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AGRICULTURAL RESEARCH IN CHINA

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The impressive growth in China's agricultural production in recent decades has been paralleled by major increases in the human and financial resources devoted to public-sector agricultural research. Recent investigations by ISNAR indicate that the national research effort made possible by these investments accounted for nearly 20% of China's agricultural output growth between 1965 and 1989.

The country's annual financial investment in agricultural research has grown nearly fourfold (in real terms) since 1961. Even more remarkable, there has been a sevenfold increase in the number of scientists and technical support staff working in the national agricultural research system (NARS), with a 1988 total of 85,000 people. China's public commitment to agricultural research, at least in terms of human resources, is the largest of any nation.

This growth in funding and personnel has taken place within a rapidly evolving economic and institutional environment — one that has prompted radical changes in the country's agriculture, including a shift in the nature of demand for technology services. This raises a number of basic policy issues concerning the size, orientation, and appropriate institutional design of China's agricultural research system.

This briefing paper is based largely on the recent ISNAR monograph titled Agricultural Research in China: Its Institutional Impact and Development *(August 1992). It begins with a short overview of developments in China's agriculture, followed by a description of the current institutional structure of the Chinese NARS. The paper then provides new quantitative information on the level and deployment of the nation's agricultural research resources and on the impact of agricultural research on production growth. It ends with a discussion of some of the more important agricultural research policy issues to emerge from the work summarized here.*

Growth in Agricultural Production and Productivity

The value of China's **agricultural output** grew at an average annual rate of 3.9% from 1952 to 1990. Until 1980 the annual rate was 3.1%. It then jumped to 8.2% for the period 1980 to 1985, but thereafter declined to a still very respectable 5.1%.

China's grain production has grown on average by 3.2% per year over the past four decades (1950-1990) — some 1.1% faster than population growth over the same period. Cash crop production has achieved notable success with increases of 4.8% per

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annum for cotton, 4.3% for oil crops, and 6.9% for fruits. This exceeds the growth rate for food grain production. The performance of the animal and fishery sectors has been even more impressive, achieving growth rates between 6% and 8% per annum during the period 1950-90.

These cross-commodity differences in the rate of output growth gave rise to changes in the structure of agricultural production. Livestock products now account for over 25% of the total value of agricultural output, more than double their share back in 1949. At 4.3% and 6.2% respectively (in 1990), forest and fish products account for a smaller but similarly rising share in the value of production.

What are the reasons for these changing patterns of production? They are no doubt a response to the rapid growth in demand for certain products that comes with higher per capita incomes, as well as to China's increased participation in international agricultural product markets. The switch to higher-valued crops and livestock products is precisely what occurred in earlier decades elsewhere in East Asia as incomes grew.

China's measured level of **labor productivity** in agriculture is low compared with that of many other developing or former socialist countries. This is consistent with the country's exceptionally low land-to-labor ratio. However, from 1952 to 1990 China's labor productivity grew substantially despite a tendency for land area per unit of labor to decrease. The average growth rate was 2.1% a year from 1952 to 1990, with the following variations: 1.1% prior to the reforms that began to have impact in 1979, 7.8% from 1980 to 1985, declining to 2.8% per year from 1986 to 1990.

For the country as a whole, the rate of growth in **land productivity** averaged about 3.8% per annum from 1952 to 1990 broken down as follows: 2.9% prior to 1980, 8.6% from 1980 to 1985, and 4.4% over the following four years. It is noteworthy that land productivity grew more rapidly than labor productivity. This indicates a general tendency to adopt land-saving and labor-using technologies throughout the country.

The Structure of China's Agricultural Research System

The Chinese NARS consists of research institutes at three different levels of government: national, provincial, and prefectural (figure 1). Related activities take place at a fourth level, the county level, and deal with technology transfer, including demonstration trials, farmer education, and other extension-related work.

National Level. The State Science and Technology Commission (SSTC) is the most comprehensive organization devoted to the coordination and management of civilian science in China. Functionally, the commission is at the apex of the hierarchy of research institutes, although administratively it interacts with them only indirectly via government ministries. Agricultural research at the national level is conducted mainly within academies and institutes under the Ministry of Agriculture. Complementing this are the research efforts of various institutes under the administrative control of other ministries.

The Chinese Academy of Agricultural Sciences (CAAS), founded in 1957, is administered by the Ministry of Agriculture. It is the principal national-level research agency within the Chinese NARS. Its research program takes a leadership role on issues of national significance, such as the continuing efforts to develop hybrid rice varieties. As of 1991, CAAS operated 37 commodity, resource, and disciplinary research institutes (or centers) located throughout the country (figure 2), as well as a graduate school and a publishing unit. There were about 10,500 staff members working for the academy, of whom 5,000 were classified as technical personnel (20% of whom are senior scientists), 800 as administrators, and 4,700 as support staff.

China has a separate ministry and academy for forestry. The Chinese Academy of Forestry (CAF) was established in 1958 and was integrated into CAAS in 1970. When the Ministry of Forestry was separated from the Ministry of Agriculture in 1978, CAF was reconstituted. It has eight research units, four in Beijing and four elsewhere in the country. CAF supports 5,050 total staff, of whom 1,230 are technical staff. Research undertaken by the academy covers all issues of basic and applied R&D related to forestry. Of the eight professional institutes under CAF, four develop improved production technologies and forest management systems and two focus on postharvest technologies for the timber and chemical industries. There is also an institute of socioeconomics as well as an information institute that acts as a clearing house for information on forestry research.

The Chinese Academy of Fishery Sciences (CAFS), founded in 1978, is administered by the General Bureau of Fishery Production of the Ministry of Agriculture. It currently supports 18 of its own research units with a total staff of 3,400 (of which 1,850 are technical). Scientists conduct both basic and applied research and develop fishery technologies. More specifically, these institutes work in fish genetics and breeding,

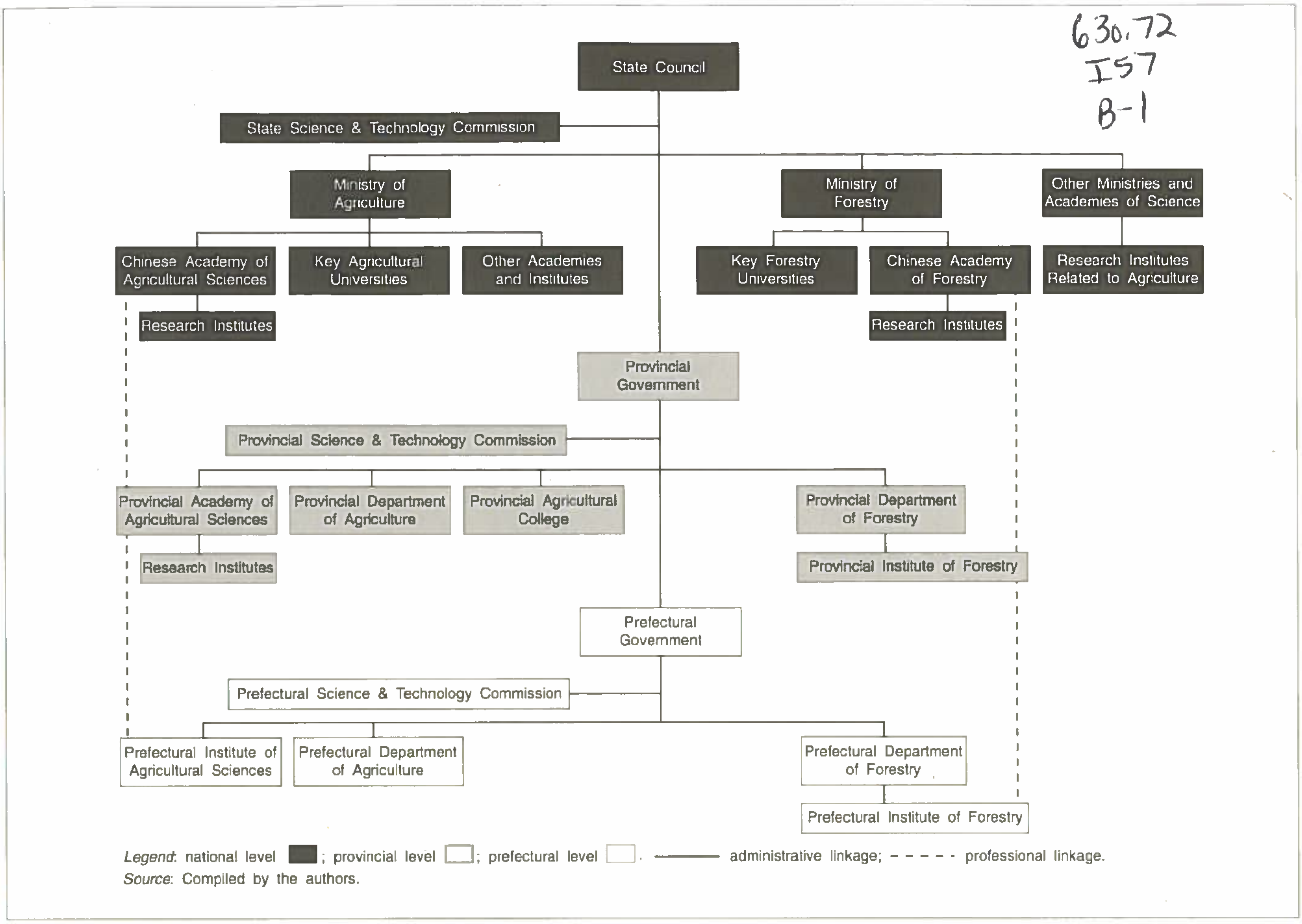


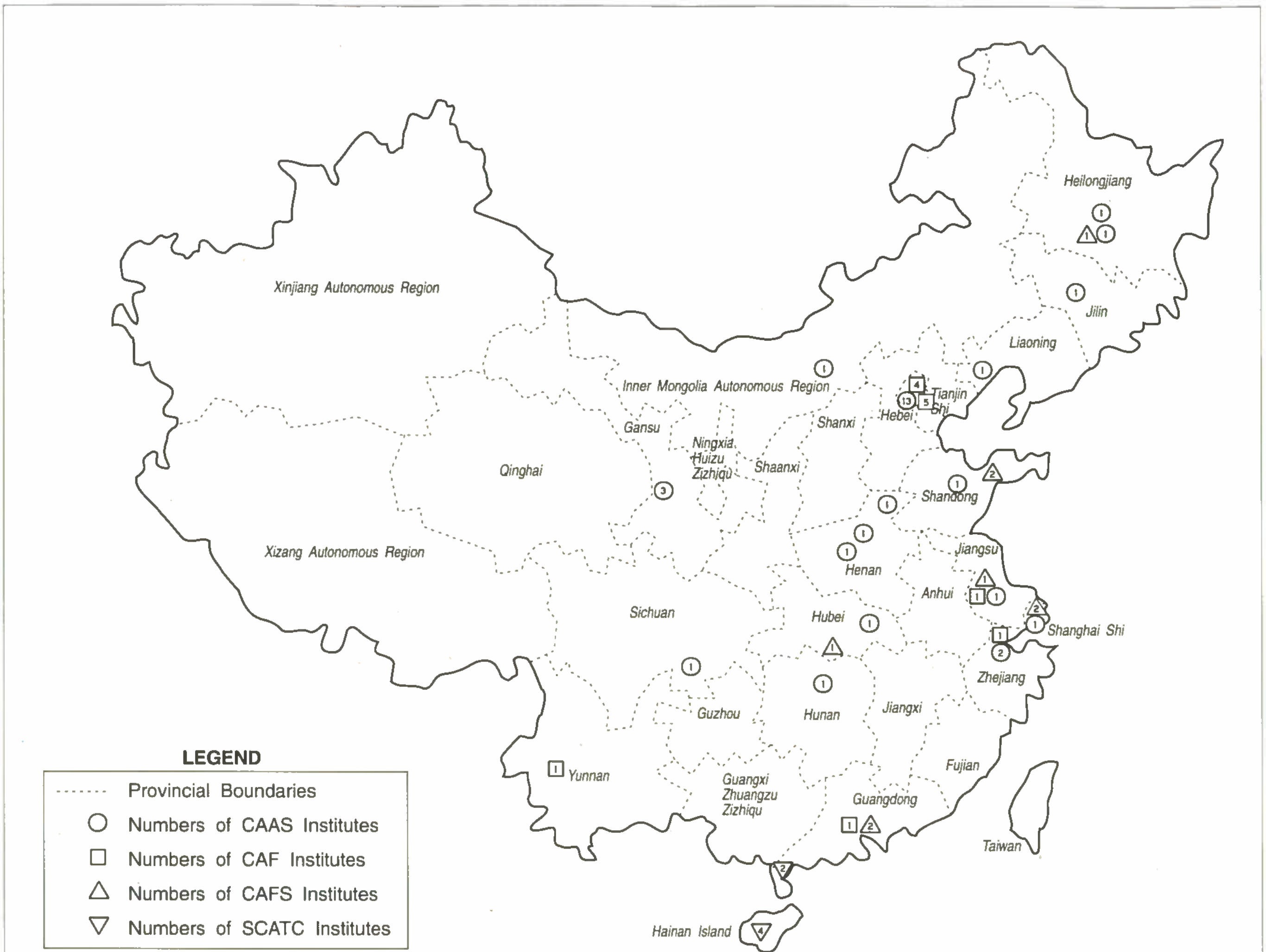
Figure 1: Organizational structure of the agricultural system, 1990

physiology, nutrition, and fish biology for both marine and freshwater environments. CAFS also does limited postharvest research on fish preservation and processing technologies and has several institutes that focus on fishing machinery and vessel design.

After the introduction in the 1970s of the "four modernization" policy — covering agriculture, industry, national defence, and science and technology — the Chinese Academy of Sciences (CAS) established five agricultural research institutes. In contrast to the research institutes of CAAS and the provincial academies of agricultural sciences, which are organized along commodity or disciplinary lines, the CAS agricultural research institutes take an integrated rural development approach. They select several counties as test sites and undertake research based on analyses of the region's natural resources, renewable energy, pollution abatement, mechanization, farming systems, and socioeconomic conditions.

Other research institutions at the national level include the South China Academy of Tropical Crops (SCATC), the Agricultural Environment Protection Institute, the Biogas Institute (under the Ministry of Agriculture), and the Institute of Water Construction (under the Ministry of Water Conservancy and Power). In addition, the Bureau of State Farms and Land Reclamation, under the Ministry of Agriculture, has its own set of research institutes. These focus on production problems arising in the large state farms located principally in the northeast, northwest, and south. The limited postharvest research currently under way is under the jurisdiction of the ministries of light industry and commerce and focuses largely on food-processing technologies. The Institute of Agricultural Mechanization Sciences, under the joint jurisdiction of the ministries of machine building and of agriculture, conducts research on agricultural mechanization while the Ministry of Chemical Industry carries out limited research related to the fertilizer and pesticide industries.

Provincial Level. Upon their establishment in the late 1950s, the provincial agricultural academies functioned as branches of CAAS. But since the Cultural Revolution, they have all been placed under the jurisdiction of their respective provincial governments and conduct research geared more to provincial circumstances. They are linked to the national institutes through a series of



Source: Compiled by the authors

Figure 2: Regional distribution of national-level research institutes

collaborative programs, with the leadership (in rice breeding for example) located at the national centers.

Jiangsu Academy of Agricultural Sciences, for example, is in many respects a typical provincial academy. A staff of about 1,260, of whom 750 are scientists and technicians, is spread among 14 institutes located in Nanjing. In this 14 are institutes for food crops, soil and fertilizer, plant protection, animal husbandry and veterinary science, feed and food, agrobiological genetics and physiology, agricultural modernization, applications of atomic energy in agriculture, and information for agricultural science and technology. In addition to applied research, the provincial academies often conduct a certain amount of basic research.

Prefectural level. At the prefectural level, the emphasis is more on applied and adaptive R&D. The principal research entity is the prefectural agricultural research institute. This is generally administered by the prefectural government. However, in three provinces — Jiangsu, Shanxi, and Heilongjiang — prefectural institutes are under the provincial academies of agricultural sciences.

Given the relatively large size of China's prefectures, research at this level is important and fruitful, having led to the release of many new varieties. Taihu Institute of Agricultural Science (in Jiangsu) is a representative example. Its prime missions are to breed improved cultivars of japonica rice; to develop new wheat and rape varieties that combine improved quality with enhanced yield and pest and disease resistance; to develop improved crop-production systems that cut costs; to analyze the potential for commercializing local agriculture with emphasis on postproduction uses of agricultural commodities; and to exploit the distinctive features of traditional plant and animal products to meet the demands of liberalized domestic markets and export trade. The institute consists of seven research divisions: crop breeding, crop cultivation, plant protection, soil and fertilizer, floriculture, animal and poultry production, and agricultural development.

Agricultural Research Investment

Since 1961 there has been an 8.5% average annual rate of growth in research personnel and a corresponding 5.9% rate of growth in real research expenditures. Both these rates have accelerated over recent years so that by 1988, the latest year for which figures are available, there were over 55,000 agricultural scientists and nearly 30,000 technical support staff in the Chinese agricultural research system (table 1). Universities account for a growing but still relatively minor share of the nation's agricultural research resources. In the early 1960s only 6% of the researchers and 2% of research expenditures were in the university sector; by the late 1980s these percentages were 15.6% and 6% respectively.

The Chinese NARS dwarfs all other public-sector agricultural research systems. In fact, in terms of numbers of researchers, it is four times larger than its nearest developing-country rival, India. However, the number of Chinese researchers with formal scientific qualifications is quite meager. Only 5-6% of its researchers hold a postgraduate degree compared with 60-70% in other less-developed Asian NARS. Even by China's own standards for science as a whole, the agricultural research community fares badly in this regard. The proportion of scientists and engineers with PhDs across all sectors averaged 0.4% in 1988, which is double the corresponding percentage for agriculture. The proportion with MSc degrees was 5.1% for all sectors and 4.6% for agriculture.

This problem of scientific qualifications is no doubt a legacy of the industry-led development strategies of the 1950s and 1960s and of the anti-intellectual climate of the Cultural Revolution years between 1966 and 1976. Over the next few years the situation will likely be redressed because of the expected influx of graduates into the research system following the surge of enrollments in China's agricultural universities during the late 1970s and early 1980s.

A country's agricultural research intensity (ARI) ratio is a measure of annual financial investments in agricultural research. It expresses these investments as a percentage of agricultural gross domestic product (AgGDP). From the 1960s to the mid-1980s, China's ARI ratio remained at about 0.4%. This stability contrasts markedly with ARI ratios in other developing countries, particularly in Asia. During the same period, the avarage ARI ratio for 92 less-develped countries on which ISNAR has statistics rose from 0.24% to 0.41%. It should be noted, though, that China's flat ARI ratio is not a reflection of a contracting or stagnating level of expenditure on agricultural research. Rather, it is largely a result of the rapid growth in agricultural

Table 1: Agricultural research investment, 1953–1988

	1953–57	1958–60	1961–65	1966–76	1977–85	1986–87	1988
Research Personnel (*in full-time equivalents*)							
Scientists and engineers (*graduates or equivalent*)							
Research institutes	—	—	6,966	11,118	27,207	41,808	46,649
Universities	193	363	504	503	3,051	6,728	8,597
Total	*193*	*363*	*7,669*	*11,621*	*30,257*	*48,536*	*55,246*
Technical support staff							
Research institutes	—	—	4,644	7,411	17,921	30,043	28,895
Universities	—	—	66	82	400	943	927
Total	—	—	*4,710*	*7,494*	*18,320*	*30,986*	*29,822*
Research expenditures (*in millions of 1980 PPP dollars per year*)[a]							
Research institutes	78.1	560.0	476.2	724.8	1,485.2	1,843.1	1,974.7
Universities	4.7	7.3	10.5	11.4	58.7	112.2	124.8
Total	*82.8*	*567.3*	*436.2*	*736.2*	*1,543.9*	*1,955.3*	*2,099.5*
Agricultural research intensity	0.07%	0.58%	0.41%	0.36%	0.41%	0.39%	0.40%

a. Current yuan data were first deflated to constant 1980 yuan using the national retail price index taken from China's Statistical Yearbook 1991, then converted to purchasing power parity (PPP) dollars using Summers and Heston's 1980 PPP over GDP conversion factor (*see* Summers, R. and A. Heston. 1991. "The Penn World Table [Mark 5]: An Expanded Set of International Comparisons." *Quarterly Journal of Economics* Vol. CVI: 327–368).

production during the 1980s. Indeed, few other less-developed countries have experienced production growth as great as China's.

Much of China's agricultural research is on crops. In 1987 nearly two-thirds of its research personnel were devoted to work on crop production. About 17% of research personnel were working in fisheries and 8% in forestry. Only 11% were devoted to research on livestock production — a subsector that accounts for around 25% of the value of agricultural output.

In 1989 only 17% of scientists and engineers working in the ministerial part of the system (i.e., excluding the universities) were based in national-level institutes. The majority of researchers (53%) were working in institutes administered, and often largely financed, at the provincial level, with the remaining 30% in prefectural institutes.

Contributions to Growth in Agricultural Output

For the country as a whole, agricultural output grew at an annual average rate of 4.9% over the 1965-89 period. This growth can be attributed to three sets of factors.

Conventional inputs. About 39% of the growth can be attributed to the use of conventional agricultural inputs, with manure and chemical **fertilizers** alone accounting for 21%. Increased **mechanization** accounted for another 12% of the growth. The number of workers in agriculture grew by 1.6% per annum; however, their low productivity meant that only 3.4% of growth in output could be attributed to **labor**. The expansion of **irrigated areas,** due to an increase in irrigation infrastructure, accounted for about the same order of magnitude of production growth (3.3%) as labor. The contribution of **land** was negligible; in fact, a decline in sown area had a small, adverse effect on output growth.

Research. Twenty-percent of the growth in China's agricultural output can be attributed to research. However, its impact was not uniform throughout the country. In the southeast, over one-third of the increase stemmed from investment in agricultural research; and in the northeast and southwest, research contributed around 30% and 23% respectively to agricultural output growth. In the north, the region that experienced the highest growth rate in production since 1965, research accounted for only 9%. Much of the gain in this region came from the increased use of fertilizers and energy as well as the market reforms of the late 1970s and early 1980s.

Other. Additional factors accounted for 42% of the growth in agricultural output. Of these, the only one that could be identified was the series of institutional reforms begun in the late 1970s. We estimate their direct contribution to growth at 14% of the total for the period 1965-89, still substantive but somewhat lower than previous estimates.

Policy and Organizational Issues

Over the past decade, China maintained a modest population growth rate of about 1.5%. However, because the current population base is large (1.14 billion in 1990) demand for food can still be expected to increase significantly. As industrialization and off-farm migration continues, the demand for marketable surpluses of cash crops will also increase. Therefore, continued growth in and the changing structure of agricultural output should characterize Chinese economic development for some years to come.

Research, along with the increased use of conventional agricultural inputs and institutional reforms, has contributed to the rapid growth in agricultural production in China over the past several decades. Accounting for about a fifth of that growth from 1965 to 1989, research was the second most influential factor. Growth rates in agricultural production after 1985, however, declined to levels prior to the institutional reforms of the late 1970s. This suggests that the productivity effects of this initial round of institutional reforms may well be largely exhausted. While further reforms offer the promise of additional growth, the new technologies, techniques, and know-how coming from agricultural research are likely to account for an ever-larger share of growth in agricultural output in the future.

The overwhelming size and institutional diversity of the Chinese system raise immediate policy concerns. Whether the level of public investment in agricultural research is in any sense optimal or appropriate is a central point of debate among policymakers. The Chinese agricultural research system dwarfs most other NARS, both in terms of research personnel and real expenditures. However, agricultural research investments in China, when considered in relation to AgGDP, are only on par with those in other Asian NARS. And they are less than one-third of those in more-developed countries.

Deciding whether an increase in the intensity of agricultural research investments in China is warranted will require the government to weigh the competing demands for its scarce resources. Certainly China has a declining comparative advantage in agriculture. However, the social rate of return to agricultural research in China over the past several decades has been high. When extrapolating past experience to the next few decades, it should be remembered that for many crops, the country's yields are already high by international standards. This situation presents both risks and opportunities if further investment is undertaken. On the one hand, research-induced yield gains for crops such as rice may not be as substantial in the future as they have been in the past. On the other hand, there are likely to be sizable benefits from "maintenance" research that seeks to replace or replenish the yield gains from past research.

China's great diversity of production systems, agroecological zones, and socioeconomic situations gives rise to many issues related to the design of research institutions and the deployment of resources. Agricultural technology is often location-specific. This requires decentralization of research, whereas the opportunities for economies of scale and scope in the production of knowledge or information point to the need for some centralization of research operations. Balancing these conflicting requirements is a critical problem in the design of an efficient organizational structure for China. In any event, there is a need to improve coordination and to harmonize research agendas across the various levels of government. While complete harmonization is neither possible nor desirable given the necessarily different aims of the national, provincial, and prefectural governments, there may be substantial economies to be realized through improvements in this area. Certainly a much clearer understanding of the potential for transferring research results from one locale to another will aid decision making in this regard.

At present, much of the research by agencies of the Ministry of Agriculture is directed toward production agriculture. But if the recent pace of change in agriculture and the Chinese economy as a whole continues, then demand for technological goods and services will radically change with it. Specifically, there will be growing demand for technologies and inputs produced off-farm — such as fertilizers, pesticides, and machinery.

Rising incomes are fueling demand for processed agricultural products. In turn, there will be a growing need for technologies to store, process, package, and market agricultural produce. This will open up the possibility of privatizing hitherto publicly controlled elements of the country's NARS, particularly those concerned with postharvest and purchased-input technologies. While this would certainly affect the role of the publicly supported research agencies, the need for continued investment in upstream research at the national level and adaptive research at the local level — especially on crops, livestock, and resource management — will continue unabated. These kinds of research are essential to sustaining growth in agriculture but are of less commercial interest to private investors.

A good deal of analysis, as well as consultation between policymakers and stakeholders, will be required if China's agricultural research system is to keep abreast of the rapid changes in the social and economic environment of the world's most populous nation.

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