AGRICULTURE FOR DEVELOPMENT POLICY BRIEF

# Meeting Growing Demand for Agriculture through Innovations In Science And Technology

*Investments in agriculture research and development (R&D) have turned agriculture in much of the developing world into a dynamic sector, with rapid technological innovation accelerating growth and reducing poverty. However, the technological challenges facing agriculture in the 21st century are probably even more daunting than those of recent decades. Land and water are becoming increasingly scarce, so the main source of growth to satisfy increased demand for food and agricultural products will be through gains in productivity.*

All regions, especially the heterogeneous and risky rainfed systems of Sub-Saharan Africa, need sustainable technologies to increase the productivity, stability, and resilience of their production systems and to confront climate change. To achieve this, public and private investment in R&D must increase and partnerships with the private sector, farmers, and civil society must be strengthened in order to stimulate user demand for R&D, increase market responsiveness and competitiveness, and ensure that the poor benefit. Furthermore, advances in the biological sciences and information sciences must be harnessed to enable smallholders to access markets and increase the resilience of production systems important to the poor.

## Beyond the Green Revolution: Gains from Agriculture R&D.

Since the 1960s, scientific plant breeding to develop improved crops suited to smallholders – the green revolution – has been one of the major success stories of development. Initiated by research centers of the Consultative Group on International Agricultural Research (CGIAR), public breeding programs in developing countries have released more than 8,000 improved crop varieties over the past 40 years. Improved varieties not only boost yields, they also make them more stable by reducing vulnerability to pests and disease.

In the 1980s and 1990s following the main period of the green revolution, the spread of improved crop varieties accounted for as much as 50 percent of yield growth of food staples, more than doubling the estimated 21 percent gains of the preceding two decades, with poor consumers being the main beneficiaries. Without those gains, world cereal prices would have been 18-21 percent higher in 2000, and caloric availability per capita would have been 4-7 percent lower. Thirteen to fifteen million more children would have been classified as malnourished and many more hectares of forest and other fragile ecosystems would have been brought under cultivation.

But while improved varieties have been one of the major success stories of development, and crop yields continue to improve, not all farmers and regions have benefited equally. Sub-Saharan Africa has seen very incomplete adoption of improved varieties, owing to the agro-ecological heterogeneity of the region, lack of infrastructure, and other factors. Additionally, progress in developing varieties that perform well under drought, heat, flood, and salinity has generally been slower than for pest and disease resistance. Such advances will be essential for adapting to climate change.

Beyond the genetic improvement of crops and animals, scientific and technical gains are won by improving the management of crop, livestock, and natural resource systems. The CGIAR invests about 35 percent of its resources in sustainable production systems, twice the 18 percent on genetic improvement. Much of this research exploits biological and ecological processes to reduce the use of non-renewable inputs, especially agricultural chemicals. An example of such an approach is "zero tillage", which lowers production costs while reducing greenhouse gas emissions and conserving soil. Other such systems include the use of nitrogen-fixing legumes or trees to improve soil fertility, thereby reducing the need for chemical fertilizers while also slowing erosion, and integrated pest management, which reduces the use of pesticides.

## A Need for Sustained and Increasing Investments in Agriculture R&D.

Agricultural productivity improvements have been closely linked to investments in agricultural R&D. Published estimates of rates of return on R&D and extension investments in the developing world average 43% a year. Despite this high return on investment, agricultural science remains grossly underfunded in developing countries. Global and national market failures continue to induce serious underinvestment in R&D and in related extension systems, especially in the agriculture-based economies of Africa.

In the developing world, private investment in agricultural R&D is very limited – 94% of the investment is from the public sector. But growth in public sector spending has slowed sharply in the past decade and as a share of agricultural GDP, remains a fraction of the public investment in industrialized countries. In the 1990s, public R&D spending in Sub-Saharan Africa fell in nearly half of the countries of the region. This declining trend is partly due to political considerations, where decision-making emphasizes short-term payoffs rather than long-term benefits, and partly due to disincentives for small countries to spend scarce resources on agricultural science when they can often "free ride" on the efforts of larger, more affluent countries. But relying on "spillovers" for productivity gains has inherent risks and limits given the uniqueness of Afrca's agro-climatic conditions and crops.

A third to a half of current R&D investments may be for "maintenance research" to deliver continued yield stability and insure against outbreaks of new pathogens. The recent emergence of a new type of stem rust (*Puccina gramis tritici*), Ug99, in wheat clearly demonstrates why maintenance research is critical. Given the narrow base of genetic resistance to the disease in existing varieties in some of the world's breadbaskets, losses are potentially devastating. An international effort by plant breeders and pathologists is underway to screen for resistant genotypes and get them into farmers' fields to prevent a global epidemic.

## New Institutions and Partnerships for Scientific Research and Extension.

Low spending on R&D is only part of the problem. To meet today's rapidly changing market demands, improving efficiency and effectiveness of R&D requires collective action and partnerships involving a variety of actors in an innovation systems framework. Many public research organizations face serious institutional constraints that inhibit their effectiveness as well as their ability to attract funds. These require serious reform. Furthermore, the high fixed costs of much of today's research put small and medium-sized countries at a disadvantage for some kinds of research. A challenge is therefore how to strengthen institutions that finance and organize research on a multinational basis.

The new world of agriculture is opening space for a wider range of actors in innovation, including farmers, the private sector and civil society. Linking technological progress with institutional innovations and markets to engage this diverse set of actors is at the heart of future productivity growth. Extension programs are shifting from a delivery model that prescribes technological practices to focusing on building capacity among rural people to empower them to identify and take advantage of available technological and economic opportunities.

For example, new decentralized approaches to plant breeding that involve farmers in the early stages of breeding and varietal selection can both speed varietal development and dissemination to 5-7 years, half the 10-15 years in a conventional plant breeding program. Partnerships between R&D and farmers' organizations aim to enhance the demand for innovation by bringing farmers' voices into R&D decision-making.

## The Future Funding of R&D for Agriculture.

The need to increase funding for agricultural R&D throughout the developing world cannot be overstated. Most urgent is to reverse the stagnant funding of agricultural R&D and broader knowledge systems in Sub-Saharan Africa. This must be driven by national leadership and funding, but will also require substantially increased and sustained support from regional and international organizations.

Continuing progress, especially in extending benefits of R&D to agriculture-based countries and less-favored regions elsewhere, depends critically on research in these environments on improving crop, soil, water, and livestock management and on developing more sustainable and resilient agricultural systems. These technological innovations, often location-specific, must be combined with institutional innovations to ensure that input and output markets, financial services, and farmer organizations are in place for broad-based productivity growth.

This policy brief has been extracted from the World Bank's 2008 World Development Report, *Agriculture for Development*. Further information and detailed sources are available in the Report. The Report uses a simple typology of countries based on the contribution of agriculture to overall growth, 1990-2005 and the share of rural poor in the total number of poor (2002 $2-a-day level). In agriculture-based countries (mostly Africa), agriculture contributes a significant (>20%) share of overall growth. In transforming countries (mostly in Asia), nonagricultural sectors dominate growth but a great majority of the poor are in rural areas. In urbanized countries (mostly in Latin America and Europe and Central Asia), the largest number of poor people are in urban areas, although poverty rates are often highest in rural areas.