OCP POLICY CENTER
THINK • STIMULATE • BRIDGE

Policy Brief

July 2018, PB-18/23

An Effective Technology Transfer System
Research and extension messages reach the majority of farmers

By Isabelle Tsakok

Summary

Why do farmers need access to newer technologies on a recurrent basis? Most subsistence farmers already know how to farm and undertake post-harvest processing from their parents. The main reason to turn to technology is that traditional techniques for subsistence agriculture are grossly insufficient when it comes to generating the productivity and output growth required to adequately lift millions out of poverty and keep them out of it. "Efficient but poor" as Schultz (1964:37) put it, because "there are comparatively few significant inefficiencies in the allocation of factors of production in traditional agriculture." Farmers in traditional agricultures are poor because they are trapped in low productivity systems condemning them to subsistence level equilibrium. For the transformation of traditional agriculture, Schultz emphasized the critical importance of public investment in the human capital of farmers and their access to new science-based agricultural technologies.

We all live today in a profoundly changing world, not one of static equilibrium. Fundamental forces of change, which are operating to transform our world include climate change; deepening globalization; the revolution in information & communications technologies (ICT); biological and biotechnological advances; relentless urbanization; and continued automation. These represent tremendous opportunities and threats to all, in particular to the vulnerable, many of whom are smallholders living on the edge of subsistence.

Three daunting challenges need to be addressed. With climate change, effective access to new technologies can make farming climate-resilient and productive; the difference between a better life and bare survival for smallholders. With increasing resource scarcity, the new technologies must be resource saving and environmentally sustainable. With fast globalizing markets and value chains, new technologies must assist not only small farmers, but also small agro-entrepreneurs, enabling them to tap into expanding markets of the Supermarket Revolution.

Introduction

Farmers the world over need good access to the results of agricultural research and extension services to improve the productivity of their farming. This is particularly important for smallholders in developing countries who cannot afford to buy such services. To transform traditional, subsistence agriculture to high productivity, commercial agriculture, Schultz (1964)[1] had long argued that it is critical that governments invest in science and technology; in extending that knowledge to farmers; as well as invest in their education so that they understand the scientific basis of the new technologies and be empowered by using it. Overwhelming evidence from countries that have successfully transformed their agricultures clearly show that Schultz was correct. However, despite such evidence, the financing of an effective agricultural technology transfer system, fed by a continual stream of new research results (henceforth referred to as R&D), extended to the majority of farmers over decades, continues to be a major problem in many developing countries (LDCs).

The existence of effective R&D and related extension services accessible to and benefiting the majority of farmers is one of the five conditions that are common to all successful cases of agricultural transformation (Tsakok, 2011: xxi).[2] In analyzing what these successful cases have in common, a major finding is that what made the critical difference between success and failure is the synergism and sustainability of these conditions combined. A long-term vision and commitment is required to bring these conditions together. It is within such an overall political economy framework that the productivity-increasing and poverty-reducing power of each condition must be understood. The more common situation of having one condition at a time, and each only over a short period of time is not good enough.

This policy brief discusses why this condition is important, what it means, what it requires of governments to put in place such a condition, and what concrete steps policy makers can consider when setting up an effective and enduring technology transfer system.

1. Schultz, Theodore W. 1964. Transforming Traditional Agriculture New Haven, CT: Yale University Press

2. Tsakok. Isabelle. 2011. Success in Agricultural Transformation: What it Means and What Makes it Happen. Cambridge University Press.

Why this condition is important

Systematic and widespread application of R&D and related extension services on basic staples by millions of farmers, working in positive incentive and marketing environments have, among other things, helped humanity escape the Malthusian nightmare of famine, and the social upheavals induced. Instead of this nightmare scenario, agriculture at a global level, has grown at around 2.2 percent a year, between 1980 to 2016; above population growth averaging 1.4 percent per year, thus driving down real cereal prices by some 1.8 percent per year over the same period.[3] Livestock expansion, in particular, poultry production, was a major factor in the agricultural growth of developing countries which drove much of this global performance. The major contributor to such growth was productivity gains not area expansion.

This is a great success story. Indeed, since the 1960s, cereal yields in developing countries have risen consistently at a global level from one ton/ha (1960) to 3 ton/ha (2005). The package of high-yielding wheat, maize and rice varieties (HYV), when used with assured water availability and fertilizer supplies brought about a revolution in yields, aptly referred to as the Green Revolution.[4] The semi-dwarf rice variety IR8, developed by the International Rice Research Institute (IRRI),[5] was widely adopted in Asia –in South Asia which had around 39 percent irrigated and in the East Asia and the Pacific region, with around 29 percent irrigated (in the early 2000s) (WDR, 2008: 51). In the 1980s and 1990s, improved crop varieties have continued to spread, contributing to as much as 50 percent of yield growth, and cost reduction benefitting poor consumers in particular (WDR, 2008: 159-60).

However, Sub-Saharan Africa (SSA) has largely not participated in, nor benefitted from, this Green Revolution. Agricultural growth per capita of agricultural population was virtually zero in the 1970s, and negative throughout

3. World Bank. 2008. World Development Report: Agriculture for Development. This report has data from 1980-2004, which has the same message about production growth exceeding population growth.

4. The term "Green Revolution" is attributed to William S Gaud of the United States Agency for International Development (USAID). He first used this term in a speech on March 8, 1968. He was contrasting the revolution brought about by these new agricultural technologies to the Red Revolution of the Soviet Union and the White Revolution of the Shah of Iran.

5. IRRI headquartered in Los Baños, Laguna, is a collaboration between the Government of the Philippines and the Ford and Rockefeller Foundations. It is a member of the CGIAR consortium.

the 1980s and early 1990s. However, there has been positive growth since the late 1990s. Annual agricultural growth in SSA has averaged 3.2 percent (2003-15), half of the 6 percent target set by the Maputo declaration in 2003. (ACET, 2017: 29).[6] The challenge remains: SSA needs an agricultural transformation. To achieve this, investing in R&D and related extension services is essential. To transform their agriculture, low productivity farmers need to have access to an effective technology transfer system.

What it means

Science-based technologies are needed to achieve multiple goals; e.g., restore/increase soil fertility; save on production inputs; conserve natural resources; withstand harsh climatic conditions and respond to climate change in a resilient and productive way; resist pests and other plant/animal diseases; increase yields; promote consumer health and nutrition; and help farmers make more money. A tall order. Not only are the challenges numerous, but several of these factors are constantly evolving; e.g., constantly mutating plant and animal viruses and diseases.

The set of agricultural technologies developed by CGIAR centers worldwide is equally diverse.[7] In addition to the Green Revolution technologies of the 1960s and 1970s, public breeding programs in LDCs have released more than 8,000 improved crop varieties over the last 40 years. The yield increases generated have reduced cereals prices by 18-21 percent by 2000, thus greatly benefitting poor consumers. These yield increases have also saved many hectares of forest and fragile ecosystems from cultivation. However, these technologies require fertilizers, and good water control to bear fruit.

In addition to genetic improvements, there has been research on technologies for better soil and resource management. An important such technology is Zero Tillage, which in comparison to conventional tillage saves labor and energy, conserves the soil, increases tolerance to drought, and reduces greenhouse gas emissions. However, this technology makes the control of weeds, pests and diseases more complex, so that farmers often have to use herbicides. Zero Tillage applied to the rice-wheat systems of the Indo-Gangetic plain requires that wheat be planted immediately after rice is harvested. Through timely sowing, this method increases wheat yields while reducing production costs by 10 percent, and water use by 20-35 percent, while improving soil structure and fertility. It is estimated that Zero Tillage on the rice-wheat systems of the Indo-Gangetic plain has a rate of return of 57 percent (WDR, 2008: Box 7.1).

Zero Tillage (ZT) is the core method in what is more broadly referred to as Conservation Agriculture (CA), a method which started decades ago but have spread; e.g., in Australia, from the 1960s on, for its winter cereals in rotation with oilseeds and legumes, to occupy 80-90 percent of its 23.5 m ha devoted to winter crops (Bellotti & Rochecouste, 2014: 21-22);[8] in the Cerrado of Brazil, where ZT/CA technology spread from virtually zero in the mid 1970s to around 12 m ha by 2000 or about 30 percent of the area under annual summer crops (FAO, 2004).[9] Weed control and therefore the use of herbicides is important in ZT/CA.

Bio-engineered plants show the substantial potential of biotechnology; e.g., plants with higher and more stable yields; reduced pesticide need; salt and flood tolerant; and more nutritious (e.g., vitamin A in Golden Rice). But they also show the controversies that arise in large part due to the nature of the institutions that invest in and market them. For example, Bt cotton[10] is grown extensively and profitably by farmers in both China and India, but in India, it has been blamed for causing suicides, because of the relatively high cost of the seeds supplied by private companies. In China, the BT seeds were low cost because they were developed by public research and the varieties were better adapted to local conditions because of decentralized breeding. In India, it was alleged that the

6. African Center for Economic Transformation. 2017. Agriculture Powering Africa's Economic Transformation.

7. The Consultative Group of International Agricultural Research (CGIAR) was created in 1971 with the mission of making knowledge of agricultural science available to all developing countries for building a more food-secure and less poverty-ridden world. Its researchers work on agriculture—crops and livestock, forestry, and fisheries. (Accessed June 02, 2018)
https://group.springernature.com/gp/group/responsible-business/consultative-group-on-international-agricultural-research-cgiar-/12076914
https://en.wikipedia.org/wiki/CGIAR (Last edited April 12, 2018)

8. Bellotti, B, and J.F. Rochecouste. "The Development of Conservation Agriculture in Australia – Farmers as innovators" in International Soil and Water Conservation Research, Vol. 2, No. 1, 2014, pp. 21-34. Winter cereals in Australia are wheat, barley, oats, and triticale.

9. FAO. Conservation Agriculture Working Group. Brazil case study of conservation tillage. Summer crops are corn, soybean, rice, cotton (Accessed June 5, 2018) http://www.fao.org/docrep/004/Y2638E/y2638e01.htm#TopOfPage

10. BT stands for Bacillus thuringiensis are a family of toxins. Instead of spraying cotton with insecticides containing toxins, they are injected in the cotton seeds, which make them insect resistant. BT cotton was successfully developed by Monsanto in 1988, and introduced commercially in 1996 in the United States, Australia and Mexico.

high cost of the seeds pushed many farmers to suicide –farmers who had to borrow but then were not able to recoup their expenditures because of crop failure (due to whatever reason). In fact, cotton areas where these suicides have occurred have been sensationalized as "the suicide belt" (Baffes, 2011:7-8).[11]

Other than the financial burden on farmers (which is of course not unique to transgenic crops), there are issues which make the use of biotechnology problematic for LDCs and the European Union (EU) alike (though for different reasons). For LDCs and for the EU, these respectively include:

- For LDCs: The dominance of private sector investment means that much of the research is driven by the commercial interests of the rich developed countries rather than the basic food needs of the poor. So far, the main bioengineered crops in LDCs are maize for animal feed, soybeans, and cotton. There is progress on food crops but it is slower. As of the early 2000s, research results on transgenic rice, eggplant, mustard, cassava, banana, sweet potato, lentil, and lupin were being field tested in public research in LDCs. By 2016, food crops grown commercially included –in DCs— canola oil, sugar beet, potato; in LDCs-mustard, rice, tomato, papaya, potato. (ISAAA, Brief 52:crops 2016);[12]

- For the EU: The EU applies the precautionary principle to the use of GM technology in the entire food chain from farmer to final consumer. Its key concerns are the possible negative impact of GMOs on the environment; decrease in biodiversity; health, and the safety of humans and animals. The EU has therefore a "comprehensive and strict legal regime" on GMOs (EU, 2014)[13] The controversies over these negative impacts are still ongoing.

11. Baffes, John. August 2011. Cotton, Biotechnology and Development. World Bank Policy Research Working Paper # 5896. The claim made that the financial burden of Bt cotton seeds was the cause of farmer suicides was vigorously disputed by Gruère, Guillaume P., Purvi Mehta-Bhatt, and Debdatta Sengupta (2008). 'Bt Cotton and Farmer Suicides in India: Reviewing the Evidence.' Discussion Paper No. 808. Washington DC: International Food Policy Research Institute.

12. International Service for the Acquisition of Agri-Biotech Applications (ISAAA), Brief # 52. Global Status of Commercialized Biotech/GM Crops:2016 . (Accessed June 7, 2018)
http://africenter.isaaa.org/wp-content/uploads/2017/06/ISAAA-Briefs-No-52.pdf

13. European Union. "Restrictions on Genetically Modified Organisms". By Theresa Papademetriou, March 2014 (Accessed June 7, 2018)
https://www.loc.gov/law/help/restrictions-on-gmos/eu.php

R&D without extension to farmers, especially to women who are important agricultural labor force components especially in SSA, is of limited use to increasing agricultural productivity and the resilience of production systems. Since the mid-1990s, the dominance of the centralized approach of the Training and Visit (T&V) system of extension has been gradually replaced by a multiplicity of decentralized and demand-driven approaches, being funded by public and private sectors, as well as NGOs and farmer organizations. The search for the "best fit" approach in different localities is an ongoing challenge. The challenge also includes how to exploit the ICT revolution to improve small farmer access to basic education and extension messages.

What it requires of governments to put in place this condition

Returns to agricultural R&D investments are consistently very high, in SSA as elsewhere—35-40 percent (WDR, 2008: Fig 7.2). For China, researchers estimate that the IRR (Internal Rate of Return) for agricultural research was 50 percent (Huang and Hu, 1998) and 70-100 percent (Fan 1997), (Huang et al: 2000: 17). [14] Despite these high returns, public sector underfunding has been a chronic problem in many developing countries. In addition, entities in the private sector have little incentive to invest in production systems that they cannot appropriate monetary benefits from. To put in place the condition of effective technology transfer to benefit smallholders thus requires that public sector overcome major structural problems.

Three main factors have undermined investment in R&D and related extension services. One, is the long-term nature required for returns to materialize and their riskiness. That is particularly true of varieties that can perform well under harsh conditions such as drought, flood, heat, and salinity. For example, it took the International Maize and Wheat Improvement Center (CYMMIT) more than 30 years to develop drought tolerant maize varieties and hybrids. Many LDC governments have preferred to subsidize private inputs such as fertilizers to obtain short-term results. Two, the self-pollinating nature of many of the most important staples; e.g., rice, wheat,

14. Huang, Jikun, Lin, Justin Y, Rozelle, Scott. Aug 2000. What will make Chinese agriculture more productive? Working Paper # 56. Center for Research on Economic Development and Policy Reform. Stanford University.

maize, sorghum—means the private sector does not have an assured market from farmers who have to buy their seeds from private companies. Three, the high fixed costs and therefore economies of scale of developing and maintaining technology transfer systems combine with the inability to contain the benefits to one's own country make investing in these services a major problem for small countries with scarce public resources. The African Union boasts of 54 members.[15]

In fact, most countries have been freeriding on the efforts of other countries. The CGIAR and its centers were set up to provide spillovers in technological innovations to benefit all. Unfortunately, SSA's potential to capture spillovers from outside the region is less than in other regions partly because many crops grown in SSA are so-called orphan crops (such as cassava, yams, millet, plantain, and teff), where there is little global public or private R&D. There is also limited scope to capture R&D spillovers within the region itself because of the considerable heterogeneity of its rain fed systems (WDR, 2008: 168); and the low percentage irrigated which also limits the spread of R&D spillovers from irrigation systems.

The Malabo Declaration (2013), requiring each African government to commit at least 10 percent of its public expenditure on agriculture, is an excellent recognition of the commitment needed; but to make a difference on the ground, it must be complemented by an actual strategy on how to do it. Experience to date amply shows that the majority of African governments have found the commitment difficult to adhere to. How government leadership has succeeded in overcoming such obstacles is presented next.

15. It is 55 members if one includes the Western Sahara that the Kingdom of Morocco does not recognize. (Dated July 31, 2017. Accessed June 28, 2018) https://africacheck.org/reports/how-many-countries-in-africa-how-hard-can-the-question-be/

What governments can do: The case of EMBRAPA, Brazil

Governments must want to realize their long-term vision of transforming their agriculture and food sector and thereby, the livelihood of their people. EMBRAPA is a case in point.

EMBRAPA (Empresa Brasileira de Pesquisa Agropecuária; Brazilian Agricultural Research Corporation) created in 1973, under the Ministry of Agriculture, funded by the Government of Brazil, is a mission-driven public organization to provide feasible and innovative solutions through research and development to promote the sustainable development of Brazilian agriculture and agrobusiness; and to benefit the Brazilian people (EMBRAPA website).[16]

Its main achievements include (Correa and Schmidt, 2014): [17]

- Turning the acidic soils of the Cerrado –22 percent of Brazil's surface areas—into productive arable land, important for grains –rice, maize and soybeans and not just beef cattle as before.
- Developing cross-breeding techniques that led to the development of soybean varieties better suited to the Cerrado's acidic soils and with a shorter lifecycle enabling two harvests per year.
- Developing cottonseeds better adapted to the semi-tropical humid conditions and with higher yields per hectare, thus reviving Brazil's cotton industry.

EMBRAPA, now considered a leading tropical research institute, has transferred more than 9,000 technologies to farmers; has built an intellectual property portfolio of more than 350 cultivars; and about 200 international patents. Key factors contributing to such performance are:

- Sustained adequate levels of public funding even

16. https://www.embrapa.br/en/about-us

17. Correa, Paula and Christiane Schmidt. June 2014. "Public Research Organizations and Agricultural Development in Brazil: How did Embrapa get it right?" Economic Premise. # 145. World Bank. (Accessed June 07, 2018) http://documents.worldbank.org/curated/en/156191468236982040/pdf/884900BRI0EP1450Box385225B000PUBLIC0.pdf

through difficult economic times. Its levels of funding compare well with levels of funding in developed countries, such as Canada, United States and Australia.

- Sustained investment in the human capital of its staff and active promotion of a meritocratic culture in the organization.

- International collaboration and research excellence. EMBRAPA has actively promoted international research partnerships, including borrowing from the international pool of knowledge; e.g., developing partnerships with USDA-ARS, and CIAT.[18]

Brazil's leadership in R&D is both inspiring and sobering:[19] Inspiring because it shows what can be accomplished when a visionary government gets to work; and sobering because it shows the long lead times and substantial resource commitment required. It is definitely a long march but one that must be taken to transform agriculture and reduce poverty.

18. United States Department of Agriculture-Agricultural Research Service; International Center for Tropical Agriculture. CIAT, founded in 1967, is a member of CGIAR, and is located in Cali, Colombia.

19. Brazil is also famous for its pioneering long term investment in turning sugar cane into ethanol, a major bio-fuel which rivals gasoline. Here too, the same components of success exist: government/public sector leadership, substantial and sustained public investment, working with universities and private sector, coordinating efforts in different fields –agriculture science and sugar cane technology; aerospace technology; and car manufacture. For more information, see link, dated 06/12/07. (Accessed June 08, 2018)
https://www.scidev.net/global/policy/feature/sugarcane-ethanol-brazils-biofuel-success.html

About the author, Isabelle Tsakok

Isabelle Tsakok is an adjunct professor at SIPA and a Senior Fellow at OCP Policy Center who focuses on rural development, agricultural economics, policy analysis, food security and poverty reduction. She holds a PhD in Economics. Dr. Tsakok has worked on development issues for over twenty-five years, first as World Bank staff and since retirement as a consultant. She has specialized in policy analysis, program and project formulation and evaluation, research and training activities in agriculture, agro-business, rural development and poverty reduction. She has worked in most regions of the developing world: Africa, Asia - South, Southeast and East, North Africa and the Middle East and Latin America.

About OCP Policy Center

OCP Policy Center is a Moroccan think tank whose mission is to promote knowledge sharing and contribute to enhanced thought on economic issues and international relations. Through a Southern perspective on critical issues and major regional and global strategic issues faced by developing and emerging countries, OCP Policy Center provides a veritable value added and seeks to significantly contribute to strategic decision-making through its four research programs: Agriculture, Environment and Food Security; Economic and Social Development; Conservation of Raw Materials and Finance; and Geopolitics and International Relations.

OCP POLICY CENTER
THINK • STIMULATE • BRIDGE

OCP Policy Center

Ryad Business Center – South, 4th Floor – Mahaj Erryad - Rabat, Morocco
Email : contact@ocppc.ma / Phone : +212 5 37 27 08 08 / Fax : +212 5 37 71 31 54
Website: www.ocppc.ma