Indonesia

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This chapter reports the results of the survey of private-sector investments in agricultural research and technology transfer in Indonesia. The purposes of this survey are to: (1) determine how much and what kind of agricultural research is being conducted by the private sector, (2) identify policy constraints and incentives to private research and technology transfer, and (3) assess major impacts of these private investments on agricultural productivity. The survey covered research and development (R&D) investments made in 1995 in the crop seed, biotechnology, pesticide, animal, and plantation industries. The results update an earlier survey by Pray for 1985.

The Indonesian survey consisted of interviewing representatives of eight companies in Jakarta, Surabaya, and Medan in June 1996. The companies included the major firms with research and technology transfer activities in plantation crops, seed, livestock, and agricultural pesticides. These interviews were supplemented with discussions with officials from the Indonesian government, U.S. Agency for International Development, U.S. Department of Agriculture, Food and Agriculture Organization, and non-governmental organizations.

Agricultural Development in Indonesia

Indonesia is the fourth largest country in the world in terms of population, with 195 million people in 1995. It is by far the largest economy in southeast Asia, with a total gross domestic product (GDP) of $198 billion in 1995. But in terms of per capita income, Indonesia lags behind Singapore, Malaysia, Thailand, and Brunei in the region.

The Indonesian economy underwent rapid growth between 1970 and 1997, averaging about 7 percent annual GDP growth. During this period, the agricultural sector grew 3 to 4 percent annually, less than the economy as a whole but still impressive given the size of the agricultural sector in the economy. Because of the more rapid growth of other sectors, agriculture's share of GDP fell from 45 percent in 1970 to 17 percent in 1995. Nevertheless, over 60 percent of the population resided in rural areas in 1998. Agriculture continues to provide the main source of employment for 44 percent of the labor force.[1]

Average per capita income has more than doubled in the past 20 years, although rural incomes remain substantially below urban incomes. A disproportionate number of those in absolute poverty live in rural, agriculturally dependent areas. Nevertheless, Indonesia has made great strides in reducing poverty rates by pursuing growth policies that seek to share the benefits of economic development. The proportion of the population living below the poverty line in 1996 was 11 percent. The number of poor people was reduced to about 22.5 million from 70 million in 1970 (Asian Development Bank, 1996). Policies that have been particularly important for poverty alleviation are agricultural policy, educational policy, and family planning policy.

Evidence of how agricultural policy has been used to reduce poverty is seen in the emphasis given to improving small-holder crop and livestock production. The government has intervened in the pricing of commodities, in the provision of inputs, and in trade (Jatileksono, 1996; Pengistu and Feridhanusetyawan, 1996). The most important example of this policy is the Mass Guidance Program (BIMAS) for rice production that was implemented in the early 1970s. Rice is by far the most important agricultural commodity and food staple in Indonesia and occupies more than half of all agricultural land (table E-1). Rice production has been the primary target of agricultural policy. Indonesia has sought to maintain stable producer and consumer prices of rice and at the same time achieve domestic self-sufficiency in production. Through the BIMAS program, government agencies supplied subsidized

[1] Figures on GDP, GDP growth, and agricultural GDP are from the World Bank (1997). Figures on population and employment are from Biro Pusat Statistik (1997).

Table E-1—Production of agricultural commodities in Indonesia, 1995

Crop	Area harvested	Production	Value
	1,000 hectares	*1,000 metric tons*	*Billion Rp*
Food crops			
Rice	11,439	49,744	49,848.0
Cassava	1,342	15,441	4,160.4
Corn	3,652	8,246	4,123.0
Soybeans	1,477	1,680	1,933.9
Peanuts	739	760	1,520.0
Sweet potato	229	2,171	796.7
Major fruits	NA	8,821	NA
Major vegetables	313	4,330	NA
Industrial crops	Estate area[1]	Small-holder area	Total area
		1,000 hectares	
Oil palm	992	656	1,648
Rubber	472	2,920	3,392
Coconut	138	3,574	3,712
Coffee	49	1,099	1,148
Cocoa	125	418	543
Tea	81	60	141
Sugarcane	497	555	1,052
Animals	Number (1995)	Slaughter (1995)	
	1,000 head		
Beef	11,534	1,517	
Buffalo	3,136	199	
Dairy	342	NA	
Pig	7,720	918	
Goats and sheep	20,335	1,444	
Poultry	933,458	NA	
Domestic hens	250,080	NA	
Layers	59,394	NA	
Broilers	594,368	NA	
Ducks	29,616	NA	

NA = Not available.

[1]Includes private and state-owned estates. Estates are cultivated on state-owned land based on exploitation rights granted by the government. Small-holders cultivate privately held land.

inputs to rice farmers and purchased production at guaranteed prices. Less intrusive intensification policies were also implemented to promote small-holder production of other food crops, industrial crops, and animal products. Under the "nucleus estate" program, for example, a large plantation is given access to land and subsidized credit in exchange for establishing and supporting small-holder production around the estate. In addition, the plantations provide a market and processing facilities for the small holders. Similar schemes have been established in livestock and horticulture production. However, in many instances the nucleus estate schemes have not worked well and have been subject to diseconomies of scale. Enhancing the incomes of small holders in Indonesian agricultural policy appears in some cases to have been given greater weight than achieving efficiency gains in agriculture.

There has been some liberalization in agricultural policy in recent years. Restrictions on trade and prices for corn and soybeans have been removed. In the input sector, subsidies on pesticides were removed in the 1980s, and subsidies on fertilizers were eliminated in 1998. The government is also playing a smaller role in the procurement and distribution of agricultural inputs compared with a decade ago. Agricultural pesticides are now mostly distributed by the private sector, and a small domestic seed industry is emerging. In the livestock sector, new government regulations introduced in 1990 removed barriers to large-scale, intensive livestock and poultry production systems. The onset of the monetary

crisis in 1998 led to further liberalization of agricultural markets under the terms of the International Monetary Fund assistance package. State trading monopolies on rice, wheat, and soybean trade were eliminated, and tariffs on several agricultural commodities were reduced. These trends carry significant implications for the role of the private sector in agricultural technology development and transfer in Indonesia.

Structure of Agricultural Input Industries

Seed Industry

The Indonesian seed industry is dominated by government agencies or state companies that produce and multiply seed for rice and other crops. Improved seed is distributed to farmers largely through government agencies and, to a lesser degree, through private marketing networks. Varietal improvement for food crops is carried out through the research arm of the Ministry of Agriculture, the Agency for Agricultural Research and Development (AARD).

The activity of the private seed industry is mostly limited to hybrid corn and some high-valued horticultural crops. In 1998, hybrid corn was planted on 7 to 10 percent of the total corn area, or on about 250,000 hectares out of 3.6 million hectares of corn. Total annual sales of hybrid corn seed were around $9 million. While hybrid seed still covers a relatively small share of the corn-growing area, the area planted to hybrids is steadily increasing, from less than 1 percent in 1985 and 5 percent in 1992 (International Maize and Wheat Improvement Center, 1994). Area planted to hybrid seed is expected to continue to grow in the future as corn use switches increasingly from food to feed. In 1998, less than 30 percent of the corn crop was used for livestock feed.

Three companies supplied the market for hybrid corn: one Thai multinational (Charoen Pokphand) and two U.S. multinationals (Cargill and Pioneer Hi-Bred International). The Thai company maintains a strategic alliance with a U.S. company (DeKalb Genetics) for its hybrid corn breeding program. However, none of these companies had breeding activities in Indonesia in 1998, but relied on varieties developed elsewhere. In Indonesia, they conduct yield trials in farmers' fields and at public research stations to select the best varieties and register them for local sale.

Hybrid corn varieties are multiplied locally and involve 3-way crosses. Seed companies import the cross between two parent (inbred) lines plus a third parent line and conduct a cross of these lines in Indonesia to produce F_1 seed for local sale. Since the hybrid seed itself cannot be used to reproduce seed with high-yield vigor, farmers need to purchase hybrid seed each year. By restricting access to their parent lines, seed companies can protect their investment in breeding.

Horticultural crops, namely vegetables and floriculture, are a second area where the private seed industry conducts breeding and supplies seed to farmers. These companies are particularly active in providing improved seed for production that is exported or processed into high-valued products. Marketing linkages are often through large agribusiness companies with processing facilities or international trade networks that contract with local farmers for the production of specific commodities. For example, one seed company provides viral-free microtuber potato seed to a private company that produces potato chips. The processing company multiplies the seed and distributes it along with other inputs and technical advice to contract farmers. The farmers produce potatoes and sell them back to the company at a price specified in the contract. In this way, the private company is assured of a steady supply of quality-specific raw material for its processing plant. The extent to which the Indonesian seed industry supplies improved seed to producers who provide fresh fruits and vegetables to local markets is not known.

At least 10 companies in Indonesia propagate seeds and seedlings for vegetables, floriculture, and some fruits. Of these, at least two companies have breeding programs. The largest vegetable seed producer with a breeding investment in Indonesia (East-West Seeds) is a joint venture with a Dutch firm. This company also maintains horticultural breeding programs in the Netherlands, Thailand, the Philippines, and other countries. Domestically produced horticultural seed competes with directly imported seed and farmers' saved seed.

Agricultural Chemical Industry

Indonesia is a large market for agricultural pesticides, with gross annual sales of around $200 - $225 million. About half of these sales are insecticides, a third herbicides, and the rest fungicides, rodenticides, and seed treatments (table E-2). Vegetables are the largest users of pesticides, accounting for about 30 percent of total

Table E-2—Private seed industry in Indonesia

Company	Seed production	Seed breeding
PT East West Seed		
(Netherlands)	Vegetables	yes
PT Bright Indonesia (Thailand)	Hybrid corn	yes
	Vegetables	NA
	Rice	NA
PT Fitotek Unggul	Vegetables	NA
	Flowers & ornamentals	yes
	Fruits	NA
PT Tanindo Subur Prima	Hybrid corn	yes
	Vegetables	NA
PT Selektani (Netherlands)	Vegetables	NA
PT Benih Prima Tani	Vegetables	NA
PT Pioneer Hibrida Indo (U.S.)	Hybrid corn	yes
PT Bibit Baru (Netherlands)	Fowers	NA
Cargill (U.S.)	Hybrid corn	yes
PT Asparagus	Vegetables	NA
PT Ganesha	Vegetables	NA
PT Mantrust	Vegetables	NA
PT Hortimate Utama	Fruit tree grafting	NA
Total seed research in 1995:	US$700,000	

NA = Not available.

Source: industry estimates from author's survey and Singh (1994)

sales. Peppers (an important export crop) account for 80 percent of pesticides used on vegetables. A large domestic and export market has emerged for processed chili pepper sauces. Rice and plantation crops each use about 25 percent of the total pesticides. The remainder of the pesticide market (20 percent) is for soybeans (8 percent), potatoes (5 percent), sugarcane (4 percent), and other crops. In 1993-97, use of herbicides grew steadily as plantation area expanded, while sales of insecticides remained stable or slightly declined in terms of real expenditures.

One of the most significant changes affecting the market for agricultural pesticides in Indonesia was the implementation of a national integrated pest management (IPM) strategy for rice in the late 1980s. In 1987, the government banned the use of 57 pesticide products for use on rice (although they could still be legally sold for other uses), phased out its pesticide procurement and distribution program, and ended subsidies by 1989. Pesticide companies in 1998 relied mostly on private channels for the distribution and sale of their products. The government also conducted a nationwide extension program emphasizing nonchemical IPM methods for insect control in rice. Despite the government policy initiatives, however, total pesticide sales for use on rice has not significantly diminished, although product formulation has changed. While there was apparently some decline in the amount of insecticide applied per hectare, it has been offset by expansion of the total rice area. Moreover, residues of banned pesticides were still detected on rice, indicating that the use-ban was not effectively enforced. The most important factor that caused a change in pesticide use and led to a decline in the intensity of insecticide use (i.e., amount per hectare) was probably the elimination of large subsidies (up to 85 percent) for pesticides.

Seven multinational companies were represented in the agricultural pesticide market. All had local affiliates or partners for product formulation and/or distribution. The elimination of pesticide procurement by government agencies forced pesticide companies to expand their local marketing efforts. Companies in 1998 maintained substantial sales and technical assistance teams to work with farmers on pest management technology.

Herbicides in Indonesia were until 1998 almost entirely used on plantation crops such as oil palm. But increasingly, farmers growing food crops were replacing manual labor used for weeding with chemical weed control. Chemical weed control has also facilitated the adoption of conservation tillage in rice and corn production. For dryland crops, conservation tillage reduces soil erosion. For paddy rice grown in

terraced fields (where erosion is not significant), conservation tillage reduces water requirements and shortens the time required for land preparation, thereby enabling increased cropping intensity in some areas. Herbicide use in rice and field crops is increasing most rapidly outside of Java where land is more abundant relative to labor. Among the small farms of Java where family labor is abundant, herbicide use has been slower to expand.

Plantation Sector

Plantation or perennial crops, particularly oil palm and rubber, have been and continue to be major export commodities for Indonesia. Plantations were first established by European and American companies in the late 19th century. The plantation sector was severely disrupted in the 1940s by World War II and again in the 1960s when foreign plantations were nationalized by the Indonesian Government. Although foreign-owned and operated plantations were subsequently invited to return, one of the most significant developments of the past two decades has been the growth in large, locally owned plantation companies. Two Indonesian companies (PT Salim and PT Sinar Mas) were the largest oil palm producers in Indonesia. In addition, several Malaysian companies invested heavily in expanding plantation production in Indonesia. Indonesia is expected to surpass Malaysia as the global leader in palm oil production within 5 to 10 years.

Perennial crops were produced not only on large private plantations, but also on state-owned plantations and by small holders. Of the 1.65 million hectares planted to oil palm, private estates constituted about 40 percent of the area, state-owned plantations made up another 20 percent, and small holders accounted for the remaining 40 percent (table E-3). Growth in area planted to oil palm was increasing in private holdings while area in state-owned plantations remained stable. State-owned plantations were reportedly only 70 to 80 percent as productive as private oil palm plantations. Large, state-owned plantations were responsible for most of the tea production. Small holders, on the other hand, were the principal producers of coconut (96 percent), coffee (96 percent), rubber (86 percent), and cacao (77 percent).

To maintain stable domestic prices for vegetable oil, the government maintained a variable levy on exported palm oil. For crude palm oil, 40 to 60 percent of the value of exports above a target price was taxed. For olin (processed vegetable oil), the export levy on sales above the target price is 50 to 75 percent. The structure of these export duties has reduced the incentive to develop olin-processing factories locally, instead favoring the export of crude palm oil. Export taxes on palm oil and olin increased following the devaluation of the rupiah in late 1997.

Table E-3—Private plantation research in Indonesia

Major companies	Oil palm area
	Hectares
PT Salim	200,000
PT Sinar Mas	160,000
PT Londsum	50,000
PT Socfindo	48,000
Other plantations	200,000
Total private plantations	658,000
State-owned plantations	334,000
Small-holders	656,000
Total research by private plantations in 1995	US$2,000,000

Source: industry estimates from author's survey.

Animal Sector

As in other southeast Asian countries, the animal industry in Indonesia features a dual economy. On the one hand are the small holders, the traditional and dominant component, who raise animals for multiple purposes, including cash sales, home consumption, draft power, manure, and as a means of household savings. The other component of the animal sector consists of medium and large commercial operations. These include local and multinational companies, often with links to foreign companies providing advanced breeding stock, veterinary services, and management methods to contract growers. These firms produce meat and animal products primarily for urban populations and export markets. The large commercial operations may also operate their own feedmills and processing plants in fully integrated systems. Despite government efforts to support and improve smallholder animal producers, the large-scale commercial sector continues to increase its market share.

The development of large scale, integrated animal production and processing units in Indonesia was a relatively recent phenomenon. The first commercial poultry operation was established in 1970 by a Thai multinational company (Charoen Pokphand). By 1995, the commercial poultry sector produced more than 650 million birds (layers and broilers), compared with 230 million native chickens in the traditional sector (table

E-1). The poultry industry includes one pure line poultry farm, 13 farms based on grandparent seeds, and 106 parent stock farms that produced 25 breeds of day-old chicks per year (McEvoy,1993). The industry was further supported by 34 veterinary drug manufacturing companies and 68 feedmills producing 2.8 million metric tons of prepared animal feed, mainly for poultry. However, the development of processing and distribution facilities has lagged behind the growth of commercial production as many consumers prefer to buy live poultry in order to be assured of freshness and quality. Thus, poultry processing continues to be performed mostly at the retail level.

A major impetus for growth in commercial swine production was expanding export demand from Singapore. Exports of swine to Singapore in 1993 consisted of 66,000 animals. Most of the 9.1 million pigs produced in Indonesia in 1993 were by small holders with under 50 sows. In the medium- and large-scale commercial enterprises, landraces were imported from abroad (Yorkshire, Hampshire, and Duroc) and raised either as pure breeds or were crossed with local types. The use of concentrated feeds for swine production was limited to medium and large producers. Small holders tended to rely on household or farm byproducts such as crop residues for livestock feed.

Some large commercial operations for beef cattle and dairy production were introduced in Indonesia. Beef cattle were imported primarily from Australia for fattening. But commercial feedlots remain relatively small, compared with the traditional sector. In 1994, about 80,000 out of a total of 11 million head of cattle were imported. Locally produced beef products also compete with imported meat. The dairy sector is small compared with the beef sector, at only 315,000 head. Foreign breeds were imported, with most milk produced on small-holder operations organized into dairy cooperatives. The productivity of local dairies is low due to poor management and low-quality feed, despite the importation and distribution of improved breeds.

Biotechnology

Agricultural biotechnology had been targeted as a strategic industry by the Government of Indonesia. Significant resources were being invested in research facilities and training of scientific staff. In 1998, however, few commercial products had been developed or transferred for use in Indonesian agriculture. No transgenic crops were grown in Indonesia in 1998, which lacks a regulatory protocol for their importation and use. However, a few companies in the commercial seed industry use micropropagation (tissue culture) to produce seedlings for horticulture, floriculture, and plantations. To facilitate biotechnology development and transfer, the government was developing a set of regulations for the importation and field-testing of transgenic crops.

Private-Sector Investment in Research and Technology Transfer

Plant Breeding

Most research by the nascent private seed industry in Indonesia is for varietal testing and improving seed propagation methods. Only three or four companies have small breeding programs (table E-2). Nevertheless, there has been gradual growth in the industry over the 1987-97 period. Private seed companies are testing varieties and propagating seed for corn, vegetables, fruit crops, and floriculture. Hybrid corn plantings increased from less than 1 percent of total corn area in 1985 to around 7 to 10 percent in 1995. Three companies active in 1985 dominated the hybrid corn market in 1995, all of them affiliates of foreign multinationals (PT Bright, a subsidiary of Charoen Pokphand, Cargill, and PT Pioneer Hibrida, a subsidiary of Pioneer Hi-Bred International).

The most significant growth in the Indonesian seed industry has occurred in horticulture. At least six companies were established over the past 10 years to propagate seeds and seedlings for vegetables, fruits, and floriculture, and two of these had breeding programs. Several of these companies are affiliates or joint ventures with foreign multinationals. Three Dutch firms have local affiliates which produce seed and seedlings for the domestic market and for export. East-West Seeds maintains a breeding program in Indonesia for vegetable crops.

The Indonesian private seed industry has engaged principally in technology transfer activities such as screening existing varieties and selecting the best ones for production and distribution. Breeding of new varieties in the private sector is still at an early stage. Most activity involves transferring varieties developed elsewhere for screening and production locally. Seed companies are also transferring improved seed propagation techniques, such as micropropagation methods

(tissue culture). Formal linkages and alliances with foreign multinational companies provide the principal source of new technology.

Locally produced seed faces competition from imported seed and from varieties produced and developed by public agricultural research institutes. More than 20 companies import vegetable seed for direct sale, especially from Taiwan. Public research institutes have also engaged in seed production and distribution. Competition from public seed research reduced incentives for the private seed industry.

Crop Protection

Agricultural chemical companies do a substantial amount of applied research on crop protection in Indonesia. Novartis, a multinational chemical company, operates two research stations in Indonesia as part of its global network of crop protection research stations. One station focuses on tropical lowland crops such as rice, sugarcane, and chili, and has been in operation since 1980. A second station was opened in 1990 for horticultural crops in tropical highlands. The principal objective of the research at these stations is to test the efficacy of new chemical treatments that had been synthesized at the company's research laboratories in Europe. A second objective is to develop new products and integrated pest management (IPM) strategies for local and regional markets. IPM involves developing pest and disease scouting methods to determine economic thresholds for pesticide application.

Other companies conduct trials with public research stations, on rented land, plantations, or in farmers' fields. These field experiments include adaptive research and demonstration trials and are closely linked with marketing efforts. Some companies also synthesized their chemical formulations in Indonesia. Manufacturing technologies are quickly transferred from the research units maintained by these companies outside of Indonesia (i.e., in North America, Europe, and Japan). Total research spending by crop protection companies in Indonesia was estimated at $2.4 million in 1995 (table E-4).

Table E-4—Agricultural chemical industry in Indonesia

Major companies	Country	Main products
Novartis	Switzerland	Insecticides, fungicides
Monsanto	United States	Herbicides
Zeneca	United Kingdom	Herbicides
Hoercst	Germany	
Rhone Poulence	France	
Cyanamide	United States	
Dupont	United States	
Total agricultural chemical sales in 1995		US$200-225 million/year 50% insecticides 35% herbicides 15% fungicides and other
Total agricultural chemical research in 1995		US$2,400,000

Source: Industry estimates from author's survey.

Plantations

At least four private plantation companies maintain research facilities in Indonesia. Three of these are locally owned, while the fourth is a subsidiary of a French-Belgian firm (SOCFINDO). Virtually all private plantation research is focused on oil palm. Improved technology for other tree crops (rubber, cacao, coffee, and tea) is from public research in Indonesia or imported from abroad.

Most oil palm research is applied and location-specific in nature, such as trials on soil fertility management. Two companies (SOCFINDO and PT Londsum) maintained breeding and varietal screening programs that produced seed for their own plantings and for sale to other plantations. All companies with in-house research programs maintained or were developing links with research institutions outside of Indonesia. These linkages are an important source of applied technology and the sole source of basic scientific advances, since local research was wholly applied or adaptive. For example, some companies contracted research with CIRAD, a quasi-public French research institution that specializes in tropical agriculture. Public and private research conducted in Malaysia is another important source of new technology. The French-Belgian firm (SOCFINDO) maintained in-house research stations in a number of other countries where it has plantations, and also had a contractual research arrangement with CIRAD for a number of years. Surprisingly, the private oil palm plantations had only weak connections to the publicly supported Indonesian Oil Palm Research Institute (IOPRI) in Indonesia. Public oil palm research was viewed by the large plantations as either not very effective or focused on small holders and state-run plantations. The public

sector is an important source of oil palm seed for the private plantations, however.

Animal Research

The presence of a pure-line poultry farm and several grandparent poultry farms by the private sector involve the employment of breeders and technicians capable of making selections during the multiplication phases of day-old chicks. It is difficult for private firms to estimate research expenditures on poultry research because they generally do not maintain separate accounts for research and production activities. A similar situation exists for swine production, although the degree of breeding and selection is less extensive.

Forestry

In the late 1990s, the private sector in Indonesia and other southeast Asian countries had begun to take interest in tropical forestry research. Growth in global demand for tropical forest products and environmental regulations on forest harvesting increased private interest in replanting harvested areas. As a result, several private companies initiated or planned research programs in tropical forestry. Most of these programs focused on the selection of the most productive species under different environments, with few efforts at breeding new forestry varieties. Another emphasis was on developing mass propagation methods for forestry seedlings. One U.S.-based multinational (Monsanto) has set up a joint venture with an Australian biotechnology firm (BIO) to mass-produce seedlings for fast-growing tree species. This research activity is based in Australia, although they were planning to develop research stations in Malaysia and Indonesia. Long-term goals are to develop transgenic forest plants with insect resistance and herbicide tolerance.

Impact of Private Investments in Research and Technology Transfer

As of 1998, few agricultural innovations could be traced to private-sector research in Indonesia. But the private sector has made important contributions in technology transfer, both importing technologies from abroad and diffusing those technologies among local producers. However, not all agricultural technologies developed in other parts of the world are well-suited for Indonesian conditions. To use such technologies locally may require either that the technology be adapted to the local environment, or that the local environment be modified to suit the technology. In crop production, adaptive research is often required to make the technology suitable to local conditions, though some environmental modifications, such as the expansion of irrigation systems, soil treatments, or the construction of greenhouses, may be made. In animal production, technology tends to be imported directly with little local adaptation. Significant economic efficiencies can apparently be achieved through large-scale integrated commercial units. Even in cases where companies contracted out some animal production with farmers, they found it necessary or desirable to maintain tight control over the management of the contracting farm. The new technology (i.e., modern breeds of poultry, swine, beef, and dairy) responds well to a package of improved inputs, included concentrated feeds, veterinary pharmaceuticals, sanitation, and close supervision. In this case, the private sector has found it more economical to change the environment under which the animals are produced rather than to breed animals for local conditions.

The most important impact of private-sector technology transfer has been in the poultry industry. Use of improved breeds has risen to 650 million broilers and layers per year, or about 75 percent of the total poultry produced in Indonesia. This entire increase occurred after 1970, when the first large-scale poultry operation was opened by a Thai multinational company (Charoen Pokphand) in Indonesia.

The seed industry has been successful at increasing farmers' corn yields by 20 percent or more among farmers who have adopted hybrid seed. Again, this increase was due to transferring technology developed under similar climatic conditions in other countries to Indonesia, rather than developing new varieties within Indonesia. In horticulture, private companies have been successful in obtaining advanced technology from abroad for rapid micropropagation of seedlings. For example, one locally owned company (Fitotek Unggul) licensed a bioreactor from a U.S. company (DNA Plant Technology) to increase production from 500,000 seedlings to more than 5 million seedlings per year of horticultural and floricultural crops. Unit production costs for seedlings declined by about 75 percent.

The private sector has played a major role in promoting new pest, disease, and weed management technologies in field crop production. An important example is the recent expansion of conservation

tillage. Conservation tillage involves the use of herbicides to replace manual weeding. In areas outside of Java, where agricultural land is relatively abundant, chemical weed control enables a farm family to reduce labor inputs per hectare and increase the area on which it can grow crops using manual labor. The use of herbicides also increases cropping intensity (number and type of crops grown per year) by reducing the turn-around time between harvesting and planting the next crop. In irrigated rice production, chemical weed control significantly reduces water requirements by reducing the need for tilling and puddling the soil prior to seeding. Farmers cultivating thin soils have also found conservation tillage a useful means of preserving topsoil through reduced erosion. The use of conservation tillage is estimated to have expanded to around 250,000 hectares between 1991, when it was first introduced, and 1995. All of this area is outside Java, and includes mainly irrigated and upland rice, corn, and soybeans. Private-sector investment in technology transfer of this technology has been substantial. The company primarily responsible for transferring the technology to Indonesia (Monsanto) maintains a staff of 200 field workers to conduct demonstration trials and provide technical advice to farmers.

In the plantation sector, applied and adaptive research efforts have primarily supported the expansion of the oil palm area. As private companies develop new plantations, agronomic research helps determine optimal soil and fertility management under local conditions. Private-sector breeding programs have also been successful at identifying improved varieties. Indonesian oil palm varieties are noted for their high oil extraction rates (22 to 25 percent, compared with under 20 percent in Malaysia).

Policy Determinants of Private Research and Technology Transfer

Until 1998, the policy measures the government used to promote small-holder agriculture had served as a disincentive for private-sector investment in agricultural research and technology transfer. The government relied heavily on administrative prices and direct distribution and procurement of farm inputs and products to achieve its policy goals. The most notable examples of this were the BIMAS programs for rice, field crops, and livestock. Public research and extension were responsible for technology development and transfer under these programs. Partly as a result of these policies, investment by the private sector in agricultural research and technology transfer has lagged considerably behind other southeast Asian countries.

In the 1990s, policy changes began to provide greater incentives for the private sector. In the late 1980s, the government reduced its role in the procurement and distribution of agricultural chemicals, thereby encouraging the private sector to develop its own marketing and extension networks. In 1991, government restrictions on the size of livestock and poultry operations were lifted, enabling more efficient integrated systems to be developed. Agribusiness units have also been established in the Ministry of Agriculture and the Ministry of Industry and Trade to promote private-sector investments in agricultural production and post-harvest processing. Trade and price liberalization has occurred for a number of important commodities such as corn and soybeans. In 1994, a new research fund was established to encourage collaboration between public research institutions and private companies. Finally, the Indonesian Government was in the process of establishing plant breeders' rights and a biosafety protocol for the importation and use of transgenic crops. While the recent nature of many of these policy developments makes it difficult to judge their long-term impact, together they signal a changing government attitude toward the role of agribusiness in agricultural development.

Few policies have been enacted that were specifically designed to promote private-sector agricultural research. No tax incentives exist for private research, and no patent protection existed prior to 1991. Thus, companies cannot seek intellectual property protection on inventions made prior to the patent law. For example, while the herbicide glyphosate was protected by patents in North America and Europe, it did not have patent protection in Indonesia. At least two companies market various formulations of this chemical in Indonesia and sell it at a price about 40 percent lower than what it normally sells for in the United States. However, patents can and have been sought for new formulations of glyphosate.

While government policy has actively discouraged insecticide use in recent years, this policy does not extend to other chemicals. Furthermore, chemical sales have not changed substantially despite the IPM policy initiative. The main government policies to affect the agricultural chemical industry were the elimination of

price subsidies and a reduction in direct procurement and distribution by government agencies. Government extension of nonchemical IPM alternative technologies appears not to have significantly affected research and technology transfer incentives on the part of agricultural chemical companies. Instead, private technology transfer in crop protection has probably increased as companies are forced to rely more on their own sales and distribution networks.

Probably the most important government policy supporting private research and technology transfer is the supply of skilled technical and scientific staff. Private companies make use of public-sector agricultural researchers as consultants or hire them as permanent staff. However, the availability of scientific personnel at the M.S. or Ph.D. level in agricultural fields is still very limited in Indonesia. Private companies have had difficulty in finding and hiring staff at this level. Many of the most prominent agricultural scientists in Indonesia are concentrated among the public research institutions and universities located in Bogor, West Java.

Linkages between public research and private research and technology transfer are limited but growing. Most private companies obtain most of their technological innovations from public and private research institutions or companies outside of Indonesia rather than from public research institutions within the country. Reasons for this include: (1) an emphasis by public agricultural policy, including research policy, on small holders and food crops, (2) varying quality in public research programs, with many of the best public researchers and research facilities concentrated in Bogor, West Java, and (3) the availability of technologies in other countries that could have been imported with relatively little adaptation to the technology. Since the early 1990s, however, new policy interest in promoting agribusiness is leading to some joint public-private activities, including with foreign firms. For example, AARD is working with the U.S. firm Monsanto to test genetically modified cotton in Indonesia, and with a Japanese tuna association to improve commercial tuna fisheries.

Summary of Agricultural Research Investment in Indonesia

Some summary statistics comparing agricultural research and development spending in Indonesia in 1985 and 1995 are presented in table E-5. Between 1985 and 1995, private investment in agricultural research increased from $2.0-$6.1 million, while research spending by AARD increased from $62-$81 million (in nominal terms using current exchange rates). As a share of total agricultural research conducted in Indonesia, private research increased from 3.1 to 7.0 percent over this period. Thus, private research, while still relatively small, grew more rapidly

Table E-5—Private and public agricultural R&D in Indonesia, 1985 and 1995

Item	1985		1995		SY
	Companies	Investment	Companies	Investment	
	Number	*$ Million*	*Number*	*$ Million*	
Seed	0	0	6	0.7	8
Crop protection	1	0.8	6	2.4	20
Plantations	3	0.6	4	2.0	
Animals	3	0.6	3	1.0	
Total private ag R&D	7	2.0	19	6.1	
Public ag R&D		62.0		81.0	
Total ag R&D		64.0		87.1	
			Percent		
Private R&D % of total ag R&D		3.1		7.0	
Agricultural value added		21,200		33,673	
Private R&D as % of value added		0.009		0.018	
Public R&D as % of valued added		0.292		0.241	
Total R&D as % of value added		0.302		0.259	

Note: Dollar values are not adjusted for inflation.

Sources: 1985 estimates from Pray (1987); 1995 estimates for private agricultural R&D from author's survey; 1995 public agricultural R&D from Agency for Agricultural Research and Development (1996); and agricultural value added from World Bank (1997).

than public research. Private research also grew relative to the size of the Indonesian agricultural sector.

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Appendix E: Companies and Officials Interviewed, June 1996

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Dr. Wolfgang Iwansik - head of R&D
Iskandar Zulkarnain - disease control
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