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From measuring impact to learning institutional lessons: an innovation systems perspective on improving the management of international agricultural research

Andrew Hall[a,*], V. Rasheed Sulaiman[b], Norman Clark[c], B. Yoganand[a]

[a] *International Crops Research Institute for the Semi-Arid Tropics, Patancheru 502324, Andhra Pradesh, India*
[b] *National Centre for Agricultural Economics and Policy Research, PO Box 11305, Library Avenue, Pusa, New Delhi- 110 012, India*
[c] *Graduate School of Environmental Studies, University of Strathclyde, Glasgow, UK*

Abstract

This paper argues that impact assessment research has not made more of a difference because the measurement of the economic impact has poor diagnostic power. In particular it fails to provide research managers with critical institutional lessons concerning ways of improving research and innovation as a process. Our contention is that the linear input–output assumptions of economic assessment need to be complemented by an analytical framework that recognises systems of reflexive, learning interactions and their location in, and relationship with, their institutional context. The innovation systems framework is proposed as an approach where institutional learning is explicit. Three case studies of recent developments in international agricultural research are presented to illustrate these points. We conclude by suggesting that the innovation systems framework has much to offer research managers wishing to monitor and learn new ways of addressing goals such as poverty alleviation. The greatest challenge however, is that such holistic learning frameworks must contend for legitimacy if they are to complement the dominant paradigm of economic assessment.

Keywords: Impact assessment; Evaluation; International agricultural research; Innovation systems; Institutional learning and change

* Corresponding author. Tel.: +91-40-23296161.
E-mail addresses: a.hall@cgiar.org (A. Hall), nagma@bol.net.in (V. Rasheed Sulaiman), n.g.clark@strath.ac.uk (N. Clark), b.yoganand@cgiar.org (B. Yoganand).

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1. Introduction

This paper responds to the core question: Why has impact assessment research not made more of a difference? Our aim is to try to explain the failure of economic impact assessment as a research management tool in terms of its limitations in providing reflective insights into how research can be improved as a process. Economic assessment leaves unquestioned the institutional context of research, the influences of this context on the research process, and the implications this has for social and economic outcomes (Nelson and Winter, 1982; Biggs 1990; Rajeswari 1995; Hall et al. 2001; Anderson et al., 2002). We suggest that economic assessment could be supplemented with contemporary, *innovation systems* perspectives, an approach where an appreciation of institutional context and institutional learning is central to analysis and research management procedures.

In order to highlight the need for such complementary approaches we present a critique of approaches to *economic* impact assessment. We focus on economic impact assessment because while the scope of impact assessment and evaluation approaches is very diverse, economic assessment remains the dominant paradigm in the international agricultural research arena, particularly in the research centres of the Consultative Group on International Agricultural Research (CGIAR), (Horton, 1998). The CGIAR centres have been a key mechanism by which the international community has deployed agricultural research for international development. Therefore the way these centres have approached impact assessment and responded to its findings is an important concern.

Our purpose is not to try to deny a legitimate role for economic impact assessment. Ex-ante economic impact assessment lends valuable credence to research investment decisions that also hinge on a range of technical, political and policy objectives. Similarly ex-post impact assessment, in an era of growing scepticism over the value of publicly funded agricultural research, provides a politically expedient way of attributing a value to past investments and justifying further support for research. Similarly technology adoption studies are a useful way of tracking and demonstrating the rate and progress of technical change. However, these assessment roles are arguably more politically important than managerially useful. Our central argument is that the measurement of the economic impact has poor diagnostic power. Only when the framework of evaluation is expanded to include an explicit institutional learning agenda will research managers be able to monitor and evolve new ways of addressing goals such as poverty alleviation.

We preface our discussion with some definitions, as there is much confusion over the term *institutional context* and the related concept *institutional learning*. The main argument then begins with a brief overview of economic assessment approaches. Next, the innovation system concept is introduced as a means of expanding impact assessment procedures to include an analysis of institutional issues. We illustrate this with three case studies where institutional learning has been an important mechanism for achieving better impact. We continue with a discussion of the implications for evaluation and impact assessment using the innovation system concept as a learning framework for research management. We end by observing that such

approaches face an up-hill struggle as they contend for legitimacy as a complementary approach with the dominant and deeply entrenched tradition of economic assessment in the international agricultural research community.

2. The institutional and organisational context of research: some definitional points

2.1. Institutions and R&D

The concept of an institution in relation to the R&D process is open to ambiguity in the literature. Different disciplinary conventions define the term in different ways. The "institutional economists" usually adopt the sociological meaning of the term, referring to things that pattern behaviour—routines, norms, shared expectations, and morals (Edquist and Johnson, 1997). The new institutional economists follow a similar convention viewing institutions-as-rules as governance structures that regulate transactions (North, 1990). The sociology of science community also adheres to this strict distinction between institutions and organisations, the latter being viewed as players or actors whose interaction is governed by institutions (rules, norms etc.) (Raina, 2001).

The convention in the science and technology policy literature is to use the term institution as an embedded concept (although there is much inconsistency.) This embedded definition refers to the behaviour of physical organisations dealing with research and development (R&D) and economic activity—research centres, universities, private companies, research foundations, farmer's associations, co-operatives and so forth. This perspective recognises that relationships and interactions between agents have to involve non-price relationships and that while the transaction costs theory of institutions cannot explain the dynamics of such systems, an interactive learning theory of institutions can (Lundvall et al., 2002).

2.2. Institutional context

The institutional context of R&D, therefore, concerns the rules and norms that govern it as a social process of learning. In practice this means the rules and norms governing:

- how research priorities emerge, are promoted and executed;
- the role of various actors involved in the production, transfer and use of knowledge;
- the relationship between the different actors and the factors that affect their relationships;
- how research performance is evaluated and rewarded (incentives), and by whom;
- how R&D is held accountable to different interest groups and society as a whole;
- how knowledge is built up, shared and used; and
- how organisations reflect and learn.

Other aspects of the institutional context concern the wider institutional environment. For example it affects the way national culture embeds in the norms of individuals and organisations and the way this affects how they operate, interact and relate to each other and how they learn and use knowledge. Therefore there can be different national cultures of science, with norms of acceptable behaviour, review and validation (personal communication Dr S. Biggs). There are also different organisational cultures and traditions in different sectors. For example government agencies (sometimes unfairly) are thought of as top-down bureaucracies, whereas non-government organisations are usually (sometimes incorrectly) presumed to have flatter management structures. These are illustrations of institutional contexts that impact on the way decisions are made, whose voice is heard and the dynamics of relationships with partners—all factors that impinge on the direction and outcome of R&D.

2.3. Institutional learning

Institutional learning, therefore, concerns the process through which new ways of working emerge. It concerns learning how to do things in new ways. It asks the questions: "What rules and norms have to be changed to do a new task or to do an old one better?" "How has our research approach changed in response to the need to improve the poverty relevance of our work and what else needs to change?" and "What can we learn from activities that did not produce the expected outcomes?" A key solution may involve learning how to learn better, a concept that the management and organisational theory literature refers to as double-loop learning (see for example Smith and Stacey, 1997). The learning process is context specific and consequently institutional learning can lead to great diversity of approaches, partnerships and strategies. As our case studies illustrate, institutional learning is an inevitable and intuitive process, a fundamental property of all social systems (ibid.). However where programmes have explicit, systematic learning objectives and procedures, research management strategies can evolve and progress rapidly (Horton, 1999).

3. Impact assessment in the CGIAR: history, conventions and limitations

3.1. Evaluation traditions

The best known impact of the CGIAR system came from its work on developing high-yielding, fertiliser-responsive varieties of rice, wheat and maize. Widespread adoption of these modern varieties in Asia rapidly increased food production. This is commonly referred to as the Green Revolution. The CGIAR has not been complacent about its success. In recent years, with the encouragement of donors, considerable effort has been spent on impact assessment activities see Feldman, 2000. Underlying this has been the feeling that while much has been achieved, the task of reducing poverty still needs more effort and that perhaps approaches that served the

CGIAR well in the past may need to be revised in the light of an increasingly complex development scenario. Furthermore, while there is now a considerable history of monitoring the performance of the CGIAR, the fact that it is difficult to detect shifts toward greater impacts has caused a growing sense of unease in the CGIAR and amongst its sponsors. This is increasingly causing some of those involved in impact assessment work to re-examine commonly used evaluation approaches, and in particular the value of these in terms of improving impact.

Horton (1998) describes a disciplinarily-diverse typology of research evaluation employed in the CGIAR. In addition to economic evaluation he cites peer review and external review by expert panels as major evaluation types, with bibliometrics, social and environmental impact assessment, and participatory evaluation as minor branches of evaluation. The professional evaluation community brings a richness of disciplinary perspectives and over the years its concerns have broadened from accountability to programme improvement, decision support and institutional learning (Horton, op cit; Horton and Mackay, 1999; Cracknell, 2000). In the CGIAR, however, the economic evaluation tradition is by far the dominant approach, with ex-post assessment dominating ex-ante analysis.

3.2. Audiences for economic impact assessment

The recommendation for international agricultural research has been that impact assessment should be routinely used with two audiences in mind (1) to provide *research managers and scientists* with information about how technology influences the welfare of agricultural producers and consumers, and to improve targeting of research programmes though adjustments in resource allocation and (2) to provide *governments and donors* with evidence of the social benefits of investment in particular research programmes and in publicly funded agricultural research generally (Alston et al., 1995; Maredia et al., 2000; TAC, 2000). In the sphere of evaluation there is always going to be a potential dichotomy between accountability and diagnostic objectives (Cracknell, 2000). But since in economic impact assessment of agricultural research the different objectives are rarely made explicit, one can only assume impact research is serving both audiences.

For readers unfamiliar with what economic impact assessment means in practice we present a synthesis in, Appendix 1, of the published impact assessments of the International Crop Research Institute for the Semi Arid Tropics (ICRISAT). The synthesis highlights the methods used, the economic impact estimated, and the consequent recommendations made.

3.3. Determinants of the impact discourse in the CGIAR

The reasons why economic impact approaches have come to dominate impact research in international agricultural research are complex. However the publication of *Science Under Scarcity: Practices for Agricultural Research Evaluation and Priority Setting* (Alston et al., 1995) as well as other "best practice" statements from the international agricultural research community (e.g. TAC, 2000) have helped estab-

lish these approaches as the industry standard. Horton (1998), citing key CGIAR documents and declarations, points out how agricultural economics has come to dominate the social sciences in the international centres; the ascendancy of economists to senior positions at a time went the CGIAR was under close scrutiny regarding value for money; and the related emergence of research evaluation as a prestigious area of specialisation within the discipline of agricultural economics. These developments have also greatly influenced thinking in national agricultural research programmes.

The discourse on impact assessment has developed as it has because of the specific circumstances that have shaped evaluation conventions within the CGIAR research system. It is informative to recognise where the advocacy for such approaches stems from and thus the types of institutional changes that will be required if complementary approaches to economic impact assessment are to be more widely used in the CGIAR.

3.4. Economic impact assessment and its limitations

Adapting from Maredia et al. (2000), the three main economic impact assessment methods are as follows:

- *Adoption studies/partial impact assessment studies*. These do not estimate aggregate benefits, but trace the use of innovations. Adoption studies may also evaluate private benefits in the form of increased farm production and incomes, assess client satisfaction with research results and seek to understand why technology is being used or not. These studies contribute a valuable understanding of the acceptability and performance of technology in given social and physical contexts. Lipton and Longhurst (1989) provide a comprehensive review.
- *The economic surplus approach*. This approach was pioneered by Griliches (1958). It estimates the returns on investment, calculating the change in consumer and producer surpluses that result from technological change brought about through research that causes the industry supply function to shift outwards. The estimated economic surpluses, together with research costs are then used to compute the net present value or internal rate of return.
- *The econometric approach*. This approach employs a production function, cost function, or total factor productivity analysis to estimate the change in productivity due to investments in research. Analysis is conducted within the framework of a production function that incorporates conventional inputs (land, labour etc.), non-conventional inputs such as education, infrastructure etc.) and the stock of technical knowledge (investments in research and extension). The estimated research coefficient is then used to calculate the value of output attributable to lagged research expenditures and to derive a marginal rate of return to research investment. It is a statistical way of isolating the effect of research on economic output. In international agriculture, Evenson (e.g. Evenson and Pray, 1991) pioneered this approach.

All three economic impact assessment approaches are employed in ex-post analysis, although adoption studies and economic surplus models are the most popular and arguably the most straightforward to use. Ex-ante studies favour the economic surplus model. While these approaches have a useful role there are also limitations and considerable debate exists on methodological issues, particularly for econometric approaches (Maredia et al., 2000). Other acknowledged limitations include: the availability of adequate input and output data on the research process and subsequent technical change (Alston et al., 1995); and the related limitation concerning the difficulty of attributing past, current or future outcomes to particular research investments and assigning a value to these outcomes. Efforts to refine methodologies and resolve the conundrum of wildly differing (but usually high) internal rates of return to research has attracted a great deal of attention from economists (e.g. Alston et al., 1998). The consequences of assessing the impact of "winners" only has also skewed the results of rates of return analysis and possibly undermined the verisimilitude of claims made by econometric studies.

Our critique of economic impact assessment does not, however, relate to these methodological limitations. Ours is a more fundamental conceptual problem and concerns the way these approaches exclude the research process and its institutional context from the analysis. As a result, impact assessment makes measurements of research inputs and outputs without measuring and accounting for the content of the research process (Rajeswari, 1995).

Economic assessment approaches take the research process as a fixed parameter in the analysis. If this parameter is taken to be stable and working optimally—as economic analysis assumes—then the task of improving the impact of research can be reduced to identifying the most important problem (priorities) on which to focus research, e.g. a particular production pest. Alternatively external conditions that are impeding the productive use of research products can be identified e.g. pricing policies. Identifying both sets of factors has added value. The trouble is that there is no optimal blueprint for the research process as procedures are evolving continuously. Similarly there is a range of institutional issues that shape the outcome of this process in different ways. Taken together this means that economic impact assessment approaches disregard an important set of process and institutional issues that represent a critical arena in which research performance and thus impact can be improved.

The next section discusses this omission and ways of planning and evaluating institutional context.

4. The institutional context of R&D and its importance

A recurring feature of the debate on the institutional context of R&D has been the tendency of different arrangements to include or exclude different groups of actors and to determine the role these actors play. For example the traditional convention has been to view scientists as the source of new agricultural knowledge, with this knowledge being delivered to farmers via a separate extension service. The shortcomings of

this hierarchy with its narrow set of actors is now the basis of the classic critique used to explain why agricultural R&D has such difficulty in addressing the specific needs of poor rural households and has tended to marginalise their potential contribution to the innovation process (Biggs and Clay, 1981; Rhoads and Booth, 1982; Richards, 1985; Chambers and Ghildyal, 1985.) Over the last two decades policy analysts have consistently urged evaluators and planners to pay more attention to the institutional context and its influence on the content and direction of R&D (Biggs, 1978, 1990, 1995; Biggs and Matseart, 1999). This same theme has informed a growing body of interpretative accounts of agricultural R&D and technology promotion efforts. For example, Anderson, (1991) and Anderson et al. (1991) provide a retrospective analysis of the political economy of international rice research in Asia; Biggs (1982) describes factors shaping international efforts to introduce a new crop into Asia; Clark and Clay (1986) give an account of experimentation with the role of scientist in relation to development actors in a rural development project in India; Greeley (1989) gives an account of the political economy of research and interventions associated with post-harvest grain losses; Rajeswari (1995, 1999) offers a retrospective analysis of the conceptual basis for evaluating agricultural R&D performance in India; Hall and Clark (1995) describe the effect of institutional arrangements on the promotion and diffusion of Rhizobium technology in Thailand; Gass et al. (1997) describe the stakeholder context of rural mechanisation; Alsop and Farrington (1998) offer an account of agricultural R&D as part of multi-agency rural development intervention in India; Lewis (2001) describes actor analysis in aquaculture research in Bangladesh; and Bellum et al. (2001) characterize the establishment of new patterns of funding from the private sector at ICRISAT.

It is now recognised that agricultural innovations come from multiple sources: research staff; development agencies; farmers; NGOs; private companies; entrepreneurs and artisans (Biggs, 1990). Each set of actors has its own agenda and these agendas may often be divergent and contested. This implies a model of agricultural innovation where interactions between actors are multiple, iterative and evolving, and where the groupings of actors that exist at a given point in time reflect the relative strengths of current political and institutional interest groups. These types of process are well known to many research and development practitioners. However in both national and international agricultural research such concepts have failed to impinge on research evaluation and planning norms. In our view this will continue until a more inclusive analytical framework is accepted as a complementary approach to conventional research management procedures (Hall et al., 2000, 2001).

5. The innovation systems perspective

While perspectives espousing an engagement with institutional context have occupied only a modest amount of attention in the international agricultural research policy community, the perspective has come to dominate the policy debate and practice in other research and economic sectors. It is surprising to find that

concepts that are informing international agricultural research policy were superseded a decade ago in this wider science and technology policy arena. Velho (2002) provides a chronology of these developments explaining how innovation systems perspectives have come to the fore. (Ruivo (1994) offers a similar discussion of the changing ''paradigms'' of science policy). The contemporary debate from this parallel policy literature now takes it as given that the linear model of innovation is of little value in evaluating and planning R&D. There has been a shift in the role of policy from examining the determinants and consequence of research, to an innovation role where emphasis is on strengthening networks of users and producers of knowledge (Velho, op. cit.).

Underpinning this shift of perspective over the last two decades has been a deepening understanding of the nature of innovation as a process and the accompanying realisation that neo-classical economics alone cannot explain the dynamics of economic systems. There are many avenues of thought that have supported this emergent view. One is the empirical work of Freeman (1987) and others on the institutional arrangements associated with innovation performance. Another is the evolutionary economics perspective of for example, Nelson and Winter (1982). This argues that human behaviour is not characterised by processes of maximisation but instead, over time, the notable feature is learning and change. Similarly the complex systems ideas that explain human behaviour (including R&D and economic performance) in terms of the boundary state, instability and the consequences for organisational and institutional learning has highlighted the value of considering development and change in systems terms (Smith and Stacey, 1997, Clark et al., 1995).

Another way of thinking about innovation is that proposed by Gibbons et al (1994) in their discussion of two modes of knowledge production. In *mode one*, knowledge is generated, often with government assistance, by a research community accountable to its disciplinary peers. Gibbons' posits that institutional changes in western societies (where the market has started to eclipse the state as the primary decision-maker) have forced science to become more socially embedded and less hierarchical, thus defining the *mode two* type of knowledge production. As societies and economic systems become ever more complex, the *mode one* type of production of knowledge will become less able to respond to rapidly changing user contexts. Only by assuming the features of *mode two* can systems cope with complexity and rapid change.

The innovation system concept serves to draw some of these ideas together. The ideas of a ''national system of innovation'' (Freeman, 1987; Lundvall, 1992) and related frameworks (Edquist (1997) and Andersen et al. (2002)) have had considerable influence in the policy analyses of institutional systems that underpin innovation. At its simplest the concept recognises that innovations emerge from systems of actors. These systems are embedded in an institutional context that determines how individual actors behave and how they interact with other elements of the system. Lundvall (1992) identifies learning and the role of institutions as the critical components of such systems. He considers learning to be an interactive and thus socially-embedded process, which cannot be understood without reference to its institutional and cultural contexts. Successful systems are characterised by:

- Continuous evolutionary cycles of learning and innovation;
- combinations of technical and institutional innovations;
- interaction of diverse research and non-research actors;
- shifting roles for information producers, information users and transfers of knowledge dependent on a need basis
- an institutional context that supports interactions, learning and knowledge flows between actors.

The application of this concept of a national system of innovation framework in the agricultural research sector is gaining ground (Hall et al., 1998, 2000, 2001, 2002a,b; Rasheed Sulaiman and Hall, 2002; Mehra, 2000; Clark, 2002; Clarke et al., 2001; Ekboir and Parellada, 2001). At the heart of this framework is the contention that R&D is always embedded in social, political and institutional contexts and that unless the influence of this environment is accounted for by decision makers, the evaluation and planning of R&D will be incomplete. What does this mean for the evaluation and planning process? Some of the principles that are required to relate R&D to institutional context include:

(i) *An inventory of innovation actors*. The framework provides a starting point for identifying the full range of actors relevant to a particular innovation system. While many of the normal public-sector actors are present in the conventional policy schema, closer investigation reveals a wider range of individuals and organisations from other sectors.

(ii) *System competency*. Once a full inventory of actors has been established it is then possible to examine the extent to which relationships exist among actors. The existence of relationships will depend on the policy context and the wider institutional environment. For example, strong public-private partnerships may have emerged through a liberal policy towards germplasm access. Alternatively, weak linkages may be a result of restrictive personnel polices for public sector scientists that prevent them undertaking contract research for the private sector. Hence analysis has the effect of directing the focus of evaluation and planning on linkages that need to be developed and on potential policy changes.

(iii) *Actor roles*. Part of the relationship analysis concerns the importance of multiple roles played by some actors and the different types of relationship these roles imply. For example, an agricultural university may be both a source of information on regional variety trials, as well as a recipient of improved breeding lines from a crop improvement centre. Both types of role are important for an effective innovation system and the evaluation and planning process needs to understand their separate but linked existences. Actors with important roles that are excluded from existing arrangements need to be recognised. Technology users and product consumers from poor communities are examples.

(iv) *Cultural context*. The types of relationship that develop in a particular innovation system reflect both the national context as well as different organisational cultures. For example the national context may have for his-

torical reasons a strongly paternalistic public sector culture with a mistrust of private sector enterprise. Or the public sector may have a strongly hierarchical culture, whereas the NGO sector may have a more decentralised, participatory culture. Partnerships between public agencies and NGOs will not necessarily lead to more participatory approaches, because of the organisational culture of the former. The evaluation and planning process needs to account for these contextual features.

(v) *Relationship dynamics*. The importance of the nature and dynamics of relationships between the entire range of actors, from the innovation systems point of view, is that their analysis reveals that such relationships are often strongly asymmetrical, preventing interactive learning. For example, partnerships between international and national agencies are often skewed by more favourable access to resources on the part of the former, by historical patterns of interaction, and by professional and cultural norms that value "outsiders" at the expense of "locals". Local political processes, interest groups, ethnic communities, and social hierarchies will all contribute to the *political economy* of the innovation process. The evaluation and planning process will benefit from an awareness of these dynamics.

(vi) *Reflection and institutional learning*. The innovation systems framework regards reflection on process and institutional learning as key elements for success. For example, systems in which there is clearly a gulf between policy rhetoric and research practice have a weakness with regard to institutional learning. Other indicators of weak institutional learning may be a reluctance to admit mistakes and confront failure and its causes, or even a reluctance to revisit key assumptions about roles or ways of working. In contrast, organisations in which senior management encourage and reward reflection and learning and where self-evaluation is undertaken regularly, demonstrate a tendency to possess a higher capacity for continuous institutional learning and innovation. The evaluation and planning process could benefit from recognising the importance of a learning culture within public-sector research organisations and their partners.

The innovation systems framework is a learning framework. This characteristic makes it critically different from conventional frameworks (such as the project cycle, of which economic impact assessment is a part) which are problem-solving frameworks. In the next section we present three case studies that demonstrate the role of institutional learning, and the way it affects the innovation systems involved.

6. Case studies of institutional learning

6.1. Case study 1. Tacit lesson learning by scientists

Based on Hall (in press), this first case study explores how scientists working on a long-term sorghum and millet improvement programme (SMIP) learned in a tacit

way the value of working in alliances with new partners. This tacit learning was then used as a response to the increasingly impact-oriented agenda of international agricultural research. SMIP is a 20 years initiative supported by United States Agency for International Development (USAID) and implemented by ICRISAT on behalf of the Southern Africa Development Community. It started in 1983 and was implemented in four five-year phases, the fourth running from 1998 to 2003. The first two phases concentrated on developing research infrastructure and human resources in the national agricultural research organisations (NAROs) of the region. This involved the establishment of breeding programs, including research infrastructure and the sponsorship of doctoral and vocational training for scientists. It was done with a view to building capacity to produce a stream of technologies, mainly improved varieties. Indeed, during these first two phases considerable technology development work took place, with 15 varieties being released.

The third phase (SMIP III) 1993–1998, while continuing capacity building and technology development activities, started to shift focus towards technology transfer. This change related to developments in research methodology, particularly farming systems and participatory approaches, and the way these developments were starting to influence the thinking and agenda of SMIP. An equally important influence was the wider political economy of international agricultural research at that time; in particular the growing disillusionment among donors and an increased scrutiny of the impacts of research efforts that they were supporting.

During phase III, SMIP began to engage in partnerships with actors other than national agricultural research organisations (NAROs). This was in response to the need to have more direct contact with farm communities and the perceived value of working with non-government organisations (NGOs) as a means of achieving this. Analysis of constraints to adoption of technology had highlighted weaknesses in variety release and dissemination systems. It also became increasingly apparent that to achieve wider improvements in seed systems (as well as in other spheres), SMIP and NARO scientists would have to link with a range of other partners—the private sector, including NGOs, and community based organisations (CBOs).

SMIP phase IV was seen by the donor, USAID, as a way of capitalising on earlier investments in capacity building, research and technology development. This technology transfer theme meant that SMIP would need to continue to broaden its focus beyond conventional scientific activities and the generation of new technology, instead adopting a stronger developmental focus. Pursuing these developmental goals through a broader range of partnerships became an explicit objective.

The developmental focus and the partnership approach were reinforced by the USAID-style project structure and its monitoring procedure. This entailed the identification of a number of *intermediate results*. Not only were these prioritised by a group of regional stakeholders, but also the quantitative indicators for the achievement of these intermediate results were defined, with annual targets set to monitor performance. The SMIP scientists leading the programme component under each intermediate result became directly accountable for achieving these targets. These included: area sown to new varieties; tonnes of sorghum and millet entering commercial markets in key locations; quantity of seed produced of new

varieties. This pattern of accountability was a significant new feature of SMIP IV. The four SMIP scientists quickly realised, based on past experience, that if they were to achieve these targets an entrepreneurial approach to partnership would be essential.

An institutional analysis undertaken after two years of phase IV (Hall, in press) found that the SMIP scientists had entered into a broad range of partnerships with both NGO and commercial sectors, as well as with their conventional NARO partners. Drawing together clusters of partners around specific themes or tasks had been used as a way of achieving targets. Hall referred to these as *task networks* and noted:

- SMIP scientists played multiple and different roles in these task networks—sometimes as facilitator, sometimes as a source of information, sometimes as the recipient of information,
- constituent actors were specific to a task theme (due to resources, interests and agendas), as well as to a particular location and institutional context (who were available and how their interaction was governed);
- there was evidence of the task networks as a mechanism for priority setting for further research, but this was limited and had not been exploited;
- SMIP's task networks appeared to represent new forms of collective capacity and important lessons could be drawn from this and shared with scientist and research managers at both ICRISAT and in the Southern Africa region;
- opportunities for learning institutional lessons and promoting them more widely were restricted by the overall problem-solving, output-orientated framework of the project design (attributable largely to the donor), and the limited formal opportunities this presented for systematic learning.

This case raises a number of points about how new research procedures evolve. The first concerns the complementarity between formal adoption studies that suggested the need to work with new partners in seed systems and the intuitive, tacit learning process through which scientists built up experiences of working in a new partnership mode. The second concerns how the skills and lessons that scientists had built up surrounding the diversification of their partnership base were used to respond to a major institutional change in terms of accountability. This led to a major research innovation for ICRISAT.

The third point, however, is that because the overall research management framework focused on monitoring progress in conventional impact terms, this innovation remained largely unrecognised (except among the scientists involved) and did not bring about wider changes in research practice in ICRISAT or its NARO partners. An important implication is that conventional monitoring systems like the one in place in this case while sufficient for accountability purposes to the donor, fail to capture, synthesise and report important institutional innovations that would appear to correlate strongly with achieving research impact.

6.1.1. Implications for impact assessment procedures

This case highlights the fact that whether or not projects or programmes are specifically designed to generate institutional lessons, learning is an integral part of any

task and the social process of research will inevitably generate such institutional innovations. It also points to the fact that the promotion and diffusion of these innovations requires explicit incentives to be in place. Requirements include incentives from those sponsoring research as well those from within the organisations conducting research. To do this will require explicit institutional changes in the areas of research funding, planning and execution. Changes are required in the conventions of research management and research evaluation. These changes must legitimise and encourage the (i) discussion, (ii) the documentation and (iii) the promotion of institutional innovations and grant them the same level of attention and importance as technological achievements enjoy.

6.2. Case study 2. Learning by confronting organisational culture

The second case explores how ICRISAT dealt with a major decision about its evolving relationship with the Indian private-sector seed industry and the how this has opened the way for a variety of relationships with partners (Bellum et al., 2001). The origins of these developments stems from the liberalisation of the Indian seed sector in 1988 and the consequent emergence of private seed companies in what had previously been a state-run domain. ICRISAT supported fledgling sorghum and millet seed companies and provided breeding material. Support was often through informal networks whereby scientists trained at the Institute found employment opportunities in the new rapidly-expanding private seed sector. During the 1990s these companies began to develop their own R&D capacity, but continued to value the improved breeding lines from ICRISAT.

However ICRISAT's breeding strategy altered in the mid to late 1990s, switching its emphasis to traits suitable for African production and consumption contexts. These were different from the traits Indian seed companies had identified as the priorities of Indian farmers and consumers. As a result the seed industry had to seek new ways to develop hybrids suitable for Indian production conditions and consumption preferences. At the same time ICRISAT began to recognise that the private sector was likely to become a major mechanism for delivering improved breeding material to farmers and that in all likelihood this would prove a more effective mechanism than the public-sector seed system.

A number of ICRISAT breeders realised that the way forward was to enter into a new form of relationship with the private sector. This meant a shift from viewing seed companies as passive recipients of breeding material, to viewing them as active research partners and as a source of research funds. There was some caution on the part of the seed industry. The key breakthrough, however, was the suggestion made by the then President of the All India Seed Association to orchestrate funding through a consortium of private seed companies. This helped reduce the cost for individual companies, and broad-based membership avoided the risk of "free riders".

The Intellectual Property Rights policy of ICRISAT is such that it does not take ownership of the material it develops. It transfers material to others under a formal transfer agreement which requires that recipients also forgo ownership (ICRISAT,

2001). Such a requirement makes exclusive arrangements with a private company difficult. The consortium approach was one way of addressing this problem. Another was by interpreting the material rights agreement in such a way that if ICRISAT material was further developed by the private sector companies by combining it with their own breeding lines, they could claim ownership of the new varieties produced.

Having convinced the private sector that funding ICRISAT was the way forward, ICRISAT breeders then faced the task of convincing ICRISAT management that partnership with the private sector was appropriate. These negotiations started at a time when the mandate of the Institute was still interpreted in a highly circumscribed fashion, based on a rigid notion of the nature of its international public good role. No previous agreement had been entered into whereby the private sector funded research at ICRISAT. There was a perception within the Institute—*albeit* never explicitly articulated—that its public good role could only be maintained through purely public funding and execution of research. In part, this perception was informed by the political realities of ICRISAT's (often highly sensitive) relationship with the Indian public-sector agriculture research organisation through which it is mandated to work.

The result was that a final decision to approve the consortium proposal could not be made at the Institute level. Responsibility for the decision was passed to ICRISAT's Governing Broad, who in turn passed it to the Indian Council for Agricultural Research. The Council approved the proposal and passed it back to the ICRISAT Director General at a time when a previous Director General from the 1970s and 1980s had returned on an interim basis following the sudden departure of the incumbent. The proposal was rejected by the Interim Director General apparently because of the relatively small sums of money involved and administrative concerns about managing small grants. Finally when a new ICRISAT Director General was appointed, he approved the proposal stating that its importance resided in the new partnerships involved rather than the financial considerations alone. This process had taken almost 2 years.

The consortium approach has subsequently evolved with sufficient success to attract additional private-sector seed companies to join the consortium and extend funding through this mechanism. The impact this has had on the organisational culture of the Institute has been widely felt. Joint initiatives with the private sector are now viewed as relevant to the broader developmental mandate of ICRISAT. It has lead to the development of a "Technology Innovation Centre" that acts as a clustering device for a range of special projects that involve new types of partnerships and relationships. For example sorghum and millet breeders are now pursuing relationships with private animal-feed industries as a means of developing new market opportunities for crops for which traditional food uses are declining. Other initiatives include an incubator for Indian biotechnology companies and linkages to a newly established science park in the nearby state capital. The special project status of the Technology Innovation Centre allows new institutional arrangements to be tested; for example cost recovery and profit sharing, joint development of research priorities with partners.

6.2.1. Implications for impact assessment procedures

This case highlights the way a new type of interaction with partners has allowed the Institute as a whole to learn new ways of operating and the way this has resulted in capacity development. Specifically it has changed the capacity of the organisation to work in a more interactive, less hierarchical way with its partners. In addition, new capacity exists as a result of the novel combinations of resources and expertise of ICRISAT and its new partners. In this case these new capacities will lead to improved impacts through the better delivery of research products to farmers. Impact assessment should be playing a role in strengthening this capacity development process, helping formalise the learning process and promoting the lessons learnt, as well as highlighting the value of these capacity outcomes in internal monitoring procedures. Another implication of this case is that impact assessment procedures must be undertaken jointly with partners who form part of this new capacity.

6.3. Case study 3. Learning as a way of dealing with the institutional context of research

The third case study discusses how the crop post-harvest programme of the Department for International Development (DFID), the UK government's international development assistance agency, has gradually recognised the need to pay more attention to the institutional context of the research it was sponsoring and how it responded with an approach that is attempting to embed institutional learning in conventional technology-development projects (Hall and Rasheed Sulaiman, 2002).

The programme is one of 10 natural-resources research programmes. These were originally established by DFID in 1995 as a way of exploiting the UK science base in support of international development. The programmes were conceived in the problem-solving framework of the project cycle with the "logical framework" used as the key programme and project planning and evaluation tool. This was supplemented by monitoring indicators used to judge progress along a notional output pathway. The translation of technical outputs into poverty/developmental impacts was dealt with as a logframe assumption about the existence of "target institutions" (meaning, in this instance *organisations*) and functioning "up-take pathways".

As projects progressed the Crop Post Harvest Programme started to recognise that process and institutional issues were having serious consequences for the success of its research initiatives. For example, in a series of projects commissioned in India to provide technical backstopping to parts of the export horticulture sector, it became apparent that the real problem was one of mobilising the different parts of the public-sector research system to act in a concerted fashion. Collaboration was particularly important for export development because of the need to deal with quality management issues in an integrated production and post-harvest supply chain. In addition, the broad range of stakeholders in the supply chain, including farmers, whose agendas and circumstances provided the context for developing these solutions, made it difficult for the research organisations to respond effectively, given their prevailing way of working with stakeholders.

At this point the programme management team took decided to try to gain a systematic understanding about the way this institutional context was affecting its research. The learning process built up slowly. First there was a pilot project that continued its focus on export horticulture, but which included a simultaneous technical and institutional analysis. This highlighted the need to identify a conceptual framework to help understand the wider contextual issues that were affecting the research process. It was at this point that the programme started to explore the innovation systems framework.

The exploration began with a policy project in India to examine how the innovation systems idea could be used in the evaluation and planning of R&D. This project was undertaken with a view to drawing both project and programme management level lessons. It was contingent on the wider programme portfolio of projects in India which in effect acted as case studies. This approach allowed the programme in South Asia to experiment with the innovation system idea, while allowing conventional projects to proceed. It became apparent that the arrangement was not ideal. Notably the institutional lessons that the policy project was gathering from the rest of the portfolio could not be used to redirect these projects as the portfolio was not structured in a truly action-research framework. It soon became apparent that the individual technical projects needed to concentrate on generating their own process and institutional lessons, for project management purposes as well to gain insights of value to the wider programme. However, it was difficult for projects that had been commissioned to deliver a narrower set of outputs, to accommodate this expanded role.

Nevertheless, the programme was able to identify and document a series of research management lessons. These included the following:

- There is a need to build stronger and more consultative linkages between public sector science and other actors in the innovation system;
- successful projects were those that focused specifically on establishing a coalition of local actors around a particular problem area;
- these actors included scientists, but not exclusively, and not necessarily as the lead actor. Moreover, roles may evolve over time;
- the selection of the most appropriate actor grouping was very often an empirical issue that could not realistically be resolved at the outset of a project;
- There was a tendency, reinforced by the output-oriented, problem-solving framework of the conventional project cycle, to under-report process lessons associated with technological success (or failure.) These lessons were often complementary to new technical knowledge;
- the relative degree of poverty focus was related to the agendas of different project partners and the dynamics that determined how these agendas were promoted in the wider arena of the project;
- Needs assessment and participatory approaches were much less important in ensuring a poverty focus than the agendas of the stakeholder involved in projects.

The programme consolidated these types of lesson through a programme-commissioned formative review (Biggs and Underwood, 2001). The review was principally concerned with providing a basis to argue for changes in the programme logframe. Specifically, there was good reason to challenge the need to monitor direct poverty impacts at the project and programme level (even though in the long-term the programme and DFID would be accountable for these outcomes). A more pragmatic approach appeared to be to track behavioural (and therefore institutional) changes that the programme was stimulating among project partners as milestones towards reducing poverty. The key leading indicator thus became the extent to which a systems capacity to innovate in a pro-poor fashion was being developed. The review recommended that to contribute to the development of this capacity the programme needed to:

- Shift to an innovation systems approach because the emphasis had to move from a problem-solving framework to a learning framework;
- shift to action research protocols rather than the project cycle management tools;
- develop projects that involve groupings of local partners (coalitions), where identifying partners becomes part of the research task;
- use stakeholder analysis to make agendas transparent;
- monitor partner and stakeholder roles and interests to maintain a poverty focus.

These broad principles have informed programme strategic plans for 2002–2005. As the programme works through some of the wider implications of this shift, it and its project partners will have to continue to use institutional learning as a core research management tool.

6.3.1. Implications for impact assessment procedures

In this third case a fundamental shift in the research-management approach of a donor research programme took place in order to more effectively deal with the institutional context of the research it was commissioning. The programme purpose is no longer solely concerned with narrowly defined impacts on poor people, but rather with the creation of ''post-harvest innovation systems that respond to the needs of the poor more effectively''. This is important because it shifts the performance of the innovation system out of the assumption column of the logframe. Thus bringing about changes in this system becomes the central endeavour of the programme.

There are two implications for impact assessment procedures. Firstly, evaluation for external accountability purposes must include systems and capacity changes along with judgements of conventional impacts on the poor. Secondly, because the programme has adopted an action research approach, monitoring and internal evaluation become critical learning tools for the projects' own management purposes. Since the projects are operating through coalitions of partners monitoring and evaluation need to be undertaken jointly by the partners as it is their collective

capacity and learning which is at stake. The programme's experiences of implementing this approach highlights the need to build up process monitoring skills among both scientific and non-scientific partners. The wider implication is that if impact assessment is to be reoriented towards a greater emphasis on learning, all actors associated with the innovation process will need to develop new skills to allow them to learn more effectively. This ability to learn will be an important indicator of the emergence of new and more effective innovation system capacities.

7. Lessons and remaining challenges

These three short case studies tend to confirm critical features of the innovation systems concept discussed earlier. Four principal features emerge.

Firstly, research is an inherently social process where learning and institutional innovations are part and parcel of technology development and promotion. The first case study illustrated how scientists were the source of this learning, derived from their own experience of trying to get research products to technology users. The second illustrates how institutional lessons were learnt by scientists and administrators contesting critical aspects of organisational culture and how this has led to the development of new capacity to work interactively with a range of partners. The third case illustrates an attempt to embed these institutional learning processes within the boundaries of the research project and legitimise institutional innovations as project outputs.

Second, research approaches and outcomes are intimately related to institutional contexts. In the first case study, institutional changes relating to the accountability of scientists, in combination with the technology transfer agenda of the donor, were very clearly related to the strategy used to implement the project. However the institutional context tended to restrict the formal learning, promotion and diffusion of institutional innovations that emerged. In the second case, the consortium funding arrangement would have been rejected if the prevailing norms within ICRISAT had not been contested and changed. Once the institutional context was altered a series of new research partnership possibilities started to become feasible. In the third case the prevailing institutional context was such that rural households had very little influence on the research process despite being, at least in the rhetoric, the principal stakeholder. The response of the donor research programme has been to try to formalise changes in this institutional context in ways that will make innovation pro-poor.

Thirdly, the institutional context of research is principally played out in the combinations of actors involved in research and the patterns of relationships between these actors. In the first case study the critical innovation was the shift to a broader-based partnership approach (although this was a response to the wider institutional context imposed by donors). This move capitalised on the developmental and entrepreneurial agendas of NGOs and the private sector. The second case concerned the emergence of the need for a new type of relationship with the private sector. In this arrangement, for the first time a ICRISAT, the research priorities were set by the

private sector and the research executed by the public sector. In the third case, the selection of appropriate project partners and exploration of their interests and the nature of their relationships with others became a central mechanism for developing pro-poor innovation capacity.

Fourthly, a feature of all three case studies is that capacity to innovate is the combined function of the actors involved, the skills they bring to partnerships and the institutional contexts that shape the interrelationships. The first two case studies in particular describe the emergence of new capacities less concerned with ICRISAT alone than with the capacity of a grouping of partners and how the grouping evolves and changes ways of operating. The third case is an example of experimentation with ways of promoting the development of innovation systems capacities that are pro-poor. One aspect of these new innovation capacities is the ability of organizations to learn. The first two cases illustrate the way learning was intuitive and informal and the way, as a result, lessons spread slowly with changes taking place over an extended period. The third case suggests that if learning is to be made part of the formal mandate of research projects with a (view to developing new innovation capacities), resources will have to be devoted to develop the learning skills of all project partners. An implication of this is that learning skills are likely to be an important indicator of capacity of an innovation system.

The case studies therefore provide reason to believe that the concept of an innovation system offers a framework for thinking about research and impact as part of a wider learning process. This has implications for the way evaluation and impact assessment is conducted by the international agricultural research community. To preface these implications we revisit some of the fundamental philosophical underpinnings of the nature of knowledge and the way that it is produced and used. The principal point raised by the innovation systems perspective is that the nature and value of knowledge cannot be viewed as independent from the processes that produce and use it. The corollary is that to judge the value or impact of new knowledge requires an understanding of knowledge production and use contexts. It is this contextual information, typically institutional in nature, that determines outcomes and impacts. Once this position is accepted then evaluation and impact assessment assumes an importance greater than the resource allocation role of economic assessment. It becomes the principal mechanism for strengthening social learning processes that allow organisations to accomplish new tasks and mandates - such as achieving impact or becoming more poverty-relevant.

Our case studies have highlighted some of the practical changes that this philosophical shift towards institutional learning and change entails in international agricultural research organisations. These include:

- moving the focus of impact and evaluation from examining changes in technology user groups to including changes in the way the research community operates as well as its interaction with other organisations and institutional (including political) contexts;
- introducing institutional changes that provide incentives to formalise learning as part of the practice of research organisations. This requires changes among

donors and senior managers of research organisations and probably within professional bodies relevant to the international agricultural research community;
- recognising capacity development as an important outcome and purpose of research;
- accepting the need to explore behavioural changes in innovation systems as a way of monitoring progress and learning, as well as a way of promoting critical institutional lessons to wider audiences in the R&D community;
- recognising the systems nature of capacity development so that evaluation becomes a task that needs to be done collectively with partners as well as at the individual organisational level;
- accepting the need to embed *evaluation as learning* in the day-to-day procedures of research staff and administrators and acknowledging the skill and resource implications of this. This implies the need for greater numbers of social scientists in international agricultural research organisations, but with a hands-on role of facilitating learning in addition to disciplinary research contributions. It also implies the need to build learning skills among all partners and to allocate time within the research process for collective learning and reflection.

We do not present the innovation systems framework as a panacea for improving the performance of agricultural research. Our aim is to draw to the attention of planners, evaluators and research managers the need for (and the possibility of) thinking about agricultural research in a more holistic and evolutionary fashion.

We see three major challenges for the innovation systems framework. Firstly we have yet to see how institutional learning has led to new stakeholder-driven ways of setting technical research priorities. Our first case showed limited evidence that this can happen when new problems of an applied nature emerge in task networks. Our second case showed that new partners can bring research priorities with them. In the third case future research priorities remain an empirical question as do the processes to negotiate them in project coalitions. Further exploration of this aspect is clearly required, and institutional experimentation to explore this issue specifically would be useful.

Secondly, since the innovation systems framework recognises that priorities and agendas are negotiated and contested, greater analytical attention will need to be given to actor interaction and dynamics. These issues have not been explored in great detail in the case studies. To do so systematically will certainly require a broader range of social science tools than is currently employed in conventional research planning and evaluation approaches. It will also require the deployment of considerable international agricultural research resources for skill development and the expansion of the number of social scientists with appropriate analytical perspectives.

Fortunately many of the necessary analytical tools already exist. For example practical ways of dealing with the need to address agency roles of different actors has a long history in the action-research tradition (Whyte, 1991). More recent approaches include stakeholder analysis (Grimble and Wellard, 1997). In the context of agricultural R&D similar principles have underpinned a number of recent approaches. For example, the contending coalitions framework (Biggs and Smith,

1998) has been proposed as a way of complementing R&D planning cognisant of the political economy in which multiple (actor) sources of innovation sit. The actor linkage matrix (Biggs and Matsreat, 1999) provides a practical tool to analyse the relationships that surround capacity-building efforts in natural resources R&D. Horton et al. (2000) discuss an action research approach using an organisational assessment framework to understand capacity building in planning, monitoring and evaluation.

Horton (1998) points out that the evaluation community has a rich array of tools and disciplinary perspectives. We note with some humility that many of the implications that the innovation systems framework has for impact assessment are similar to the combined learning of decades of evaluation practice (see Horton, 2002). The third challenge therefore does not concern methodological developments to support the adoption of an innovation system framework. It concerns, rather, institutional developments in the international agricultural research community and the need to contest economic analysis as the impact assessment method of choice. Without the legitimization of the innovations systems framework and related learning-based evaluation approaches, agricultural science will remain stuck in repetitive cycles of project implementation and output evaluation. Bereft of learning, it will fail to find better ways to fulfil the social and economic purpose that its significant potential promises.

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Appendix A

Table 1 summarises the findings of the eight publications in the Impact Series of ICRISAT. These studies document the adoption of ICRISAT technologies, the technology design features responsible for the adoption (or non-adoption) of technologies, estimations of the net present value of these technologies and associated rates of return to investment. Issues concerned with the research process are sometimes apparent in general observations made by these studies. For example "partnerships between ICRISAT, NARS and farmers are important" or "farmers' preferences need to be give greater consideration". However recommendations do

Table 1
summary of impact assessment studies at the International Crop Research Institute for the semi-arid tropics

Technology assessed/region	Assessment approach	% Adoption, net present value (NPV), rate of return (ROR)	Key observations and recommendations
Fusarium wilt resistance in pigeonpea in India (Bantilan and Joshi, 1996)	Adoption study and economic surplus model	60% adoption in target zones NPV of US$ 62 million 65% ROR	•*Observation*: Seed supply constrains restricted diffusion of technology, although informal seed flows soon emerged to solve this. •*Recommendation*. Encourage public sector seed corporation to increase seed production of wilt resistant varieties.
Raised bed and furrow (RBF) land management And Groundnut production technology in India (Joshi and Bantilan, 1998)	Adoption study Economic surplus model	31% adoption for RBF 84% adoption for new groundnut varieties NPV US$3 million 25% ROR	•*Observation*: Adoption rate high when farmers had access to "technology-generating and technology-transfer systems"(pp. 49) •*Observation*: Adoption of technology dependant on access to complementary inputs •*Observation*: Technology adoption had positive equity and gender consequences •*Recommendation*. Allocate resources to design cost-effective implements for maintenance of RBF •*Recommendation*: Addition investments in technology dissemination •*Recommend*: Investigate whether lack of adoption was due to lack of complementary inputs or wrong choice of target region.
Sorghum research spillovers. West Africa (Yapi et al., 1999a,b)	Adoption study Economic surplus model	33–27% adoption NPV of US$ 15 million in Chad and US$ 4.6 million in Cameroon 75% and 95% ROR	•*Observation*: Research lags would have been longer and rates of return would have been lower if variety development had only taken place in the local NARS •*Observation*: Farmer preference is key to adoption •*Recommend*: Spillovers can be helped by further collaboration between NARS and their international counterparts •*Recommendation*: Pay attention to seed systems.

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Table 1 (*continued*)

Technology assessed/region	Assessment approach	% Adoption, net present value (NPV), rate of return (ROR)	Key observations and recommendations
Pearl millet variety, Namibia, (Rohrbach et al., 1999)	Adoption study Economic surplus model	50% adoption NPV 11 million 50% ROR	•*Observation*: Success of national breeding programme reflect: strong assistance from ICRISAT; closer collaboration with farmers; and complementary investments in seed production. •*Recommendation*: Past returns to investment do not necessarily indicate future levels. Investments in crop management might be a fruitful area, but the nature of labour and cereal economies make this questionable.
Short duration pigeonpea India (Bantilan and Parthasarathy, 1999)	Adoption study	98–49% adoption	•*Observation*: Introduction and adoption of nitrogen fixing crop into cropping system related to farmers' concerns for long-term land productivity •*Recommendation*: Further studies needed to highlight positive and negative impacts of short duration pigeon pea, in order to help scientist develop varieties suited to farmers needs.
Sorghum variety S 35 (Yapi et al., 1999)	Economic surplus model	NPV 15 95% ROR	•*Observation*: Success relates strongly to spillovers from international agricultural research and the existence of a complementary donor funded seed programme. •*Recommendation*: Future research should strive to determine more appropriate sowing dates for the variety in each region and extension should teach farmers how to delay their sowing dates.
Improved pearl millet varieties in India Ramasamy et al., 2000	Adoption study Econometric analysis	75% adoption NPV US$ 0.225 million IRR 27%	•*Observation*: Both ICRISAT, NARS and private companies have been sources of new varieties and this has lead to widespread adoption of improved material •*Observation*: Adoption related to education, irrigation, distance to market, presence of private sector seed producers and regional characteristics. •*Observation*: The new variety has not affected food security

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Table 1 (*continued*)

Technology assessed/region	Assessment approach	% Adoption, net present value (NPV), rate of return (ROR)	Key observations and recommendations
			•*Recommendation*: Grain yield and drought resistance should be addressed by breeding programme •*Recommendation*: Rural education, extension services and supply of modern inputs should be strengthened
Impact of sorghum and millet research in Mali (Yapi et al., 2000)	Adoption study Economic surplus model	30% adoption sorghum 37% adoption millet NPV US$16 million sorghum NPV US 25 million millet ROR 69% sorghum ROR 50% millet	•*Observations*: Adoption limited by lack of information, improved seed, and low soil fertility. Also farmers prefer improved local germplasm rather than high-yielding new varieties developed with exotic germplasm, suggesting that the improvement of locally adapted land race maybe most appropriate breeding strategy. •*Recommendation*: Capitalise on market developments that will encourage the use of high productivity exotic germplasm, a strategy for high-yielding high-input cultivars would satisfy this niche.

not address ways in which these concerns could be addressed based on the institutional lessons they imply.

The studies also helped identify seed systems as being a critical constraint and indeed this observation underpinned a series of further (and valuable) in-depth studies. Equity and gender concerns associated with new technologies were noted, but were not analysed in terms of the research process and its relationship to an institutional context that may have promoted attention to these concerns. More recently the impact of technical change on social capital was documented as a new type of research output, although its relationship to the nature of the research process, particularly in terms of group articulation of agendas etc., was not analysed.

Arguably the most important use of the ICRISAT Impact Series was that it presented tangible, quantified evidence of the value of ICRISAT's research at a time of declining donor support and intense scrutiny of the outputs of international agricultural research institutes. This was an entirely legitimate use of impact assessment. However, it did not alter the process of priority setting. This remained a process of scientific advocacy by ICRISAT's own (physical and social) scientists, pejoratively referred to in the Institute as the promotion of scientists' *hobbyhorses*. Similarly, impact assessment did not contribute to restructuring the relationship between ICRISAT's agenda and the agendas of diverse technology user groups and their intermediaries. Neither did it help inform decisions on the Institute's choice of focus along the strategic-adaptive-developmental research continuum. Observations made in the Impact Series publications would suggest all these issues needed to be revisited, even if such a course of action was not reflect in the recommendations made. In fact ICRISAT did make some of these types of changes to the research process. These changes did not arise, however, as the result of systematic impact assessment studies, but usually through the efforts of individual scientists responding to opportunities and changing circumstances by innovating.

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