Chapter 11

Resource Allocation for Agricultural Research in South Asia: Trends, Challenges, and Policy Implications

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Abstract

Quantitative evidence presented in this report demonstrates that total public agricultural research and development (R&D) spending in South Asia has risen considerably since 2000. This trend was largely driven by India, which has the highest investment levels and strongest human resource capacity in agricultural research South Asia by far (in terms of absolute size, average qualification levels of researchers, and the scientific outputs they produce). Compared with India, agricultural R&D faces greater challenges in the four other South Asian countries for which data were available (Bangladesh, Nepal, Pakistan, and Sri Lanka). Underinvestment in agricultural R&D in these countries is considerable, and agricultural research staff is significantly less-qualified than in India, the combined result of prolonged recruitment freezes, losses of highly qualified senior staff, limited training opportunities, and an aging population of researchers. In addition, political instability in some countries has either delayed or complicated much needed institutional and policy reforms. The scientific competence of South Asia's agricultural R&D agencies is high, particularly in India, but as in many developing regions of the world, stronger linkages are needed to connect agricultural research agencies and their staff with the end users of their research to improve the relevance, effectiveness, and efficiency of research outputs. Further efforts to strengthen sub-regional linkages are also needed in order to better utilize limited resources and reduce wasteful duplication. In addition, good governance is key to promoting the effectiveness and efficiency of research, and ongoing policy and institutional reform will be needed to further strengthen agricultural R&D and innovation in South Asia.

Keywords: Resource allocation, agricultural research, policy, South Asia

Background

South Asia has made remarkable progress toward economic growth and poverty reduction since the turn of the millennium; nevertheless, the sub-region is still home to nearly half the world's poor and malnourished people. Poverty and malnutrition in the sub-region are not only widespread, but also increasingly concentrated in lagging rural areas, where roughly three-quarters of South Asia's poor people reside. The vast majority of the rural poor depend on the production of rainfed crops, livestock, forestry, and informal (often migratory) employment for their livelihoods.

To provide a pathway out of poverty for the sub-continent's rural poor and to tackle the widening rural–urban income gap, a revival of the agricultural sector is urgently needed. The World Bank predicts that the population of South Asia will reach 2.3 billion people by the year 2050, up from 1.8 billion today (World Bank, 2019). In order to feed these 500 million extra people and to address other pressing challenges—including adaptation to climate change and rising and volatile food prices—it is crucial that agricultural productivity in the sub-region be increased without delay.

A persuasive body of empirical evidence has demonstrated that agricultural research and development (R&D) has been a major contributor to agricultural innovation, productivity increases, and poverty reduction around the globe over the past six decades. From the 1960s through the 1980s, the so-called Green Revolution allowed significant increases in agricultural production in South Asia through the implementation of research-based agricultural methods and new technologies. These had a tremendously positive impact on food security and rural incomes; more recently, however, the impact of the Green Revolution has begun to level off. Further, the challenges that South Asia's rural population face remain daunting. Land and water have become increasingly scarce in some parts of the subcontinent as these resources have been diverted to nonagricultural activities, while misguided government policies together with climate change and rising fuel prices have added to the woes. All over the subcontinent, the call for a reinvigoration of the agricultural sector has intensified in recent years. Effective and well-targeted agricultural R&D plays a key role in this regard.

Despite the well-documented evidence that the payoffs to agricultural research are considerable, most South Asian countries continue to underinvest in agricultural R&D. Given the substantial time lag between investing in research and reaping its rewards—which is typically decades, not just years—agricultural R&D requires a long-term commitment in terms of sufficient levels of sustained funding and well-staffed research agencies. Quantitative data are essential for agricultural R&D stakeholders to be able to analyze trends in agricultural R&D investments and capacity; identify gaps; set future investment priorities; and better coordinate agricultural R&D across institutes, regions, and commodities. R&D indicators are also an indispensable tool when assessing the contribution of agricultural R&D to agricultural output and productivity growth and to economic growth more generally. This paper analyzes agricultural R&D indicators for five South Asian countries (hereafter referred to as South Asia): Bangladesh, India, Nepal, Pakistan, and Sri Lanka. It presents trends and challenges with regard to agricultural R&D investments and human resource capacity throughout the sub-region, and provides policy recommendations for ways to address some of these challenges.

The analysis in this report is based on detailed data collected by the International Food Policy Research Institute's (IFPRI's) Agricultural Science and Technology Indicators (ASTI) program.[1]. Since 2000, ASTI has periodically surveyed 500+ agricultural research agencies in the sub-region from the government, higher education, and nonprofit sector. The data in this report are presented in a highly aggregated fashion, but can be broken down by specific agency, sector, or commodity for more in-depth analysis upon request. [2]Unfortunately, ASTI has never implemented surveys in Afghanistan, Bhutan, and the Maldives. These countries are therefore excluded from the analysis. The most recent year for which data are available for Bangladesh, Nepal, and Sri Lanka is 2016. India's most recent data are for 2014 and Pakistan's for 2012.

Institutional Setup of Agricultural Research in South Asia

The landscape of South Asian agricultural R&D is highly complex, comprising a large number of governments, higher education, nonprofit, private sector, and international research agencies. The data presented in this report include only public national agricultural R&D. Staff and spending data for private-sector companies and international agricultural R&D agencies operating in the sub-region, such as the centers of the Consultative Group on International Agricultural Research (CGIAR), have been excluded. Over the past three decades, the institutional structure of public agricultural R&D in South Asia has remained largely unchanged. While there have been ongoing internal reorganizations, none of the countries has undertaken fundamental restructuring of its research system, as was common practice throughout the 1960 and 1970s. Despite differences in size and structure, the organization and coordination of national agricultural R&D systems bear some similarities across the five countries: all have national agricultural research councils that coordinate agricultural R&D, set priorities, and administer competitive grant schemes, although their roles and scope of authority vary and in some cases are undergoing change. The specifics relating to each country are discussed in turn below.

India has by far the largest agricultural R&D system in the sub-region in terms of staff, expenditures, and number of agencies. The Indian Council for Agricultural Research (ICAR) directly oversees 97 agencies, including 4 "deemed" universities, 45 research institutes, 17 national research centers, 6 national bureaus, and 25 project directorates. The research institutes and national research centers under ICAR primarily focus on research; the project directorates are responsible for the coordination of research

[1] For more information on ASTI, its methodology, and its findings, please consult http://www.asti.cgiar.org.

[2] The data exclude private-sector expenditures in agricultural R&D and spending by international organization, such as those by CGIAR institutes.

conducted by different agencies, including the state agricultural universities (SAUs); while the national bureaus primarily focus on natural resource conservation. The research conducted by ICAR's institutes covers a broad range of areas, including crops, livestock, fisheries, natural resources, agricultural engineering, policy, and management. ICAR institutes vary considerably in size, the largest by far being the Indian Agricultural Research Institute (IARI), followed by the Indian Veterinary Research Institute (IVRI), both of which, together with the National Dairy Research Institute (NDRI) and the Central Institute for Fisheries and Education (CIFE), are classified as "deemed" universities. Researchers from some of the other ICAR institutes serve as faculty staff to nearby SAUs, which are mandated to perform state-specific research and education; were created following on the U.S. land grant system; and comprise multiple faculties focusing on key areas like crops, horticulture, animal science, fisheries, and so on. Many SAUs attract students from across Asia at both the undergraduate and postgraduate levels. The country's largest SAUs include Chaudhary Charan Singh Haryana Agricultural University (HAU), Punjab Agricultural University (PAU), Acharya N. G. Ranga Agricultural University (ANGRAU), and Tamil Nadu Agricultural University (TNAU). A number of other government and higher education agencies are involved in agricultural R&D in India, but their collective shares of total public agricultural R&D remains small. Notably, the Indian Council of Forestry Research and Education (ICFRE) undertakes forestry research related to climate change, biodiversity, desertification, and sustainable management (Stads et al., 2016).

In **Pakistan**, the main agricultural R&D agency is the Pakistan Agricultural Research Council (PARC), whose broad mandate is the coordination of research among federal, provincial, and higher education agencies. PARC oversees a number of federal government research agencies located across the country. One of the largest is the National Agricultural Research Center (NARC), which in turn oversees a number of its own research institutes. Aside from PARC/NARC, 18 other federal government agencies conduct agriculture-related R&D under various ministries. Despite the size and large number of institutes at the federal level, agricultural R&D also falls within the domain of Pakistan's provincial governments. With the devolution of agriculture to the provinces in 2010, provincial research systems have gained a clearer mandate in R&D. A key challenge, however, will be to ensure an equitable division of resources and capacities both between the federal agencies and the provinces, as well as among the provinces themselves, given that half of the provincial-level R&D staff are currently located in Punjab Province, a major wheat-growing area. Efforts are underway to strengthen PARC and improve its relevance and effectiveness under the government's new configurations and economic growth priorities. Similar processes are being pursued in light of the government's plans to devolve public universities to the provinces. The role of Pakistan's universities in agricultural R&D has become increasingly important in recent years. Student enrollments in agricultural faculties have more than doubled since 2003, and agricultural scientist have also followed a steep upward trend. The University of Agriculture, Faisalabad is Pakistan's largest agricultural university (Stads et al., 2015).

In **Bangladesh**, the activities of 10 different crop, livestock, forestry, and fisheries research institutes are coordinated by the Bangladesh Agricultural Research Council (BARC). The largest of these institutes are the Bangladesh Agricultural Research Institute (BARI), focusing on a wide range of crops, and the Bangladesh Rice Research Institute (BRRI). The fact that the BARC–affiliated institutes fall under five different ministries has complicated and limited the overall coordinating role of the BARC Secretariat. Outside of the BARC–affiliated institutes, 10 other government agencies and 32 higher education agencies conduct agricultural R&D in Bangladesh. The higher education agencies also follow the national research priorities set by BARC. Bangladesh Agricultural University (BAU), in particular, has strong research capacity and its number of research projects has been on the rise in recent years (Stads & Gao, 2019).

In **Sri Lanka**, the Sri Lanka Council for Agricultural Research Policy (SLCARP) exercises a high degree of central authority over agricultural research by overseeing and coordinating the activities of all 13 government and 7 higher education agencies involved in agricultural R&D. The bulk of the country's agricultural R&D is carried out by the government sector. Aside from the Department of Agriculture (which oversees institutes involved in rice, horticultural, and food crops research), public R&D is conducted by a number of R&D institutes specializing in plantation crops, as well as institutes focusing on livestock, fisheries, forestry, postharvest activities. The University of Peradeniya is the country's largest agricultural university (Stads & Thi Pham, 2019).

The vast majority of agricultural R&D in **Nepal** is carried out by the Nepal Agricultural Research Council (NARC), which assists the national government in formulating agricultural policies and conducts research related to crops, livestock, aquaculture, natural resources, postharvest, climate change, agroeconomics and marketing. The Agriculture and Forestry University (AFU) and Tribhuwan University (TU) are the major universities engaged in agricultural R&D. Unlike other countries in the sub-region, nongovernmental organizations (NGOs), such as Local Initiatives for Biodiversity, Research and Development (LI-BIRD), play an increasingly important role in agricultural R&D in Nepal (Stads, et al., 2019).

The institutional composition of public agricultural R&D in South Asia has remained relatively unchanged since the mid-1990s. Government agencies represented about two-thirds of agricultural R&D capacity in the sub-region, while the higher education sector accounted for roughly one-third, and the nonprofit sector for less than 1% (Figure 1). These sub-regional shares mask major cross-country differences. While the government sectors in Bangladesh, Nepal, Pakistan, and Sri Lanka employ the majority of these countries' agricultural researchers, in India the higher education sector dominates in terms of R&D staff numbers: in 2014, universities (mostly SAUs) accounted for 61% of

Indian agricultural R&D capacity. Nepal is the only country in the sub-region where the nonprofit sector plays a significant role in agricultural R&D, representing 7% of the country's agricultural research capacity in 2016.

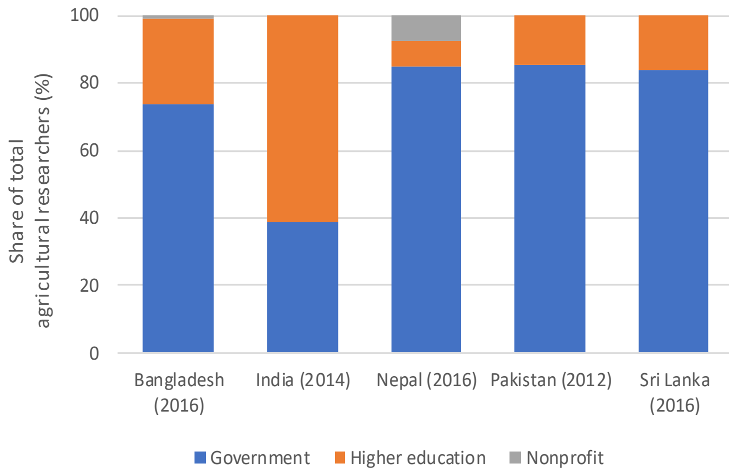


Figure 1. Institutional distribution of public agricultural research staff

Source: ASTI Survey Data (various years)

Long-Term Trends in Agricultural Research Investment and Capacity

Agricultural Research Spending

Total public agricultural research spending in South Asia increased from 2.5 billion to 4.1 billion dollars (in 2011 PPP prices) during 2000–2012, an increase of 66% (Table 1).[3][4] This growth was almost entirely driven by **India**, the sub-region's largest country. ICAR's expenditures accelerated in 2009 due to a nationwide pay rise for civil servants, which drove up ICAR's salary costs. In 2011, India's universities adopted the same pay structure as ICAR, explaining the increase in higher education spending that year. Another nationwide civil servant salary increase took place in 2017, which must have certainly driven up the cost of national agricultural R&D once again. In contrast, the amount that Indian research agencies spent on research programs, infrastructure, and equipment has remained fairly constant over time. The budgets of some state agricultural universities have fallen in recent years, but the World Bank loan-funded National Higher Agricultural Education Project is set to reverse this trend.

3 At present, the preferred method for calculating the relative size of economies or other economic data, such as agricultural research spending, is purchasing power parity (PPP) conversion. PPP exchange rates measure the relative purchasing power of currencies for a wide range of goods and services, converting current GDP prices of individual countries into a common currency.

4 These amounts include salary costs, operating and program costs, as well as capital investments.

Table 1. Agricultural research spending, 2000–2016

Countries	2000	2006	2012	2014	2016
	(million 2011 PPP dollars)				
Bangladesh	200.4	198.0	252.4	269.0	287.9
India	1,904.0	2,318.3	3,397.8	3,298.4	na
Nepal	39.2	28.2	53.3	75.1	81.9
Pakistan	235.6	295.6	332.5	na	na
Sri Lanka	104.5	92.0	78.2	89.2	112.4

Source: ASTI Survey Data (various years)
Note: na denotes that data are unavailable.

Although the rapid increase in Indian agricultural R&D spending in recent years overshadows the trends occurring in the subcontinent's smaller countries, an examination of relative shifts in investment levels over time reveals some interesting cross-country and cross-institutional differences and challenges. In **Bangladesh**, agricultural R&D spending has shown an upward, albeit erratic trend since the mid-1990s. Before the turn of the millennium, increased government contributions and project-related funds derived from the World Bank loan–funded Agricultural Research Management Project (ARMP) led to a rapid increase in the country's agricultural research spending levels. The completion of this project caused public expenditures on agricultural R&D to fall by more than one-third during 2000–03, but expenditures quickly recovered in subsequent years.

Agricultural R&D spending in **Nepal** is characterized by severe year-to-year fluctuations, largely linked to the influx of donor funding. The completion of World Bank loan–financed Agricultural Research and Extension Project (AREP), which ran from 1998 to 2002, led to a sharp decline in agricultural R&D investment levels. Spending rebounded somewhat after the 2006 signing of the Comprehensive Peace Accord due to increased government support for public agricultural R&D, but the launch of the Agriculture Development Strategy (ADS) and the Prime Minister Agriculture Modernization Project (PMAMP) were the main drivers behind the more recent increase in the country's agricultural research expenditures.

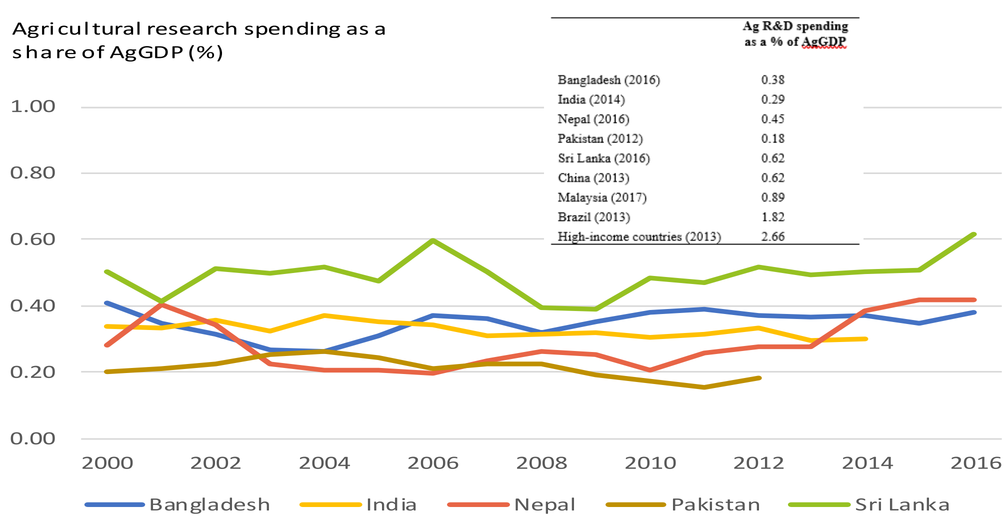
In **Sri Lanka**, total agricultural research spending rose by more than 40% (in inflation-adjusted terms) during 2013–2016, after being more or less stagnant during the previous decade. The nationwide pay rise for public sector employees in 2015 was an important factor behind this increase. Operating and program costs as well as capital investment also rose considerably in 2016, largely driven by the Coconut Research Institute and the Department of Agriculture's Fruit Research and Development Institute.

Growth in **Pakistan**'s agricultural research spending has been modest but erratic since 2000. Close to 80% of total expenditures by federal and provincial government agencies, on average, is spent on salary-related costs. The cost of actual research programs is to a large extent funded through the Agricultural Research Endowment Fund (managed by

PARC and funded through the sale of wheat donated by the United States government), the government-funded Research for Agricultural Development Program, the US-funded Agricultural Innovation Program for Pakistan, the Australia Pakistan Agriculture Sector Linkages Program, and various other donors.

Intensity of Agricultural Research Spending

Analyzing absolute levels of research expenditures explains only so much. Another way of comparing the commitment to public agricultural R&D investments across countries is to measure total public agricultural R&D spending as a percentage of agricultural gross domestic product (AgGDP). This relative measure goes beyond absolute agricultural R&D spending levels to indicate the intensity of investments. On average, South Asia invested around US$ 0.35– US$ 0.40 in agricultural research for every US$ 100 of agricultural output (Figure 2), which is low given the high levels of poverty and malnutrition and low agricultural productivity in the sub-region—all in the context of adverse climate change impacts. South Asian agricultural research intensity ratios are also well below the 1% target recommended by the United Nations (United Nations, 2011). Although Sri Lanka's research intensity ratio has shown considerable volatility over time, it has been consistently higher than ratios in Bangladesh, India, Nepal, and Pakistan. Nonetheless, intensity ratios of all South Asian countries are well below the global average (0.77% of global AgGDP). High-income countries invest 2.7% of their AgGDP in agricultural research, on average. China invests around 0.6%, Malaysia around 0.9%, and Brazil around 1.8%. It should be noted, that when comparing intensity ratios across countries, broader agricultural and economic contexts need to be taken into account as well.



	Ag R&D spending as a % of AgGDP
Bangladesh (2016)	0.38
India (2014)	0.29
Nepal (2016)	0.45
Pakistan (2012)	0.18
Sri Lanka (2016)	0.62
China (2013)	0.62
Malaysia (2017)	0.89
Brazil (2013)	1.82
High-income countries (2013)	2.66

Figure 2. Agricultural research intensity ratios, 2000–2016

Source: ASTI Survey Data (various years)

Agricultural Research Staff

Roughly 20,000 full-time equivalent (FTE) agricultural researchers are active in South Asia.[5] On average, agricultural researcher numbers in India have hovered around 12,000–13,000 FTEs (Table 2). During 2000–2009, levels markedly decreased at ICAR and the universities in response to years of stagnating recruitment. The number of agricultural researchers has begun to rise again in more recent years, largely due to the establishment of a number of specialized universities focusing on animal science, together with an intensification of recruitment efforts by ICAR agencies. With 3,678 FTEs in 2012 agricultural researchers, Pakistan has the second-highest agricultural R&D capacity in the sub-region, followed by Bangladesh (2,269 FTEs in 2016), Sri Lanka (648 FTEs in 2016), and Nepal (520 FTEs in 2016). It is important to note that the definition of what constitutes a researcher in South Asia differs both across countries and among institutes within countries, making is difficult to draw meaningful cross-country comparisons of human resource capacity. In India, for example, an entry-level researcher at ICAR or the SAUs requires at least MSc degree, whereas researchers at the agricultural research councils in the other four countries only require a BSc degree. Moreover, a large number of PhD-qualified researchers in India are employed as technicians rather than as researchers at ICAR, so it is important to include these staff members in any assessment of overall agricultural research capacity.

Table 2. Agricultural researchers in SAARC countries

Agricultural Researchers	Bangladesh (2016)	India (2014)	Nepal (2016)	Pakistan (2012)	Sri Lanka (2016)
Agricultural researchers (FTEs)	2,268.6	12,746.6	519.7	3,678.3	648
Share of researchers with PhD degrees	37%	73%	12%	21%	29%
Share of female researchers	22%	18%	19%	12%	52%

Source: ASTI Survey Data (various years)

Agricultural Research Focus

Governments and agricultural research agencies across South Asia are limited in their choice of options of how to allocate scare resources. It is important that they allocate sufficient resources to the right types of research and on the right commodities for agricultural R&D to have lasting effects on productivity growth and poverty reduction.

[5] ASTI calculates its human resource and financial data in full-time equivalents or FTEs. This method takes into account the proportion of time researchers spend on research compared with other nonresearch activities. University employees, for example, spend the bulk of their time on teaching, administration, and student supervision rather than on research. As a result, four faculty members estimated to spend 25% of their time on research would individually represent 0.25 FTEs and collectively be counted as 1.0 FTE.

Table 3. Distribution of agricultural researchers by commodity area

Commodities	Bangladesh (2016)	India (2014)	Nepal (2016)	Pakistan (2012)	Sri Lanka (2016)
	Share of total agricultural researchers (%)				
Cereals	18.1	14.0	17.6	22.0	9.2
Roots and tubers	4.4	2.4	1.9	2.8	3.7
Pulses	4.8	5.6	6.0	5.2	4.1
Oil-bearing crops	3.8	6.5	0.8	2.9	7.5
Horticultural crops	9.2	12.8	13.9	12.7	10.5
Other crops	12.3	11.6	4.4	10.2	26.9
Livestock	11.1	16.0	16.9	17.3	4.5
Forestry	3.4	3.9	4.9	2.7	0.7
Fisheries	8.7	4.8	13.9	3.2	8.3
Natural resources	6.5	2.1	2.7	8.3	4.6
Socioeconomics	3.1	5.0	1.7	3.4	8.6
Other	14.8	15.4	15.2	9.3	11.4
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: ASTI Survey Data (various years)

Notes: Other crops include mostly fiber crops (cotton, jute) and plantation crops (tea, rubber). The category "Other" includes non-commodity areas, such as on-farm postharvest research, agricultural engineering, pastures and forages, and food and nutrition science.

ASTI collected detailed information on the allocation of FTE researchers across commodity areas. More than half of all FTE researchers in the 5-country sample conducted crop research, whereas 15% undertook livestock research (Table 3). Fisheries and forestry research accounted for 5 and 4%, respectively. These aggregated figures reveal some important cross-country differences. For example, Pakistan's research agenda is heavily orientated towards cereal crops. In Pakistan, 22% of agricultural researchers conducted research on cereals in 2012. In contrast, just 9% of agricultural researchers in Sri Lanka conducted research on cereals in 2016. In Sri Lanka, plantation crops (tea, rubber, coconut, sugarcane) are the most researched crops.

A closer look at thematic research areas of agricultural researchers in India reveals some interesting differences between ICAR and the higher education sector (Table 4). ICAR's research focuses on issues of national importance, whereas university research mandates target state-level priorities. Compared with the universities, research undertaken at ICAR generally has better funding, as well as better research infrastructure and equipment. ICAR researchers spend relatively more of their time on basic science, germplasm conservation, socioeconomic research, and emerging areas (such as biotechnology and nanotechnology). University research, on the other hand, tends to be more applied. The emergence of state veterinary universities is reflected in the substantial focus on livestock health by universities. Forestry research falls under Indian Council of Forestry Research and Education (ICFRE) and hence does not feature prominently on either ICAR's or the universities' research agendas.

Table 4. Focus of agricultural researchers at ICAR and in higher education by thematic area, 2014

Thematic area	**ICAR**	**Higher education**
	Share of FTE researchers (%)	
Crop genetic improvement	14.9	11.7
Crop production (agronomy, fertilizer)	10.6	11.0
Crop protection	9.7	8.8
Other crop-related themes	1.5	1.3
Genetic improvement of livestock	2.7	5.2
Livestock health	3.8	13.1
Livestock management	1.5	7.6
Pastures, forages, and animal nutrition	2.4	5.5
Other livestock-related themes	2.2	2.9
Fisheries-related themes	4.7	9.5
Soil	1.6	2.5
Water	1.3	2.9
Agricultural engineering	2.2	1.2
Biodiversity, germplasm conservation	7.0	1.7
Farming systems	2.2	2.1
Food safety	1.5	1.2
Emerging areas (biotechnology, nanotechnology)	5.5	2.4
Onfarm postharvest research	6.0	2.5
Socioeconomic and policy research	13.0	4.3
Other themes	5.8	2.6
Total	**100.0**	**100.0**

Source: ASTI Survey Data (various years)

Challenges in Agricultural Research

The data in the section above give a concise overview of the status and direction of agricultural research capacity and investment in South Asia. ASTI collected a lot more detailed and disaggregated information that goes beyond the scope of this paper, including institute-level data on agricultural research staff by degree, gender, age, and discipline; financial data by cost category and funding source; research focus data; and data on research outputs (peer-reviewed publications and varietal release). Based on a thorough analysis of the data presented above, as well as these additional ASTI indicators, a number of important challenges facing South Asian agricultural research systems emerged. These challenges are briefly described below. The severity of each of these challenges differs from one country to the next, given the different size and scope of sub-region's agricultural research and policy environment in which they operate.

i. Severe underinvestment in agricultural research

As the agricultural research intensity ratios presented above indicate, South Asia is underinvesting in agricultural research. South Asian governments have a critical responsibility when it comes to providing sufficient and sustained agricultural R&D funding and for creating a more enabling environment within which agricultural innovation can prosper. Given the substantial time lag between investing in research and reaping its rewards—which usually takes decades, not just years—agricultural research requires a long-term commitment of sufficient and sustained funding. In reality, these long research cycles rarely coincide with short-term election cycles, shifting political agendas, and changes in government budget allocations—all of which have major implications for agricultural research. Decision-makers have limited incentive to support long-term investment in agricultural research because extracting political credit for doing so is difficult. Agricultural research directly competes with other important public investment areas, including education, health, and infrastructure, the impacts of which are more rapidly visible than those of research.

It is hard to quantify the exact level of underinvestment. Conventional recommendations of agricultural research intensity levels, such as the 1% of AgGDP investment target recommended by the United Nations, assume that national investments should be proportional to the size of the agricultural sector. In reality, a country's capacity to invest in agricultural research depends on a range of variables, including the size of the economy, a country's income level, the level of diversification of agricultural production, and the availability of relevant technology spillovers from other countries. In efforts to address these nuances, ASTI developed a multi-factored indicator of research intensity that comprises a range of weighted criteria (Nin Pratt, 2016). Under this approach, countries with the same mix of inputs are expected to require similar minimum levels of research investment, and investment below that level can be interpreted as an indicator that the country is potentially underinvesting based on its particular input mix.[6]

[6] A major difficulty in building this indicator is to define the weights necessary to aggregate the individual indicators into a single measure of R&D intensity. These weights should reflect the importance that the five determinants of R&D have as constraints of R&D investment in each country. Data envelopment analysis (DEA) approach was used to obtain a multifactored research and development (R&D) intensity measure. A

ASTI's weighted indicator of research intensity demonstrates that all 5 South Asian countries are indeed underinvesting in agricultural research (Figure 3). Underinvestment is most severe in Sri Lanka, Bangladesh, and Pakistan. These countries should be able to at least double their agricultural research spending. India stands out from the other South Asian countries in that its actual agricultural research investment is in fact very close to potential. The analysis also reveals that a 1-percent investment target is unrealistic for 4 of the 5 countries. Only Sri Lanka is capable of investing more, based on the structural characteristics of its economy and agricultural sector. An agricultural research investment target of 1.73% of AgGDP is thought to be realistic and attainable for Sri Lanka. To have met this target in 2016, the country would need to have invested 15.4 billion Sri Lankan rupees, instead of the 5.5 billion it actually invested (both in current prices). In other words, the gap between actual investment in agricultural research and estimated attainable agricultural research investment was nearly 10 billion rupees in 2016 alone. Even though the 2016 investment gap is lower than in the 1980–2010 period, it remains very high, raising questions as to what Sri Lanka's agricultural productivity could have looked like today had these investments been made in the past (Nin Pratt, 2016).

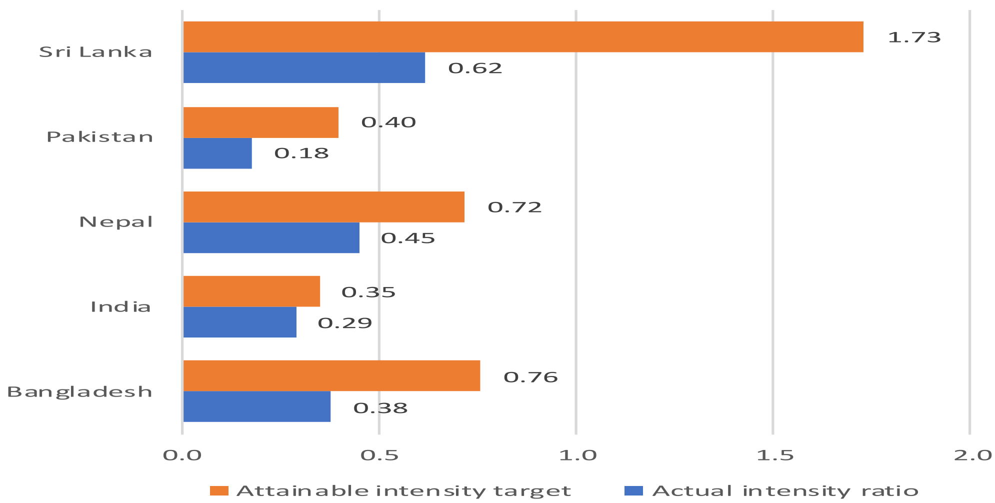


Figure 3. Actual agricultural research spending and attainable investment targets

Sources: ASTI Survey Data and Nin Pratt (2016)

ii. Relatively limited funding for non-salary research costs

As mentioned before, recent increases in agricultural research spending were largely driven by rising salary costs of agricultural research staff, rather than costs supporting

well-known feature of DEA is that it looks for endogenous weights that maximize the overall score for each decision-making unit given a set of other observations, yielding the most favorable country-specific weights.

actual research programs and infrastructure upgrades. Salary costs account for 75–80% of total expenditures by Pakistan's federal and provincial government agencies and India's ICAR institutes. No formula can determine the optimal allocation of agricultural R&D costs across salaries, operating and program costs, and capital investments: this breakdown depends on numerous factors, including country size, agroecological diversity, research mandates, and the composition of staffing. That said, when salary-related expenditures consume 80% of a country's total agricultural research budget, a clear imbalance exists, such that too few resources remain to support the costs of operating viable research programs. Pakistan certainly has insufficient support for the day-to-day operation of research programs, which undoubtedly affects the quality and quantity of research outputs in this country. Taking salary costs out of the equation, Pakistan invests just 0.04% of its AgGDP on actual agricultural research activities and the costs of running and upgrading research centers, which is clearly insufficient.

iii. Limited diversification of R&D funding sources

Governments are by far the dominant source of funding for the sub-region's research institutes, though donors and development banks play an important role in funding research in Bangladesh, Nepal, and Pakistan as well. The private sector is currently the least developed source of sustainable financing for public-sector agricultural R&D in the sub-region, which is a missed opportunity given the severe level of underinvestment. On a positive note, an increasing share of Indian agricultural research is funded with revenues generated through the sale of goods and services. The management of intellectual property and commercialization of technologies and other innovations have gained momentum at ICAR, and were integral to the National Agricultural Innovation Project (NAIP). However, Indian universities have been much slower in pursuing this revenue stream through the provision of fee-based research and consultancies and the sale of seed and plant material. In Pakistan, all internally generated resources through the sale of goods and services are channeled back to the national Treasury, which creates a disincentive for agricultural R&D agencies to pursue this revenue stream.

iv. Aging pool of researchers, particularly at the PhD level

Long-term public-sector recruitment restrictions have left institutes in Bangladesh, Nepal, Pakistan, and Sri Lanka with an aging pool of agricultural researchers, many of whom are set retire within the next decade. In Nepal, as of 2016, more than 70% of NARC's PhD-qualified researchers and 60% of AFU's agricultural researchers were in their 50s. In Sri Lanka, nearly two-thirds of the researchers at the government research agencies with PhD degrees are older than 50, whereas in Bangladesh, nearly 60% of PhD-qualified researchers at Bangladesh Agricultural Research Institute (BARI) and about half of those at the other Bangladesh Agricultural Research Council (BARC)-affiliated institutes are in their fifties. On average, researchers with MSc and BSc degrees were considerably younger, as were university-based scientists. Given that the mandatory civil servant retirement age is 57 in Sri Lanka, 59 in Bangladesh, and 60 in Nepal, the bulk of PhD-qualified researchers are set to retire in the coming years. Recent figures for Pakistan are unavailable, but 2012 data indicate that the situation is similar there. In India, the distribution of researchers by age bracket is much more balanced.

v. Lack a critical mass of highly qualified researchers in certain key disciplines

A minimal number of PhD-qualified researchers is generally considered fundamental to the conception, execution, and management of high-quality research and to communicating its results to policymakers, donors, and other stakeholders at national and regional levels. Despite the overall growth in the total number of PhD-qualified agricultural researchers in South Asia over time, the smaller countries in the region have yet to achieve a critical mass. In Nepal, for instance, just 12% of agricultural researchers hold PhD degrees. NARC lacks a critical mass of PhD-qualified researchers in a number of key areas, including plant breeding, plant pathology, agronomy, soil science, and veterinary science. Given its aging pool of researchers, capacity gaps are only expected to increase in the coming years. Similarly, in Sri Lanka, as of 2016, more than 40% of the officially approved positions for scientists at the government research institutions were vacant. Pakistan severely lacks horticultural breeders, entomologists, plant pathologists, and virologists.

vi. Poor incentive structures for researchers resulting in staff turnover and unfilled vacancies

In Bangladesh, Nepal, and Sri Lanka, many government agricultural research agencies are challenged in their ability to compete with universities and the private sector when it comes to recruiting, retaining, and motivating well-qualified researchers. Low salaries, limited opportunities for promotion and training, and a lack of performance-based incentives constitute key impediments to staff motivation. These factors have also caused many younger researchers to seek more attractive opportunities both in-country and abroad. In Bangladesh, for example, more than 300 highly qualified researchers left for better remunerated opportunities elsewhere during 2000–2012. The country's civil service system of promotions restricts researchers' opportunities for career advancement. In Nepal, another major disincentive to a career in agricultural R&D is the fact that a PhD qualification has no impact on salary levels. In Pakistan, large differences in salaries, training opportunities, and performance-based incentives between federal and provincial research institutes make the provincial agencies less attractive as employers. Better incentive structures are needed to retain capacity over time.

vii. Female researchers severely underrepresented

Female researchers offer unique insights, perspectives, and skills that can help research institutions more effectively address the specific challenges of farmers in South Asia, the majority of whom are female. Furthermore, attracting women into agricultural research would be a highly beneficial strategy for addressing the aforementioned low researcher capacity in many countries. Despite increases in the shares of female researchers over time in most countries, female participation in agricultural R&D in South Asia remains very low. In Pakistan, just 12% of all agricultural researchers are female. In India, women represent 18%, in Nepal 19%, and in Bangladesh 22%. Moreover, female scientists are far less likely to hold PhD degrees than their male colleagues, so these countries still have a long way to go in increasing female participation in agricultural R&D and hence integrating gender perspectives into the formulation of related policies. Interestingly, Sri Lanka stands out from the other countries in the sub-region in that the majority (52%) of its agricultural researchers are female. However, comparatively few Sri Lankan women hold managerial positions.

viii. Research not always focused on priority commodities

In some countries, major incongruences exist between the crops that generate the highest shares of gross value of national crop production and the crops that are researched the most, raising questions as to the allocation of scarce research resources. Rice, for instance, accounts for 28% of India's total value of crop production, but only 11% of India's crop researchers conduct rice research (Figure 4). Wheat, cotton, and vegetables appear to be under-researched in India based on their crop values as well. In contrast, a disproportionately large share of Indian researchers' time is dedicated to pulses following numerous recent nationwide initiatives promoting pulses. In Sri Lanka, rice and coconut appear to be under-researched based on their production values, while relatively more resources are allocated to plantation crops like tea, rubber, and sugarcane than the production values of these crops alone would warrant. In Pakistan, cotton, sugar, and rice appear to be under-researched.

In all countries, a balanced research portfolio that allocates sufficient resources to food, plantation, and export commodities is of vital importance to address the multitude of challenges the agricultural sector is facing, including stagnating productivity, high regional disparities in malnutrition, and underperforming sectors that need to become more efficient, innovative, and globally competitive.

The concept of congruency analysis can be useful in assessing the distribution of research efforts across commodities, but it is not an allocative rule. Research effort might be appropriately disproportionately allocated to a product with modest current value but projected high growth in demand. In addition, multiple objectives for agricultural development might channel research efforts toward a product with lesser weight in sectoral value added but particular relevance for, for example, nutrition or job creation. Finally, congruence analysis does not take spillovers across national borders into account. Not every country needs to invest in every commodity if barriers to moving new technologies across national boundaries are low. It is therefore important to view research support in a sub-regional context and strengthening regional linkages.

Congruence analysis therefore is not in itself a sufficient tool for allocation of research funds, but it offers important insight into the current distribution of capacity and resources, highlights where regional alliances should be strengthened, and can be combined with analysis of foresight and general equilibrium models.

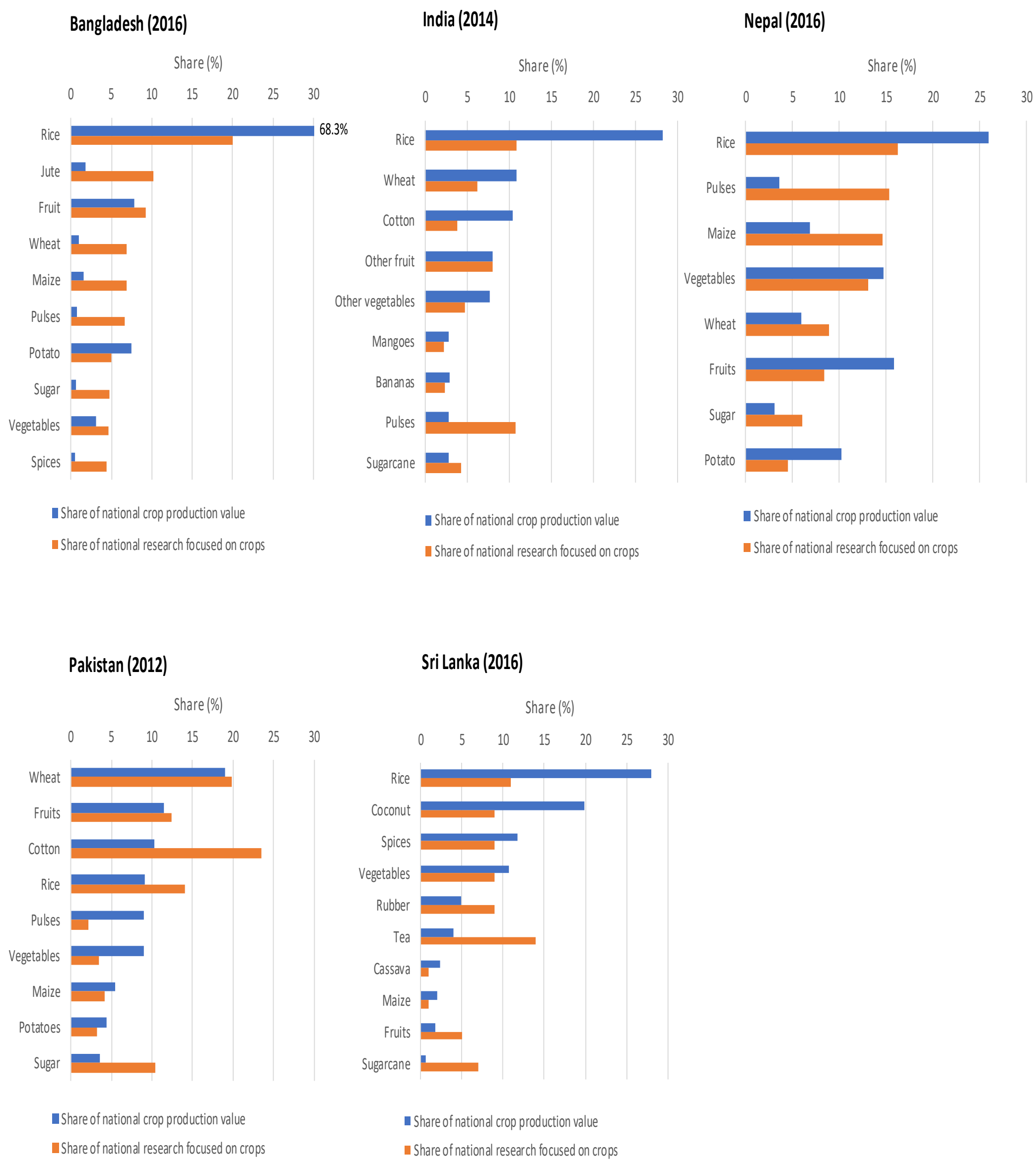


Figure 4. Congruence between agricultural research and production value

Sources: ASTI (various years) and FAOSTAT (http://faostat.fao.org)

ix. Low scientific output of research institutes

By international standards, average numbers of publications per agricultural researcher are relatively low in South Asia. On average, each ICAR researcher publishes 1.8 peer-reviewed articles per year. The scientific output per FTE researcher within the higher education sector was slightly higher (2.1 per year). Sri Lankan agricultural researchers published just 0.55 peer-reviewed publication per scientist per year, and the ratios in the other countries are comparable. On a positive note, however, the number of peer-reviewed publications per researcher has risen over time.

x. Institutional and governance challenges

The institutional setup of agricultural research in South Asia gives rise to numerous challenges and inefficiencies. In Pakistan, for instance, the complex structure of agricultural research and extension at district, provincial, and federal levels complicates the coordination of research and the dissemination of its outputs; it also triggers costly duplication of effort. There is little evidence to suggest that provincial agricultural research systems have been significantly strengthened since they were restructured following a major amendment to the constitution in 2010, which devolved agricultural sector responsibilities to the provinces. The majority of donor funding continues to be channeled to Islamabad, with very little reaching provincial agencies. In Sri Lanka, ministerial fragmentation (between the Ministry of Agriculture and the Ministry of Plantation Industries) complicates decision making on agriculture-related matters, including agricultural research. Similarly, in Bangladesh, BARC's mandate of coordinating the country's agricultural research is severely constrained by the fact that research institutes are administered by different ministries and under different legislation and regulations, and that BARC has no authority in allocating its funding despite being responsible for reviewing the institutes' research programs and budgets each year. While the 2012 BARC Act conferred the council with greater authority to approve research programs and recommend budget allocations to supervising ministries, BARC still lacks the autonomy to allocate funding based on designated research priorities and the quality and quantity of results and outputs. Such autonomy is needed to enhance the efficiency and effectiveness of Bangladesh's agricultural research.

xi. Ineffective extension systems

ASTI undertook long-term projections of the impact of historical agricultural research investment on agricultural output and productivity in South Asia, and of the impact of increased investment on future productivity growth. It found that political unrest (such as in Nepal and Sri Lanka), ineffective institutions, and an underachieving agricultural extension system have been important underlying factors limiting the long-term impact of agricultural research on agricultural productivity.

Historically, agricultural R&D planning in South Asia has operated from the top down, and linkages between agricultural R&D agencies and extension or advisory services have generally been weak. The need to improve linkages between agricultural R&D agencies and other organizations is widely recognized across the subcontinent, however. India's National Agricultural Innovation Project (NAIP) and Bangladesh's National Agricultural Technology Program (NATP) both have large components devoted to developing research consortia with civil society and private partners.

Problems often cited in association with public agricultural extension systems include insufficient funding, an inadequate number of extension workers, lack of extension worker qualifications and skills, lack of focus on farmers' needs, poor information and communications technology infrastructure and capacity, and dilution of impact due to thin coverage. Another problem is the fact that several different ministries are directly involved in assisting farmers with limited cooperation and coordination. The absence of a functional and active participation in extension priority setting of local government is problematic too. Agricultural research does not operate in isolation. The drivers of agricultural transformation are multidimensional and interrelated. A more holistic approach to agricultural innovation, comprising research, extension, education, and policy is vital, as are an effective institutional framework, governing mechanisms, and political environment that stimulate interaction between these players.

Policy Implications

i. Governments must address underinvestment in agricultural R&D and take the necessary policy steps to diversify funding sources

ASTI evidence does not indicate significant improvement in the relative intensity of agricultural research investment (agricultural R&D spending as a share of AgGDP) in South Asia over time (see Figure 1). Despite various national initiatives to promote stronger investment in agriculture (including agricultural research), agricultural R&D spending in most South Asian countries is still far below the levels required to sustain their agricultural sectors' needs. Countries that have increased their expenditures substantially, such as Bangladesh and India, have directed most of the funds toward (much-needed) salary increases, rather than actual research programs. National governments urgently need to address underinvestment in agricultural R&D and ensure the full disbursement of approved budgets. They must provide stable and sustainable levels of funding to secure a strategic program of effective research activities that yields increased agricultural productivity.

Rather than relying too much on donor contributions and development bank loans to fund critical areas of research, governments need to determine their own long-term national priorities and design relevant, focused, and coherent agricultural R&D programs. Donor and development bank funding needs to be closely aligned with national priorities, and donor programs should synergistically complement these priorities. Mitigating the effects of any single donor's abrupt change in aid disbursement (the main driver of funding volatility in Bangladesh, Nepal, and Pakistan) is crucial, highlighting the need for greater funding diversification—for example, through the sale of goods and services, or by attracting complementary investment from private sector.

The private sector is currently the least developed source of sustainable financing for agricultural R&D in South Asia (its funding potential remains largely untapped in most countries). Cultivating private funding requires that national governments provide a more enabling policy environment through tax incentives, protection of intellectual property rights, and regulatory reforms to encourage the spill-in of foreign technology. In some countries, policy reform is needed to stimulate the diversification of funding sources, including funding by regional or local governments, and the private sector.

ii. Governments must invest in training and capacity building and remove status and salary discrepancies between government- and university-based researchers

Few research institutes in South Asia have autonomous status in setting their own financial, human resource, or operating policies, which limits their ability to diversify their funding sources, offer competitive salaries and working conditions, and generally maximize efficiency levels. Growing concern exists regarding the lack of human resource capacity in agricultural R&D to respond effectively to the challenges that agriculture in South Asia is facing. In all countries except India, long-term recruitment restrictions have resulted in a situation where the majority of PhD-qualified researchers are set to retire by 2025.

In order to address the most immediate capacity challenges, in 2017, the Sri Lankan government agreed to fund 300 million Sri Lankan rupees annually (in current prices) for capacity strengthening and MSc and PhD training of agricultural researchers over the 2018–2022 period. As part of this program, a total of 41 candidates (21 women and 20 men) from the government research institutions commenced postgraduate training in 2018 and 2019 in the Philippines, Malaysia, and Thailand, with more to follow in the coming years. In addition, a number of Sri Lankan researchers are pursuing PhD training at Indian universities as part of the Memorandum of Agreement between ICAR and SLCARP. In Bangladesh, a large number of scientists are currently pursuing PhD training, both in-country and overseas, as part of the National Agricultural Technology Program (NATP: 2009–2024), funded through loans from the World Bank and IFAD. Similarly, a few Nepalese agronomists are currently being trained overseas. However, training opportunities in other disciplines, including horticulture, livestock, and fisheries are rare for Nepalese scientists.

This large-scale training of young South Asian agricultural scientists to the PhD level after years of neglect is a positive development of course. However, it is important that countries develop more systematic human resource strategies going forward, incorporating existing and anticipated skills gaps and training needs, rather than retroactively responding to large-scale losses of qualified researchers to retirement or greener pastures. The successful implementation of such human resource strategies will require both political and financial support, and not just from foreign donors. In addition, national governments must expand their investments in agricultural higher education to allow universities to increase the number and size of their MSc and PhD programs—or establish such programs in countries were MSc and PhD programs are still lacking—and to improve the curricula of existing programs. This includes the establishment and expansion of various regional capacity-building initiatives, so that smaller countries can benefit from the expertise of larger countries.

In addition to degree-level training, research institutes should involve present and past tenured researchers in mentoring their younger colleagues. In some countries, this may involve increasing the official retirement age of researchers or instituting some form of flexible working arrangements for retired researchers. Developing incentives to create a more conducive work environment for agricultural researchers is crucial. In a large number of countries, significant discrepancies exist in the remuneration, working conditions, and incentives offered to researchers at government agencies compared with their university-based colleagues (or in the case of Pakistan between federal and provincial institutes). These inequities need to be removed or overcome to enable the government R&D agencies to attract, motivate, and retain well-qualified researchers.

In India, four ICAR institutes have so-called deemed university status, which is an accreditation that allows them to award degrees. In Nepal, a proposal is currently under preparation to grant NARC deemed university status based on the Indian model. Such status, if adopted, would provide certain senior researchers with a (part-time) teaching mandate to enable the Council to more quickly and effectively strengthen its capacity. This would enhance junior researchers' access to higher degrees and contribute to staff retention, but it would require an official amendment to the NARC Act (1991). This could be a model to be considered by other countries as well.

iii. Governments must develop and enforce ambitious long-term national agricultural innovation policy agendas

Although most countries have numerous official agricultural and food security policies in place, many of them are not rigorously pursued or enforced, so the impact of some of these policies remains limited. Moreover, some countries lack a clear sense of direction in the area of agricultural innovation, dispersing coordination across too many ministries or governance levels, leading to duplication of activities or even competition. Consequently, a critical area needing urgent attention is the development of strong, national agricultural research and innovation policy agendas, together with the necessary expertise to support these agendas long term.

It is essential that governments strengthen the institutional, financial, and infrastructural foundations of agricultural R&D agencies so they can more effectively address farm productivity challenges. Strengthening the planning capacity at the research program level is crucial to the overall effectiveness of R&D agencies. Many agricultural R&D agencies currently lack efficient administration systems and practices needed to more effectively monitor progress and inform strategic decision making.

Governments will also need to provide the necessary policy environment to stimulate cooperation among the country's agricultural R&D agencies in order to maximize synergies and efficiencies in the use of the scarce resources available to universities and government agencies. Channeling a larger share of research funding through competitive mechanisms may enhance cooperation and make research more demand-driven.

In addition, governments must take action to ensure that improved varieties and technologies released by agricultural R&D agencies are disseminated to and adopted by farmers. This involves strengthening extension agencies and actively promoting cooperation between research and extension. The establishment of a central body, such as MANAGE in India, that develops the necessary regulatory framework, management systems, and personnel to integrate and optimize national and provincial level extension strategies may be a useful model for other countries to be considered.

iv. Governments must strengthen research linkages in-country and at the sub-regional level

Further integration of R&D at the sub-regional level is indispensable too. Cross-country collaboration is cost-effective because countries can more rapidly capture technology spillovers across geographic boundaries and reduce research duplication. India has a sophisticated national agricultural research system that produces technologies and methods applicable to other countries in the sub-region. Nonetheless, collaborative research across countries on issues of sub-regional significance is still relatively limited, and initiatives that build and enhance linkages need to be further strengthened in order to maximize possible synergies. More support is needed for regional bodies, networks, and mechanisms that can help effectively define, implement, and fund a regional research agenda targeting issues of common interest. Both the Asia Pacific Association of Agricultural Research Institutions (APAARI) and the SAARC Agriculture Centre (SAC) have key roles to play when it comes to promoting spillovers of technical and institutional innovations throughout the subregion and sharing knowledge and experiences across countries.

Conclusion

New quantitative evidence presented in this report demonstrates that total public agricultural R&D spending in South Asia has increased considerably since the turn of the millennium. This trend was largely driven by India, which has the highest investment levels and strongest human resource capacity in agricultural research in South Asia by far (both in terms of size and qualification levels). Other aspects that set India apart from its neighbors are the comparatively important role of its private sector in agricultural R&D, and the sweeping NAIP–stimulated agricultural R&D reform process, which is exploring new forms of consortia-based partnerships involving farmers and private enterprises to increase the relevance and efficiency of research. Overall, Indian agricultural research is relatively well-funded, although the budgets of some state agricultural universities have fallen in recent years.

Compared with India, agricultural R&D in the other South Asian countries faces greater challenges. These countries are characterized by severe underinvestment in agricultural research and their investment levels have shown large year-to-year fluctuations, in many instances due to the instability of donor funding. Agricultural research staff in these countries is also significantly less-qualified than in India, the combined result of prolonged recruitment freezes, losses of highly qualified senior staff, limited training opportunities, and an aging pool of researchers. In addition, political instability in some countries has either delayed or complicated much-needed institutional and policy reforms. Various policy initiatives have been or are in the process of being implemented to address institutional inefficiencies, strengthen research capacity, and make research more responsive to end user needs. However, more ambitious policy measures are needed to tackle the subregion's severe underinvestment in agricultural research, to ensure that research institutions stay adequately staffed into the future, and to strengthen research linkages both in-country and at the sub-regional level.

Recommendation: Institutionalizing ASTI in South Asia and Embedding its Evidence in National and Regional Policy Programs

Eleven years of Bill and Melinda Gates Foundation (BMGF) funding has enabled ASTI to update and expand its set of agricultural research and development indicators in South Asia, automate its systems of data collection and reporting, develop a number of interactive data dissemination tools, foster partnerships with key stakeholders, expand the initiative's analytical component, and enhance its outreach for increased impact on the ground. ASTI's data and analyses have been extensively used by governments, donors, and international organizations to identify key capacity gaps or areas of underinvestment, guide agricultural research investment and policy decisions, and demonstrate the returns to investments in agricultural research. Without ASTI, information and analysis of agricultural research investment and capacity in the subregion would be completely lacking, and comparative analyses across countries, and over time would not be possible. It is important, however, that datasets are more frequently updated and expanded to other countries in the region.

BMGF funding to ASTI is drawing to a close this year. In formulating its future strategy, ASTI recognizes that its long-term sustainability and impact ultimately depend on countries taking ownership of their national data, and that more focus is needed on effective data analyses and creative outreach activities to ensure that targeted messages are incorporated into national and regional decision-making processes. For these reasons, ASTI is focused on creating a multi-stakeholder platform that will support (i) sustainable national level data collection: (ii) demand-driven collaborative data analyses and research; and (iii) a diverse set of delivery mechanisms to inform policy.

ASTI has already successfully devolved the functions of data collection, processing, and provision in Southeast Asia and the Pacific, by entering into a strategic partnership with APAARI. IFPRI and APAARI are keen to follow a similar approach in South Asia and are actively exploring funding opportunities. The main objective would be to build a solid foundation for the long-term monitoring and analysis of agricultural research investment, capacity, and outputs and to enhance knowledge on the inputs, performance, and outcomes of agricultural research systems in all countries in the region. IFPRI's role would evolve to focus on coordination, quality control, training, and support; maintaining the international database; and producing regional and international syntheses and analyses.

Ideally, ASTI would be strategically positioned in SAARC Agriculture Center's 2020–2030 strategic framework in order to ensure optimal uptake and impact. There will be a critical role for SAARC in disseminating ASTI evidence to policy makers and other key stakeholders in the region, and in ensuring that the evidence gets embedded in national and regional agricultural policy decision making processes.

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