Strategy Paper

Ensuring Food and Nutrition Security in Asia: The Role of Agricultural Innovation

Seventh TAAS Foundation Day Lecture

January 11, 2013

by

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Progress Through Science

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Progress Through Science

Trust for Advancement of Agricultural Sciences (TAAS)

GOAL

An accelerated movement for harnessing agricultural sciences for the welfare of people.

MISSION

To promote growth and advancement of agriculture through scientific interactions and partnerships.

OBJECTIVES

- To act as think tank on key policy issues relating to agricultural research for development (ARD).
- Organizing seminars and special lectures on emerging issues and new developments in agricultural sciences in different regions of India.
- Instituting national awards for the outstanding contributions to Indian agriculture by the scientists of Indian and other origin abroad.
- Facilitating partnerships with non-resident Indian agricultural scientists visiting India on short leave.

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Introduction

According to new estimates from the Food and Agriculture Organization (FAO) of the United Nations, nearly 870 million people suffer from hunger today. Over 50 countries have levels of hunger that are "extremely alarming," "alarming," or "serious" according to the IFPRI 2012 Global Hunger Index, many of which are in South Asia and Africa South of the Sahara. Furthermore, according to the World Health Organization of the United Nations, more than two billion suffer from micronutrient deficiencies with a significant share residing in Asia.

Asia's food and nutrition security is under stress due to many interconnected factors that include population growth and urbanization, demographic changes, increased labor cost, high and volatile food prices, natural resource constraints, and climate change. In order to achieve food and nutrition security in Asia an integrated and more innovative development agenda must be adopted in terms of strategies, investments, technologies, institutions, and partnerships.

In this paper we discuss the important role that investments in agricultural research and development (R&D) and the resulting advances in agricultural science and technology play in reducing poverty and food insecurity in Asia.

1. Persistent poverty, food and nutrition insecurity in Asia

Global poverty measured at the $1.25 a day line has been decreasing since the 1980s. According to the World Bank, the number of people living in extreme poverty fell from 1.9 billion in 1981 to less than 1.3 billion in 2008 (World Bank 2012). If this trend continues, the MDG goal of cutting the rate of absolute poverty between 1990 and 2015 is on track.

Much of this decline happened in Asia with East Asia (driven mainly by China) showing the largest decline in poverty in the world (share of people living on less than $1.25 a day fell from 84 percent in 1981 to 14 percent in 2008; see Table 1). Due to this dramatic progress in poverty alleviation, East Asia is recognized as the only region in Asia that has already achieved, well in advance, the Millennium Development Goal (MDG) target of reducing 1990 poverty rates by half by 2015.

Asian countries experienced an unevenly decline in poverty rates over the past two decades, however. Between 1981 and 2008, the poverty rate in South Asia fell from 58.7 percent to 34.4 percent with a similar trend seen for India. Despite this progress, poverty remains widespread in South Asia with the number of people living in poverty declining only by about 7.5 percent from 1990 (617 million) to 2008 (571 million) (World Bank 2012). As a result, South Asian countries risk not meeting the MDG targets by 2015.

Compared to the progress achieved in poverty reduction, less progress has been made in cutting hunger and malnutrition, and food and nutrition insecurity continues to be an important challenge in Asia. The region as a whole is not on track in meeting the MDG goal of cutting the rate of

Table 1. Share of people living on less than 2005 PPP $1.25 a day (%)[1]

Region	1981	1990	2005	2008
Asia	67.9	53.0	26.0	23.1
Middle East and North Africa	9.6	5.8	3.5	2.7
Southern Asia	58.7	51.5	37.8	34.4
India	59.8	51.3	40.8	37.4
Caucasus and Central Asia	7.5	9.8	7.2	3.7
Eastern Asia	84.0	60.2	16.3	13.1
China	84.0	60.2	16.3	13.1
South-Eastern Asia	57.1	45.3	18.9	17.2

Source: World Bank (2012)

1In order to generate the poverty estimates, we used the country grouping followed by the FAO except for Middle East & North Africa and Eastern Asia groups due to lack of data. The Eastern Asia group in Table 1 contains China and Mongolia while the corresponding FAO group (see Table 2) also includes Democratic People's Republic of Korea and the Republic of Korea for which poverty data is missing.

undernourishment by half between 1990 and 2015. Only in the Southeastern Asia, the trend is on the MDG target.

According to the latest estimates of the Food and Agriculture Organization (FAO) of the United Nations, more than half a billion people in Asia—nearly two thirds of the global total—are still undernourished (Table 2). However, estimates also indicate that recent improvements in global undernutrition are due to progress in Asia. Between 1990-1992 and 2010-2012, the prevalence of undernutrition in the region fell by 24 percent (by 176 million people), with China, Thailand, and Vietnam experiencing especially substantial reductions in both the number of undernourished people and the rate of undernourishment. At the same time, in countries like Nepal, Pakistan, and Philippines even though the rate of calorie undernourishment decreased, the number of undernourished living in these countries has actually increased.

Given their large population size, China and India alone are home to almost two thirds of the region's undernourished population. India accounts for some 217 million, or a quarter of all undernourished people globally. As a result, India is likely to miss the Millennium Development Goal of

Table 2. Level of undernourishment in Asia, 1990-92 to 2010-12

Region		1990–92	1999–2001	2004–06	2007–09	2010–12
Asia	Number (millions)	739	634	620	581	563
	Prevalence (%)	23.7%	17.7%	16.3%	14.8%	13.9%
Western Asia	Number (millions)	8	13	16	18	21
	Prevalence (%)	6.6%	8.0%	8.8%	9.4%	10.1%
Southern Asia	Number (millions)	327	309	323	311	304
	Prevalence (%)	26.8%	21.2%	20.4%	18.8%	17.6%
Caucasus and Central Asia	Number (millions)	9	11	7	7	6
	Prevalence (%)	12.8%	15.8%	9.9%	9.2%	7.4%
Eastern Asia	Number (millions)	261	197	186	169	167
	Prevalence (%)	20.8%	14.4%	13.2%	11.8%	11.5%
South-Eastern Asia	Number (millions)	134	104	88	76	65
	Prevalence (%)	29.6%	20.0%	15.8%	13.2%	10.9%

Source: FAO. 2012. The 2010-12 figures are projections.

halving, between 1990 and 2015, the proportion of people who suffer from hunger.

Another major aspect of food and nutrition security relates to micronutrient deficiency, i.e. the prevalence of deficiencies in essential micronutrients such as vitamin A, iron, and iodine. Micronutrient deficiencies have the potential to weaken the mental and physical development of children and adolescents and to reduce the productivity of adults due to illness and reduced work capacity. Micronutrient deficiencies are extremely widespread in Asia. Iron deficiency is considered the leading cause of anemia globally and South Asia has the second largest prevalence of anemia (after Africa) among children and pregnant women, with approximately two-thirds of children and nearly half of pregnant and non-pregnant women affected (WHO 2012). The loss in productivity as a result of micronutrient deficiency is estimated to cost India the equivalent to 2.95 percent of GDP annually (FAO 2012).

Despite the above challenges Asia is facing today, there are reasons to be hopeful about the future. The experience of the Green Revolution has shown that enormous progress can be made in feeding great numbers of people. Technological innovations as well as effective policies and institutions were critical for success during this period.

Agriculture continues to play a significant role in the national economy and food security situation of many developing countries in Asia and its sustained growth will be critical to eradicate poverty, hunger, and malnutrition from the region. In order to achieve these goals, an integrated and more innovative agricultural development agenda must be adopted in terms of strategies, investments, technologies, institutions, and partnerships.

In the rest of the paper we discuss the important role that investments in agricultural R&D and the resulting advances in agricultural science and technology play in reducing poverty and food insecurity in Asia.

2. Investments in agricultural R&D: an increasingly dividing world

In the past several decades, agricultural research has played a crucial role in accelerating agricultural productivity growth in developing countries that contributed to reducing poverty, hunger, and malnutrition (Nin-Pratt and Fan 2010). However, despite the huge returns to agricultural research, public spending in agricultural R&D relative to agricultural output has not been increasing in many poor countries (Figure 1).

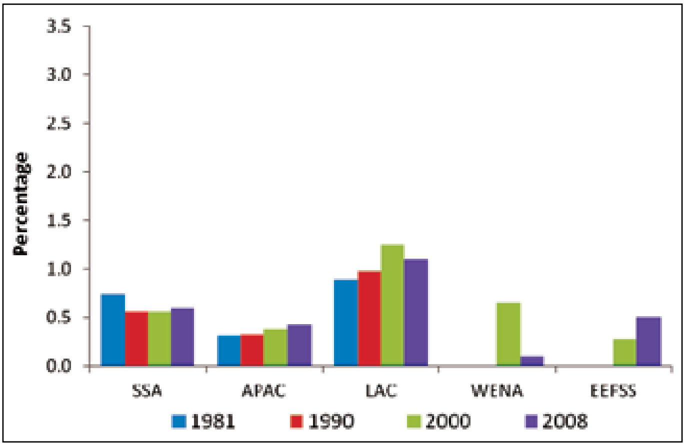

Figure 1 Public Agricultural R&D spending as a share of agricultural GDP by region (%)

Source: Beintema et al. 2012
Note: SSA=Africa south of the Sahara; APAC= Asia-Pacific countries; LAC = Latin America and the Caribbean; WANA=West Asia and North Africa; EEFSS = Eastern Europe and former Soviet States. The rates exclude high-income countries.

In 2008, for every $100 of agricultural GDP (in 2005 PPP), the Asia-Pacific region spent only $0.42, which is the lowest across the regions. This is, for example, in direct contrast to developed countries that spend about $2.36 on public agricultural R&D for every $100 of agricultural output (Pardey et al. 2006). This fact highlights the underinvestment in agricultural R&D in developing Asian countries and the gap in capacity to generate new technology between rich and poor nations (Nin-Pratt and Fan 2010).

Within Asia-Pacific there are also large variations both in the total amount and growth rate of spending in agricultural R&D. While China and India are the main drivers of both expenditure levels as well as growth of spending in agricultural R&D in Asia, other emerging countries such as Indonesia and Vietnam have also significantly increased their spending in R&D.[2] On the other hand, public spending in agricultural R&D in other developing countries in Asia including Cambodia, Lao PDR, Nepal, and

[2]For example, between 1996 and 2007, China and India increased their annual spending in agricultural R&D by about 12 and 9 percent respectively. The two countries together with Brazil account for about half of public agricultural R&D spending in developing countries.

Papua New Guinea have either stagnated or even declined in the past decade (Beintema *et al.* 2012).

The CGIAR (Consultative Group on International Agricultural Research) consortium, which is comprised of 15 centers that advance global food security through research, also makes significant contributions to public spending in agricultural R&D in developing countries. Since 2006, after more than a decade of slow growth, R&D spending by the CGIAR has increased significantly. In 2011, total spending by CGIAR exceeded $700 million, a 41 percent increase from 2006 after adjusting for inflation (Beintema *et al.* 2012).

In comparison to other regions, the share of CGIAR spending in the Asia-Pacific region has shown minimal changes over time. In 1990, 30 percent of total CGIAR expenditure was allocated to the Asia-Pacific region and a similar share was allotted in 2008 (Figure 2). It is also noteworthy that the volume of expenditure for the region has increased by about 22 percent during the same time while both the volume and share of CGIAR spending has decreased for Latin America, West Asia, and North Africa. However, even with this increased spending in Asia, total CGIAR expenditure represented only 2% of the total national system investment in the region in 2008 (Beintema *et al.* 2012). This

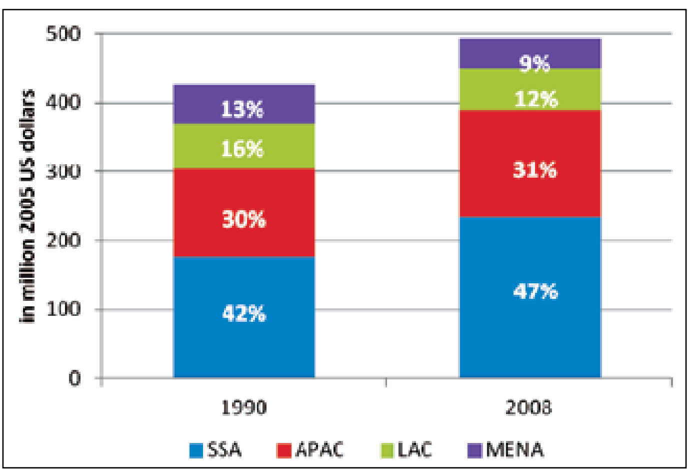

Figure 2 CGIAR spending in agricultural R&D by region

Source: Beintema et al. (2012)

Note: SSA=Africa south of the Sahara; APAC= Asia-Pacific countries; LAC=Latin America and the Caribbean; WANA=West Asia and North Africa; EEFSS= Eastern Europe and former Soviet States.

is a concern given that agricultural spending in R&D in Asia is among lowest in the world in relation to its agricultural output. CGIAR investments in Asia must be accelerated in order to support country led strategies to achieving food and nutrition security in the region.

Assessing the impacts of any type of public spending is complicated. Many factors influence the relationship between public spending and development outcomes, and these factors act in complex and sometimes contradictory ways and with a lag. However, as Fan, Mogues, and Benin (2009) show, broad conclusions can be made. Their study examines the impacts of public spending on agriculture, education, health, and road infrastructure on growth, welfare, and poverty reduction in a number of Asian and African countries studied (Table 2).

The returns reported in Table 2 show that agricultural spending in research and development generally has the largest positive effects on growth and poverty reduction. In many cases government agricultural spending in R&D has contributed substantially to agricultural productivity, rural household income, rural household consumption, and rural poverty reduction. For each unit of local currency spent on the agricultural R&D, on average 11 local

Table 2 Returns to Public Spending in Asia and Africa

Sector	China	India	Thailand	Ghana	Uganda	Tanzania	Ethiopia
	Returns to agriculture or rural income (local currency/local currency spending)						
Agric. R&D[a]	6.8	13.5	12.6	16.8	12.4	12.5	0.14
Education	2.2	1.4	2.1	-0.2	7.2	9	0.56
Health	n.e.	0.8	n.e.	1.3	0.9	n.e.	-0.03
Roads	1.7	5.3	0.9	8.8	2.7	9.1	4.22
	Ranking in returns to poverty reduction						
Agric. R&D	2	2	1	n.e.	1	2	n.e.
Education	1	3	3	n.e.	3	1	n.e.
Health	n.e.	4	n.e.	n.e.	4	n.e.	n.e.
Roads	3	1	2	n.e.	2	3	n.e.

Source: Fan, Mogues, and Benin (2009)

[a] This refers to agricultural spending in R&D except in Ethiopia and Ghana, where it is agricultural spending aggregated across subsectors.

currency units are returned in terms of increased agricultural productivity or income across the Asian countries studied (Table 2).

Investments in agricultural R&D have substantially reduced rural poverty by stimulating agricultural growth and reducing food prices. However, as the results in Table 2 shows, spending in agricultural R&D is not always the top contributor to reducing poverty, suggesting that cross-sectoral impacts (such as the contribution of rural road infrastructure to agricultural productivity) may be substantial. The type of agricultural spending can be as important as the amount and the organization and governance of agricultural policymaking influence the productivity of expenditures undertaken in support of the sector (Fan, Mogues, and Benin 2009).

Looking more closely at India, the results also show that about 13.5 rupees are returned for every rupee invested in agricultural R&D. This finding has important policy implication for India. Even though the Indian government has substantially increased its expenditure on agricultural R&D since the late 1990s, by 2009 public spending on R&D was only \$0.40 for every \$100 of agricultural GDP (ASTI 2012). The government of India should, therefore, increase investments in agricultural R&D, rural infrastructure, and education as these have high payoffs in terms of raising smallholder farmers' productivity and incomes. This increased investment should be accompanied by cutting inefficient agricultural subsidies as these have come at the expense of high return investments in the past.

In Table 3 we present the result of a simulation exercise by Nin-Pratt and Fan (2010) that shows the impact of doubling agricultural R&D investments between 2010 and 2015 on agricultural production growth and poverty reduction, while maximizing total agricultural output.

Doubling investment in agricultural R&D and output maximizing scenario results in 261 million people moving out of poverty globally by 2025, compared with 153 million under historical rates of investment. Of this 261 million, 124 million live in South Asia (with 100 million in India), 78 million live in SSA, and 57 million live in East and Southeast Asia.

The empirical results presented in this section have important policy implications. In order to foster agricultural growth and reduce poverty in developing Asian countries with significant rural population, public institutions must prioritize spending in agricultural R&D as this generally has one of the largest positive effects on growth and poverty reduction. The results also show that investments must be made in public spending items with

Table 3. R&D investment and impact on poverty and output growth doubling investment between 2010 and 2015 and maximizing global output (poverty line is $1.25/day)

	R&D investment (mill. 2005 US$)		Number of poor (mill.)	Changes in the number of poor (mill.)	Agricultural productivity growth rate (%)
	2008	**2025**	**2008**	**2008-2025**	**2008-2025**
Asia	2864	10585	1002	–181	1.2
East & South East Asia	1956	7514	304	–57	1.29
China	1457	6102	208	–42	1.38
South Asia	908	3072	698	–124	1.01
India	707	2367	569	–100	1
Africa South of Sahara (SSA)	772	1666	364	–78	0.51
West Asia & North Africa	546	1047	9	–1	0.32
Latin America	957	2030	44	–1	0.44
Total	**5139**	**15328**	**1419**	**–261**	**0.95**

Source: Nin-Pratt and Fan (2010)

cross-sectoral impacts such as rural road infrastructure and education as these compliment investments in agricultural R&D.

How do investments in agricultural R&D contribute to achieving these developmental goals? One important way is through their advancement in agricultural science and technology that provides small-scale, resource-poor farmers and other marginalized groups with new agricultural inputs such as biotic and abiotic stress-resistant high-yielding crop varieties that promote the sustainable intensification of crops. In the next section we discuss the important role that technological innovations in agriculture such as biotechnology (including genetically modified and transgenic crops) and nanotechnologies play in achieving these goals.

3. Emerging technologies in agriculture and food

New agricultural technologies are emerging in many developing countries with a potential to fundamentally transform the agriculture and food sector.

Biotech crops, which include genetically modified (GM) and transgenic (carrying a transgene inserted from another species) crops, have promise for poor farmers in this respect. However, biotechnology in agriculture has generated a great deal of controversy in recent years. Crop specific and in-depth investigation is required to determine the potential benefits and risks of these new technologies before we settle the debate on biotech crops (Smale *et al.* 2009).

Bt cotton is by far the most studied biotech crop in Asia and analysis of the economic impacts of other crops has only begun. The evidence supports the conclusion that Bt cotton reduces pest damage and insecticide use and increases yields, but the magnitude of profits is highly variable, particularly in India (Smale *et al.* 2009).

Studies also suggest that the potential export losses from adopting GM field crops (such as rice, wheat, maize, soybeans, and cotton) that are resistant to biotic and abiotic stresses are outweighed by the potential gains from higher productivity. Adopting biotech crops also allows net importing countries to greatly reduce their imports. Gruère, Bouët, and Mevel (2007) find that GM rice is the most advantageous crop in the four countries they considered including Bangladesh, India, Indonesia, and the Philippines.

Looking at India's rice sector more closely, hybrid rice accounted for less than 6 percent of the country's 44 million hectares under rice cultivation as of 2008–2009 (Figure 3). The poor performance on this front is largely

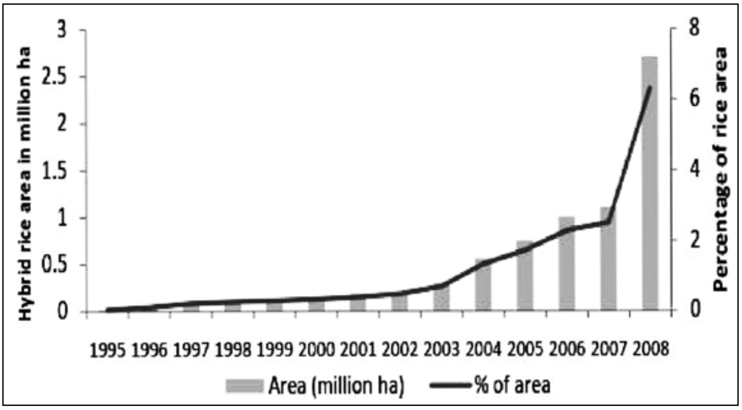

Figure 3. Area under hybrid rice cultivation in India, 1995–2008

Source: Spielman et al., (2011)

attributable to farmers citing inconsistent yield performance, low grain quality, high susceptibility to pests, and other factors that led to significant levels of rejection and dis-adoption (Janaiah 2002). In the last several years, the adoption of hybrid rice in India appears to be gathering momentum, however. Since 2005, the proportion of area under hybrid rice has grown at a rate of about 40 percent per year, though from a low base (Spielman *et al.*, 2011).

In contrast to India's experience, as of 2010, hybrid rice in China accounted for more than 50 percent of all land under rice cultivation, yielding between 15 and 31 percent more than other cultivated rice varieties. The dissemination of hybrid rice between 1978 and 2008 contributed to a 68.4 percent increase in national rice yields, raising average yields from 4.0 to 6.7 tons per hectare during this period (Figure 4). Total national rice production similarly increased by 44 percent, from 136.7 million tons in 1978 to 197 million tons in 2008 (Li, Xin, and Yuan 2010).

Other existing and emerging agricultural technologies with great potential for smallholders in South Asia include submergence-tolerant rice, and high-yielding chickpea and pigeon pea varieties (USAID 2012). These and other technologies that have been proven to work in different contexts and agro-ecological environments should be scaled up to reach more small scale farmers in Asia.

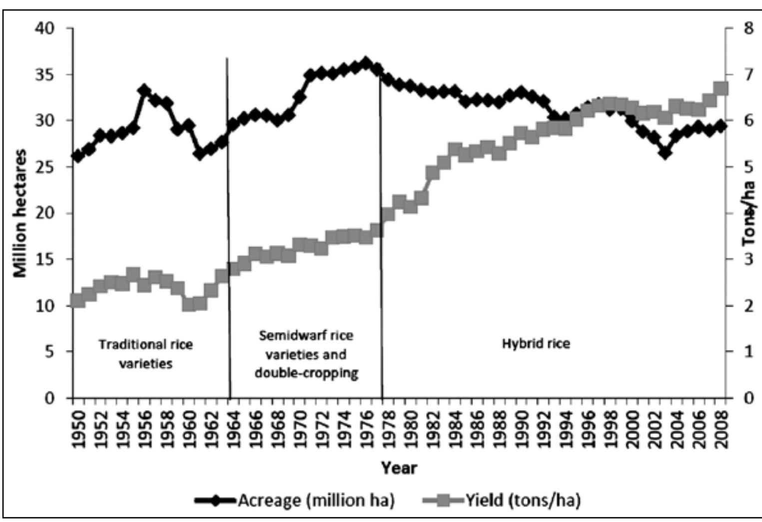

Figure 4. Rice cultivation and yields in China, 1950–2008

Source: Li, Xin, and Yuan (2010)

Promising nanotechnol¬ogy applications such as artificial photosynthesis could also address, among others, low use efficiency of agricultural production inputs and stress of drought and high soil temperature in many Asian countries. However, little research has targeted developing-country needs and, in particular, the needs of the poor, which has created critical gaps in the scientific understanding of ways to improve the situation of the poor both as producers and as consumers (Gruère, Narrod, and Abbott 2011).

National and international agricultural research systems should increase their exploration of nanotechnologies to increase agricultural productivity for small farmers in Asia while at the same time ensuring food and water safety. They should also work in partnership with the private sector to make the technologies commercially viable both for smallholders and agri-businesses. Scaling up complimentary agricultural innovations such as new small-scale irrigation, mechanization, and mixed farming will also be necessary to improve smallholders' resource-use efficiency, boost agricultural productivity, and promote sustainable intensification of crop production (USAID 2012).

Any investments in biotechnology to increase smallholder's productivity should also be designed with a nutritional lens, focusing on both the quality and quantity of food crops. This is particularly relevant since smallholders account for the largest share of undernourished and micronutrient deficient people in Asia. In this respect several biofortification efforts such as conventional breeding of beta-carotene-rich sweet potato and iron- and zinc-biofortified pearl millet are already underway in India. Beta-carotene-rich rice (known as "golden rice") also holds much promise for poor consumers in Asia (Wilton Park 2012). Developing Asian countries should prioritize public research investment to increase the development of these technologies and effective supply chains so as to increase production and consumption of these nutrient-rich foods (Kadiyala, Gillespie, and Thorat 2012).

Regulatory uncertainties and excessive restrictions surrounding agricultural biotechnologies and GM crop improvement in many Asian countries need to be removed in order to promote the development of agricultural technologies and provide all stakeholders the confidence to invest. This allows for a high-innovation environment in which both private and public institutions formulate strategies and partnerships based on agricultural biotechnologies that offer smallholders a range of technological solutions to different agro-ecological constraints throughout Asia. Governments should also put in place monitoring and evaluation (M&E) systems to ensure that activities surrounding agricultural biotechnologies are socially and environmentally responsible. The results of the M&E exercise should also be effectively communicated with consumers in a transparent manner.

4. Engaging new players in agricultural R&D

Ensuring global food security has usually been perceived as the responsibility of a few developed countries and multilateral organizations such as the World Bank and United Nations agencies, but the strengthening of new players in Asia, including countries such as China, India, and Indonesia; new institutions such as charitable foundations; and the private sector, is also playing an increasingly important role of ensuring food security, alleviating poverty, and ending hunger in Asia (Chen and Joshi 2011).

The private sector that operates in agricultural R&D is increasingly becoming important player in conducting advanced research, developing new technologies, and deploying products for the benefit of smallholder farmers in developing countries. In India, for example, 64 percent of the 460 Protection of Plant Varieties (PPV) applications received by the PPV Authority in 2008–2009 were from the private sector, with the remaining 36 percent from public research organizations and farmers themselves (Figure 4). The private sector has shown a demonstrated capacity to move seed and seed technology products from discovery into product development and, ultimately, to delivery to farmers in India (Spielman *et al.*, 2011).

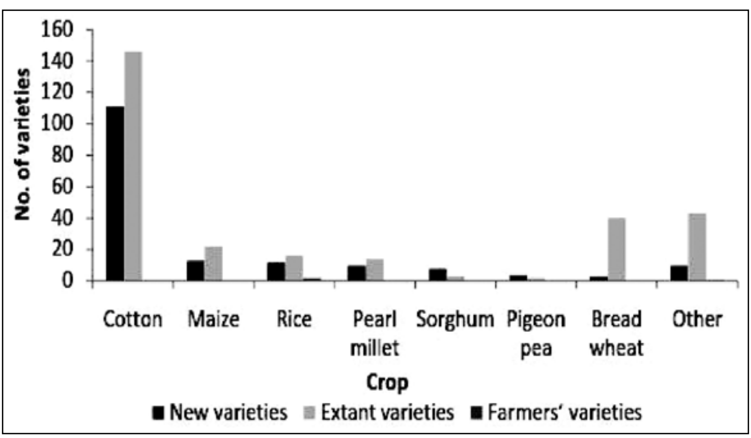

Figure 5. Applications for registration of plant varieties in India under PPV&FR Act, 2008–2009

Source: Spielman et al., (2011)

Public-private partnerships (PPP) can also provide effective and sustainable investment on agricultural innovations that benefit poor producers and consumers in Asia. However, PPP in national agricultural research system of many developing countries and the CGIAR are generally not being leveraged to promote innovation, reduce research costs, close the wide yield gap between farmers' fields and on-station research fields, and ultimately reduce poverty (Spielman *et al.* 2007). Public institutions should, therefore, provide an enabling environment for effective cooperation to take place by becoming more innovative in the ways they conduct business (such as by creating incentive schemes) and building strategic relationships with the private sector.

Emerging countries in Asia such as, China, India, and Indonesia, which have experienced rapid growth and increased integration into the global economy in recent years, have also significant potential to contribute to the region's food security. Given the large share of the world's undernourished living in India, and to some extent China, policies and initiatives to combat hunger and ensure the region's food security are especially relevant within these emerging countries. These countries need to prioritize their own public spending on agricultural research and development and improve access to input and output markets for smallholder farmers. Linkages between emerging and other developing countries in Asia should also be strengthened with the goal of enhancing the long-term, pro-poor benefits of agricultural R&D, technological cooperation, trade, investment, and mutual learning for both sides (Fan and Brzeska 2010; UNCTAD 2012).

5. Innovations in policy, institutions, and markets

Increased investments in agricultural R&D and the generation of new agricultural technologies that hold much promise for poor smallholder farmers in Asia will not have the desired outcomes unless they are supported by strong and complimentary public policies and institutions. The experience of the Green Revolution in Asia in the second half of the 20th century provides an important lesson in this respect. Farmers were incentivized to adopt Green Revolution technologies through access to a holistic package, which included inexpensive inputs (fertilizer, improved seed, pesticides, and irrigation water), credit to buy these inputs, and secured access to agricultural output markets at stable prices. Providing increased role for the private sector in Asia also contributed to reducing marketing inefficiencies and governance problems such as corruption (Hazel 2009).

Asian countries that have instituted a more equitable distribution of productive assets such as land were also better able to take advantage of the Green Revolution by promoting wide spread reduction of poverty through increased agricultural productivity and incomes. The land reform policies followed by China and Vietnam provide good examples. When China began its economic reforms in the late 1970s, it began by freeing up rural markets and decentralization of agricultural production from collective to individual households (Nin-Pratt, Yu, and Fan 2010). Land was relatively equitably distributed among rural households as a result of these reforms and in just six years – between 1978 and 1984 – crop production grew by 42.2 percent (Bruce and Li 2009). This strong agricultural growth continued even after the initial reform. The experience of Vietnam also sheds a similar light. Under the Doi Moi reform process, which took hold in 1988, Vietnam overturned collective agriculture and gave farmers land-use rights. As a result of these market oriented reforms, use of improved agricultural technologies became profitable for many farmers and the agriculture sector grew by 3.8 percent a year from 1989 to 1992 (Kirk and Tuan 2009).

Finally, in order to take advantage of agricultural innovations, smallholder farmers in Asia should also be linked to front and back ends of agricultural supply chains that ensure viable business opportunities for both farmers and agri-businesses. Establishing these linkages is not only about providing assured markets, reducing risk, and ensuring fair prices, but also providing critical services such as credit, insurance, grading and inspection, technology extension, and market information. Information and Communication Technologies (ICTs) such as the radio have played an important role in agricultural technology transfer during the Green Revolution in Asia (APAARI 2004). The potential of existing and new ICTs should be exploited more fully so that smallholder farmers can more easily access relevant and timely information on agricultural input and output markets. These institutional services can help elevate the scale at which smallholders can operate, raise their productivity and income, and mitigate the risks involved in participating in markets for agbiotech crops (Gulati, Joshi, and Landes 2006).

6. Conclusion

Food and nutrition insecurity continues to be an important challenge in Asia. Even though the region is on track to meet the MDG target of reducing 1990 poverty rates by half by 2015, many Asian countries, notably South Asian countries, are falling behind on the MDG goal. The region as a whole is also not on track to meeting the MDG of halving the hunger rate between 1990 and 2015. Looking forward, the region will face emerging problems such as population growth and urbanization, demographic changes, increased labor cost, high and volatile food prices, natural resource constraints, and climate change. Strong performing agricultural sector is required in Asia in order to solve the complex and interconnected problems of poverty, hunger, and malnutrition. In order to achieve this, an innovative development agenda must be adopted in terms of strategies, investments, technologies, institutions, and partnerships.

This paper addresses the important role that investments in agricultural research and development and the resulting advances in agricultural science and technology play in reducing poverty and food insecurity in Asia. Governments in developing Asian countries must prioritize public spending in agricultural research, education, and rural infrastructure as these hold much promise in reducing poverty and food insecurity in the region.

Investments in agricultural R&D contribute to the advancement of agricultural science and technology that provides smallholder farmers with new agricultural inputs such as biotic and abiotic stress-resistant high-yielding crop varieties that promote the sustainable intensification of crops. Biotech crops have promise for poor farmers in this respect. However, further research is required to determine the potential benefits and risks of these new technologies. For those that are proven to work for both consumers and producers, regulatory uncertainties and excessive restrictions surrounding biotech crops must be removed in order to widen the technology pipeline and provide both private and public sectors the confidence to invest. In order to ensure the uptake of agricultural innovations by smallholder farmers, future efforts must also have farmers' needs and preferences as their organizing principle. Strong complimentary public policies and institutions are also necessary for the success of agricultural innovations in Asia.

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Recent TAAS Publications

- Brainstorming Workshop on "Climate Change, Soil Quality and Food Security" August 11, 2009 - Proceedings & Recommendations (Hindi/English).
- Fourth Dr. M.S. Swaminathan Award for Leadership in Agriculture - A brief Report, August 11, 2009.
- Millions Fed: Proven Successes in Agricultural Development, January 19, 2010 (Translation in Hindi jointly published by IFPRI, APAARI and TAAS) Hindi/English.
- National Seminar on "Quality Seed for Food Security through Public-Private Partnership" April 13-14, 2010 - Proceedings & Recommendations.
- TAAS Foundation Day Lecture on "Climate Change and Food Security : From Science to Sustainable Agriculture" by Dr. Mahendra M. Shah, May 7, 2010.
- NSAI Foundation Day Lecture on "Revitalizing Indian Seed Sector for Accelerated Agricultural Growth" by Dr. R.S. Paroda, October 30, 2010.
- Brainstorming Session on Prospects of Producing 100 million tons of Wheat by 2015 and presentation of Fifth Dr. M.S. Swaminathan Award for leadership in Agriculture - Proceedings & Highlights, December 18, 2010.
- TAAS Flyer - English
- TAAS Flyer - Hindi
- Stakeholder Interface on GM Food Crops, May 19, 2011 - Recommendations.
- National Dialogue on Building Leadership in Agricultural Research Management, Hyderabad, August 27 - 28, 2010 - Proceedings & Recommendations.
- TAAS Foundation Day Lecture on "Harnessing Knowledge for India's Agricultural Development" by Dr. Uma Lele, August 12, 2011.
- Sixth Dr. M.S. Swaminathan Award Lecture for Challenges and Opportunities for Food Legume Research and Development, January 25, 2012.

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Shenggen Fan was appointed director general of the International Food Policy Research Institute (IFPRI) in December 2009. After joining IFPRI in 1995 as a research fellow, he led IFPRI's program on public investment and later became the director of IFPRI's Development Strategy and Governance Division. Shenggen has conducted extensive research on pro-poor development strategies in developing countries in Africa, Asia, and the Middle East. His work has helped identify which kinds of public spending are most effective in reducing poverty and generating agricultural growth.

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