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Impact of Agricultural Research in South Asia since the Green Revolution

In the 1960s when South Asians faced widespread famine, the technology-driven agricultural solutions of the Green Revolution (GR) were an unprecedented success, creating food surpluses within 25 years despite a 70% increase in population[1]. The GR raised many out of poverty, saved large areas of forest and wetlands from conversion to cropping, and helped launch the economic transformation of the region. But even as one important research agenda was fulfilled, new problems and challenges arose for national and international agricultural research systems.

Poverty had not been eliminated and although poverty shares fell, the number of poor people still remained high. Widespread malnutrition, increasingly in the form of micronutrient deficiencies rather than calorie or protein shortages, also remained. The GR introduced new environmental problems of its own, especially those related to the poor management of irrigation water, fertilizers and pesticides. Doubts have arisen about the sustainability of intensively farmed systems, and off-site externalities such as water mining, pollution of rivers and waterways, and loss of biodiversity have imposed wider social costs.

The economic transformation that followed the GR also dramatically changed the context for agricultural research and development (R&D). Rising incomes and urbanization led to more diversified diets, with rapid growth in demand for many high-value foods and slow growth in demand for food staples. Agriculture's share in GDP declined steadily, but its share in the workforce declined more slowly, leading to widening income gaps between agricultural and non-agricultural workers. Continued rural population growth also increased the number of small-scale and marginal farmers. Many of the rural poor have diversified their livelihoods to the point where agriculture now plays a relatively minor role, a shift that has been facilitated by the growth of the nonfarm economy.

In this evolving context, the priorities for R&D needed to change. How well have the R&D systems adjusted and how effective have they been in address-

ing these emergent problems? To answer these questions, agricultural economist Peter Hazell led a critical review of the evidence on the impacts of agricultural research undertaken by the Consultative Group on International Agricultural Research (CGIAR) and its national agricultural research system partners. The study focused on the post-GR era, broadly defined as the early 1980s to the present. Hazell categorized the results from an exhaustive literature search of peer-reviewed and published materials into productivity, social, environmental, and policy impacts.

An economic and social transformation: An unfinished agenda

Notwithstanding the generally favorable post-GR economic trends in South Asia, agriculture and the rural sector remain problematic. Despite out-migration, rural populations and agricultural work forces have continued to grow and have not yet reached a tipping point at which they begin to decline. This has led to increasing pressure on the land, with ever-increasing numbers of marginally sized farms, and to widening productivity gaps between agricultural and non-agricultural workers. Emergent challenges for agriculture and the rural economy include:

- Creating policies that enable more rapid agricultural diversification and high-value production
- Increasing viable exit opportunities for more small-scale farmers and landless workers
- Providing marketing options for small-scale farmers who are increasingly marginalized in competitive and consumer-driven market chains
- Addressing the needs of the rural poor who are much less dependent on agriculture than in the past
- Addressing the poverty problems of many less-developed regions that have been left behind by the GR
- Responding to growing environmental problems in agriculture and a growing demand for clean water for non-agricultural uses.

National responses to some of these issues have been slow. Governments continue to subsidize power, water, and fertilizers for farmers, which results in an unprofitable relationship of dependence, less investment in rural infrastructure and R&D, inefficient use of increasingly scarce water, and environmental damage due to overuse of water, fertilizers, and pesticides.

But there have been improvements. There has been progress in the liberalization of markets for food staples, governments have promoted high-value exports, and the private sector has expanded its research beyond pesticides, fertilizers, and agricultural machinery into crop breeding. The active involvement of non-governmental organizations (NGOs) has helped to expand the agricultural R&D agenda on natural resources management (NRM) and sustainable agriculture, the problems of less-favoured areas (LFAs) and poor farmers, and more participatory research approaches.

In real terms, South Asian countries nearly tripled their public spending on agricultural R&D between 1981 and 2002 and allocated greater shares of their research spending to livestock production, high-value agriculture and environmental, social, and policy issues. The priorities of the CGIAR centers have also changed in similar ways, though, less encouragingly, their total real expenditure in South Asia has grown little since the GR and currently stands at about US$65 million each year, or just 3% of the region's total R&D budget.

A review of the evidence shows that agricultural R&D has been broadly successful in achieving many of its new goals, although much remains to be done.

Productivity impacts: A sound investment

In an era of continued population growth and scarce resources, maintaining and improving productivity continues to be the main goal of agricultural R&D in South Asia. Traditional pathways have focused on yield levels and variability, but research on crop improvement, labor-saving technologies, and NRM contributes to overall productivity gains and sustainability.

The yields of major food crops have continued to grow on average, though sometimes at slowing rates. Crop improvement research has raised yield potentials, as illustrated by the development of hybrid varieties for most of the major food crops. Breeders have also given greater priority to stabilizing yields through varieties that are more tolerant to environmental and pest stresses, and are genetically more diverse. Farmers have widely adopted improved varieties.

Studies of the economic return to investments in commodity-specific research show an average rate of return of 60%, with no sign that this rate is declining over time.

Of course, studies of commodity-specific research investments may lead to a biased impression if evaluators tend to select more successful investments to study, so it is also important to look at the returns to aggregate public spending on agricultural research. Several studies at this level of aggregation give rates of return of between 24% and 143%, with an average of 63%. This is much higher than

any reasonable discount rate. In India, the rate of return to agricultural research has also been shown to be higher than all other public investments in rural areas. By reducing the price of food and other raw materials and boosting rural incomes (and hence rural spending power), technology-driven increases in agricultural production also generate powerful growth linkage benefits for the non-agricultural economy. In terms of the amounts of income they generate, these indirect benefits can be almost as large as the direct impacts within agriculture.

The CGIAR centers have remained at the forefront of crop improvement research, and large shares of the varieties released by national programs contain improved genetic material obtained from the centers. Impact assessments that attribute some of the benefits from R&D to CGIAR centers also confirm impressive contributions. They show annual benefits in excess of US$1 billion just from the CGIAR's work on rice, wheat, and maize, which is more than enough to cover the costs of the CGIAR's entire global program, let alone the US$65 million or so spent in South Asia each year. These kinds of calculations are at best indicative, but do suggest that from a narrow productivity perspective the CGIAR's research in South Asia continues to be a sound investment.

Social impacts: Success… and lingering problems

Agricultural research has had mixed impacts on the poor within adopting regions. Impacts vary with the type of technology and the socio-economic conditions in which they are released. With agriculture playing a smaller role in the livelihoods of the rural poor today than in the GR era, benefits of agricultural growth may now be weaker unless solutions are carefully targeted.

When seen through the lens of growth linkages and food prices, it is much clearer that agricultural productivity reduces poverty. Lower food prices benefit both rural and urban poor people. Aggregate analysis for India shows that more people are raised above the poverty line per dollar spent than by almost any other public investment in rural areas. But the power of these indirect effects may be lessened in the future by increased market liberalization and the diminishing importance of the agricultural sector.

Although agricultural R&D has made important contributions to reducing poverty, it has been less successful in reducing widening income gaps between the rich and poor. Moreover, many LFAs have been left behind, and while spill-in benefits, such as cheaper foods and improved income opportunities from migration to more-favored areas can buffer these inequalities, they rarely eliminate them.
Finally, the problem of 'hidden hunger' persists; despite sufficient amounts of food, many South Asians continue to suffer from micronutrient deficiencies, which can affect long-term health and productivity. Agricultural research that contributes to diversifying diets and enriching the nutrient value of food staples can address hidden hunger, but to be fully effective they need to be complemented with investments in nutrition education and health services that are targeted at women.

Environmental impacts: Barriers to adopting solutions

The total area of forest and woodlands in South Asia has changed little since the GR, but other environmental indicators are less encouraging. Several international land-assessment exercises have reported widespread degradation of most types of agricultural land, with some estimates as high as 40–75%. Much of this degradation has arisen in LFAs and has little if anything to do with GR technologies. In LFAs the issues include: soil erosion, declining soil fertility, encroachment of cropland into forests and fragile lands, and biodiversity loss. Biodiversity loss is also a symptom in GR areas, along with water contamination from fertilizers and manures, pesticide poisoning of people and wildlife, and unsustainable use of rivers and groundwater for irrigation.

Considerable research has been directed at these environmental problems. In GR areas, R&D has focused on the problems of sustaining high yields in stressed environments and reducing such off-site environmental problems as pollution of waterways. In LFAs, research has focused on ways of reversing resource degradation and sustainably intensifying agricultural production. These problems have attracted a diverse set of NGOs as well as the usual public and international research institutions.

Promising results in GR areas have come from research on more robust crop varieties, efficient use of water and fertilizers, integrated pest management, zero tillage, and incorporating more organic matter into intensively farmed soils. Evidence is less clear on the benefits of organic farming or the system of rice intensification since these typically require more labor and land per unit of output and can rarely match the high productivity levels achieved with GR technologies.

Research in GR areas has generated favorable benefit–cost ratios, but adoption rates are dwarfed by the scale of the environmental problems. Higher labor requirements, high levels of knowledge required of farmers, continued subsidies

on water and fertilizers in many South Asian countries, and the externality nature of some environmental problems are all obstacles to adoption. Policy changes are needed in government and local institutions to create a more conducive environment for adoption.

In LFAs, crop improvement research focusing on plant tolerance of drought and poor soil conditions and resistance to pests and diseases has shown promise. With higher, more stable yields, subsistence-oriented farmers encroach less on adjacent fragile lands. Research on soil fertility management, water harvesting and watershed development programs that can increase agricultural productivity, reduce soil erosion, and improve groundwater levels have also shown favorable results, most using little if any fertilizer, which is often uneconomic in LFAs. Still, poor infrastructure and market access, high labor requirements, the need for farmer training, inadequate property rights, and the need for effective collective action all hold back the spread of these innovations.

Policy impacts: Opportunity for change

The economic transformation of South Asia and the success of the GR have necessitated some major changes in agricultural policies. With market liberalization, the established roles of the state in marketing, storing and distributing food, providing farm credit and modern inputs, and regulating international trade and agro-industry have all been challenged. The rapid emergence of high-value agriculture and the seriousness of some of the environmental problems associated with agriculture have also required new policy responses. As governments have sought to navigate these turbulent waters, there has been an important opportunity for policy research to help inform the debate.

Although much policy research has been undertaken in South Asia since the GR – some of it by CGIAR centers – and case studies show favorable impacts, more is needed to identify practical ways to overcome the roadblocks to adopting environmentally favorable technologies and NRM practices.

Emerging issues

This study uncovered several issues in research policy and measurement of impact assessment, and Hazell raises a number of questions:

- Can targeting agricultural R&D to the problems of marginal smallholder farmers in South Asia be cost-effective in light of the dwindling role of agriculture in their livelihoods, and the cost of developing tailored solutions?
- Are food price effects and growth multipliers now weakened by market liberalization and economic growth to the point where agricultural R&D can no longer make significant reductions in poverty?
- How can research empirically assess the links between agricultural research investments and poverty and environmental outcomes, lacking an agreed set of environmental and poverty indicators?

Hazell also notes the need for a comprehensive analysis of the benefits and implications of regional spillovers and spillins from agricultural research.

Conclusions

National and international systems have responded well to the changing needs of South Asia in the post-GR era, both in terms of their budgetary allocations and the kinds of research they have undertaken. Market liberalization has opened the agricultural R&D field to a more diverse set of agents, and private firms and NGOs have filled in the gaps for important research and extension needs. However, there is a clear need for more research to determine how agricultural R&D can best meet the complex and evolving challenges in South Asia.

Notes:

The full version of the study on which this brief is based is:

Hazel P.B.R. 2008. An Assessment of the Impact of Agricultural Research in South Asia since the Green Revolution. Science Council Secretariat: Rome, Italy.

1. Rosegrant M.W. and Hazell P.B.R. 2000. Transforming the Rural Asia Economy: The Unfinished Revolution. Oxford University Press: Hong Kong.

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