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Ex-post environmental impact assessment: lessons from four CGIAR case studies

For forty years, the CGIAR has been engaged in improving the productivity of agriculture for the benefit of the rural poor in developing countries. The CGIAR's awareness of the environmental impacts of its work is reflected in the prominence of the environment in the CGIAR's new strategic objectives, one of which calls for the Centers to "conserve, enhance and sustainably use natural resources and biodiversity to improve the livelihoods of the poor in response to climate change and other factors." Nevertheless, relatively little effort has been made to measure the impacts of CGIAR research on the environment. This brief describes four case studies undertaken to evaluate the costs and benefits of agricultural research to the environment.

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Key messages

- There has been no systematic attempt to measure the impacts of CGIAR research on the environment.
- Four case studies sought to evaluate the costs and benefits of agricultural research to the environment, employing techniques that allow monetary values to be assigned to environmental goods and services.
- Challenges relate to expertise gaps within the Centers, the need to refine tools and approaches and a lack of clear incentives and resources at the system level for the complex biophysical models and datasets required for more integrated *ex-post* impact assessments.

Background

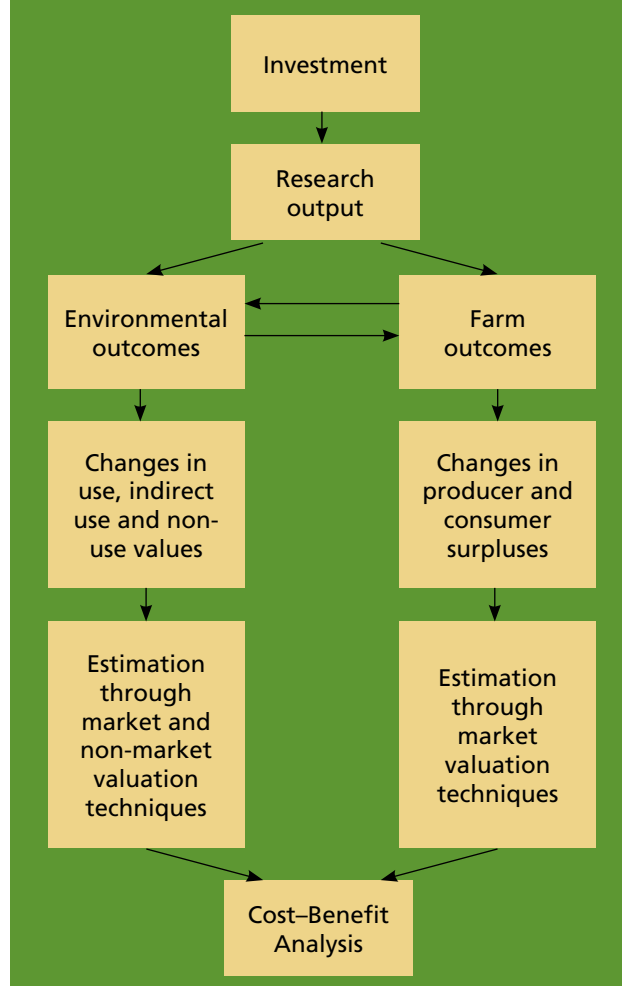
The relationship between agriculture and the environment is one of the most vexing issues facing many governments today. Policymakers in both developed and developing countries are under increasing pressure from donors, consumers and civil society to halt the environmental decline caused by agricultural demand for scarce land and water resources. A better quantified understanding of the relationship between agricultural production and the environment is a critical starting point.

Conceptual issues

Most evaluation work in the CGIAR has concerned increases in on-farm productivity. This type of evaluation is relatively straightforward: it compares the value of changes in producer and consumer surpluses resulting from research-based interventions to the costs of that research. Making the link between research outputs and environmental outcomes is a greater conceptual and empirical challenge. Many factors play a role in determining environmental conditions and these are often not easy to measure. In addition, determining the geographical extent of any impacts can pose difficulties. Frequently, impacts are diffuse and spread over large areas and extrapolating the results derived from a small-scale trial to full implementation may not be a simple process. Likewise, measuring the trade-offs between research costs and environmental impacts requires factoring in the values that people place on such impacts. Again, these are not easy to measure.

A number of value frameworks have been developed to measure environmental impacts. Based on welfare economics, these frameworks interpret the relevant values held by people in terms of the impacts on their well-being. A number of techniques have been developed for estimating the values of non-marketed goods and services. Choice modeling is a tool for predicting the trade-offs that people might make in a certain situation by presenting them with a range of hypothetical scenarios, each with different environmental and livelihoods costs. Contingent valuation offers another survey-based technique for estimating the economic value of ecosystem and environmental services. By calculating the societal values associated with the environmental changes brought about through new interventions based on agricultural research, scientists can weigh them against the economic consequences of that research investment. Thus, increases in farm income

Figure 1. Integrating research inputs, outputs and outcomes



and the consequent improvements in well-being, including hunger alleviation, can be measured against any associated environmental harm.

The case studies

Supplemental irrigation of wheat in Syria

The International Center for Agricultural Research in Dry Areas (ICARDA) has invested in supplemental irrigation techniques for the past two decades and, while the relationship between these techniques, wheat yields and the resulting economic benefits to farmers has been measured, until recently, the broader environmental impacts of supplemental irrigation had not. An ICARDA case study considered the relationship between supplemental irrigation and the extent of groundwater depletion and soil salinity accumulation and compared the values associated with these changes to those associated with

traditional irrigation practices. In 2010, data were collected from nearly 600 wheat-growing households across Syria. The estimated benefits of supplemental irrigation ranged from zero to more than 423 million Syrian Pounds (SYP) (US\$8.5 million) per year. The variability is due to different assumptions about the fate of the water 'saved' under supplemental irrigation. A choice modeling approach confirmed that farmers would be willing to pay more for the lower salinity land that is a by-product of supplemental irrigation.

The ICARDA study concluded that the estimated environmental benefits of supplemental irrigation supplement the economic benefits of yield improvements and cost savings to offset any additional capital costs, such as the installation of sprinkler systems.

Zero tillage in rice-wheat systems in South Asia

A study carried out by the Indian Council for Agricultural Research (ICAR) and the Indian Agricultural Research Institute (IARI) considered the environmental impacts of the introduction of zero tillage in rice-wheat systems in the Indo-Gangetic Plains. Zero tillage is a technique for growing crops without disturbing the soil by ploughing. The study examined changes in water availability in the soil and reductions in greenhouse gas emissions. Zero tillage was found to eliminate the need for pre-planting irrigation and to reduce the amount of water needed by the crops after sowing. An average of 36% of water was saved per household. And because zero tillage requires less cultivation, less diesel fuel was needed, reducing the emission of greenhouse gases from 52.1 to 62.9 kg/ha of CO₂ – a benefit both on and off of the farm.

Zero tillage agriculture reduces costs and increases yields through higher water infiltration and reduced erosion. Based on interviews with farmers, the ICAR study concluded that the water savings and reduction of emissions were additional environmental benefits that justify the research investments that have led to the widespread use of zero tillage in the Indo-Gangetic plains.

Sluice gate management in the Mekong delta

At the request of the Government of Viet Nam, The International Water Management Institute (IWMI) looked for better ways to manage sluice gates in the Mekong River delta. The request arose from a conflict between shrimp farmers and rice growers over the impacts of the sluice gates on the relative flows of saline water – needed for shrimp cultivation – and fresh water – needed for growing rice. IWMI developed a management plan for

the sluice gates that increased yields from both shrimp and rice cultivation. Improving the quality of the waterways in the Mekong delta also affected the flora and fauna living there. An IWMI case study assessed these impacts and the benefits they brought to the local people of Bac Lieu Province. The study focused on a research investment targeted at improving the environment for agriculture that had more than productivity implications for the local farm population.

IWMI carried out a participatory rural appraisal where selected families were asked to assess any changes in soil acidity, water salinity, and flora and fauna arising from the new sluice system. The second phase of the exercise involved 120 households, which were also asked whether they would be willing to pay for the sluice gate operations. Respondents were also asked to apportion their willingness to pay between the economic and environmental net benefits of the sluice gates.

The study found that, on average, households would pay between US\$39 and US\$73 per year for sluice gate operations. From 12-15% of this amount was apportioned to flora and fauna changes caused by sluice gate operations. Extrapolated across the population of the affected area, these figures yield an aggregate value for the environmental improvements of up to US\$200,000 per year. These benefits exceed the likely costs of sluice gate operations, so that the environmental benefits alone justify the operating costs.

Potato genetic diversity in Peru

Over the years, CIP's potato breeding efforts have improved the livelihoods of Andean farmers through the introduction of higher yielding, disease resistant varieties. However, the new varieties have displaced native landraces, reducing local potato diversity. Without diversity, crop losses may be greater in the event of a disease outbreak that affects the genetically uniform, high yielding varieties.

An environmental impact assessment looked at the loss of species and genetic diversity in two districts in the Peruvian Andes over a period of 30 years. An inventory was made of current diversity, followed by interviews with community elders about their perceptions of change over time. The two case study sites yielded similar results, despite differences in market access and climate. The findings suggest that crop diversity, yield and price all influence farmers' planting choices. An increase in the yield of a commercial variety will encourage farmers to plant more of that variety. However, any resulting

Table 1.
Case study results

Research focus	Sample size	Environmental impact	Value estimate (US\$)
Supplemental irrigation of wheat in Syria	591	Water Soil	\$102/ha 0.12/m ³
Zero tillage in rice-wheat systems in South Asia	66	Water	\$142 per respondent
Sluice Gate management in the Mekong delta	120	Flora Fauna	\$5.56 per respondent
Potato genetic diversity in Peru	85	Biodiversity	Not estimated ^a

^a This study estimated the loss of native cultivar diversity as a result of the adoption of modern varieties.

loss of diversity will be a considered a cost, because it is valuable to the household as well. The study permits an analysis of the extent to which farmers are willing to trade off improved yield with reduced biodiversity.

Conclusions and lessons learned

The four case studies demonstrate that existing *ex-post* impact assessment work can be extended to link research investment to environmental values. There are challenges however. Understanding the environmental impacts of research is difficult, partly because there are multiple inputs to research and assigning proportional responsibility is not straightforward. Nor do existing modeling studies target all of the factors that create or destroy value for people. The case studies were concerned with the direct impacts of research on farm profits. Indeed, only the benefits to farm households were considered, even where non-marketed goods and services were targeted by the study (e.g. flora and fauna in the Mekong delta). This leaves the field of non-market valuation of the off-farm effects of CGIAR research investments still open for exploration.

The valuation elements of the four studies also leave unanswered questions. While the use of choice modeling in the ICARDA and CIP studies demonstrates the feasibility of this technique, more development is required to ensure unbiased results and accuracy in countries where literacy levels are low. The use of contingent valuation by ICAR and IWMI demonstrates the flexibility of the technique, but also shows the need to refine the method to meet specific circumstances.

Technical limitations notwithstanding, the studies show the significance of some of the environmental impacts resulting from Center research. Such knowledge will become increasingly important for informing the CGIAR's policy and strategic research decisions. The CGIAR needs to broaden its approach to *ex-post* impact assessment to routinely – but selectively – include the environmental costs and benefits of Center research. Evaluation staff need to acquire the skills to carry out valuation exercises, including non-market valuation. And researchers will need grounding in environmental as well as agricultural sciences to enable adequate biophysical analysis. Until now, a lack of clear incentives at the system level, combined with the high cost of constructing complex biophysical models and collecting good data on changes in environmental quality, has resulted in organizations such as the CGIAR being underinvested in the models and datasets required for more integrated *ex-post* impact assessment.

There are methodological challenges as well. Establishing the links between biophysical analysis and economic valuation is especially important. The focus needs to be on the effects of research on people, not the environment *per se*. Under the benefit-cost analysis conceptual framework, it is not the environment that benefits or endures costs. Rather it is people who enjoy benefits when the environment is improved and experience costs when it is degraded.

References

The four case studies described in this Brief are available at: <http://impact.cgiar.org/eia2008-2011>.

