AST Agricultural Science & Technology Indicators
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CHINA

RECENT DEVELOPMENTS IN AGRICULTURAL RESEARCH

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LONG-TERM INVESTMENT AND CAPACITY PATTERNS IN AGRICULTURAL R&D

China has achieved remarkable economic and agricultural growth over the past three decades. This growth lifted rural household incomes and transformed the structure of the economy (Fan, Qian, and Zhang 2006). Agriculture in particular has played a crucial role in China's success in achieving food security and reducing poverty. Furthermore, agricultural output has continued to rise in recent years. Grain production has reached new highs, and modern hybrids have boosted yields of major crops such as rice and maize. These agricultural developments emerged from a series of policy reforms, infrastructural improvements, and investments in agricultural research and development (R&D).

China stepped up its agricultural R&D spending after the turn of the millennium, ending a period of stagnation in the 1990s. Total public investment in agricultural R&D doubled from 2001 to 2008, reaching 14.0 billion yuan or 4.0 billion PPP dollars (both in constant 2005 prices) (Figure 1). Note that unless otherwise stated all dollar values in this note are based on purchasing power parity (PPP) exchange rates. PPPs reflect the purchasing power of currencies better than standard exchange rates because they compare the prices of a broad range of local goods and services—as opposed to internationally traded ones.

Government research agencies accounted for 84 percent of public funds for agricultural R&D in 2008, while the remaining 16 percent were directed to the higher education sector (Table 1). That same year, the public sector employed some 43,000

Table 1—Public agricultural R&D spending and research staff levels, 2008

Type of agency	Total spending: Yuan	Total spending: PPP dollars	Total spending: Shares	Total staffing: Number	Total staffing: Shares
	(billion 2005 prices)	(billion 2005 prices)	(%)	(1,000 FTEs)	(%)
Government	11.7	3.4	84	26.6	62
Higher education	2.2	0.7	16	16.6	38
Total public	**14.0**	**4.0**	**100**	**43.2**	**100**

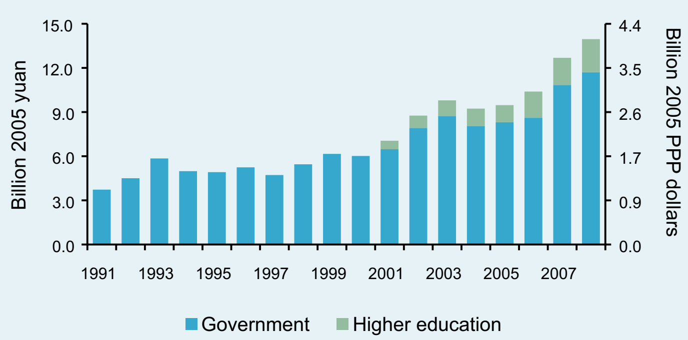
Source: Compiled by authors from NBS and MOST 2009.

Note: "Total staffing" refers to researchers that are nationally classified as scientists and engineers.

Key Investment and Capacity Trends

- China has the world's largest and most decentralized public agricultural research and development (R&D) system. It employs some 43,000 full-time equivalent (FTE) researchers in more than 1,000 research agencies at the national, provincial, and prefectural levels.
- Government investment in agricultural R&D doubled from 2001 to 2008, ending a period of stagnation in the 1990s. Government commitments are expected to increase further in the coming years.
- The intensity of China's agricultural R&D investment (measured as public spending on agricultural research as a share of agricultural output) was 0.5 percent in 2008. This ratio is close to the average for the developing world, but only half of the world average.
- The private sector is increasingly involved in agricultural R&D. In 2006, 16 percent of China's total spending on agricultural R&D came from private enterprises, up from less than 3 percent in 1995.

Figure 1—Public agricultural R&D spending adjusted for inflation, 1991–2008



Source: Calculated by authors from NBS and MOST various years.

Note: Data for the higher education sector were not available for 1991–2000.

full-time equivalent (FTE) agricultural researchers (those classified nationally as scientists and engineers); 62 percent staffed government research agencies. Private-sector agricultural R&D data were unavailable for 2008. But two years earlier, in 2006, the private sector's contribution was estimated at 16 percent of total agricultural R&D spending in the country (Hu et al. 2011).

Consistent information on funding and human resources for agricultural R&D is difficult to obtain for China due to the sheer number of agencies involved as well as the complexity of oversight and funding structures. Various estimates of agricultural R&D investment are reported in the literature, and these are often difficult to reconcile. The data here pertain to primary agriculture—crops, forestry, livestock, fisheries, and agricultural services—as well as the more general area of water conservation. Agricultural machinery and food processing—two categories that are often considered part of the agricultural sector—are excluded from the current dataset to enable cross-country comparisons.

The core of China's public agricultural research system is formed by an array of agricultural research agencies at the national, provincial, and prefectural levels.[2] The main national agricultural research agency is the Chinese Academy of Agricultural Sciences (CAAS). Other key national institutes are the Chinese Academy of Fishery Sciences (CAFS) and the Chinese Academy of Tropical Agricultural Sciences. These, and others, report to the Ministry of Agriculture (MOA). Their focus is on basic research and technologies that address key national priorities and challenges.

The Chinese Academy of Sciences (CAS) is the nation's foremost research institution in natural sciences and technologies. CAS undertakes agricultural research as well as overseeing multiple institutes, such as the Institute of Genetics and Developmental Biology, the Institute of Geographic Sciences and Natural Resources Research, the Institute of Botany, the Institute of Zoology, the Institute of Microbiology, and the Institute of Subtropical Agriculture. CAS is administered by the Ministry of Science and Technology (MOST).

Each provincial government oversees its own provincial academies of agricultural sciences. In contrast to the national agencies, provincial institutes concentrate on applied research tailored to the agroecological challenges within their provincial boundaries. Prefectures have their own agricultural research institutes as well, which similarly focus on adaptive research of local relevance. Extension falls under the provincial Departments of Agriculture and activities take place at the county level. Links between extension and research institutes or universities are not well-developed (Fan, Qian, and Zhang 2006).

It is unclear just how many public agencies are active in agricultural research in China. However, MOA tracks the number of institutes under its own authority and under provincial and prefectural departments of agriculture. At the end of 2007, it counted 1,105 research institutes. Of these, 59 institutes were administered by MOA, 454 were provincial institutes, and 592 were prefectural institutes. These numbers differ somewhat from those of the mid-1980s, when 84 national institutes were in operation alongside 414 provincial institutes and 624 prefectural ones. Thus the country has seen a reduction in the number of agencies at the national and prefectural level, and an increase in provincial-level agencies.

ASTI Website Interaction

- Detailed definitions of PPPs, FTEs, and other methodologies employed by ASTI are available at asti.cgiar.org/methodology.
- The data in this brief are derived from secondary sources, or were estimated. More information on data coverage is available at asti.cgiar.org/china/datacoverage.
- Additional agricultural R&D resources are available at asti.cgiar.org/china.

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Provincial and prefectural institutes tend to be relatively small, averaging, respectively, about 50 and 20 researchers. National institutes are generally larger, employing 100 researchers on average. Though the individual institutes at the lower levels are smaller, their collective R&D capacity is greater. Together, provincial and prefectural institutes accounted for 88 percent of government agricultural research investment in 2007, reflecting the system's high degree of decentralization (MOA various years).

The share of the higher education sector in total public agricultural research investments, while relatively small at 16 percent, has nonetheless grown rapidly since 2001. In absolute terms, this represents an investment of 2.2 billion yuan or 0.7 billion PPP dollars (in 2005 constant prices). Much of the recent growth in spending went to noncrop research areas, such as livestock and forestry (NBS and MOST various years). The higher education agencies employed some 17,000 FTE researchers in 2008, 38 percent of the country's total public agricultural researchers (NBS and MOST various years).

Both multidisciplinary and agriculture-specific universities are active in agricultural research. In 2007, China had 54 agricultural universities or colleges. Each province has at least one agricultural university, and there are various other agriculture-related colleges as well. National agricultural universities were administered by MOA up until 2000, when they were transferred to the Ministry of Education. Provincial departments of education oversee the remaining agricultural universities and colleges (Fan, Qian, and Zhang 2006). Since 2009, MOA and the Ministry of Education have worked together to support eight major agricultural universities (Central, China, Jilin, Nanjing, Northwest, Shanghai, Southwest, and Zhejiang), with the goal of enhancing agricultural education and research capacity.

The private sector has become increasingly active in agricultural R&D in China. From 1995 to 2000, private investment rose from an estimated 3 percent of total agricultural research expenditure to 9 percent (Pray and Fuglie 2001). At the start of this period most of the private funding came from foreign sources. Later, however, national actors grew more involved, though most of these enterprises were still partially state-owned. A nationwide survey by MOA found that private-sector spending had reached 16 percent of total agricultural research expenditure in 2006, totaling 2.0 billion yuan or 0.6 billion PPP dollars (both in 2005 prices) (Hu et al. 2011). The origin of the funding changed also from the 1990s, with domestic enterprises now accounting for almost all of the expenditure. Moreover, this figure does not include investment in food processing, which is left out of the scope of agricultural research in this note for the purpose of international comparisons (as it is also excluded from international calculations of AgGDP). The size and growth of R&D investment in the food processing industry has been substantial and totaled 1.4 billion yuan or 0.4 billion PPP dollars (both in 2005 prices) in 2006. If the subsector were included, it would constitute 42 percent of all private agricultural R&D investment in China (Hu et al. 2011).

The research focus of private actors differs from that of public agencies. Private enterprises typically invest in research areas where intellectual property rights are more strongly enforced. They are thus better able to secure potential profits from new technologies. Most private investment in agricultural R&D has been directed towards livestock research, with smaller shares going to crops and fisheries (Hu et al. 2011).

POLICY ENVIRONMENT

The State Council Steering Group for Science, Technology, and Education coordinates science and technology (S&T) at the national level. S&T policy and its implementation are primarily the responsibility of MOST, though others may be involved as well. Some of these are, for example, the National Development and Reform Commission (NDRC), CAS, the Chinese Academy of Engineering (CAE), and line ministries such as the MOA and the National Natural Science Foundation of China (NSFC). Also influential are the Ministry of Finance, the Ministry of Commerce, and to a lesser extent, the Ministry of Personnel and the State Intellectual Property Office (OECD 2008). In 2007, total government expenditure on R&D across all sectors was 89.4 billion PPP dollars (in 2005 prices), equivalent to 1.3 percent of GDP. Of this general R&D expenditure, the agricultural sector comprised 4.2 percent in that year (NBS and MOST 2008).

During the "Cultural Revolution" from 1966 to 1976, China's agricultural R&D system was nearly destroyed. After 1978, the government adopted policies to reestablish agricultural R&D agencies and, subsequently, to improve the effectiveness of the R&D system. Significant outcomes of this early period were the patent system, policies promoting commercialization of research, and competitive funding schemes. Reforms after 1999 continued the emphasis on research commercialization, along with a sharper focus on promoting innovative capacity and high-tech, large-scale agricultural production systems. In April 2001, the State Council released its "Development Plan for Agricultural S&T 2001–2010." Four key areas of that plan were structural transformation of the agricultural and rural sector, increased agricultural revenue, environmental protection, and international competitiveness.

Post-2007 reforms addressed issues of efficiency, duplication, and profitability. Innovation in agricultural S&T was promoted, a supply-chain approach to research was adopted, and new funding mechanisms were established to further partnerships between research institutes, universities, and industry.

The government has reduced barriers to private-sector investment in agricultural research as well. In the past, state-owned enterprises had enjoyed favored status. Private investment was discouraged, both outright and by a lack of clear regulatory structures for intellectual property rights and foreign ownership of joint ventures (Pray and Fuglie 2001). Following the reforms of the 1990s, some agricultural research institutes became commercial enterprises, and commercial agriculture-related enterprises began to invest in research.

China's "open door" policy of the late-1970s considerably boosted agricultural and technical cooperation. Thus began a tradition of Chinese engagement in scientific and technological exchanges with numerous countries and regions. China currently has cooperative agreements on agricultural S&T with 20 countries. It also has formal cooperation agreements with the United Nations Development Programme (UNDP), the Food and Agriculture Organization of the United Nations (FAO), and the centers of the Consultative Group on International Agricultural Research (CGIAR).

HUMAN AND FINANCIAL RESOURCES

Agricultural R&D Staffing

The 1990s reforms to improve efficiency led to a drop in government staffing levels from an average of 122 employees per research institute in 1986 to 85 in 2007 (the number of institutes also fell slightly, as mentioned earlier). Average researcher qualifications improved, however. The share of staff classified as scientists and engineers increased from one-third of all active research staff (researchers and research support staff) in 1986 to three-quarters in 2008 (NBS and MOST various years). These scientists and engineers generally held a BSc degree or higher. Of all government R&D personnel, 12 percent held a doctorate, 29 percent held a master's degree, and 59 percent held a bachelor's degree in 2009. Women comprised one-third of the research staff that same year.

The agricultural research output of government agencies also grew since the reforms. The number of papers published rose considerably, to more than 23,000 in 2007 from about 7,000 in 1986. Some 630 books were published and 575 patents were awarded. Looking more closely at the share of published books, national institutes contributed 35 percent, provincial institutes 50 percent, and prefectural institutes 13 percent. In the case of patents, national, provincial, and prefectural institutes accounted for 31, 50, and 18 percent, respectively (MOA various years).

In recent years, universities have further enhanced their ability to conduct research by recruiting faculty globally. In private research facilities, 13 percent of the agricultural researchers were qualified to the MSc or PhD level in 2006 (Hu, Liang, and Huang 2009).

In addition to researchers, public research institutes, universities, and private enterprises employ technicians, other research support staff, and administrative staff. In 2008, government agencies employed 7,583 technicians and other research support staff, or 0.28 research support staff per researcher. The research support staff ratio was much lower in the higher education sector, at just 0.04 (NBS and MOST 2009). Universities typically have fewer research support staff, as their primary mandate is education rather than research.

Funding sources and mechanisms

Government research institutes derive their funding from different sources than private enterprises (Figure 2). Most public research institute funding comes from government grants, the share of which increased from 55 percent in 1990–95 to 86 percent in 2006–07. Government grants are awarded as core funds to be applied towards salaries and benefits or as project funds obtained through competitive schemes. The share of project funds in MOA grants to agricultural research institutes has increased steadily over the years.

Private enterprises earn most of their income through commercial activities such as the sale of goods and services. These funding sources accounted for about 90 percent of their income in 2006–07, up from 70 percent in 1996–2000.

Bank loans have declined in prominence as a funding source for both government institutes and business enterprises. In 2006–07 they accounted for less than 1 percent and 6 percent of income, respectively.

Funding for agricultural R&D in China underwent substantial reform after 1985, which however rendered it increasingly complex. Prior to these reforms, funding was delivered through five-year government plans (Huang, Hu, and Rozelle 2004). Research staff numbers, rather than institute performance, determined funding allocations. The reforms encouraged research institutes to establish commercial companies and promoted competitive funding through NSFC, MOA, and other government agencies and foundations. It also stimulated collaborative efforts with international organizations and foreign agencies. The new policies rewarded performance by offering financial incentives for researchers (Fan 2000). Competitive funding greatly increased due to the reforms, rising from zero in 1985 to some 30 percent by 1998, and further to 41 percent by 2006 (Huang and Hu 2008).

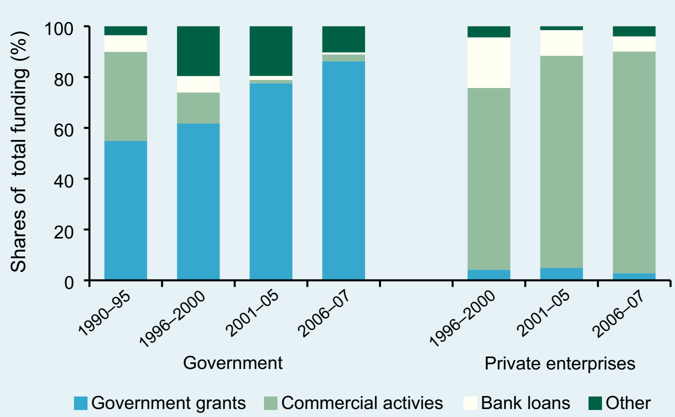
At the national level, NDRC authorizes yearly ministerial budgets, including the budgets of MOST and NSFC. S&T funding for the national research agencies, such as CAS and CAAS, is then channeled through MOST, MOA, and related ministries according to the S&T plan. Prior spending patterns and political motivations influence budgets. Local governments fund the provincial and prefectural institutes. These institutes also receive funds from the national institutes when undertaking collaborative research projects. Research priority setting and budget allocation processes are often not formal or transparent within the ministries and institutes (Fan, Qian, and Zhang 2006).

MOA and the Ministry of Finance provide other funds as well for specific purposes. Some project funds are allocated to attract leading advanced technology from abroad. A number of new funds were created in 2006 to support sustainable innovation within research academies and institutes. Another recent initiative for agricultural R&D involved establishment of an innovation system for major agricultural commodities. Ten agricultural products were included in 2007, with coverage expanding to 50 products in 2009. The initial three-year phase offered 967.5 million yuan (in current prices) for research on key technologies and their practical application.

ALLOCATION OF RESEARCH ACROSS COMMODITIES

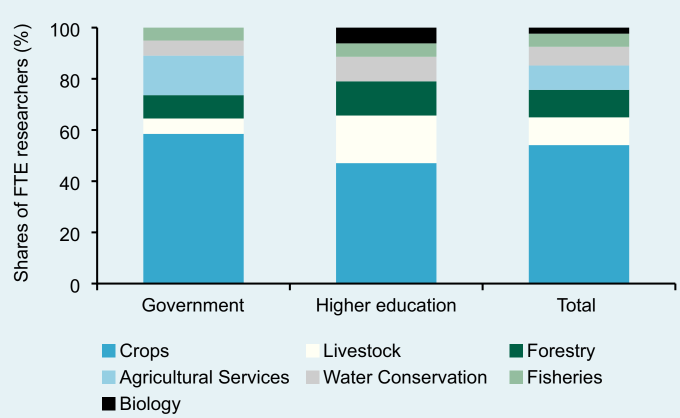
Allocation of resources across various lines of research is a significant policy decision. China's main public agricultural research focus is crops, which accounted for more than half of all research activity in 2008 (Figure 3). Following crops in terms of importance were agricultural services (15 percent), forestry (9 percent), livestock (6 percent), and water conservation (6 percent). In the higher education sector, researchers targeted livestock (19 percent),

Figure 2—Funding sources for government agencies and private enterprises involved in agricultural R&D, 1990–2007



Source: Calculated by authors from NBS and MOST various years.
Note: Data for 1990–95 were unavailable for private enterprises.

Figure 3—Research focus by major commodity area, 2008



Source: Calculated by authors from NBS and MOST 2009.
Note: The category "agricultural services" refers to non-commodity specific research areas including post-harvest, agricultural engineering, inputs, etc.

forestry (13 percent), and water conservation (10 percent). Remaining government and higher education researchers focused on fisheries and biological sciences.

CHINA'S AGRICULTURAL R&D INVESTMENT IN A GLOBAL CONTEXT

A comparative indicator used to track agricultural R&D spending across countries and over time is the research intensity ratio, calculated as total public spending on agricultural R&D as a percentage of national agricultural output (AgGDP). In China, this ratio ranged between 0.3 and 0.5 percent during 1986–2008 (Figure 4). In 2000, which is the latest year for which global data are available, China's agricultural research intensity ratio was 0.4 percent. In other words, China spent $0.40 on agricultural research for every $100 of agricultural output. While substantially less than the 2.4 percent that high-income countries spent on average on agricultural research, it is more comparable to the 0.6 percent average for the developing world (Beintema and Stads 2010). As recently as 2008 China's agricultural R&D intensity of 0.5 remained below the generally recommended 1.0 percent for developing countries.

However, in absolute terms, China's agricultural research spending far exceeds that of any other country except the United States. In 2000, China contributed 9 percent of the 25 billion PPP dollars spent on public agricultural R&D globally (in 2005 prices) (Beintema and Stads 2010). Moreover, China has significantly increased its agricultural R&D spending since that time, outpacing both Brazil and India (Figure 5).

CONCLUSION

After three decades of reform, agricultural R&D in China has made considerable progress. Total public expenditures on agricultural R&D doubled from 2001 to 2008, and private expenditure on agricultural R&D grew at an even faster rate. Moreover, preliminary data for more recent years suggests that investments have continued to rise. Furthermore, the government's recently released 2012 Number 1 document indicates that agricultural technology remains high on the policy agenda (Huang 2012).

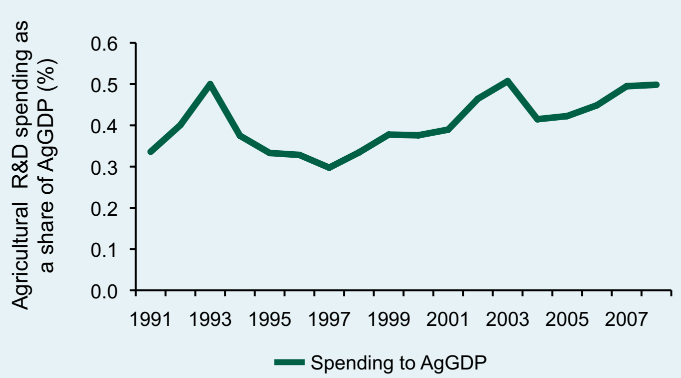
Policy reforms have contributed greatly to the increased public and private investment. Measures have strengthened the patent system and diversified R&D funding sources by introducing commercialization and competition. Agricultural researcher qualifications have risen as well. The share of scientists and engineers holding a bachelor's degree or higher is now significantly greater than in the 1980s. The productivity of government agencies has likewise improved, as evidenced by the rising number of patents and publications.

Despite the progress achieved, problems remain in China's agricultural R&D system, and new challenges have emerged. Numerous ministries and agencies are involved in managing and conducting agricultural R&D. The resulting high level of decentralization limits coordination and has led to funding inefficiencies and duplication of research effort. In addition, due to the nature of the social welfare system, individual government institutes bear a substantial financial burden in relation to their retirees. This problem is growing as the number of retirees rises. Innovation capacity is still limited as well, and is related to the relatively small share of researchers with postgraduate degrees. Most patents are for the adaptation of technology, rather than for new inventions; investment in basic research is still very low. Finally, commercialization of research continues to present both opportunities and challenges. In China, as elsewhere, it has proven difficult to strike an appropriate balance between market-oriented research and research that meets specific developmental needs.

NOTES

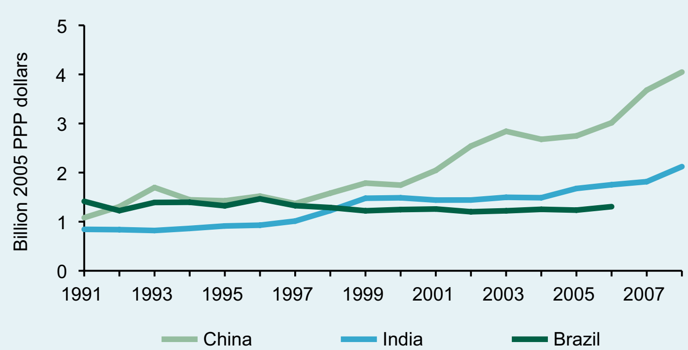
[1] This Country Note is based on the 2011 report "Agricultural R&D as an Engine of Productivity Growth: China" by Kevin Z. Chen and Yumei Zhang. Unlike other ASTI Country Notes, which are based on primary ASTI data, this study is based on secondary sources, supplemented by interviews with key researchers and policymakers. As is recognized in the literature, obtaining accurate data on agricultural R&D in China is challenging. Several ministries provide funding and oversee agricultural research, with each publishing its own statistical yearbooks.

Figure 4—Intensity of public agricultural research spending, 1991–2008



Sources: Calculated by authors from NBS and MOST various years and World Bank 2011.

Figure 5—Public agricultural R&D spending in China, India, and Brazil, 1991–2008



Sources: Calculated by authors from NBS and MOST various years; Pal, Rahija, and Beintema 2012; and Beintema and Stads 2010.

Multiple data sources must therefore be compiled to capture the scale, structure, and overall trends of government agricultural R&D, and to estimate the contribution of higher education and the private sector. The definitions, categories, and measurements used in these sources often differ from those used by ASTI. For these reasons, caution is advised when comparing these statistics with ASTI data.

[2] China has 34 provinces and 332 prefectures. The data presented in this note covers only mainland China which includes 31 provinces.

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