local level. Aggregate benefits for these policy changes were modest, but the impact pathways from ACIAR-supported POR to policy changes were strong and plausible. For example, in Vietnam, a revised schedule for irrigation water developed through POR was implemented, increasing yields, reducing irrigation system costs and providing benefits of $13 million, a benefit-cost ratio of 10, and unmeasured environmental benefits.

In another case, the POR was aimed at private decision-makers in the oil palm processing sector in Papua New Guinea to encourage greater participation of smallholders. The POR devised an electronic payments scheme for smallholders, an e-payment card for women collecting loose fruit, and model land-use agreements between plantation companies and local communities. The impact evaluation (Fisher, Winzenried, & Sar, 2012) estimated substantially increased smallholder participation with benefits of $55 million and a benefit-cost ratio of 20:1 to the investment in POR.

### Influence studies of outcomes

Given the difficulty of attribution noted for much POR, many studies stop short of estimating full economic impacts and look for influence of the POR on subsequent policy decision. These qualitative types of evaluations have been carried out by the Canadian International Development Research Center, and the UK Overseas Development Institute for their multi-sectoral policy research and have been found to be particularly useful in learning about policy processes and impact pathways (Raitzer & Ryan, 2008). This better understanding of policy processes in turn should improve the design of POR in ways that enhance the probability of successful impacts.

Given that costs of POR are usually quite modest, it is likely that any POR that influences important policy decisions in a positive way and in a timely manner, will provide high payoffs, even if only a small share of the benefits are attributed to the specific POR. In fact, the majority of IFPRI and other CGIAR studies only evaluate influence. Of the 21 studies reviewed by Raitzer and Ryan (2008), 10 documented influences, generally relying on interviews of relevant stakeholders as "data." Of the 10 most recent impact briefs on the IFPRI web site, only two attempt to quantify impacts. However, in most other cases, the evaluator was able to validate at least some influence on policy decisions. Their most recent study reviewed the combined influence of all IFPRI POR in Ethiopia and identified a number of areas where POR was likely to have influenced policy decisions (Renkow & Slade, 2013).

It is probably that some of the most important impacts of CGIAR's policy research has been influential in setting the global policy agenda, even though these impacts cannot be readily quantified in terms of development goals of income generation and poverty reduction. Examples include Bioversity's role in successfully concluding the International Treaty on Plant Genetic Resources (Gotor, Caracciolo, & Watts, 2010), and the influence of IFPRI's research on international trade liberalization and the Doha trade negotiations (Hewitt, 2008).

Finally, it is important to note that many outputs of POR may provide benefits beyond immediate changes in policy decisions. Much POR produces new knowledge and data that influence future generations of research. POR in IFPRI has also had a strong focus on capacity building at the country level, which should ultimately lead to better policy decisions.

### Biophysical research and policy

An implicit assumption in the above review is that POR is largely social science research. However, biophysical research may sometimes be designed specifically to influence policy decisions. An early worthy but largely forgotten effort in this direction is Martinez, Sain, and Yates (1991) who used agronomic research on fertilizer response to successfully argue for a change in fertilizer import policies in Haiti. Some of the biophysical research on natural resources management is also aimed at policy and institutional change (Walker et al., 2010). The potential of these types of POR has not been sufficiently recognized.

In some cases, changes in the enabling environment may result directly from new opportunities provided by biophysical research. The obvious example is the growing availability of transgenic varieties that is pressuring countries to introduce an appropriate biosafety regulatory environment in order to be able to take advantage of the new technology. Design of such regulations to minimize costs at acceptable risks is a research topic in itself, given that a weak or non-existent regulatory environment appears to be a major constraint on realizing impacts from investment in transgenic technology.

## *Evidence gaps*

Over the past decade, impact studies of POR have greatly expanded our understanding of how POR can influence policies and welfare. They have highlighted the importance of networks of influence, messaging (dissemination), the importance of context and windows of opportunity, and the key role of participatory processes of designing and implementing POR in close interaction with policy-makers, as ways to enhance impacts (Masset et al., 2011).

However, it is clear that impact evaluation of POR is still in its infancy. There is a lack of robust methods especially for defining a counterfactual and attributing policy changes to POR

(Lindner, 2011). The use of Bayesian approaches to assess changes in the subjective beliefs of decision-makers has been proposed (Schimmelpfennig, O'Donnell, & Norton, 2006; Lindner, 2011) but they have not proven practicable.[5] It is likely that there will be no standard practices to evaluate POR and methods will need to be adapted to each situation.

In aggregate, very little is being spent on impact evaluation relative to the investment in POR and the most urgent priority is to step up the investment in impact evaluation. A critical issue is to what extent impact evaluations of POR should attempt to quantify welfare benefits versus focus on qualitative studies that document influence. Clearly, much is being learned from qualitative studies about policy processes and impact pathways that should help increase the number of cases in which it is possible to do full impact evaluation. One strategy therefore is to expand case studies of influence and simultaneously broaden the institutional base of POR impact evaluation. Almost all evidence to date is from international or donor organizations and a new round of evaluations of POR impacts should include national institutions conducting POR. Local policy researchers may be more cost effective and more in tune with country policy processes and priorities.

Better methodology for impact evaluation of POR remains a big challenge. It is now more than a decade since the first major workshop on methods for evaluating impacts of POR (Pardey & Smith, 2004). SPIA and IFPRI have agreed that a reassessment of the state of art is needed and this should be a priority for moving forward.

# IV. BROADER QUESTIONS FOR THE THEME

Beyond the two questions posed for this review, there are other large gaps in the literature on the evidence base for improving R&D.

The first of these relates to evaluating the impact of interventions on the goals of Feed the Future—poverty reduction, food security and nutrition, and sustainability. The overwhelming majority of evaluations to date have focused on evaluating impacts in terms of economic returns to investment in R&D, although there has been a recent flurry of effort to extend the analysis to evaluate poverty impacts, mostly for locally targeted programs. To date, only a handful of evaluations have analyzed impacts on food security in its various dimensions, including nutrition. There is also a dearth of evaluations for measuring environmental impacts—important as USAID emphasizes sustainable intensification.

These imbalances relate to the greater methodological and data challenges for evaluating impacts on a broader set of development indicators. For locally targeted R&D programs, these challenges are not insurmountable, providing sufficient resources are available for RCT-type designs, where appropriate, and for setting up panel household data sets (de Janvry et al., 2011). RCT designs that collect anthropometric data have successfully demonstrated nutritional impacts of new crop varieties, although this is a costly exercise (Low et al., 2007). Panel data on household incomes and/or expenditures are also increasingly available and appropriate statistical methods for evaluating impacts of new technologies on poverty and food consumption are well established in the impact literature (de Janvry et al., 2011). However, many recent poverty-oriented impact evaluations have relied on single visit household data using the Propensity Score

[5] In this approach, a probability distribution of decision-maker beliefs would be tracked over time and related to specific POR.

Matching statistical technique—an approach that is likely to lead to serious biases in estimates (de Janvry et al., 2011).

The major challenge is then to invest more in data collection for impact evaluation. For larger programs aimed at supporting R&D systems nationally or internationally, resource requirements for national or cross-country household data collection over time are daunting. One option would be to work more closely with partners who are already collecting household data, such as the rural LSMS being implemented by the World Bank in African countries with support of the Bill and Melinda Gates Foundation. A major advance would be to set up systems for regular collection of adoption data on improved varieties and other management practices as part of these regularly collected household data sets. Development partners could also support other approaches to regular collection of adoption data, including crowd-sourcing using mobile phones and DNA fingerprinting of crop varieties. Likewise measurement of sustainability indicators, such as use of toxic pesticides or soil health measures could be integrated into household surveys that are conducted on a periodic basis. The lack of such data has been a serious impediment to evaluating research on NRM.

Microlevel impacts at the household level need to be complemented by wider evaluation of impacts on food security, poverty, and the environment, that operate via impact pathways in product markets and labor markets on food prices, employment, and wages. Methods for combining household data with a growing set of general equilibrium models are in their infancy but there are good examples to draw upon (Martin, 2013).

As USAID re-engages in capacity building for NARS (Anderson et al., 2013), a critical issue will be to develop impact evaluation indicators relevant to these investments. This is an area with little track record to draw on and that is ripe for methodological development and exploratory studies. Outcome indicators as described in detail in Rajalahti, Woelcke, and Pehu (2005) would be a good starting point. More formal impact evaluation of capacity building has been piloted by ACIAR (Gordon & Chadwick, 2007). An integral part of capacity building should be enhanced capacity by NARS to evaluate their own impacts, given that almost no NARS has a strong track record in this area. More and better impact evaluation by NARS would also go a long way to building databases for wider impact evaluation.

Development partners also need to develop intermediate outcome measures that are appropriate to monitoring investments intended to improve R&D, taking into account the long-term and highly uncertain nature of research payoffs. Emphasis on annual measures such as the number of hectares on which new technologies have been adopted risks biasing investments toward research with very short-term payoffs, which could have negative implications for investment in more strategic research with much greater but longer term pay offs.

While it is beyond the scope of this review to suggest intermediate outcome indicators, a sensible approach is to recognize the uniqueness of R&D investments and avoid common indicators. Milestones for each R&D investment can relate to pay offs such as progress in technology development, innovation dissemination, and/or institutional development. Each investment project can then be rated against these milestones and an aggregate rating computed for the whole portfolio. Ratings can be complemented by impact evaluation five to seven years after the research has been initiated, perhaps on a random basis as now being implemented by ACIAR. Following the example of ACIAR—which has an impact database covering more than 90 completed projects (Harding et al., 2009) —a growing portfolio of such impact evaluations over time would allow periodic meta-studies of the overall impacts of investments in R&D.

In the end, a judicious balance of methods will be needed to fill evidence gaps in evaluating impacts of improving R&D systems. This review has shown that relatively low cost case studies

and participatory evaluations that are well grounded in a theory of change can provide valuable feedback on what works where. At the same time, carefully selected and designed in-depth evaluations based on RCT methods or time series household data and preferably conducted by independent evaluators can greatly increase the credibility of the evidence base for investing in R&D. The evidence to date strongly supports such investments as a high payoff activity for development partners and NARS in the future.

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# ANNEX: SUMMARY OF KEY IMPACT STUDIES WITH A GOOD EVIDENCE BASE FOR PARTNERSHIPS

| | Location | Partnership | Method | Comment |
|---|---|---|---|---|
| Pamuk et al., 2012 and Pamuk et al., forthcoming | Sub-Saharan Africa | Innovation platforms vs. conventional extension or no extension | RCT and Difference in Difference from panel household data | Pamuk et al., 2012 is a paper that has not been formally peer reviewed or published |
| Cavatassi et al., 2011 | Ecuador (potatoes) | Innovation platforms versus conventional market linkages | Explicit counterfactual and use of instrumental variable regression | Mix of methods to triangulate |
| Evenson and Gollin, 2003 | Global crop varietal improvement | CGIAR-NARS | Economic surplus and IMPACT model with an explicit counterfactual | IMPACT is a global and regional partial equilibrium model |
| Fan, et al., 2005 | India and China (rice improvement) | CGIAR-NARS | Economic surplus | Elasticities from econometric models used to estimate effects on poverty reduction |
| Raitzer and Kelly, 2008 | Global CGIAR | CGIAR-NARS | Meta-analysis of existing studies | Quality standards imposed for inclusion of studies. Benefits compared to all CGIAR costs |
| Harding et al., 2009 | Global | ACIAR-NARS | Meta-analysis of existing studies | Benefits compared to all ACIAR costs |
| Bervejillo et al., 2012 | Uruguay | Public-Farmer Organizations | Econometric analysis of growth | |
| Avila et al., 2010 | Peru | Competitive fund for public-private-NGO collaboration in innovation | Survey with some baseline information and explicit counterfactual | |
| Harris, 2011a and 2011b | Thailand and Laos | ACIAR-NGO | Economic surplus | Low cost study |