INVESTING IN AGRICULTURAL PRODUCTIVITY IN INDONESIA

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ABSTRAK

Investasi dalam riset pertanian adalah kunci bagi peningkatan produktivitas pertanian. Di Indonesia, investasi pemerintah dalam riset pertanian telah berkembang dengan pesat di dalam dua dekade terahir, sekalipun banyak lembaga riset pertanian tetap mengalami kekurangan dana. Sektor swasta memberikan sumbangan yang sangat besar terhadap pembiayaan riset pemerintah dalam bidang tanaman perkebunan dan kehutanan. Dalam dekade terakhir juga telah terjadi perlipatan dua di dalam nilai riil dari investasi dalam riset pertanian yang dilakukan oleh perusahaan-perusahaan swasta, walaupun investasi swasta ini tetap kecil dibandingkan dengan negara-negara berkembang lainnya di Asia. Perusahaan-perusahaan bibit, bahan kimia, dan ternak multinasional memainkan peranan yang semakin besar di dalam transfer teknologi baru ke Indonesia. Perubahan-perubahan kebijakan yang terjadi baru-baru ini telah meningkatkan dorongan bagi sektor swasta untuk melakukan investasi dalam riset pertanian dan transfer teknologi.

***Kata kunci**: investasi penelitian, transfer teknologi, pemerintah, swasta, produktivitas pertanian.*

ABSTRACT

Investment in agricultural research is a key to agricultural productivity growth. In Indonesia, public investment in agricultural research has expanded significantly in the past two decades, although many agricultural research institutions remain underfunded. The private sector contributes substantially to the financing of public research on plantation crops and forestry. The past decade has also seen a doubling in real terms of agricultural research investment by private companies, although this private investment remains small compared with other developing countries in Asia. Multinational seed, chemical, and animal companies are playing a growing role in transferring new technology to Indonesia. Recent policy shifts have increased private-sector incentives to invest in agricultural research and technology transfer.

***Key words**: research investment, technology transfer, government, private sector, agricultural productivity*

INTRODUCTION

Investment in agricultural technology is one of the keys to agricultural productivity growth and development. Historically, the limited ability of small-holder agriculture to finance or conduct its own technology development has meant that most of the responsibility for agricultural research has rested with the public sector. But the last several decades have seen rapid growth in agricultural research by private firms (Pray and Fuglie, 1999). The private sector, for example, has dominated the application of biotechnology to agriculture (James, 1998). By the early 1990s, private-sector investments in agricultural research exceeded public research investments in the largest industrial countries, although in developing countries private research was still relatively small (Alston, Pardey and Roseboom, 1997). With new technology increasingly proprietary and in the hands of private firms, this disparity in private agricultural research investment has led to concerns that developing countries may not enjoy wide access to many of the new developments in agricultural technology.

The purpose of this paper is to examine the roles and significance of the public and private sectors in investment in agricultural research in Indonesia. In the next section of the paper we review trends in public agricultural research. While government spending for agricultural research has expanded rapidly over the past 25 years, we show that non-government sources play a critical role in funding research for industrial commodities. The section also reviews efforts to reorganize public agricultural research to make it more effective. In the second section of the paper we turn to

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private agricultural research in Indonesia. Historically, private research has focused on plantation commodities, although within the past several years there has been increased activity in the seed, crop protection and animal sectors. Estimates of private research investments are presented based on the author's interviews with major agribusiness firms. The third section deals with public-private linkages in agricultural research, especially how public policies influence incentives for private research and technology transfer.

ORGANIZATION AND FINANCING OF PUBLIC AGRICULTURAL RESEARCH

A Brief History of Agricultural Research in Indonesia

Agricultural research in Indonesia dates back to the tropical botanical gardens that were established by colonial authorities in the early 1800s. The purposes of these gardens were to collect and study tropical plant species and introduce new export commodities to the colonies. The most prominent of these was the botanical garden in Bogor, West Java, established in 1817. During the 19th Century, the garden accommodated a large number of specialists and made considerable contributions to fundamental studies in tropical botany, but scientists gave scant attention to the practical problems of farming (Oudejans, 1999).

Applied agricultural research was stimulated by the plantation owners who demanded solutions to immediate crop management and disease problems. Plantation growers, who produced mainly for export, could not only profit from an expansion of supply but through their associations also had the means to fund commodity-oriented research. Sugar cane planters were the first to establish a research station, in East Java in 1885, followed by coffee and cacao in 1901, tea in 1902, tobacco in 1907, and rubber in 1916. Most of these experiment stations remained relatively small, usually with fewer than 10 senior scientists. An exception was the sugar research station, which by the 1920s had a staff of 35 Europeans and more than 200 Indonesians (Oudejans, 1999). Sugar scientists achieved significant technical advances, such as discovering a method for sexually crossing sugar cane which allowed breeders to develop disease-resistant varieties and led to dramatic increases in sugar cane yield (Pray, 1991).

Government-supported agricultural research was given a firmer footing with the establishment of a Department of Agriculture (DoA) in 1905 under the leadership of Melchior Treub. Treub was a highly-regarded Dutch scientist who sought to organize the new department along the lines of the U.S. Department of Agriculture, which at that time placed a heavy emphasis on research. While the new DoA was mainly concerned with plantation crops, an experiment station for rice and secondary food crops was established in 1907. Nevertheless, the commitment to food crops was insufficient to significantly boost yields and in the 1920s and 1930s, food production lagged behind population growth and Indonesia was often forced to rely on imports to meet basic needs.

Agricultural research in Indonesia was severely disrupted by World War II (1942-45), the War of Independence (1945-49) and a steadily deteriorating economy during the 1950s and early 1960s. Many foreign-owned plantations were also nationalized during this period. A subsequent sharp decline in plantation production curtailed support for the plantation-supported experiment stations. The erosion of scientific and technical personnel engaged in agricultural research was not reversed until the late 1960s.

The "New Order" government of President Suharto, which came to power in 1965/66, put in place sound macroeconomic policies and established food self-sufficiency as a national priority. Funding for agricultural research was substantially increased. To improve the coordination of agricultural research, a new Agency for Agricultural Research and Development (AARD) was established in 1974 within the Ministry of Agriculture. AARD was given overall responsibility for food, forestry and fisheries research.

Organizational Changes in Public Agricultural Research

Public agricultural research in Indonesia has undergone several reorganizations since the establishment of AARD in 1974. In 1979, AARD created a Board of Management to oversee estate crop research, which had previously remained outside AARD's jurisdiction. But despite AARD's nominal control, plantation crop research was largely self-financing and thus maintained considerable autonomy. In 1983, forestry research was transferred from AARD to the newly established Ministry of Forestry (MoF). In 1999, research on industrial crops (coconut, medicinal plants, tobacco and fiber crops) was

also transferred to MoF's Forestry Research and Development Agency (FORDA), along with the nominal control the plantation research institutes. With these changes, AARD held about 70 percent and FORDA 30 percent of all public agricultural and forestry research staff in Indonesia (see Figure 1).

Agricultural research in AARD underwent a major internal reorganization in 1994/95. Some regional substations of the Central Food Crop Research Center (CRIFC) were upgraded and given mandates to lead research on specific commodities. In addition, technology assessment centers were established in each province to establish closer links between research, extension and on-farm testing of new technology. These changes reflected 1) the steadily growing research capacity of the regional substations, 2) an increased emphasis on secondary food crops once rice self-sufficiency was achieved in the mid-1980s, and 3) a concern that linkages between research and extension were inadequate to move technology into the hands of small farmers quickly.

A small amount of public agricultural research in Indonesia takes place outside the Ministries of Agriculture and Forestry. Agricultural universities have a strong cadre of agricultural scientists but research activities are limited due to a lack of funds for research. The Indonesian Institute for Sciences (LIPI) also supports some fundamental research in agricultural sciences, such as at its biotechnology research institute.

Funding and Staffing of Public Agricultural Research

Indonesia achieved significant progress over the past 25 years in building capacity in agricultural research. When AARD was formed in 1974, it had only 19 Ph.D., 167 M.Sc., and 250 B.Sc.-level agricultural scientists. By 1996, the number of agricultural scientists employed in AARD and FORDA had risen to 368 Ph.D., 994 M.Sc. and 2,616 B.Sc.-level scientists, an almost 10-fold increase in research staff. Research expenditures also increased in real terms, although funding per scientist declined (Figure 2). But despite this rapid growth, by the late 1980s support for agricultural research in Indonesia measured as a percentage of agricultural GDP and as a percentage of total government expenditure still ranked near the botton compared with other developing countries in Asia (Pardey, Roseboom, and Fan, 1998).

The financing of public research Indonesia comes from a number of sources, including the general government budget, special assessments on commodity groups, foreign aid, or raised by the research stations themselves through product sales, technology licenses, and contract research. The importance of the sources of funds for agricultural research differs significantly among commodities and institutions (Table 1). AARD's budget comes primarily from general government revenues with a significant supplement from foreign donors. Few resources are raised from the private sector since under current policy any additional revenue must be returned to the government treasury.

Plantation research is mainly financed from the plantation sector itself. The quasi-independent status of the Indonesian Planter's Association for Research and Development (IPARD) allows plantation research stations to keep revenues from product sales. Further, members of IPARD contribute funds for research on plantation crops. Government budgetary contributions to plantation crop research accounts from only about 5 percent of research resources and the private sector the other 95 percent. Due in part to the different ways of financing agricultural research and the special status of IPARD, scientists working at the plantation crop research institutes are significantly better funded than researchers at AARD or FORDA. In 1996, research expenditures per scientist in the plantation sector were about four times higher than at AARD.

For forestry research, nearly two-thirds of the budget comes from a special assessment on forest concessions. Overall, government revenues provided about half the total annual budget form agricultural and forestry research in Indonesia in 1997, foreign aid 11 percent, and the remaining 37 percent from the private sector through product sales and contributions or assessments from commodity groups.

Allocation of Research Resources

More detailed evidence on the allocation of scientific resources for agriculture is presented in Table 2. These figures are based on the number of research staff assigned to the various research institutes in 1996. For example, of the 305 research staff in the Central Research Institute for Food Crops, 43 were assigned to the central administration, 127 to the Biotechnology Research Institute, 93 to the Rice Research Institute, 91 to the Research Institute for Legumes, Root and Tuber Crops, 103 to the Maize and Cereals Institute, and 74 to

the Institute for Swamp Crops (mainly rice). Commodity institutes generally have about a 1-to-2 ratio of Ph.D.-to-M.Sc.-level staff. However, institutes that focus on biotechnology (one in food crops and one in plantations) are heavily weighted in favor of Ph.D. staff. The agricultural technology assessment institutes (ATAI/LATAI) have a relatively large number of B.Sc.-level staff, many of whom serve in extension training.

Impact of Public Agricultural Research

Some of the principal goals of public agricultural research in Indonesia have been to enhance food security, increase rural income, and alleviate poverty. The focus on rice research in the 1970s and early 1980s to achieve food self-sufficiency contributed to a significant increase in rice yield and cropping intensity. Salmon (1991) estimated that rice research expenditures between 1965 and 1977 achieved an annual internal rate of return of 151%. But productivity growth in food crops has not only been achieved in rice. Evenson (1994) found a significant correlation between the level of research investments and that rate of productivity growth for rice, maize, and soybeans between 1971 and 1990. Formal studies on returns to research on other crops have not yet been done, but the rate of yield growth for several of these commodities has exceed 4 percent per year since the mid-1970s (e.g., potatoes, cabbage, bananas, cacao). Several factors have been at work explaining productivity changes in Indonesia over the past 25 years, however, and more careful study is needed to determine how agricultural research contributed to these gains. In addition, more study is needed of the impact of new agricultural technology on rural incomes, equity, poverty alleviation, human nutrition, and environmental quality.

PRIVATE INVESTMENT IN AGRICULTURAL RESEARCH AND TECHNOLOGY TRANSFER

Private-sector research is playing an increasingly important role in the generation of new agricultural technology not only in industrialized countries but in many developing countries as well (Pray and Fuglie, 1999). It was shown in the previous section that about 37 percent of funds for public research originate from the private sector. In addition, private agribusiness companies conduct their own research aimed at generating proprietary products for use within the company or for sale to farmers or other companies.

The evidence presented below on private-sector research in Indonesia is based on interviews conducted by the author in 1996 and compares in scope to an early survey conducted in 1985 (Pray, 1986). In Indonesia, private-sector agricultural research is carried out by private plantations, seed companies, agricultural chemical companies, animal production firms and food processing companies. Most of this research is applied or adaptive, often aimed at testing and screening new products developed elsewhere for application in Indonesia. The private sector, especially multinational corporations based in industrialized countries, are playing a growing role in making new agricultural technology available to Indonesian farmers.

Plantation Agriculture

Plantation crops (oil palm, rubber, cacao, sugar cane, tea, coffee, and spices) are grown by both small-holders and large state-owned and private estates. Privately-owned large estates dominate in oil palm production and have a significant presence in rubber.

Two Indonesian companies (PT Salim and PT Sinar Mas) are now the largest oil palm producers in Indonesia. In addition, several Malaysian companies are investing 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.

At least four private plantations 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 of private plantation research is focused on oil palm. Improved technology for other plantation crops is mainly provided by public research institutes or is imported from abroad.

Most private oil palm research is applied and location-specific in nature, such as trials on soil fertility management. Two companies (SOCFINDO and PT Londsum) maintain breeding and varietal screening programs that produce seed for their own plantings and for sale to other plantations. All of the companies with in-house research programs collaborate with research institutions outside of Indonesia, such as with a French-based tropical research institute (CIRAD) and the Palm Oil Research Institute of Malaysia (PORIM.).

These linkages are an important source of applied technology and the sole source of basic scientific advances since local research is wholly applied or adaptive. The private oil palm plantations have only weak connections to the publicly-supported Indonesian Oil Palm Research Institute (IOPRI). Research at IOPRI is viewed by the large private plantations as focused on the needs of small-holders and state-run plantations. IOPRI is an important source of oil palm seed for the private plantations, however.

Plant Breeding

Government agencies or state companies provide most of the improved seed to Indonesian farmers although a small private seed industry is developing. The Indonesian private seed industry so far has engaged primarily in technology transfer activities such as screening existing varieties and selecting superior lines for production and distribution. Private seed companies focus on hybrid seed for maize and vegetables. Since hybrid seed loses its yield advantage if replanted, most farmers repurchase new seed each year. By restricting access to the parent lines, a seed company can remain the sole supplier of a new variety. In this way a company can recoup its research investment in varietal development.

Three companies dominate the market for hybrid maize: 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 maize breeding program. None of these companies carry out breeding activities in Indonesia at this time but rather test varieties that have been developed elsewhere and select the best varieties for local sale. Since the hybrid seed itself cannot be used to reproduce seed with high yield, farmers need to purchase hybrid seed each year. By restricting access to their parent lines, seed companies can recoup their investment in breeding.

In horticulture , more than twenty companies import vegetable seed for direct sale, and at ten companies conduct varietal trials to test the performance of imported varieties under local conditions, and two companies have breeding programs in Indonesia. Seed companies also transfer improved seed propagation techniques to Indonesia from abroad, such as micropropogation methods (tissue culture). Formal linkages and alliances with foreign multinational companies provide advanced new technology. For example, one of the companies with a horticultural breeding program in Indonesia is a joint venture with East-West Seeds, a Dutch-based seed company. East-West seed also has research activities Netherlands, Thailand, the Philippines and Bangladesh.

Crop Protection

Indonesia is a large market for agricultural pesticides with gross annual sales of around $200 to $225 million. About half of these sales are insecticides, one-third herbicides, and the rest fungicides, rodenticides, and seed treatments. Vegetables are the largest users of pesticides accounting for about 30 percent of total sales. Chili peppers (an important export crop) account for 80 percent of pesticide sales for vegetables. Rice and plantation crops use about 25 percent of the total pesticides each. The remainder of the pesticide market is for soybeans (8 percent), potatoes (5 percent), sugar cane (4 percent), and other crops.

In the last five years the use of herbicides has grown steadily as plantation area has expanded, while sales of insecticides have remained stable or slightly declined. Herbicides in Indonesia were until recently almost entirely used on plantation crops such as oil palm. But as wages for hired labor rise, farmers growing food crops are replacing manual labor used for weeding with chemical weed control. 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.

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, phased out its pesticide procurement and distribution program, and by 1989 had ended pesticides subsidies. The government also conducted a nation-wide extension program emphasizing non-chemical IPM methods for insect control in rice and to a lesser degree in vegetables. Together, these initiatives significantly reduced insecticide application rates on rice and caused many rice farmers to adopt new chemical products (Oudejans, 1999).

Seven or eight multinational companies are represented in the agricultural pesticide market. All

have 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 now maintain substantial sales and technical assistance teams to work with farmers on pest management technology.

Agricultural chemical companies conduct a substantial amount of applied research on crop protection in Indonesia. One multinational chemical company (Novartis) operates two research stations in Indonesia as part of its global network of crop protection research stations. One of these stations focuses on tropical lowland crops such as rice, sugar cane, and chili, and has been in operation since 1980. A second station was opened in 1990 for horticultural crops in tropical highlands. The principle objective of the research at these stations is to test the efficacy of new chemical treatments that have been synthesized at the company's research laboratories in Europe. A second objective is to develop new products and pest control strategies for local and regional markets.

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 synthesis 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).

The Animal Sector

The animal industry in Indonesia features both small, traditional producers who raise animals for multiple purposes, and large commercial operations with links to multinational companies to obtain advanced breeding stock, concentrated feeds, veterinary services, and management methods. The multinational companies may operate their own feed' mills and processing plants and contract with growers in fully integrated systems. Despite efforts on the part of the government to support and improve small-holder animal producers, the large-scale commercial sector has significantly increased its market share in poultry and swine.

The development of large scale, integrated animal production and processing units in Indonesia is 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 to 230 million native chickens in the traditional sector. In 1995 the poultry industry included one pure line poultry farm, 13 grandparent farms, and 106 parent stock farms that produced 25 breeds of day old chicks per year (McEvoy, 1993)..

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

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 difficulty 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. There appears to be little or no private research on cattle or other ruminents in Indonesia, although some private companies import improved cattle breeds from abroad.

Forestry

Growth in global demand for tropical forest products and environmental regulations on forest harvesting have increased interest by private companies in tropical forestry research. Several companies in Indonesia have initiated or are planning research programs to select and multiply the most productive species under different environments. One U.S.-based multinational (Monsanto) has established a joint venture with an Australian biotechnology firm (BIO) to mass produce seedlings for fast growing tree species. This research activity is currently based in Australia, although they plan to establish research stations in

Malaysia and Indonesia. Long-term goals are to develop transgenic forest plants with insect resistance and herbicide tolerance.

Private Agricultural Research Expenditures

Table 3 presents our estimates of agricultural research expenditures by private companies in Indonesia for 1995 and compares them Pray's 1985 survey (Pray, 1986) and with public research expenditures for these years. Between 1985 and 1995, private investment in agricultural research increased from $2.0 million to $6.1 million. In 1995, the plantation sector, seed sector, and crop protection sector each spent around $2 million for research. Research spending by AARD increased from $62 million to $81 million over this period. As a share of total agricultural research conducted in Indonesia, private research increased from 3.1 percent to 7.0 percent over this period. Thus, private research, while still relatively small, grew more rapidly than public research. Private research also grew relative to the size of the Indonesian agricultural sector.

Compared to other developing countries in East and South Asia, private agricultural research In Indonesia lagged behind (Table 4). The largest amount of private research in Asian developing countries was in India at about $55 million a year in the mid-1990s. The next largest amounts of private research expenditure are in Thailand, Malaysia and China, at between $15 to $20 million per year. The Philippines had about $10 million of private agricultural research, followed finally by Indonesia and Pakistan with about $6 million each. Relative to the size of its agricultural economy, private agricultural research expenditures in Indonesia was at just under two hundreds of one percent. In contrast, the private sectors in Thailand and Malaysia spend the equivalent of about one tenth of one percent of agricultural GDP on agricultural research.

Impact of Private Research

The private sector has made important contributions to agricultural productivity in Indonesia by transferring technologies from other countries. In crop production, adaptive research is often required to make the technology suitable to local conditions. In animal production, technology tends to be imported directly with little local adaptation.

Probably 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 since 1970, when the first large-scale poultry operation was opened by a Thai multinational company (Charoen Pokphand) in Indonesia. The recent economic crisis has caused the modern poultry sector to significantly contract in size, however.

The seed industry has been successful at increasing farmers' yields of maize by 20 percent or more among farmers who have adopted hybrid seed. 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 micropropogation 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 productions costs for seedlings reportedly declined by about 75 percent as a result of this innovation.

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 a recent expansion of chemical tillage which 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 in which it can grow crops using manual labor. Farmers cultivating thin soils have also found chemical tillage a useful means of reducing soil erosion since crop residues are left on the soil surface rather than manually incorporated into the soil. The use of chemical tillage is estimated by private chemical companies to have expanded to around 250,000 hectares between 1991 and 1995. All of this area is outside Java and includes mainly irrigated and upland rice, maize, and soybeans. Private-sector investment in technology transfer of this technology has been substantial. The company that was 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 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.

POLICY DETERMINANTS OF PRIVATE RESEARCH AND TECHNOLOGY TRANSFER

Many of the policy measures used by the Indonesian government to promote small-holder agriculture 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 are 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 lagged behind other South East Asian countries (Pray and Fuglie, 1999).

Recently policy changes have begun to provide greater incentives for private agricultural research and technology transfer. 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 Ministry of Agriculture and in 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 maize and soybeans. In 1994, a new research fund was established to encourage collaboration between public research institutions and private companies. Finally, the Indonesian government is 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 assess their impact, together they signal a changing government attitude toward the role of agribusiness in agricultural development.

Few policies have been enacted that are 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 is protected by patents in North America and Europe, it does 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.

Although government policy has actively discouraged insecticide use in recent years, this policy has not extended to herbicides or other chemicals. Furthermore, chemical sales have not changed substantially despite the IPM policy initiative. According to private pesticide companies, the main government policies to affect agricultural chemical demand were the elimination of price subsidies and a reduction in direct procurement and distribution by government agencies. Government extension of non-chemical IPM alternative technologies does not appear 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 personnel through public research and universities. Private companies make use of public-sector agricultural researchers as consultants or hire them as permanent staff. The availability of experienced scientifists at the M.Sc. or Ph.D. level in agricultural fields has expanded rapidly in Indonesia over the past two decades.

Linkages between public research and private research and technology transfer are limited but growing. Most private companies have obtained 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) the emphasis of 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 can be imported with relatively little adaptation. However, new policy interest in promoting agribusiness developed in the early 1990s. This has led 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. But relatively weak regulations and intellectual property rights continue to discourage private sector technology transfer, especially of new agricultural biotechnology applications.

SUMMARY AND DISCUSSION

During the last two to three decades, Indonesia has achieved considerable progress in increasing its investment in agricultural productivity. Human capital resources at public agricultural and forestry research institutions have been significantly strengthened and private investments in agricultural research and international technology transfer have expanded. But relative to other developing countries in Asia, public and private spending on agricultural research remains low. Scientists at public agricultural research institutions, with the exception of the plantation institutes, remain significantly underfunded.

The private sector supports agricultural research in two ways: by helping to fund research at public institutions and through direct investments in research by private companies. In Indonesia, non-government sources (contributions and assessments on commodity groups, revenues from product sales and contract research, etc.) provided more than one-third of the funds for public agricultural and forestry research in 1996. But these sources remain heavily concentrated on a few export-oriented commodities. Private in-house research is also limited to technologies where the scale of production is large (oil palm plantations) or where innovations can be protected through trade secrets (e.g., hybrid maize, hybrid vegetables, hybrid poultry, and pesticide formulations). Direct government support remains critical for a wide range of crop, animal, natural resource, and social science research.

The relatively low level of spending on research by private companies in Indonesia is probably a result of a previous policy environment. But several policy shifts in the last few years signal a greater interest by Indonesia in enhancing the contribution of the private sector to agricultural development. Liberalization of agricultural input and product markets, the establishment of agribusiness promotion sections in government Ministries, collaborative research between public researchers and private companies, and moves to provide intellectual property rights and biotechnology regulations, have provided positive incentives for greater private-sector investment in agricultural research and technology transfer. Encouraging private agricultural research will be critical if Indonesia is to gain timely access to new innovations in agricultural biotechnology, where multinational "life-science" companies play a leading role in development and commercialization. There are a range of additional options that Indonesia could consider to strengthen public-private collaboration in agricultural research, such as technology licensing, joint research ventures, research consortiums, and public matching funds for private contributions to research, among others (see the papers in Fuglie and Schimmelpfennig, 1999, for an in-depth discussion of these options).

There are at least two major concerns regarding the welfare consequences of increased reliance on private agricultural research. One is that costs of agricultural inputs will rise and fewer benefits from agricultural technology will get to farmers. A second is that private research will concentrate mainly on large commercial farmers and ignore the needs of small producers. While it is true that as an incentive for private research a larger share of the economic benefits of new technology are likely to be retained by the private sector, the rate of agricultural productivity growth should be sufficiently increased to more than pay for the higher costs of inputs. If not, then farmers will have little incentive to adopt the new, higher-cost inputs. Furthermore, while most private research in developing countries has tended to focus on the large commercial sector, there are also examples where private research has resulted in significant benefits for small producers, such as millet and sorghum growers in India (Pray et al., 1991). Vegetable seed companies also provide seed mainly to small holders. Some of the key requirements for private research to include the needs of small producers include an adequate means to protect investments in intellectual property and rural institutions to support technology development and adoption, especially strong, public research and extension systems.

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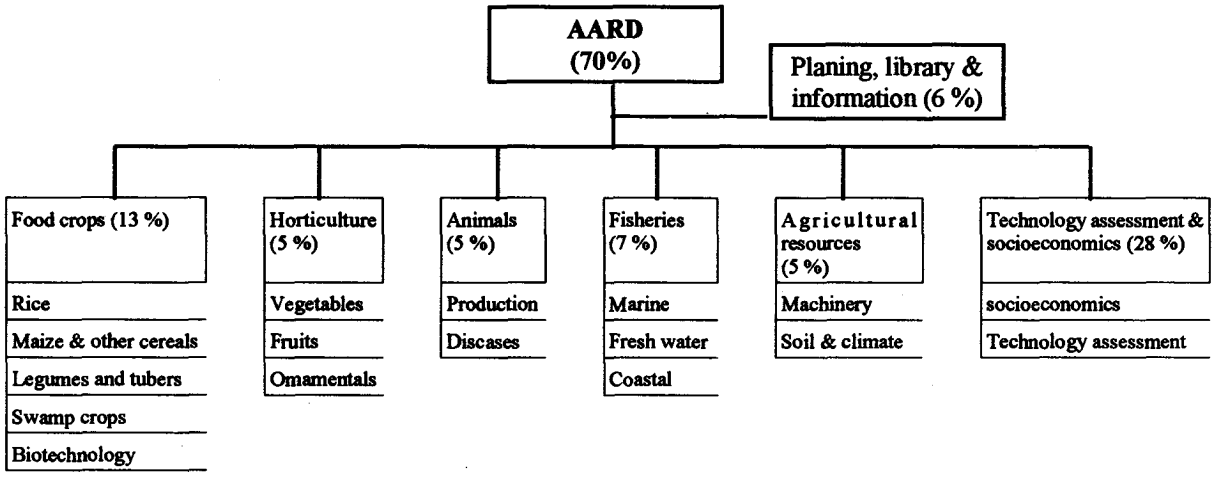
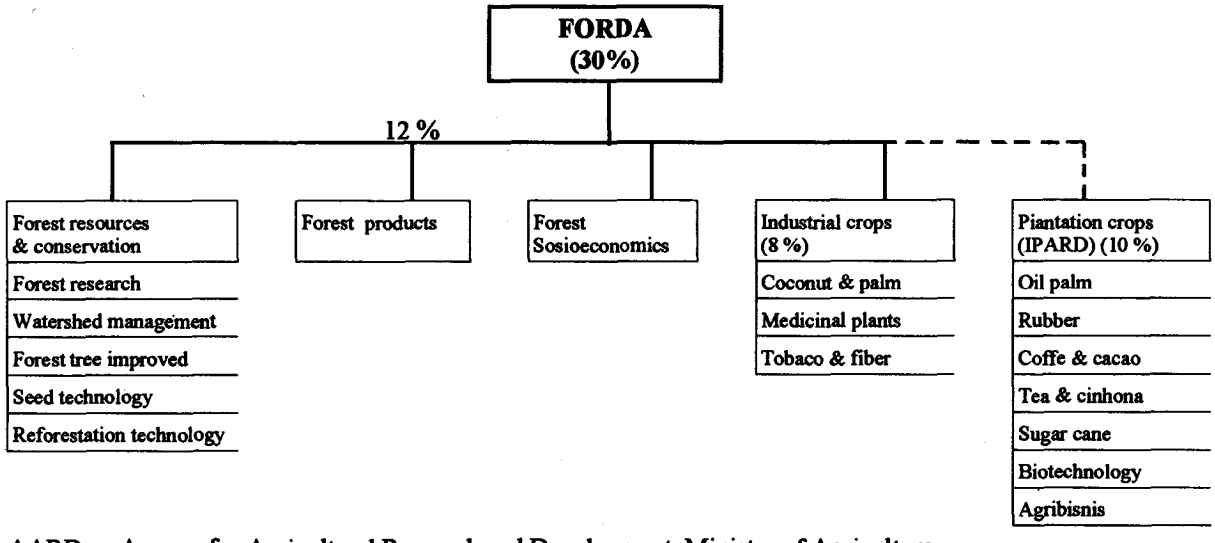
Figure 1. Structure of agricultural and forestry research in Indonesia, 1996



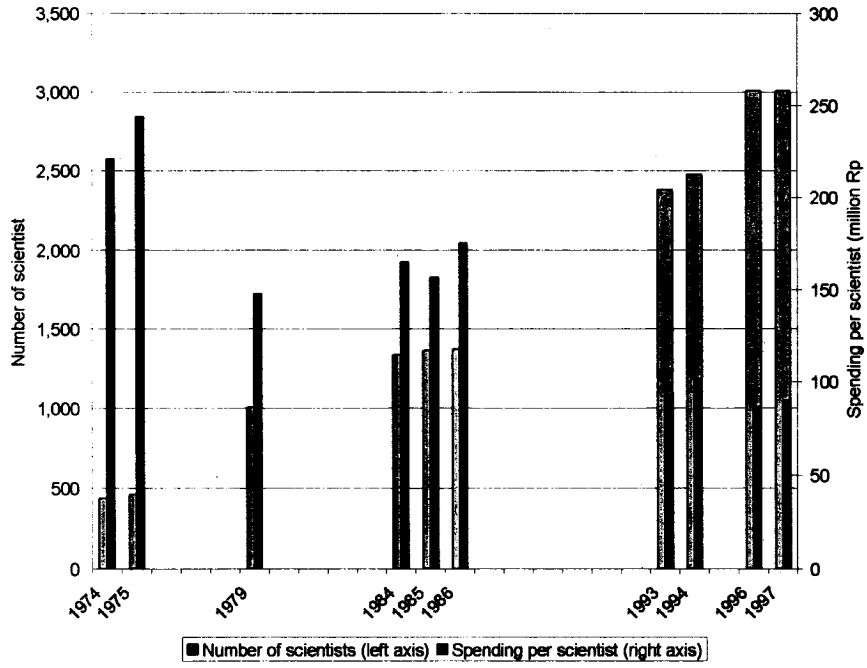


AARD : Agency for Agricultural Research and Development, Ministry of Agriculture

FORDA : Forest Research and Development Agency, Ministry of ForestryI

IPARD : Indonesia Planters Assosiation for Research and Development (Percentages give of all agricultural and forestry research staff in 1996

Figure 2. Number of agricultural scientists and expenditures per scientist in Indonesia, 1974 to 1997



Agricultural scientists are defined as all AARD staff with B.Sc. degree or above. Data after 1983 does not include forestry research. Expenditures are in constant 1997 Rupiah (adjusted for inflation by the GDP price deflator). Sources: Funding and number of scientists from 1974 to 1986 from Pardey and Roseboom (1989). Data for 1993 to 1997 from AARD (various annual issues).

Table 1. Sources of funds for agricultural research in Indonesia in 1996

(Millons of Rupiah)	Goverment	Private/own	Foreign Aid	Total	Million Rupiah per scientist
Crops, Animals, Fisheries	139,940	6,770	36,170	182,880	58.9
Plantations	7,340	85,280	0	92,620	238.1
Forestry	13,815	24,125	0	37,940	78.1
Total	161,095	116,175	36,170	313,440	78.1
(% of total)					
Crops, Animals, Fisheries	76.5 %	3.7 %	19.8 %	100.0 %	
Plantations	7.9 %	92.1 %	0.0 %	100.0 %	
Forestry	36.4 %	63.6 %	0.0 %	100.0 %	
Total	51.4 %	37.1 %	11.5 %	100.0 %	

Sources :Crops, Animals, and Fisheries research funding is from AARD (1996); Forestry research funding is from Badan Penelitian dan Pengembangan Kehutahan (1997); Plantations research funding is from the Indonesian Planters Association for Research and Development (IPARD), unpublished data.

Table 2. Allocation of scientists among agricultural research institutes in 1996

Institution	Full-time scientiie staff				Percent of total			
	Ph.D.	M.Sc.	B.Sc.	Total	Ph.D.	M.Sc.	B.Sc.	Total
Food crops	8	13	22	43	2.2	1.3	0.8	1.1
Biotechnology	34	22	71	127	9.2	2.2	2.7	3.2
Rice	14	24	55	93	3.8	2.4	2.1	2.3
Legume & root cops	7	37	47	92	1.9	3.7	1.8	2.3
Corn & other cereals	9	32	62	103	2.4	3.2	2.4	2.6
Swamp crops	6	24	44	74	1.6	2.4	1.7	1.9
Total Food Crops	78	152	305	535	21.2	15.3	11.7	13.4
Holticulture	3	4	4	21	0.8	0.4	0.5	0.5
Vegetables	9	16	16	62	2.4	1.6	1.4	1.6
Fruits	4	9	9	56	1.1	0.9	1.6	1.4
Ornamentals	8	18	18	60	2.2	1.8	1.3	1.5
Total Holticulture	24	47	47	196	6.5	4.7	4.8	4.9
Animals	51	69	93	213	13.9	6.9	3.6	5.4
Fisheries	26	79	185	290	7.1	7.9	7.1	7.3
Industrial Crops	5	10	28	43	1.4	1.0	1.1	1.1
Medicinal plants	13	32	77	122	3.5	3.2	2.9	3.1
Tobaco & fiber crops	6	20	62	88	1.6	2.0	2.4	2.2
Coconut & other palms	2	17	26	45	0.5	1.7	1.0	1.1
Total Industrial	26	82	208	316	7.1	8.2	8.0	7.9
Ag Machinery	1	7	36	44	0.3	0.7	1.4	1.1
Land & climate	14	50	95	159	3.8	5.0	3.6	4.0
Socio-economics	20	45	57	122	5.4	4.5	2.2	3.1
ATAI/LATAI *	27	167	793	987	7.3	16.8	30.3	24.8
Secretariat/Planning/Library	9	40	192	241	2.4	4.0	7.3	6.1
TOTAL AARD	276	738	2,089	3,103	75.0	74.2	79.9	78.0
Plantation Crops								
Oil palm	8	30	39	77	2.2	3.0	1.5	1.9
Rubber	18	41	32	91	4.9	4.1	1.2	2.3
Sugar	12	26	78	116	3.3	2.6	3.0	2.9
Coffee and cacao	8	13	16	37	2.2	1.3	0.6	0.9
Tea and cinchona	4	15	16	35	1.1	1.5	0.6	0.9
Biotechnology	9	6	6	21	2.4	0.6	0.2	0.5
Agribusiness	3	8	1	12	0.8	0.8	0.0	0.3
TOTAL PLANTATIONS	62	139	188	389	16.8	14.0	7.2	9.8
FORESTRY (FORDA)	30	117	339	486	8.2	11.8	13.0	12.2
TOTAL AGRICULTURE	368	994	2,616	3,978	100.0	100.0	100.0	100.0

*ATAI/LATAI are provincial-level agricultural technology assessment institutes created in AARD's 1994/95 reorganization.
Sources: Number of scientists at AARD institutes from AARD (1996); Number of forestry scientists from Badan Penelitian dan Pengembangan Kehutahan (1997); Number of scientists at plantations institutes from Dewan Riset Nasional (1996).

Table 3. Private and Public Agricultural R&D in Indonesia, 1985 and 1995

	1985		1995	
	Companies	$ Million	Companies	$ Million
Seed	0	0	6	0.7
Crops Protction	1	0.8	6	2.4
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 R&D	-	64.0	-	87.1
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 %	-	0.081 %
Public R&D as % of Value Added	-	0.292 %	-	0.241 %
Total R&D as % of Value Added	-	0.302 %	-	0.259 %

Sources: 1985 estimates from Pray (1986); 1995 estimates for private agricultural R&D from author's survey; 1995 public agricultural R&D from Agency for Agricultural Research and Development (1996); agricultural value added from World Bank (1997).

Table 4. Private Agricultural R&D Expenditure, Growth and Research Intensity

Country	Privat R&D Expenditure (million 1995 USD)		Percent increase in R&D in past 10 years	Private Research Intensity (Private R&D as % of Ag Value Added)	
	1985-7	1995-8		1985-7	1995-8
Large Low Incame					
China	0.0	11-16.0	Infinite	0.000	0.009
India	25.7	55.5	116	0.026	0.059
Middle Incame					
Malaysia	14.1	16.6	19	0.173	0.150
Thailand	10.6	17.4	64	0.124	0.095
Mid Size, Low Incame					
Indonesia	2.8	6.1	118	0.010	0.018
Philipines	6.2	10.5	69	0.059	0.064
Pakistan	2.4	5.7	138	0.019	0.036
Total	61.8	122.8-127.8	99-107	-	-

Source: Pray and Fuglie, 1999.