In 2003, the CGIAR Secretariat asked the Standing Panel on Impact Assessment (SPIA) to initiate a series of impact assessment studies on natural resources management (NRM) research. The main objectives of this SPIA initiative were to obtain better information on the demonstrable impacts of CGIAR investments in NRM research, to identify gaps in data and methodology, and to provide avenues for better NRM impact assessment in the future. This impact brief summarizes the results of the seven case studies selected after review for more detailed analysis. The full version of the study on which this brief is based is: CGIAR Science Council Standing Panel on Impact Assessment. 2006. Natural Resources Management Research Impacts: Evidence from the CGIAR. Working Paper. Science Council Secretariat: Rome, Italy. The study is available at http://impact.cgiar.org/

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Natural Resource Management Research by the CGIAR: Evidence of Impacts

Over the past 20 years, the Consultative Group on International Agricultural Research (CGIAR) has become a major provider of natural resource management research (NRMR). In principle, NRMR, which covers a broad spectrum of topics relevant to the management of land, soils, water, and biodiversity, should generate knowledge that gives rise to a range of technologies for enhancing the productivity and sustainability of ecosystems.

But does it actually do so? Concern has been expressed regarding the dearth of credible, documented evidence that NRMR really contributes to the CGIAR's mission – to reduce poverty and improve food security while protecting the environment.[1] In 2003, in response to this concern, the CGIAR Director requested the Standing Panel on Impact Assessment (SPIA) of the CGIAR's Science Council to assess the impacts of the CGIAR system's investments in NRMR. It was felt that this pioneering initiative would also improve the system's capacity to conduct such assessments in the future.

Center case studies

SPIA built its assessment around three pillars: (i) case studies of CGIAR NRMR, (ii) evidence of NRMR impacts from a specific CGIAR systemwide program, and (iii) the refinement of NRMR impact assessment methods. This brief describes the results for the first of these pillars.

The SPIA case studies included research conducted by seven CGIAR centers and their partners. The aim was to collate evidence from the various types of NRMR commonly conducted by the CGIAR. These case studies were selected on the basis of the quality of the proposals submitted by each center and were subjected to several rounds of rigorous peer review. The

full set of case studies and the methodology used will be published by CAB International in 2007 in a book entitled *The Impact of Natural Resource Management Research: Studies from the CGIAR* (edited by Professors Hermann Waibel and David Zilberman). Some of the case studies have already been published by individual centers, while the Science Council has also published briefs on each study.

The seven case studies were from the Centro Internacional de Agricultura Tropical (CIAT), the Center for International Forestry Research (CIFOR), the Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT), the International Center for Agricultural Research in the Dry Areas (ICARDA), the World Agroforestry Centre (ICRAF), the International Water Management Institute (IWMI), and the WorldFish Center (WorldFish).

The cases are very diverse, both geographically and in terms of type of research. Two are from sub-Saharan Africa, one from North Africa, two from Asia, and one has global coverage (see Table 1). Some are macro-oriented, meaning that they emphasize policies and institutions, while others are micro-oriented – focusing on commodities and farm-level technology (see Table 2).

Most of the research evaluated in the studies had started in the mid-1980s or early 1990s, so there was a reasonable time-span between research and impact assessment, even though some of the projects are still ongoing. As of October 2006, the total CGIAR investment in these projects exceeds US$18 million (see Table 1). All the projects involved national agricultural research groups and other partners working alongside the centers.

Investment was often difficult to quantify since the research was mostly multidimensional and sometimes embedded in other activities at the center. As a result, the figures in Table 1 are estimates based on center and national records, together with expert judgments. In several cases, the term 'research investment' also includes some investment in extension. Sometimes centers engage in dissemination and extension to introduce and spread NRM technologies. All the projects involved significant participation by national and other partners, which further complicated costing.

Most of the micro-oriented case studies employed a neoclassical economics framework that followed in the footsteps of similar studies used to assess the impact of crop germplasm improvement (CGI)

Table 1.
Overview of NRMR project case studies

Center	Project type	Countries	Research period	Research investment (million US$)[a]
CIAT	Cassava productivity enhancement, soil conservation technologies and farmer participatory research	Thailand, Vietnam	1993–2004	4.0
CIFOR	Criteria and indicators for sustainable forest management	Global	1994–1999	3.3
CIMMYT	Zero tillage in rice–wheat systems	India	1990–present	3.5
ICARDA	Alley cropping with *Opuntia/Atriplex*	Morocco Tunisia	1995–2002	< 1.0
ICRAF	Tree fallows in maize	Zambia	1986–2002	~3.5
IWMI	Irrigation management transfer	South Asia Central Asia	1992–present	Not specified
WorldFish	Integrated agriculture– aquaculture	Malawi	1986–mid-1990s	1.5

[a] Nominal values

Table 2.
Conceptual framework and methodologies

Center	Conceptual framework	Major methodologies used
CIAT	Household production and welfare theory	Simultaneous equations of adoption and productivity change, consumer and producer surplus, rates of return
CIFOR	Institutional economics and information theory	Impact pathway and client analysis
CIMMYT	Production and welfare theory	Statistical and descriptive analyses, partial budgets, consumer and producer surplus, rate of return
ICARDA	Production and welfare theory	Mathematical programming, ecological modeling, adoption and production functions, stochastic simulation
ICRAF	Production and welfare theory	Literature analysis, partial budgets, rates of return
IWMI	Institutional economics and information theory	Bibliometric and webmetric analyses, client surveys
WorldFish	Household production and welfare theory	Adoption functions, total factor productivity, stochastic production frontiers and technical efficiency analysis, descriptive statistics for income and profit, consumer and producer surplus, rates of return

research.[2] Typically, the researchers started out by studying the adoption of research outputs, then investigated the effects of these outputs on farm productivity and income. All the micro-oriented studies applied a welfare economics framework to calculate a broader economic rate of return to society. Three of these (CIAT, CIMMYT, and WorldFish) also calculated the distribution of project benefits among producers and consumers. However, none was able to examine the overall impacts on the poor, since baseline data were not available and sample sizes were too small.

The two macro-oriented studies – the CIFOR and IWMI cases – had to use a different methodology. It was not possible to identify the economic benefits of CIFOR's research on criteria and indicators for the certification of sustainable forestry management or IWMI's information and policy advice on irrigation management transfer. It was also not possible to identify a counterfactual – a control to demonstrate what would have happened without the research. Both these projects had complex impact pathways in which the attribution of specific impacts was complicated by the difficulty of isolating contributions from other parties. The analyses therefore concentrated on describing and quantifying the demand for specific NRM information or technologies developed and/or promoted by the project, through interviews, user surveys, bibliometric techniques, and webmetric searches.

Findings

It seems likely that the centers' assessments underestimated both the costs and the benefits of the research conducted by the projects. Internal rates of return (IRRs) were calculated using conservative assumptions which, for example, excluded spillover and environmental benefits. Despite this limitation, most projects had an IRR similar to other agricultural research and development (R&D) projects, with the exception of CGI research (see Reflections and lessons). Table 3 summarizes the impact assessment results for each project.

For two of the three case studies in which producer and consumer surpluses were calculated (CIMMYT and WorldFish), the finding was that the projects had benefited consumers more than producers. In these two cases, the elasticity of demand for the commodities involved was low, with that for wheat being lower than for fish.

Reflections and lessons

The assessment shows that, in so far as estimated benefits (*ex-post* and *ex-ante*) can be quantified, the CGIAR investment in these NRMR projects has paid off. However, this assessment includes projected values, since the period over which the benefits accrue was assumed to exceed the period of project implementation.

The IRRs from this set of NRMR projects (with the exceptions of CIAT and CIMMYT) do not always match that those of CGI research, mainly because of the difficulty and cost of scaling up NRMR outcomes. Thus, for example, NRMR innovations are seldom such that there is a ready-made private-sector interest in promoting adoption and bearing the costs of dissemination, as is the case with the seed companies and other private-sector entities that tend to take over the dissemination of CGI research outputs. NRMR is also likely to have additional environmental benefits beyond its effects on productivity. Several case studies identified such benefits (see Table 3), but in most cases these were not quantified and were hence excluded when calculating IRR.

NRMR sometimes requires CGIAR centers to step outside their traditional domain and engage in extension in order to achieve an impact. This raises the question of the comparative advantage of the CGIAR in undertaking extension activities. The question is: 'How can the centers make sure that their NRM technologies become adopted if delivery systems are largely dysfunctional or even absent?' The uptake of

Table 3.
Impact of NRM projects

Center	Scale (actual (A)[1] and predicted (P)[2])		Consumer (C) and producer (F) surplus	Internal rate of return (IRR)	Other documented impacts
	Land area/production	Number of users			
CIAT	2800 t cassava per village per year (A)	8 villages	F: 100%	~ 40%	Knowledge and institutional learning
CIFOR	45 million ha of forest under certification (P)	n.a	n.c.	n.c.	Cost savings for certifiers
CIMMYT	0.82 million ha (A) 3.4 million ha (P)	n.a.	C: 65% F: 35%	57%	Conservation of water and energy resources
ICARDA	Tunisia: 470 ha (A) 96,000 ha (P) Morocco: 1650 ha (A) 350,000 ha (P)	n.a.	n.c.	Tunisia: 16% Morocco: 48%	Reduction of soil erosion Net environmental benefit: US$131/ha
ICRAF	n.a.	Approximately 77,000 farmers (A)	n.c.	15% (over a 25-year period)	Carbon sequestration Risk reduction Reduced soil erosion
IWMI	n.a.	50,000 downloads in five years (A) 7500 copies of IMT guidelines (A)	n.c.	n.c.	Demand for policy advice
WorldFish	1000 t of fish per year (A) 15,000 t per year (P)[3]	n.a.	C: 60% F: 40%	12%	Household nutrition

n.c. Not calculated
n.a. Not available
(A)[1] Actual *ex post* evidence of adoption by the end of the data collection period of the project, i.e., around 2002/2003
(P)[2] Predicted adoption at national level outside the project intervention area
(P)[3] Calculated adoption on the basis of the observed annual growth rate up to 2016

agroforestry innovations in many countries has faced this constraint. The constraint arises not only because of the usual problems with scarce resources in national extension services but because private-sector interest in taking over dissemination is also typically absent. This is associated with the inherent difficulties of upscaling knowledge-based and/or labor-intensive technologies and practices. In addition, NRM technologies are often location-specific, in contrast to the often widely adapted improved varieties produced by CGI research. This can limit the size of recommendation domains while adding to the complexity, and hence the costs, of extension. One way of overcoming the extension constraint, as the case studies show, is for the centers to form partnerships with local and/or international nongovernment organizations (NGOs). Another way forward is to embody NRM technology in a saleable private good, as was done by CIMMYT and its partners in the Indo-Gangetic plains.

The case studies varied in the ways they defined, and then quantitatively assessed, impacts. The two macro-oriented cases (CIFOR and IWMI) overcame this challenge through the concept of impact pathways, along which they traced usage of the information generated by the projects. Using this approach the two centers were able to identify plausible impacts, but not to quantify them. For the five cases in which quantification of benefits and costs was possible and IRRs were calculated, the conclusion was that the benefits of NRMR are likely to surpass the costs significantly, when both are appropriately discounted to a common point in time. While the IRRs as calculated do not generally match those of the CGIAR's CGI research, it should be remembered that the positive environmental returns to NRMR were not included. If they had been, the benefits of NRMR might appear comparable to those from CGI research research, but this can only be tested if many more NRM impact assessment studies are carried out.

Some of the micro-projects also yielded findings that fostered incremental improvements in natural resource policies or institutions. However, due to methodological challenges and lack of data, it was not possible to quantify the economic benefits of these improvements. A methodology is urgently needed that will identify and quantify the various potential impacts that were excluded from these assessments. And while this methodology is under development, further conceptual and empirical analyses should be conducted.

Collecting the right kind of data is another concern. At the time when these projects were launched, the centers did not use explicit *ex ante* impact projections to plan their research, and none of the projects assessed had a baseline survey. Hence, it was not possible to use analytical models that could have reduced the counterfactual problem, and, to some extent, the attribution problem. Similarly, studies that apply non-market valuations of environmental goods and services are not widespread in the CGIAR. None of the NRM case studies incorporated this dimension in their research, perhaps because of poor data availability in developing countries. However, it is increasingly evident that these data are imperative if reliable

Lessons learned

- The returns to the NRMR projects covered by the SPIA assessment are more than sufficient to justify the research investments, but they generally fall below those associated with CGI research.
- Rates of return to NRMR would doubtless be higher if environmental benefits were included.
- More efforts, and better methods, are needed to quantify and value environmental benefits.
- Quantification of benefits for macro-oriented NRMR projects is complex and requires new models and methods.
- Adoption costs (for example, farmer learning time) are often difficult to quantify. It is important that they should be, since they could have a sizeable impact on rates of return.
- Lack of baseline data leads to assumptions rather than hard data on the impact of NRMR. This shortcoming needs to be addressed in future NRMR projects.
- There is a need for more comparative studies across regions and countries. These could enhance cost-effectiveness and impact by generating knowledge that is more widely applicable.
- The centers need to institutionalize and strengthen NRMR and related impact assessment activities, both within their own organizations and in national research systems.

conclusions about the impacts of at least some types of NRMR are to be reached. Also missing was empirical evidence on poverty reduction. In a few cases, *ad hoc* attempts to quantify this had been made, but the database was insufficient for valid analysis.

Conclusion

New theoretical frameworks and methodologies are needed for assessing the impact of NRMR. A dynamic model that takes into account stakeholder learning and adaptation is vital in order to assess not merely increases in productivity and savings in labor but also environmental costs and benefits and the adoption of recommendations from policy and institutional research. Analysis using such methodologies could reduce the number of misguided policy interventions that currently thwart development or result in unwanted outcomes. It could also build the case for increased investment in NRMR and inform future development efforts. It is disappointing to note the lack of progress in methodology development since NRMR was first launched in the CGIAR system more than 20 years ago.

There is evidence of significant positive economic impact from the wide variety of NRMR cases assessed in this study; indeed, the IRRs should be acceptable to most investors in CGIAR research. At the same time, the case studies have raised a new set of questions and issues that require the centers not only to do more of the same type of assessment but also to analyze a broader set of NRMR impacts, not just the economic ones.

Finally, while the results from these case studies suggest that the returns to NRMR are lower than those to CGI, it is not yet possible to draw this conclusion with any certainty, nor even to compare the costs and benefits of these two kinds of research. This is because there is wide discrepancy both in the way benefits are measured and in the volume of documentation between the two. There are hundreds of CGI impact studies, but, as yet, only a few NRMR impact studies. The onus is thus on the centers to step up their efforts in this area and come up with more evidence of impact. The insights gained from the seven SPIA case studies can provide guidance for such follow-up activity.

This exercise should therefore mark the beginning of a more comprehensive assessment of the impact of the CGIAR's investment in NRMR.

Notes

1 World Bank. 2003. *The CGIAR at 31: An Independent Meta-Evaluation of the CGIAR*. Vol. 1: Overview Report. World Bank: Washington, DC; and Kelley T. and Gregersen H. 2005. NRM impact assessment in the CGIAR: meeting the challenges and implications for the CGIAR, pp. 341–359 In: *Natural Resources Management in Agriculture: Methods for Assessing Economic and Environmental Impacts* (Shiferaw B., Freeman H.A., and Swinton S.M., Eds). CAB International: Wallingford, UK.

2 Evenson R.E. and Gollin, D. 2003. *Crop Variety Improvement and Its Effect on Productivity: the Impact of International Agricultural Research*. CAB International: Wallingford, UK.

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