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Charting the CGIAR's Future - Reshaping the CGIAR's Organization

Report from TAC's Standing Panel on Impact Assessment

Attached is the report from TAC Standing Panel on Impact Assessment (SPIA), formerly the Impact Assessment and Evaluation Group (IAEG).

The attached report will be discussed under Agenda Item 10(c): Committee Reports and will be presented by the SPIA Chair.

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CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH

TECHNICAL ADVISORY COMMITTEE

Report of
TAC's Standing Panel on Impact Assessment
to ICW 2000

TAC SECRETARIAT

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

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TAC STANDING PANEL ON IMPACT ASSESSMENT (SPIA)

Report to ICW00

1. Background: Composition and Organization of SPIA

At ICW99 the CGIAR agreed with the proposal prepared by the Cosponsors for the integration of the IAEG and TAC (see Box 1 for details). The new name for the IAEG is the Standing Panel on Impact Assessment (SPIA).

Box 1: Implementation of TAC/IAEG Integration
(From the Summary Record of Cosponsors Meeting, International Centres Week 1999, Washington, D.C.)

The Cosponsors endorsed the implementation arrangement for the TAC/IAEG integration. The key features of the arrangement are:

- Functions of the IAEG would be integrated into a new standing panel on impact assessment which would be directly linked to TAC's sub-committee on priorities and strategies (SCOPAS);
- Membership in the panel would consist of a TAC member as Chair and two external experts in impact assessment (with a third slot remaining vacant for the time being);
- Linkages with EPMRs would be maintained through interaction between the panel and TAC's sub-committee on external reviews (SCOER);
- Independence of outputs and reporting would be ensured;
- Recognition of the panel's expert role in choosing topics and planning assessments; and
- TAC Secretariat will have a special wing to cover the full range of activities of the panel and the SCOPAS.

Members of SPIA continue to be Drs. Cristina David (Philippines) and Frans Leeuw (Netherlands). The Chair is Dr. Hans Gregersen (US). At the recommendation of the SPIA Chair, the position of the third member remains vacant for the time being until SPIA's role and activities within TAC have been determined. Dr. Guido Gryseels has served as Executive

Secretary of the IAEG up until his appointment as Deputy Executive Secretary of TAC. He has Secretariat responsibility for SPIA as well as SCOPAS. Both members of SPIA have expressed a desire not to continue when their terms expire at the end of 2000. A new list of candidates is being drawn up for presentation to the Cosponsors at ICW00.

2. Original and Evolving Mandate of the IAEG

The IAEG was established to:

- provide Members with timely, objective and credible information on the impacts at the System level of past CGIAR outputs in terms of the CGIAR goals;
- provide support to and complement the centres in their ex post impact assessment activities.

SPIA members believe that these functions are still as relevant as they were when the IAEG was established. However, it is becoming increasingly evident - as most recently emphasised by the System Review Report - that there is a third important function for ex post evaluation, namely,

- to provide feedback to priority setting, and create synergies by developing links to ex ante assessment and the overall planning and evaluation functions of TAC and the CGIAR Secretariat.

It is for that reason that the TAC Chair recommended that SPIA be closely linked to TAC's Standing Committee on Priorities and Strategies (SCOPAS). The Chairs of SCOPAS and SPIA both agreed, as did the Cosponsors. The challenge now is to develop the most effective and efficient operating mode possible, while maintaining the CGIAR Members' desired level of credibility and objectivity in impact assessment activities. The mode of operation and mandate for SPIA within TAC were reviewed and discussed at TAC79 at IITA, Ibadan. The conclusions were that:

- The impact assessment activities of SPIA are as relevant for the work of SCOER (TAC's Standing Committee on External Reviews) as that of SCOPAS;
- SPIA should be closely associated with both SCOPAS and SCOER so that work can be planned in such a way as to maximize the complementarities and avoid duplication of activity; thus,
- The chairs of SCOPAS and SCOER should become ex officio members of SPIA and the chair of SPIA should be an ex officio member of both SCOER and SCOPAS.

The need for objectivity, credibility, and transparency led to the original idea of assigning evaluation to a group of experts independent of the centres, the CGIAR Secretariat and TAC. The centres carry out the activities that result in impacts, the CGIAR Secretariat is directly involved in the allocation and management of resources of the System, and TAC is responsible for priority setting and overall resource allocation, policy advice, centre programme reviews and recommendations, and other planning activities. The original concern for credibility through independence is still a strong consideration. However, since the IAEG was originally established, it has become evident that there is need for closer association between the different assessment and evaluation activities in the System.

3. Ongoing SPIA Activities

The SPIA is involved in a number of complementary impact assessments related to the activities of the System in the context of its fundamental goals of poverty eradication, food security and environmental protection and enhancement. Substantial progress has been made in the studies addressing these contributions. The SPIA has seven ongoing activities (see figure 1).

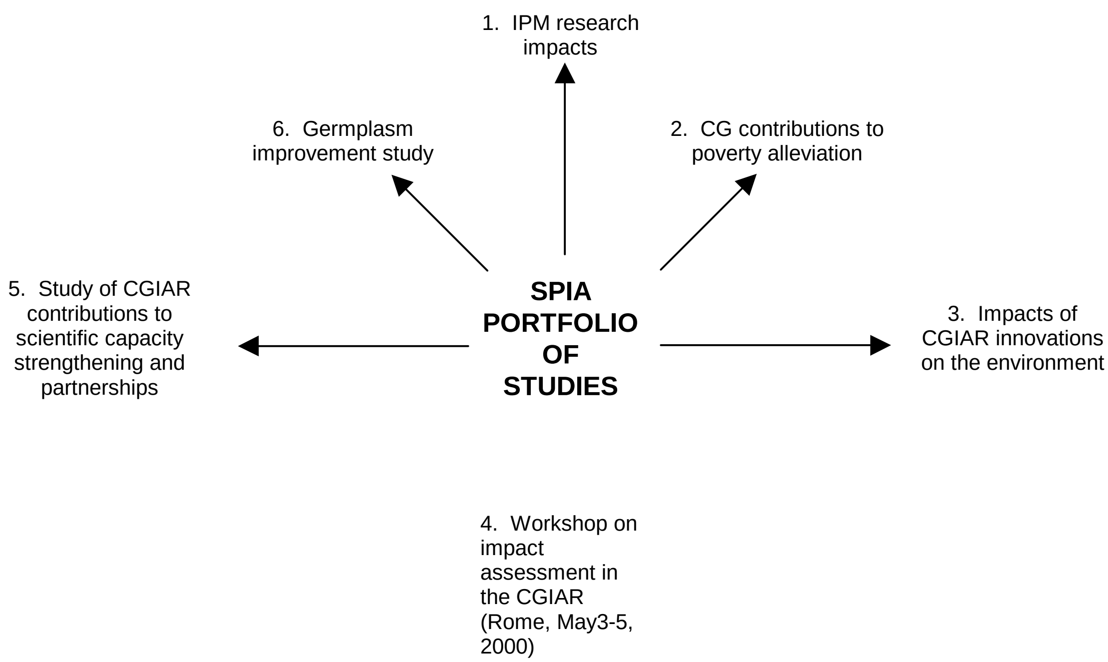

Fig. 1: SPIA Ongoing Assessments and Studies

The SPIA (then IAEG) reported in depth on a number of these activities at ICW99 and provided further progress at MTM00. Box 2 provides a summary of the results as reported in the ICW99 *Preliminary End of Meeting Report.* More detailed written reports were distributed at ICW99 and MTM00 and are available from the Secretariat.

Box 2: Excerpts from the Preliminary End of Meeting Report for ICW99

IAEG Studies on the Impact of CGIAR Research on Poverty Reduction, Germplasm Improvement, Environment, and Integrated Pest Management

The Group received a report on recent IAEG activities from Professor Hans Gregersen, the current Chairman. The IAEG was established to provide timely, objective, and credible information on the impacts of CGIAR outputs, and to support centres in their *ex post* impact assessment activities. The Group endorsed the IAEG's preliminary reports on the CGIAR's impact on poverty eradication, food security and environmental protection, and urged the IAEG to move quickly into the next phases of these studies.

1. Crop Germplasm

Under the direction of Professor Robert Evenson of Yale University, the IAEG is undertaking a study of crop germplasm impacts covering ten crops for which the international and national research systems have been engaged. The studies cover crops that constitute 80 percent of the area planted in developing countries. Professor Evenson presented the preliminary findings on investments in crop genetic improvement, varietal production, IARC content and indirect IARC impacts on varietal production, measuring production impacts of improved varieties, and economic effects.

Findings: Investment in Crop Genetic Improvement (CGI)
a) For the more developed country and crop programs, virtually all were strengthened in response to the establishment and strengthening of the international research programs.

b) For national programs with little capacity in the 1960s, the international programs effectively supplied much of the genetic material on which these programs were subsequently based.

Findings: Varietal Production
a) The continued high level of NARS and IARC production of improved varieties appears to be the result of improved access to genetic resources in NARS and the cumulation of traits and landrace content in more recently released varieties.

Findings: IARC Content and Indirect IARC Impacts on Varietal Production
a) The direct contribution of IARC programs is impressive. In the 1980s and 1990s, they were producing proportions of varieties that were well above their scientist and investment proportions. In a number of crops, IARC programs were continuing to contribute more than half of all improved released varieties into the 1990s.

Findings: Measuring Production Impacts of Improved Varieties
The proportion of area planted to improved varieties has grown steadily in all crops and in the 1990s, improved varieties are the dominant crops. Farmers have placed value on improved varieties because they have adopted them. Had the IARCs not been established (even while NARS were built to within 10 percent of their late-1990s levels), varietal production would have been 35 to 50 percent lower.

Findings: Economic Effects
Investments in IARC germplasm improvement have produced low food prices and massive gains to consumers, who are the largest beneficiaries of IARC programs. Poor consumers have benefited most of all. For the world's smallest farm producers, the total producer and consumer gains are large.

Box 2 continued: Excerpts from ICW99 End of Meeting Report

2. Poverty Reduction

Peter Hazell of IFPRI reported the preliminary results of IAEG’s study of poverty reduction. An extensive review and synthesis of the literature on the links between agricultural research and poverty has confirmed that agricultural research can have very favourable impacts on the poor, but that this is not an inevitable outcome and depends on sufficient enabling conditions. These conditions include an equitable distribution of land, secure ownership and tenancy rights, efficient inputs and output markets that serve all types of farmers, research and extension systems that are not biased towards large farms, and scale neutral technologies.

3. Impacts on the Environment

Details of the IAEG's study on the impact of CGIAR activities on the environment were provided by Dr. Mike Nelson of New Zealand. The preliminary analysis revealed that land saved from deforestation as a result of productivity research in seven key mandated food crops was in the range of 170 to 420 million hectares, with another 50 million hectares in reduced requirements for permanent pasture attributable to forage/livestock research.

4. Impacts of CGIAR Integrated Pest Management Activities

Professor Herman Waibel of Hannover University provided highlights of IAEG’s study on the impact of research on integrated pest management. He noted that research on IPM has been underway in all centres for a long period, and that the technological paradigm of IPM is dominant and there is also increasing appreciation given to treating IPM in a social science context. The future of IPM is heavily dependent on developments in biotechnology that will determine the nature of future partnerships. Finally, the study clearly shows that CGIAR’s investments have been profitable, and that even in the long term, the rate of return to investment in IPM research is in the magnitude of 15 to 40 percent.

4. Current Status and Future Plans for SPIA Assessments

Below are briefly outlined the current status and future plans for each of the following activities:

4.1 Assessment of Germplasm Improvement Impacts

The IAEG commissioned a study of the impact of CGIAR germplasm improvement, conducted by Professor Robert Evenson of Yale University in collaboration with the centres. Its provisional results were reported and discussed at ICW99 (Document No. ICW/99/08/b). Further results were presented at the February 2000 meeting of the American Association for the Advancement of Science (Washington, DC). Drawing upon a wealth of data the study's preliminary conclusions are, *inter alia*, that the direct contribution of IARC programmes to varietal production has been impressive, with annual varietal improvement total factor productivity gains ranging from 1 to 2 percent per year. Without the IARC investment in varietal improvement, it is estimated that for the period 1990-95 wheat production would have been reduced by roughly 50 percent and rice production 35 percent. In economic terms, counterfactual analyses suggest that wheat prices would have been 26 to 34 percent higher without the IARC investment, and food imports into developing countries would have been considerably higher. The gains to consumers from lower food prices disproportionately benefited the poor. Finally, the area planted to crops would have been significantly higher, creating more pressure on biodiversity habitats and on fragile land problems. A further progress report was presented at a Seminar during MTM 2000. The final report will be available in November 2000, and will subsequently be published in book form by CABI during 2001.

4.2 Assessment of the Impacts on Poverty Alleviation

At present, the CGIAR System does impact assessments that are focused almost entirely on showing the extent of adoption of new technologies and their impacts on farm productivity. What is now needed is an in-house capacity within CGIAR Centres and NARS (trained staff, methods, cultural acceptance, etc.) to undertake the more difficult task of assessing poverty impacts on a continuing basis. These assessments must (a) lead to better targeting of research priorities to the changing needs of the poor, and (b) demonstrate poverty impact and hence the relevance of CGIAR investments.

The primary objective of this impact assessment activity, which is being implemented by IFPRI on behalf of SPIA, is to initiate capacity for such poverty assessments. It is a first step in a continuing process of improvement and adaptation of poverty impact assessment and priority setting within the CGIAR System and its key NARS partners. The project will also provide assessment of some of the more recent post-green revolution work of the CGIAR Centres. The specific objectives of the project are:

1. To assess the impact on the poor of a representative set of recent and ongoing CGIAR research activities, including commodity improvement work, NRM, and policy research.

2. To identify and test best practice methods for quantitatively assessing the impact of CGIAR research on the poor.

3. To develop and test appropriate methods of social and institutional analysis to examine the context in which new technologies are released and adopted to better understand how agricultural research impacts on broader definitions of poverty and social outcomes (including empowerment, sustainable rural livelihoods, etc), and how research might be better targeted or integrated within the broader context of social development for sustainable rural livelihoods.

4. To strengthen the capacity of CGIAR Centres and NARS to undertake poverty impact assessments and to internalize poverty impact assessment culture for the future. Such capacity must be responsive to the changing needs of the poor over time.

The study is organized in two phases. Phase I was undertaken between November 1998 and August 1999. The main published output was a review and synthesis of the literature on the links between agricultural research and poverty undertaken by John Kerr and Shashi Kolavalli (consultants). It provides an update of the Lipton and Longhurst (1989) review undertaken for the 1985 CGIAR Impact study. The review by Kerr and Kolavalli has been published as an IFPRI/IAEG working paper. The review confirms that agricultural research can have very favorable impacts on the poor, but that this is not an inevitable outcome and depends on the presence of sufficient enabling conditions. For green revolution type technologies, these conditions include an equitable distribution of land, secure ownership and tenancy rights, efficient input and output markets that serve all types of farmers, research and extension systems that are not biased towards large farms, and scale neutral technologies. The review also highlights the shortcomings of many past impact assessment studies, particularly their failure to establish adequate counterfactual situations for comparative purposes, or to adequately control for many confounding factors that impacted on the outcomes.

Phase II consists of a series of case studies documenting the impact on poverty alleviation of a representative sample of CGIAR research activities carried out in a broad range of countries, thereby contributing to a better understanding of the CGIAR's impact on the poor at regional and global levels. The studies will address the different channels through which agricultural research can impact the poor, including intra-household effects, on-farm production effects, labour market effects, and indirect growth, non-farm and food price effects. The studies will also contribute to improved understanding of the conditioning economic and social factors that determine whether and how agricultural research benefits the poor, and will provide guidelines on appropriate policies that may be needed to complement technological change to enhance favourable impacts on the poor. It is anticipated that the research methodologies developed and tested in the course of Phase II will contribute to identifying best practice impact assessment methods for future use by the CGIAR and its NARS partners. The case studies will be conducted in two waves. The first is ongoing and will be completed in December 2002. A synthesis paper based on the first wave of case studies will be completed by August 2002 and presented at ICW2002. The second wave of will begin by the end of 2000 and be completed by June 2003, leading to a second synthesis paper by August 2003. This paper will be presented at ICW 2003. A final project report will be completed by December 2003.

IFPRI has produced a set of project briefs that report on the progress of this study. These will be circulated during ICW00.

4.3 Assessment of the Impacts of CGIAR Integrated Pest Management (IPM) Activities

The IAEG commissioned a study on the impact of research on integrated pest management (IPM) conducted by the CGIAR. Professor Hermann Waibel of Hannover University, a recognized international expert in the field of evaluation and impact assessment of IPM, conducted the study. A draft of his report (Document No. ICW/99/08/c) was presented and discussed at ICW99. The report clearly shows that the CGIAR's investments have been profitable, and that even in the long term, the rate of return to investment in IPM research is on the magnitude of 15 to 40 percent. Dr. Waibel stresses the need to assess the impact of IPM in the broader context of the overall crop management system. The report is currently in press.

4.4 Assessment of Impacts of the CGIAR on the Environment

Phase I of this assessment was completed for ICW99. Phase II is ongoing. A progress report on the work is presented as Appendix A. The same Panel that undertook Phase I is carrying out Phase II. As a result of the initial phase it became clear that quantitatively assessing the environmental impact (EI) of CGIAR would be complex and, to meet standards of analytical rigor, would probably be time-consuming and costly. Furthermore, results from ex post evaluation are subject to significant time lags. Accordingly it was decided to move forward on three fronts, to enable specification of options for evolving system-wide arrangements aimed at providing global and regional estimates of EI:

- empirical questions arising in refining global estimates of land savings (and associated environmental services) attributable to research on the System's key commodities, as the major positive environmental impact;

- empirical evidence of negative (and non-land saving positive) EIs associated with adoption of research results from germplasm and associated technology packages for the key commodities;

- conceptual issues in establishing an operational System-wide procedure to evaluate the extent to which the outcomes from application of CGIAR NRM research in rainfed agriculture, irrigation, forestry and fisheries are physically, economically or socially sustainable. This work will draw on a number of past activities of TAC and the Centres and will be linked closely to the work of the ad hoc CGIAR group on INRM, which is having a major meeting on NRM in August in Penang.

In Phase I, scenarios were developed for land savings which may be attributable to the CGIAR research on seven key commodities basically built around germplasm modification and management packages (including IPM) aimed at maximizing financial returns from the new varieties. In the second phase, the data base on six of these commodities (provided by the SPIA/TAC study on the productivity impacts from crop germplasm improvement) will be used in association with more disaggregated GIS data to develop a refined estimate of land saving scenarios including the geographic location of the likely savings. An effort will also be made to establish whether additional savings may have been attributed to research on post-harvest losses.

The literature on positive and negative environmental impacts associated with irrigated and rainfed agricultural development is being reviewed for evidence of those impacts which are applicable to the seven commodities addressed in Phase I. Particular attention is being given to issues of: monoculture; agricultural chemicals in soil, water and air affecting human health; damage to soil structure; the spread of plant disease; and reduced use of agro-chemicals due to IPM. Dr. Prahbu Pingali from CIMMYT is cooperating with Dr. Mywish Maredia in completing this work.

In order to explore in more depth the issues in evaluating sustainability performance of NRM, a case study was contracted to look at empirical evidence and evaluate options for obtaining such evidence in the case of hillside situations. The conclusions from this study highlight the complexities of undertaking such evaluations and confirm the Panel's original premise that the logical way to proceed is through case studies.

Results of Phase I and ideas for Phase II were discussed during the SPIA/TAC workshop on 3-5 May in Rome on "The Future of Assessment in CGIAR: Needs, Constraints and Options" (see item below). At that workshop the Panel experts received feedback from the centres on the Phase I report and progress in Phase II, particularly with respect to those aspects of EI which they see as relevant to the selection and design of research projects (especially in the area of monitoring and evaluation – M&E). Options for centre collaboration beyond the workshop were explored with the centre impact focal points, since the next phase of the work will require some direct centre input. It became clear at the workshop that centres feel that the SPIA panel should continue to focus on the environmental impacts of CGIAR germplasm improvement work primarily, and that the Panel should for the time being, and particularly until after the forthcoming CGIAR INRM meeting in Penang, not become involved in issues related to the impacts of NRM research.

Dr. Michael Nelson, Panel Chair, attended, on behalf of SPIA, the CGIAR Penang meeting (August 2000) on integrated natural resources management research. He presented an overview of SPIA's work and participated in the breakout group that worked on impact assessment. In addition, Dr. Nelson and the Chair of SPIA presented an assessment of the papers presented at Penang that dealt with impact assessment of NRM research.

4.5 Workshop on the Future of Impact Assessment in the CGIAR: Needs, Constraints and Options

TAC/SPIA sponsored and organized this workshop which took place on 3-5 May at FAO, Rome. The overall goal of the workshop was to start the process of formulating a set of realistic and operational guidelines for future impact assessments in the CGIAR based on experiences gained from previous CGIAR impact studies and expertise available in the broader evaluation community. Specifically, the workshop:

- identified the CGIAR's impact assessment needs and objectives;
- developed a common understanding of the state-of-the-art of theory, methodology, practice, utilisation, and diffusion of assessments in the CGIAR;
- identified what needs to be done to strengthen existing impact assessment capacity within the CGIAR;
- improved participant understanding of opportunities and constraints involved in linking *ex post* evaluations to forward looking strategic planning and priority setting;
- provided opportunity to discuss good practices in the field of impact assessment beyond traditional economic assessment of impacts of research on productivity enhancing technologies, e.g., impacts in the areas of environment and natural resources management, training, and other capacity strengthening activities; and
- initiated the process of developing principles and guidelines for future impact assessment work in the CGIAR, particularly in the context of linking IA to the use of logframes in CGIAR planning.

The workshop was structured into three sessions. The first discussed stakeholder perspectives on impact assessment needs and progress in the CGIAR based on overviews presented by the major stakeholders. The second focused on technical and analytical issues based on presentations by outside experts and discussion by a panel and from the floor. Specific issues and analytical opportunities were discussed related to ongoing impact assessment activities in the areas of capacity strengthening and environment. The third session attempted to integrate stakeholder perspectives with technical possibilities and options, and to reach conclusions and make recommendations on where future impact assessment and evaluation activities should be going in the CGIAR.

The workshop was attended by more than 60 participants and included representatives from all the CGIAR Centres; the Chair of the Oversight and Finance Committees; SPIA and TAC members, members of the CGIAR who have been supporting SPIA activities, representatives of the Co-sponsoring agencies; outside evaluation experts, and staff of the TAC, CGIAR and NARS Secretariats. Professional moderators facilitated the workshop. Documentation consisting of keynotes, overview papers, and centre presentations is available on the TAC website and will be published in a proceedings. Members wishing a hard copy of the proceedings can contact Dr. Guido Gryseels at the TAC Secretariat.

4.6 State-of-the-Art Paper on Impact Assessment

SPIA presented a paper on the "State of the Art" in agricultural research evaluation at an ASARECA/ECART/CTA workshop on impact assessment of agricultural research in eastern and central Africa, which was held in Entebbe, Uganda, from 15-19 November 1999. SPIA also helped to organise this workshop. The proceedings of this workshop have been published by CTA. Copies of the SPIA paper are available from Dr. Gryseels at the TAC Secretariat.

4.7 Study of CGIAR Contributions to Scientific Capacity Strengthening and Partnerships

There is widespread opinion among NARS representatives and CGIAR members that the CGIAR activities in training and capacity strengthening have provided significant contributions over the years to the growth and sustainability of national agricultural research systems. Thus, SPIA is commencing an assessment of the impacts of the CGIAR's impact on scientific capacity strengthening of NARS. This assessment will be conducted in close collaboration with the NARS Secretariat and the centres.

As an initial step, the SPIA developed and updated data on the accomplishments of the CGIAR in training activities since the 1984 TAC training study and subsequently attempt to measure the impact of those activities. The desk study provides an overview of current centre activities in the area of training and human resource development. It provides aggregate information on centre achievements with respect to number of trainees, type of courses, and so on. SPIA has now completed this "Synthesis Report on Training Activities at CGIAR Centres" (copies available from the TAC Secretariat on request). A SPIA consultant, Dr. S. Husain, undertook a review of methodology. Further, the theme, needs and potentials were discussed at the May workshop in Rome (see above). Based on these three items – the review of on-going training activities, the review of methodology, and the discussion at the workshop – SPIA decided to move ahead with the assessment in stages. The focus of future SPIA activity in this area will be on: (1) documenting and evaluating, to the extent possible, the changes in institutional capacities, motivation and research environments (achievements) that can be associated with CGIAR capacity strengthening activities; and then (2) assessing alternative scenarios of how those changes might be associated with impacts in terms of CGIAR goals.

A panel will be formed to work on the full assessment. In the meantime, SPIA will move ahead with phase I, starting with an expansion and completion of the inventory of centre programs and accomplishments and training budgets. Also, a questionnaire will be designed and pilot tested for use with trainees and with those administering the agencies to which the trainees return after training. The study will draw on centre expertise, particularly from those managing and carrying out the training activities of the centres. In fact, several training focused groups with the System already have provided substantial input to the assessment.

The study will be conducted in collaboration with TAC's Standing Committee on External Reviews, since that Committee also wanted to do a stripe review of training and more broadly capacity strengthening activities in the System and what they had accomplished. The NARS Secretariat also will make an input into the study.

5. The Evolution of SPIA within the TAC

TAC has recognized in the past that there are different stages of evaluation and assessment along a time continuum. Looking towards the past, we have *ex post evaluation of performance, achievements and impacts.* The resulting information is used in accounting for past use of resources and in planning the future. During the present stage along the continuum, there is *monitoring, evaluation and assessment* aimed at providing information to guide present activities and revision of ongoing plans. Looking towards the future, there is *ex ante assessment* of likely future environments and of expected impacts from planned and on-going research. The resulting information is used in planning future activity.

While we have a time continuum from past research outputs, through present research activities and on to expected future activities and output, the evaluation and assessment activities and their outputs fit into a broader dynamic evaluation cycle, in which the results of M&E continuously feed back into assessment and priority setting. Thus, all three points along the time continuum involve evaluation or assessment to provide information for *planning future priorities, strategies and activities*. Even in the case of ex post impact evaluations for accountability purposes, the resulting outputs mainly are used for future planning and resource allocation.

The question here is: where should SPIA and its activities fit within this overall evaluation and assessment cycle? What should be its structure and functions within the overall TAC framework? While it was fully expected that this question would be debated at TAC78, priority had to be given to TAC's input for the Vision and Strategy exercise. Thus, the TAC-SPIA integration issue was postponed to TAC79 in September this year.

The results of that lively discussion at TAC79 can be stated briefly: (1) TAC members want to have the opportunity to contribute to the review of SPIA studies. (2) If a TAC member has a particular interest and expertise in the area being assessed, then that member might become more actively involved; (3) In consultation with TAC, the TAC Chair decided, and SPIA accepted, that the chairs of SCOER and SCOPAS would become ex officio members of SPIA and the SPIA chair would become an ex officio member of the other two standing committee, in order to ensure closer linkages among the work of the three groups; (4) TAC reaffirmed that SPIA should continue to maintain its independence by having final say in terms of choice of topics for assessment, choice of panels and choice of reviewers of SPIA studies. (5) At the same time, TAC members would have an opportunity to suggest themes for reviews; and (6) TAC would be the first body to receive draft SPIA reports and would have the channels through which to make a commentary and suggest modifications prior to final publication.

APPENDIX A

ENVIRONMENTAL IMPACTS

OF THE CGIAR´S

PRODUCTIVITY ENHANCEMENT RESEARCH

Report prepared by Michael Nelson and Mywish Maredia with assistance from Prabhu Pingali (CIMMYT) and Jan Groenewold (TAC Secretariat), under guidance from Hans Gregersen (SPIA) and Guido Gryseels (TAC Secretariat)

ENVIRONMENTAL IMPACTS

OF PRODUCTIVITY ENHANCEMENT RESEARCH

Introduction

1. At ICW 1999 SPIA was instructed to pursue the question of environmental impacts associated with CGIAR research, initiated in the Phase I report.[1] This follow-up report :

   - reviews some of the conceptual underpinnings for assessing positive and negative environmental impacts associated with the Green Revolution (GR) technologies (primarily based on crop germplasm improvement - CGI) and the subsequent evolving research on natural resource management (NRM).
   - refines the range of land saving estimates for the seven key CGIAR-mandated commodities covered by the SPIA CGI study[2]; and
   - examines the evidence for attributing negative environmental impacts to productivity enhancement research in the above seven commodities.

I. Concepts Reviewed

2. Why should the CGIAR be concerned with measurement of environmental impacts attributable to the knowledge it generates through research? This knowledge is clearly an intermediate product which is modified or expanded by NARs, and transmitted to resource users by various extension activities of government or the private sector and adopted on the basis of farmers´ perceptions of risk and income potential conditioned by policy and public and private investment.. Thus, the impact on poverty, productivity and state of renewable natural resources (RNR), must be regarded as a "joint product". Nevertheless, at least in the area of GR technologies, the System has been seen as a prime engine of change – change that attracted worldwide attention for its massive contribution to food output and perceptions that this created ecological problems[3].

3. In view of this situation the CGIAR needs to estimate the system-wide negative environmental impacts which have been associated with its productivity enhancement research. At the same time, it is hypothesized that there have been significant positive environmental impacts attributable to this same research (land-savings and

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[1] CGIAR. 1999. "Environmental Impacts of the CGIAR : An Initial Assessment". Document No. ICW/99/08/d. Washington D.C.

[2] Evenson, R.E. 2000. "Crop Genetic Improvement and Agricultural Development." Yale University.

[3] For example see: Pingali, P. and M. Rosegrant (1998). "Intensive Food Systems in Asia : Can the Degradation Problems be Reversed?". Paper presented to AAEA meetings,. Salt Lake City, July 31-August 1; and, as an alternative view, see : Ashby, J. 2000. "Integrated Research on Food and the Environment : An Exit Strategy from the Rational Fool Syndrome in Agricultural Science." Paper presented at the workshop Integrated Natural Resource Management in the CGIAR : Approaches and Lessons Penang, Malayasia, August 21-25, pp 3-8

reduction in use of agricultural chemicals). Therefore, to complete the picture on environmental performance of the GR, some approximation of positive impacts appears warranted.

4. At the outset, in order to sharpen the issues, the position is taken that, because of the way CGIAR strategies have evolved through two stages over the past 30 years, two distinct approaches are required to address EIA research for each stage. The initial stage, associated with GR technologies to enhance productivity of key food commodities, gained widespread attention: first, for its remarkable success in averting famine; and second, for its perceived contribution to environmental damage. Recognition of the potential for negative environmental impacts accelerated evolution towards the second stage - post GR technologies, focusing more on long-term gains in productivity (including environmental services) associated with conserving or enhancing quality of the natural resource base. Thus, the first stage may be characterized as **productivity enhancement** with a single objective, but with progressive incorporation of soil and water management research, where sustainability was assumed. The second stage has been characterized as **NRM** where there are multiple objectives; sustainability is not assumed; it is an objective, along with poverty alleviation and productivity/efficiency in RNR use. Although these two stages merge into each other, their characteristics call for differing concepts and methodologies in EIA which are contrasted in this section. Crucial to this contrast is how one defines **environmental impacts vis à vis externalities,** and a related question is how one distinguishes between **environmental impacts** of GR technologies and **sustainability performance (impact)** of post GR technologies.

5. **Environmental Impacts vis a vis Externalities:** In Phase I of this study, which applied exclusively to productivity enhancement based on CGI, environmental impacts were defined as *unexpected impacts on human welfare associated with biophysical changes due to application of CGIAR research*. The following elements were considered in tracing the linkage between research and the environment:

- CGIAR research is planned and carried out with **development impacts** in mind. These are characterized as any impact on human welfare (living standard, health, equity) that was initially planned for and incorporated into the calculus of projected value to be derived from the research being considered.

- Environmental impacts may be positive or negative. On the positive side is avoidance of damage to renewable resources, in particular land-saving and other losses avoided or reduced e.g.Y decline as a result of research. Negative impacts relate to unintended side effects such as increased hardship due to increased competition for limited supplies of water, increased costs to protect the environment at a level that would have existed without the CGIAR-generated technology, or increased environmental losses due to use of CGIAR technologies (e.g., salinization and waterlogging or health problems due to irrigation and use of agro-chemicals).

- Development impacts are always explicitly included in research project calculations and directly or indirectly linked to **biophysical changes** – changes in erosion rates, soil fertility, nutritional content of crops, water quality and quantity, crop losses, vegetative cover.

- The planned biophysical changes are necessary conditions for achieving agricultural productivity goals. However, the new technologies may also generate unplanned biophysical changes on site and the planned changes themselves may result in chain reactions leading to additional unplanned changes in the biophysical environment downstream. When any of these unforeseen changes are associated with negative or positive consequences for long-run human welfare, they are termed **environmental impacts** e.g. flood damage, health risks sedimentation or potential loss of valuable biodiversity, and in this case were considered synonymous with **externalities.**

- For the purposes of this assessment these impacts occur when application of research results lead to: (a) expected biophysical changes that create **unexpected** impacts on people and their welfare; and (b) **unexpected** biophysical changes that have impacts on human welfare. It is these impacts on people that are interpreted as "environmental impacts" or externalities.

6. **Environmental Versus Sustainability Impàct - Implications for EIA:** In the case of productivity enhancement research, development impacts are measured in terms of change in physical units – yield, area, total field production, total consumption and materials balance (chemical or biological inputs and discharges). The basic assumption is that with estimates of these development impacts, one is in a position to speculate on geographically referenced change in the state of RNR attributable to such impacts. It is also assumed that most of the changes in state of RNR (e.g. erosion, contamination and land-saving) were not planned in research project or program design; therefore the concept of externalities becomes the basis for measuring positive and negative environmental impacts of research. This rests exclusively on ex post evaluation.

7. In contrast to productivity enhancement research, the operative point of entry for estimating environmental impacts of NRM research is **not** the externality concept. By definition, one would expect NRM research to be designed to **internalize** all aspects of change in state of RNR associated with productivity enhancement research as well as any other measures proposed which will modify the use rate. In fact, NRM research will not internalize **all** the attributable changes in the state or rate of RNR use. One might argue that with rigorous specification of baseline situations (and control), and ex post evaluation, it would be possible to detect unplanned chain reactions from adoption of research results through change in RNR state to positive or negative impacts on long-run social welfare.

8. Although such externalities from NRM may be important, e.g. downstream or climate change, it is likely that those associated with use of the results of NRM research will be positive, or, if negative, that they will be relatively insignificant. Given this, plus the long time lags between application and impact, and the high cost of developing credible time series data on the complex variables and dynamic interactions involved, there appears to be little justification for devoting significant resources to such externalities. This is particularly true considering the political and technical imperatives faced by the CGIAR.

9. Thus the operative basis for estimating “environmental impacts” of NRM is the concept of sustainability. This is an explicit objective of the research design and, therefore, at least in theory, should be subject to routine M&E to determine performance of the project or program. Again, in contrast to productivity enhancement research, estimation of environmental performance (sustainability impacts associated with application) of NRM research results will have to rest on **ex ante analysis.**

10. Methodological Issues: The options and constraints in assessing positive environmental impacts attributable to CGIAR research on the seven principal mandated commodities were discussed in the Phase I report. The approach rests on the hypothesis that research that has yielded higher total production and consumption of these key commodities has, on net balance, resulted in less area in production in the 1990s than would have been the case without these research results.

11. There are still a number of unanswered questions:

i. Has CGIAR research led, in fact, to **accelerating** forest clearing or conversion of range and pasture to more environmentally damaging uses that would offset the positive impacts?

ii. Has CGIAR research led to water savings in rainfed and irrigated agriculture or in forestry which have provided additional positive impacts in the form of productive and environmental services to other sectors?

iii. What might have been the practical geographic constraints on expanding land in production in absence of Y increases – i.e. would there simply have been less production from the area now in crops or would there have been major changes in trade patterns?

iv. What are the probabilities of obtaining credible range of counterfactual estimates of the structure and locus of 1990s production, consumption and trade, through linking a global GIS to a general equilibrium model that incorporates such aspects as total factor productivity, marginal costs of changing land use and cropping intensities, crop substitution, demand elasticities and transport costs?

v. Even with a credible estimate of land and water savings, or land cover that is less damaging to the state of RNR (the environment) than would otherwise have occurred, can the environmental **impacts** be approximated in any meaningful way, i.e. change in long-run social well being?

12. The basic hypothesis in Phase I was that there have been significant land-saving benefits (positive environmental impacts attributable to productivity enhancement research). Sorting out the type of questions listed above should contribute to ex ante specification of appropriate research objectives with respect to land and water savings and design of M&E. However, given the nature of these questions and the likelihood that adequate GIS data does not exist for reasonable scaling up from the scenarios, a question is how much further effort should go into ex post evaluation with the expectation that land saving would become a specified objective of productivity enhancement research, and therefore subject to M&E?

13. Aside from change in land use, the one remaining question on potential positive environmental impacts of productivity enhancement research is: has this research led to an improved state of RNR with beneficial consequences for long-run social welfare? Again, this would be addressed in terms of externalities. If the research on germplasm and related soil/water management packages were designed to reduce chemical contamination and erosion, improve soil fertility or stabilize water flows, these would be considered development impacts subject to standard M&E. Clearly the latter area merges into NRM research.

14. Environmental degradation as a result of research leading to intensification in use of land, water, forests and fisheries has been the topic of much rhetoric and speculation. It has also been the subject of numerous case studies. Given the constraints in estimating impacts on people (para 11[v]), the initial question to be addressed is:
    - How much may CGIAR productivity enhancement research have contributed to deterioration of the state of RNR?
      The operative concept is counterfactual:
    - How much of the documented deterioration would **not** have occurred if these research results had not been available?

II Positive Environmental Impacts

15. The only positive environmental impacts associated with CGIAR research addressed by SPIA in this phase are potential land savings linked to increase in yields in the seven principal CGIAR mandated commodities.[4] The Phase I report also discussed issues of land and water savings due to research in reduction of losses beyond farmers´ fields and water use. However, it was decided not to pursue these two sources of impact due to the site-specific nature of water resources (watershed, river basin), which complicates aggregation to global estimates, and the lack of information on cause-effects relationships of post-harvest losses. From the review at ICW 1999 SPIA was instructed to examine in more detail both the extent of land

[4] Evenson, R.E. op.cit.

savings which might be attributed to agricultural research, and the type of land which might have been saved.

Land Savings

16. The base set of potential land savings linked to CGI research over the 30-year period 1960s/1990s assumes: (i) the distribution of production between less developed countries (LDC) and more developed countries (MDC) would have remained unchanged (see Tables 1 and 2); and (ii) the 1990s production would have been achieved with yields at the 1960, 1970 and 1980 levels respectively. The incremental land requirements (harvested area adjusted for cropping intensity)[5] would have been as follows:

Assumed Yield Level	Incremental Area (million ha)		
	LDCs	MDCs	World
1960s Y	600	80	680
1970s Y	340	50	390
1980s Y	100	0	100

17. Scenarios of land savings were developed from this set of estimates based on assumptions with respect to:

- The original state of lands which would be converted to agriculture – forest, natural grass and woodlands, and semi-arid and arid areas (developed for irrigation).

- The geographic location of the expanded area in production that would have been required. It was assumed all LDCs would be engaged in tropical agriculture and MDCs in temperate crops (five of the seven crops were grown in both).

- Cropping intensity – average for LDCs (1988/90) was 70% for rainfed and 100% for irrigated agriculture.

- Differential yields between tropical and temperate zones for the five crops grown in both; average yields in OECD countries were 70% higher than in LDCs.

[5] Cropping intensity for rainfed agriculture estimated at 70% in LDCs and 100% in MDCs.

18. The four scenarios discussed in the Phase I report cover a 20-year period 1970s/1990s where land savings in LDCs ranged from 170 to 460 million ha. (the low scenario called for an additional 120 million ha increase in area in MDCs in the five crops common to both areas). Extending the estimates to a thirty-year time frame raises the upper limit to 600 million ha (see para 16).

19. These estimates are clearly simplistic and are subject to a series of qualifications discussed in the Phase I report (pp. 30-31) suggesting both under- and over-estimation, since:

    - in absence of research by the CGIAR and its national partners, yields are likely to have increased;

    - in the event of yield stagnation in LDCs the 1990s production level would have been significantly less. Bringing new land into production would have involved increasing marginal costs; food prices would have been higher and total consumption lower.

20. Because of these factors, the calculated land savings were reduced by 50% to approximate more credible LDC estimates, i.e. 300 million ha over 30 years (world estimate 340 million ha). These approximations still lack the rigor of applying an equilibrium model to agro-ecological zones at country and regional levels to generate global counterfactual estimates which would handle substitution across all commodities, trade adjustments, demand elasticities, etc. (see para 11[iv]).

21. One approximation of the counterfactual situation is provided by applying a coefficient of substitution between yield and area of 1: 0.5.[6] Over the 30 years, area in these seven crops in LDCs increased from 400 to 505 million ha (+ 105 million ha); in MDCs area decreased from 240 to 210 million ha (- 30 million ha); and net worldwide increase was + 75 million ha. These changes occurred together with an approximate doubling of average yields (see Table 1). With no change in yield, application of the above coefficient suggests land in production in LDCs in the 1990s would have been 160 million ha higher than observed, and worldwide 230 million ha higher (see Table 3). These estimates are respectively 45% and 30% lower than the respective estimates for LDCs and world figures proposed in para 20. They are considered to be at the conservative end of the range of likely savings.

22. It should be stressed that all the above estimates of land savings are based on the assumption that they are the result of yield increases which derive from research carried out in the private (corporate and non-governmental), public and international domains worldwide. However, Evenson[7] provides the basis for a counterfactual estimate of the land savings directly attributable to CGIAR crop germplasm research since the 1960s – 26 million ha in LDCs and 36 million ha worldwide (see Table 4).

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6 This coefficient is derived from regression of FAO data on change in yields and crop area between 1961 and 1996 for 90 countries (information provided by R.E.Evenson).

7 Evenson, op. cit., p.33.

Thus, this branch of the System´s research can be said to have contributed 10-15% of total land savings attributable to all research on the seven commodities.

23. The question of land savings has been addressed only with respect to the seven primary CGIAR-mandated crops. The CGIAR itself deals with 29 commodities. The Phase I report also speculated on potential land savings that may be attributed to research on livestock and forage that has increased carcass weights and milk production per head. If those increases had not been achieved, the speculation was that an additional 50 million ha of permanent pasture would have been required in the 1990s, perhaps from deforestation or conversion of savanna. Other potential environmental damage avoided would have been increased grazing pressure on marginal hillsides and semi-arid savannas and woodlands, and encroachment by domesticated animals onto wildlife reserves and lands formerly considered too marginal to warrant exploitation.

24. One study has attempted to come to grips with the question of overall land savings attributable to improved production technology in all commodities.[8] The agricultural area (crops plus permanent pasture) was taken as 4.43 billion ha in 1961, increasing to 4.81 billion by 1993. Without technological advancement, the latter area would have to have increased at least by 3.5 billion ha more than the 0.38 billion ha actually converted. Land savings amounted to 0.97 billion in crops and 2.58 billion ha in pasture (see Table 5). The counterfactual situation for these estimates is based on the assumptions that : (i) cropland would have expanded over the 30-year period in proportion to observed population growth; (ii) the per capita consumption of all commodities would remain unchanged over this period; and (iii) agricultural lands would have been, on average, as productive as pre-1961 lands.

25. The seven commodities addressed in the Phase I report account for 50% of the crop area covered by the global study. Using this relationship, the estimate of land savings from research on the seven would amount to 485 million ha, which is 50-100% higher than the range estimated in Phase I. The difference derives from the more conservative assumptions on the counterfactual situation in the latter figures. The figure established as the maximum limit of incremental land required for the seven crops in the 1990s is 680 million ha (para 16). Goklany´s assumptions on the counterfactual situation reduce this to 485 million ha, and on basis of Phase I assumptions, it is reduced to a range of 230-340 million ha (paras 20-21).

26. Regardless of the precise area which would have been developed in absence of new agricultural technology, the environmental impact (as defined in Section I) will hinge on **where** this land would have been developed and with what consequences for long-run human wellbeing. In order to clarify this question a review was made of the change in land use and intensification, judged by fertilizer use over the period 1960s to1990s in five countries[9] which account for approximately 50% of the agricultural

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[8] Goklany, Indur M. 1999 "Meeting global food needs : The environmental trade-offs between increasing land conversion and land productivity." Technology 6: 107-130

[9] Brazil, China, India, Inonesia, Nigeria.

output from LDCs (see Annex A). Taken separately, these countries illustrate a broad range of scenarios of change in land use 1960/1990 and from what source the 1990s consumption might have to have been supplied in absence of yield increase.

27. A number of inferences may be drawn from these five cases:

- Deforestation within country: In countries with extensive tropical forests (Indonesia, Brazil) the additional area of forest cleared for these seven crops could have been as little as 20 million ha. Deforestation would have been a significant factor in countries with limited remaining forested lands (Nigeria, India and China), and therefore with much greater risk of biodiversity loss.

- Deforestation or intensification ex country: The issue here hinges on imports required to meet 1990s domestic consumption levels in the event that only half the increase in Y from 1960s to 1990s had been realized. In order to make up the shortfall in India and China, as land was simply not available for expansion, an additional 70 million ha would have to have been converted to these crops for export. To meet the 1990s import levels in Brazil and Indonesia would have required a further 30 million ha in production at 1960 Ys. Most of these exports would have been in wheat and barley. Thus, a reasonable scenario is that: 60 million ha in temperate zones may have been converted from forest, pasture or fallow and 40 million ha deforested in tropical zones to meet the export demand.

- The role of irrigation: In spite of the massive expansion in irrigated area in these countries over the period – 47 million ha (95% in India and China) and the assumption that Ys on these areas would be 150% of rainfed crops, the land saving which may be attributed to this technology would only have been 25 million ha, i.e. without irrigation, land savings estimates for the five countries would increase from 110 million ha to 135 million ha.

- The use of fertilizers in the five countries increased at 9% annually (8% for all LDCs) over the 30-year period – three times the world average. In addition, LDC share of world fertilizer consumption increased from 16% to 60%. Since the HYVs were targeted towards LDC food production, one might infer that a significant part of the differential growth in fertilizer consumption is attributable to adoption of this technology. Undoubtedly the introduction of these fertilizer-responsive and fertilizer-efficient varieties did have a significant impact on use.. However, there are several other factors that probably had equally significant impacts on use, such as domestic manufacture, prices, subsidies or irrigation.

III Negative Environmental Impacts

28. There is a large body of literature that focuses on the negative externalities and environmental impacts associated with HYVs, the Green Revolution, and the practice of monoculture that resulted from the mainstream agricultural research. Increased soil

erosion, water-logging, salinization of soils, contamination of surface and groundwater, loss of biodiversity, evolution of new pests, and other forms of natural resources degradation in recent decades have been attributed to more intensive use of fertilizers, pesticides, irrigation, HYV crops, mechanical technology, and excessive animal stocking rates on pasture lands.

29. To provide a more balanced view of the environmental impacts which have resulted from intensification and productivity-enhancing technologies, the Panel undertook a review of the literature with the aim of:

- Documenting the evidence found in the literature linking the input components of intensification with changes in the RNR use and externalities generated on the environment;
- Identifying the conditioning factors that contribute towards the negative environmental consequences of intensification; and
- Providing a preliminary analysis of problems and possibilities of assessing negative environmental impacts of agricultural research, particularly with respect to the extent to which degradation of the agricultural resource base over the past three decades might be associated with CGI research.

The Link between Productivity-enhancing Research and Externalities: Evidence from the Literature

30. Figure 1 summarizes the linkages between different components of the productivity-enhancing technology (namely, monoculture, increased use of fertilizers, pesticides and irrigation) and the RNR consequences and externality effects as evidenced from the literature review. As the illustration shows, tracing the link between research and environmental impacts is a complex process involving many different variables and factors. Some of the links in the "impacts" chain are well established in the literature (as denoted by the dark arrow lines). For example, the negative externalities on human health of increased use of pesticides are well documented; albeit for selected crops and regions. Other linkages (denoted by softer lines and arrows) in the "impacts" chain are discussed and debated in the literature, but not well established empirically. Thus the link between research that led to the development of HYVs and the loss of genetic diversity is a weak one.

31. As illustrated in Figure 1, changes in farming practices, such as multi-cropping, monoculture, increased use of irrigation, fertilizers and pesticides are influenced not only by research but also by "other factors", especially policies and actions of governments. Several studies establish a strong link between policies (e.g., subsidy) and increased or overuse of some of these inputs (e.g., pesticides and water) and the subsequent consequences on RNR and externality impacts. However, there is no strong evidence that links research (directly) to the negative externalities identified in the illustration. Tracing the link from observed externality effects (positive or negative) back to research (so as to attribute the effects to research) is an unexplored area of research, mostly because of the complexity involved and the difficulty in isolating the contribution of research from other factors.

Estimates of Negative Externality Impacts and Environmental Consequences of Productivity-enhancing Technology: Available Evidence and Preliminary Assessment

32. Table 7 summarizes the overall status of evidence available in the literature on the various negative externalities linked with monoculture, and the increased use of irrigation, fertilizers and pesticides. With the exception of salinity problems associated with irrigation, the changes in water table levels, and the health impacts of pesticides, the evidence on the extent of the negative externality problems is not well documented. For example, evidence of water, air and soil degradation linked with increased input use in agriculture is too scattered and site-specific to enable generalizations about the global extent of these problems.

33. Estimates of overall environmental/economic costs associated with negative externalities of productivity-enhancing research (listed in the last column in Table 7) are not found in the literature. There is however increasing evidence of environmental impacts of crop monoculture and intensification in the form of declining partial and total factor productivity. Many studies report evidence of declining rates of growth in crop yields in intensively cultivated regions of South and Southeast Asia. Attempts have also been made to get approximate figures for the costs of certain classes of intensification inputs; albeit for industrialized countries, especially for USA. These are usually based on assigning monetary values to losses of crop yield or human illnesses or death.

34. Any attempt to put an overall economic or environmental cost value on the consequences of the externalities identified in the literature will necessarily be crude. However, in order to give an idea of the magnitude of the externality problems that impact the land-use variable, panel members did some "back of the envelope" calculations of the total productivity losses due to the soil salinity problems on irrigated areas in developing countries (see Table 6). The loss was equivalent to 45 million ha in efficient irrigation. In other words, the cropping area required to produce the same amount of output as produced on the existing irrigated land (with salinity problems or abandoned) would be 45 million ha less than the cropping area in the late 1990s.

35. Such negative externality effects need to be deducted from the positive externality effects on "land savings" discussed in Section II. However, in both cases the question arises: how much of the observed consequences can be attributed to research? What would have been the trend in the salinity problem without agricultural research? The answer hinges on the methodological and conceptual issues of impact assessment, namely the problem of attribution and determining the counterfactual. The emerging conclusions from the literature review indicate the difficulty and complexity of solving these problems. One thing is clear – loss of productivity equivalent to 45 million ha, cannot exclusively be blamed on the research in HYV of irrigable crops such as rice and wheat.

Myths and Realities in Environmental Degradation from Productivity-enhancing Technology: Emerging Conclusions

36. Several conclusions are drawn from the review of the literature related to the negative externalities associated with monoculture and the increased intensity of "external" input use—irrigated water, fertilizers, and pesticides. These are summarized below.

- The literature is replete with anecdotes and case examples of how the HYVs negatively impacted the environment and social structure and, as a result, impaired long-run human well-being. However, **there is too much "noise" based on ideology and very little scientific inquiry in support of some of the claims of negative externalities**.
- The literature also contains counter-arguments that the concerns about the negative externalities of intensification and agricultural research are valid but somewhat misplaced. Several studies cite examples that show that the role of HYVs in generating the negative environmental impacts is greatly overstated and point out some of the breakthroughs and outputs of modern scientific research that not only mitigate the problems but also ameliorate the environment.
- Many of the problems cited in the literature, such as the loss of genetic diversity and effects on air, water and soil pollution as a result of monoculture and/or intensive use of chemical inputs are either not substantiated by data or the evidence is too scattered to enable any generalizable conclusions about their validity, at least in the context of developing country agriculture.

37. **In cases where the scientific evidence strongly linking a technology component with negative externality does exist (for e.g., soil salinity) it is difficult to trace the link (and blame) to mainstream research.** There are two main reasons for this:

- Firstly, **factors other than agricultural technology** (other technological changes and perverse policies or institutional arrangements) **have played an important role in creating these problems.** For example, poor irrigation system design and management are primary factors leading to salinity problems. The pesticide problem is partly a consequence of input "misuse" or "overuse". This has occurred for several reasons, including the subsidized or almost free availability of some inputs (e.g., water, electricity) and changes in consumer demand for cosmetic quality which induces farmers to use more pesticides. There are also institutional causes of negative environmental consequences. An example is soil degradation as a result of decline in soil fertility, triggered by the lack of property rights. In situations where these rights do not exist, management lags behind resulting in the mining of nutrients, erosion and soil degradation.

- Secondly, **many of the environmental problems** observed today **have nothing to do with new technologies** that resulted from agricultural research (such as the GR technologies developed in the 1960s and 1970s). The underlying causes of agricultural intensification are usually multi-faceted. Problems associated with intensive use of irrigation would have occurred without the use of modern varieties or other inputs. For example where the traditional Basmati rice variety is grown in India and Pakistan has one of the world´s worst salinity problems. Similarly, some contend that the practice of monoculture would have gained popularity even in the absence of the GR. Thus, it is difficult to show that in the counterfactual situation of "without research" the world would be free of many of the negative externalities that exist today.

38. **The evidence of negative externalities of intensive input use in developing countries is limited to GR crops—wheat and rice,** and to a limited extent to maize. There are many other CGIAR mandated crops (e.g., potatoes, beans, roots and tubers) that are important in developing countries (and for which improved technologies have been developed and adopted by farmers) but for these crops little evidence has been presented on negative externalities. This either reflects the fact that negative externalities associated with input intensification are limited to wheat and rice or that there is a need for more studies documenting the externality impacts in other crops in developing countries. Because of the bias in the documentation of externality problems towards wheat and rice, it is difficult to separate the negative impacts associated with the GR, which was a product of the mainstream agricultural research (spearheaded by the CGIAR) from the impacts of agricultural intensification, which is caused by factors other than research. The confusion between these two phenomena (GR and intensification) has led to misconceptions linking environmental degradation with agricultural research.

39. **Problems and possibilities for environmental impact assessment of productivity enhancing research.** There is no strong evidence that directly links research to the negative externalities identified in Figure 1 and listed in Table 7. Tracing the link from observed externality effects (positive or negative) back to research is an unexplored area, mostly because of the complexities involved and the difficulty in isolating the contribution of research from other factors. However, it seems likely that mainstream research has increased the intensive use of inputs. A possible option for ex post assessment of environmental impacts is therefore to construct a "without" technology scenario based on input use observations lagged by "n" number of years, where "n" is to be determined based on a careful examination of technical and policy factors for a given input on a case by case basis. Such estimates can best be derived using a general equilibrium framework and modeling input use as functions of different technical, economic and policy variables.

40. **Whether the cause is technological change, government policy, or institutional framework, the pressures for greater input use to increase productivity have certainly increased the hazards to the environment.** Even though it is difficult to establish a link between the negative externalities and agricultural research, the evidence found in the literature provide a powerful message that agricultural research needs to be sensitive to the results of new technology, and that EIA should be incorporated in overall research impact evaluation to provide a more balanced view of the environmental costs and benefits.

41. **In review,** without doubt **some** of the GR technologies set in train **some** of the negative environmental impacts which are manifest today – but a credible estimate of the percentage would be extremely difficult to calculate. At the same time, recognition of the actual or potential RNR degradation and its consequences for human well-being have triggered a number of remedial responses. Over-application of pesticides and fungicides led to CGI research to develop pest-resistent varieties and integrated pest management. Although fertilizer use increased because of the advent of HYVs, the varieties became more efficient in the uptake of nutrients, thus reducing fertilizer input per unit of output. HYVs favored expansion of irrigation, sometimes onto unsuitable areas, or onto areas requiring a standard of water management that was not available. The attribution of environmental damage to HYVs in such cases is clearly questionable. Nevertheless, these consequences generated a response in the form of additional research on water management (creation of IIMI) and development of varieties which were resistent to salinity and more efficient in use of water. The charge that HYVs have reduced biodiversity is difficult to sustain. The countless crosses that have been made by NARs and the private sector could be said to have increased genetic diversity. As argued in Section II, increased production reduced the loss of biodiversity on forest lands which otherwise would have been cleared for agriculture. In addition, the System (and others) have responded by setting up genebanks.

IV Conclusions

42. Positive Environmental Impacts from CGI Research: Using the simple assumption that without research yield of the seven key CGIAR-mandated commodities would have remained unchanged over the 30-year period 1960s/90s, the 1990s level of production would have required an additional 600 million ha in agriculture in LDCs (680 million ha worldwide). Scenarios of how the 1990s shortfall might have been met suggest land savings in LDCs in the range of 220 to 600 million ha, depending on assumptions on trade and production in MDCs. Taking into account a potential counterfactual situation where yield would have increased without research and 1990s consumption levels would not have been attained, these estimates were halved i.e. 300 million ha as the limit of land saved in LDCs, and 340 million ha worldwide. Applying a coefficient of substitution between yield and land of 1 : 0.5[10] results in an estimated land saving of 160 million ha in LDCs and 230 million ha world wide. A study of worldwide land savings from research in all commodities over the same period places this at 970 million ha in crops and 2,580 million ha in pasture.[11] Of the area savings in crops, approximately 50% would have been accounted for by the seven key CGIAR-mandated commodities, i.e. 485 million ha world wide. The difference between this estimate and the 230-340 million ha range suggested in this study is explained by the assumptions with respect to the

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[10] Evenson op.cit.
[11] Goklany op.cit.

counterfactual situation. One might propose a general equilibrium approach to sharpen the estimates. However, the geographically-referenced data on land use and state of RNR, plus the national, regional and global economic relationships required for such a model, appear to constitute serious constraints to an exercise of this nature.

43. Regardless of the precise figure, it is concluded that significant land savings may be attributed to yield-increasing research over the 30-year period. Due to the nature of the System´s research and its relationships with NARs, the private sector and advanced research centers in MDCs, it is impossible to disaggregate savings according to source of research. At this point it is suggested the case be rested – the CGIAR has been a major player on the world research scene, particularly in the seven key mandated crops, and it can take due credit for significant positive environmental impacts deriving from overall land savings which could have exceeded 200 million ha. There seems little point in seeking to refine the precise figure and establish a percentage which might be attributed to the CGIAR.

44. **Negative Environmental Impacts:** A broad range of negative environmental impacts associated with intensification of agriculture since the 1960s has been widely documented, although not aggregated at a regional or global scale. For many critics, the CGIAR´s CGI research has been seen to be at the heart of this intensification and therefore is to blame for the environmental consequences – pollution, salinization, erosion, loss of biodiversity (monoculture), etc. The record shows that the process of agricultural intensification and the factors which have oriented it are complex, particularly with regard to the role of policy in areas such as resource entitlements, prices, taxes, subsidies, trade and public expenditures affecting the quality and quantity of physical and human capital in rural areas.

45. In the case of rice and wheat, environmental problems associated with HYVs have been identified e.g. pesticides (rice) and fertilizer/irrigation problems (wheat). There is little evidence of environmental damage attributable to other CGIAR mandated commodities. If one looks at plausible scenarios of the counterfactual situation (without CGI research), much of the environmental damage would have occurred anyway due to the policies discussed above.

46. It is concluded that in certain areas the introduction of HYVs did have unintended impacts on RNR, in part due to policy distortion and in part due to unforeseen chain reactions in the ecosystems. Credible global estimates of this damage would be extremely difficult to approximate. And this damage only constitutes a small fraction of the environmental degradation that is said to be the result of agricultural intensification over the past three decades. The System has responded to evidence of RNR degradation, attributable both to the CGI research and other sources. CGI itself was modified and research was progressively moved towards broader questions of NRM. As in the case of positive environmental impacts, there appears little point in attempting to assess what part of the environmental degradation in agricultural areas might have been attributable to CGI research since the 1970s. This interpretation of "environmental change" here refers **only** to change in the state of RNR, **not** to the

consequences of this change for long-term social wellbeing (see interpretation of environmental impact in Section I). If the CGIAR wishes to venture further into this area it will be fraught with data requirements to support a general equilibrium or simulation modeling of counterfactual situations. It is concluded that the review of the rhetoric, myths and realities of the GR´s negative impact on the environment (Section III) is sufficient to lay to rest the debate.[12]

[12] This topic is the subject of a forthcoming SPIA publication by M.Maredia and P.Pingali.

Table 1

Change in Area 1960s to 1990s

For Seven Principle CGIAR Mandated Crops
(million ha)

Crop	**Developing Countries**			**World**		
	1960s (1)	1990s (2)	Change (3)	1960s (4)	1990s (5)	Change (6)
Barley	18.8	22.2	3.4	60.5	66.8	6.3
Cassava	10.8	16.8	6.0	10.8	16.8	6.0
Maize	72.0	96.9	24.9	110.1	139.9	29.8
Pulses	53.5	59.8	6.3	66.4	69.2	2.8
Rice	124.8	148.7	23.9	126.2	150.6	24.4
Sorghum	42.6	39.9	-2.7	48.5	44.8	-3.7
Wheat	79.7	120.4	41.7	217.5	226.5	9.0
Total	**401.2**	**504.7**	**103.5**	**640.0**	**714.6**	**74.6**

Source: Phase I report, Annex 2 (without adjustment for cropping intensity)

Table 2

Estimated Incremental Area of

Seven Principle CGIAR Mandated Crops

Between 1960s and 1990s, Assuming 1990s Output Produced at

1960s Yields
(million ha)

Crop	**Incremental Area (30 year period)**	
	Developing Countries (1)	**World (2)**
Barley	7.0	25.4
Cassava	6.1	4.1
Maize	98.2	109.8
Pulses	9.5	17.6
Rice	120.1	120.3
Sorghum	12.7	13.9
Wheat	168.4	212.1
Total	**422.0**	**503.1**

Source: **Phase I report, Annex 1**

Table 3

Counterfactual Estimates of Incremental Change in Area of Seven Principal CGIAR Mandated Crops (1960s – 1990s) Assuming No Change in Yields Over the Period*

Crop	Developing Country Changes (30 years)		World Changes (30 years)	
	Yield (%) (1)	Area (million ha)** (2)	Yield (%) (3)	Area (million ha)*** (4)
Barley	52	4.9	37	11.2
Cassava	23	1.3	24	1.3
Maize	104	37.4	79	43.5
Pulses	14	0.4	25	0.8
Rice	82	51.2	80	60.2
Sorghum	44	9.3	30	6.7
Wheat	138	54.3	94	106.5
Total		**158.8**		**230.2**

* Based on a coefficient of substitution between yield and area of 1 : 0-5 (Source Evenson estimate)

** Col. 1 of Table 1 x (0.5 x Col.1 Table 3)

*** Col. 4 of Table 1 (0.5 x Col.3 Table 3)

Table 4

Counterfactual Estimates of Incremental Change in Area

Of Seven Principal CGIAR Mandated Crops (1960s – 1990s) in Absence of

Germplasm Research

Crop	**Actual 1990s Area (million ha)**		**Counterfactual Multiplier (%)***	**Incremental Area in Production in 1990s (million ha)**	
	Developing Countries (1)	**World (2)**	**(3)**	**Developing Countries (4)**	**World (5)**
Barley	22.2	66.8	0.05	1.11	3.34
Cassava	16.8	16.8	0.07	1.18	1.18
Maize	96.9	139.9	0.03	2.91	4.20
Pulses	59.8	69.2	0.07	4.20	4.84
Rice	148.7	150.6	0.06	8.90	9.04
Sorghum	39.9	44.8	0.05	2.00	2.24
Wheat	120.4	226.5	0.05	6.05	11.33
Total	**504.7**	**714.6**		**26.4**	**35.8**

* Adjusted by 20% from Table 9 of Evenson report to cover 30 years rather than 25 years.

Table 5

Global Estimate of Land Savings

1960 – 1990

Years and Area Change	Area (billion ha)		
	Crops	Permanent Pasture	Total
1961	1.34	3.09	4.43
1993	1.45	3.36	4.81
Actual Increase 61/93	0.11	0.27	0.38
Area Saved 61/93	0.97	2.58	3.55

Source: Goklany op. cit

Table 6. Estimates of negative environmental consequences and land-use implications of soil salinity problems in developing countries

POTENTIAL AREA IMPACTED BY EXTERNALITY	
A Total irrigated area –1998 (1000 ha) [a]	**205,000**
B Estimated area with salinity problem (1000 ha) [b]	
Severe salinity	**20,500**
Some salinity	**53,300**
NEGATIVE ENVIRONMENTAL CONSEQUENCES	
C Land abandoned due to salinity (1000 ha)	
Estimates available for India and Mexico	**10-15% of irrigated land**
All LDC region (extrapolation assuming 12% of irrig. land)	**24,600**
D Decrease in yields due to salinity [c]	
Severe salinity	**50%**
Some salinity	**20%**
LAND USE IMPLICATIONS [d]	
E Area needed to produce the same amount of Production without salinity problem (1000 ha)	
Severe salinity (50% less than existing area)	**10,250**
Some salinity (20% less than existing area)	**42,640**
F Area that could have been saved if no salinity problem existed (1000 ha) (difference between problem area and the area needed to produce the same amount of output)	
Severe salinity	**10,250**
Some salinity	**10,660**
Total land savings avoided due to salinity (late 1990s) (1000 ha) [e]	45,510

a. FAO Online database

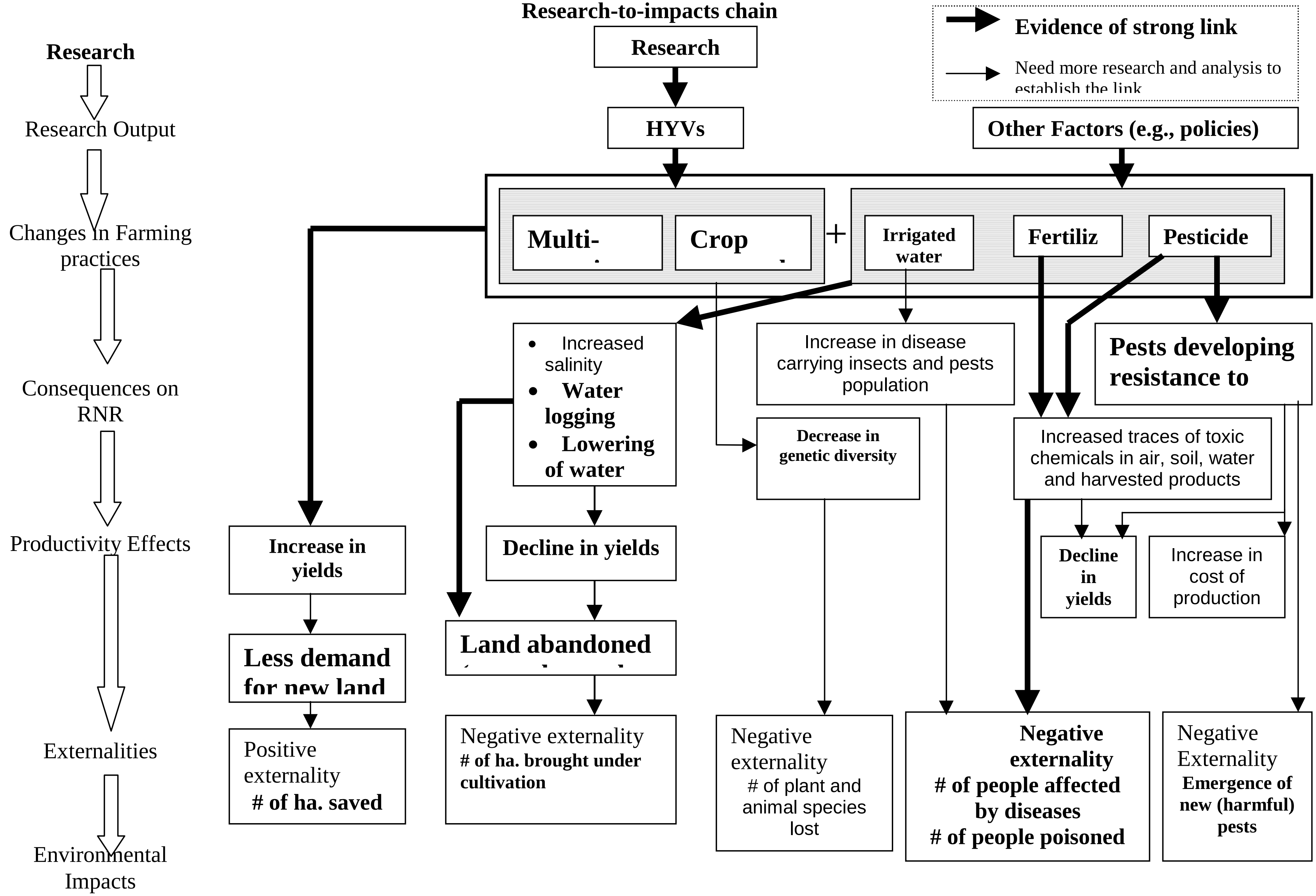
b. Calculated as follow: The 1990 FAO report cited in Umali (1993) estimates “10% of all irrigated land suffer from severe salinity and additional 60-80

million hectares (*about 26%)* are affected to some extent". The area with "severe" and "some" salinity problems in developing countries are based on these percentages.

a. **A study by Joshi and Jha (1990) (cited in Umali 1993) found yields on wheat and paddy were 41-56 percent lower on the salinity degraded soils. 50% yield loss for "severe salinity" based on this study; 20% yield loss for "some salinity" is an educated guess of the Panel members.**
b. **Calculated by the Panel members based on above estimates**
c. **Sum of C and F.**

Table 7. Estimates of negative externalities of productivity-enhancing technology components in developing countries

Negative Externality	Evidence from the literature	Estimates of area/extent of a given problem	Environmental/economic implications
Loss of genetic variability	Discussed in the literature but evidence not substantiated	No quantitative estimates available	Loss of biodiversity
Salinity and water logging	Evidence of this problem in irrigated areas available and well documented.	20-30 M ha globally suffer from severe salinity; additional 60-80 M ha suffer some water logging and salinity problem	Land abandoned Declining productivity
Changes in the level of water table	Evidence of both increase and decrease in water table level is found in the literature; evidence scattered and location specific	Water table increase reported in the range of 0.1 to 3.0 meters per year in some irrigated project areas. Reported water table decline range from 0.4 to 1.0 meters per year in some regions.	Declining productivity
Loss of soil fertility/erosion	Evidence documented for rice in Asia; evidence of linkage in other crops not substantiated	No global estimates available	Declining productivity
Water pollution	Most evidence found in developed countries; scattered evidence in LDCs	No global estimates available	Increased health costs; loss of aquatic flora and fauna
Air pollution	Discussed but not substantiated in LDCs	No global quantitative estimates available	Increased health costs; lower productivity
Food contamination	Scattered evidence in LDCs	No global estimates available	Increased health costs
Impacts on human and animal health	Case-specific evidence on this linkage available. Most evidence relates to pesticides and its health effects	Globally 1.1 million cases of acute pesticide poisoning each year resulting in 20,000 deaths. 1	Increased health costs and social/economic costs associated with lower labor productivity
Effects on pest population	Case-specific examples and scattered evidence	No global estimates available	Increased costs of production (pesticides) and declining productivity


Research-to-impacts chain
Evidence of strong link
Need more research and analysis to establish the link
Research
Research Output
Changes in Farming practices
Consequences on RNR
Productivity Effects
Externalities
Environmental Impacts
Research
HYVs
Other Factors (e.g., policies)
Multi-
Crop
+
Irrigated water
Fertiliz
Pesticide
Increased salinity
Water logging
Lowering of water
Increase in disease carrying insects and pests population
Pests developing resistance to
Decrease in genetic diversity
Increased traces of toxic chemicals in air, soil, water and harvested products
Increase in yields
Decline in yields
Decline in yields
Increase in cost of production
Less demand for new land
Land abandoned
Positive externality
# of ha. saved
Negative externality
# of ha. brought under cultivation
Negative externality
# of plant and animal species lost
Negative externality
# of people affected by diseases
# of people poisoned
Negative Externality
Emergence of new (harmful) pests

Scenarios of Where Land Savings May Have Been Realized

As a Result of Productivity Enhancement

In Five Major Developing Countries[13]

Brazil: There are clearly no limits to the availability of land in expanding production at the 1960s yields. The land savings from research on the seven crops over 30 years is placed at 15 million ha, 95% of which is in maize and rice. The conversion of two million ha of arable land to irrigation should reduce the requirement to 14 million ha. Since annual and permanent crops, and permanent pasture all expanded during this period by a total of 79 million ha, it may be safely assumed that the additional area would have been drawn from the "forest" category of land use. At the same time, net imports of these commodities increased by 66 million tons, 80% of which was wheat and barley. The area expansion implications of these imports, presumably largely in temperate zones, at 1960s yields would have been in the order of 60 million ha. The foregoing figures clearly overstate the land savings that may be attributable to productivity enhancement research by the CGIAR and others. Assuming half these savings to be more plausible, the potential damage to RNR avoided would amount to 8 million ha of deforestation domestically, and 30 million ha converted from pasture, forest or other permanent cover to annual crops in exporting countries. About 20-25 million ha of this may be expected to be from temperate exporting regions of the world.

India: In contrast to Brazil, India faces clear land capability limits in meeting 1990s production levels at 1960s yields. To meet this level, the seven crops would have to expand by 114 million ha, 85% in wheat and rice. Over this period annual and permanent crop area increased by seven million ha and pasture declined by four million ha, i.e. a net increase in agricultural area of three million ha. At the same time, 28 million ha of rainfed cropland were converted to irrigation. With the increased cropping intensity and higher yields, this additional irrigated area would have reduced the required expansion by about 20 million ha. Thus, the shortfall equivalent to 94 million ha in annual crops, could have to be made up by: (i) conversion of forest (20 million ha), pasture (5 million ha) and other cover (10 million ha); and (ii) an increase in imports (primarily rice and wheat) which would have required conversion of about 60 million ha in exporting countries. In practice, there were major shifts in the trade pattern – the net shift in wheat was 8.4 million tons (from 7.3 million tons imported in the 1960s to 1.1 million tons exported); in rice, the net was 4.3 million (from one million tons imported in the 1960s to 3.3 million tons exported in the 1990s); imports of sorghum dropped from one million tons to zero; the shift in trade in the other four crops was negligible. The net effect of these trade shifts at 1960 yields would have reduced the area expansion required in exporting regions by about 10 million ha.

Halving the above estimates gives a scenario where the potential for avoidance of environmental damage (i.e. the potential positive environmental impact of research) could have been 18 million

[13] China, Brazil, Indonesia, Nigeria, India.

ha changed from forest or other permanent cover within India, and 35 million ha converted in exporting countries, with 5-10 million ha being in temperate regions.

China: Like India, China has limited lands available beyond that developed by the 1990s to meet requirements if 1960 yields were to apply. Between the 1960s and 1990s total agricultural area was expanded by175 million ha, of which 80% was conversion to permanent pasture. The requirement to meet 1990s production levels at the 1960s yields would be an additional 156 million ha, 95% in maize, rice and wheat. The expansion of irrigation by 16 million ha over this period would reduce this requirement to about 140 million ha, part of which could be met by further expansion on to the 129 million ha in forest and woodlands; about 20 million ha of this area was converted over 30 years to crops and pasture. At three times this rate of deforestation for conversion to the seven crops, the shortfall in area would be reduced to 100 million ha. Additional lands could have been brought into production from the "other" land cover category. Over 150 million ha from this category was converted to agriculture during the 30-year period; a further 30 million ha could have been placed under annual crops.

In trade there was little change over the period under study – net imports of wheat increased by one million tons; in the sum of the remaining six crops imports and exports cancelled themselves out. Thus, assuming a realistic counterfactual situation with half the above land-use changes, the negative environmental impacts avoided by the yield-increasing research would be associated with 20 million ha deforested and "other" land cover removed from 15 million ha domestically, and the expansion of 35 million ha in exporting regions. About a third of this would be expected to come from temperate zones.

Nigeria: Only five of the seven mandated crops are relevant in Nigeria (wheat and barley are insignificant). There was minimal change in land use over the 30-year period – two million ha of forest converted to annual crops. An additional 12 million ha would have been required to meet the 1990s production for five crops at 1960s yields, 90% of which would have been in maize, pulses and sorghum. There was no change in trade, thus increasing deforestation at six times the rate that prevailed between the 1960s and 1990s would have covered the shortfall and essentially eliminated the area in forest and woodlands.

Under a scenario where only 50% of this change would have occurred, the possibility of avoiding potential environmental damage through research on the five commodities centers on domestic deforestation of 6 million ha. Since the only trade implication is an increase of one million tons in wheat imports, no significant change in land use in exporting regions would be expected.

Indonesia: Only the four crops suited to the humid tropics (cassava, maize, pulses and rice) are relevant to this case. To meet the 1990s production level of these at 1960s yield would require an additional 24 million ha in rainfed agriculture, of which 70% would be in rice. The one million ha of increased irrigation over the 30-year period would reduce the requirement by about one million ha.

Trade shifts were minor – a net increase in exports amounting to 0.6 million tons of cassava, and 1.6 million tons of rice, which is essentially cancelled out by a net increased imports of one million tons of maize.

Assuming land savings at half the level suggested above, and assuming a shortfall of production from 12 million ha in the four humid tropical crops to be met by clearing forest, would mean a rate of deforestation double that which actually prevailed over the period. In addition, land expansion in wheat exporting countries would have been 2 million ha.