AGRICULTURAL SCIENCE
AND TECHNOLOGY INDICATORS

AGRICULTURAL R&D IN INDONESIA:

POLICY, INVESTMENTS, AND INSTITUTIONAL PROFILE

ASTI Country Report

Gert-Jan Stads, Haryono, and Siti Nurjayanti

November 2007

International Food Policy Research Institute
and
Indonesian Agency for Agricultural Research and Development

ABOUT THE ASTI INITIATIVE

The Agricultural Science and Technology Indicators (ASTI) initiative compiles, processes, and makes available data on institutional developments and investments in agricultural R&D worldwide, and analyzes and reports on these trends. Tracking these developments in ways that make for meaningful comparisons among different countries, types of agencies, and points in time is critical for keeping policymakers abreast of science policy issues pertaining to agriculture. The main objective of the ASTI initiative is to assist policymakers and donors in making better informed decisions about the funding and operation of public and private agricultural science and technology agencies by making available internationally comparable information on agricultural research investments and institutional changes. Better informed decisions will improve the efficiency and impact of agricultural R&D systems and ultimately enhance the productivity growth of the agriculture sector. The ASTI initiative is managed by the ISNAR division of the International Food Policy Research Institute **(www.ifpri.org)** and comprises a network of national, regional, and international agricultural R&D agencies. Primary funding for the ASTI initiative's survey round in Asia was provided by the World Bank and IFPRI core funding.

The ASTI data and associated reports are made freely available for research policy formulation and priority-setting purposes, and can be found at the ASTI website: **www.asti.cgiar.org**

ABOUT THE AUTHORS

Gert-Jan Stads is a consultant with the ASTI initiative under IFPRI. Dr. Haryono is the Secretary of IAARD, and Siti Nurjayanti is head of the data and information subdivision under the IAARD Secretariat.

ACKNOWLEDGEMENTS

The authors are grateful to numerous colleagues in Indonesia for their time and assistance in collecting data, particularly the public and private sector agencies for their active participation in the conduct of this activity. They express special gratitude to Dr. Achmad Suryana, the Director General of IAARD for his insightful comments and suggestions as well as guidance in the preparation of this report. They also wish to thank Nienke Beintema, Widi Hardjono, and Dr. Marhendro for contributing useful comments on various drafts of this report, and Messrs. Endro and Nandi for coordinating the data collection activities under the technical supervision of Dr. Haryono. The authors would also like to express their gratitude to the Asia Pacific Association of Agricultural Research Institutions (APAARI) for facilitating the ASTI survey in the Asia-Pacific region.

This country report has been informally peer reviewed, but has not been subject to a formal review process managed by IFPRI's Publications Review Committee. The views expressed in the paper are those of the authors, and not necessarily those of the organizations where they work.

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

LIST OF TABLES

LIST OF FIGURES

ACRONYMS *

ACIAR	Australian Centre for International Agricultural Research
ADAT	Agency for Development and Application of Technology
ADB	Asian Development Bank
AgGDP	Agricultural Gross Domestic Product
AIAT	Assessment Institute for Agricultural Technology
APEC	Asia–Pacific Economic Cooperation
ARMP	Agricultural Research Management Project
ARMP–II	Agricultural Research Management Project – Phase II
ASEAN	Association of Southeast Asian Nations
ASTI	Agricultural Science and Technology Indicators
ATCWG	Agricultural Technical Cooperation Working Group
ATWGARD	ASEAN Technical Working Group on Agricultural R&D
AusAID	Australian Agency for International Development
BAKOSURTANAL	National Coordinating Agency for Surveys and Mapping
BATAN	National Nuclear Energy Agency
BPPT	Agency for Technology Assessment and Application
BSc	Bachelor of Science
CGIAR	Consultative Group on International Agricultural Research
CIFOR	Center for International Forestry Research
CIP	International Potato Center
CIRAD	Agricultural Research Centre for International Development (France)
CRDRSAT	Center for Research and Development of Remote Sensing Application and Technology
DINAS	Provincial and District Support Service
FORDA	Forestry Research and Development Agency
fte	full-time equivalent
GDP	gross domestic product
IAARD	Indonesian Agency for Agricultural Research and Development
IBRC	Indonesian Biotechnology Research Center for Estate Crops
ICABIOGRD	Indonesian Center for Agricultural Biotechnology and Genetic Resources Research and Development
ICAERD	Indonesian Center for Agricultural Engineering Research and Development
ICALRD	Indonesian Center for Agro-Climate and Land Resources Research
ICAPRD	Indonesian Center for Agricultural Postharvest Research and Development
ICASERD	Indonesian Center for Agricultural Socio-Economic Research and Development
ICASRD	Indonesian Center for Animal Sciences Research and Development
ICCRI	Indonesian Coffee and Cocoa Research Institute
ICECRD	Indonesian Center for Estate Crops Research and Development

ACRONYMS (CONTINUED)

ICFORD	Indonesian Center for Food Crops Research and Development
ICHORD	Indonesian Center for Horticulture Research and Development
ICRAF	World Agroforestry Center
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFPRI	International Food Policy Research Institute
IITA	International Institute for Tropical Agriculture
IMF	International Monetary Fund
IOPRI	Indonesian Oil Palm Research Institute
IPARD	Indonesian Planters Association for Research and Development
IPB	Bogor Agricultural University
IPTTMO	Intellectual Property and Technology Transfer Management Office
IRIEC	Indonesian Research Institute for Estate Crops
IRITC	Indonesian Research Institute for Tea and Cinchona
IRTC	Indonesian Rubber Technology Center
IRRI	Indonesian Rubber Research Institute
IRRI	International Rice Research Institute
ISRI	Indonesian Sugarcane Research Institute
ITTO	International Tropical Timber Organization
JICA	Japan International Cooperating Agency
LAPAN	National Institute of Aeronautics and Space
LIPI	Indonesian Science and Technology Agency
MHP	PT Musi Hutan Persada
MSc	Masters of Science
NRC	National Research Council
NSU	North Sumatra University
OECD	Organisation of Economic Co-operation and Development
PAATP	Participatory Development of Agricultural Technology Project
PhD	Doctor of Philosophy
PPP	purchasing power parity
R&D	research and development
RCB	Research Center for Biotechnology
RCFMFPPS	Research Center for Marine and Fisheries Product Processing and Socio-Economics
RISTEK	State Ministry of Research and Technology
S&T	science and technology
SMART	Sinar Mas Agro Resources and Technology
SMARTRI	Sinar Mas Agro Resources and Technology Research Institute
UBC	University of British Columbia
UMP	Universitas Muhammadiyah Purwokerto
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific, and Cultural Organization
USAID	United States Agency for International Development

ABSTRACT

This report presents an overview of the Indonesian national agricultural R&D system in the context of the country's wider national science and technology (S&T) policy. The discussion includes institutional developments and recent trends in human and financial resources based on data collected under the Agricultural Science and Technology Indicators (ASTI) initiative.

With close to 5,000 full-time equivalent researchers in 2003 (26 percent of which were female), Indonesia has one of the largest agricultural research systems in Asia. However, the country's agricultural R&D expenditures suffered severely in recent years as a result of the financial crisis that swept Asia in the late 1990s. In 2003, the country invested $254 million in agricultural R&D (in 2000 international dollars), which was well below pre-crisis levels. Indonesia's total agricultural R&D spending accounted for less than 2.5 percent of the Asia–Pacific region's total agricultural R&D spending in 2000 (excluding OECD countries).

The Indonesian Agency for Agricultural Research and Development (IAARD) is country's central agricultural R&D agency. It works through nine major units that focus on socio-economics, soils and agro-climates, engineering, food crops, estate crops, horticulture, livestock, biotechnology, and postharvest activities. IRIEC is a semi-public R&D agency that is linked to IAARD, but not formally part of it. It conducts research on Indonesia's principal plantation crops and is by far the largest agricultural R&D agency in the country in terms of research spending. FORDA, on the other hand, is the archipelago's principal forestry R&D agency. The higher education sector (dominated by IPB) plays a fairly important role in Indonesian agricultural R&D as well.

Public agricultural research on livestock, food, and horticulture crops in Indonesia is heavily reliant on government funding, while IRIEC is mostly financed through the sale of plantation crops and contract research. Although donor funding plays only a limited role in total financial support to Indonesia's agricultural R&D (compared to some other countries in Southeast Asia), multilateral donor-financed projects such as ARMP–II and PAATP have had a significant impact on the structure and quality of Indonesia's agricultural R&D system.

Compared to most countries in the Asia-Pacific region, the private sector plays a relatively important role in conducting agricultural R&D in Indonesia. We estimated that about 19 percent of total (public and private) spending in agricultural R&D was done by the private sector, mostly plantation and seed companies.

AGRICULTURAL R&D IN INDONESIA

POLICY, INVESTMENTS, AND INSTITUTIONAL PROFILE

Gert-Jan Stads, Haryono, and Siti Nurjayanti

INTRODUCTION

Given the more rapid growth of other economic sectors, the agricultural sector's share of Indonesia's gross domestic product (GDP) fell from 45 percent in 1970 to 15 percent in 2004 (World Bank 2005). Nevertheless, agriculture still represents an important input to the national economy and an important livelihood for the rural population. In fact, the vast majority of Indonesia's rural poor depend on agriculture for employment and income as well as their own food supply. Consequently, agricultural research and development (R&D) is prioritized by the Indonesian government.

During the past few decades, R&D has contributed significantly to the impressive performance of Indonesia's agricultural sector, the two most outstanding achievements being the attainment of self-sufficiency in rice production in 1984 and the development of a strong, competitive export-crop sector. However, it must now continue to improve its capacity to address the country's changing needs and priorities. This paper presents an overview of the Indonesian national agricultural R&D system and places it in the context of the country's wider national science and technology (S&T) policies. It discusses the institutional development of the agricultural R&D system and describes recent trends in human and financial resources based on data collected under the Agricultural Science and Technology Indicators (ASTI) initiative (IFPRI–IAARD 2003–05). Keeping track of this type of information is important for policymakers and donors to make better-informed decisions about the funding and operation of public and private agricultural S&T agencies. The quality of such decisions has a direct impact of the efficiency and effectiveness of agricultural R&D systems.

Macroeconomic Context

Indonesia consists of roughly 130,000 islands stretching in an east–west direction over 3,000 miles (5,000 kilometres). With its population of 218 million in 2004, Indonesia is

the fourth-largest country in the world in terms of population after China, India, and the United States (World Bank 2006). Nearly 60 percent of the country's population lives on the island of Java, which has a population density of more than 900 per square kilometre (350 per square mile). Indonesia is by far the largest economy in Southeast Asia. But in terms of per capita income, the country lags well behind many of its Southeast Asian counterparts. The archipelago's economy underwent considerable growth during 1970–1997, averaging roughly 7 percent per year. However, the financial crisis that hit Asia in 1997 severely affected Indonesia. The country's economy shrank by 13.1 percent between 1997 and 1998. Since then, modest economic growth has resumed, albeit at substantially lower growth rates than those recorded in the decade prior to the economic crisis (World Bank 2006).

Arable farmland comprises roughly a quarter of the archipelago's land area (World Bank 2006). Indonesian farms produce food crops for domestic consumption and cash crops for export. Rice is the country's principal food crop. Indonesia was once a large importer of rice, but in the late 1960s and 1970s the government introduced improved varieties, increased the use of fertilizers and pesticides, provided better infrastructure for irrigation, and improved the systems of farm credit. By the mid-1980s, the country had attained self-sufficiency in rice production. Most of the rice is grown on the island of Java. Cassava is the second most important food crop, followed closely by maize. Non-food crops, such as rubber, oil palm, sugarcane, and cocoa are becoming increasingly important. Indonesia is currently the world's second-largest exporter of rubber and oil palm (behind neighboring Malaysia) and the third-largest exporter of cocoa and coffee. Many of the plantations are based on the less-populated islands of Sumatra, Borneo (Kalimantan), and Papua. Total agricultural exports declined rapidly during the years immediately following the Asian financial crisis, but are currently back at pre-crisis levels (FAO 2006). Even so, in 2005, agricultural exports accounted for less than 10 percent of the country's total exports. Large quantities of food are still imported.

Livestock raised in Indonesia include cattle, buffalo, pigs, goats, sheep, and poultry. Most of the livestock industries are concentrated in Java. The key priority of the Indonesian government as far as the livestock sector is concerned is the expansion of the

poultry industry, in particular the broiler industry. However, the avian influenza crisis has recently struck a massive blow to the country's poultry sector.

Indonesia possesses the world's second-largest tropical forest (after Brazil). Large numbers of Indonesians depend directly on forests for their livelihoods, whether it is gathering forest products for their daily needs or working in the wood-processing sectors of the economy. However, rapid deforestation as a result of large-scale illegal logging is a major problem. In certain remote regions, illegal logging is the main industry and for a large proportion of villagers it is a staple income source. However, despite the economic rewards reaped by timber companies in exchange for this rapidly diminishing resource, the community as a whole does not receive much benefit.

Marine waters cover more than 70 percent of Indonesia's territory and the country is endowed with vast fisheries and marine resources. Shrimp exports grew dramatically during the 1990s, surpassing all but rubber as an agricultural export earner (Fuglie and Piggott 2006). Marine and fisheries development has been accorded a high priority by the Government of Indonesia. It is seen as one of the prime movers of the national economy. However, the industry has not yet reached its maximum capacity due to fishermen's low productivity, insufficient facilities, poor infrastructure, poor transportation and communication to support distribution of products, and lack of market intelligence.

Science and Technology Policies and Investments

The State Ministry of Research and Technology (RISTEK) is responsible for formulating all national policies for research, science, and technology in Indonesia. Although it has little control over the allocation of research funds, it does operate a number of competitive grants and other funding programs. RISTEK has formulated a six-focus program, concentrating on the following areas:

- Food and agriculture: Food resilience through agricultural systems, aquaculture, agro-industry and agribusiness.
- Energy: Sustainable energy supply through the creation and use of new and renewable sources.
- Transportation: Creating an effective and efficient multi-mode land-, air-, and sea-based transportation system.

- ICT: Using information communication technology to increase economic prosperity and good governance.
- Health and pharmaceuticals
- Defense

The Indonesian government has stated that science and technology is to play an important role in maintaining the country's economic expansion. Indonesian science and technology policy emphasizes industrial development and it pays special attention to human resource development, small and medium-sized companies, and technology-intensive industries. And while government institutions still dominate many R&D activities, they are restructuring to be more relevant to the private sector. Environmental and health-care technologies are also priorities of the government. Indonesia is seeking foreign technology and partnerships to speed up developments in these areas.

During 1999–2002, total (agricultural and non-agricultural) R&D spending by the Indonesian government remained relatively stable at around 650 billion current Indonesian rupiahs per year. However, as a percentage of GDP, government R&D spending shows a consistent decline throughout this period. In 2002, Indonesia's public R&D investments totaled 0.04 percent of the country's GDP, down from 0.06 percent in 1999. This was one of the lowest levels in Asia. In comparison, neighboring countries such as Malaysia, Singapore, and the Philippines invested 0.50, 1.89, and 0.11 percent in 2000, respectively (RISTEK 2006; MOSTE 2003).[1] In 2000, private-sector R&D accounted for more than one-third of total R&D spending in Indonesia (RISTEK 2006). If private-sector R&D is factored in, Indonesia invested 0.08 percent of its GDP on R&D in 2000, still well below the levels recorded in neighboring countries.

THE ORGANIZATION OF INDONESIAN AGRICULTURAL R&D

Indonesian Agency for Agricultural Research and Development

The Indonesian Agency for Agricultural Research and Development (IAARD) is Indonesia's central agricultural R&D agency and it falls under the Ministry of Agriculture. IAARD's mission is to create, engineer, and develop new innovations needed to foster an agribusiness system that supports the agricultural sector to become a

[1] The share for the Philippines is for 2003.

strong sector in national development. The agency was founded in 1974 and it works through nine major units that focus on socio-economics, soils and agro-climates, engineering, food crops, estate crops, horticulture, livestock, biotechnology, and postharvest activities. Each unit manages several research institutes that conduct research in these fields. The head of IAARD is appointed by the Indonesian president and reports directly to the minister of agriculture. The head is responsible for the organization and overall direction of the agricultural research program and the services that support it.

The Jakarta-based IAARD Secretariat provides technical and administrative services to all units within the agency, as well as direct support to the Director General of IAARD. Between them, the Secretariat's four divisions (financial administration, human resource administration, general administration, and organizational management) coordinate budget preparation and financial administration for the IAARD units, manage all matters pertaining to personnel, and perform general administration duties such as revising and monitoring the agency's regulations and managing official correspondence and inquiries on behalf of IAARD.

IAARD's research centers and institutes undertake research that aims to develop policy alternatives and technology components. They then pass their findings on to the agency's Assessment Institutes for Agricultural Technology (AIATs) in each province for testing. Given the variability of Indonesia's agricultural ecosystems, R&D was decentralized in order to generate location-specific technologies based on farmers' needs and circumstances. Because the AIATs are located close to the areas they serve, they are able to adapt technologies to suit each location so farmers will be able to adapt to them quickly (IAARD 2003). The network of AIATs covers all regions in Indonesia, so that development, diffusion, and use of research results as well as the provision of location-specific information and technology are ensured (AARD–ISNAR 2002). These regional assessment centers were established in 1994 and have received strong support from international donors, notably the World Bank and the Asian Development Bank (ADB) through the second phase of the Agricultural Research Management Project (ARMP–II) and the Participatory Development of Agricultural Technology Project (PAATP), respectively (see Financing Agricultural Research on page 32). Prior to the decentralization and establishment of AIATs, there were no mechanisms for planning and

setting priorities for agricultural R&D at the provincial/regional level. Information concerning provincial research needs was identified by the district-level Government Office of Agriculture and channeled through the Directorates General of the Ministry of Agriculture to IAARD. In decentralized agricultural research, after 1994, new mechanisms were designed and implemented at the provincial level to allow the involvement of stakeholders, including beneficiaries, in the planning of agricultural R&D activities. Through the AIATs, IAARD researchers and extension workers are integrated into one structure. AIAT staff work closely with other regional and provincial agencies in planning and implementing a common regional R&D program with the active participation of university researchers, farmers' groups, extension workers, the Provincial and District Support Service (DINAS), the private sector, and community and locally based organizations (World Bank 1995).

As of 2003, IAARD had 25 AIATs, the coordination of which is the responsibility of the Indonesian Center for Agricultural Socio Economic Research and Development (ICASERD). The 25 AIATs are scattered over the archipelago, with eight institutes in Sumatra, five in Java, two in Nusa Tenggara, four in Kalimantan, one in Maluku, four in Sulawesi, and one in Papua.

Institutional Categories

This study categorizes Indonesian agricultural R&D agencies by government agencies, higher education agencies, nonprofit agencies, and businesses (see Appendix A for definitions and methodology used in this report). Sixty public-sector agencies were identified to be involved in agricultural R&D in Indonesia, in addition to a sizeable number of private-sector agencies (see Appendix C for a full list of agencies included in our survey sample). Completed survey forms were received from 73 of them, or—in a few cases—used secondary data sources (16 government agencies, 1 nonprofit institution, 41 higher education agencies, and 15 businesses). In 2003, these 73 agencies employed more than 5,100 full-time equivalent (fte) researchers and spent $287 million (in 2000 international prices) or 576 billion Indonesian rupiahs (in 2000 constant prices) on agricultural R&D (Table 1). Our survey sample excluded two public-sector agencies due to data unavailability: the Agency for Development and Application of Technology (ADAT) and the Faculty of Fisheries of Diponegoro University, both of which were

reported to conduct only minimal agricultural R&D. The 15 private-sector agencies that conduct agricultural R&D in Indonesia and are included in our survey sample employed a total of 248 fte scientists. Based on Fuglie (2001) and in-depth interviews with the principal private-sector agencies in Indonesia, it was estimated that the survey sample covered 70 percent of private-sector plantation crop research, 40 percent of seed research, 80 percent of forestry research, and 30 percent of agricultural research carried out by chemical companies. If the missing private-sector agencies are factored in, the private sector employed an estimated 430 fte researchers and spent $59 million on agricultural R&D (in 2000 international prices) in 2003, the equivalent of 119 billion Indonesian rupiahs (in 2000 constant prices).

Table 1—*Composition of agricultural R&D expenditures and researchers, 2003*

Type of agency	Total spending		Total researchers	Share		Agencies in sample[a]
	2000 Indonesian rupiahs	2000 international dollars		Spending	Researchers	
	(*millions*)		(*fte's*)	(*percentage*)		(*number*)
Public agencies						
IAARD	156,685.7	78.2	2,396.0	25.0	45.0	9
IRIEC	122,990.8	61.4	229.0	19.6	4.3	1
FORDA	56,834.7	28.4	546.0	9.1	10.3	1
Other government agencies[b,c]	21,717.8	10.8	178.1	3.5	3.3	5
Nonprofit agencies[d]	68.8	0.03	2.4	0.01	0.05	1
Higher-education agencies[e,f]	149,900.9	74.8	1,541.1	23.9	29.0	41
Subtotal public	*508,198.8*	*253.6*	*4,892.6*	*81.1*	*91.9*	*58*
Private agencies						
Recorded	67,306.5	33.6	248.4	10.7	4.7	15
Estimated omitted agencies[g]	118,676.8	59.2	430.1	18.9	8.1	na
Total	*626,875.5*	*312.8*	*5,322.7*	*100.0*	*100.0*	*na*

Source: Compiled by authors from ASTI survey data (IFPRI–IAARD 2003–05).

[a] See Appendix C for a list of the 73 agencies included in our survey sample.

[b] Staff at the other government agencies spent between 10 and 100 percent of their time on research, resulting in 1,541.1 fte researchers.

[c] Expenditures for BAKOSURTANAL are estimates based on average expenditures per researcher at the remaining government agencies.

[d] Staff at KAFFAH, the only nonprofit agency in our sample, spent 30 percent of their time on research, resulting in 2.4 fte researchers.

[e] Staff at the higher education agencies spent between 10 and 100 percent of their time on research, resulting in 1,541.1 fte researchers.

[f] Expenditures for the higher education sector in our sample are estimates based on average expenditures per researcher at the government agencies.

[g] Expenditures for the omitted private enterprises are estimates based on average expenditures per researcher for the private enterprises for which data were available.

Scaling up our sample totals to account for the missing private-sector agencies brings the total number of (public and private) fte agricultural researchers in Indonesia to 5,323 and total agricultural R&D expenditures to $313 million (in 2000 international prices) or 627 billion constant Indonesian rupiahs (in 2000 constant prices).[2]

Government agencies

As mentioned previously, IAARD works through nine major units, all of which are described briefly below. Bogor-based ICASERD is by far the largest IAARD agency in terms of research staff. In 2003, the agency employed 870 fte researchers. They carried out policy research related to agricultural programs, making use of agricultural, socio-economic, and policy analysis and research results. As previously mentioned, ICASERD coordinates the location-specific activities of the AIATs in Indonesia's provinces, which partly explains the high number of fte researchers employed at the center.

The Indonesian Center for Food Crops Research and Development (ICFORD) is charged with generating research on the country's primary staple crops including rice, maize and other cereals, and legumes (such as soybeans, peanuts, and root and tuber crops). The focus of the institute's research is broad and includes plant genetics (breeding and management of germplasm), agronomic studies, pest and disease management, and biotechnology. The scope of ICFORD's work is compounded by the diverse growing conditions found in Indonesia. The center manages three research institutes: the Indonesian Research Institute for Rice in Sukamandi-Subang (West Java), the Indonesian Cereals Research Institute in Maros (South Sulawesi), and the Indonesian Legumes and Tuber Crops Research Institute in Malang (East Java). In addition, ICFORD coordinates the works of a number of research stations and experimental farms. In 2003, 348 fte researchers were active at ICFORD.

The Indonesian Center for Estate Crops Research and Development (ICECRD) is responsible for conducting R&D on estate crops. The center has four research institutes:

[2] Compiling expenditure data for higher education agencies proved difficult. The little data that were obtained often included only the explicit expenditures earmarked for research – such as the operational costs associated with university research or project funds received from external sources – rather than a comprehensive accounting of the costs including salaries, rent, and utilities appropriately prorated to reflect the share of total faculty time spent on research. To redress these problems, an estimate of total expenditures for the higher education sector was calculated using the average expenditures per researcher for the government agencies scaled by the total fte researchers employed by the higher education agencies in our sample.

the Indonesian Medicinal and Aromatic Crops Research Institute in Bogor (West Java), the Indonesian Tobacco and Fiber Crops Research Institute in Malang (East Java), the Indonesian Coconut and Palmae Research Institute in Manado (North Sulawesi), and the Indonesian Spices Research Institute in Sukabumi (West Java). Each of these institutes performs research on cultivation, breeding, farming systems, post-harvest processing, and biotechnology. ICECRD also manages a research station focusing on intercrops (IAARD 2003). ICECRD employed 332 fte researchers in 2003.

The Indonesian Center for Agro-Climate and Land Resources Research (ICALRD) conducts research on a wide scope of topics related to land use, soil and climate variables affecting productivity, and sustainable agriculture. Its other role is to produce maps for development and land-use planning at the national, regional, and ecosystems level. ICALRD has four research institutes, two of which are based in Bogor, some 60 kilometers (40 miles) from central Jakarta: the Indonesian Agroclimate and Hydrology Research Institute and the Indonesian Soil Research Institute. The other two institutes are the Indonesian Agricultural Environment Research Institute located in Jakenan (Central Java), and the Indonesian Wetland Research Institute in Banjarbaru (South Kalimantan). In 2003 ICALRD had 307 fte researchers.

The Indonesian Center for Animal Sciences Research and Development (ICASRD) conducts research on livestock breeding, reproduction, post-harvest handling, forage and feedstuffs, veterinary sciences, pharmacology, livestock germplasm, and germplasm of fodder crops and micro-organisms. ICASRD has two institutes, both located in Bogor, focusing on animal production and veterinary medicine. Production studies concentrate on pasture and feed developments and improved breeding lines, while disease studies identify and develop treatments and vaccines for a variety of livestock afflictions. In addition, the center operates two research stations located in Pasuruan (East Java) and Sungei Putih (North Sumatra). The first focuses on beef and cattle research, while the latter concentrates on goats. In 2003, ICASRD had 201 fte researchers.

The Indonesian Center for Horticulture Research and Development (ICHORD) is charged with horticultural R&D. The center oversees R&D activities of four research institutes: the Indonesian Ornamental Plants Research Institute in Cianjur (West Java), the Indonesian Research Institute for Citrus and Subtropical Fruits in Batu (East Java),

the Indonesian Tropical Fruits Research Institute in Solok (West Sumatra), and the Indonesian Vegetables Research Institute in Bandung (West Java). Their research includes plant breeding, germplasm conservation and use, cultivation, pest and disease control, post-harvest handling, and various socio-economics aspects. In 2003 ICHORD had 138 fte researchers.

As its name implies, the Indonesian Center for Agricultural Biotechnology and Genetic Resource Research and Development (ICABIOGRD) is responsible for the research and development of agricultural biotechnology and genetic resources. Its work covers research on cell and tissue biotechnology, genetic engineering, bioprospecting of agricultural genetic resources, and biosafety. In 2003, this Bogor-based agency employed 117 fte research staff.

The Indonesian Center for Agricultural Postharvest Research and Development (ICAPRD) was established in 2002. The center is responsible for the research and development of agricultural postharvest technology. Its work covers the identification and characterization of agricultural-quality products, the use of agricultural waste and development of new products, the physical, chemical and biological aspects of process technology, systems for quality management and food safety, and components of systems technology that support agribusiness. ICAPRD is based in Bogor and employed 49 fte researchers in 2003.

The Indonesian Center for Agricultural Engineering Research and Development (ICAERD) is the smallest of the IAARD centers in terms of research staff. The center designs and builds prototypes of various types of farm equipment, covering the spectrum from land preparation to post-harvest processing. ICAERD tests equipment to standardize, certify, and monitor equipment use. ICAERD has also re-engineered agricultural machinery for production and postharvest purposes. In 2003, the agency employed 34 fte researchers.

The Indonesian Research Institute for Estate Crops (IRIEC) was established by the Indonesian Planters Association for Research and Development (IPARD) and is a semi-public R&D agency. While IRIEC is not formally part of IAARD, it is managed through the agency, and the head of IAARD is an *ex officio* member of the IRIEC board. IRIEC has five research centers for different commodities, namely the Indonesian Rubber

Research Institute (IRRI), the Indonesian Oil Palm Research Institute (IOPRI), the Indonesian Research Institute for Tea and Cinchona (IRITC), the Indonesian Coffee and Cocoa Research Institute (ICCRI), and the Indonesian Sugarcane Research Institute (ISRI). Each of these institutes performs research on cultivation, breeding, farming systems, and postharvest processing. In addition to these commodity-research institutes, IRIEC is also supported by three other centers at the Bogor headquarters: the Indonesian Rubber Technology Center (IRTC), the Indonesian Biotechnology Research Center for Estate Crops (IBRC), and the Indonesian Information and Training Center for Estate Crops (IITC) (IAARD 2003; IRIEC 2005). Combined, the R&D institutes under IRIEC employed 229 fte researchers in 2003.

Forestry and fisheries research were once part of the IAARD system, but now constitute separate components of the Indonesian agricultural R&D system, falling under the jurisdiction of separate ministries. The Forestry Research and Development Agency (FORDA) has its headquarters in the Ministry of Forestry's building in Jakarta. FORDA is involved in forest-product technology, biotechnology, forest-tree improvement, and forestry socio-culture and economics. The agency has four research centers and 15 research stations scattered all over the archipelago. Most of the research takes place in the agency's headquarters in Bogor. FORDA employed 546 fte researchers in 2003.

The Research Center for Marine and Fisheries Product Processing and Socio-Economics (RCFMFPPSE) was part of IAARD until 2001, when it was separated and became an independent agency under the Ministry of Marine Affairs and Fisheries. RCFMFPPSE, along with its three research institutes, conducts studies in three basic fields: marine fisheries, freshwater fisheries, and coastal aquaculture. All the agency's research activities are conducted at its Jakarta base. There are 32 monitoring agencies scattered all over the country, but they are not involved in research. In 2004, RCFMFPPSE had 70 fte researchers.

The Research Center for Biotechnology (RCB) under the Indonesian Science and Technology Agency (LIPI) provides the core scientific resources for systematic collections and associated biodiversity information in Indonesia. RCB's collections are the largest in Asia and include many unique and irreplaceable scientific reference biological specimens, including some dating from the nineteenth century. Agricultural

research also plays an important role in RCB's mandate. In 2003, RCB's 81 fte researchers focused principally on rice, beef, and forestry research.

The National Institute of Aeronautics and Space (LAPAN) conducts aerospace research. One of the centers under LAPAN's umbrella, the Center for Research and Development of Remote Sensing Application and Technology (CRDRSAT), is involved in limited research on the use of remote sensing. CRDRSAT employed 36 fte researchers in 2003.

The National Nuclear Energy Agency (BATAN) and the Geomatics Research Division of the National Coordinating Agency for Surveys and Mapping (BAKOSURTANAL) were both involved in limited agricultural R&D as well. In 2003, they employed 6 and 2 fte agricultural researchers, respectively.

Higher education agencies

The main role of higher education agencies in agricultural R&D has traditionally been the training of scientific personnel. However, higher education agencies are also involved in (limited) agricultural R&D themselves. Bogor Agricultural University (IPB) is very much at the heart of the Indonesian agricultural R&D system. It is by far the largest agricultural university in the country. It was founded in 1963, following the enactment of new higher education laws, and consists of 8 faculties, 36 departments, and 30 research centers located on the campus grounds of 250 hectares. In 2000, IPB became an autonomous university. This status enabled the university to manage its assets for academic excellence as well as for entrepreneurial purposes. Agricultural research takes place around seven IPB faculties: the Faculty of Agriculture, the Faculty of Veterinary Medicine, the Faculty of Marine Sciences and Fisheries, the Faculty of Animal Husbandry, the Faculty of Forestry, the Faculty of Agricultural Technology, and the Faculty of Mathematics and Natural Sciences. Combined, these faculties employed 501 fte agricultural researchers in 2003.

Twenty-three other Indonesian universities were identified to be involved in agricultural R&D. Combined, they employed 1,040 fte agricultural researchers in 2003, spread over 34 faculties.[3] Nine of these universities were located in Java, four in Sumatra,

[3] 33 of the 34 faculties are included in our survey sample. Data for the Faculty of Fisheries of Diponegoro University were unavailable and this agency is therefore excluded from further analysis in this report.

three in Sulawesi, three in Kalimantan, one in Bali, one in Lombok, and one in Papua (see a complete list of the universities and faculties in Appendix C). Udayana University in Bali (182 fte researchers), the University of Hasanuddin in South Sulawesi (100 fte researchers), and Padjajaran University in West Java (97 fte researchers) were the largest universities in terms of total agricultural research staff. Crop research was prominent at most universities, although livestock, fisheries, and socio-economic research played an important role as well.

Nonprofit institutions

A handful of nonprofit institutions in Indonesia are involved in agricultural research, which are often limited and ad hoc in nature. Data was obtained for only one: the Kaffah Foundation. This foundation was established in 1989 to support regional development programs with particular reference to helping empower people to develop their economic activities and welfare. Limited crops, livestock, forestry, fisheries, and socio-economic research is conducted by the agency's 2.4 fte researchers.

Private-sector agencies

The sample includes 15 businesses, ranging from locally owned enterprises to companies with a majority of foreign ownership. Private-sector research in Indonesia is discussed later in this report.

International Linkages and Cooperation

Indonesia's agricultural R&D agencies participate in a significant amount of collaborative research at the national, regional, and international level. IAARD actively explores and develops research collaboration and cooperative agreements with numerous national, regional, and international institutions. In-country research collaboration takes place mainly with the universities, other government agencies, and private institutions. Cooperation with foreign countries is through bilateral, multilateral, and regional relationships. IAARD has a long history of collaboration with various members of the Consultative Group on International Agricultural Research (CGIAR), beginning with the International Rice Research Institute (IRRI). This cooperation has been extremely productive, generating rice varieties and lines that have been adopted by farmers throughout Indonesia. This Philippines-headquartered institute operates a country office

in Bogor. In the 1980s two CGIAR centers with mandates for forestry and natural resources research established a significant presence in Indonesia: the Center for International Forestry Research (CIFOR) opened its world headquarters in Bogor and the World Agroforestry Center (ICRAF), which is based in Kenya, established its Southeast Asia Regional Program in this city. Training sessions and symposia, co-sponsored by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and the International Institute of Tropical Agriculture (IITA), have strengthened IAARD's research on legumes and root crops. IAARD has also made significant progress in increasing potato production with the help of the International Potato Center (CIP), which also has an office in Bogor.

Bilateral links are strong between IAARD and Australia, Canada, Germany, Japan, Malaysia, the Philippines, South Korea, the United Kingdom, and the United States. Collaboration takes places in the form of grants, science and technology transfer, and technical assistance. At the Southeast Asian level, linkages are particularly strong. IAARD is a member of the Technical Working Group on Agricultural R&D (ATWGARD) of the Association of Southeast Asian Nations (ASEAN) and it plays a key role in the Agricultural Technical Cooperation Working Group (ATCWG) under the Asia–Pacific Economic Cooperation (APEC), as part of which IAARD has been appointed leader of the Agricultural Technology Transfer and Training (ATT&T) program.

Linkages between IAARD and the university and private-sector agencies have been strengthened during the past decade with the support of loans from the World Bank and the ADB. The World Bank-financed ARMP–II and PAATP, funded by the ADB, set aside special funds for collaboration between IAARD scientists and universities, international research centers, and private-sector companies (Fuglie and Piggott 2006). Collaboration involved joint research, hands-on training, technical assistance, scientist/manager exchange, and information sharing (World Bank 1995).

Being largely financed by the private sector, IRIEC works closely with private plantation companies such as Swasta Nasional, Good Year, and London Sumatra. It also conducts research on behalf of PT Perkebunan Nusantara, a government-owned estate. At the international level, FORDA works closely with CIFOR. FORDA's Director-General

is on CIFOR's Board of Trustees and both agencies collaborate in a sustainable forest management project. In addition, FORDA maintains close linkages with the French Agricultural Research Centre for International Development (CIRAD) (on biotechnology and wood processing), the European Union (on sustainable forest management projects), and the United States Agency for International Development (USAID) (on wood industry revitalization). FORDA also collaborates with the private sector, mainly with the paper industry and timber plantations such as PT Musi Hutan Persada (MHP). RCMFPPS cooperates with IPB, universities in Australia and Germany, the World Fish Center, the Australian Centre for International Agricultural Research (ACIAR), and the Japan International Cooperation Agency (JICA). BIOTECH–LIPI is involved in joint research projects with Leiden University and the Laboratory of Genome Analysis in Wageningen, both in the Netherlands.

IPB works closely with other universities throughout Indonesia. In addition, long-term research agreements exist with research agencies and universities in Australia, Canada, France, Germany, Japan, the Netherlands, South Korea, and the United States.

HUMAN AND FINANCIAL RESOURCES IN AGRICULTURAL R&D

Agricultural R&D Staffing Trends

During the period 1994–2003, total agricultural research staff in our sample of 58 public-sector agricultural R&D agencies decreased at an average rate of 0.5 percent per year, from 5,185 to 4,893 (Table 2). This overall rate masks differences among institutional categories. Research staff totals at the nine IAARD agencies combined and IRIEC show a consistent decline throughout this period, while the total number of researchers at FORDA and the higher education sector rose steadily. As a result, the relative shares of the various public agricultural research staff categories shifted considerably during 1994–2003 (Figure 1). The share that the nine IAARD agencies (excluding IRIEC) occupy in total fte research staff has consistently declined from nearly 58 percent in 1994 to 49 percent in 2003. Similarly, the share of IRIEC dropped from 6 to 5 percent throughout the same period. FORDA's share in total public agricultural R&D staff, on the other hand, rose steadily from 7 percent in 1994 to 11 percent in 2003, following important recruitment efforts. The share that the higher education agencies occupy also grew. It increased from 26 percent in 1994 to 32 percent in 2003, despite the 2000–05 recruitment

freeze at IPB. The shares of the other government and nonprofit institutions in total agricultural staff remained relatively unchanged.

Table 2—*Long-term composition of agricultural R&D staff of national and regional government agencies, 1994-2003*

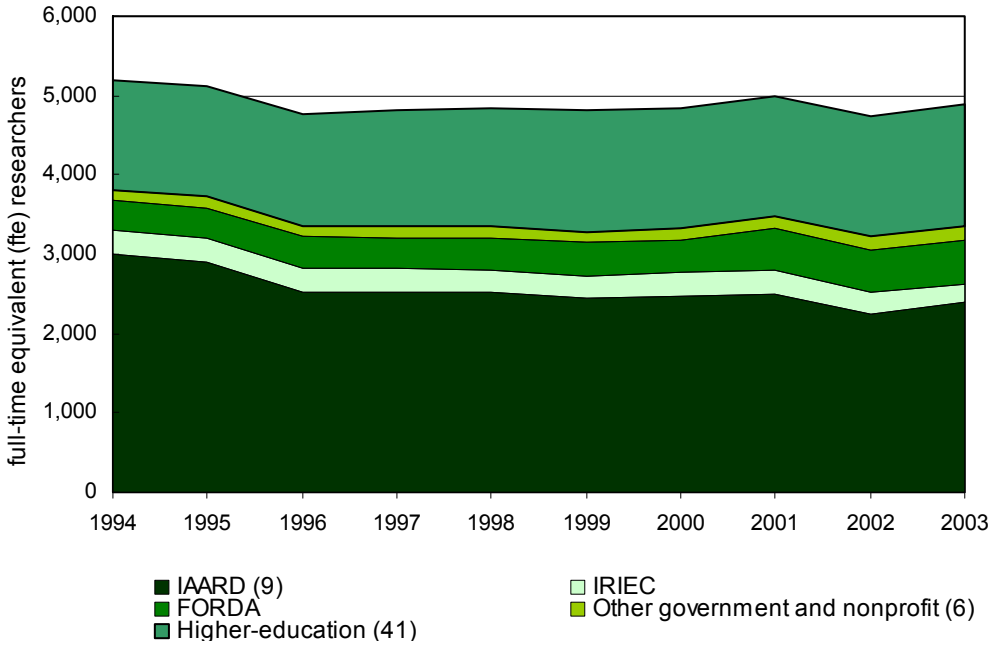
Agency	1994	1997	2000	2003
Number		(*fte's*)		
IAARD (9)	3004.8	2517.0	2465.0	2396.0
IRIEC	305.0	296.0	299.0	229.0
FORDA	367.7	397.0	423.0	546.0
Other government and nonprofit (6)	136.5	141.8	150.8	180.5
Higher education (41)	1371.1	1470.6	1509.1	1541.1
Total (58)	*5185.2*	*4822.3*	*4846.9*	*4892.6*

	1994-97	1997-2000	2000-03	1994-2003
Annual growth rate		(*percentage*)		
IAARD (9)	-6.5	-0.9	-1.9	-2.4
IRIEC	-1.1	0.2	-8.7	-2.2
FORDA	2.6	2.0	8.3	4.8
Other government and nonprofit (6)	0.8	1.8	6.1	2.4
Higher education (41)	2.1	1.0	0.7	1.3
Total (58)	*-2.9*	*0.1*	*-0.2*	*-0.5*

Source: Compiled by authors from ASTI survey data (IFPRI–IAARD 2003–05).

Notes: See Appendix C for a full list of agencies included in each category. The numbers in parentheses indicate the number of agencies in each category. Annual growth rates were calculated using the least-squares regression method, which takes into account all observations in a period. This results in growth rates that reflect general trends that are not disproportionately influenced by exceptional values.

Figure 1—*Composition of public agricultural researchers, 1994–2003*



Source: Compiled by authors from ASTI survey data (IFPRI–IAARD 2003–05).

Notes: See Table 1. Figures in parentheses indicate the number of agencies in each category. The category "Other government and nonprofit" consists of 5 government agencies and 1 nonprofit agency.

The total number of agricultural researchers fell more rapidly during 1994–96 than it did during other subperiods, mainly as a result of rapidly decreasing research staff numbers at ICFORD, ICASRD, and ICASERD. During this period, IAARD underwent a complete restructuring with the establishment of the AIATs. Total research staff at the nine IAARD agencies showed a constant decline during 1994–2003, from more than 3,000 fte researchers to less than 2,400. Only ICALRD and ICAERD employed more researchers in 2003 than they did in 1994. The remaining IAARD agencies all reported a decline in their researcher totals. The overall decline of IAARD research staff was the result of some major organizational reshuffling, including the move of fisheries research activities to the Ministry of Marine Affairs and Fisheries. The drop was most severe at ICFORD as the number of research units at this center was reduced from six to five in the mid-1990s, and some researchers were moved to either the Biotechnology Research Institute in Bogor, AIAT West Sumatra, or to the Agricultural Departments of the District Governments. Several institutes involved in livestock research underwent similar

restructuring. IRIEC's research staff totals showed a somewhat more irregular trend, but its 2003 researcher total was about three-quarters of the total recorded a decade earlier due to a recruitment freeze.

In contrast, research staff at the remaining four institutional categories increased steadily throughout 1994–2003. FORDA and the other government agencies showed much more rapid growth during 2000–03 than they did during 1994–2000. This is because many of the FORDA technicians obtained researcher status towards the end of the 1990s. RCFMFPPSE was responsible for the rapid growth in the other government agencies category during 2000–03. The agency was established in 2001 and its number of researchers doubled during 2001–04. In contrast, growth at the higher education agencies was highest during the mid-1990s. As mentioned previously, the legal status of IPB (which accounts for one-third of research staff in the higher education sector) changed in 2000 and the university endured a recruitment freeze during 2000–05 as a result. Retirees were not replaced, resulting in a modest decline in the total number of researchers at IPB. Nevertheless, the higher education sector as a whole experienced consistent growth throughout 1994–2003 and employed 1,541 fte researchers in 2003.

The distribution of the 58 public-sector agencies is skewed toward agencies with between 20 and 49 fte researchers: one out of five of the agricultural agencies fall into this category (Table 3). Most government agencies, however, have more than 50 fte researchers. In 2002, just two agricultural research agencies employed more than 500 fte researchers (ICASERD and FORDA), and five agencies employed between 200 and 500 fte researchers (ICFORD, ICECRD, ICALRD, IRIEC, and ICASRD). All these agencies fall into the government category. The individual capacity of the majority of higher education units is small compared to the capacity of the government R&D agencies. Roughly 70 percent of the 41 higher education units – many being university faculties and departments – employed less than 50 fte researchers. The research capacity of many private-sector agencies is also small: of the 15 agencies in our sample, 11 employed less than 20 fte researchers.

Table 3—*Size distribution of agricultural R&D agencies, 2003*

Number of fte researchers	Government	Higher education	Nonprofit	Private	Total
			(*number of agencies*)		
Less than 10	2	4	1	7	14
10–19	0	8	0	4	12
20–49	3	17	0	3	23
50–99	2	11	0	1	14
100–200	2	1	0	0	3
200–500	5	0	0	0	5
Greater than 500	2	0	0	0	2
Total	*16*	*41*	*1*	*15*	*73*

Source: Compiled by authors from ASTI survey data (IFPRI–IAARD 2003–05).
Note: Higher education includes faculties and units.

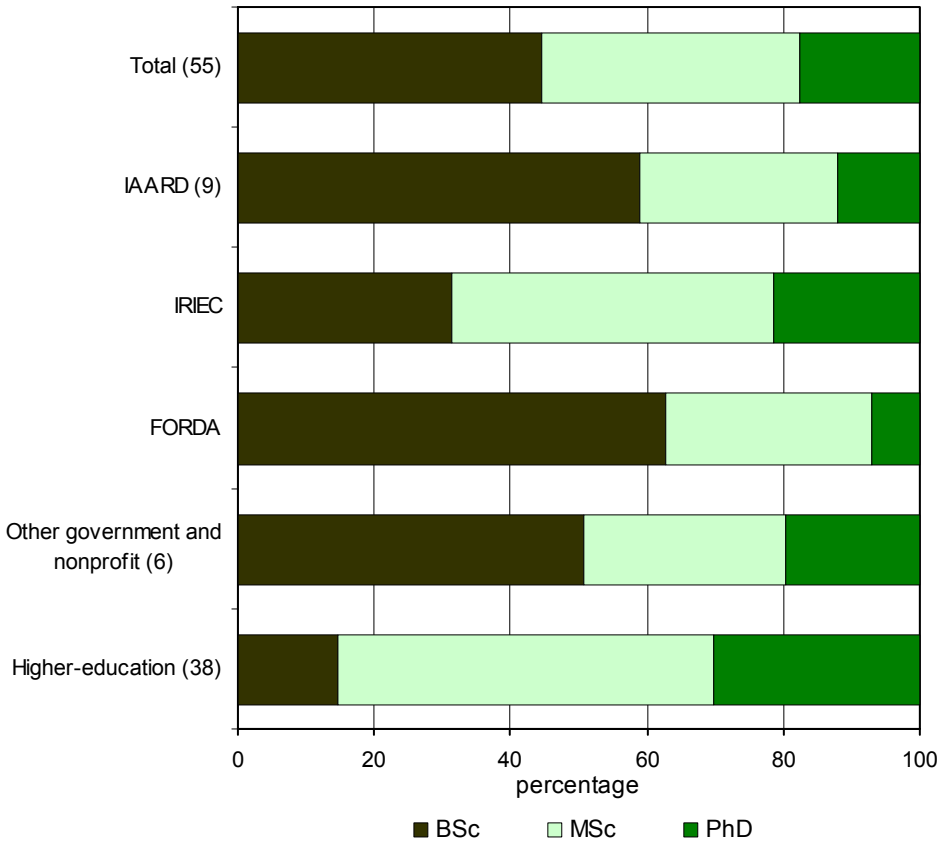
Degrees

Indonesia made major progress during the past three decades in building agricultural research capacity. When IAARD was established in 1974, only seven scientists held a PhD degree (Fuglie and Piggott 2006). By 2003, this total had risen to 227 (including PhD-qualified researchers at IRIEC). Of the 3,577 fte agricultural researchers in a 53-agency sample, 18 percent held a PhD degree, 43 percent a MSc degree, and 39 percent a BSc degree (Figure 2). The Indonesian share of researchers trained to the postgraduate level (MSc or PhD) is slightly lower than in India (88 percent) and Malaysia (69 percent), but higher than in other countries in the region, such as the Philippines (41 percent) and Vietnam (36 percent) (Beintema and Stads 2007). The share of research staff holding postgraduate degrees at the higher education agencies (82 percent) is much higher than the corresponding shares at the government agencies (48 percent). This is a consistent finding in countries in the region and developing countries worldwide.

Average degree levels of Indonesian research staff improved significantly across the board throughout 1994–2003. For the 38 public agencies combined, the shares of PhD and MSc holders were higher in 2003 than they were in 1994. IRIEC in particular experienced a tremendous improvement in the qualifications of its research staff. In 1994, just 42 percent of IRIEC researchers were trained to postgraduate level, compared to 69 percent in 2003. This share was much higher than the corresponding share for most IAARD agencies. In comparison, ICFORD and ICSARD had postgraduate shares around the 40 percent mark during the same year. Average postgraduate shares in the higher education sector diverged widely as well, from 55 percent at the Faculty of Agriculture of

Universitas Muhammadiyah Purwokerto (UMP) to 100 percent at the agricultural research unit of North Sumatra University (NSU).

Figure 2—*Educational attainment of research staff by institutional category, 2003*



Source: Compiled by authors from ASTI survey data (IFPRI–IAARD 2003–05).
Note: Figures in parentheses indicate the number of agencies in each category.

Human resource development and training were an important part of the World Bank-financed ARMP–II. The new region-based decentralized R&D approach required an extensive reorientation and retraining of staff who, thus far, had been working mostly in commodity-oriented component research. A quarter of the newly appointed AIAT staff was scheduled for long-term (degree and diploma) training during 1995–2001. In addition, considerable financial support was provided for short-term, non-degree/diploma training to strengthen staff capability in the specific skills required to effectively carry out the regional R&D programs. ARMP–II's training component totaled US$8.9 million (9 percent of the total project costs) (World Bank 1995). Upon the project's completion in 2001, 428 IAARD scientists had received long-term training. Of these, 21 were trained to

PhD level and 341 to MSc level. Of the 21 PhD candidates, 8 were from the AIATs and 13 from the national research institutes. Seven participants obtained PhD degrees at overseas universities. Of the 341 MSc candidates, 190 came from AIATs, 151 from national research institutes. Thirty-eight were trained overseas. In addition, 23 staff completed BSc degrees at Indonesian universities and an additional 5,455 staff received short-term training (134 of whom went abroad for training). The total number of IAARD staff trained at the close of the project far exceeded the number envisaged in ARMP–II's original design (World Bank 2003).

PAATP also contained an important training component. During 1999–2003, 18 IAARD scientists received PhD training and 33 IAARD scientists MSc-level training at universities in Australia, Malaysia, the Netherlands, and Thailand. In addition, 23 IAARD researchers received a PhD degree, 160 researchers a MSc degree, and 12 researchers a BSc degree from Indonesian universities as part of this project. Moreover, 111 IAARD staff members participated in 37 overseas short-term courses in the field of biotechnology, hybrid-rice technology, supply-chain management, bio-fertilizer technology, integrated crop management, agricultural information systems, and research management. In addition, IAARD maintains a research manpower development program as part of its integral strategic planning. This program includes the recruitment and development of capable researchers through a variety of degree programs as well as short-term training for career-building purposes (AIM 2003).

Roughly 40 percent of FORDA's PhD holders received their degrees from Indonesian universities and the remaining 60 percent were trained abroad (notably in Europe, Japan, and the United States). In the past, FORDA reserved a special budget for PhD-level staff training abroad, but this has recently been cut. A small budget for MSc training remains nonetheless. In recent years, an annual average of 5 to 10 researchers at BIOTECH–LIPI have been sent abroad for training. Most of the research staff at RCMFPPS is recruited as fresh graduates directly out of universities and trained on the job. Canada's University of British Columbia (UBC) funds MSc- and PhD-level training for two of the agency's scientists in Canada each year.

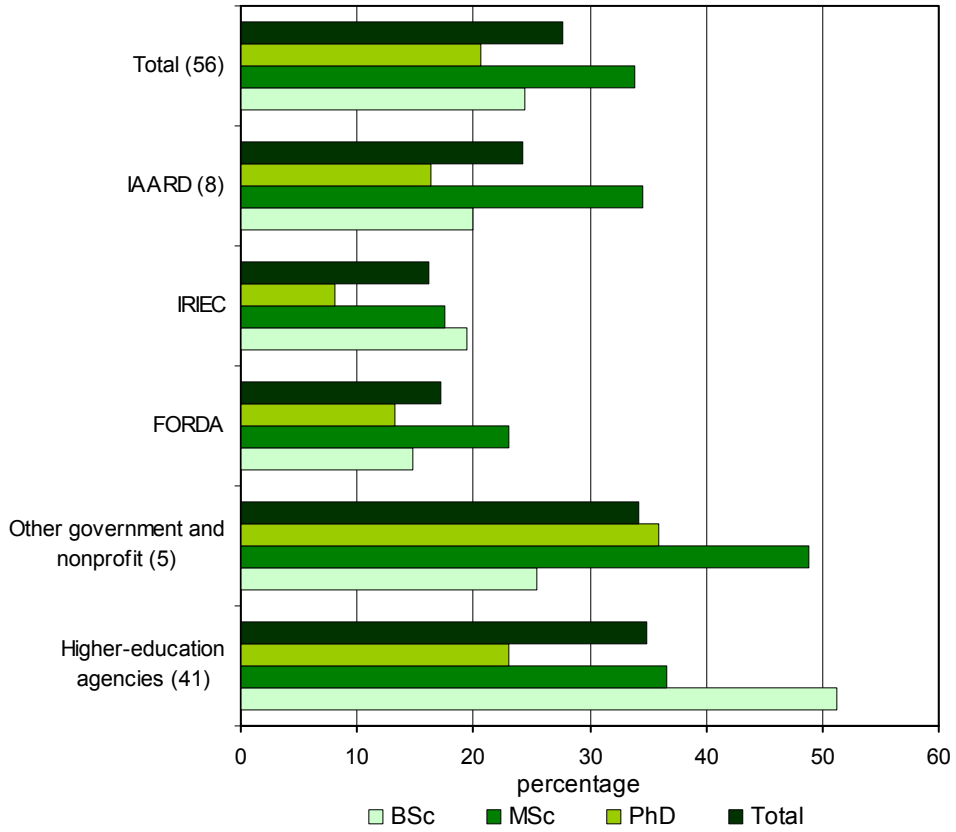
Between 2000 and early 2005, there was a recruitment freeze at IPB. Staff numbers declined, but the quality of existing staff improved steadily. During this period, IPB scientists continued their studies and hence degree levels increased throughout the period. Most PhD-holders obtained their degree from overseas universities (in Australia, Canada, France, Germany, Japan, the Netherlands, South Korea, and the United States).

Gender

Despite a rise in the number of women pursuing scientific careers worldwide, female researchers still tend to be underrepresented in senior scientific and leadership positions (Sheridan 1998). Indonesia is no exception. In 2003, 28 percent of the fte researchers at the country's public agricultural R&D agencies were women (Figure 3). In addition, 21 percent of the PhD-qualified researchers, 34 percent of those with MSc degrees, and a quarter of those with BSc degrees were women. The share of female researchers in Indonesia is similar to that recorded in other Southeast Asian nations such as Malaysia (34 percent) and Vietnam (31 percent), which are higher than the average for the Asia–Pacific region (21 percent) (Stads et al. 2005; Stads and Nguyen 2006; Beintema and Stads 2007). Indonesia does not have a gender gap in education. In fact, more than half of the students enrolled in the country's science programs were female in the early 2000s (Cohen 2001). Of note is that the share of female researchers is much higher in the higher education agencies (34 percent) and the other government agencies (33 percent) than in the IAARD agencies (24 percent), IRIEC (16 percent), and FORDA (17 percent). Generally speaking, female students tend to be drawn more towards lecturing positions at universities or government officer positions rather than strictly research positions, as the latter are perceived as jobs that allow them less time with their family.

Interestingly, the overall share of female researchers with postgraduate degrees (MSc or PhD) in our a 56-agency sample is higher than the corresponding male share (Figure 4). In 2002, 67 percent of all Indonesian female researchers were trained to postgraduate level, compared to 61 percent of their male colleagues. However, the share of men holding PhD degrees (22 percent) was higher than the corresponding share for women (15 percent) during that year.

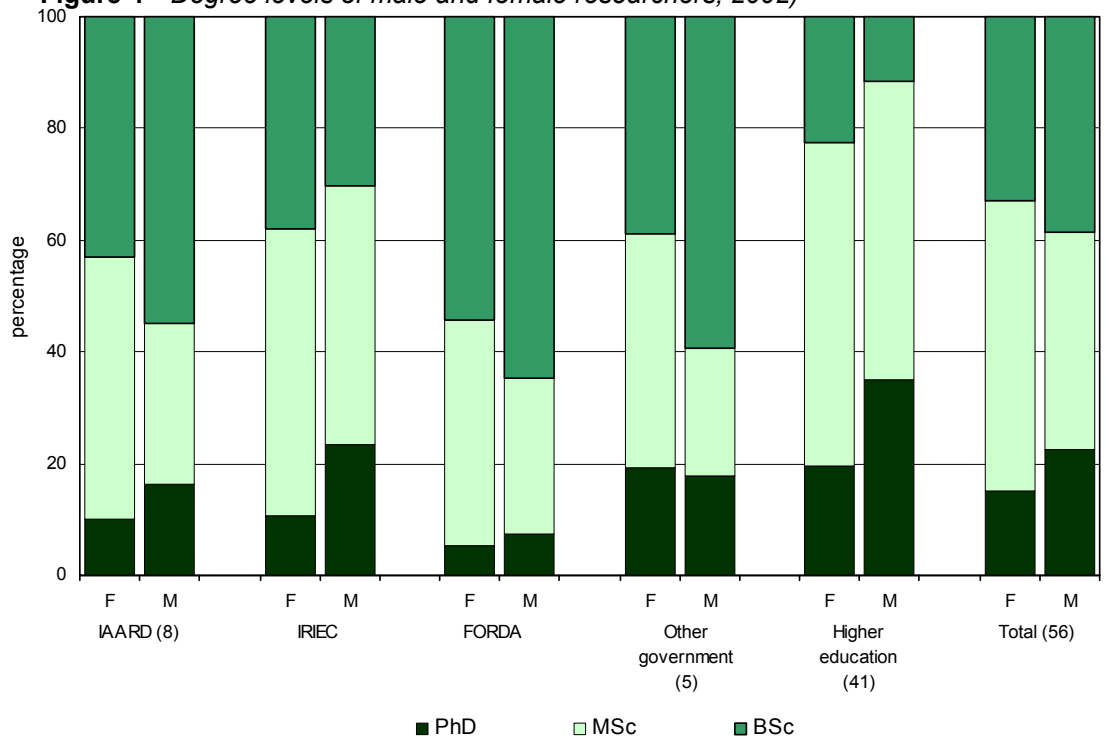
Figure 3—*Share of female researchers, 2003*



Source: Compiled by authors from ASTI survey data (IFPRI–IAARD 2003–05).

Note: Figures in parentheses indicate the number of agencies in each category.

Figure 4—*Degree levels of male and female researchers, 2002)*



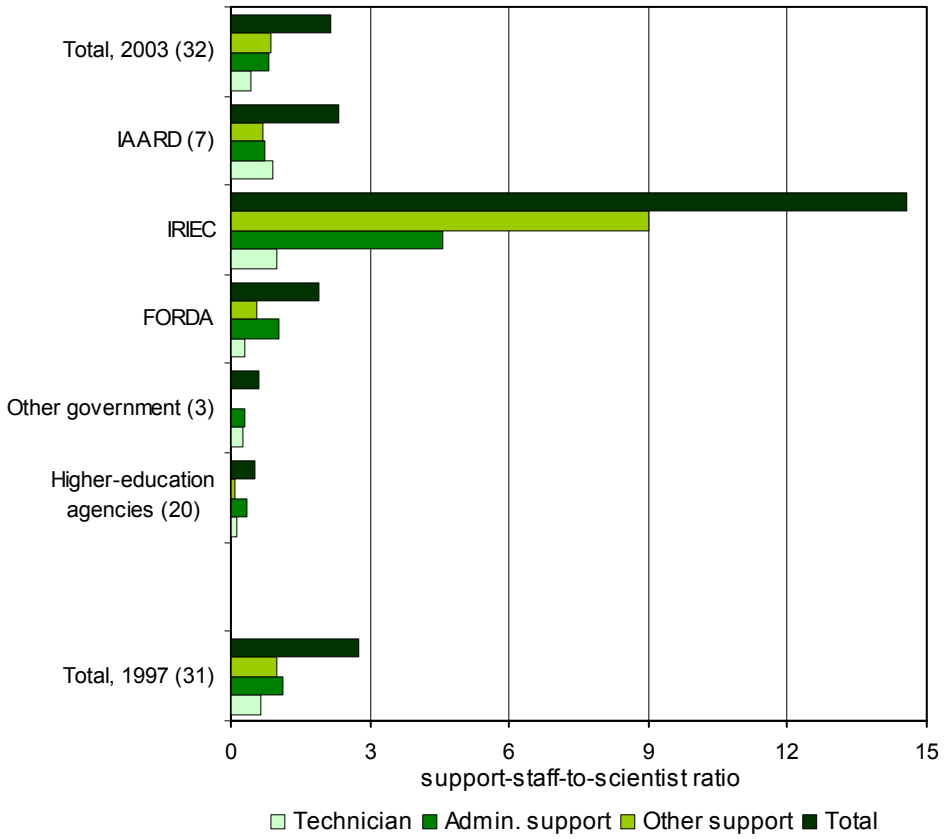
Source: Compiled by authors from ASTI survey data (IFPRI–PCARRD 2003–05).

Note: Figures in parentheses indicate the number of agencies in each category.

Support Staff

In 2003, the average number of support staff per scientist in our 32-agency sample was 2.1 – comprising 0.5 fte technicians, 0.8 fte administrative personnel, and 0.9 fte other support staff such as laborers, guards, drivers, and so on (Figure 5). Six years earlier, there had been 2.8 support staff for every researcher. A decrease was observed in all three categories throughout 1997–2003, but it was most severe for the administrative support staff category. All institutional categories in our sample experienced a modest decline in their total support staff numbers. The exception to this rule was IRIEC, which saw its support-staff-per-researcher ratio rise from 11.6 in 1997 to 14.6 in 2003. This high ratio is due to the high number of support staff in the "other" category. These are mostly laborers working on the plantations.

Figure 5—*Support-staff-to-researcher ratios, 1997 and 2003*



Source: Compiled by authors from ASTI survey data (IFPRI–IAARD 2003–05).

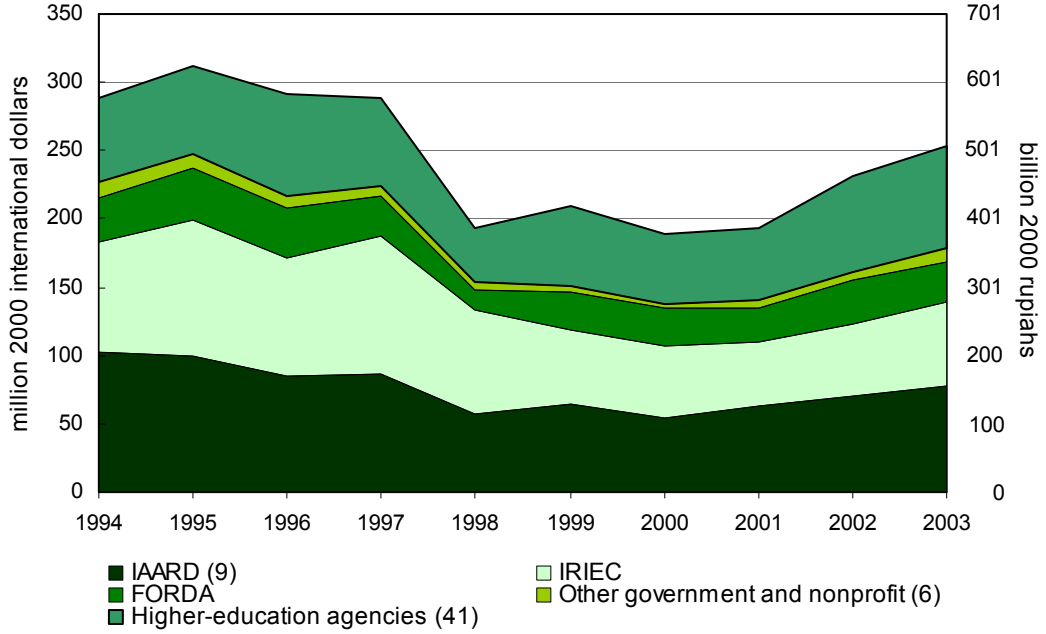
Note: Figures in parentheses indicate the number of agencies in each category.

PUBLIC AGRICULTURAL R&D INVESTMENT TRENDS

During 1994–2003, agricultural R&D investments for our sample of 58 public R&D agencies (excluding the private sector) declined by an average of 6.9 percent annually from $289 million to $254 million (Figure 6 and Table 4). The aforementioned economic crisis that Indonesia experienced during 1997-2000 took its toll on agricultural research, with real expenditures falling by one-third during 1997–98. Spending rebounded somewhat after 2001. However, the 2003 spending levels (in real terms) were still well below the levels recorded a decade earlier. The steep decline in public agricultural R&D expenditures during 1997-98 was part of overall government austerity measures necessary to meet the criteria set by the International Monetary Fund (IMF) to reduce deficit spending. The Ministry of Agriculture's spending on agricultural R&D fell by about half (in real terms) over this period even though R&D spending rose as a share of

all agricultural expenditures (Fuglie and Piggott 2006). FORDA in particular was hit very hard by the Asian financial crisis. The agency's R&D expenditures nearly halved during 1997–98, but rebounded quickly after that.

Figure 6—*Composition of public agricultural R&D spending, 1994-2003*



Source: Compiled by authors from ASTI survey data (IFPRI–IAARD 2003–05).

Notes: See Table 1. Figures in parentheses indicate the number of agencies in each category. The category "Other government and nonprofit" consists of 5 government agencies and 1 nonprofit agency. Expenditures for the higher education sector in our sample are estimates based on average expenditures per researcher at the government agencies. Underlying data are available at the ASTI website (www.asti.cgiar.org).

Table 4—*Long-term composition of public agricultural R&D spending, 1994-2003*

Agency	1994	1997	2000	2003
Spending		(*million 2000 international dollars*)		
IAARD (9)	102,676	86,877	54,389	78,189
IRIEC	*80,167*	*101,048*	*52,282*	*61,375*
FORDA	32,066	28,864	27,995	28,362
Other government and nonprofit (6)	12,349	7,304	2,883	10,827
Higher education (41)	57,465	59,196	42,331	57,959
Total (58)	*284,724*	*283,288*	*179,880*	*236,713*

	1994-97	1997-2000	2000-03	1994-2003
Annual growth rate		(*percentage*)		
IAARD (9)	-6.5	-12.1	12.7	-4.6
IRIEC	*5.7*	*-20.6*	*6.3*	*-7.1*
FORDA	-3.2	5.1	2.7	-2.0
Other government and nonprofit (6)	-15.3	-25.4	52.7	-6.9
Higher education (41)	0.8	-7.2	12.5	-1.6
Total (58)	*-1.2*	*-12.4*	*10.4*	*-4.4*

Source: Compiled by authors from ASTI survey data (IFPRI–IAARD 2003–05).

Notes: See Appendix C for a full list of agencies included in each category. The numbers in parentheses indicate the number of agencies in each category. Annual growth rates were calculated using the least-squares regression method, which takes into account all observations in a period. This results in growth rates that reflect general trends that are not disproportionately influenced by exceptional values.

Once again, the average annual growth rates by institutional category mask important differences between the various agencies in each category. Although total R&D expenditures for the nine IAARD agencies combined were lower in 2003 than they were in 1994, ICAERD and ICFORD reported increases in their spending levels (in real terms) of 62 and 47 percent, respectively, throughout this period. In contrast, expenditures at ICECRD and ICHORD dropped by roughly half during 1994–2003. Research spending at RCFMPPS increased markedly during 1994–2003, which was mainly due to the fact that it was upgraded from being a Level 5 agency under the Ministry of Agriculture to a Level 2 agency under the Ministry of Fisheries in 2002. Level 2 agencies (like the agencies under IAARD) have the right to plan their own budget, and research spending went up rapidly as a result. A new RCFMPPS research laboratory was completed in 2005.

The breakdown of agricultural R&D expenditures by institutional category in the 58-agency sample differed noticeably from the breakdown of fte researchers in Figure 1. In 2003, the IAARD agencies accounted for a quarter of total agricultural R&D

expenditures compared with 45 percent of total fte research staff, while IRIEC had 20 percent of the expenditures and just 4 percent of the fte researchers. This reflects IRIEC's generally stronger financial situation compared with the IAARD agencies. The institutional breakdown of fte researchers and spending for the other government, nonprofit, and higher education agencies were more or less the same.

Spending per Scientist

Agricultural R&D expenditure per researcher remained stable at around $60,000 (in 2000 international prices) during 1994–97, but dropped below $40,000 in 2000 (Table 5). Average spending has rebounded considerably since, but in 2003 ($52,000), it had still not reverted to pre-crisis levels. There were large differences in 2003 spending-per-scientist levels among the various agencies and institutional categories. Average expenditure per researcher totaled $268,000 at IRIEC, compared to an average of just $33,000 at the nine IAARD agencies combined. The variations can be explained by the focus of the research because activities related to plantation crops are more generously funded than activities focusing on food crops.

Table 5—*Spending per scientist, 1994-2003*

Agency	1994	1997	2000	2003
		(thousand 2000 international dollars)		
IAARD (9)	34	35	22	33
IRIEC	263	341	175	268
FORDA	87	73	66	52
Other government and nonprofit (6)	90	52	19	60
Higher education (41)	42	40	28	38
Total (58)	*55*	*59*	*37*	*48*

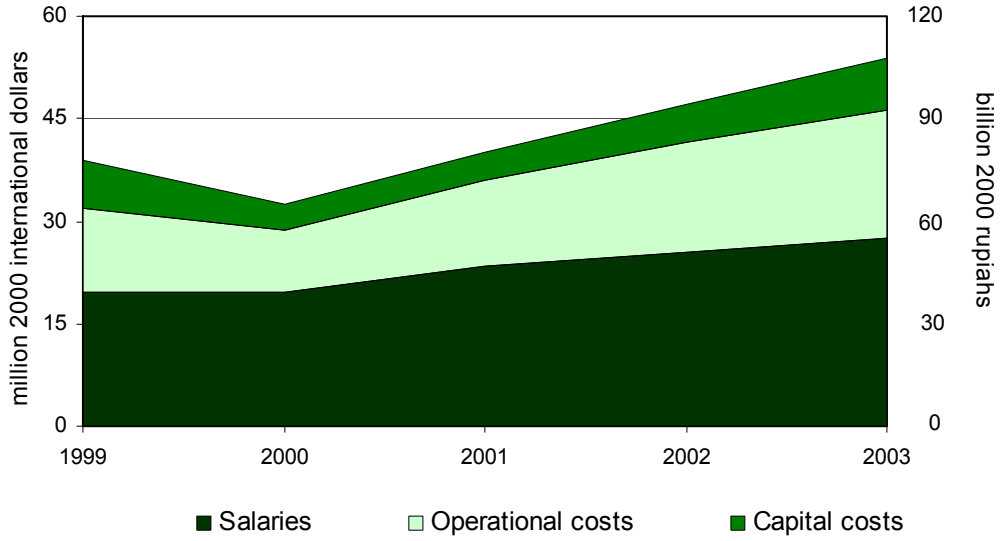
Source: Compiled by authors from ASTI survey data (IFPRI–IAARD 2003–05).

Notes: See Appendix C for a full list of agencies included in each category. The numbers in parentheses indicate the number of agencies in each category.

Cost Categories

The allocation of research budgets across salaries, operating costs, and capital costs affects the efficiency of agricultural R&D and therefore detailed data on cost categories of government agencies were collected as part of this study. During 1999–2003, salaries accounted for an average of 55 percent of the nine IAARD agencies' expenditure, operating costs for 32 percent, and capital costs for 13 percent (Figure 7). These shares have not fluctuated much over the years. Time-series data were not available for IRIEC, the largest government R&D agency in Indonesia in terms of spending, but in 2003, the agency spent 35 percent of its budget on salaries, 45 percent on operational costs, and 20 percent on capital costs (Figure 8). Of note are the very high share of operating costs at FORDA and the high share of capital costs at RCFMFPPSE–AMFR.

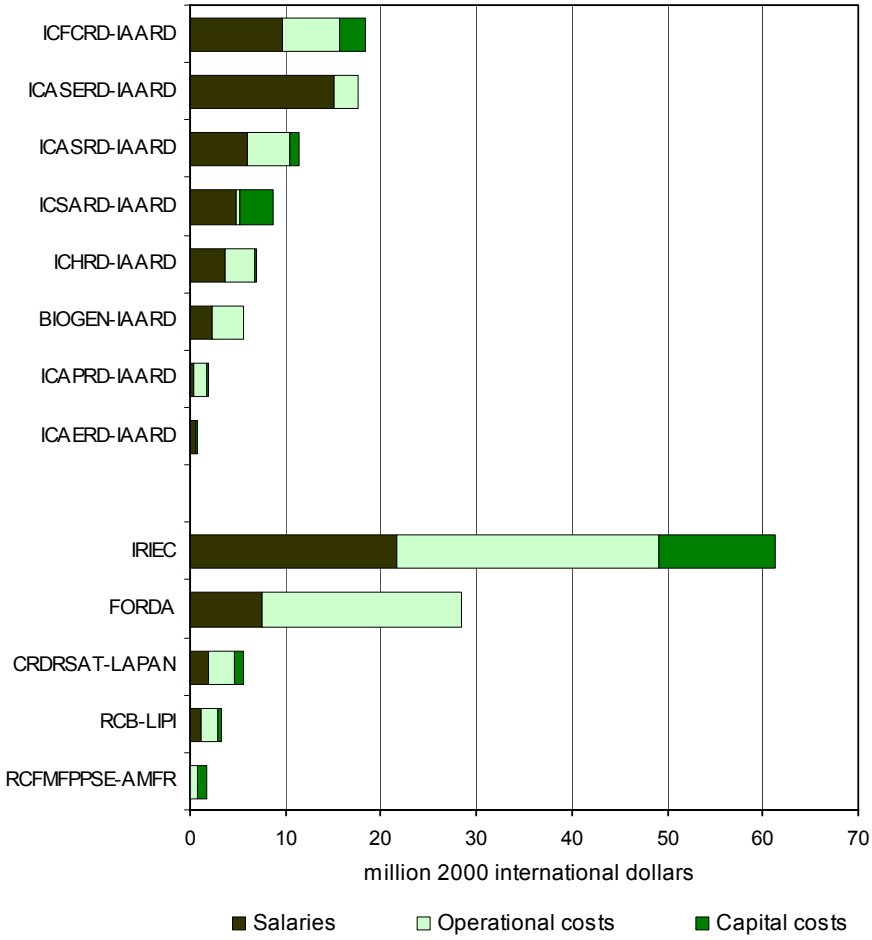
Figure 7—*Cost category shares of IAARD agencies' expenditures, 1999-2003*



Source: Compiled by authors from ASTI survey data (IFPRI–IAARD 2003–05).

Notes: Sample excludes IRIEC.

Figure 8—*Government agency expenditures by cost category, 2003*



Source: Compiled by authors from ASTI survey data (IFPRI–IAARD 2003–05).

The budget allocated to each of Indonesia's R&D agencies is centrally determined in the annual general appropriations. The general appropriations specify the amounts allocated to salaries, wages, and other personnel benefits; maintenance and other operating expenses; and capital outlays for the implementation of various programs/projects during a particular year. The individual research institutes submit their proposed budgets to the Research Center at the IAARD Secretariat. Before implementation, the general appropriations need to be passed by both the House of Representatives and the National Planning Agency.

A salary standardization law provides the salary rates of all government employees in Indonesia. All government employees are given a salary grade and rank upon entry into a government agency (including IAARD scientists and support staff).

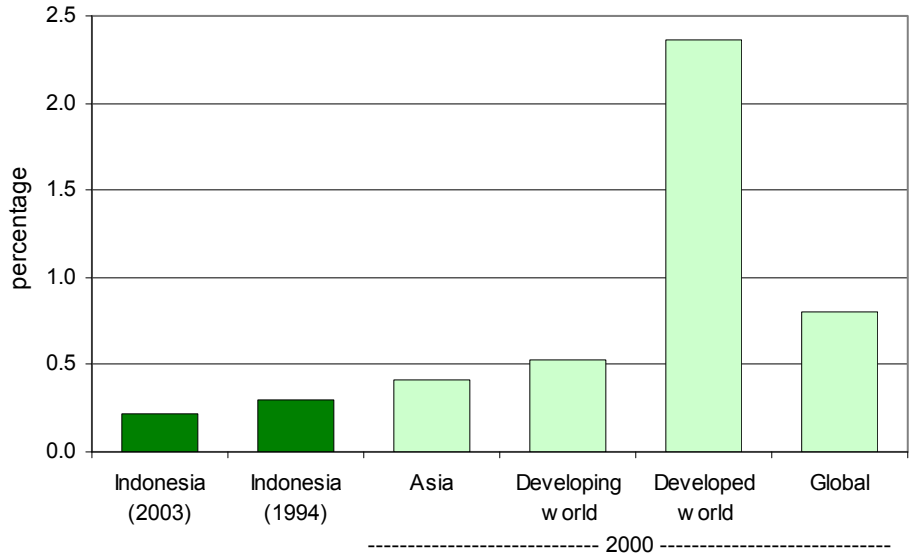
Salary levels of staff are based on (1) the number or years in service and (2) the current grade and rank. Salary increases are automatically given every two years, for a maximum of 32 years in service (AIT 2003).

Budgetary expenditure by the Indonesian government can be classified as either *routine* or *development* expenditure. Routine expenditure includes salaries of research and support staff as well as maintenance costs of research facilities. Development expenditure, on the other hand, includes research operations, staff training, development and dissemination of research results, and procurement. In times of financial austerity, development budgets may be sharply reduced while routine budgets remain largely unaffected.

Intensity Ratios

Total public spending as a percentage of agricultural output (AgGDP) is a common research investment indicator that helps to place a country's agriculture R&D spending in an internationally comparable context. The public-sector intensity ratio was 0.22 percent in 2003 (Figure 9). If private-sector agricultural R&D investments were factored in, the 2002 Indonesian intensity ratio would rise to 0.27 percent. The intensity with which Indonesia invested in agricultural research in 2003 was similar to Southeast Asian counterparts such as Vietnam (0.17) and Laos (0.24), but much lower than in neighboring Malaysia (1.92) and the Philippines (0.46) (Beintema and Stads 2007). Unsurprisingly, the Indonesian intensity ratio experienced a sharp decline during the years of the Asian financial crisis, but rebounded slowly after that. The 2002 ratio for Indonesia was roughly half the average for Asia (0.41) and the developing world as a whole (0.53) that year.

Figure 9—*Agricultural research intensity compared regionally and globally*



Sources: Indonesia data were compiled from Table 2 and Figure 6; AgGDP data are from World Bank (2006); Asia, developing world, and global data are from Pardey et al. (2006).

FINANCING PUBLIC AGRICULTURAL R&D

During the past decade, the funding of public research in Indonesia has come from a number of sources, principally the national government, internally generated resources (through product sales and technology licenses), public and private enterprises, and bilateral and multilateral donors. During 1995–2003, 89 percent of the combined budget of a sample of eight IAARD agencies came from the national government, 5 percent from foreign donors and loans, and the remainder from other sources (Figure 10a). Few resources are raised from the private sector (only 0.2 percent on average during 1995–2003). Under existing policy there is little incentive to do so, as any privately generated revenue at the institute level must be returned to the government treasury.

Considerable fluctuations in the different sources of funding can be observed from one year to the next. During 1997–98, for example, government contributions for our sample's eight IAARD agencies fell by more than 40 percent (in real terms) as a result of the Asian financial crisis. This drop mainly reflects a reduction in the development budget of these agencies, not in the routine budget. Both bilateral and multilateral donors offer technical assistance grants/loans to IAARD agencies. These donors include the World Bank, ADB, USAID, the United Nations Development

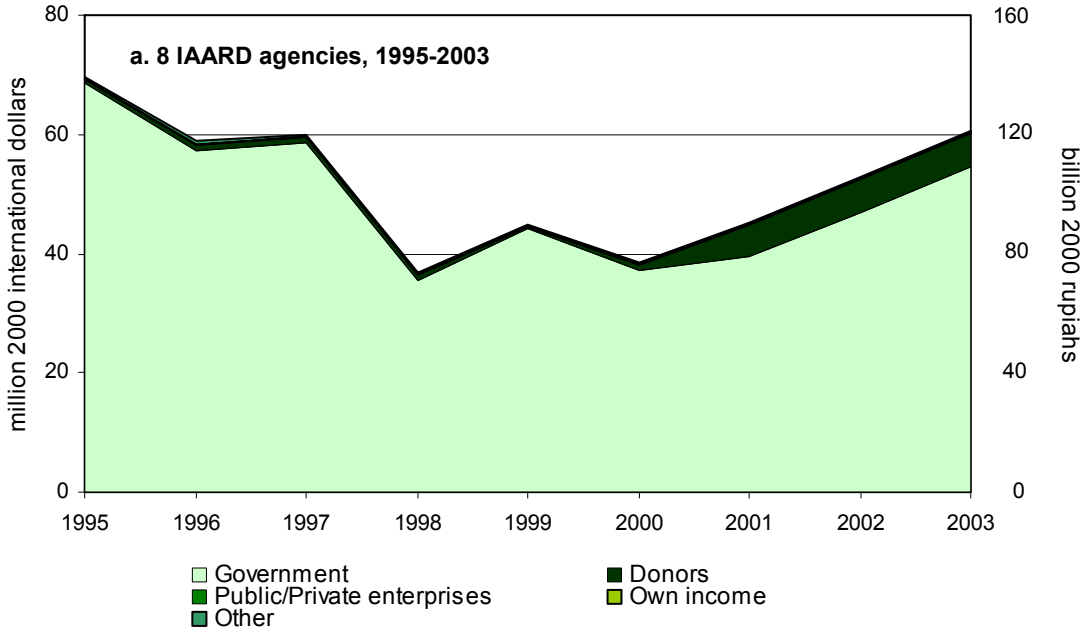
Program (UNDP), ACIAR, IRRI, JICA, and the Australian Agency for International Development (AusAID).

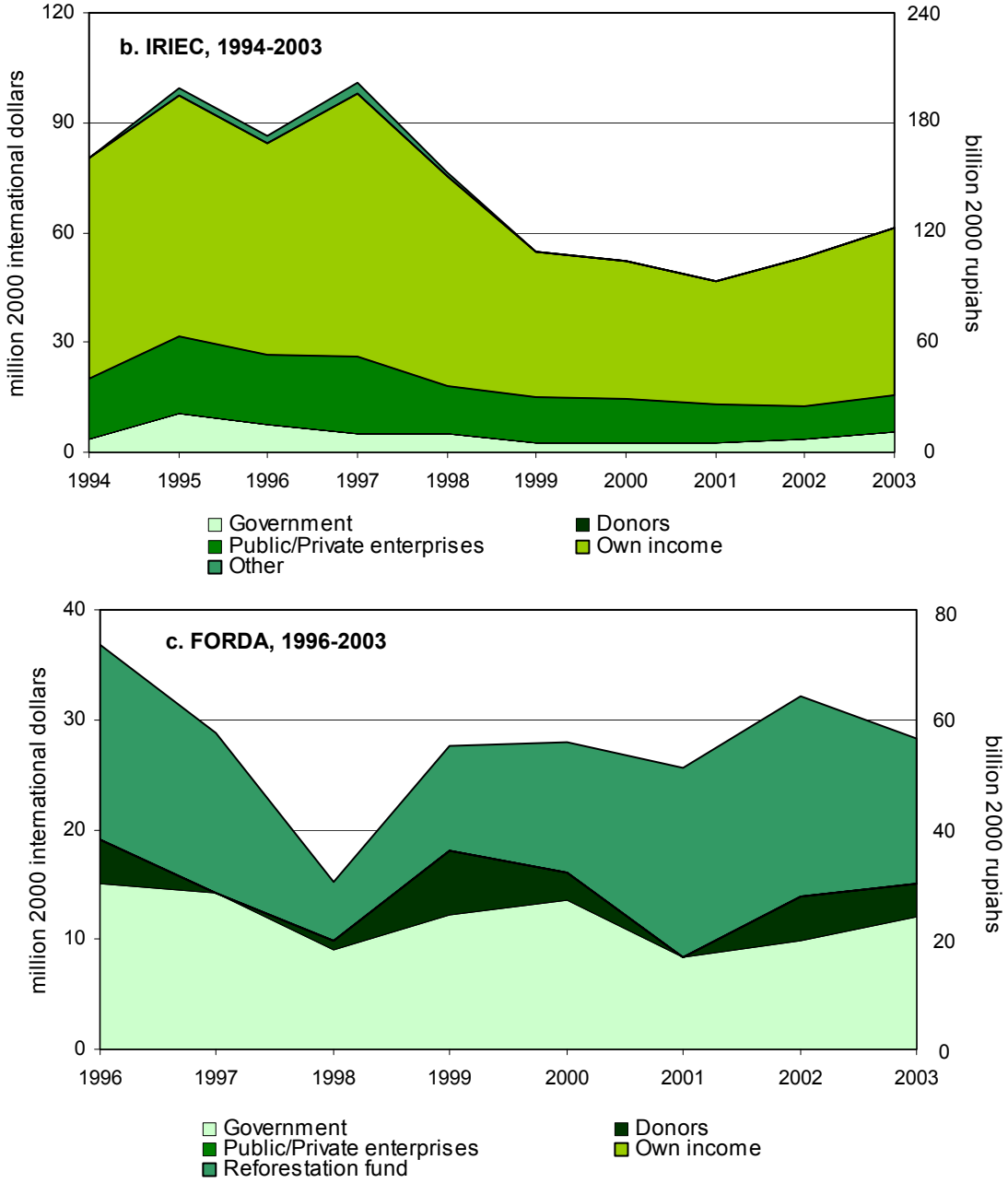
The most important bilateral donor to IAARD is the Australian government through ACIAR and AusAID. Australia has had a long history of financial support to neighboring Indonesia and ACIAR has recently financed projects to combat avian influenza, swine fever, and foot and mouth disease, as well as smallholder agribusiness development initiatives, and an integrated soil and crop management project for the rehabilitation of vegetable production in the tsunami-affected areas.

Agricultural R&D funding differs considerably from one commodity to the next. As we explained earlier, government revenues supplemented with foreign loans and grants make up nearly 95 percent of IAARD's budget for crop and livestock research. Research on plantation crops, on the other hand, is mainly financed by the plantation sector itself. During 1994–2003, just 7 percent of IRIEC's expenditure was financed by the Indonesian government (Figure 10b). The institute's most important source of income was the sale of plantation crops (which accounted for an average of 72 percent of its total income during 1994–2003), followed by contract research for public/private enterprises (21 percent). Unlike IAARD agencies, IRIEC has a semi-autonomous status and is allowed to keep revenues from product sales. IRIEC therefore actively approaches plantation companies to conduct research on their behalf. The oil palm research conducted by IRIEC is very profitable, but the institute's sugarcane and biotechnology R&D activities make a loss. The money made in the oil palm sector is allocated to these less profitable sectors. Partly due to the different funding mechanisms and the institute's special status, scientists working at IRIEC research institutes are considerably better funded than IAARD research staff. As we showed earlier, in 2003 research expenditure per scientist at IRIEC institutes was more than eight times higher than at IAARD institutes. However, an often-voiced concern is that IRIEC does not sufficiently address the needs of small producers of estate crops, that it mainly serves the interests of the large estates instead. Future productivity in estate-crop production could be significantly enhanced if IRIEC developed an effective delivery system for smallholders as well (Fuglie and Piggott 2006).

The forestry research sector is less dependent on financial support from the national government than the food crops and livestock R&D sectors. During 1996–2003, an average of 42 percent of FORDA's budget was provided by the Indonesian government (Figure 10c) and 9 percent by grants from foreign donors and loans from development banks. Japan is FORDA's only bilateral donor. Other donors include the World Bank (1996–99) and the International Tropical Timber Organization (ITTO) (2003). However, the largest share (48 percent on average during 1996–2003) of FORDA's budget was financed through a special assessment on forest concessions, the so-called reforestation fund. Through this fund, FORDA receives a certain amount for each hectare of forest logged in the country. This fund is managed by the Ministry of Forestry and paid directly by the forest logger. Forestry research appears to have been less affected by the Asian financial crisis than research on livestock, food, and estate crops. By 1999, total expenditure/funding at FORDA had already reverted to pre-crisis levels.

Figure 10—*Funding sources of government agencies*





Source: Compiled by authors from ASTI survey data (IFPRI–IAARD 2003–05).
Note: Figure 10.a excludes IRIEC.

Fisheries research in Indonesia is still largely financed by the national government. During 1999–2003, 98 percent of RCFMPPS's funds came from the Indonesian government. The World Fish Center is the agency's largest donor. Although exact shares were not available, a large share of BIOTECH–LIPI's funding was internally generated through contract-based research for private-sector agencies (such as

Kalbefarma) and higher education agencies (such as IPB). In addition, the agency received substantial financial support from UNDP and the United Nations Educational, Scientific, and Cultural Organization (UNESCO) for an industrial forest estate project. This project focused on high-quality seeds for industrial forest estates (20 species of trees, including acacias). Other donors to BIOTECH–LIPI included the Netherlands and Australia.

Research at most Indonesian higher education agencies is mainly financed by the national government, principally through the Ministry of Science and Technology or through competitive grants. In 1997, a special fund was set up to provide financial support for joint IAARD-university agricultural R&D projects as part of ARMP–II (Fuglie and Piggott 2006). In contrast to most other Indonesian universities, agricultural R&D at IPB is largely financed by the private sector. As mentioned previously, IPB became an autonomous university in 2000. This status enabled the university to manage its own resources. In 2003, an estimated 70 percent of the university's R&D budget was financed by private-sector companies such as PT Indofood Sukses Makmur Tbk, PT Unilever Indonesia Tbk, and PT Heinz ABC Indonesia. It is therefore not surprising that private-sector companies – the food industry in particular – largely drive IPB's research agenda. Other private-sector companies include Partamina – Indonesia's state oil company – and a number of chemical companies. Government funding sources to IPB's agricultural R&D (in order of importance) include the Ministry of Research and Technology, the Ministry of Education, and the Ministry of Agriculture.

World Bank and ADB Loans

In the 1990s and early 2000s, the World Bank and the ADB provided several large loans to support agricultural research in Indonesia. These loans had a counterpart funding component from the Indonesian government and have played a critical role in strengthening the province-based AIATs.

The World Bank has strongly supported agricultural R&D in Indonesia since 1975 through a number of agricultural research projects, including the Agricultural Research and Extension Project, the National Agricultural Research Project, and the Agricultural Research Management Project (ARMP). The latter had a total cost of US$35.3 million and was implemented during 1989–94. It addressed the efficient use of

research resources, mainly in national research institutes. The project aimed to institutionalize regional, farming-systems R&D in different agroecological zones and ensure the transfer and wider application of technology in a much more applied approach (World Bank 1995).

ARMP–II was the follow-up project of ARMP. The principal objective of ARMP–II was to reinforce regional agricultural R&D by collaboratively developing and transferring location-specific, market-oriented and client-driven technologies to support agribusiness and agro-industry development. The project consisted of four main components: the establishment of a network of AIATs in twelve provinces; improved regional research and development management; expanded research in priority areas and commodities; and strengthened research and development linkages to local, national, regional, and international research organizations (World Bank 1995). The project ran from 1995 until 2002 and had an initial total cost of US$101.8 million. However, the financial crisis affected the Indonesian government's ability to provide adequate counterpart funding and subsequently led to the cancellation of a substantial part of the original loan amount (World Bank 2003). Despite these revisions, the project has succeeded in developing AIATs that have successfully tested and disseminated location-specific technologies, which have increasingly been adopted by farmers. In addition, ARMP–II has made IAARD's organizational structure and institutional culture more demand-driven and farmer-oriented (World Bank 2003).

The overall objective of the ADB-financed PAATP was similar to that of ARMP–II. Strengthening the capacity of IAARD formed an important part of the project, as did the acceleration of the transfer and adoption of location-specific, user-oriented agricultural technologies. The project ran during 1997–2004 and its total cost was initially budgeted at US$108.1 million (ADB n.d.). However, like ARMP–II, at PAATP's closure in 2004, the amount the project actually disbursed turned out to be much lower due to the Asian financial crisis. Nonetheless, PAATP is said to have successfully achieved its objectives. The project has significantly strengthened IAARD's research capacity in terms of human resources and infrastructure. In addition, the AIATs have developed location-specific agricultural technologies that have been successfully adopted and applied by farmers across the archipelago.

Commodity Levies on Export Crops

As in other countries in the region, such as Malaysia and Papua New Guinea, a commodity-levy system for export crops was in place in Indonesia until the 1980s. Producers used to pay a tax on the production or export value of the commodity, and a share of the resulting revenues was earmarked for research. The mechanisms for collecting revenues and shares allocated to research varied across commodities. However, large-scale fraud at the provincial level led to the abolition of the system. In 2005, talks began to reinstate a similar system, but it is too early to say whether this will be achieved.

Intellectual Property and Technology Transfer Management Office

During the 1990s, IAARD research institutes and agricultural universities started to explore new ways of partly auto-financing agricultural R&D. As government policy does not allow government agencies to retain funds raised through product sales, IAARD established a semi-autonomous foundation in 1999: the Intellectual Property and Technology Transfer Management Office (IPTTMO). IPTTMO was to help commercialize IAARD innovations and is responsible for patenting and licensing IAARD innovations to private firms. As a semi-autonomous foundation, IPTTMO has the legal authority to retain earnings from technology licensing. So far, most of the patents have been for machinery innovations, animal vaccines, or feed additives (Fuglie and Piggott 2006).

Competitive Funds

Competitive funds aim to optimize the performance of agricultural research through increased collaboration between the various actors involved in agricultural research in a particular country. In Indonesia, competitive funds are an important financing mechanism for agricultural R&D, especially in university-led R&D. The Ministry of Education's competitive research grant program for universities (the University Research Grant) was started as part of ARMP and continued under ARMP–II. It emphasized the role of local universities and twinning arrangements between a provincial university, a more advanced university elsewhere, and IAARD units. In addition, the grant also aims to strengthen R&D linkages with extension services, policymakers, the Directorates General under the MOA, the Provincial and District Support Service (DINAS), the private sector, community and locally based organizations, and other development projects, in the areas

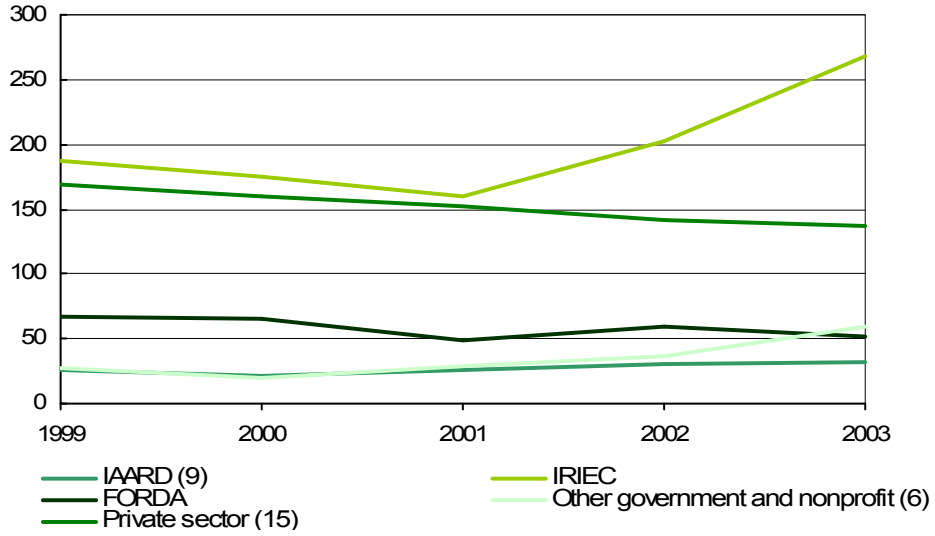
of comparative advantage in the region. Joint proposals are reviewed by a special IAARD Research Grant Board (World Bank 1995).

The Ministry of Science and Technology (through the National Research Council) is operating a competitive fund as well. IAARD started competitive funding in 1995, a model that was extended to the entire Indonesian agricultural R&D system in 2002. Both are handled at the national level (AARD–ISNAR 2002).

PRIVATE AGRICULTURAL R&D

Compared to many other countries in Southeast Asia, the private sector accounts for an important share of agricultural R&D conducted in Indonesia. Fifteen private-sector agencies responded favorably to our request for information. Some important companies were reluctant to provide information on their financial and human resources. Based on the sample agencies for which data were available, 5 percent of Indonesia's total agricultural research staff and 11 percent of its agricultural R&D spending was attributed to the private sector. Scaling up the total to compensate for the omitted agencies would increase the private-sector share of total agricultural research expenditures considerably to about 19 percent in 2003 (see Table 1). As mentioned before, private-sector agricultural R&D expenditures in Indonesia was estimated to total $59 million in 2003 (in 2000 international prices). Fuglie and Piggott (2006) estimated that private companies in Indonesia conducted roughly one-third of their own research and the remaining two-thirds represented purchased planting materials and other technology products from government and higher education institutes. Average R&D expenditures per researcher in the private sector agencies were well above the averages for IAARD, FORDA, and the other government agencies, but below average spending per researcher at IRIEC (Figure 11).

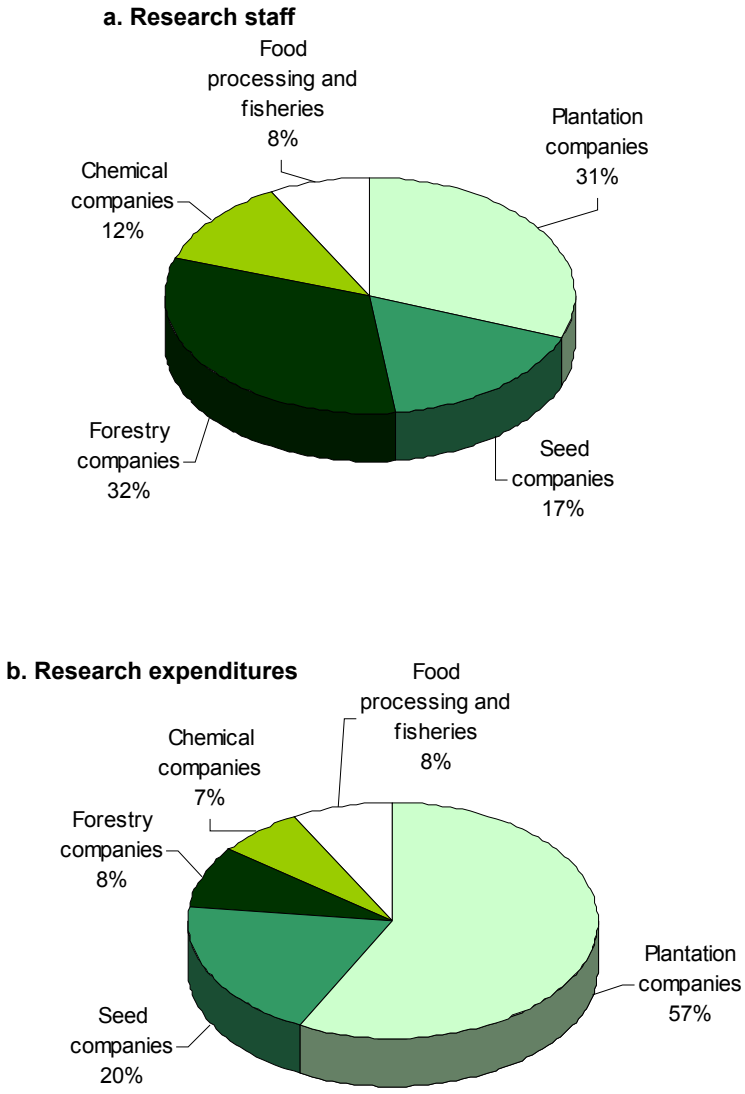
Figure 11—*Trends in expenditures per researcher, public and private sector, 1999–2003*



Source: Compiled by authors from ASTI survey data (IFPRI–IAARD 2003–05).
Notes: See Figures 1 and 6.

A distinction was made between plantation companies, seed companies, forestry companies, chemical companies, and food-processing and fisheries companies. It was estimated that the forestry companies and the plantation companies each accounted for roughly one-third of total agricultural R&D staff in the private sector in 2003 (Figure 12a). Spending shares, however, looked quite different (Figure 12b). The plantation companies accounted for close to 60 percent of total agricultural R&D spending by the private sector, while the forestry companies accounted for just 8 percent during the same year. The reason for this relatively low share in spending by the forestry agencies is the inclusion of semi-private companies like Inhutani and Perhutani in our sample. These companies are government-linked and have considerably less resources than forestry companies like MHP, where average expenditure per researcher levels were estimated to be up to 10 times higher than at the semi-private companies. Moreover, Perhutani employed 70 fte researchers in its teak center in 2003, which had an important impact on the total share of forestry researchers in the private sector.

Figure 12—*Long-term composition of agricultural R&D staff and spending in the private sector, 1996–2003*



Source: Compiled by authors from ASTI survey data (IFPRI–IAARD 2003–05).

Notes: We estimated—based on Fuglie (2001) and in-depth interviews with the principal private-sector agencies in Indonesia—that our survey sample covered 70 percent of private-sector plantation crop research, 40 percent of seed research, 80 percent of forestry research, and 30 percent of agricultural research carried out by chemical companies. Expenditures for the missing agencies were estimated based on the average expenditures per researcher for the remaining agencies in the respective category.

As mentioned previously, Indonesia is currently the world's second-largest exporter of rubber and oil palm (behind neighbouring Malaysia) and the third-largest exporter of cocoa and coffee. A large number of plantations managed by commercial enterprises or state-owned enterprises have been established in the vast, fertile, and

sparsely inhabited areas of Sumatra, Kalimantan, and Papua. Many of the larger plantations are involved in agricultural R&D. The three largest plantation companies in terms of research staff included in the survey sample are PT Sinar Mas Agro Resources and Technology Corporation (PT SMART Tbk), PT PP London Sumatra Indonesia Tbk. (Lonsum), and PT Socfindo. PT SMART Tbk has a total planted area of over 98,000 hectares in Sumatra and Kalimantan and PT SMART Research Institute (PT SMARTRI Tbk.) is PT SMART's internationally recognized research institute. Although it conducted rubber, coconut, tea, and banana research in the past, SMARTRI's research focus is now solely on oil palm. It carries out an average of 200 trials annually and employed 30 fte researchers in 2003. Research spending has actually declined in recent years, because trials have become increasingly succesful and the cost per trial has declined as a result. SMARTRI outsources some its research activities to foreign companies or Indonesian universities. Lonsum's R&D focus is mainly on oil palm, although the company is also involved in rubber and cocoa research. In 2005, the company employed 33 fte researchers, spread over the Bah Lias Research Station (North Sumatra), the South Sumatra plant, and the Seed Production Unit in Kalimantan. PT Socfindo is an oil palm plantation company with operations in North Sumatra and Aceh. Some 25 fte oil-palm researchers were active at PT Socfindo in 2003. In addition to conducting their own R&D, many plantation companies contract parts of their research out to IRIEC or IPB.

Indonesia's private seed industry is mostly limited to hybrid corn and some high-valued horticultural crops (Fuglie 2001). It is our estimate that private-sector seed research accounted for one-fifth of total agricultural R&D spending in 2003. Three companies supplied the market for hybrid corn: Charoen Pokphand (Thailand), Cargill (United States), and Dupont (United States). In Indonesia, these companies conduct yield trials in farmers' fields and at public R&D stations (Fuglie 2001). The largest vegetable-seed producer in Indonesia is East–West Seeds. This Dutch company also maintains horticultural breeding programs in Bangladesh, the Netherlands, the Philippines, Thailand, and Vietnam and employed 26 fte researchers in Indonesia in 2005. In addition, PT Sang Hyang Seri (Persero), an Indonesian-owned company, was involved in rice,

corn, vegetable, and ornamental research and employed 7 fte agricultural scientists in 2003.

The bulk of Indonesia's forestry research is conducted by FORDA. However, an increasing number of timber plantations are establishing their own research centers and government agencies are increasingly losing staff to the private sector, where salaries are reportedly 50 percent higher. Most forestry research in Indonesia is still government-linked nonetheless. PT Musi Hutan Persada is the largest private-sector forestry R&D agency in terms of spending. The company is a joint venture between the state-owned PT Inhutani V and PT Enemi Musi Lestari (Barito Pacific Group) and it employed 19 fte researchers in 2003, which focused mostly on acacia research. FORDA has assisted MHP in setting up its Sumatra-based research center. Before, MHP used to come to FORDA directly with its research needs. A network exists with the other tree-plantation companies in Sumatra, and 13 companies are "members" of this network. They exchange seed material, hold annual meetings, and organize joint research.

Chemical companies accounted for roughly one-tenth of private-sector agricultural R&D spending in Indonesia in 2003. The biggest players in this field are Bayer Crop Science, Novartis, and Dupont. Bayer Crop Science employed 15 fte researchers who are involved in pesticide and herbicide R&D for rice, vegetables, and oil palm. The company also contracts a lot of its research activities out to public-sector agencies, including the Rice Research Institute, the Horticulture Research Institute, the Food Crops Research Institute, the Oil Palm Research Institute, IPB, the University of Lampung, and Padjadjaran University. Novartis has its world tropical research headquarters in Indonesia.

The Indonesian government has enacted few policies to promote private-sector agricultural R&D, despite the fact that ARMP–II and PAATP set funds aside to involve the private sector in agricultural R&D. No tax incentives exist for private research (Fuglie 2001).

RESEARCH ORIENTATION

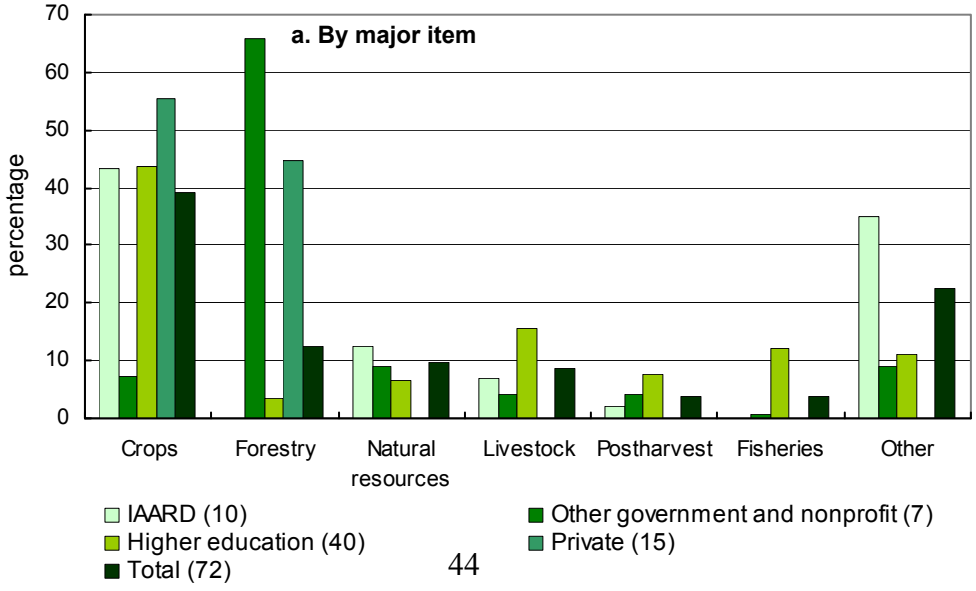
The allocation of resources among various lines of research is a significant policy decision, and so detailed information was collected on the number of fte researchers working in specific commodity and thematic areas.

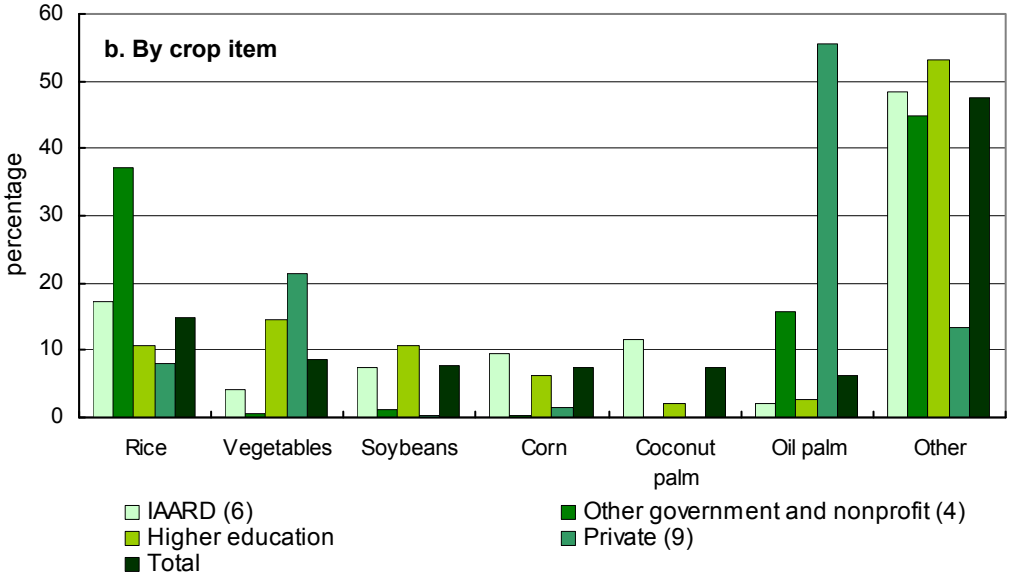
Commodity Focus

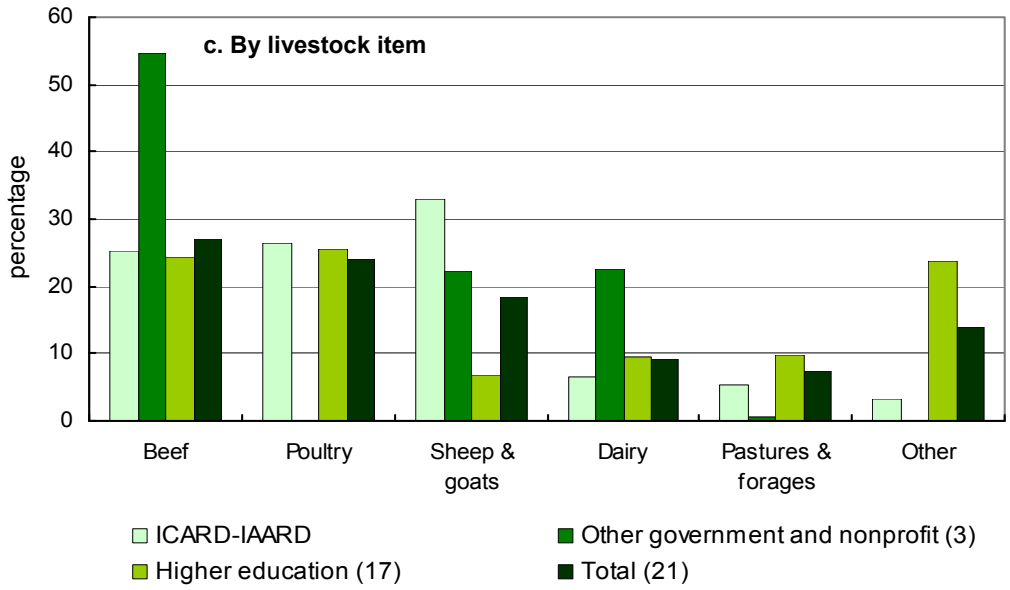
Nearly 40 percent of the 5,119 fte researchers in a 72-agency sample (including the private sector) conducted crops research in 2003 (Figure 13a). Forestry research accounted for 13 percent, natural resources research for 10 percent, and livestock research for 9 percent. Research staff at the higher education agencies spent relatively more time on livestock and fisheries research than their counterparts at the government agencies. Forestry research was prominent at the other government agencies, which is not surprising given FORDA's research mandate. The 15 private-sector agencies in our sample concentrated exclusively on crops and forestry research.

In 2003, rice accounted for 15 percent of the research conducted on crops; vegetables accounted for 9 percent, and soybeans and maize accounted for 8 percent each (Figure 13b). Other important crops were coconut palm and oil palm. More than a quarter of livestock researchers focused on beef in 2003 (Figure 13c). Poultry research represented 24 percent and research on sheep and goats 19 percent. Dairy and pastures and forages research accounted for 9 and 7 percent, respectively. Of note is the relatively high beef research focus of the other government agencies, mainly due to the high number of beef researchers at RCB–LIPI.

Figure 13—*Commodity focus, 2003*







Source: Compiled by authors from ASTI survey data (IFPRI–IAARD 2003–05).

Notes: Figures in parentheses indicate the number of agencies in each category. Figure 12b only includes agencies involved in crop research; Figure 12c only includes agencies involved in livestock research.

Thematic Focus

In 2003, 13 percent of the 4,190 fte researchers in a 68-agency sample (including the private sector) were working on crop genetic improvement, 9 percent on crop pest and disease control, and 11 percent on other crop-related themes (Table 6). Soil research accounted for 8 percent. The remainder of the researchers focused on livestock and

natural resource-related themes, while only a small portion of researchers focused on postharvest and water themes. Appendix D gives an overview of biotechnology R&D research in Indonesia.

Table 6—*Thematic focus, 2003*

	IAARD	IRIEC	FORDA	Other government and nonprofit	Higher education	Private	Total
Number of agencies in sample	8	1	1	6	40	12	68
Number of researchers				(*fte's*)			
Crop genetic improvement	206.8	57.3	109.2	36.8	43.4	75.6	528.9
Crop pest and disease control	113.6	114.5	10.9	0.3	80.2	34.8	354.3
Other crop	147.1	57.3	49.1	26.6	137.1	28.1	445.4
Livestock genetic improvement	66.5	—	—	19.4	25.1	—	111.1
Livestock pest and disease control	60.9	—	—	0.6	28.1	—	89.7
Other livestock	54.8	—	—	4.6	103.0	0.1	162.4
Soil	225.1	—	10.9	3.6	94.5	1.9	336.1
Water	126.2	—	21.8	7.0	54.1	1.3	210.5
Other natural resources	1.4	—	43.7	9.2	29.0	37.0	120.2
Postharvest	68.1	—	60.1	15.8	80.1	3.2	227.3
Other	993.6	—	240.2	56.6	283.5	30.6	1,604.5
Total	*2,064.0*	*229.1*	*546.0*	*180.5*	*958.2*	*212.5*	*4,190.3*
Shares by research theme				(*percentage*)			
Crop genetic improvement	10.0	25.0	20.0	20.4	4.5	35.6	12.6
Crop pest and disease control	5.5	50.0	2.0	0.2	8.4	16.4	8.5
Other crop	7.1	25.0	9.0	14.7	14.3	13.2	10.6
Livestock genetic improvement	3.2	—	-	10.8	2.6	-	2.7
Livestock pest and disease control	3.0	—	-	0.4	2.9	-	2.1
Other livestock	2.7	—	-	2.5	10.7	0.1	3.9
Soil	10.9	—	2.0	2.0	9.9	0.9	8.0
Water	6.1	—	4.0	3.9	5.6	0.6	5.0
Other natural resources	0.1	—	8.0	5.1	3.0	17.4	2.9
Postharvest	3.3	—	11.0	8.8	8.4	1.5	5.4
Other	48.1	—	44.0	31.3	29.6	14.4	38.3

Source: Compiled by authors from ASTI survey data (IFPRI–MARDI 2003–04).

Note: Figures in parentheses indicate the number of agencies in each category.

Biotechnology Research[4]

Indonesia has one of the world's most diverse natural resources. The country aims to use this diversity in a sustainable manner as one of the modalities and comparative

[4] This section draws largely on IUCN–RBP (n.d.).

advantages in the development of biotechnology. Since 1985, the country has placed a high priority on biotechnology development in order to address food production needs in a more sustainable agricultural system. During that year, the State Ministry of Science and Technology established a national committee for biotechnology to prepare and formulate national biotechnology policies and programs. It also designated four national centers of excellence for agriculture, industrial and medical biotechnology: the Central Research Institute for Food Crop Biotechnology under IAARD, the Research Center for Biotechnology (RCB) under the Indonesian Science and Technology Agency (LIPI), the Medical Faculty of the University of Indonesia in Jakarta, and the Agency for Technology Assessment and Application (BPPT) for industrial biotechnology in Jakarta.

Besides these centers of excellence, additional research institutes are also involved in biotechnology research, including the Central Research Institute for Plantation Crops, the Central Research Institute Industrial Crops, the Indonesian Sugar Research Institute, the Research Institute for Animal Production, the Research Institute for Animal Diseases, and the Central Research Institute for Freshwater Fisheries. All these institutes are placed under IAARD. Moreover, the Department of Forestry is involved in (limited) biotechnology R&D as well.

In addition to these government agencies, the Indonesian government established *Inter-University Centers* in Bogor Agricultural University (IPB), Bandung Institute of Technology, and Gadjah Mada University in Yogyakarta focusing on agricultural, industrial, and medical biotechnology, respectively. These centers are attached to the universities and play an important role in the development of biotechnology in Indonesia in their respective areas.

After the financial crisis in 1998, the focus of biotechnological R&D priorities shifted temporarily to techniques aimed at responding immediately to the needs of the Indonesian people (especially in both food production and adding value to agricultural products for export production). However, as a long-term strategy, Indonesia aims to achieve a competitive position in the global biotechnology market. The national government stresses the importance of improving national capabilities in this field and has stated that strategic research programs should be based on Indonesia's competitive advantages in biological diversity. Drug discovery projects, genomics, conservation of

germplasm, genetic improvement of agriculture commodities (food crops, horticulture, fruits, animal husbandry, etc.), marine biotechnology and environmental biotechnology (bio-remediation) are projects planned to be undertaken in this field.

Biotechnology R&D in Indonesia is funded through both internal and external resources. The national government has launched various (competitive) funding schemes in order to accelerate the development of biotechnology, including the Integrated Supreme Research grant program, the Joint Supreme Research program, the competitive grant for universities, and the International Integrated Competitive Joint Research program. Research priorities in the field of biotechnology are formulated by the National Research Council (NRC), while the selection of research proposals that are to be financed through a competitive grant is carried out by a panel of experts consisting of NRC and university representatives. External funding for biotechnology R&D projects has been forthcoming through World Bank loans, USAID, the Rockefeller Foundation, Winrock International, ACIAR, the European Union, and JICA. Most of these donors have been involved in the initial development of biotechnology capacity, such as building infra-structure and developing human resources, rather than financing actual research projects.

CONCLUSION

Indonesia's total number of agricultural researchers in Indonesia fell slightly during 1994–2003 due to major reorganizations in government-led agricultural R&D. Nevertheless, with close to 5,000 fte researchers in 2003, Indonesia has one of the largest agricultural research systems in Asia. Despite the decline in researcher totals, qualifications of Indonesian agricultural research staff improved steadily in recent years, principally due to donor-financed training programs. Due to the Asian financial crisis, agricultural R&D spending has been severely cut since 1997. In 2003, the country invested $254 million in agricultural R&D (in 2000 international dollars), which was well below pre-crisis levels.

Like most developing countries around the world, agricultural research in Indonesia is largely a government affair, with the private sector accounting for an estimated 19 percent of total expenditures. IAARD is Indonesia's central public agricultural R&D agency and it oversees nine major research centers, which focus on

socio-economics, soils and agro-climates, engineering, food crops, estate crops, horticulture, livestock, biotechnology, and postharvest activities. IRIEC is a semi-public R&D agency that is linked to IAARD, but not formally part of it. The institute conducts research on Indonesia's principal plantation crops (rubber, oil palm, tea, cocoa, coffee, and sugarcane) and is single-handedly by far the largest agricultural R&D agency in the country in terms of research expenditures. FORDA, on the other hand, is the archipelago's principal agency involved in forestry research. The higher education sector (dominated by IPB) plays a fairly important role in Indonesia as well, accounting for 30 percent of the country's public agricultural R&D expenditures.

The World Bank-financed ARMP–II has had a serious impact on the structure of Indonesia's agricultural R&D in the mid-1990s. Rather than a centralized (mostly Bogor-based) agricultural R&D system, research became more decentralized and location-specific technologies based on farmers' needs and circumstances were created.

Public agricultural R&D in Indonesia remains largely underfunded by regional and international standards. In 2003, Indonesia invested $0.22 for every $100 of agricultural output, which was nearly 30 percent lower than the equivalent ratio recorded a decade earlier, and half the Asian average of $0.41. In 2003, the national government provided 90 percent of funding to the nine IAARD agencies. Research on plantation crops, on the other hand, is almost entirely financed by the plantation sector itself. IRIEC generates three-quarters of its income internally through the sale of plantation crops and contract research. Close to half of FORDA's funds come from a reforestation fund, which is allocated proportionally for each hectare of forest logged in the country. Interestingly, IPB-based research is largely financed by the private sector. Although donor funding plays only a limited role in total financial support to Indonesia's agricultural R&D (compared to some other countries in Southeast Asia), multilateral donor-financed projects such as ARMP–II and PAATP have had a significant impact on the structure and quality of Indonesia's agricultural R&D system.

BIBLIOGRAPHY

AARD–ISNAR (Agency for Agricultural Research and Development and International Service for National Agricultural Research). 2002. *Decentralization issues in agricultural research and development in Indonesia*. Draft. Jakarta and The Hague: AARD–ISNAR.

ADB (Asian Development Bank). n.d. Participatory Development of Agricultural Technology Project. <http://www.adb.org/Documents/News/1997/pi1997048.asp>. Accessed October 2006.

AIM (Asian Institute of Management). 2003. Report on Staff Performance Assessment and Enhancement Systems of the Agency for Agricultural Research and Development, Indonesia. <http://www.isnar.cgiar.org/pbms/pdf/SPAE_AARD.pdf>. Accessed October 2006.

Beintema, N. M. and G. J. Stads. 2007. *Measuring Diversity in Asian and Pacific Agricultural R&D Resources*. ASTI Background Report. Washington, D.C.: IFPRI. *(in preparation)*

Cohen, P. 2001. Muslim women in science. <http://www.sciencemag.org/cgi/eletters/290/5489/55>. Accessed October 2006.

FAO (Food and Agriculture Organization of the United Nations). 2005. FAOSTAT. <http://faostat.fao.org/default>. Accessed January 2005.

Fuglie, K. O. 2001. Indonesia. In *Private investments in agricultural research and international technology transfer in Asia*, edited by C. E. Pray and K. O. Fuglie. Agricultural Economics Report No. 805. Washington, D.C.: United States Department of Agriculture.

Fuglie, K. O. and R. Piggott. 2006. Indonesia: Coping with economic and political instability. Chapter 4 in *Agricultural R&D policy in the developing world: Too little too late?*, edited by J. M. Alston, P. G. Pardey, and R. Piggott. Washington, D.C.: IFPRI.

IAARD (Indonesian Agency for Agricultural Research and Development). 2003. *This is IAARD*. Jakarta.

IFPRI-IAARD (International Food Policy Research Institute and Indonesian Agency for Agricultural Research and Development). 2003–05. Agricultural Science and Technology Indicators (ASTI) survey for Indonesia. Unpublished surveys. IFPRI and IAARD, Washington, D.C.

IPB (Bogor Agricultural University). 2006. History and Development. <http://www.ipb.ac.id/pi/2.html>. Accessed October 2006.

IRIEC (Indonesian Research Institute for Estate Crops). 2005. *Empowering of Indonesian Research Institute for Estate Crops toward Centers of Excellence.* Bogor, Indonesia.

IUCN-RBP (World Conservation Union - Regional Biodiversity Program). (n.d.) Biodiversity Indonesia. <www.biodiversityasia.org/books/risk/indone8.pdf+rcb+lipi&hl=en&ct=clnk&cd=20t=clnk&cd=20> (accessed October 2006).

MOSTE (Ministry of Science, Technology, and Environment). 2003. *The second national S&T policy and plan of action*. Kuala Lumpur.

OECD (Organisation for Economic Co-operation and Development). 1994. *The measurement of scientific and technical activities 1993: Standard practice for surveys of research and experimental development—Frascati Manual*. Paris: OECD.

Pardey, P. G., and N. M. Beintema. 2001. *Slow magic: Agricultural R&D a century after Mendel*. IFPRI Food Policy Report. Washington, D.C.: IFPRI.

Pardey, P. G., J. Roseboom, and B. J. Craig. 1992. A yardstick for international comparisons: an application to national agricultural research expenditures. *Economic Development and Cultural Change* Vol 40, No.2 (January 1992): 333-49.

RISTEK (State Ministry of Research and Technology). 2006. S&T Indicators. <http://www.ristek.go.id/english/indicators.html>. Accessed October 2006.

Salmon, D. C. 1984. *An evaluation of investment in agricultural research in Indonesia, 1965-1977*. A thesis submitted to the Faculty of the Graduate School of the University of Minnesota.

BIBLIOGRAPHY (continued)

Sheridan, B. 1998. *"Strangers in a strange land": A literature review of women in science.* CGIAR Gender Program Working Paper No.17. Boston, MA and Washington, D.C.: Simmons Institute for Leadership and Change and CGIAR Secretariat.

Stads, G. J., P. S. Faylon, and L. J. Buendia. 2007. *Agricultural R&D in the Philippines: Policy, investments, and institutional profile*. ASTI Country Report. Washington, D.C.: IFPRI and PCARRD.

Stads, G. J. and V. H. Nguyen. 2006. *Vietnam*. ASTI Country Brief No. 34. Washington, D.C.: IFPRI and MARD.

UNESCO (United Nations Educational, Scientific and Cultural Organization), Division of Statistics on Science and Technology. 1984. Manual for statistics on scientific and technological activities. UNESCO, Paris. Mimeo.

World Bank. 1995. *Staff appraisal report Indonesia Second Agricultural Research Management Project*. Report No. 13933-IND. Washington, D.C.

World Bank. 2003. *Implementation completion report (CPL-38860; SCL-38866; SCPD-3886S) on a loan in the amount of US$40.1 million to the Republic of Indonesia for the Second Agricultural Research Management Project*. Report No. 25940. Washington, D.C.

World Bank. 2005. *World development indicators 2005*. Washington, D.C. CD ROM.

APPENDIX A. ASTI Methodology and Data Collection

The ASTI initiative involves a large amount of original and ongoing survey work focused on developing countries, but it also maintains access to relevant S&T data for developed countries collected by other agencies. The initiative maintains collaborative alliances with a number of national and regional R&D agencies, as well as international institutions, and over the years has produced numerous national, regional, and global overviews and policy analyses of agricultural R&D investment and institutional trends. For each country in which ASTI is active, the research team typically works with the national agricultural research institute, which coordinates the in-country survey round and coauthors and co-publishes the resulting country briefs with IFPRI. These surveys focus on research agencies, not research programs.

The dataset for the country sample underpinning this report includes information on roughly 250 agencies and was processed using internationally accepted statistical procedures and definitions developed by the Organisation of Economic Co-operation and Development (OECD) and the United Nations Educational, Science, and Cultural Organization (UNESCO) for compiling R&D statistics (UNESCO 1984; OECD 2002). Agricultural R&D investments are measured on a performer basis. Estimates were grouped into four major institutional categories: government agencies, higher education agencies, nonprofit institutions, and business enterprises. Public agricultural research is defined to include government agencies, higher education agencies, and nonprofit institutions, thereby excluding private enterprises. Government agencies are directly administered by the national government and are typically departments or institutes within a certain ministry. Nonprofit institutions, on the other hand, are not directly controlled by the national government and have no explicit profit-making objective. These agencies are often linked to producer organizations or commodity boards. Higher education agencies are academic agencies that combine university-level education with research. They include agricultural faculties, as well as specialized R&D institutes under universities. Private-sector agencies are agencies whose primary activity is the production of goods and services for profit. Some of these companies have an R&D unit dedicated to agricultural research, but R&D is generally not their main activity. Agricultural research

activities undertaken by international organizations are explicitly excluded from the dataset and are reported separately.

Agricultural research, as defined here, includes research on crops, livestock, forestry, fisheries, natural resources, the use of agricultural inputs, and the socioeconomic aspects of primary agricultural production. Also included is research concerning the onfarm storage and processing of agricultural products, commonly referred to as postharvest or food-processing research. Not included in the current data compilation are research activities in support of agrochemical, agricultural machinery, or food processing industries (which are better reported under those industries), as well as the more basic and discipline-oriented research activities undertaken by departments such as microbiology and zoology. Strict delineations, however, have not always been possible.

A complete list of agencies involved in agricultural R&D was identified at the onset of the survey, and each agency was approached to participate. To this end, three different survey forms were developed: one for government agencies and nonprofit institutions, one for faculties and schools, and one for the private sector. All forms had different sets of questions, and those for government agencies and nonprofit institutions requested the most detail. In general the forms consisted of four sections:

- Institutional details, such as address, affiliation, organizational structure (including number of research stations), institutional history, and so on;
- Human resource information, such as number of researchers by degree level, head count and full-time equivalents (that is, staffing adjusted for time spent on research), share of female researchers, and support staff by various categories;
- Financial resources, such as expenditures by cost category and funding source; and
- Research focus by commodity (about 35–40 items) and by theme (about 20 items).

Time series data were collected for the main indicators (research investments, research funding sources, and research staff totals); the remaining indicators were mostly for a particular benchmark year. Additional qualitative information was collected through country visits involving in-depth meetings with various agencies, given that quantitative information often doesn't provide the full picture of developments in agricultural R&D resources.

The reported research-personnel data are expressed in full-time equivalent (fte) researchers. Researchers should hold at least a BSc degree or equivalent. Fte corrections were made only when more than 20 percent of the reported research staff time was spent on activities other than R&D, such as extension, teaching, or technical services. The contribution of PhD students in research taking place at higher education agencies is usually not included.

Internationally Comparable Measures of R&D, Using PPPs

Comparing economic data from one country to the next is very complex due to important price level differences that exist between countries. Putting the agricultural R&D expenditures of two countries side by side is particularly difficult, given that roughly two-thirds of research expenditures are typically spent on local research and support staff, rather than on capital or other goods and services, which are usually traded internationally.

The quantity of research resources used in economies with relatively low price levels tends to be understated when R&D spending is converted from different countries to a single currency using official exchange rates. Similarly, the quantity of resources used in countries with high price levels tends to be overstated. Purchasing power parities (PPP) are conversion rates that equalize the purchasing power of different currencies by eliminating the differences in price levels between countries. Therefore, a PPP rate can be thought of as the exchange rate of dollars for goods in the local economy, while the U.S. dollar exchange rate measures the relative cost of domestic currency in dollars. A country's international price level is the ratio of its PPP rate to its official exchange rate for U.S. dollars. Thus the international price level is an index measuring the cost of a broad range of goods and services in one country relative to the same bundle of goods and services in a reference country, in this case the United States. For example, Japan's international price level (that is, the ratio of PPP to exchange rate) of 1.57 in 2000 implies that the price of goods and services in Japan was 57 percent higher than the price of comparable goods and services in the United States that year. In contrast, the corresponding 2000 ratio for Kenya of 0.20 in Kenya indicates that a bundle of goods and services that cost $20 in Kenya would have cost $100 in the United States (Pardey and Beintema 2001).

No fully satisfactory method has so far been devised to compare consumption or expenditures across countries, either at different points in time or the same point in time. The measures obtained, as well as their interpretation, can be highly sensitive to the deflator and currency converter used. Most financial figures in this report have been expressed in "international dollars" for the benchmark year 2000. At the country level, all expenditure and funding data have been collected in local currency units (Philippine pesos). These amounts were subsequently converted to 2000 international dollars by deflating the local currency amounts with each country's GDP deflator of base year 2000 and converting to U.S. dollars with a 2000 PPP index (both the GDP deflators and PPP values were taken from the World Bank 2004). For convenience of interpretation, the reference currency—in this case international dollars—is set equal to a U.S. dollar in the benchmark year 2000.

APPENDIX B. Historical Perspectives[5]

Indonesia has had a long history of agricultural R&D since the Dutch established *'s Lands Plantentuin* (the State Botanical Garden) in Bogor in 1817. During colonial rule, most agricultural research in the Dutch East Indies was fragmented into a number of institutes having little contact with one another. Much of the Dutch research effort was for the estate crops that formed the backbone of the colony's exports. The first research institutes for rubber were established by the Dutch in 1912 (Bogor, West Java) and 1917 (Medan, North Sumatra) with funding provided by the estates. Many rubber clones that were produced during that era are still widely planted in the Far East and in Africa. Important research work for sugarcane was done by the Dutch as well. The first sugarcane experiment station was established in East Java in 1885. By 1900, it had become the world's leading producer of sugarcane varieties. The first rice facility was set up by the Dutch in 1905 and it began developing some very successful varieties. These varieties, developed in the 1930s and 1940s, are known in Indonesia today as "national improved varieties", and are still widely planted.

Agricultural R&D in the Dutch East Indies was carried out largely by researchers from the Netherlands and the colonial government showed little interest in developing a pool of trained native agricultural scientists. When Indonesia attained independence in 1949, the Dutch had left a very fragmented system with almost no agricultural scientists trained to continue the research work. In fact, independence found Indonesia with just 230 college graduates of whom only two were agricultural scientists capable of continuing research work on rice. The Dutch, however, did leave excellent facilities for research in terms of buildings and land.

During 1949–1965, the period immediately following Indonesia's independence, agricultural R&D did not form a priority for the Sukarno government. Most of the government's efforts in agriculture seem to have been directed to extension and the establishment of agricultural science programs at the agricultural institute at Bogor and at Gajah Mada University. The extensive facilities left by the Dutch seem to have gone largely unused. During this time, there were no budgets for agricultural R&D. Each

[5] This section draws largely on Salmon (1984).

directorate within the Ministry of Agriculture conducted what research it deemed appropriate out of more general budget categories.

The Indonesian government's first five-year development plan (1969–1974) emphasized rice production and mandated research responsibilities to the Ministry of Agriculture to be implemented in its Directorates-General of Food Crops, Estate Crops, Forestry, Fisheries, Animal Husbandry, and other agencies. For the first time since the Second World War, the government was willing to step forward with significant and consistent budget support for agricultural R&D. This money, along with foreign donor support, was used to provide training as well as perform experiments. Although budget support improved tremendously after 1969, funding was still provided to the research institutes from individual directorates within the Ministry of Agriculture rather than through a specialized agricultural research agency. As a result, research efforts remained fragmented and uneven in quality. In 1969, the government of Indonesia – with USAID assistance – established a Joint Agriculture Research Survey Team to survey agricultural R&D in the country. This yielded the recommendation that a national agricultural research system be established and a Presidential Decree in 1974 authorized the establishment of research and development agencies in the several departments and ministries of government. This decree created the Indonesian Agency for Agricultural Research and Development (IAARD). IAARD is within the Ministry of Agriculture and is responsible for all agricultural research in the country. The different Central Research Institutes were transferred to IAARD in about 1977, and almost all government funding for research is paid to the institutes through IAARD.

IAARD has gone through a number of reorganizations since its establishment to adapt to the changing demands of Indonesia's agricultural sector. Reorganizations took place in 1979, 1983, 1990, and 1994. The reorganization of 1983 separated the Ministry of Forestry from the Ministry of Agriculture. Forestry research was separated from crops and livestock research as a result, prompting the establishment of the Forest Research and Development Agency (FORDA). The Presidential Decree of 1990 established a revised organizational structure of IAARD consisting of a Secretariat, two centers, two research centers, five research and development centers, and special association with the Indonesian Planters Association for Research and Development (IPARD) and the

Indonesian Sugar Research Institute (ISRI). In accordance with ministry mandates, IAARD centers continued to manage the activities of 16 research institutes located throughout the country and to play a coordinating role with another 10 institutes conducting research on estate crops under the auspices of the IPARD and ISRI. In 1994, a network of regional assessment centers for agricultural R&D was established in order to generate location-specific technologies based on farmers' needs and circumstances. These so-called Assessment Institutes for Agricultural Technology (AIATs) were developed with strong support from the World Bank and ADB to cover all regions in Indonesia, so that development, diffusion, and use of research results as well as the provision of location-specific information and technology is ensured. Few changes have occurred in Indonesia's agricultural R&D system since 1994.

APPENDIX C. Agencies Included in Survey Sample, 2003

Type of agency	Supervising agency	Executing agency	Research focus	Researchers	
				Headcount	fte's
Government agencies	Indonesian Agency for Agricultural Research and Development (IAARD)	Indonesian Center for Food Crops Research and Development (ICFORD)	Crops	348	348.0
		Indonesian Center for Agricultural Engineering Research and Development	Crops, natural resources	34	34.0
		Indonesian Center for Estate Crops Research and Development (ICECRD)	Crops	332	332.0
		Indonesian Center for Agricultural Postharvest Research and Development (ICAPOSTRD)	Postharvest	49	49.0
		Indonesian Center for Agro-climate and Land Resources Research and Development (ICALRD)	Natural resources	307	307.0
		Indonesian Center for Animal Science Research and Development (ICASRD)	Livestock, feed	201	201.0
		Indonesian Center for Agricultural Biotechnology and Genetic Resources Research and Development (ICABIOGRD)	Rice, natural resources	117	117.0
		Indonesian Research Institute for Estate Crop (IRIEC)	Crops, socio-economics	229	229.0
		Indonesian Center for Horticulture Research and Development (ICHORD)	Crops, postharvest, socio-economics	138	138.0

Type of agency	Supervising agency	Executing agency	Research focus	Researchers	
				Headcount	fte's
		Indonesian Center for Agricultural Socio Economic Research and Development (ICASERD)	Socio-economics	870	870.0
	—	Indonesian Forest Research and Development Agency (FORDA)	Forestry, natural resources, socio-economics	423	423.0
	Agency for Marine and Fisheries Research (AMFR)	Research Center For Marine and Fishery Product Processing and Socio-Economic (RCFMFPPSE)	Postharvest, socio-economics	70	70.0
	Agency for Development and Application of Technology			N.A.	N.A.
	National Coordinating Agency for Surveys and Mapping ()	Geomatics Research Division	Natural resources	23	2.3
	National Nuclear Energy Agency		Crops, livestock, natural resources	64	6.4
	National Institute of Aeronautic and Space (LAPAN)	Center for Research and Development of Remote Sensing Application and Technology (CRDRSAT)	Crops, forestry, fisheries, natural resources, environment, information system	52	36.4
	Indonesian Science and Technology Agency (LIPI)	Research Center for Biotechnology (RCB)	Crops, livestock, forestry	81	81.0
	—				
Nonprofit		Kaffah Foundation	Socio-economics, crops, livestock, fisheries	8	2.4
Higher education agencies	North Sumatra Muhammadiyah University (NSMU)	Faculty of Agriculture	Crops, postharvest, socio-economics	50	12.5
	Sebelas Maret University (SMU)	Faculty of Agriculture	Socio-economics, crops, livestock	145	36.3
	Sam Ratulangi University (SRU)	Faculty of Agriculture	Environmental, natural resources, livestock, crops, socio-economics	229	57.3
	Semarang University	Faculty of Agriculture Technology and Animal Husbandry	Socio-economics, crops, livestock, fertilizers	12	3.0

Type of agency	Supervising agency	Executing agency	Research focus	Researchers	
				Headcount	fte's
	University of Mataram (UM)	Faculty of Agriculture	Crops, postharvest, socio-economics	168	42
	Tanjung Pura University (UNTAN)	Faculty of Agriculture	Socio-economics, crops, postharvest	99	24.8
	Andalas University	Faculty of Agriculture		182	45.5
		Faculty of Animal Husbandry	Crops, livestock, natural resources	130	32.5
	Bogor Agricultural University	Faculty of Agriculture		1252	500.8
		Faculty of Veterinary Medicine		113	45.2
		Faculty of Marine Sciences and Fisheries		180	72.0
		Faculty of Animal Husbandry		113	45.2
		Faculty of Forestry		136	54.4
		Faculty of Agricultural Technology		166	66.4
		Faculty of Mathematics and Natural Sciences	Crops, livestock, fisheries, postharvest	226	90.4
	Padjadjaran University	Faculty of Agriculture		257	64.3
		Faculty of Animal Husbandry	Fisheries, crops, livestock	132	33.0
	Udayana University	Faculty of Agriculture		155	51.2
		Faculty of Animal Husbandry		111	36.6
		Faculty of Veterinary Science		76	25.1
		Faculty of Mathematics and Natural Sciences		155	51.2
		Faculty of Agriculture Technology	Crops, livestock	53	17.5
	Gadjah Mada University	Center for Rural and Regional Development Studies	Socio-culture, socio-economics	19	13.3
	Satya Wacana Christian University	Faculty of Agriculture	Wheat, vegetable	23	5.8
	Universitas Muhammadiyah Purwokerto	Faculty of Agriculture	Crops, socio-economics	11	2.8

Type of agency	Supervising agency	Executing agency	Research focus	Researchers	
				Headcount	fte's
	Muhammadiyah University of Yogyakarta	Faculty of Agriculture	Crops	34	8.5
	Diponegoro University	Faculty of Animal Sciences	Livestock, socio-economics, postharvest	128	32.0
	University of Jember	Faculty of Agricultural Technology	Postharvest, natural resources, socio-economics	53	13.3
		Faculty of Agriculture	Crops, socio-economics	78	19.5
	University of Lampung	Faculty of Agriculture	Crops, livestock, postharvest, socio-economics	244	61
	North Sumatra University	Research Unit	Crops	75	75.0
	Mulawarman University	Faculty of Fisheries and Marine Sciences	Fisheries, socio-economics, natural resources	43	10.8
		Faculty of Agriculture	N.A.	87	21.8
	Haluoleo University	Faculty of Agriculture	Crops, natural resources, socio-economics, fisheries	180	18.0
	Lambung Mangkurat University (LMU)	Faculty of Agriculture	Natural resources, rice, livestock	118	29.5
	University of Hasanuddin	Faculty of Agriculture and Forestry	Crops, forestry	202	50.5
		Faculty of Marine Science and Fisheries	Fisheries	114	28.5
		Faculty of Animal Husbandry	Livestock	84	21.0
	Brawijaya University	Faculty of Agriculture	Crops, socio-economics, forestry	133	33.3
		Faculty of Fisheries	Fisheries	78	19.5
	University of the State of Papua	Faculty of Agriculture	Crops, postharvest, socio-economics	176	44.0
Private	Bakrie Sumatera Plantations, Tbk.		Oil palm	3	3.0
	Bayer Crop Science, R&D Unit		Crops	15	25.0
	PT East West Seed Indonesia, R&D Division		Vegetables	26	26.0
	PT Gunung Madu Plantations		Sugar cane	12	12.0

Type of agency	Supervising agency	Executing agency	Research focus	Researchers	
				Headcount	fte's
	Inhutani I (East Kalimantan, South Sulawesi)		Forestry	7	7.0
	Inhutani II (South Kalimantan)		Forestry	N.A.	2.5
	Inhutani III (Central and West Kalimantan)		Forestry	N.A.	2
	London Sumatra – Bah Lias Research Station		Oil palm, cocoa, rubber	33	33.0
	PT Musi Hutan Persada		Forestry	19	19.0
	Perhutani (Java)		Forestry	70	70.0
	PT. Perkebunan Nusantara XIV (Persero)		Sugar cane, oil palm	3	3.0
	PT Sang Hyang Seri (Persera)		Rice, maize	7	7.0
	Sinar Mas Agro Resources & Technology Coporation - Agribusiness Division (SMARTRI)		Oil palm	32	32.0
	Socfindo		Oil palm	25	25.0