ASTI Country Brief | May 2020

INDONESIA

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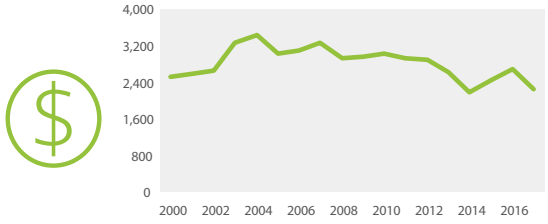
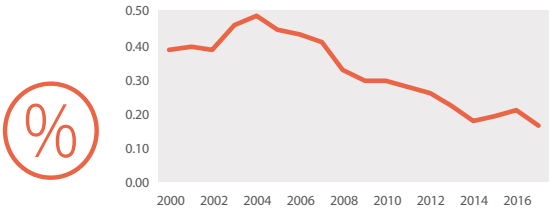
AGRICULTURAL RESEARCH SPENDING



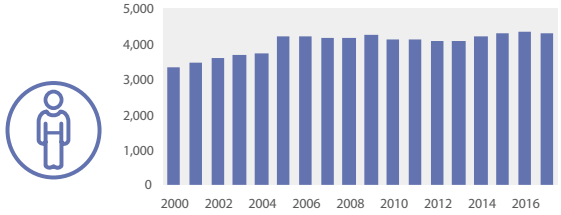
	INDONESIA	MALAYSIA	THAILAND	VIETNAM
Billion rupiah (2011 constant prices)	2,271.0			
Million PPP dollars (2011 constant prices)	629.7	629.0	847.2	177.6

SPENDING INTENSITY



	INDONESIA	MALAYSIA	THAILAND	VIETNAM
Agricultural research spending as a share of AgGDP	0.17%	0.85%	0.94%	0.20%

AGRICULTURAL RESEARCHERS

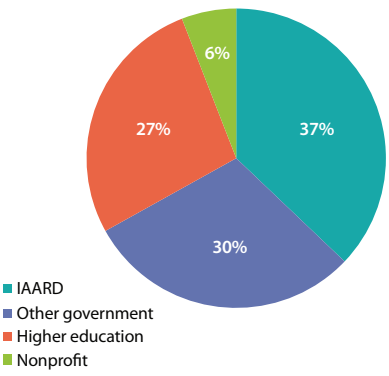


	INDONESIA	MALAYSIA	THAILAND	VIETNAM
Full-time equivalents	4,289.5	1,543.4	2,911.4	4,250.1
Share of researchers with MSc and PhD degrees	71%	72%	50%	67%

Notes: Data in the table above are for 2017. Research conducted by the private for-profit sector is excluded from this country brief due to lack of available data. Information on access to further resources, data procedures and methodologies, and acronyms and definitions is provided on Page 8. See **www.asti.cgiar.org/indonesia/directory** for an overview of Indonesia's agricultural R&D agencies.

- Indonesian agricultural R&D spending declined steadily in the decade leading to 2017 (in inflation-adjusted terms).
- The country's agricultural research spending as a share of AgGDP also fell substantially, from 0.48 percent in 2004 to just 0.17 percent in 2017. This ratio is among the lowest in Southeast Asia.
- On average, Indonesia's total number of agricultural researchers remained relatively constant during 2004–2017, at around 4,200 FTEs, but average qualification levels improved over time.

INSTITUTIONAL PROFILE, 2017

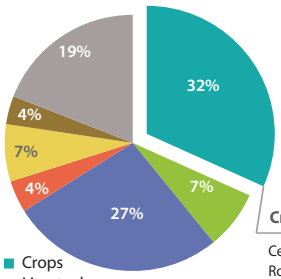


RESEARCHER PROFILE, 2017

By gender (%)

By qualification level (FTEs)

RESEARCH FOCUS, 2017



Crop categories

Cereals	8 %
Roots and tubers	2 %
Pulses	0.5 %
Oil-bearing crops	5 %
Horticultural crops	7 %
Other crops	10 %

KEY CHALLENGE

- Average qualification levels of Indonesian agricultural researchers have improved markedly over time. As of 2017, however, nearly two-thirds of PhD-qualified researchers and 40 percent of those qualified to the MSc-degree level were more than 50 years old. Given that the majority of researchers retire at the age of 58, large-scale capacity losses are imminent in the coming years.

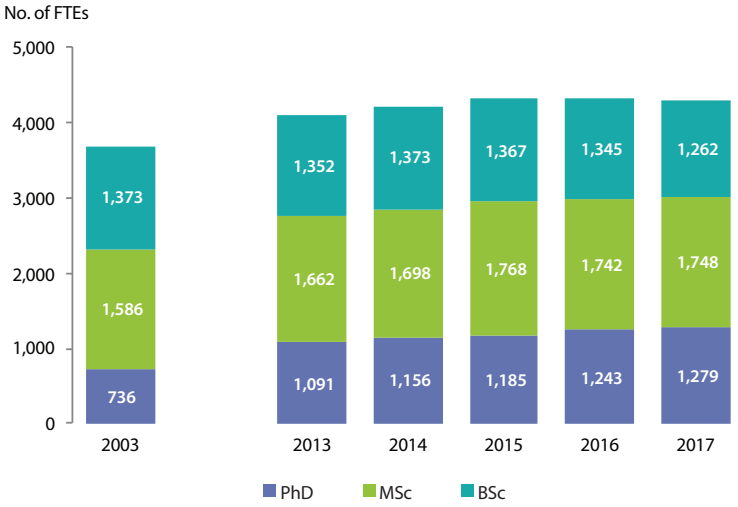
POLICY IMPLICATIONS

- In order to address the most pressing capacity gaps, it is critical that large-scale training opportunities be provided for young BSc- and MSc-qualified scientists and that, prior to retiring, senior researchers mentor their younger colleagues. The country's research agencies will need to monitor anticipated skills and specialization gaps, and promptly respond to training needs as they arise. A system of incentives also needs to be established to ensure that young scientists are motivated and retained over time.

Agricultural researchers by degree level, 2017

	PhD	MSc	BSc	TOTAL
SECTOR/AGENCY		(FTEs)		
Government				
IAARD centers				
ICABGRRD	39.0	21.0	15.0	75.0
ICAERD	9.0	12.0	13.0	34.0
ICALRRD	59.0	58.0	101.0	218.0
ICAPHRD	16.0	32.0	9.0	57.0
ICASEPS	34.0	20.0	9.0	63.0
ICASRD	35.0	35.0	13.0	83.0
ICATAD	107.1	268.1	198.8	574.0
ICECRD	62.0	66.0	74.0	202.0
ICFCRD	39.0	53.0	26.0	118.0
ICHRD	43.0	69.0	56.0	168.0
FORDA	99.0	437.0	596.0	1,132.0
Other government agencies	40.4	81.1	25.3	146.7
Subtotal	582.5	1,152.2	1,136.1	2,870.7
Higher education				
Bogor Agricultural University	237.5	70.5	6.5	314.5
Udayana University	56.2	70.2	1.2	127.6
Other higher education agencies	350.1	360.1	12.9	723.1
Subtotal	643.8	500.9	20.5	1,165.2
Nonprofit				
IRIEC	53.0	93.0	98.0	244.0
LPTP	—	2.0	7.5	9.5
Subtotal	53.0	95.0	105.5	253.5
TOTAL	**1,279.3**	**1,748.1**	**1,262.1**	**4,289.5**

Agricultural researchers by degree level, 2003 and 2013–2017



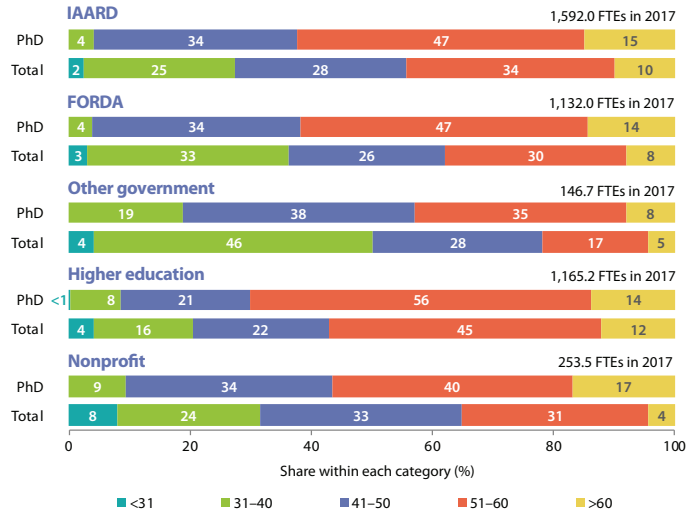
- The average qualification levels of Indonesia's agricultural researchers have improved steadily over time: the share of scientists with PhD degrees rose from 20 percent in 2003 to 30 percent in 2017. University-based researchers are more highly qualified on average than their colleagues in the government and nonprofit sectors. In 2017, roughly three-quarters of scientists at Bogor Agricultural University were PhD-qualified. In contrast, more than half of FORDA's researchers were only qualified to the BSc-degree level.

CAPACITY STRENGTHENING AT IAARD

- During 1997–2004, the Asian Development Bank supported large-scale postgraduate training of IAARD staff. More recently, during 2014–2019, as part of the World Bank loan-funded *Sustainable Management of Agricultural Research and Technology Dissemination* (SMARTD) project, close to US$18 million was invested in MSc training for 93 IAARD scientists and PhD training for 68 scientists. SMARTD also funded the participation of a large number of researchers at international seminars, workshops, and conferences. In addition, IAARD has earmarked 20 billion rupiahs per year for training of researcher, extensionist, and administrative staff through its own means. In the coming years, 15 researchers will be selected annually for PhD training and 50 researchers for MSc training.

  Besides internally-funded training, IAARD researchers can apply for various other government scholarships. Indonesia's Ministry of Finance offers highly competitive scholarships for MSc and PhD training overseas. During 2013–2017, five IAARD researchers secured such scholarships for training in Germany, the Philippines, and the United Kingdom. Similar scholarship opportunities are available from the Ministry of Higher Education and Technology and the Ministry of Agriculture (for their respective employees), as well as from the Ministry of National Development Planning. During 2013–2017, 30 Indonesian researchers received a John Allwright Scholarship from ACIAR for postgraduate training in crop, animal, marine, forestry, and agroeconomic sciences at Australian universities.

Agricultural researchers by age bracket, 2017



As of 2017, 62, 61, and 70 percent of the PhD-qualified researchers at IAARD, FORDA, and the higher education agencies, respectively, were more than 50 years of age. In response to an aging pool of civil servants, the Indonesian government recently raised the official retirement age for all government employees, including (agricultural) researchers. These measures will buy more time for senior scientists to train and mentor their younger colleagues in the decade ahead. It is important, however, that a large number of young MSc- and BSc-qualified researchers are given the opportunity to upgrade their qualifications during this period in order for Indonesia's agricultural research agencies to maintain an appropriately qualified pool of agricultural scientists into the future.

NEW RECRUITMENT AND RETIREMENT DIRECTIVES FOR RESEARCH AGENCIES

All Indonesian research agencies operate under a strict hierarchy, classifying junior, middle, and senior positions, and administrative and research branches. In 2019, new regulations applying to both the government and university sectors raised the retirement age from 57 to 60 years for junior and middle-level research and administrative staff; to 65 years for senior research and administrative staff; and to 70 years for research professors. Pre-existing regulations requiring that staff in official research positions at higher education institutions hold a minimum qualification of an MSc degree were extended to government research agencies in 2019. Researchers who only hold BSc degrees have only until 2023 to upgrade their qualifications, be demoted to an administrative position, or retire. As a result of these changes, qualifications among Indonesian agricultural researchers are expected to improve considerably over the next few years. Moreover, various performance-based incentives have been established to motivate researchers. IAARD, for example, offers royalties to researchers who develop and obtain patents on new research products.

PhD-qualified agricultural researchers by discipline, 2017

	FTEs			
DISCIPLINE	**IAARD**	**Other government agencies**	**Higher education**	**TOTAL**
Plant breeding/genetics	87.9	—	37.0	**125.0**
Plant pathology	36.8	—	49.5	**86.3**
Plant physiology	8.0	—	18.6	**26.7**
Agronomy (incl. botany and seed science)	13.8	—	18.8	**32.5**
Other crop sciences	20.6	—	26.6	**47.2**
Animal breeding/genetics	2.0	—	2.4	**4.3**
Animal husbandry	31.7	—	24.0	**55.7**
Animal nutrition	6.5	—	14.5	**21.1**
Veterinary medicine	1.0	—	57.2	**58.2**
Other animal and livestock science	4.6	—	34.0	**38.6**
Forestry and agroforestry	—	99.0	11.2	**110.2**
Fisheries and aquaculture	—	7.4	48.6	**56.0**
Soil science	35.8	—	61.4	**97.2**
Natural resource management	12.5	—	13.0	**25.5**
Water and irrigation management	9.9	—	6.8	**16.7**
Ecology and biodiversity conservation	8.6	—	15.1	**23.7**
Food science and nutrition	15.8	—	26.9	**42.8**
Socioeconomics (incl. agricultural economics)	52.6	—	48.9	**101.5**
Extension	7.0	—	7.2	**14.2**
Biotechnology	—	33.0	—	**33.0**
Other	88.1	—	122.0	**210.1**
Total	**443.1**	**192.4**	**643.8**	**1,279.3**

Note: The nonprofit sector is excluded because data for IRIEC and LPTP were not available.

Indonesia's agricultural R&D system employs the largest number of PhD-qualified researchers among Southeast Asian countries (close to 1,300 FTEs). Of the country's PhD-qualified researchers, 29 percent were crop scientists, 14 percent were livestock scientists, and 9 percent were forestry scientists. Indonesia's agricultural R&D agencies employ relatively few PhD-qualified scientists focusing on animal breeding, water/irrigation management, or biotechnology.

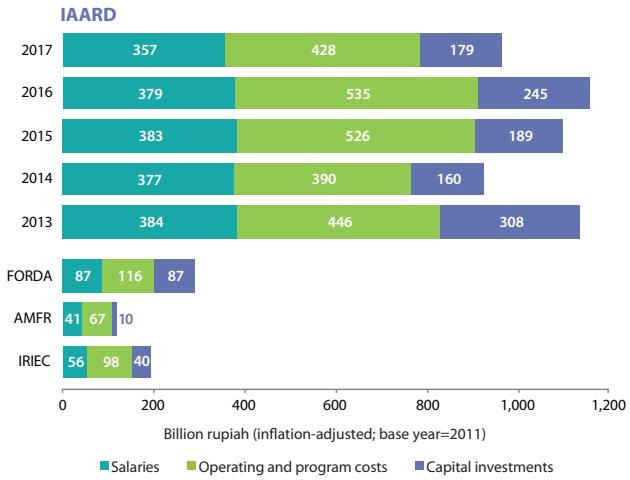
KEY CHALLENGE

- Although public investment in the agricultural sector has increased steadily over time, investment in agricultural R&D has fallen. Indonesia spends proportionally less on agricultural R&D than most countries in Southeast Asia or other populous middle-income countries, raising concerns over the country's capacity to address the critical challenges it faces, including low agricultural productivity, low competitiveness in international markets, rural–urban income inequality, environmental degradation, and the adverse impacts of climate change.

POLICY IMPLICATIONS

- A well-staffed and funded agricultural research system is fundamental to improving agricultural productivity, increasing competitiveness, and raising smallholder incomes. Sufficient levels of long-term sustainable government funding are needed to operate viable research programs. Diversification of funding should also be promoted through more enabling policies that stimulate private funding. In turn, R&D institutes need to ensure that the research they conduct is closely aligned with the needs of the agri-food sector.

Total expenditures by cost category, 2013–2017



Note: Data for FORDA, AMFR, and IRIEC are averages for the 2013–2017 period.

- IAARD's spending during 2013–2017 was erratic, largely in response to the irregular influx of SMARTD funding. This funding enabled the provision of competitive research grants; upgrades to large-scale infrastructure; the procurement of laboratory equipment; and the construction of some new laboratories, offices, and experiment stations. Salary-related expenses accounted for 36 percent of IAARD's total expenditures during 2013–2017 on average, operating and program costs represented 44 percent of the total, and capital investments represented 20 percent. The relative allocation of spending across these cost categories was roughly similar at the other (non-IAARD) government agencies.

IAARD expenditures by center, 2017

CENTER	Billion rupiah (inflation-adjusted; constant 2011 prices)
ICABGRRD	26.6
ICAERD	25.2
ICALRRD	75.3
ICAPHRD	18.9
ICASEPS	34.7
ICASRD	60.5
ICATAD	391.4
ICECRD	118.5
ICFCRD	102.1
ICHRD	110.8
TOTAL	**964.0**

SMARTD STRENGTHENED IAARD'S INSTITUTIONAL CAPACITY

- Typical for a populous middle-income country in transition, Indonesia's agri-food system and consumption patterns have evolved rapidly over time, making it difficult for IAARD to stay on top of the changes. The general consensus is that Indonesia's agricultural sector needs to become more competitive, primarily by focusing on value addition, in order to accelerate economic growth and poverty reduction. Concerns over national food security and import substitution have drawn attention to the ongoing need for increased sustainable productivity and value-chain efficiency among some of the country's main food crops. In its 2009–2014 Strategic Plan, the Ministry of Agriculture stressed its commitment to achieving and maintaining self-sufficiency in rice, maize, soybean, sugar, and beef production; enhancing food diversification; increasing value-added, exports, and competitiveness; and enhancing farmers' livelihoods.

  In line with these goals, the SMARTD program was approved in 2012 to strengthen IAARD's institutional capacity for the development and disseminatation of relevant innovative and demand-driven technologies that meet the needs of producers and the agri-food system as a whole. This US$95.3 million program was funded through a World Bank loan and Indonesian counterpart funding. The program consisted of four main components: (1) strengthening IAARD's research capacity; (2) rehabilitating and upgrading the infrastructure of some of IAARD's units; (3) implementing improved research management strategies, processes, and instruments; and (4) implementing monitoring and evaluation protocols. By its completion in 2019, the program was widely regarded as having strengthened IAARD's institutional capacity and performance (World Bank 2019). Food sovereignty and farmer welfare continue to be the main goals in the Ministry of Agriculture's Strategic Plan for 2020–2024. In the absence of large-scale external funding, it is important that SMARTD's initiatives and achievements can be sustained under the new plan.

Number of journal articles by government research agencies and Bogor Agricultural University, 2013–2017

	GOVERNMENT RESEARCH AGENCIES			BOGOR AGRICULTURAL UNIVERSITY		
TYPE OF PUBLICATION	**2015**	**2016**	**2017**	**2015**	**2016**	**2017**
Articles in international journals	67	77	113	462	489	586
Articles in Asian journals	50	31	39	27	22	59
Articles in Indonesian journals	518	597	528	515	515	616
TOTAL	**635**	**705**	**680**	**1,004**	**1,026**	**1,261**
Peer-reviewed articles per FTE researcher per year	0.24	0.26	0.25	3.41	3.57	4.51

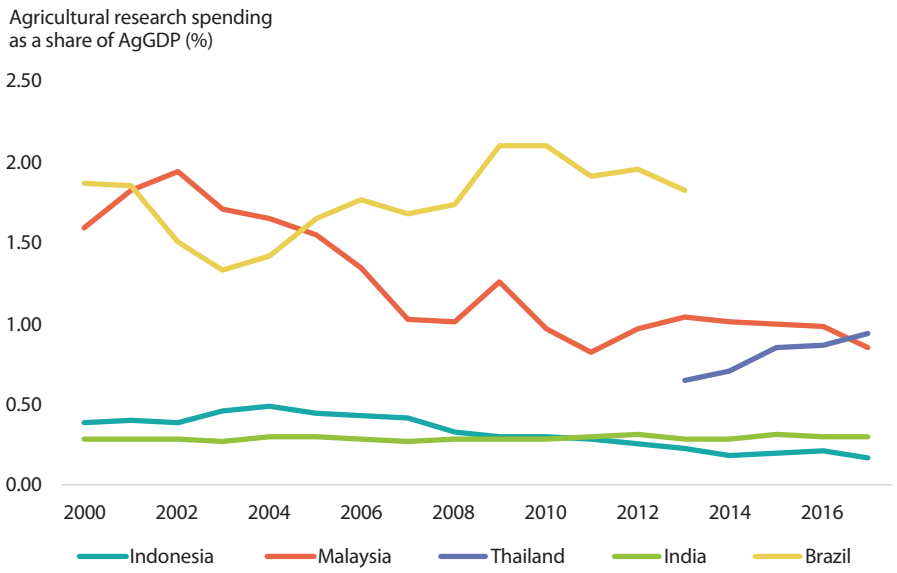
Note: Data for the government research agencies include AMFR, FORDA, and 9 of IAARD's 10 centers (data for ICASRD were not available).

- The publication record of Indonesian researchers remains low by international standards. In 2017, the average number of journal articles per government researcher was just 0.25 compared with 4.51 by scientists from Bogor Agricultural University (18 times higher).

FUNDING SOURCES FOR AGRICULTURAL R&D

- During 2013–2017, about 80–90 percent of agricultural research conducted by IAARD, FORDA, AMFR, and the universities was funded by the government ministries supervising them.
- IRIEC, which in contrast to IAARD centers has semiautonomous status, is predominantly funded through revenues from the sale of plantation crops and technology inputs (such as seed stock), as well as through private contract-based research.
- Donors and development banks play an important role in funding agricultural R&D in Indonesia, but the exact amount of donor funding is difficult to quantify because the government passed the "one-door regulation," requiring that all external funding be channeled through the Ministry of Finance. The main donors to the IAARD centers have been the World Bank (for institutional strengthening), ACIAR (for livestock and horticultural research), the Japanese International Corporation Agency (for research on mechanization, maize, and rice), and the International Rice Research Institute (for rice research). ACIAR is also an important donor to FORDA.
- Revenue from royalties more than quadrupled at the IAARD centers during 2013–2018, from 1.2 billion to 5.1 billion rupiah. The centers also generate funding through the sale of goods and services, but such funding represented less than 1 percent of IAARD's total funding in 2017.
- University-led research is funded through a variety of (competitive) government, donor, private, and foreign university sources. Bogor Agricultural University, for instance, receives considerable funding through the Interdisciplinary Research and Education Fund from Wageningen University in the Netherlands. Its oil palm research is funded through the National Research and Innovation Agency, the Indonesian Oil Palm Estate Fund, and a number of private entities.

Agricultural research intensity, 2000–2017



Source: ASTI.

- In 2010, in its Indonesia Agriculture Public Expenditure Review, the World Bank noted the urgent need for Indonesia to increase the level and quality of its agricultural R&D investment and the development of a knowledge-intensive innovation system to enhance future agricultural productivity growth and competitiveness. Nonetheless, Indonesia's investment in agricultural R&D as a share of AgGDP steadily declined from 2010 to reach just 0.17 percent in 2017—well below ratios recorded in other populous middle-income countries. Indonesia is widely regarded as an innovation "follower". BRIC countries, such as Brazil and India, invest more in agricultural R&D, have recorded higher agricultural productivity growth over time, and have generated more patents and royalty fees through their R&D systems.

PRIVATE-SECTOR AGRICULTURAL RESEARCH

- The private sector plays an important role in agricultural R&D in Indonesia, particularly in the plantation-crop, horticultural, and agricultural input subsectors. Reliable investment data for Indonesian private firms are not available, so comparisons of public versus private investments developments over time are not possible. What can be said is that, as the world's largest palm oil exporter and the second-largest rubber exporter, Indonesia has many large plantations with sizeable R&D programs. The most important of these in the plantation-crop sector are SMART, Lonsum, and Socfindo. In addition to conducting in-house research, many plantation companies also outsource research to IRIEC and Bogor Agricultural University. Indonesia's private seed industry is concentrated mostly around hybrid maize and some high-value horticultural crops. Companies like Charoen Pokphand (Thailand), Cargill (United States), and Dupont (United States) conduct yield trials for hybrid maize in farmers' fields and at public R&D stations. East–West Seed (the Netherlands) is Indonesia's largest private performer of R&D for vegetable seed. Fertilizer, pesticide, and herbicide R&D for rice, vegetables, and oil palm is conducted by multinational corporations like Syngenta, Bayer Crop Science, and Dupont, which operate R&D facilities in Indonesia but also outsource a considerable amount of their research to IAARD centers and local universities.

  Countries like Malaysia, the Philippines, Thailand, and Vietnam have long offered tax incentives to companies undertaking R&D. Indonesia has never implemented such incentives, but in 2019 the country's Finance Ministry began the process of drafting legislation that would allow companies to reduce their taxable income by as much as 300 percent of the cost of their R&D activities. These changes are expected to take effect by the end of 2020 and are likely to stimulate private (agricultural) R&D investment in the coming years.

KEY CHALLENGE

- In Kalimantan and Sumatra, burgeoning oil palm production is causing deforestation and pressure on food crop production. Rapid urbanization in Java is prompting a loss of agricultural land. Rising sea levels are making vast areas of formerly arable land ever more saline, and other negative effects of climate change are increasingly felt throughout the country. All these factors are putting tremendous pressure on Indonesia's agricultural sector at a time when productivity growth is very low.

POLICY IMPLICATIONS

- Future agricultural growth will be highly dependent on technical change that prompts yield increases, a more efficient use of scarce resources, and a reduction in crop losses. A considerable increase in investments in agricultural R&D is critical to ensure that farmers have access to a steady supply of technologies that meet their needs. It is also critical that these innovations reach farmers through an effective and well-funded extension system.

New crop varieties and breeds released by IAARD, 2014–2018

CROP	2014	2015	2016	2017	2018	TOTAL
Ornamental plants	15	14	6	12	22	69
Rice	6	5	3	5	7	26
Vegetables	7	9	4	2	3	25
Fruit	3	10	3	1	6	23
Maize	3	3	–	5	2	13
Soybeans	5	1	–	4	2	12
Cotton	5	–	–	3	3	11
Coconuts	–	1	2	4	4	11
Peanuts	2	2	–	–	4	8
Sugarcane	–	–	1	4	2	7
Coffee	–	2	–	–	4	6
Sweet potatoes	2	1	–	–	2	5
Mung beans	2	–	–	–	2	4
Wheat	3	–	–	–	–	3
Cassava	–	1	–	–	2	3
Sorghum	2	–	–	–	–	2
Other plantation crops	9	6	10	10	8	43
Total	**64**	**55**	**29**	**50**	**73**	**271**

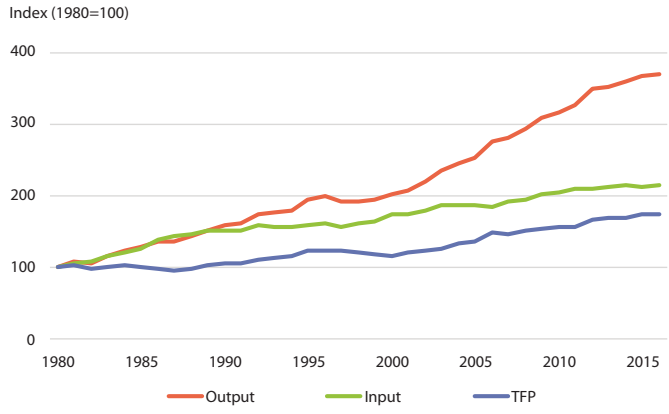
- During 2014–2018, IAARD centers released a total of 271 new varieties and breeds, a quarter of which were ornamental plants (chrysanthemum, orchids, gerbera, gladiolus). Other important crops include rice, vegetables, fruit, maize, soybeans, cotton, and coconuts. The Office of Plant Variety Protection is responsible for registering new varieties in Indonesia. All varieties from IAARD breeding programs undergo extensive laboratory, field, and multi-location trials before being formally released. Superior varieties are registered for patent rights. IAARD has obtained an increasing number of patents in recent years, which underscores the potential for further commercialization of innovative technologies. The agency has also had increasing success in licensing its technologies to the private sector.

LIMITED AGRICULTURAL PRODUCTIVITY GROWTH

- Increasing the efficiency of agricultural production—that is, getting more output from the same amount of resources—is critical for improving agricultural growth in Indonesia. Total factor productivity (TFP) is an indicator of how efficiently agricultural land, labor, capital, and other inputs (seed, fertilizer, and so on) are used to produce a country's agricultural outputs (crops and livestock). TFP is calculated as the ratio of total agricultural outputs to total production inputs. When more output is produced from a constant amount of resources—indicating that resources are being used more efficiently—TFP increases.

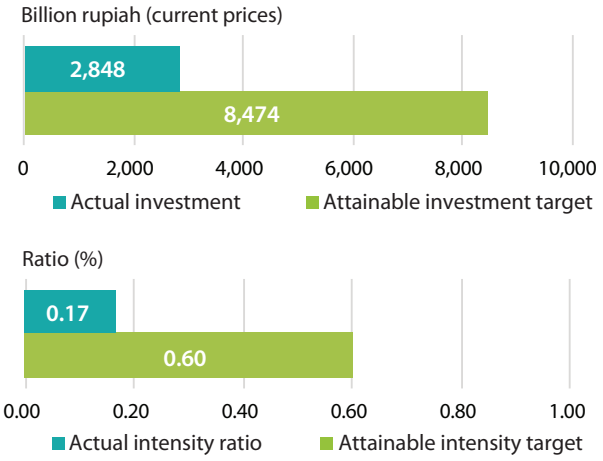
Agricultural output in Indonesia nearly quadrupled during 1980–2016, predominantly driven by growth in the use of inputs. While output grew at 3.6 percent per year during this period, TFP grew at just 1.5 percent per year. In fact, long-term TFP growth has been considerably lower in Indonesia than in the rest of Southeast Asia, reflecting the fact that agriculture in Indonesia is highly labor-intensive and makes little use of capital investment. The rapid growth in the country's agricultural output since 2000 can largely be attributed to farm subsidies. However, unlike other agricultural investments—such as in rural roads, irrigation, extension services, or R&D—the overall impact of such subsidies on farm productivity is quite limited. Overall, Indonesia's rice yields have stagnated since the 1990s, but maize and horticulture yields have performed much better. Nevertheless, rice continues to dominate public agricultural R&D spending and policy, in part crowding out support for other commodities in which Indonesia appears to have a comparative advantage. The country could significantly improve the effectiveness of its public spending and future agricultural productivity by shifting the composition of its public spending away from subsidies. Further investment in agriculture should focus on increasing productivity growth by deepening capital investment and moving toward higher value-added commodities (World Bank 2010).

Long-term growth in agricultural input, output, and productivity, 1980–2016



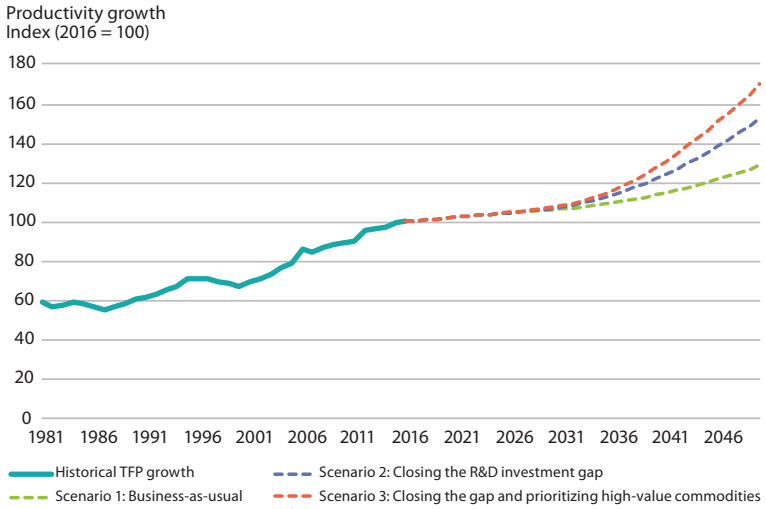
Source: Calculated by authors based on USDA-ERS (2019).

Actual research spending and attainable targets, 2017



Source: Calculated by authors based on ASTI (2020) and Nin-Pratt (2016).
Notes: Traditionally, agricultural research intensity ratios compare investment and AgGDP levels to determine whether countries may be underinvesting. ASTI's Intensity Index incorporates additional factors that account for the size and nature of a nation's economy and hence facilitate more accurate cross-country comparisons. For more information, see https://astinews.ifpri.info/2017/07/01/a-new-look-at-research-investment-goals-for-ssa/.

Productivity projections based on research prioritization of high-value commodities, 2016–2050



Sources: Calculated by authors based on ASTI (2020), USDA-ERS (2018), Nin-Pratt (2016), FAO (2018), and World Bank (2018).
Note: For more information on the methodology behind these projections, see https://www.asti.cgiar.org/knowledge-stocks and https://www.asti.cgiar.org/tfp-projections.

THE IMPACT OF HIGHER AND SMARTER RESEARCH INVESTMENTS ON AGRICULTURAL PRODUCTIVITY

▲ Conventional recommendations of agricultural research intensity levels, such as the 1 percent target set by the United Nations, assume that national investments should be proportional to the size of the agricultural sector. In reality, a country's capacity to invest in agricultural research depends on a range of variables, including the size of the economy, a country's income level, the level of diversification of agricultural production, and the availability of relevant technology spillovers from other countries. In efforts to address these nuances, ASTI developed a multi-factor indicator of research intensity that comprises a range of weighted criteria (for further details, see Nin-Pratt 2016). Under this approach, countries with the same mix of inputs are expected to require similar minimum levels of research investment, and investment below that level can be interpreted as an indicator that the country is potentially underinvesting.

ASTI's weighted indicator of research intensity demonstrates that Indonesia is underinvesting in agricultural research. Based on the structural characteristics of its economy and agricultural sector, Indonesia's attainable agricultural R&D investment target is estimated to be 0.60 percent of AgGDP—more than three times higher than the country's actual 2017 investment ratio of 0.17 percent. To have met this 0.60 percent target in 2017, Indonesia would need to have invested 8,474 billion rupiah instead of the 2,848 billion rupiah it actually invested (both in current prices). In other words, the gap between the country's actual agricultural research investment and its estimated attainable agricultural research investment was 5,626 billion rupiah in 2017 alone. This raises the questions as to what Indonesia's present-day agricultural productivity could have been had all these accumulated investments been made in the past, and what future productivity could be were investments raised to attainable levels.

To answer these questions, ASTI ran long-term projections of the impact of historical agricultural research investment on the country's agricultural output and productivity (Scenario 1), and of the higher investment rates needed to close the gap (Scenario 2). Projections indicate that Indonesia would need to increase its agricultural R&D investment by 8.1 percent per year to close the investment gap by 2030, which is ambitious but not impossible. Beyond 2030, growth could contract to 3.5 percent per year, and remain constant thereafter. This would translate to overall growth of around 5.4 percent per year for the entire 2016–2050 period. Under this investment scenario, TFP is projected to increase by more than 50 percent between 2016 and 2050, compared to just 28 percent if the country continues to invest at historical rates. Given the inherent time lag in the impact of R&D investment on productivity, the historically low (and declining) rates of Indonesia's R&D investment during the 2000s and 2010s will have a sustained negative impact on future TFP growth. Nevertheless, by raising agricultural R&D investment to levels that close the abovementioned investment gap, Indonesia could boost its agricultural productivity growth to 1.2 percent per year during 2016–2050 (instead of just 0.7 percent per year if it continues to invest at historical rates).

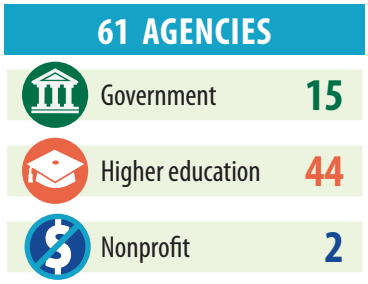
Since both the quantity and the quality of agricultural R&D investment is relevant, ASTI also conducted a detailed analysis of the impact of raising investment to the estimated attainable levels and prioritizing the allocation of funding to research on high-value commodities. Under this third scenario, productivity is projected to nearly triple by 2050 for fruit and vegetables, to double for oil crops and rice, and to increase by as much as 40 percent for livestock and fisheries. For all of this to happen, an average yearly rate of R&D investment growth of 15 percent is needed for livestock, fruit and vegetables, and oil crops during 2016–2030, and 6 percent per year for all other commodities. So while total R&D investment remains the same under Scenarios 2 and 3, the projected productivity response is considerably higher under Scenario 3. These results illustrate the need for Indonesia to increase its agricultural research investment and target high-value commodities to increase the sector's profitability and global competitiveness.

THE INDONESIAN EXTENSION SYSTEM

▶ IAARD's national research centers and institutes undertake crop, livestock, soil, socioeconomics, and postharvest research. Subsequently, 33 assessment institutes for agricultural technologies—which are managed by ICATAD and are located in the provinces—test the new varieties and technologies on farmers' fields. About one-third of the assessment institutes' employees are researchers who work closely with extension staff to adapt the new technologies. Each assessment center also runs programs focusing on the needs of the province in which it is located. This system has significantly strengthened linkages between researchers and local-level extension agents.

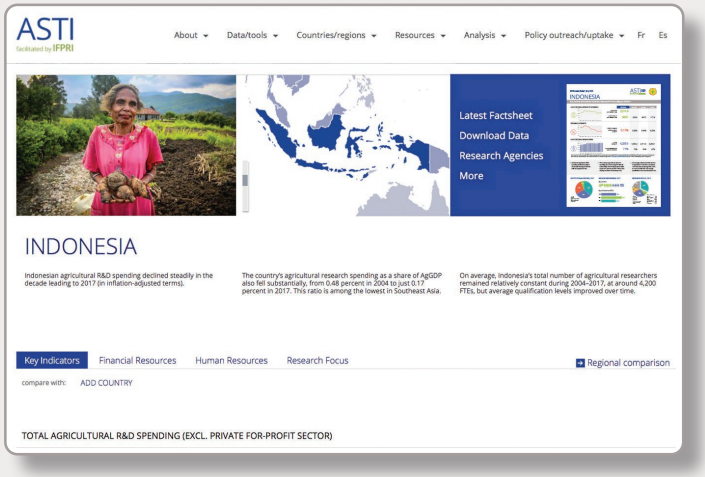
OVERVIEW OF INDONESIA'S AGRICULTURAL RESEARCH AGENCIES

Sixty-one agencies conduct agricultural research in Indonesia (excluding the private for-profit sector). Two-thirds of the country's researchers are employed at 15 government research agencies. IAARD is the research arm of the Ministry of Agriculture. The agency is responsible for formulating and implementing R&D on priority commodities and cross-commodity issues, and for disseminating agricultural innovations. IAARD supervises 10 centers that conduct research on food crops, horticulture, estate crops, livestock, land resources, socioeconomics, machinery development, postharvest issues, biotechnology, and agricultural technology assessment. Through ICATAD, IAARD also manages 33 assessment institutes for agricultural technology. Five other government agencies (separate from IAARD) also conduct agricultural R&D in Indonesia. The largest of these are FORDA (1,132 FTEs), the Indonesian Science and Technology Agency's Research Center for Biotechnology (111 FTEs), and AMFR (29 FTEs), which focus on forestry, agricultural biotechnology, and fisheries research, respectively. Bogor Agricultural University is Indonesia's main agricultural university. In 2017, it employed 315 FTE researchers focusing on R&D related to crops, livestock, forestry, fisheries, and agricultural engineering. Other important universities include Udayana University (128 FTEs) and the University of Hasanuddin (94 FTEs). The remaining higher education agencies are dispersed across the archipelago and each employed between 4 and 50 FTEs in 2017. IRIEC (244 FTEs) is a nonprofit agency that conducts research on estate crops (mostly oil palm and rubber) and manages five commodity research centers and a biotechnology unit. Analysis of private-sector entities is excluded from the country brief due to lack of available data.



For a complete list of the agencies included in ASTI's dataset for Indonesia, visit **www.asti.cgiar.org/indonesia**.

For more information on ASTI's **data procedures and methodology**, *visit* **www.asti.cgiar.org/methodology**; *for more information on agricultural R&D in Indonesia, visit* **www.asti.cgiar.org/indonesia**.



ACRONYM LIST

ACIAR	Australian Centre for International Agricultural Research
AgGDP	agricultural gross domestic product
AMFR	Agency for Marine and Fisheries Research
FORDA	Forestry Research and Development Agency
FTE(s)	full-time equivalent(s)
IAARD	Indonesian Agency for Agricultural Research and Development
ICABGRRD	Indonesian Center for Agricultural Biotechnology and Genetic Resource Research and Development
ICAERD	Indonesian Center for Agricultural Engineering Research and Development
ICALRRD	Indonesian Center for Agricultural Land Resources Research and Development
ICAPHRD	Indonesian Center for Agricultural Post Harvest Research and Development
ICASEPS	Indonesian Center for Agriculture Socio Economic and Policy Studies
ICASRD	Indonesian Center for Animal Science Research and Development
ICATAD	Indonesian Center for Agricultural Technology Assessment and Development
ICECRD	Indonesian Center for Estate Crops Research and Development
ICFCRD	Indonesian Center for Food Crops Research and Development
ICHRD	Indonesian Center for Horticulture Research and Development
IRIEC	Indonesian Research Agency for Estate Crops
LPTP	Institute for Rural Technology Development
PPP(s)	purchasing power parity (exchange rates)
R&D	research and experimental development
SMARTD	Sustainable Management of Agricultural Research and Technology Dissemination
TFP	total factor productivity

ABOUT ASTI, IFPRI, APAARI, AND IAARD

Working through collaborative alliances with numerous national and regional R&D agencies and international institutions, **ASTI** is a comprehensive and trusted source of information on agricultural R&D systems across the developing world. In the Indo–Pacific region, ASTI is facilitated by the **International Food Policy Research Institute (IFPRI)** and the **Asia-Pacific Association of Agricultural Research Institutions (APAARI)**. The **Indonesian Agency for Agricultural Research and Development (IAARD)**, under the Ministry of Agriculture, formulates and oversees the research activities of 10 agricultural research centers.

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