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Impact Assessment of Agricultural Research for Development and Poverty Reduction [1]

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Background

One of the goals of the international community formulated at the Millennium Summit is to reduce by half the number of people living in extreme poverty by the year 2015. The majority those one billion people who try to survive on less than 1 $ per day live in rural areas and depend on agriculture as their main source of livelihood. Continued population growth, especially in the least developed countries, and the increase in food demand due to rising incomes in other parts of the world, require further growth in the supply of agricultural commodities. Since the possibilities for a further expansion of agricultural land are practically exhausted additional supply has to come from productivity growth. Also, to overcome poverty and malnutrition, agricultural productivity growth and rural development have to be pro-poor, i.e. development efforts must be designed and implemented for low income and resource poor target groups.

Tight budgetary constraints and on-going changes in the institutional setting challenge the international agricultural research system to deliver results that have better impact on the poor. It thus brings into focus impact assessment studies of agricultural research and the lessons that can be drawn from these studies in order to better identify the research needs of the future.

The objective of the paper is to conduct an overview on the impact of research in agriculture for developing countries; in particular past investments of the International Agricultural Research Centres (IARC) of the Consultative Group on International Agricultural Research (CGIAR) are analyzed. Mostly reference is made to the studies carried

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out by the Standing Panel of Impact Assessment (SPIA)[3] under the Science Council (SC) of the CGIAR. Furthermore some of the current and future challenges of impact assessment in agricultural research aimed at the development of poor countries are outlined. The paper thus addresses three major questions:

1. Has the impact of past agricultural research been significant?
2. Have the poor benefited from agricultural research?
3. What are the challenges ahead?

Finally an outlook on the future of agricultural research for development and poverty reduction is given. The procedure is as follows. The first part of the paper summarizes and interprets major impact assessment studies of the CGIAR. The second part deals with the question of poverty impact and some of the criteria that need to be fulfilled to improve the poverty impact of agricultural research. The last part of the paper deals with emerging opportunities in agricultural research and the challenges that will arise for impact assessment from this research. Since an overview paper can only be flashing through some of the major issues discussion necessarily has to remain brief.

The impact of past agricultural research

There is broad consensus in the agricultural research community that past investments in agricultural R&D generally has paid handsomely and has yielded high rates of return. The most prominent source for this claim is the study of Alston and Pardey (Alston et al 1996). The authors based their conclusions on numerous studies in the USA and in developing countries. They found that generally not only rates of return of R&D in agriculture are high but there is also a low probability that these rates would be below acceptable levels or even be negative. Summarizing their study results of over 1000 cases, a cumulative distribution curve of rates of returns (CGIAR 2000) shows that there is also little difference between industrialized and developing countries. Furthermore, the modal value is in the order of 30 %, which is a reasonable internal rate of return (Figure 1).

3 The author is a member of SPIA. The helpful comments of Hans Gregersen and David Raitzer from SPIA on an earlier draft are highly appreciated. Similar thanks go to Stephan Krall from GTZ as well as staff members of the institute. Special that's to Hildegard Garming for performing some quick calculations. The usual disclaimer applies: the views presented here are those of the author and any errors are the author's sole responsibility.

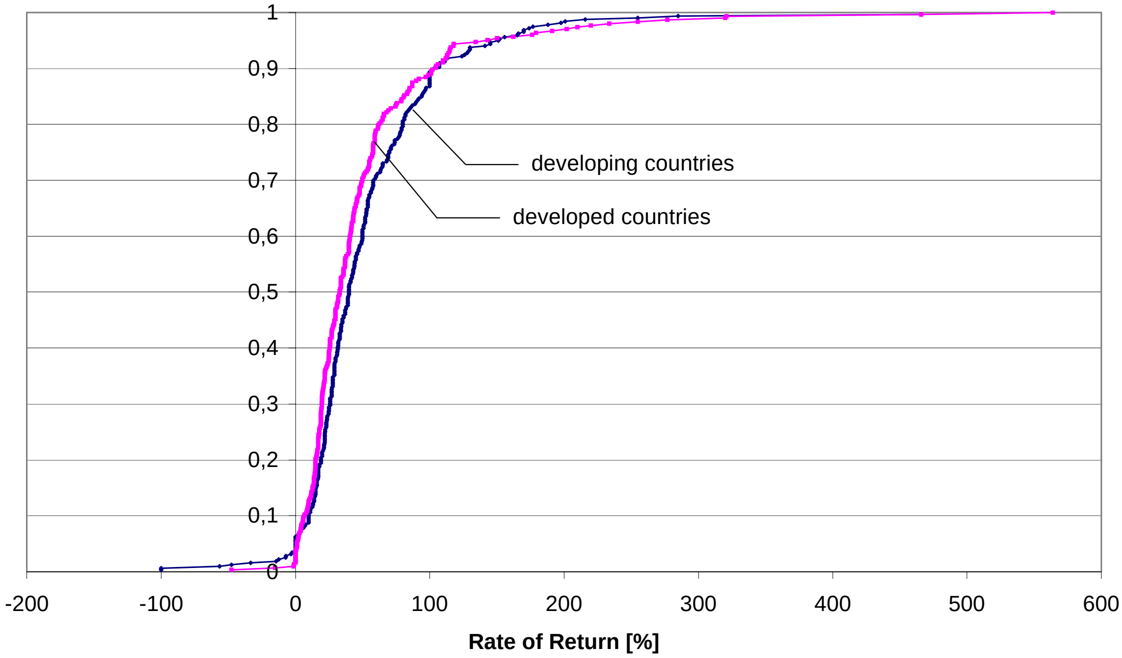

Fig. 1: Cumulative distribution of IRRs of Agricultural R&D projects based on the data of Alston et al 1998.

Recently a "meta cost benefit analysis" of all investment in agricultural research of the International Agricultural Research Centres of the CGIAR has been carried out (Raitzer 2003). The study synthesises available benefit estimates, and compares those with total CGIAR investment since inception of the system. From the time of establishment, the CGIAR has invested approximately US $ 7.12 billion[4]) in various research and development activities. This amount includes investments in the four Centres that already existed prior to the establishment of the CGIAR.

In the meta analysis (Raitzer 2003) two main criteria were used to select impact studies available in the literature. The first criterion was to only include studies with a high degree of transparency, i.e. those that had clearly derived key assumptions, that provided a comprehensive description of data sources, and that had a full explanation of data treatment. The second criterion was clear "demonstration of causality", i.e. studies that used a plausible counterfactual and that demonstrated a precise institutional attribution of the impact. Using these criteria, scenarios were selected and ranked according to significance. The most conservative scenario was based on studies where benefits until the cut off point in 2001 were

4 2001 inclusive, in 1990 dollars

“significantly demonstrated”, while in the most optimistic scenario studies had been included where benefits had been judged to be plausible and were extrapolated to the year 2011.

Against an aggregate investment of 7,120 million 1990 US dollars (6,900 million of investment in the CGIAR, plus relevant pre-CGIAR costs), all scenarios produced benefit-cost ratios higher than one, indicating that investment is efficient. For the most rigid scenario [5]a ratio of 1.94 was achieved while for the most optimistic scenario the ratio jumped to 17.26. When taking the mid level scenario a benefit cost ratio of 4.76 was obtained. In this scenario 15 studies were included, of which in four cases benefits were significantly demonstrated and empirically attributed. Seven studies showed significant benefit demonstration and in the remainder benefits were assessed as “plausible”. An aggregation of the benefits reported in these studies showed that the respective research projects have generated more than 90 % of the total CGIAR benefits. Over 80 % of that can be attributed to plant genetic improvement while the remainder is attributable to cassava mealy bug bio-control and only a minor rest is policy research (Raitzer 2003).

The strong belief that investment in agricultural research and development has been highly economical has been the dominant paradigm in agricultural economics for a long time. It has led to the famous ‘Under investment in Agricultural Research Hypothesis’ (e.g. Schultz 1971). Recent empirical studies support this view (Evenson and Gollin 2003). However, arguments were also raised against this hypothesis (e.g. Fox 1985) and an upward bias in the rate of return was demonstrated in some cases (e.g. Pardey et al 2004). One problem is that the market model, which is the dominant approach to evaluating the impact of agricultural R&D, can lead to overestimation of the benefits if a large proportion of the produce is not marketed or if poor infrastructure results in high transaction costs. Furthermore, costs can be underestimated if the technology produces negative effects on the environment and natural resources. On the other hand, an underestimation of benefits can occur if R&D produces positive environmental and natural resource management impacts, which have not been included in the market effects.

Issues with regards to impact assessment methodology will remain the subject of scientific discussion. However, an equally important question is why apparently the donor community did not show the response expected by agricultural researchers to such overwhelming evidence. A high marginal rate of return of agricultural research investment

5 Interestingly only 15 out of about a hundred published impact assessment studies had passed this test.

would suggest that more resources should be invested in this field in order to achieve the goals of international development including poverty reduction. Despite widely acknowledged successes, funding for the CGIAR has stagnated in real terms during recent years (Anderson 1998)[6]. The reasons for donor reluctance for additional funding for agricultural research can be multifarious, including e.g. a lack of understanding of the methodology, lack of trust in the objectivity in the analysis, a perception of "cherry picking ", i.e. that only success cases were reported while failures were ignored. Hence the question can be raised whether the impact assessments conducted thus far have really made a convincing case?

One possible explanation is the discrepancy between existing evidence of research success and donor expectations. For example, looking at available impact studies it becomes clear that impact has been well demonstrated in the field of crop genetic improvement (CGI). However, the same evidence is not available from investments in natural resource management (NRM) research. Perhaps guided by the sustainable development paradigm, donors have increasingly invested in the latter field. The proportion of total resources spent on environmental protection rose from 14 to 17 percent between 1993 and 1997 and on protecting biodiversity from 6 to 11 percent (Barret 2002). Clearly, the rising proportion of research funds directed at NRM increases the need for accountability and consequently impact assessment (Kelley and Gregersen, 2004). Measuring impact of NRM research is inherently more difficult than for CGI research. The products of NRM research are basically knowledge-intensive technologies whose application to solve local problems almost always requires further adaptation and can cause high set up costs. Another problem is that its effects may be complementary to CGI research, which raises the difficult question of benefit attribution. In addition, NRM's output are often non-rival and non-excludable public goods where no market prices exist and hence under-valuation is likely. For example, a recent survey of 1100 agricultural research impact assessment studies found that only 11 included environmental impacts (Alston et al. 1998).

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6 For 2005 CGIAR expects a more relaxed budgetary situation with additional funds available. However in view of the strained budgetary situation in some OECD countries the long-term prospects remain uncertain. In Germany for example the approved budgetary commitments for 2005 to be allocated to international agricultural were reduced substantially by the Ministry of Economic Cooperation and Development

Furthermore, there are cases in international agricultural research where technologies had been developed whose adoption and diffusion is constrained by economic and institutional factors. A good example is research on Integrated Pest Management (IPM) in Asia (and perhaps in other regions as well). Ecological research at the International Rice Research Institute on IPM developed the hypothesis that high levels of insecticide use may rather amplify than moderate pest pressure and will increase the likelihood of pest outbreaks (Kenmore 1985). Economic research found that lower insecticide use leads to higher farm profits and at the same time reduces negative health externalities (Rola and Pingali 1993). In spite of such scientific evidence IPM practices did not become adopted on a large scale in Asian rice production. Misguided pesticide policies including various forms of subsidies for and weak extension systems have played a role here. Hence investment efficiency is questionable because the IPM concept has been developed since almost thirty years ago. A simulation of the benefit cost ratio of IPM research investment showed that large time lags in adoption will render research investment to become inefficient. If the direct benefits commence after a time lag of 30 years only the benefit cost ratio will come down to unity. If benefits from reducing health externalities are included a research time lag of 35 years leads investment inefficiency (CGIAR 2000).

To sum up, the evidence that exists from impact assessment of past agricultural research is clearly positive. On the other hand some impact studies have limitations that should not be ignored. Available studies have mostly relied on market-based valuations and largely concentrated on calculating the rate of return on investment. However, a high rate of return simply suggests that the amount invested in a given project with a specific technical design has paid off. It neither says something on the benefits of alternative projects nor does it say anything about the significance of this investment for the economy. Take for example a typical 5 million US $ research investment with the first benefits occurring after 15 years. Let the benefits for the farm households be US$ 1000 per year[7] over a time span of 10 years. An internal rate of return (IRR) of 20% can be achieved if only 6000 farmers adopt the technology. Considering not only the benefits to producers but also those to consumers, the

7 As probably the case with past agricultural research the typical technology adopter in does not belong to the group of extremely poor farmers. In relation to a common poverty reference such a farm household is more likely to be found around the US$ 2 /capita /day group. , which would be around US $ 3600 per household and year. Thus the calculation assumes an benefit of some 25 % in household income from the adoption of a new technology.

number of farmer adopters can be even lower to reach the same rate of return[8]. Hence, the project will be successful in terms of investment efficiency but the scale of the project for the national economy could be insignificant[9]. Furthermore, a high rate of return says nothing about the effectiveness of the investment on other development goals such as poverty reduction or the prevention of famines.

Did the poor benefit from agricultural research?

Generally, R&D investment in agriculture has aimed at increasing agricultural productivity. By the same token impact assessment has not specifically looked at poverty impact per se but has emphasized the quantification of economic gains resulting from productivity improvement. It was taken for granted that such productivity increases will foster benefits throughout the broader target economies, and thereby 'trickle down' to achieve the poverty alleviation goal. In another SPIA initiated study the development impact of crop genetic improvement research has been analysed (Evenson and Gollin, 2003*)*. This research is perhaps the most comprehensive documentation of crop genetic improvement investment and related impacts that is currently available. It covers the production and diffusion of improved crop varieties for 11 food and feed crops in the developing countries from 1960 to 1990. The following economic and social gains of investments in CGI were established on the basis of IFPRI's IMPACT model (Evenson and Rosegrant 2003):

- Around 20 % reduction in world food and feed grain prices
- Increase in world food production by 4-5 %
- Around 15 million ha savings in agricultural land
- 5 % increased in per capita caloric supply in poor countries
- Over 2 % reduction in child malnutrition particularly in South Asia
- 5 % reduction in food imports in the developing countries

8 If producer rent is equal to consumer rent, with a ratio of 60% rural (producer) households and 40% urban consumers, the IRR of 20% is reached with only 3600 farm households.

9 if the same simulation is calculated with the US $ 7.5 billion of investment in the CGIAR system, a number of 4.2 million farmers and 2.8 million consumers would suffice to achieve an internal rate of return of 20%

In addition to its quantitative estimates this study also has produced results that aim to qualify the economic and social estimates (Evenson and Gollin, 2003, p. 12):

- Taking all IARC mandate crops into account the production of improved varieties has increased in each decade over the 40-year history of the Green Revolution.
- Improved varieties have been produced for all crops on all continents and in all agro ecological zones but distribution research output has been uneven.
- Research progress depends on the pre-existing research stock and the effort expended on research

In the discussion of how and to what extent the green revolution has benefited the poor some key questions arise from past impact assessments. Two questions can be highlighted:

1. The weakest evidence of agricultural research impact is in the region with the most dramatic poverty record in relative terms: Sub Saharan Africa. With the exception of maize the adoption of modern cultivars in Africa has been low. Less than 30 % adoption was observed on crops, which are important for food security in Africa: cassava and sorghum (Evenson and Gollin, 2003, p. 23 and p 32). Hence, what happened with agricultural research in Africa?
2. A recent study on the poverty impact of agricultural research (Adato and Dick-Meinzen forthcoming) showed that although indirect impacts of productivity growth can be established, the requirements of the poor for new agricultural technologies often differ from the priorities set by scientists. Therefore, does agricultural research sufficiently service the poor?

On the first point, in a review on the performance of agriculture in economic development in Africa, Eicher (2003) discussed the role of agriculture sector investments including those of research. During the 1990s the CGIAR has allocated about 45 percent of its budget to Africa. Little is known so far on the pay-off for this investment. However there are positive and negative signs. On the plus side the generally high pay off in genetic improvement investments and the establishment of Sub-Regional Organizations (SROs) for agricultural research such as ASARECA can be listed. On the negative side, public investment in agricultural extension in particular the T&V has turned out to be a rather agonizing experience in Africa (Anderson and Feder 2003). Also, it is being argued (Lele 2003) that CGIAR's research on natural resource management, which, given the nature of agricultural systems in Africa is highly important, had questionable pay-offs. One of the priority studies of SPIA for 2005 therefore is impact of agricultural research in Africa.

With regard to the second question raised above, a SPIA initiated study carried out by IFPRI has investigated the poverty impact of agricultural research (Adato and Dick-Meinzen forthcoming). The study has produced important lessons. Foremost, through six in-depth case studies on the poverty impact of agricultural technologies in three continents innovative impact indicators and new insights on constraints to adoption were found. In particular the impact of technology on the vulnerability to poverty was identified as an important criterion. A good example was the case of a project that introduced integrated agriculture - aquaculture technology in Bangladesh. Fishpond owners experienced increased vulnerability through fish diseases, poisoning of ponds and intra group conflicts. At the same time the vulnerability of women was reduced through the possibility of increased employment from vegetable production around the homestead. The study on poverty impact has demonstrated at least three important conditions for agricultural technology to directly benefit the poor. First, the technology must take into account asset requirements of the poor. Second, the existence and the effectiveness of mediating institutions in representing the interests of the poor are crucial. Third, and perhaps most importantly, the perceived effect of the technology on increasing or reducing the household vulnerability was found to be a critical factor in determining whether or not the technology benefited the poor (Adato and Dick-Meinzen forthcoming). Vulnerability is a concept that has entered the discussion in connection with the implications of external shocks that have occurred repeatedly in the recent past and that were caused by various political, ecological and financial factors. The notion of vulnerability goes beyond the conventional risk versus expected benefit trade-off paradigm because it recognizes the dynamics of coming in and out of poverty as a reference. Vulnerability can be defined as “risk minus the ability to cope”. Hence, a technology may be more or less risky and may strengthen or weaken the ability of poor households to cope with risk.

In conclusion, there is vast evidence that indirectly agricultural technologies have benefited the poor. However on the direct poverty impact of agricultural research more research is needed in order to confirm the criteria that agricultural technologies need to fulfil these are going to adopted by the poor.

Challenges of the future

Biotechnology is likely to play an important role in future agricultural research. It will be one of the major opportunities but is also likely to remain a challenge. Much hope has been raised by recently published reports (e.g. FAO 2004) but can the potential be realized under the conditions of developing countries what can be expected from biotechnology for poverty reduction?

Genetically engineered plants for pest, disease and drought resistance as well as other breeding traits may soon become a major product of plant breeding. While until to date the majority of biotechnology applications are in industrialized countries with herbicide resistance as the dominant technology, its introduction in developing countries has started. The technology has raised great hope based on some ex- ante impact assessments, but there are challenges for ex-post impact assessment in terms of methodology and data. Most of the ex-ante and "early adoption studies" were in cotton and only few in CGIAR mandate crops. One of the messages that are emerging from field implementation in developing countries is the need for paying more attention to the institutional dimension. As pointed out by de Janvry et al (forthcoming) the impact of biotechnology will depend on "*the ability to put in place the necessary public and private institutions for the generation, transfer, delivery, regulation, and adoption of bio-technological innovations favourable to poverty reduction. Since weak institutional development is an integral feature of under-development, and a pro-poor bias in developing country institutions has been notably lacking, this poses particular difficulties in achieving success that need to be pro-actively addressed*".

A good example for the need of institutional development is the example of Bt cotton in China. While initially Pray et al (2002) found the technology to be successful in reducing chemical pesticide use and raising yields recent case studies provide some warnings. For example, (Yang et al in press) found high levels of pesticide use after Bt cotton introduction in China. Furthermore, an in-depth case study in Shandong province (Pemsl et al 2003) has shown that the seed market has failed to assure input quality. More than 60 % of the seed samples had Bt toxin concentrations lower than the standard set by the company who first introduced transgenic varieties. Neglect of product quality and product adulteration may take place with high value transgenic seeds because there are economic incentives for private agents to ignore these standards and the costs of monitoring and law enforcement are high. Another crucial question is who will really benefit from biotechnology in poor countries. Biotechnology is an expensive technology, considering the high costs for research and development, which can only be recouped if marketing is done efficiently and on large scale. The private sector as the main driver will therefore target crops and areas as well as stipulate policies that assure high profits. Doubts have been raised whether a lot of benefits will go to poor farmers in developing countries or will rather be enjoyed by the agro-biotech companies who are interested in market success and not necessarily in successful (in terms of poverty impact) application of this technology (Peters, 2000, p. 324).

Adoption and impact of biotechnology will become a major theme in future impact assessment studies. Provisions must be made now in order to produce results that are valid, representative and provide lessons for technology design, institutional and policy conditions.

Outlook

This “helicopter view” of impact assessment of international agricultural research for the development of poor countries necessarily leaves a lot of questions unanswered. However the need for further agricultural research is supported by available impact studies and the challenges ahead. It also is clear that given the changing political, economic and social frame conditions, which will affect agriculture, more of the same will no longer be enough. The political influence of agriculturists in donor countries is declining. Thus for agricultural researchers in both industrialized and developing countries working on smaller budgets will become a hard reality. For example, looking at the actual provision of funds by the German Ministry of Economic Cooperation and Development (BMZ) for the CGIAR and associated centres shows that while over the past ten years the decline was only moderate, what is changing dramatically is the amount of the funds committed and the gap between budgets made available and future fund commitments is widening (Krall, personal communication).

While one should not exclude the possibility that such trends can be reversed it is clear that new avenues must be sought. An important factor is that the institutional setting of agricultural research especially in the industrialized countries is undergoing irreversible changes. For example, the demand for higher education in agriculture in the context of independent academic programmes is declining in developed and in developing countries. Thus independent agricultural faculties could soon be sub-merged in larger units such as biology, engineering and economics. However, the importance of global food security, reduction of inequality and the elimination of extreme poverty will be even more important for the development of the world economy than in the past. In addition to the millennium development goals arguments strengthening the stability of the economic growth process in a globalized world should be an even stronger incentive for donor countries to do more in this field. Therefore, agricultural issues are research topics that should be made attractive to a wider range of scientists and therefore more participation across scientific disciplines is needed eventually leading to the emergence of new disciplinary settings. Future agricultural research must be concentrated at the interface of food production, human health and environment. Agriculture is just too important for world development to be left to the agriculturists alone.

Putting international agricultural research into a broader poverty context has also implications for defining and measuring research outcomes and impact. This requires advancing the impact assessment methodology. These advances must build on the lessons learned so far. Although in the past donors tended to ignore the "rates of return message" economic analysis will remain important in future studies. However, to do good economic analysis also requires good data. Data need to be collected before the project starts and realistic counterfactual scenarios need to be thought of from the beginning. Thus, good ex post impact assessment must start ex ante. In this regard, the collection and use of panel data will become important. It is also important that large-scale surveys for example of technology adoption are complemented by in-depth case studies. Branches of economics such as ecological and institutional economics need to be given a bigger share and more valid and meaningful combinations between quantitative and qualitative approaches need to be found. For example, to value non-market goods in natural resource management or to appreciate the generation of knowledge and empowerment will avoid a bias toward those projects whose benefits can be more easily measured. Political realities, vested interests and power structures must be considered in impact assessment especially when assessing the true costs of technology introduction.

In the long run promoting a culture of impact assessment among IARCs, NARS and NGOs in addition to keeping a fair number of independent external assessments could stimulate much needed innovative approaches. These can help to move the science of impact assessment beyond a mere accountability purpose and put more emphasis on the lessons learned.

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