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2 Acronyms

ACIAR	Australian Centre for International Agricultural Research
ADB	Asian Development Bank
AgGDP	agricultural gross domestic product
APAARI	Asia-Pacific Association of Agricultural Research Institutions
API	Application Programming Interface
ASEAN	Association of Southeast Asian Nations
ASTI	Agricultural Science and Technology Indicators
BAU	business as usual
BMGF	Bill and Melinda Gates Foundation
CARDI	Cambodian Agricultural Research and Development Institute
CGE	computable general equilibrium
CGIAR	Consultative Group on International Agricultural Research
DMP	Data Management Portal
DOST	Department of Science and Technology (Philippines)
FAO-RAP	Food and Agriculture Organization of the United Nations – Regional Office for Asia and the Pacific
FTE	full-time equivalent
GDP	gross domestic product
ICASEPS	Indonesian Center for Agriculture Socio Economic and Policy Studies
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IMPACT	International Model for Policy Analysis of Agricultural Commodities and Trade
IPSARD	Institute of Policy and Strategy for Agriculture and Rural Development
M&E	monitoring and evaluation
MAF	Ministry of Agriculture and Forestry (Laos)
MOALI	Ministry of Agriculture, Livestock, and Irrigation (Myanmar)
NAFRI	National Agriculture and Forestry Research Institute (Laos)
NARI	national agricultural research institute
NARI	National Agricultural Research Institute (Papua New Guinea)
NARS	national agricultural research system
NGO	nongovernmental organization
PCAARRD	Philippine Council for Agriculture, Aquatic, and Natural Resources Research and Development
PNG	Papua New Guinea

R&D	research and development
RST	Research, Science, and Technoogy (Papua New Guinea)
SEARCA	Southeast Asian Regional Center for Graduate Study and Research in Agriculture
SERD	Socio-Economic Research Division (Philippines)
SRF	Strategic Results Framework (Papua New Guinea)
TFP	total factor productivity
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific

3 Executive summary

Quantitative data are essential to improving the understanding on the crucial role of agricultural research in enhancing agricultural productivity and reducing poverty, particularly in a context of climate change and population growth. Policymakers, research managers, donor organizations, and other stakeholders need reliable and up-to-date quantitative data to analyse research investment and capacity trends, identify key gaps and neglected areas, set future investment priorities, promote efficient resource use, and ensure effective coordination and coherence of agricultural research initiatives.

The Agricultural Science and Technology Indicators (ASTI) is the leading program globally that compiles, analyses, and publishes agricultural research data relating to institutional developments, investments, human resource capacity, and research outputs in low- and middle-income countries (see http://www.asti.cgiar.org). In order to make its outputs more responsive to stakeholder needs and enhance the use and policy relevance of the program at the country and regional level, ASTI has embarked on a new strategic direction that is founded on a more demand-driven, decentralized, and partnership-based approach to sourcing data, conducting analyses, strengthening capacity, and ensuring outreach. The main objective of this new approach is to arm national and regional stakeholders with the tools they need to undertake key analyses and to communicate those results in efforts to improve outcomes in their countries.

As part of this devolution of ownership and implementation, and thanks to generous support from the Australian Centre for International Agricultural Research (ACIAR), ASTI entered into a strategic partnership with the Asia-Pacific Association of Agricultural Research Institutions (APAARI), which—as a multistakeholder partnership agency and its consequent links with the national agricultural research institutes (NARIs) in Southeast Asia and the Pacific—proved to be a very suitable organization to manage the day-to-day operation of the program. Under this partnership model, IFPRI trained APAARI secretariat staff and country focal points on ASTI's methodology, and data collection and analysis procedures. A dedicated APAARI-based project coordinator and research assistant oversaw in-country data collection. The findings were published in a series of country briefs, a regional synthesis report, and a number of analytical studies. All datasets were made available on the ASTI and APAARI websites through various interactive tools.

The data revealed that Southeast Asia made considerable progress in building and strengthening its agricultural research and development (R&D) capacity during 2000–2017. All of the region's countries reported higher numbers of agricultural researchers, improvements in their average qualification levels, and higher shares of women participating in agricultural R&D over this period. In contrast, regional agricultural research spending remained stagnant, despite considerable growth in agricultural output over time. The region will need to increase its agricultural research investment substantially in order to address future agricultural production challenges more effectively and ensure productivity growth.

Through continuous engagement with heads of the NARIs and through establishing linkages with relevant regional platforms, APAARI played a critical role in disseminating ASTI policy recommendations, in enhancing the uptake of ASTI evidence and policy recommendations, and in ensuring the long-term institutionalization of the project. IFPRI provided technical backstopping, developed publications and online tools, and trained APAARI staff and country focal points. IFPRI also took the lead in a number of analytical studies focused on the efficiency of national agricultural research systems (NARSs) and the long-term productivity impact of agricultural research, and transferring the analytical concepts and methods to capable in-country analysts.

4 Background

Over the past three decades, strong economic growth, rising agricultural productivity and output, and the structural transformation of the agricultural sector have driven considerable advances in food security in Southeast Asia and enabled the region to become a net exporter of agricultural commodities. Notwithstanding these extraordinary economic transformations, a large share of the region's population, whose income levels are just above the poverty line, remain vulnerable to unforeseen income and price shocks; natural disasters; and public health shocks, such as the current COVID-19 pandemic. Despite the gradually diminishing contribution of agriculture to gross domestic product (GDP) and employment, the sector will continue to play a crucial role in driving future economic growth, poverty alleviation, and food security across Southeast Asia in the coming decades. The ongoing process of economic growth and structural transformation requires major sustained investments in the agricultural sector because the long-term success of economywide poverty reduction and sustainable improvements in food security depend on a growing economy that successfully integrates labor and capital markets in rural and urban areas, and stimulates higher productivity in both (Timmer 2015).

Over the past decades, agricultural output has grown more rapidly in Southeast Asia than in other developing regions around the world (USDA-ERS 2019). A significant share of this past agricultural production growth, however, was driven by the expansion of cultivated land area and the exploitation of the natural resource base (with accompanying environmental degradation). With the main drivers of historical growth in agricultural production virtually exhausted, future agricultural growth in the region will be highly dependent on technical change to enable yield increases, more efficient use of scarce resources, and a reduction in crop losses. Investments in agricultural research and development (R&D) are critical in this regard. They are a key driver of agricultural productivity growth over time, and will ensure that farmers have access to a steady supply of innovations that meet their needs.

Despite the importance of agricultural R&D to sustained agricultural productivity growth, many Southeast Asian countries continue to underinvest. This underinvestment in agricultural research constrains sustainable future growth and, in turn, countries' capacity to tackle the complex issues of food insecurity, poverty, climate change, land and water resource degradation, and shifting dietary patterns. Given the substantial time lag between investing in research and reaping its rewards—which is typically decades, not just years—agricultural research requires a long-term commitment of sustained funding (Dias Avila and Evenson 2010; Fuglie, Wang, and Ball 2012; Alston et al. 2009). Public spending on agricultural research is a sensible investment that has been shown to outperform other public agricultural expenditures, including irrigation and fertilizer subsidies, in terms of raising agricultural productivity (Diaz-Bonilla, Orden, and Kwieciński 2014).

Quantitative data are essential to improving the understanding on the crucial role of agricultural research in enhancing agricultural productivity. Policymakers, research managers, donor organizations, and other stakeholders need reliable and up-to-date quantitative data to analyse research investment and capacity trends, identify key gaps and neglected areas, set future investment priorities, promote efficient resource use, and ensure effective coordination and coherence of agricultural research initiatives.

ASTI is the leading program globally that compiles, analyses, and publishes agricultural research data relating to institutional developments, investments, and human resource capacity in low- and middle-income countries. The program is placed under the International Food Policy Research Institute (IFPRI) and functions through collaborative alliances with national R&D agencies, regional coordinating bodies, and international institutions. ASTI is widely recognized as the authoritative source of information on the status and direction of agricultural R&D systems in developing countries. A large number of international organizations, as well as national-level decision makers around the world,

have been using ASTI data and analyses to assess agricultural research in developing countries, and to influence policy for increased agricultural growth and productivity.

At the time of the start of the project, ASTI datasets were up-to-date for most developing regions around the world, including Africa, the Middle East, South Asia, and Latin America and the Caribbean. Funding constraints, however, had prevented ASTI from maintaining datasets with the same level of quality and detail for Southeast Asia and the Pacific. The most recent year for which ASTI data were available for Southeast Asia and Papua New Guinea (PNG) was 2003, so there was a pressing demand from international, regional, and national-level stakeholders for updated information to inform their decision making and priority setting.

Getting a more accurate picture of the present situation and the future prospects of research investment and capacity was particularly important for Southeast Asia because four decades of fast income growth and urbanization had changed the role of the food and agricultural sectors in these societies. The region is now richer, more urban, better connected both within each country and across borders, and much better fed than half a century ago. These changes also raise the question whether it is necessary to shift research investment priorities from agricultural self-sufficiency goals based on staple commodities to a more diversified portfolio that could contribute more effectively to sustain growth and reduce food insecurity and poverty. At the same time, climate change also has a major impact on agriculture throughout the region, affecting future research priorities.

At the onset of ACIAR-funded ASTI activities in Southeast Asia and PNG, there was limited quantitative information available to policymakers, research managers, donors, and other stakeholders on the status and direction of public and private agricultural research investment and capacity, the impact of past research investment (and other types of agricultural investment) on the recent performance of agriculture in the region, or to make informed decisions on future investment priorities. ASTI produced a series of outputs that reduced this pressing knowledge and information gap. These outputs will play an important role in guiding future agricultural R&D investment decisions, including ACIAR’s.

5 Objectives

The aim of the project was to reduce the knowledge and information gap on the inputs, performance, and outcomes of agricultural research systems in Southeast Asia and PNG, and to build regional/national capacity to institutionalize this work on the long run. The work was focused around three main activities: **1) Data Collection, 2) Analysis,** and **3) Outreach**. Capacity strengthening was a key element cutting across these three activities.

Activity 1: Data collection

Collect detailed information from a complete set of agricultural R&D agencies operating in Southeast Asia and the Pacific, and facilitate stakeholder access to this data through a variety of online tools as well as a series of country and regional publications.

Activity 2: Analysis

Develop a joint IFPRI/APAARI/country research agenda (including new indicators, tools, and methods) that will enhance the understanding and political recognition of agricultural research as a major driver of agricultural productivity growth, economic development, and enhanced food security.

Activity 3: Outreach

Disseminate key findings through a set of demand-driven outputs, and engage with key national and regional initiatives and frameworks to enhance the use and policy relevance of ASTI and explore ways to embed ASTI evidence in policy processes.

Overarching: Capacity Strengthening

Devolve the day-to-day management of ASTI in the Asia–Pacific region from IFPRI to APAARI and lay the foundation for the long-term institutionalization of data collection and analysis at the country level.

6 Methodology

1. Data Collection

APAARI set up long-term collaborative alliances with NARIs in the participating countries. Heads of these institutes designated knowledgeable people (focal points) to oversee in-country data collection. Each of these country focal points were familiarized with ASTI procedures, definitions, methodology, and data collection approaches during a 3-day inception workshop in Bangkok.

After the inception workshop, each focal point prepared a complete list of government, higher education, non-profit, and private for-profit agencies involved in agricultural R&D in their respective country. The agency lists needed to include all R&D institutions involved in crop, livestock, forestry, fisheries, natural resources, and socioeconomic research. Only research performers were included. Agencies funding research, without conducting any in-house research themselves, were excluded.

ASTI prepared three different survey forms to reflect institutional differences: One for government and non-profit agencies, one for higher education agencies, and one for private companies. Where needed, these survey forms were translated into local languages.

The surveys collected (quantitative) data in the following areas:

- Institutional details (agency address, ministerial affiliation, website, etc.)
- 2013–2017 research spending data broken down by cost category (salaries, operating costs, capital investments)
- 2013–2017 research funding data broken down by source (government, donors, producer organizations, internally generated resources, other)
- 2013–2017 research staff data broken down by degree (PhD, MSc, BSc)
- 2017 research staff data broken down by gender, age bracket, and discipline
- 2013–2017 support staff data broken down by type (technicians, admin, other)
- 2017 support staff data broken down by gender
- 2017 research staff data broken down by commodity area and thematic area
- 2013–2017 data on new varieties released
- 2013–2017 data on peer-reviewed publications (national journals, regional journals, international journals, books, book chapters)
- 2013–2017 student numbers enrolled in agricultural faculties
- 2013–2017 student numbers graduated from agricultural faculties

Countries were given the opportunity to review the survey forms before dissemination, and to provide comments on the wording to make sure that all questions would be clearly understood by local respondents. Countries were also encouraged to consult with a wide variety of in-country stakeholders to assess what (if any) supplementary data they would like to see collected in addition to the core set of ASTI indicators. This would make the information that is being collected more relevant to the needs of the country and of the participating agencies. ASTI surveys allowed for this flexibility, as long as the core set of indicators listed above was not compromised. Malaysia was the only country to propose additional questions. They saw this ASTI survey round as an important opportunity to collect detailed additional time-series data on intellectual property and protection, and on the types of collaborative research activities Malaysian research agencies engage in.

The final survey forms were uploaded to ASTI's online Data Management Portal (DMP) and each agricultural research agency in Southeast Asia and the Pacific was given a unique agency ID tied to the appropriate survey form. The country focal points were given access to the DMP, so that they could download the various survey forms for their respective country and distribute them to the responding institutions.

IFPRI/APAARI left it to the countries themselves to decide how they felt data collection could best be implemented. Most countries kicked off the work through formal letters from NARS leaders (or agricultural ministers) to all the directors/deans of responding institutions. Some countries decided to use the project budget to organize in-country workshops to which they invited all R&D agencies (across ministerial boundaries) to explain the scope and objectives of the project and to familiarize stakeholders with data collection methodology, analysis, and a plan for outreach. ASTI assisted these countries in the organization of such workshops through the provision of training and other materials.

Data collection activities took roughly 6–12 months in most countries. Data collection was a lot more straightforward in countries with just a handful of agricultural R&D agencies, such as Laos or Papua New Guinea, than in countries with very large national agricultural research systems (like the Philippines or Indonesia). Focal points uploaded all completed survey forms to the DMP. The ASTI team checked the data quality and followed up on important inconsistencies and/or omissions. In many cases, this required quite some back and forth between the APAARI project manager and the country focal points. The ASTI team also carefully merged the new datasets with ASTI's existing data series for Southeast Asia and PNG (where available). Overall, data quality was believed to be very high, as there weren't many major discrepancies and/or inconsistencies in the long-term spending or capacity trends for most key agencies. In case the newly collected data was considerably higher or considerably lower than the historical data trends, the ASTI team followed up with the country focal points to obtain an explanation or a revision of the data submission. Overall agency coverage was very high. Of the 350 agencies in Southeast Asia and the Pacific identified at the onset of the survey, completed survey forms with high quality data were received for about 85%. The missing agencies were mostly very small faculties or non-governmental organizations (NGOs) without a very clear agricultural R&D mandate. A decision was made on a case-by-case basis to either remove these agencies from the sample, or to estimate data for these agency based on an external data source (website, annual report) or by extrapolating older ASTI data for this particular agency to a more recent year.

The final country datasets were shared with country focal points and NARS leaders for validation before being uploaded to the ASTI website. The ASTI website only provides country-level data (with just a handful of agency-specific indicators through the online country agency directories).

In addition to quantitative data, qualitative information was gathered through supplementary surveys and face-to-face meetings with specific agencies. This provided a more complete picture of national agricultural research systems than can be attained through quantitative data alone. The qualitative information focused primarily on the policy and institutional environment in which national agricultural R&D takes place. This qualitative information was an important input into the country briefs.

2. Analysis

To identify relevant (and demand-driven) research questions based on ASTI data, a special workshop was organized by APAARI and IFPRI in Bogor in July 2018. A group of analysts and researchers from Indonesia, the Philippines, Sri Lanka, and Vietnam, were invited to present their views on what the most important agricultural policy research questions are for the coming decades and how ASTI evidence can help answer these questions. The workshop was the first step toward the implementation of an analytical research agenda focused on agricultural research investments, capacities, and policy developments in the Indo-Pacific region. During this workshop, the participants indicated they would like to see more in-depth analysis conducted around themes related to:

1) Efficiency of agricultural R&D systems
2) Technical change and productivity growth.

Following the Bogor workshop, IFPRI developed a research action plan. The analysis was going to be conducted at two different levels: a) Regional; b) Selected countries, with different approaches and involvement of regional partners.

Apart from contributing to the analytical agenda of the project, the country studies were developed to strengthen the analytical capacity of research groups in participating countries. Qualified researchers from partner countries were the principal investigators of the country analytical studies, but they received very close support and supervision from IFPRI. The proposed deliverables included a) reports on the strengths, weaknesses, and performance of national research systems in selected countries, and b) forward-looking R&D priority setting and implications for investment at the national and regional levels.

Four countries were selected based on the analytical capacity of the research institutions to which they belong, the qualification of the researchers participating in the project, and the interest shown by institutions and individual researchers to be part of these studies. Originally, the four selected countries were Indonesia, Malaysia, the Philippines, and Vietnam. Because of severe delays in regular ASTI data collection in the Philippines, this country was later replaced by Myanmar. Each country assigned a researcher to conduct the analysis working with a group of researchers in his/her institution. IFPRI provided technical support for the analysis and familiarized the research groups with the latest tools and frameworks for analysis. On average, four to five researchers from each country were involved in the studies. The IFPRI coordinator of the analytical component of the project made two trips to the region, each time visiting all four countries to discuss the contents of the study, to follow up on progress, and to gauge what additional support they needed for the analysis. In addition, frequent contact through virtual meetings and email was kept between the IFPRI analytical coordinator and the country researchers.

2.1 Research Theme 1: Efficiency of Agricultural Research Systems

This research theme made intensive use of ASTI human resource and investment data, complemented with secondary data from national sources and FAOSTAT. Analytical comparisons of countries' research systems were conducted using a set of indicators specifically developed for the purpose of this study to determine areas of strengths and weaknesses of NARS.

A system of indicators for the analysis of R&D investment

The method used for the analysis adapted a model of R&D activity, where inputs are used to produce research outputs. Inputs include human capital (researchers); physical capital (equipment, labs, buildings, etc.); organization, and the sources of financing. The production process of a research body transforms input into output through research projects, training courses, and technical services. The outputs of the research system include new products and processes associated with the publication of books and reports, project results, software innovations, and patents, among others. This research process

takes place under an internal organization and institutional governance that directly impact staff motivation and access to resources. The external environment and structural characteristics of the economy are also important factors affecting the efficiency of a research system.

The analysis of the efficiency of transforming research input into research output requires the use of different indicators that measure the quantity, quality, and mix of inputs together with a measure of output quality and quantity. A hierarchical system of indicators was developed for the purpose of this project that allows identification of strengths and weaknesses in the production of research outputs at different levels of the process.

Indicator of overall performance:

i. *Cost per quality-adjusted published article*

The cost per unit of output is a relevant economic indicator to evaluate the performance of a production process as it compares the output to inputs used in its production. Its value depends on productivity, quantity, and quality of inputs and the cost incurred in using those inputs. Based on the limited availability of output data for cross-country comparisons, we used 1) the number of articles published in agricultural sciences (adjusted by quality) as the most reliable output to compare across countries to evaluate the research process (SCIMAGO 2020), and 2) R&D spending data from ASTI (2020) to measure of the cost of the research system. This indicator of overall results is then decomposed into different sub-indices that allow us to identify areas of performance that explain differences in costs per unit of output between countries.

Cost per unit of research output can be decomposed into:

ii. *Cost per researcher*
iii. *Output per researcher*

The cost per researcher is defined as the ratio of total costs of the number of researchers in the system measured in FTEs, while productivity of researchers is measured as the ratio of quality-adjusted scientific publications (AH) and the number of researchers. These two indicators depend on the combination of human resources and capital used by the research system. High costs per researcher could result, for example, from high fixed costs of underutilized equipment and infrastructure (a small number of researchers for the available infrastructure). The degree composition of researchers could also affect research costs given that higher salaries are required to increase the quality of human capital. But the quality of human resources is one of the drivers of productivity, so there is a trade-off between cost per researcher and productivity. The mix of inputs reflected in the cost structure of the system could also affect productivity if, for example, there is not enough operational capital available for researchers to dispose of resources to work at full capacity. The following indicators were defined to describe the mix of inputs used:

iv. *Share of salaries in total costs*
v. *Share of capital costs in total costs*

Quality of human resources:

vi. *Share of PhDs + MSc in total FTEs*
vii. *Ratio of PhD/MSc*

The cost structure and the composition of human resources are in part determined by how much the country invests in R&D (investment intensity), which depends directly on available sources of funding and political decisions and priorities. Limited and volatile funding constrains investment, and this translates in a lack of resources for research systems, which in turn could constrain the quality of human resources or access to the capital required to perform investment effectively.

Investment intensity and funding:

viii. *Investment gap = Actual R&D investment / Potential investment*

ix. *The growth rate of R&D investment 2008–2017*

Constraints and commitment to funding R&D investment are measured by three indicators:

x. *Share of government funding + levies and sales in total funding*

xi. *Ratio of funding from donors and government funding + Levies & sales*

xii. *Funding volatility = standard deviation of the growth rate of investment*

The first indicator is a measure of the financial autonomy of the system and its capacity to access funding. The second indicator is in general associated with severe funding constraints (mostly in poor countries) and the dependence of the system on donors. The volatility of an investment is associated with funding constraints and the impossibility of the system to secure funding to plan and develop quality research in the medium and long run.

Finally, environmental or exogenous factors affect the efficiency of the process while the level of R&D investment affects the quantity and quality of research output and these factors are also considered in the analysis. For example, a small country like Laos would be unlikely to develop a research system the size of Thailand because of the structural differences between both countries. Thailand, Indonesia, and Malaysia rank highly for agricultural research in the region, based on the size of their investment and their output. Vietnam and the Philippines appear at a second level, with Cambodia and Laos on the third tier, characterized by lower levels of investment and research output. Myanmar has the smallest and least developed research system in the region. Keeping in mind it is important to consider a variety of differences between countries to make meaningful comparisons and derive valid conclusions from the system of indicators in the analysis.

2.2 Research Theme 2: Technical Change and Productivity Growth

This theme focused on the long-term impact of agricultural research investment on agricultural productivity growth at the country and regional levels, by determining research investments needed at present to achieve medium- to long-term agricultural productivity, food security, and poverty reduction goals in the coming decades. With this goal in mind, a methodology for the analysis of forward-looking R&D investment decisions, based on a theoretically sound conceptual framework, was adapted for the needs of this project. Two major conceptual areas contribute to this methodology. The first area relates R&D investment to knowledge generation and accumulation and its transformation into agricultural productivity growth. The second conceptual area is the basis for the measure and analysis of productivity growth and its links with R&D investment. In what follows we summarize the main aspects of the methodology used.

R&D investment and knowledge stocks

The underlying assumption behind R&D investment and productivity is that a string of R&D investments creates a stock of knowledge that yields returns into the future. For example, we can build the knowledge stock for agricultural production in a country as the sum of all agricultural R&D investment in the past; however, the knowledge generated by this investment does not last indefinitely. Some of this knowledge becomes obsolete or decays as it is replaced by new knowledge or it becomes of no value as demands for new technologies change with time. We can think of R&D as an investment that builds knowledge capital, and knowledge decay as equivalent to capital depreciation. A dollar invested in research in a particular year does not influence productivity in that same year.

It takes time for this investment to generate returns and when it does, it keeps generating benefits for several years. This is what is known as the lagged effect of R&D investment.

To calculate this knowledge stock, we need to determine how fast R&D investment enters and exits the stock of knowledge, and how the stock depreciates. We adopted the widely used perpetual inventory method (PIM) to build the R&D knowledge stock in analogy with physical capital. The model requires little information: an initial value of the stock, the series of gross R&D investment, and three key parameters: a depreciation or decay rate of the stock (δ), a stochastic gestation lag period (*G*), and a parameter (*β)* that defines the shape of the gestation period.[1] Using these parameters, it takes a simple calculation to obtain the knowledge stock (*KS*) for each country: $KS_t = KS_{t-1}(1-\delta)+R_{t-g}$, where *t* is the current period, δ is the decay rate or "depreciation", *G* the gestation period. In other words, the knowledge stock in period t is equal to the knowledge stock in the previous period (t-1) less the depreciation of the stock (1- δ) and plus the R&D investment from period t-G (R_{t-G}), which means that there is a period (G) during which the investment matures until it can contribute new knowledge to the knowledge stock. If G=0, then investment in t incorporates immediately to the stock, no gestation period. The larger G, the longer it takes to investment to contribute to knowledge.

The second piece of the conceptual framework used for this analysis relates changes in knowledge stocks to changes in Total Factor Productivity (TFP) assuming that in the long run, productivity growth is driven by new knowledge applied to agricultural production, mostly generated by scientific research from country's own investment and from knowledge generated in other countries (knowledge spillovers). In its most simple version, the model explains percentage changes in TFP (%TFP) based on percentage changes in knowledge stocks (%KS)*: %TFP*= α×*%KS*, where α is a coefficient (the R&D elasticity) that translates changes in knowledge stocks into changes in TFP, specific for different countries and/or regions. This relationship between TFP and KS represents the benefits and costs of R&D investment, where the benefits are given by changes in TFP and costs result from R&D expenditure in previous periods that contribute to changes the knowledge stock. Conceptually, the change in SK (%SK) represents a change in the capacity of a country to produce "new ideas", new knowledge that can be applied to the production process, while the impact of "new ideas" on productivity is given by the parameter α.

For this study, knowledge stocks by crop and livestock activity were calculated using ASTI (2020) research focus data available for each country. This is information on the proportion of total time researchers spend in activity-specific programs. As there is no information of TFP at the crop level, TFP growth by crop was calculated by calculating the contribution of the yield (output/land) of each crop to total yield of the agricultural sector. It was then assumed that the contribution of each crop to TFP growth is the same than its contribution to aggregated yield. A similar measure is used for livestock but in this case, yields are calculated as output/animal stock.

Agricultural productivity

TFP was used as the main measure of performance of the agricultural sector. As a productivity measure, TFP accounts for the productivity of all major inputs used in the production process. This study followed O'Donnell (2011) by calculating output, input, and TFP indices with desirable axiomatic properties that, unlike widely used indices like the Törnqvist and Fisher indices, can be used for multi-lateral and multi-temporal comparisons.

Detailed secondary data to calculate TFP was not readily available and building a new dataset for TFP analysis was beyond the scope of this work. Instead, we used available

[1] The method used to derive these parameters is explained in Nin-Pratt and Magalhães (2018).

data from USDA-ERS (2019) and FAO (2020) at the country level to get at least a rough picture of the performance of the agricultural sector in the focus countries in recent years and the contribution of different crop and livestock activities to growth. Inputs and outputs were aggregated into indices of total outputs and inputs using constant prices from a "representative" year within the analyzed period. Inputs included were cropland, animal stock, machinery, fertilizer, feed, and labor.

Other tools and data used

Baseline projections from IFPRI's International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) were used to project growth of consumption at the country level and used to compare projected consumption with projected output that results from TFP growth from different R&D investment portfolios.

Capacity strengthening

The four country case studies were the tool used to develop analytical capacity targeting analysts selected by NARS leaders. The main goal was exposing them to methodologies to analyze the efficiency of research systems and the links between R&D investment and productivity. The approach included close collaboration between local researchers and IFPRI through a series of meetings and workshops where the contents of the study were defined, and short lectures and group discussions were used to introduce new concepts and explain methods and tools used. All the presentations and materials used in the lectures were shared with the researchers for future reference.

7 Achievements against activities and outputs/milestones

Objective 1: To update and expand ASTI database; facilitate stakeholder access to datasets and other outputs

no.	activity	outputs/ milestones	completion date	comments
1.1	Set up long-term collaborative alliances with NARIs in participating countries	- Collaborative agreements signed between APAARI and countries - Focal points assigned to oversee in-country data collection - Funds disbursed to assist data collection efforts	Q1 of 2018	
1.2	Inception workshop	Workshop organised in Dec 2017 and focal points familiarized with ASTI, its procedures, definitions, methodology, and outreach aspects	December 2017	Summary report on inception workshop shared with ACIAR.
1.3	Quantitative and qualitative data collection	Complete agency-level and country-level datasets for Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, PNG, Thailand, and Vietnam	2019	- Total of 383 agencies surveyed. - Detailed data was collected on human resources (including detailed data by degree, gender, age, and discipline), investment, research focus and research output data - Data collection initiated in Fiji, but aborted due to inertia and different data collection approach needed for small island nations
1.4	Prepare country publications	- 8-page country briefs completed for Cambodia, Indonesia, Laos, Malaysia, Myanmar, PNG, Thailand, and Vietnam. - Briefs widely disseminated and posted on www.asti.cgiar.org - Briefs for Cambodia, Indonesia, Laos, and Vietnam were translated into local languages	2019–2020	- We are currently exploring an alternative output for the Philippines. - Agency coverage and data quality in the Philippines didn't allow preparation of a country brief to the same standard as in the other countries.

no.	activity	outputs/ milestones	completion date	comments
1.5	Prepare regional synthesis report	- 88-page report completed and widely disseminated (https://www.asti.cgiar.org/pdf/SoEA-Ag-Regional-Report-2020.pdf)	October 2020	
1.6	Make datasets available	National and agency-level data have been made available on the ASTI website through various interactive tools: - country pages - regional benchmarking tool - data download tool - agency directories	2020	- ASTI is encouraging partners to embed (partial) datasets/tools on third-party websites - Datasets will also be made available on FAOSTAT through an API

PC = partner country, A = Australia

Objective 2: To analyse a) the performance of agricultural research in the region and b) the impact of higher research investment on future productivity growth

no.	activity	outputs/ milestones	completion date	comments
2.1	Consultative process to identify regional and country research priorities based on ASTI data	- Workshop in Bogor attended by key analysts from 4 countries to identify priority research areas - Workshop summary report and analytical strategy (shared with ACIAR)	July 2018	Originally, the four selected countries were Indonesia, Malaysia, Philippines and Vietnam. Because of severe delays in regular ASTI data collection in the Philippines, this country was later replaced by Myanmar.

no.	activity	outputs/ milestones	completion date	comments
2.2	Analysis of strengths and weaknesses of national research systems in Southeast Asia	- Analytical concept and methodology developed by IFPRI - Country partners familiarized with concept and methodology - Country partners applied concept in practice, and took the lead in developing country reports - Analysis incorporated in regional ASTI regional synthesis report (https://www.asti.cgiar.org/pdf/SoEA-Ag-Regional-Report-2020.pdf)	2020 (for Malaysia and Vietnam) Ongoing in Myanmar (late start)	- COVID has delayed the implementation of this work in Myanmar, but the team of analysts is keen to finalize the work (with the help of IFPRI's coordinator) - The remaining study (Indonesia) never took off despite regular meetings with the team of researchers involved and two trips of IFPRI's coordinator to the country.
2.3	Priority setting and resource allocation in agricultural research	- Analytical concept and methodology developed by IFPRI - Country partners familiarized with concept and methodology - Country partners applied concept in practice, and took the lead in developing country reports - Analysis incorporated in regional ASTI regional synthesis report (https://www.asti.cgiar.org/pdf/SoEA-Ag-Regional-Report-2020.pdf)	2020 (for Malaysia and Vietnam) Ongoing in Myanmar (late start)	- COVID has delayed the implementation of this work in Myanmar, but the team of analysts is keen to finalize the work (with the help of IFPRI's coordinator) - The remaining study (Indonesia) never took off despite meetings with the team of researchers involved and two trips of IFPRI's coordinator to the country.

PC = partner country, A = Australia

Objective 3: To strengthen human capacity and institutionalize data collection and analysis.

no.	activity	outputs/ milestones	completion date	comments
3.1	Recruit and train APAARI-based regional coordinator	- Regional coordinator recruited in November 2017 - The APAARI-based ASTI team was strengthened in July 2018 with the recruitment of a research assistant (funded through the BMGF-funded portion of ASTI)	- Recruited at the onset of the project - Training is a continuous process	- Regional coordinator is strong at coordination of data collection and stakeholder engagement, but weaker at data analysis and report writing. As such, she required more support and supervision from IFPRI than originally anticipated.
3.2	Build a network of country focal points	- Focal points were familiarized with ASTI and its procedures, definitions, methodology and outreach aspects at the inception workshop. - Additional capacity strengthening for focal points in Indonesia, Malaysia, Myanmar, Philippines, and Vietnam as part of activities 2.2 and 2.3.	- Continuous interaction between APAARI/IFPRI and country focal points	
3.3	Build a network of in-country institutions that submit data at regular intervals.	- Network successfully established. - Laid the foundations for the long-term monitoring of agricultural R&D resources - Built in-country capacity - Some countries have taken initial steps to institutionalize ASTI data collection long-term	Continuous process	- Multi-nodal networks are being explored in certain countries (more detail provided in **Section 8.2**)

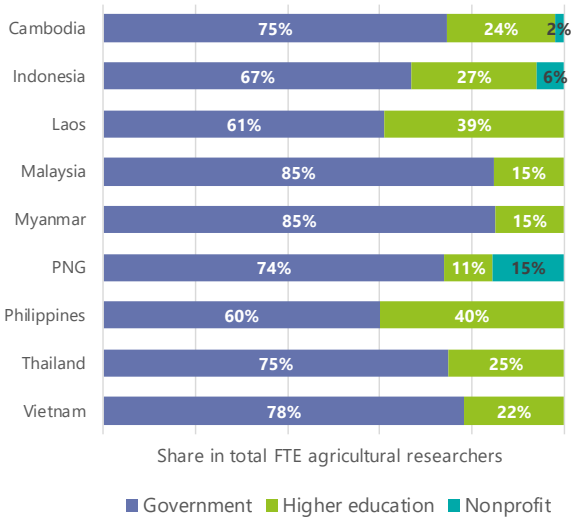
no.	activity	outputs/ milestones	completion date	comments
3.4	Large-scale outreach	- Country briefs and regional synthesis broadly disseminated. - Active outreach on social media, newsletters, and blog posts - Organized various well-attended country outreach events - Organized various well-attended regional outreach events - Presented data findings to APAARI Executive Committee, ACIAR staff, and ACIAR alumni	Q3 and Q4 of 2020 (and beyond)	- Additional outreach activities are scheduled in Q1 of 2021
3.5	Embedding ASTI in broader agricultural policy or M&E frameworks		Ongoing	It is too early at this stage to provide a detailed overview of the uptake of ASTI information in policy processes. However, significant anecdotal evidence is already emerging from a number of countries that ASTI data and publications are feeding into policy and decision-making processes. A number of those impact stories are presented in **Section 8.3**. Over the next few months, IFPRI and APAARI will continue to follow up with the countries to find out how ASTI evidence is informing policy and to what extent the data and publications are taken up by key stakeholders. IFPRI and APAARI will make sure that these success stories are carefully monitored and documented.

PC = partner country, A = Australia

8 Key results and discussion

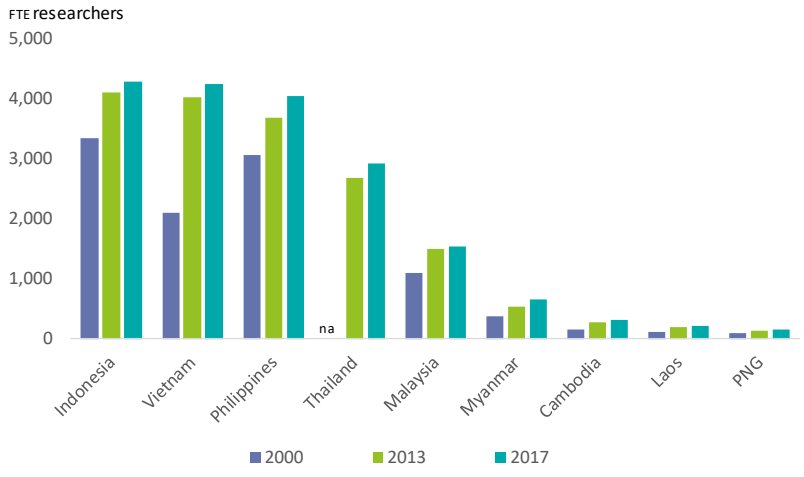
The first-hand data collected as part of this project allowed IFPRI and APAARI to prepare a highly accurate picture of the present situation of agricultural R&D investment, capacity, and outputs across Southeast Asia and PNG, and provide future prospects. Key indicators that were synthesized based on these data collection activities are presented in the pages below. More granular country-level or agency-level is available in the various country publications as well as in the online data tools on the ASTI website.

INSTITUTIONAL COMPOSITION OF AGRICULTURAL RESEARCH



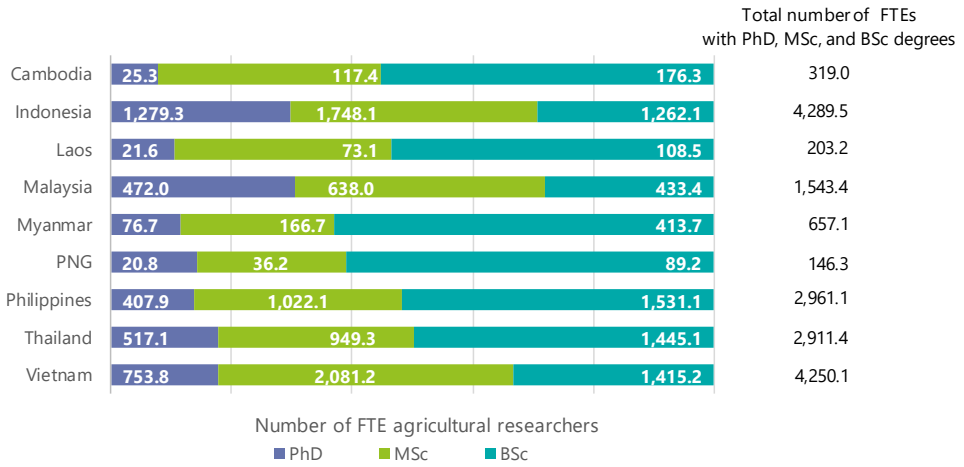
- The bulk of agricultural research in the region is conducted at government research agencies.
- The role of the higher education sector has gradually risen over time in most countries, albeit slowly.
- The emergence of many new universities has in some cases led to an increased fragmentation of agricultural research systems.

HUMAN RESOURCE CAPACITY



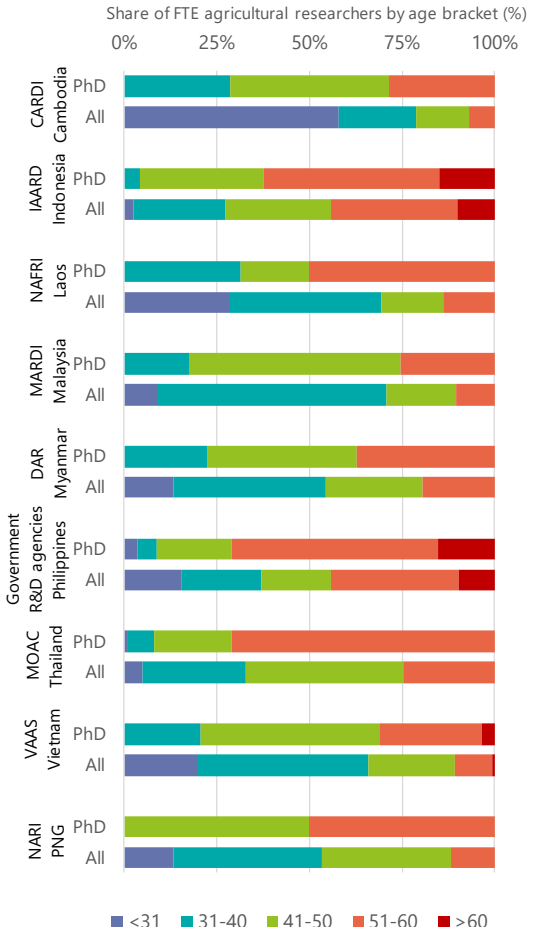
- All countries in the region have steadily expanded their agricultural research capacity over time.
- In Cambodia and Vietnam, researcher numbers more than doubled during 2000–2017, while Laos and Myanmar reported roughly 80 percent growth.
- Growth was slower but substantial nonetheless in Indonesia, Malaysia, PNG, the Philippines, and Thailand.

RESEARCHER QUALIFICATIONS



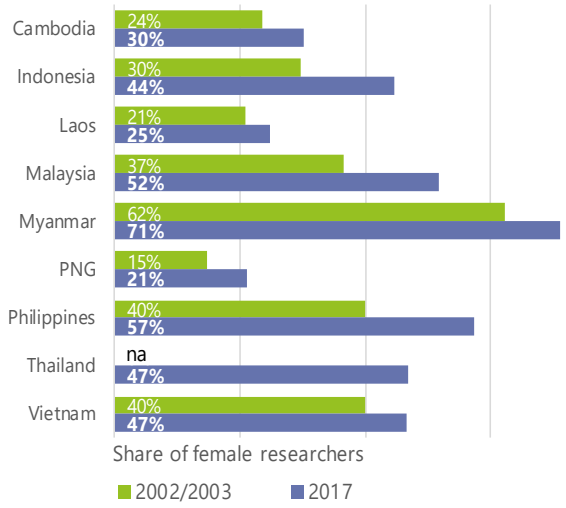
- Overall, average qualification levels of agricultural researchers have improved over time.
- Average qualifications are highest in Malaysia and Indonesia.
- Cambodia, Laos, and PNG lack a critical mass of researchers with PhD degrees.

AGE COMPOSITION OF RESEARCHERS



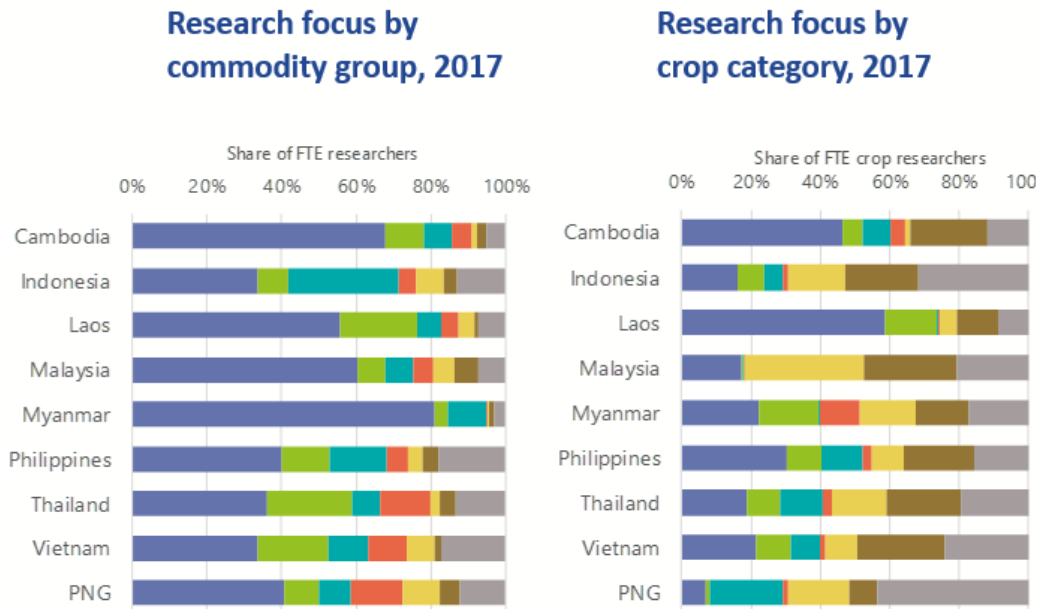
- A very large portion of researchers with PhD degrees in the Philippines, Indonesia, and Thailand are approaching retirement age.
- Research systems in Cambodia, Laos, Myanmar, and Vietnam are staffed by considerably younger researchers.

GENDER DISTRIBUTION OF RESEARCHERS



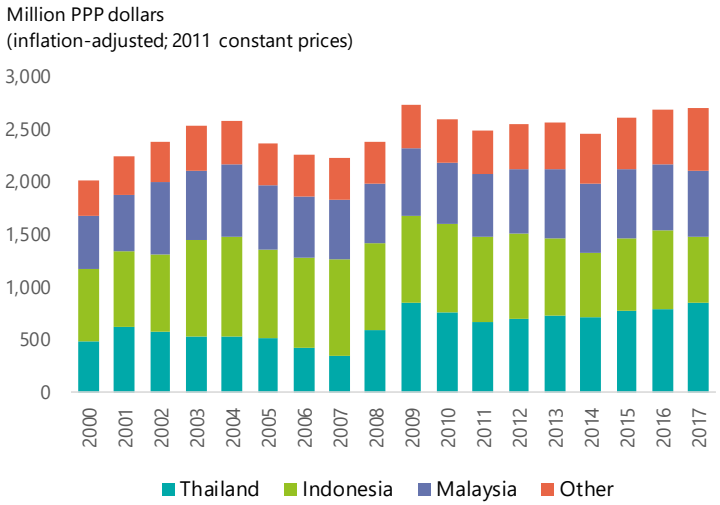
- Female involvement in agricultural R&D is much higher in Southeast Asia than in the rest of the world.
- All countries expanded their pool of female scientists during 2002–2017. Growth was strongest in the Philippines, Indonesia, and Malaysia.
- However, women remain less likely to hold PhD degrees or management positions compared to their male colleagues.

RESEARCH FOCUS



- Research systems in Cambodia, Laos, Malaysia, and Myanmar are heavily focused on crops.
- Systems in Indonesia, PNG, Thailand, and Vietnam are more balanced across commodity groups.
- The research agendas of Cambodia and Laos are rice-centric. Oil palm research is dominant in Malaysia.

AGRICULTURAL RESEARCH SPENDING



- Agricultural research spending rose sharply after the 2007/08 global food crisis, but has remained fairly stagnant since.
- Thailand, Indonesia, and Malaysia account for the bulk of regional agricultural research expenditures

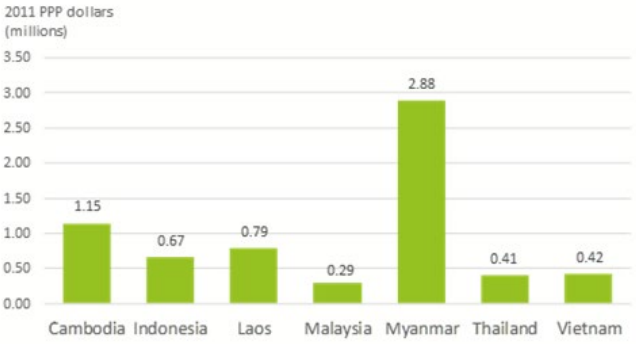
INTENSITY OF RESEARCH SPENDING

	2000	2013	2017
	agricultural R&D spending as a % of AgGDP		
Cambodia	0.19%	0.20%	0.22%
Indonesia	0.39%	0.22%	0.17%
Laos	0.68%	0.28%	0.26%
Malaysia	1.59%	1.04%	0.85%
Myanmar	0.03%	0.03%	0.06%
Philippines	0.35%	0.28%	0.41%
Thailand	0.98%	0.64%	0.94%
Vietnam	0.17%	0.19%	0.20%
PNG	0.37%	0.51%	0.31%

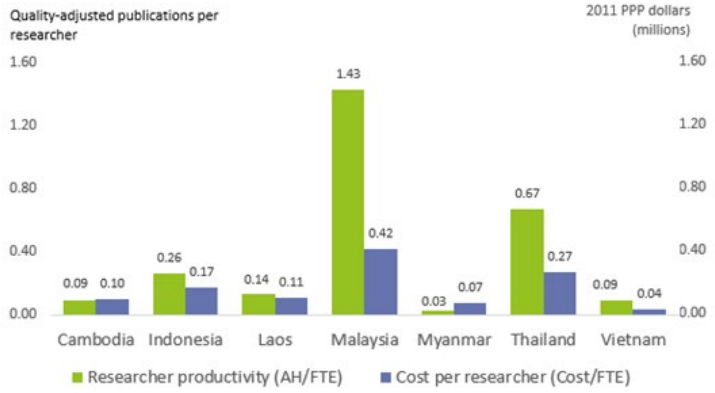
- Overall, Southeast Asia's agricultural research spending as a percentage of agricultural GDP has fallen substantially since 2000.
- Thailand and Malaysia have the region's highest research intensity. Myanmar the lowest.

RESEARCHER PRODUCTIVITY

Research spending per quality-adjusted article



Researcher productivity and cost per researcher compared



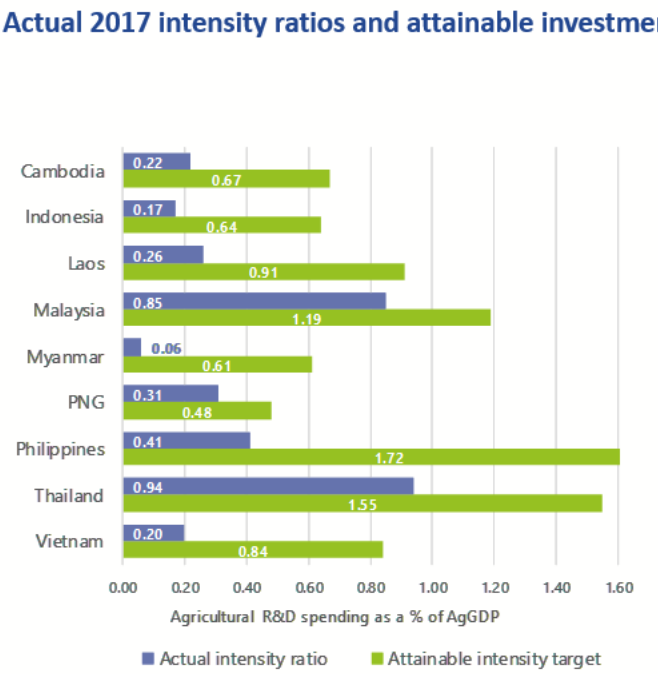
- Malaysia and Thailand are leading countries in agricultural research in the region, based on the size of their scientific output.
- Despite their higher cost per researcher, their cost per unit of output is considerably lower than in countries with less developed research systems.

OVERALL SYSTEM PERFORMANCE

	Cambodia	Indonesia	Laos	Malaysia	Myanmar	Thailand	Vietnam
Cost per unit of output	–	/	-	+++	---	++	+
Cost per researcher	+	-	/	---	++	–	+++
Researcher productivity	-	+	/	+++	---	++	-
Qualification of researchers	---	+++	–	++	–	+	/
Cost structure	–	-	/	++	---	/	+++
Intensity	-	+	/	+++	---	++	--
Funding	-	/	–	++	---	+++	/

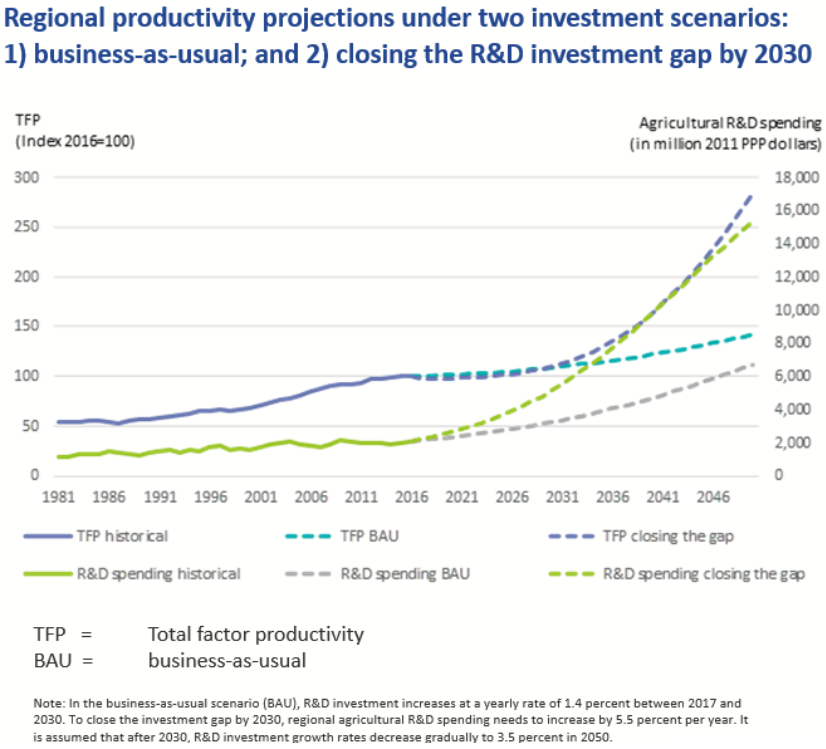
- Countries with the largest and most developed research systems—Malaysia, Thailand, Indonesia, and Vietnam—perform better than the other countries in nearly all indicators.
- Overall system performance is particularly low in Myanmar.

UNDERINVESTMENT IN AGRICULTURAL R&D



- ASTI's weighted indicator of attainable research intensity demonstrates that all Southeast Asian countries are underinvesting in agricultural research.
- Underinvestment is most severe in Myanmar.
- Philippines, Vietnam, and Indonesia should be able to roughly quadruple their R&D investment, while Cambodia and Laos should be able to triple theirs.

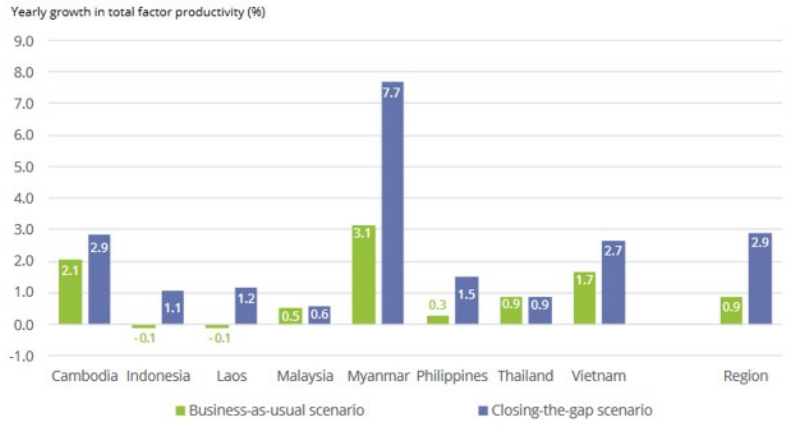
FUTURE PRODUCTIVITY RESPONSE TO HIGHER RESEARCH INVESTMENT TODAY (1)



- If all countries close their R&D investment gap by 2030, regional agricultural productivity levels in 2050 are projected to be nearly 3 times higher than 2017 levels.
- In contrast, if R&D investments continue to increase at long-term historical rates into the future, regional productivity would grow at just 42 percent during 2017–2050.

FUTURE PRODUCTIVITY RESPONSE TO HIGHER RESEARCH INVESTMENT TODAY (2)

Projected annual productivity growth during 2017–2050 under two investment scenarios: 1) business-as-usual; and 2) closing the R&D investment gap by 2030



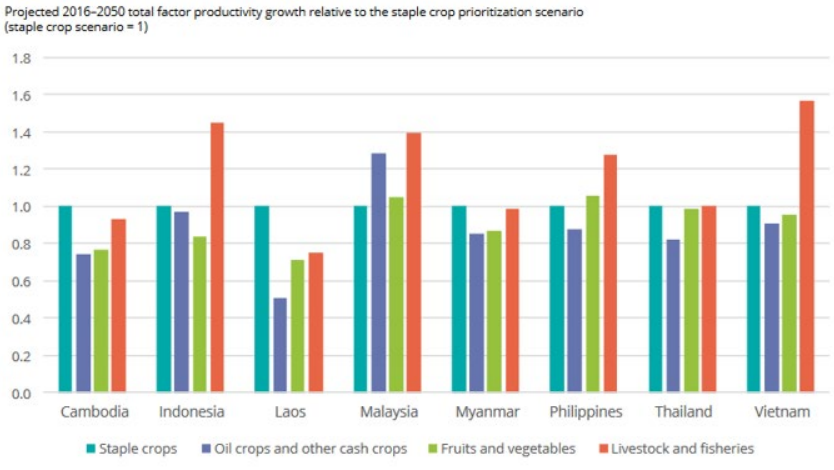
Source: Calculated by authors based on USDA-ERS (2019).

Notes: Under the Business-as-usual scenario, each country's long-term average historical growth rate is used to project future investment; under the Closing-the-gap scenario, growth of investment is calculated as the yearly rate required for the country to shift its actual level of agricultural research investment to its attainable level during 2016–2030 (See Figure 12).

- Raising agricultural research spending to levels that will close the investment gap will trigger considerable agricultural productivity growth across Southeast Asia.
- Projected productivity gains will be highest in Myanmar and Cambodia.

PROJECTED PRODUCTIVITY GROWTH UNDER ALTERNATIVE INVESTMENT PRIORITIZATION SCENARIOS

Projected annual agricultural productivity growth during 2017–2050 under four different scenarios of R&D investment prioritization



Sources: Calculated by authors based on ASTI (various years), FAO (2020), and USDA-ERS (2019).

Notes: The four scenarios, respectively, prioritize investment in (1) cereals, roots and tubers, and pulses (that is, staple crops); (2) oil crops, sugarcane, coffee, cocoa, rubber, and other cash crops (that is, oil crops and other cash crops); (3) fruit and vegetables; and (4) livestock and fisheries. In all these scenarios, investment in target commodities increases at a yearly rate of 6 percent, whereas investment in all other commodities increases at a yearly rate of 3 percent. See Appendices C and D for further detail.

- In Indonesia, Malaysia, Philippines, and Vietnam, fastest future productivity growth will be achieved by prioritizing R&D investment in high-value commodities.
- Prioritizing R&D investment in staple crops will still generate high future productivity growth in Cambodia, Laos, Myanmar, and Thailand.

Conclusion of the Analysis

Southeast Asia and PNG made considerable progress in building and strengthening their agricultural R&D capacity during 2000–2017. All of the region's countries reported higher numbers of agricultural researchers, improvements in their average qualification levels, and higher shares of women participating in agricultural R&D. In contrast, regional agricultural research spending remained stagnant, despite considerable growth in agricultural output over time. As a result, the region's agricultural research intensity—that is, agricultural research spending as a share of agricultural GDP—steadily declined from 0.50 percent in 2000 to just 0.33 percent in 2017. Although the extent of underinvestment in agricultural research differs across countries, all Southeast Asian countries and PNG invested below the levels deemed attainable based on the analysis summarized above. The region will need to increase its agricultural research investment substantially in order to address future agricultural production challenges more effectively and ensure productivity growth.

The region's least developed agricultural research systems (Cambodia, Laos, Myanmar, and PNG) are characterized by low scientific output and researcher productivity as a direct consequence of underfunding and lack of well-qualified research staff. While Malaysia and Thailand have significantly more developed agricultural research systems, they still report key inefficiencies and resource constraints that require attention. Indonesia, the Philippines, and Vietnam occupy intermediate positions between these two groups of high- and low-performing agricultural research systems.

Growing national economies, higher disposable incomes, and changing consumption patterns will prompt considerable shifts in levels of agricultural production, consumption, imports, and exports across Southeast Asia over the next 20 to 30 years. The resource-allocation decisions that governments make today will affect agricultural productivity for decades to come. Governments therefore need to ensure the research they undertake is responsive to future challenges and opportunities, and aligned with strategic development and agricultural sector plans. ASTI's projections reveal that prioritizing investment in staple crops will still trigger fastest agricultural productivity growth in Laos. However, Indonesia, Malaysia, the Philippines, and Vietnam could achieve faster growth over the next 30 years by prioritizing investment in research focused on fruit, vegetables, livestock, and aquaculture. In Cambodia, Myanmar, and Thailand, the choice between focusing on staple crops versus high-value commodities was less pronounced, but projections did indicate that prioritizing investments in oil crop research would trigger significantly lower growth in agricultural productivity.

9 Impacts

9.1 Scientific impacts – now and in 5 years

The project has added to an increased understanding on the inputs, outputs, and performance of the region's agricultural research systems. It has quantified in great detail the level of (under)investment and the capacity (gaps) in agricultural research. None of this information was previously available and it is now widely accessible for use by national, regional, and international stakeholders as an important benchmark to track future progress against development goals.

In addition, the data collected provide an important input into the assessment of the long-term impact of agricultural research investment on agricultural productivity growth and poverty reduction. This will enhance the understanding among policymakers (and other key stakeholders) why sufficient and sustained funding for agricultural research is critical for future growth of the agricultural sector. ASTI's new datasets for Southeast Asia and the Pacific have already fed (and will continue to feed) into economic models projecting long-term productivity growth under various different investment scenarios. Such scenario building empowers planners and policymakers in their resource allocation decisions.

ASTI data are a global public good, freely available on the ASTI website. Over the past decades, scientists covering a wide range of research areas have freely used ASTI data as an important input into their research. These have included studies on crop improvement and adoption, on the impact of research on productivity and poverty reduction, on capacity development for resilient food systems, on gender issues in agriculture, on agricultural research investment needs under various different climate change scenarios, and the relation between investments in agriculture and food price volatility, to name but a few. The availability of new and up-to-date ASTI data for Southeast Asia and the Pacific is likely to constitute a major input into the production of a similar flow of new scientific evidence in the coming years.

9.2 Capacity impacts – now and in 5 years

The project has strengthened the capacity of country-based institutions (both focal points and representatives from related local organisations working in agricultural research) and that of APAARI staff through development of stronger skills in data collection, management, and analysis. This improvement in individual capacity is linked to improvement in institutional capacity to collect and analyse data within partner countries and across the region as well as in planning of outreach events.

1. Data component

ASTI has built a well-functioning network of country focal points throughout the duration of the project. All focal points were familiarized with ASTI methodology, survey tools, and data collection procedures at the onset of the project during a 3-day inception workshop. This workshop also focused on familiarizing these focal points with analytical applications of the data (including the evaluation of R&D performance and using ASTI data for projections of future agricultural research impact). Focal points also received training on approaches to enhance the dissemination and uptake of ASTI outputs. Additional training was provided during various country visits by IFPRI and APAARI staff.

In addition, IFPRI's Senior Program Manager has spent a considerable portion of his time at the APAARI office in Bangkok to familiarize APAARI staff with ASTI, its data management system, its data analysis procedures, its report writing guidelines, and to

ensure the overall quality of datasets and publications. ASTI has become a true flagship project of APAARI and strengthened APAARI's overall institutional capacity.

Throughout the project, the focal points (but also representatives from national R&D agencies) have developed stronger skills in data collection, management, and analysis. Their involvement in ASTI have also brought them in contact with peers in other countries in their region. Some focal points indicated that this experience has been a very valuable one for their professional and personal growth. Or as one ASTI Focal Point from the Philippines put it: *"By being involved in the project, I improved my networking and linkaging abilities. To facilitate surveys, one has to navigate several channels. I was able to get in touch/contact with various leaders/staff of key government institutions…my confidence increased".* Newly acquired skills like these will yield positive outcomes beyond the life cycle of the project.

Many of the focal points have emerged as true in-country experts in the field of agricultural research investment and capacity trends thanks to their involvement with ASTI. They will be able to use their newly acquired skills to disseminate the findings of their work to key in-country stakeholders, to engage in policy dialogue, and to further lay the foundation for the long-term institutionalization of ASTI in their respective countries. ASTI hopes to continue tapping into this network of in-country experts for future data collection and analysis rounds.

This improvement in individual capacity is linked to the second stage of capacity building: improved institutional capacity to collect and analyse data within the partner countries. The project has contributed to an increased awareness and understanding of the need of well-established data collection and analysis systems. Through their involvement in the first cycle of ASTI data collection and analysis, many countries have become convinced of the need of well-established agricultural R&D investment and capacity data collection and analysis systems. They see the benefits that ASTI provides in better managing agricultural research decisions (including funding allocation and addressing research gaps); advocating for increased funding for R&D; and addressing capacity gaps (including gender dimension) within agricultural research.

In the coming years, ASTI will be working with the leading national R&D agencies and some of their partners institutions across Southeast Asia and the Pacific to build on the successes of the first phase, and to raise ASTI from a one-off data collection initiative to a more permanent, institutionalized, and country-owned system for data collection and analysis. By creating a certain data collection routine, data management systems at the agency level will improve, as agencies know they need to systematically report data every two years or so. This will further strengthen individual and institutional capacities. Some of the countries have started exploring steps how ASTI data collection can be facilitated and institutionalized on the long run:

- During an ASTI outreach event in **Cambodia**, attended by key senior stakeholders from various ministries, mechanisms were discussed for the implementation of a next survey round of ASTI. Elevating ASTI from the Cambodian Agricultural Research and Development Institute (CARDI) to an agency up the hierarchical structure would facilitate future data collection (as it could be made mandatory). Shared implementation of ASTI by CARDI and a few other agencies would facilitate data collection and enhance in-country ownership and impact.
- Similarly, at a recent outreach event in **Laos**, there was widespread consensus among stakeholders that ASTI needs to be sustained. Future work would ideally be implemented by a multi-stakeholder team comprising of representatives from the National Agriculture and Forestry Research Institute (NAFRI) and the higher education institutions. This is to ensure that ASTI outputs attract broader support and that the evidence is better embedded in policy processes.

- In **Myanmar**, the Ministry of Agriculture, Livestock, and Irrigation (MOALI) is very strong supporter of ASTI. ASTI data are already an important input into Myanmar's Agricultural Research Masterplan, and MOALI's Department of Planning wants to see data collection activities sustained and institutionalized on the long run. They say that having a neutral outside organization like IFPRI/APAARI pinpoint the weaknesses and gaps of the Burmese agricultural research system is more effective in having a policy impact than when a Burmese organization does so.
- **Papua New Guinea**'s Research Science Technology (RST) Secretariat is very supportive of ASTI and they would like to see PNG's National Agricultural Research Institute (NARI) continuing the implementation of future ASTI data collection (to which NARI has agreed). RST has also said it is keen to work closely with NARI on the effective use of the ASTI data in its policy and capacity planning.
- The Philippine Council for Agriculture, Aquatic, and Natural Resources Research and Development (PCAARRD) in the **Philippines** has taken important steps to institutionalize ASTI within its Socio-Economics Research Division (SERD). With funding support from the PCAARRD Board, SERD will begin updating ASTI indicators to 2018–2019 from December 2020. Data collection and analysis (using ASTI survey forms and data management portal) will be implemented jointly by SERD and 3 universities.

2. Analytical component

Compared to the many successes achieved in building individual and institutional capacity on the data collection front, successes in building analytical capacity were more restricted. Researcher teams from 4 countries received in-depth multi-day training from an IFPRI expert on calculating TFP for various commodities, using index numbers to measure TFP, and calculating knowledge stocks.

However, of the three country case studies originally proposed, two (Malaysia and Vietnam) were completed successfully, one study (Myanmar) started late[2], and one (Indonesia) never took off despite various meetings with the team of Indonesian researchers involved and two trips of IFPRI's coordinator to the country.

Different factors are behind the limited capacity impact, including: a) inadequate analytical capacity in the participating countries/institutions, and b) project priorities and activities not necessarily responding to capacity demands.

- The analytical capacity of teams in the participating countries was limited. Even though ASTI identified key agricultural policy think tanks (outside of the NARIs), such as the Institute of Policy and Strategy for Agriculture and Rural Development (IPSARD) in Vietnam and the Indonesian Center for Agricultural Socio Economic and Policy Studies (ICASEPS) in Indonesia, most senior (socio-) economists at these organizations had no or very limited knowledge and experience in agricultural productivity measurements, efficiency analysis, mathematical optimization, or stochastic frontier analysis.
- To have achieved better results in this context, the project would have required a much longer period of more formal training on all of these different concepts and on the application of analytical tools, with the country studies being an application

[2] Myanmar joined the activity after the study of the Philippines was cancelled due to severe delays in data collection. Covid has delayed the implementation of the work, but they remain committed to complete the work in the coming weeks.

of new acquired capacities as the final step of the process instead of the main tool used for capacity strengthening.
- Based on the importance of other activities of the project and the time needed to complete them (e.g. data collection, analysis, report writing), it was not feasible to allocate more staff time and resources on training and capacity strengthening, so the results obtained are within what was expected, given these constraints.

In sum, focusing on country studies as the main instrument for capacity building in the second year of the project generated positive results for the two groups (Malaysia and Vietnam) that completed the task. Both countries (as well as Myanmar) were very grateful to IFPRI for the opportunity to be trained in economic analysis. They were pleased with the new skills they acquired, and said they would certainly apply these skills in future work. However, more time and resources will need to be spent in the future to achieve the more ambitious goal of developing analytical excellence in the region. Achieving this in every single country seems unfeasible given severe capacity constraints in many countries. Strengthening the analytical capacity of a single regional center of excellence might be a more sensible approach (see Recommendations section).

9.3 Community impacts – now and in 5 years

ASTI differs from most ACIAR-funded research projects in that it does not directly involve farmers. Nonetheless, its potential to benefit a large number of smallholders is obvious. The greatest impact of this project will be better-informed decision makers, either within government, donor organisations, or within the research institutes themselves. Exposing the critical gaps in agricultural research investment and capacity as ASTI has done will positively lead to stronger management and improved funding allocation, eventually resulting in improvements in smallholder farming systems throughout the region.

It is too early at this stage to provide a detailed overview of the uptake of ASTI information in policy processes. However, significant anecdotal evidence is already emerging from a number of countries that ASTI data and publications are feeding into policy and decision-making processes. A number of those (preliminary) impact stories are presented in the bullet points below. Over the next few months, IFPRI and APAARI will continue to follow up with the countries to find out how ASTI evidence is informing policy and to what extent the data and publications are taken up by key stakeholders. IFPRI and APAARI will make sure that these success stories are carefully monitored and documented.

- **Laos**: The Ministry of Agriculture and Forestry (MAF) is developing its 5-year plan and Agriculture Development Strategy. NAFRI has indicated that the ASTI information will be an important input into this process and in making the case that more funding needs to be made available for agricultural research and capacity strengthening.
- **Myanmar**: The Ministry of Agriculture and Livestock (MOALI) is developing its 5-year Research Master Plan Road Map. MOALI's Department of Planning, which coordinated the ASTI work in Myanmar, is on the working group of the Agricultural Research Master Plan and communicated that the ASTI data (and comparisons with other ASEAN countries) has already proved to be a great asset in making the case for much higher investment in R&D, a greater focus on postgraduate training for scientists, and increasing scientist salaries in this Master Plan.
- **Papua New Guinea**: NARI is developing its new Strategic Results Framework (SRF), which is due to be launched in 2021. ASTI can be brought under the technical component of the SRF, which covers services related to monitoring and

evaluation (M&E) and data systems. This will institutionalize ASTI on the long run. In addition, there are plans to more closely integrate ASTI with the Research and Science Council's strategic plans. It is important that the timing of both initiatives is synchronized for maximum impact.

- **Philippines**: PCAARRD sits within the Department of Science and Technology (DOST), which is responsible for formulating and coordinating S&T policies and projects. Through DOST, PCAARRD has direct linkages to Congress. PCAARRD's Socioeconomic Research Division (which is leading ASTI activities in the Philippines) is increasingly focused on technology forecasting. They see ASTI as an important component of this shift and have integrated ASTI data collection as part of their on-going activities. On the long run, this will result in a system whereby up-to-date ASTI information directly informs and influences policy and decision-making.
- **Vietnam**: The Agriculture Ministry through its Department of Planning is developing the Agricultural Sectoral Plan for the next 10 years. IPSARD, which has co-implemented an ASTI analytical study in Vietnam, has indicated it will use the ASTI information to inform key decisionmakers at the Department of Planning. IPSARD also aims to incorporate the outcomes of ASTI analysis in Vietnam's vision for 2045, for which it is responsible.
- **Indonesia**: ASTI outputs are to inform the development of the Ministry of Agriculture's strategic plan. The ministry is particularly interested in the analysis on the efficiency of R&D institutes and the research efforts needed to achieve self-sufficiency in a broader range of commodities.

Although it is too early to assess to what extent ASTI evidence will influence agricultural R&D resource allocation decisions or policy change, the examples above give reason to believe that the information is already being taken up by key stakeholders. Better-informed decisions made by these stakeholders will translate into improved policy decisions, which will ultimately have important community impacts on the long run.

During two independent reviews of ASTI in 2014 and 2018, about 100 key stakeholders from different backgrounds were surveyed on their use of ASTI information (years after the completion of survey rounds). Stakeholders came from a range of local, national and international organisations. Over 50% of these stakeholders indicated that they accessed ASTI documents as a major source of information for their own policy documents.

Many of those that did not use the ASTI data to inform policy documents directly referred to other positive uses of the data such as:

- Use in policy dialogue at events rather than in the form of documents
- Use by other parties to inform policy e.g. superiors, partners, network contacts
- Use for internal advocacy / information sharing with colleagues / partners / stakeholders
- Use of ASTI data within other document types e.g. internal briefs / memos / reports; research papers; newsletters; lecture notes

Whilst the long-term impact of such uses on improvements in agricultural productivity and food security may not be understood for some time in Southeast Asia and PNG, it is clear that ASTI data is providing key information for policy makers. The strength of ASTI's work is not only in vigorous data collection but also in the presentation of data as useful, simple information that can be used by policymakers without agricultural or research backgrounds.

9.3.1 Economic impacts

It is impossible to put an exact figure on the economic value of ASTI's work, and too early for a detailed assessment of the economic impact of the current project. However, from ASTI impact assessments conducted by independent experts in 2014 and in 2018, ASTI data and reports have proven to be instrumental in attracting increased government and donor funding for agricultural research in many countries in Africa, Asia, and Latin America.

Some Southeast Asian partner institutions have already indicated they want to use ASTI evidence to advocate for increased funding. This will hopefully translate into increased agricultural R&D investment in the coming year, and higher agricultural and economic growth on the long run.

9.3.2 Social impacts

Agricultural research has made a significant contribution to agricultural productivity, poverty reduction, and food security in Southeast Asia over the past decades. The availability of high-quality data and analysis on the status and direction of agricultural research investment and capacity will help policymakers and donors make better-informed and targeted investment decisions, which will ultimately have a positive social impact on the long run. For example, the project has revealed severe underinvestment in agricultural research throughout the region and underscored the lack of a critical mass of highly qualified scientists in a number of countries to address current and emerging issues that the agriculture sector is facing. ASTI's forward-looking R&D investment scenarios in particular are an important tool for decisionmakers to forecast the impact of increased R&D investment on agricultural production, and therefore on a range of related social issues.

ASTI data also revealed important gender disparities in agricultural research. Although female participation is much higher in Southeast Asia than in other parts of the developing world, women in Southeast Asia still hold much lower average qualification levels than their male colleagues and are less likely to hold research management positions. ASTI evidence like this can trigger policy decisions to recruit more female scientists and invest in their training. Therefore, the availability of detailed sex-disaggregated data can contribute to stimulating women's empowerment and social change.

9.3.3 Environmental impacts

Unlike most ACIAR-funded projects, the project is not an agricultural research project that directly involves field research or farmers. Rather, it was a socio-economic desk study with limited environmental effects.

9.4 Communication and dissemination activities

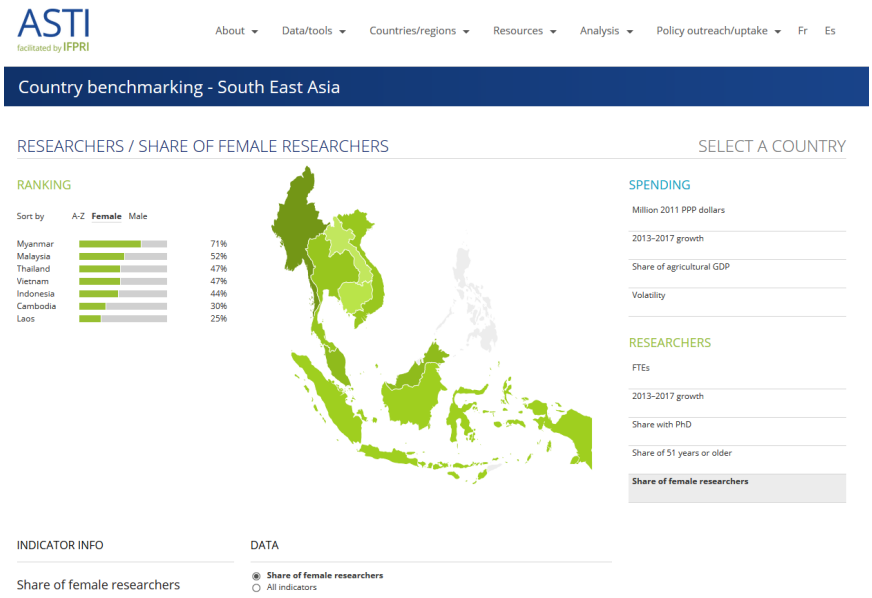
- A series of 8-page country briefs with key policy, investment, and capacity trends in agricultural R&D were developed and broadly disseminated to in-country stakeholders. Country briefs were prepared for Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Papua New Guinea, Thailand, and Vietnam (see Reference list for links).
- Country briefs were translated into local languages in Cambodia, Indonesia, Laos, Myanmar, and Vietnam for increased relevance and impact.

- A flagship synthesis report with regional trends, challenges, and policy recommendations was produced and widely disseminated to key stakeholders in the region and beyond.
- All publications have been made available on the ASTI website (www.asti.cgiar.org) and the APAARI website (www.apaari.org).
- In addition to publications, the project has produced a large number of interactive online outputs, including:

ASTI COUNTRY PAGES

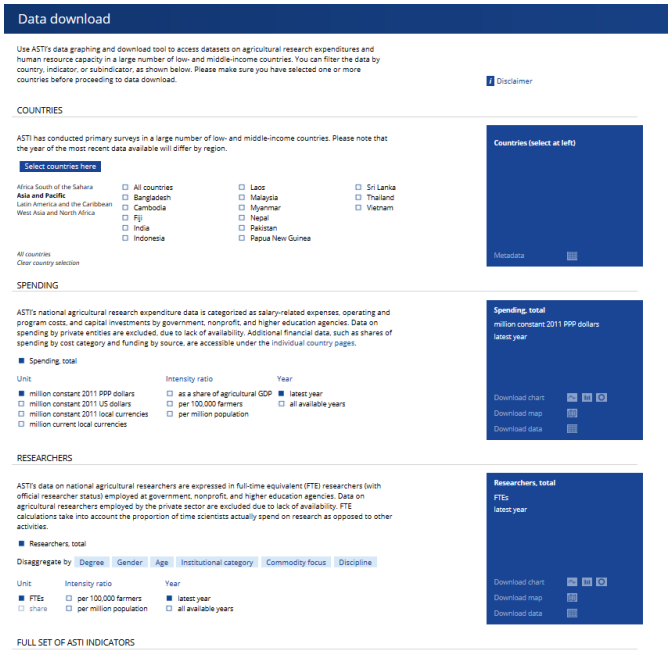
(for example: https://www.asti.cgiar.org/papua-new-guinea)

REGIONAL BENCHMARKING TOOL



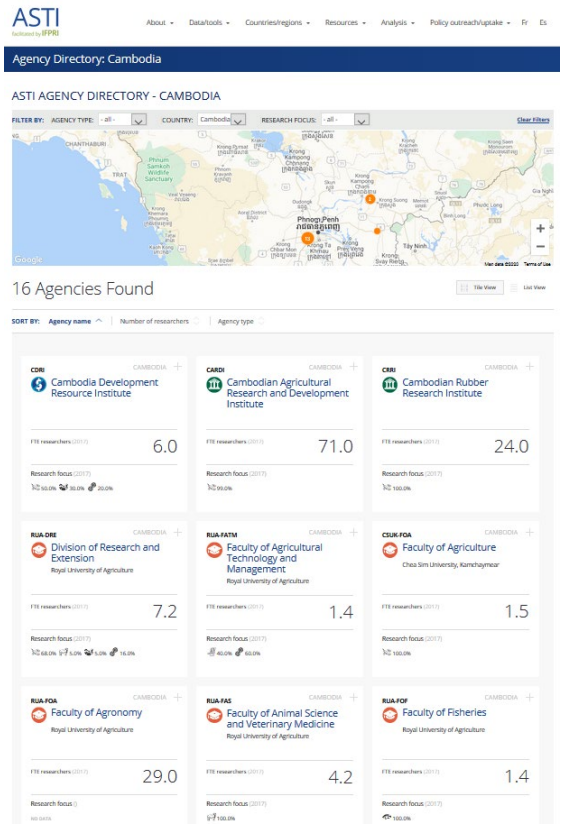
(https://www.asti.cgiar.org/benchmarking/southeast-asia)

DATA DOWNLOAD TOOL



(https://www.asti.cgiar.org/data)

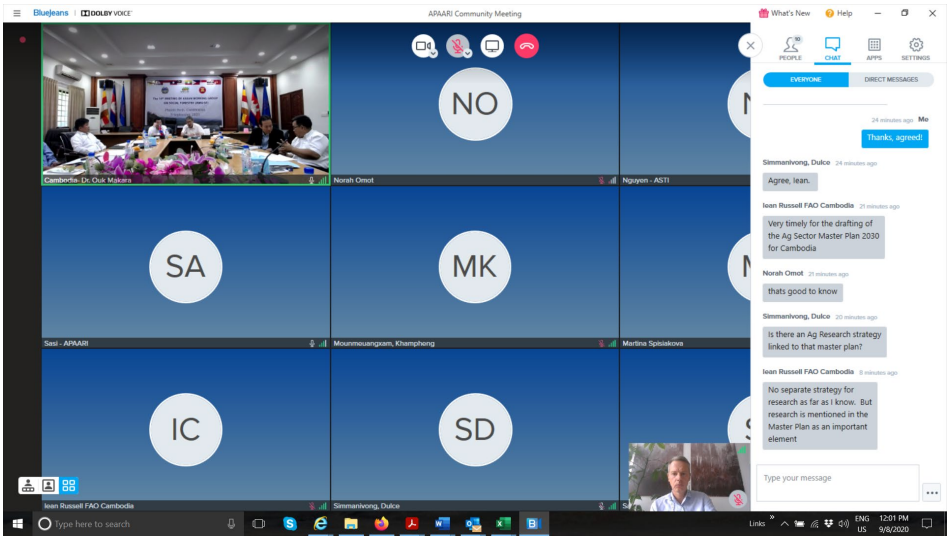
AGENCY DIRECTORIES



(e.g. https://www.asti.cgiar.org/cambodia/directory)

- APAARI and the implementation partners carefully mapped key stakeholders, existing policy decision making processes and platforms, and policy influence pathways well in advance of the completion of project outputs. This ensured the effective dissemination and targeting of key stakeholders.
- Due to the corona crisis, in-country stakeholder outreach events as originally planned were not possible, which was very unfortunate as this would have enhanced the visibility and impact of ASTI outputs at the country level. ASTI had no alternative but to resort to online outreach instead. During September–November, a series of 2 to 3-hour webinars have been organized in Laos, Cambodia, Myanmar, PNG, and the Philippines with additional events in Indonesia, Malaysia, and Vietnam scheduled for December 2020 and January 2021. These webinars were well attended by key stakeholders and senior officials from various ministries (including ACIAR country managers). In addition to presenting the key country-level data findings, these outreach events were also used to receive feedback from the audience on how to embed ASTI evidence in policy and decision-making and ways to institutionalize the work on the long run. Language barriers and connectivity issues made the webinars a bit of a challenge at times, but overall ASTI still feels very happy about the overall reach we were able to achieve under the circumstances and the many positive reactions to our work from the audiences.

ASTI Outreach Event in Laos in September 2020



ASTI Outreach Event in Cambodia in September 2020, attended by NARS leaders and senior Ministry of Agriculture officials

- In addition to in-country outreach, various regional-level outreach events were organized bringing NARS leaders and other key stakeholders together. These were a good opportunity for countries to share their ASTI experiences and there was widespread consensus that ASTI is an important initiative for regional research priority setting and decision making. All countries stressed they want to see ASTI sustained/institutionalized.
- Dulce Simmanivong organized an ASTI outreach event for ACIAR Alumni from Cambodia, Laos, Myanmar, and Thailand. During this event, key findings for these countries were presented by the ASTI team, and ways to embed this evidence in policy processes in these countries discussed. The ACIAR alumni can play an important “ambassador” role in ensuring that ASTI evidence gets taken up in policy- and decision-making processes.
- On 11 December, there will be a 2-hour webinar targeting key regional, international, and multilateral stakeholders, including ASEAN, the Asian Development Bank (ADB), the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA), the Food and Agriculture Organization of the United Nations’ Regional Office for Asia and the Pacific (FAO-RAP), the United Nations Economic and Social Commission for Asia and the

Pacific (UNESCAP), donor organizations (World Bank, International Fund for Agricultural Development (IFAD), Korea, Japan, Taiwan), Consultative Group on International Agricultural Research (CGIAR) centers, and other regional organizations. The webinar will be an excellent opportunity for stakeholders to share their insights and expectations of the region's agricultural innovation, and to start a dialogue on how ASTI evidence can be integrated into regional policy processes.

- In addition to webinars, many of the key findings and publications have been shared on APAARI's and IFPRI's social media channels, newsletters, and blog posts.

10 Conclusions and recommendations

10.1 Conclusions

Since the initiation of ACIAR-funded ASTI activities in Southeast Asia and the Pacific, IFPRI and APAARI have achieved a lot. A well-functioning network of country focal points was established and trained; close to 350 individual research agencies were surveyed; a demand-driven analytical agenda around topics relevant to the countries was designed and implemented; a series of country publications, regional syntheses, and online data tools were produced; key stakeholders and policy influence pathways were mapped; and the outputs and main findings of the work were carefully targeted to decision-makers and other stakeholders to ensure uptake of the evidence in policy processes. IFPRI and APAARI are currently engaged in large-scale outreach of the project findings, in close collaboration with country partners and ACIAR country managers. This is work in progress, but anecdotal accounts indicate that ASTI findings are already proving to be a valuable input into the design of agricultural development strategies throughout the region. Another immediate impact of the project has been improved capacity at APAARI and making the monitoring of agricultural research resources an integral part of APAARI activities (which is very much in line with its mandate).

Very importantly, the participating countries have become truly convinced of the importance of this work, and want to see it sustained and expanded. To prevent the many gains achieved during the first phase of the project from being eroded in the absence of viable mechanisms to sustain them, IFPRI and APAARI are seeking ACIAR support for a second phase. In the first phase, the focus was mainly on laying the foundations for the long-term monitoring of agricultural research resources. In a second phase, the focus will be on further capacity strengthening, expanding the scope of the work (both geographically and in terms of analysis), ensuring that the ASTI evidence gets embedded in agricultural research priority setting and decision-making processes, as well as the long-term institutionalization of the work.

Ideally, the second phase will commence in 2021, allowing ASTI to take advantage of the momentum created by the release of the phase I outputs.

10.2 Recommendations

Enhancing in-country ownership and the long-term institutionalization of ASTI

ASTI focal points/organizations have done a great job in collecting very high-quality data from a complete set of agencies involved in agricultural R&D placed under different ministries/departments. But one important lesson we learned from implementing the project is that to truly embed ASTI evidence in national-level policy frameworks and processes, the ownership and responsibility of ASTI needs to be shared more broadly with key agencies in the country. The following factors are important considerations for a next phase:

- ASTI was externally initiated, and the evidence produced in collaboration with the NARIs has been collected outside national data processes and systems. As such, while very useful—and clearly highly relevant given early evidence of its use—it has not been properly incorporated into the systems that national governments rely on for evidence. Strengthening relationships and advocacy with national government institutions (including bureaus of statistics) is an important step in creating the conditions necessary to integrate data into official channels.
- The issues and challenges facing the agricultural sector are often too complex and multilayered for individual organizations to resolve. Although the NARIs did a fantastic job coordinating ASTI in their respective countries, there is a need for a

more formal network of country partner institutions working together on the political, bureaucratic, and public dimensions of an issue to promote change. Mapping the key actors provided a crucial starting point toward identifying potential and actual networks of support. Putting these networks to work with the intention of strengthening the role and perceived value of agricultural research would significantly enhance the long-term impact of ASTI. Some of the countries have already taken initial steps to establish multi-stakeholder ASTI networks (see Laos, PNG, and Philippines examples in Section 8.2) in order to integrate ASTI evidence better in policy and decision-making processes, but this work needs to be expanded in a next phase.

- Major change requires time, allowing for changes in leadership, changes in political systems, and various unexpected crises (such as COVID-19) and opportunities. This reality did not always fit well with tight project timelines and, hence, presented a challenge. Wherever possible, project timeframes should be driven by an internal, country-owned schedule, so that the implementation of ASTI activities is better synchronized with government processes. This suggests the importance of longer timeframes for program support, as well as a flexibility to adapt and change direction as the need arises.

Further strengthening APAARI

ASTI has truly become a flagship project of APAARI. APAARI's Executive Secretary has actively showcased ASTI at various events and face-to-face meetings with stakeholders, and the project has positively contributed to APAARI's professionalism and its visibility in the region. Going forward, it is important that IFPRI will continue to play a crucial capacity strengthening role for Bangkok-based ASTI staff (especially in the area of data analysis and data quality control, which remain relatively weak to date) so that APAARI's capacity to manage ASTI independently becomes stronger over time. IFPRI will also need to continue working closely with APAARI's Executive Secretary and communications manager on the development and implementation of a strategic stakeholder outreach plan, as well as on strategic partnership building. Moreover, IFPRI and APAARI need to explore opportunities to expand ASTI activities into the Pacific, which will provide a unique opportunity to APAARI to strengthen its presence and visibility in this region.

Strengthening regional analytical capacity

Given severe capacity constraints in a number of countries, ASTI believes it would be beneficial to house its analytical research activities for the Indo-Pacific region in a **regional center of excellence** with strong analytical capacity. Ultimately, the center of excellence will be responsible for implementing a demand-driven research agenda with regional relevance, and play a critical capacity strengthening role for weaker countries (through buddy programs, development of training modules, etc). Institutional commitment to support the initiative should be a major criterium to select this institution as this is one of the major factors that will determine the sustainability of the initiative beyond the duration of the project. There is the need to train a good number of staff within the target institution in modelling and analysis to ensure institutional capacity. Trainees should be selected based on capacity needs, giving priority to analysts with working experience or specialization in the relevant areas of analysis and to young analysists. The training should focus on the following main topics: (i) introduction to production economics; (ii) productivity and efficiency analysis; (iii) hands-on training on the use of spreadsheets in decision making analysis: linear and non-linear optimization models and basic econometric techniques; (iv) hands-on training in the use of standard economic models like IFPRI's IMPACT model and/or the its standard computable general equilibrium (CGE)

model; (v) data needs, sources and availability; (vi) application to selected relevant policy issues as part of the training.

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