This brief is based on the paper by Mitch Renkow (2011) Assessing the environmental impacts of CGIAR research: toward an analytical framework. In: CGIAR Independent Science and Partnership Council (2011) *Measuring the Environmental Impacts of Agricultural Research: Theory and Applications to CGIAR Research*. Independent Science and Partnership Council Secretariat: Rome, Italy.

INDEPENDENT SCIENCE & PARTNERSHIP COUNCIL
CGIAR

INDEPENDENT SCIENCE & PARTNERSHIP COUNCIL

STANDING PANEL ON IMPACT ASSESSMENT

BRIEF NUMBER 38

Neil Palmer (CIAT)

*Nourishing the Future through Scientific Excellence*

# Environmental impacts of agricultural research: concepts and tools to strengthen the evidence base

Farming systems produce a range of food, fiber, fodder and other products that generate economic impacts over different scales, often at the same time. Farming systems also generate environmental impacts in the form of changes to the natural environment. Agricultural research carried out by the Consultative Group on International Agricultural Research (CGIAR) often aims to achieve economic impacts by raising agricultural productivity, but there are also environmental and social impacts associated with the adoption of research-derived agricultural technologies or policies. These may be positive or negative, intended or unintended, and may be felt on-farm, locally or globally. This brief examines efforts so far to evaluate these environmental and social impacts, and the lessons for drawing together a comprehensive assessment framework.

## Key messages

- Assessment and analysis of the environmental and social impacts of CGIAR research has been minimal and unsystematic, with a few exceptions.
- Tools exist for identifying and assessing the environmental and social impacts of agricultural research.
- Systematic, system-wide assessment of the environmental impacts of CGIAR research requires prioritization of research projects for assessment and prior identification of the indicators to be collected, as well as greater financial investment in data and relevant expertise.

## Background

During its forty years of existence, research by the CGIAR on genetic improvement, natural resource management and policy has generated a broad array of technological, management and knowledge products. These have produced a similarly broad set of economic, social and environmental impacts. Over the past two decades, formal *ex-post* assessment of these impacts has become increasingly institutionalized within the CGIAR (Walker et al., 2008). This emphasis has followed increasing demand by donors and CGIAR managers for evidence that specific research investments have generated large benefits and a reasonable rate of return.

While a large body of evidence documents and quantifies the direct and indirect effects of CGIAR research using economic surplus approaches (e.g., Raitzer, 2003), very few studies quantify social or environmental impacts. Ideally, a unified analytical approach would jointly consider impacts across all three dimensions – economic, social and environmental. Achieving this is constrained, however, by two factors. First, economic impacts are far more readily measured in monetary terms compatible with cost–benefit analysis than social or environmental impacts. In contrast, social and environmental impacts arise to a large degree from changes in flows of goods and services for which there is no market.

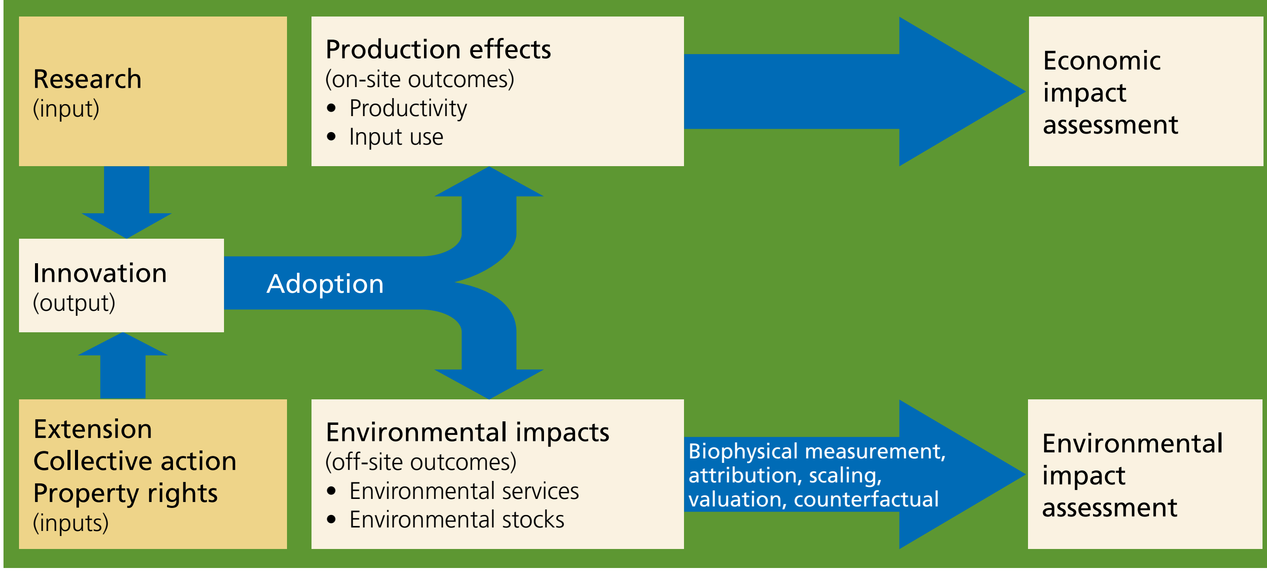
Second, the social and environmental outcomes of a given research initiative result from fundamentally more complex interrelationships among humans or between humans and their natural environment than do economic outcomes. This also renders social and environmental impact assessment a much more difficult task.

## Environmental impacts of CGIAR research: the evidence to date

It is widely recognized that negative environmental consequences have followed from agricultural intensification and that the Centers have been instrumental in facilitating that intensification process dating back to the Green Revolution. It is also widely acknowledged that substantial research emanating from the CGIAR has made positive contributions to reducing, or helping to internalize, negative externalities originating in both intensive and extensive agricultural systems. Figure 1 shows pathways from research and extension to economic and environmental impact.

It is surprising then that so little has been done in the way of accurately tracing the entire chain of outputs, outcomes and impacts of CGIAR research on the natural environment. Moreover, the studies that have been conducted have tended to focus on positive outcomes, such as technologies or knowledge-based management regimes that redress some negative environmental externality. No study to date has directly attempted to measure the extent to which negative environmental effects reduce the large economic benefits attributable to CGIAR-related productivity increases.

**Figure 1. Pathway from research and extension to economic and environmental impact assessment**



The review carried out by Renkow (2011) has revealed a very thin record of research to assess the environmental impacts of technologies and knowledge products generated by CGIAR research. Progress has been noted on quantifying *ex-post* impacts of pesticide use, but this research focused primarily on human health impacts. A few examples of *ex-post* policy-oriented research have quantified the environmental impact of CGIAR analyses of timber harvesting policies (by the Center for International Forestry Research, CIFOR) and pesticide reduction policies (by the International Potato Center, CIP and the International Rice Research Institute, IRRI). Some steps have been taken toward documenting improvements in nutrient management and soil and water quality associated with CGIAR research activities. Overall, however, there are no studies of CGIAR research outputs that can be regarded as a 'template' for guiding future *ex-post* environmental impact assessments.

There are several possible explanations for the paucity of efforts to quantify the impacts of CGIAR research on the environment. First, measuring environmental services in a consistent manner over a period of time is difficult. It requires sampling a large number of variables that need to be controlled for in any meaningful statistical analysis. Moreover, sampling needs to begin at a very early stage in the adoption/diffusion process.

Second, valuing those environmental services also poses a distinct challenge. With the exception of CIFOR's work on deforestation and the work of CIP and IRRI on pesticide use, this appears to have been an insurmountable obstacle for most CGIAR research in this area. Particularly noticeable is the absence of non-market valuation of the environmental services affected by CGIAR technology, management or knowledge products.

Measuring environmental and social impacts also typically requires substantial interdisciplinary collaboration, the organization and administration of which can be challenging. The substantial fieldwork needed is also costly. Finally, particularly in the case of assessing the negative environmental impacts of CGIAR research, Centers have little incentive to pursue research that has a real probability of putting them in a bad light.

## Key lessons and critical issues

A number of important themes emerged from Renkow's review that identify critical issues that need to be addressed in pursuing environmental impact assessment of CGIAR research. These include the following.

- A distinction needs to be made between on-site 'production effects' and 'off-site environmental impacts'. The former will generally be reflected in a standard *ex-post* economic impact assessment. The latter, however, have largely been overlooked by past assessment work and pose distinct challenges, both in terms of biophysical measurement and non-market valuation.
- Environmental outcomes from agricultural practices may be positive or negative. The former are generally anticipated consequences of research activities, whereas the latter tend to be unanticipated. Importantly, the benchmark data on environmental stocks and flows required for the comparison of situations before and after an intervention will generally be unavailable for assessing unanticipated negative impacts of existing technologies.
- Environmental impacts will be felt by a variety of agents – both consumers of environmental goods, and producers for whom environmental goods are inputs. The multiplicity of agents that are impacted and the variety of pathways by which those impacts are transmitted increase the number of measurement and valuation challenges faced by analysts.
- Environmental impacts vary significantly by type of agricultural system (intensive or extensive, irrigated or rainfed) and by the scale over which those impacts are generally felt. Principal off-site impacts associated with intensive systems tend to reflect improper management of nutrients, agrochemicals and (in irrigated areas) water resources, whereas the primary impacts associated with extensive systems have to do with conversion of lands to agricultural uses.
- Impacts on biodiversity and climate change are global in scale. These pose special challenges with respect to biophysical measurement, valuation and development of counterfactuals as they hinge on projections of highly uncertain future events.
- A specific management practice or technology can have markedly different biophysical impacts in different locations, so repeated measurement of environmental indicators from a variety of locations is necessary. So too are modeling efforts that reflect this spatial variability, in order to reliably upscale observed or projected environmental outcomes.

A number of tools have been identified that have the potential to address these challenges. A large body of knowledge exists for identifying and measuring biophysical indicators of changes in both stocks of environmental goods and flows of ecosystem services emanating from them. Likewise, a variety of models exists for tracking and predicting changes in these indicators resulting from external shocks associated with agricultural technologies and the policies that affect them. Continuing advances are being made in our ability to conduct non-market valuations of environmental goods and services, as demonstrated by the growing body of such studies in developing countries.

## Moving forward on assessment

The necessary tools exist to allow the serious pursuit of environmental impact assessment as a mainstream activity of the 'new' CGIAR, in which "sustainable management of natural resources" is now a core objective. In order to move forward, a substantial commitment is needed of organizational, financial and human resources to the process. Four imperatives stand out with regard to the system-wide deployment of resources.

First, because environmental impact assessment is a complex and costly undertaking, it is not feasible to build such studies into each and every new research project (or to subject every completed project to an *ex-post* impact assessment). Rather, there is a need to prioritize which CGIAR projects are to be subject to this sort of evaluation. A sensible approach may be to focus first and foremost on technologies, practices or policies with: (a) the largest aggregate economic impacts, since for the most part these will be the projects affecting the largest number of individuals over the widest geographic area; and (b) the most profound aggregate environmental effects (positive or negative).

This approach to prioritization would tend toward concentrating more ex-post environmental impact assessment efforts on past crop genetic improvement, pest management and policy research outcomes, and less on natural resource management research outputs and outcomes, which have generally been adopted over a relatively limited geographic and demographic scale. Beyond current SPIA research initiatives into the environmental impacts of past CGIAR crop genetic improvement research on genetic diversity and land use, examples of attractive targets for ex-post environmental impact studies include: (a) the negative impacts due to increased use of mono-cropping and agrochemicals of Green Revolution technologies; and (b) the positive impacts of biological control of harmful pests.

Second, for those priority-selected projects, environmental monitoring and valuation strategies need to be built into the project design. Benchmark measurements taken prior to project initiation are critical to gaining an ex-post understanding of the environmental outcomes attributable to technological change, as well as for facilitating appropriate counterfactual development. Tackling the valuation problem will require considerable advance planning in terms of survey design and other data collection activities.

Third, it is clear that significant financial resources will have to be devoted to vigorously pursuing environmental impact assessment as a core element of the CGIAR's evaluative activities. Incorporating environmental impact assessment as a standard component of project design is likely to mean increasing the size of research teams, due to the highly interdisciplinary nature of the work.

Finally, some changes in the human capital base on which the CGIAR draws would appear warranted. Existing staff at some Centers may not possess the expertise needed to pursue some of the tasks that need to be undertaken as part of environmental impact assessment. While some retraining might be feasible, augmenting existing staff resources to include environmental economists would seem inevitable. Alternatively, there is scope for partnering with institutions and individuals outside of the CGIAR that have a comparative advantage in research on environmental issues.

## References

Raitzer, D. 2003. *Benefit-Cost Meta-Analysis of Investment in the International Agricultural Research Centers of the CGIAR.* Prepared on behalf of SPIA, CGIAR Science Council Secretariat: Rome, Italy.

Walker, T., Maredia, M., Kelley, T., La Rovere, R., Templeton, D., Thiele, G., and Douthwaite, B. 2008. *Strategic Guidance for Ex-post Impact Assessment of Agricultural Research.* Report prepared for SPIA, CGIAR Science Council Secretariat: Rome, Italy.

CGIAR

Independent Science & Partnership Council Secretariat
c/o FAO
Viale delle Terme di Caracalla snc, 00153 Rome, Italy
www.sciencecouncil.cgiar.org
t: 39 06 57056782 f: 39 06 57053298
e: ISPC-Secretariat@fao.org