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Improving market integration for high value fruit and vegetable production systems in Indonesia

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1 Acknowledgments

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2 Executive summary

This project focussed on using empirical evidence from 2000 household surveys to inform policy and project design in ways that encourage more profitable and productive horticultural seed choices by farm households. This project results contribute to a better understanding of the factors influencing the seed adoption choices made by chilli, citrus, mango and shallot producers. The goal is to gain policy and program insights and communicate the key messages to improve small holder productivity and profitability. Project partners include The Indonesian Center for Horticulture Research and Development (ICHORD), Bogor Agricultural University (IPB) and the University of Adelaide's Centre for Global Food & Resources.

The project draws on qualitative and quantitative methods to understand what influences household behaviour when making choices over which variety and which seed type to plant - - certified hybrid or saved, open pollinated seeds. For each commodity, analysis draws on household surveys to examine the conventional views on how seed and input markets operate based on empirical results. The issues examined reflect the priority concerns identified by government policy makers, technical experts and private sector seed companies.

The research methods were designed to address four project objectives and the associated activities. The project used a mixture of, literature reviews, desk studies, key informant interviews, focus groups and expert workshops to inform the study design, shape the household survey instrument, identify priority issues, and design policy and business community engagement. The project undertook formal surveys in 2016 and 2017 of some 2,000 farm households, interviewing both the male and female household heads in separate surveys. The project objectives include:

Objective 1: Assess the progress of interventions designed to improve chilli, citrus, mango and shallot seed value chains.

Objective 2: Examine the patterns, determinants and effects of smallholder participation in seed markets, documenting project and policy lessons on how to address constraints to improve adoption of hybrid/certified seeds for in chilli, citrus, mango and shallot value chains.

Objective 3: Develop practical 'working linkages' between the public policy sectors, FFV industry associations and the academic community to encourage knowledge development, policy dialogue and industry advocacy in ways that benefit small producers.

Objective 4: Build empirical research capacity and outreach programs to better inform policy discussions and project design for improving smallholder engagement.

Addressing these objectives, project produced: (i) one of the largest horticultural farm survey efforts in Southeast Asia, with nearly 2000 farms (400 mango, chili 526, shallot 531, citrus 500); (ii) a survey unique to Indonesia of upstream input sources and types; (iii) a rare set of panels of farms of the same households in 2011 and again in 2016 for chillies, shallots and mangoes; (iv) a comparison of two tree crops using the same method (mango and citrus) and two annuals (chili shallot); a full set of female households head interviews for all 1500 surveys with gender disaggregated data; (v) detailed view for all four crops of marketing/harvesting including tebasan and market channels, as well as post-harvest handling; (vi) variety detail and variety change; and (vi) detailed information on non-seed inputs (fertilizer, pesticide, hormones) and interaction with market channel.

The gender specific survey results challenges misunderstandings and conventional wisdom in Indonesia in three ways that can support positive social impacts in the future: (i) the level of female participation of both family and hired labour- - female reaches 60% overall; (ii) over and under allocation of labour related to constraints in accessing services and technologies; and (iii) how chilli, citrus and shallot farm household decision are made - - a much higher level of joint decision making in Indonesia than recognised and certainly very different than the African literature.

Among the key outputs include a series of studies examining the impact on horticultural seed markets related to Indonesia's Horticultural Law restricting foreign investment to 30% ownership. These studies focus how the law impacts horticultural production, value chain transformation, competitiveness and market concentration, private extension and technological transfers.

The project initiated an Agricultural Business Forum providing a networking platform for seed companies, government policy makes and academics to meet, discuss, learn and share ideas. Bogor Agricultural University's Department of Agricultural Economics and Agribusiness programs are managing the forum beyond the end of project. Stakeholders include Horticultural industry bodies, food retailers, seed and input companies, MoA and the academic community.

During the final year, the project team established a program of training workshops with large and small seed companies with Bogor Agricultural University providing workshops to: (i) introduce seed company staff to the household questionnaires, panel data covering more than 1,500 interviews in 2011 and 2016; (ii) train seed company staff on how to use software for analyzing the data set; (iii) train seed company and ICHORD staff on how to access, manipulate and evaluate the data set. Twelve staff from five seed companies have been trained to date.

Project generated knowledge, the household data and training tools are available to inform horticultural advisory services and university teaching and research programs. Analytical insights into household use of horticultural seeds and the seed industry transformation can encourage more effective, scale neutral government regulatory and policy interventions. One example is to review the trade rules limiting shallot mini-bulb imports.

The project directly supported three four PhD students. Their PhD topics address issues such as gender and household income impact of hybrid vs open-pollinated varieties, the key role of off-farm female labour in certified chilli seed adoption, the education outcomes associated with adopting citrus production, how climate events and risk perceptions of the male and female households heads influence the choice of certified disease-free seedlings vs non-certified seedling.

3 Background

For a number of reasons beyond ACIAR's and project partners' control, this project faced a series of implementation delays. The delays related to and coincided with Indonesia's parliamentary elections, presidential elections, IAARD freezing all ACIAR research projects due to Australia's tapping the phone of the President's spouse, the appointment of a new Minister of Agriculture and the emergence of a new Strategic Plan for Indonesian Agriculture 2015-2019.

The 2015-2019 Agricultural Strategic Plan redefined research strategy for Indonesia's horticultural agricultural sector in important ways. To align with the new research priorities, our key government project partner, The Indonesian Center for Horticulture Research and Development (ICHORD) organized and guided discussions at a planning workshop in Adelaide 4 to 7 December 2014. The three key outcomes of that meeting include: (i) include extension staff in the capacity building and outreach programs with IPB and ICHORD staff; (ii) focus all the value chain research on seed value chains, building on previous household surveys of horticultural producers; and (ii) focus on four key horticultural products requested by IAARD, chillies, mangoes, shallots and citrus.

The overall aim of this project is to more effectively promote the growth and development of Indonesia's fresh fruit and vegetable value chains, focusing specifically on ways smallholders and rural communities can participate and benefit more fully. The research focussed on using empirical evidence to inform policy and project design in ways that encourage more profitable and productive horticultural seed choices by farm households. This project aligns with Indonesia's horticulture policy objectives: to accelerate and sustain growth and development of the fruit and vegetable industry and to enhance its contribution to food security, poverty reduction, employment and wealth creation.

The four seed value chains resulted from the Strategic Plan of Indonesian Ministry of Agriculture of 2015-2019 targeting seed system research as research priority and the MoA targeting chillies, shallots, mangoes and citrus and priority crops. ICHORD recognizes that while a significant amount of resources is dedicated to developing new seed varieties and disseminating these technologies, there is little known regarding how seed markets behave, especially the factors influencing how and why farmers make seed choices (hybrid vs saved seeds and open pollinated sees). The structure and behaviour of seed value chains is not well understood, and partners agree to redress this gap in the project. ICHORD also requested to include extension staff in the training and outreach programs to build closer networks, improved skills and an understanding of the role of value chain research to better design and target extension programs and improve adoption.

In practice, the project shifted the focus of Objectives 1 and 2 in two ways. First, in addition to the already completed process of literature reviews, validation field work and case studies outlined in Objective 1, the project targeted the four key horticultural products as its main focus. Second, instead of examining the patterns, determinants and effects of successful horticultural value chain upgrading (no matter which product) from the projects identified in Objective 1, the project focuses on seed markets in the patterns, determinants and effects of successful seed markets for the four targeted crops.

The MoA's concern about the horticultural industry is driven by evidence that it has been unable to respond to changing demands, leading retailers to source heavily from international markets. The project team's interviews with supermarket buyers, industry

associations and key members of the Indonesian Chamber Commerce (KADIN) during project development highlighted a growing frustration with from domestic sources.

Like other rapidly growing economies, the demand side influences of income, urbanization and demographics are reshaping Indonesia's food chains in fundamental ways. A rapidly growing and urbanizing population is buying more protein rich and diverse foods, including higher volumes of fresh fruits and vegetables (FFV). The growth in per capita food consumption is in high value foods --animal products, fruits, vegetables, fish, oils and prepared food. Per capita consumption of low value grains and tubers continues to decline. Over the 15-year period from 2000 to 2015, daily per capita consumption of fruits more than doubled, with estimates showing per capita consumption of fruits and vegetables tripling by 2050 (unning-Trant et al., 2050).

The increasing consumer demand for FFV includes new middle- and high-income households with a willingness to pay for distinct varieties, better quality, safer standards, more uniformity, private labels and related attributes associated with product and chain Agricultural development projects are attempting to take advantage of modernizing chains to enhance small farmer incomes and food security. International donors, NGOs, national and local governments provide a wide range of smallholder assistance for high value product chains in Indonesia.

The World Bank and USAID alone have invested more than USD $140 million on high value crop supply chain projects since 2006. The EU, Dutch (HORTIN), ADB and various UN agencies all have major value chain projects. Cities across Indonesia will add 45 million people between 2010 and 2025 (World Bank 2009). Planet Retail forecasts consumer grocery spending to increase by 50% between 2010 and 2015. At present, grocery spending accounts for two-thirds of total consumer spending. Over the past decade, the annual compound sales growth for the leading 14 food retail chains in Indonesia is more than 19%, almost 4 times faster than GDP growth. (Reardon et al, 2010).

This rapid transformation presents small farmers with new and potentially profitable opportunities to participate in modern value chains. Small holders and agribusinesses are presented with opportunities to diversify, move up the product value ladder and build collaborative links with consumer driven markets. Farmers upgrade from producing bulk commodities for spot markets assessed on basic visual quality attributes to producing preferred varieties, grades, progressively incorporating a wider range of characteristics related to production and process practices, record keeping, traceability along the supply chain, and risk and quality management structures (Jaffe, et al. 2011).

In most cases, participating in modern chains mean higher real wages and more jobs per hectare, more income for rural communities and less outward migration than areas producing rice, for example. Recent ACIAR research demonstrates per capita household income for small producers participating in modern chilli chains in Indonesia is around 80% higher income than households selling to traditional markets (Sahara, et. al, 2012). Participating in the modern FFV chains present opportunities to capture the benefits of a high-growth economy that have largely eluded small farmers in the past.

Food retail executives, horticultural project managers, government officials and local researchers emphasised the lack of understanding about how producers make choices about which type of seeds to grow and the incentives contributing to their success. This project aims to address this knowledge gap.

4 Objectives

The overall aim of this project is to more effectively promote the growth and development of Indonesia's seed value chains, focusing specifically on ways smallholders and rural communities can participate and benefit more fully from improved access to appropriate seeds for chillies, citrus, mangoes and shallots.

Objective 1: Assess the progress of interventions designed to improve chilli, citrus, mango and shallot seed value chains.

Activity 1.1. Inventory and review donor, government, NGO and supermarket programs promoting horticulture seed market development in Indonesia over the past 10 years.

Activity 1.2. Conduct key informant interviews and desk studies to analyse existing evaluations of projects and policies identified in Activity 1.1.

Activity 1.3. Interview key companies to assess private sector seed value chain initiatives, identifying constraints and issues to investment over the past 10 years.

Activity 1.4. Conduct field trips to sites identified in desk studies and key informant interviews to validate and compare to local seed chain issues.

Activity 1.5. Map and link potential policy, project or private sector seed company initiatives to smallholder chain outcomes to prepare appropriate seed chain case studies.

Activity 1.6. Design and carry out semi-structured interviews for each value chain segment along the seed chain to prepare 'case studies' mapping chain segments between seed breeders, foundation seed producers and certified seed retailers as well as suppliers and chains for non-certified seeds.

Objective 2: Examine the patterns, determinants and effects of smallholder participation in seed markets, documenting project and policy lessons on how to address constraints to improve adoption of hybrid/certified seeds for in chilli, citrus, mango and shallot value chains.

Activity 2.1. Fields trips to villages and districts to assess the validity of using previous ACIAR household surveys to create panel data sets for chillies, shallots and mangoes.

Activity 2.2. Undertake key informant field studies for each of the four seed chains to identify hypotheses and issues for developing community level and household survey instrument.

Activity 2.3. Workshop to incorporate information from 2.2 into survey design and new questionnaire modules for seed markets and for gender roles.

Activity 2.4. Enumerator training using tablets for panel surveys of chillies, shallots and mangoes and random household survey for citrus.

Activity 2.5. Data entry, analysis, and report writing from 2.4-2.5.

Activity 2.6. Complete seed chain case studies based on semi-structured interviews and insights from HH survey.

Activity 2.7. Team conference to present results from 2.4-2.6 to stakeholders.

Objective 3: Develop practical 'working linkages' between the public policy sectors, FFV industry associations and the academic community to encourage knowledge development, policy dialogue and industry advocacy in ways that benefit small producers.

Activity 3.1 Organize 2 half-day workshops with seed companies, Indonesian Chamber of Commerce (Kadin), agribusiness firms, donors, NGOs, industry bodies, agricultural scientists and key government agencies to identify networking opportunities, highlight project activities and determine capacity gaps. The government policy organizations include ICASEPS, the Ministry of International Cooperation and the Domestic Trade Department of the Ministry of Trade.

Activity 3.2 Hold individual (one-on-one) workshops with seed businesses to nurture project relationships, share outcomes of successful seed value chain research in other Southeast Asian countries, and seek enduring collaboration in organized industry activities.

Activity 3.3 Design and (by year two of the project) conduct bi-annual agricultural business symposiums involving IPB, the agricultural science research community, policy forums with seed companies, government agencies and related stakeholders. The forums aim to promote solutions and advocate better policy outcomes for agricultural businesses.

Activity 3.4 Organise one regional conference in each case study site to present project outcomes and promote lasting collaboration between public, private and academic sectors.

Activity 3.5 Establish collaboration with plant and post-harvest research community, linking project outcomes and identifying approaches to technical solutions to upgrading chains.

Objective 4: Build empirical research capacity and outreach programs to better inform policy discussions and project design for improving smallholder engagement.

Objective 4 focuses specifically on building ICHORD research capacity to identify key constraints and opportunities in seed value chains, evaluate upgrading options, and provide tools and strategies for development change.

The capacity building activities include providing staff with skills to: (i) define criteria and justify the value chain for analysis, measure its performance, and evaluate the benefits and costs associated with upgrading options; (ii) identify opportunities and mechanisms for smallholders to benefit from the growth in demand for high-value horticultural products and access the available retail structures, including modern retail chains; and (iii) foster institutional and infrastructure innovations to generate equitable and sustainable benefits to value chain actors, including the mitigation and management of risk.

5 Methodology

The project team designed research methods specific to each objective and the associated activities with the aim to answering a set of research questions. The project used a mixture of qualitative methods, literature reviews, desk studies, key informant interviews, focus groups and expert workshops to inform the study design, shape the household survey instrument, identify key issues, and design policy engagement.

Key informants list includes, village leaders, government officials, NGOs, donor project officers, traders, retailers, cooperatives, farm and women group leaders. Multiple expert workshops were attended by the Directors of the two leading horticultural seed companies in Indonesia, BSI and East West Seeds. Medium and small seed companies were also included in the workshops. The relevant industry bodies and major international development donors also attended and hosted workshops, including participants from OECD, the World Bank and ADB.

Econometric analysis of primary household survey data was used to identify the determinants of decisions on seed choices and the welfare impacts of those decisions as part of Objective 2. The remainder of this section provides general information on the research methods used to answer the research questions associated with each Objective.

Objective 1: Assess the progress of interventions designed to address upgrading in Indonesia's chilli, citrus, mango and shallot value chains.

Research questions for Objective 1 are:

a) What evidence exists that donor and national projects are learning from successful experiences and adjusting approaches to seed and other value chain programs?
b) What are the specific roles played by food retailers in the varietal and seed selection of producers?
c) Which organizational structures are most successful at overcoming smallholder participation barriers to high quality seeds?

To answer these questions, the project team undertook qualitative literature reviews, organised a series of workshops and engaged experts at Agribusiness Forums to inform and shape Objective 1 research work to ensure it is relevant. The literature reviews examined international experiences regulating and promoting horticultural seed chains and the conduct, structure and performance of seed markets. Additional work focused on market concentration in Indonesia's seed industry, the role of private, public and university partnerships and, finally, the pros and cons of restricting foreign direct investment.

The workshops and forums brought together private sector seed companies, horticultural industry organizations, the Chamber of Commerce, academics, and government agencies including IIARD, ICHORD, BTPT and the Ministry of Trade. Several agribusiness forums focused on how Indonesia's Horticulture Law (No.13, 2010), which restricts FDI has affected the horticulture seed industry in Indonesia. The FDI restrictions are of great interest to the Ministry of Trade.

Specific topics included:

a) the impact of the horticulture law on production of the priority horticulture crops (chilli, shallot and tomato);

b) how seed production and markets are likely to evolve if large seed company relocated or restructure;
c) shifts in market concentration in the seed market as a result of the horticulture law;
d) how private extension and technological transfer are affected by FDI restrictions; and
e) the output price impacts chilli, shallot and tomatoes and (vi) whether potential trade policies can mitigate the negative impact of the FDI restrictions.

The project produced studies on the impact of FDI on high priority horticultural production, eg, chilli and shallot scenarios, examples of public private partnerships in Indonesia, cross country comparisons and experiences, structural market changes related to large seed companies relocating off-shore, Indonesia's production and marketing seed systems; a matrix of country experiences with seed research and development activities, the output price impacts on chillies and shallots; and whether potential trade policies can mitigate the negative impact of the FDI restrictions.

Objective 2: Examine the patterns, determinants and effects of smallholder participation in seed markets, documenting project and policy lessons on how to address constraints to improve adoption of hybrid/certified seeds for in chilli, citrus, mango and shallot value chains.

Research questions for Objective 2 are:

a) How do government policies, public investments, private sector initiatives and science-based researcher interact to influence successful smallholder inclusion and use in Indonesia's seed chains for chilli, citrus, mango and shallot?
b) How do gender based roles and decision-making influence choice of seeds?
c) What are the differences (market channels, institutions, outputs produced, inputs, farmer organizations, and other household characteristics) between smallholder households who access certified, high productivity seeds and those that do not?
d) What influences and incentives encourage smallholder participation in certified seed chains upgrading?
e) What are the smallholders and rural employment effects due to the transformation of the seed sector in the domestic market?
f) What seed value chain structures and institutional arrangements are most effective in improving the smallholders' capacity to engage with the transformation?

Objective 2 dominated the project time, effort and resources. This section presents an overview of research methods by crop, explaining the sample choice and questionnaire development. The project draws on qualitative and quantitative methods to understand household behavioural and seed choice of chilli, shallot, mango and citrus producers. For each commodity, analysis draws on household surveys to examine the conventional views on how seed and input markets operate based on empirical results. The issues examined reflect the priority concerns identified by government policy makers, technical experts, private sector input suppliers and food retailers.

The project undertook the formal surveys in 2016 and 2017 of some 2,000 farm households and 260 mango nurseries and rapid reconnaissance mainly of the upstream

segments (input provision and farming and rural wholesalers) of all four product value chains (inputs and outputs).

For all but citrus, the household sample is based on 2011 household surveys allowing panel data for 1,500 farmers. Surveys of both male and female heads of households is one of the key research methods to address Objective 2, to examine the patterns, determinants and effects of horticultural seed market transformation, documenting how to address constraints to improve adoption of hybrid/certified seeds for chilli, citrus, mango and shallot value chains. All except for the citrus survey are panel surveys, based on the previous ACIAR work.

The chilli household survey

The chilli research is based on data from two household surveys of producers in West Java province. The first survey, in 2010, includes 485 farmers who sell to traditional market channels and 112 who sell to supermarkets. The supermarket sample came from a list provided by traders and supermarkets of farmers in Ciamis who sell chilies to supermarkets. The traditional supply chain farmer respondents were randomly selected from three districts in West Java: Garut, Ciamis and Tasikmalaya.

An 18-page structured questionnaire covered household composition, housing and asset ownership, other variables influencing supermarket participation and household income, and the appropriate variables related to trade relationships between farmers and buyers. The first survey was conducted in March and April 2010 by 12 enumerators. The second chilli survey wave was completed by this project team in June 2016 with 573 of the original 597 households re-interviewed. Two survey instruments were used, one for the male head of household and one for the female head of household.

Preparation for the household interviews included literature reviews, mapping the chilli seed chain, interviews with key experts, focus groups with farmer groups, women's groups, traders and local community leaders. The panel data allows the project team to observe household changes during the 5 years period for chilli production, chilli seedling use, production and purchasing choices, chilli marketing and household incomes, assets and perceptions.

This second data set also allows new cross-sectional data providing the necessary information to examine differences in seasonal demand for nursery seeds compared with packets; seasonal demand for hybrid vs open-pollinated varieties; and how access to labour influences seed type choices. The research team collaborated with local, regional and national government offices. ICHORD's research staff and graduate students from IPB joined a team of professional enumerators to interview the chilli households. Preparation for the household interviews included mapping the chilli supply chain, interviews with key experts, focus groups with farmer groups, women's groups, traders and local community leaders.

The project team collected the data sets to support the seed choice analysis:

- Chilli seed and variety choice in Indonesia
- Where do chilli producers source their seeds
- How chilli seed and variety choices influences productivity
- Sources of Information and Knowledge about chilli seed varieties
- How seed and variety choice Influence pesticide and fertiliser use
- How seed and variety choice influence labour demand
- How chilli seed choices impact gender roles

- How shifting gender roles impact chilli productivity outcomes
- Asymmetry in Farm-wholesale-retail price chilli transmission
- Why households switch in and out of chilli production
- Chilli post-harvest and Marketing Practices
- The 2016 chilli survey income and land ownership structure
- Sources of information and knowledge about chilli management
- How FDI restrictions impact Indonesia's chilli sector
- Village level population data, land area, public infrastructure;
- Gendered labour counts for each phase of production (categorized in hired and household);
- Quantity measurements for every input for the most recent completed cycle;
- Yield measured in three different ways (per bush, per plot, total revenue and average price);
- Disease, erosion, and flooding on each plot;
- Daily rainfall, temperature, color-profile (10 bands) of main chili plot; and
- Crops planted throughout the year.

The collected data allow analysts to address a major policy dilemma facing the Ministry of Agriculture, and a key focus of this project's research, how to reduce the trade-off between expanding chilli production and shrinking staple food production. On the one hand, participating in higher value horticultural chains, like chillies, present opportunities for small holders to capture greater benefits from Indonesia's high-growth economy that has eluded them in the past.

On the other hand, horticulture area expansion tends to result in less area planted to staple crops important to the policy community. BPS reports national average chilli yield has increased to 12 to 14 tonne/ha, an excellent productivity performance over the past decade yet well below their potential output levels.

The research presented with the household data explore explore a range of issues including: (i) whether and why farm households select certified, hybrid varieties; (ii) income and resource ownership structure of households producing hybrids vs open-pollinated, (iii) chilli management practices and yields by seed type and size of holding; (iv) why households chose to produce or not produce chillies, (v) productivity impacts of family and hired labour by gender; (vi) price transmission and market signals from consumers to producers; and (vii) the influence of on-farm and off-farm income**.**

The shallot household survey

Like the chilli survey, the shallot households represent a unique panel data set. The first survey includes 700 shallot producing households from 2011. For this project, the team re-interviewed 526 of those same households in 2016. The farm households are shallot producers from the Brebes District of Central Java Province. Brebes is one of the most important shallot production areas in Indonesia.

The 2011 and 2016 surveys included separate interviews with both the female and male household heads. The survey instruments used a structured questionnaire covering: household composition; personal and farm assets; land ownership and tenure categories; all agriculture crops produced during a 12 month period; seed choice and related technology and market channel choices; management and production practices by seed variety; market opportunities for different seeds; on-farm and off-farm sources of household income; and variables related to trade relationships between farmers and their shallot buyers.

The 2016 data set also provides additional cross-sectional data allowing the research team to model the demand for male and female labour, testing if the two demand functions are identical, and identify unique factors influencing the demand of one but not the other; examine differences in motivations and selling arrangements for farmers using *tebasan* practices (selling shallots in the ground to buyers just before harvest); understand what influences decisions of farmers who sell after harvest and the relative probability of farmers in choosing *tebasan* or post-harvest shallots; and explore resource allocation efficiency by scale and gender management.

Preparation for the household interviews included literature reviews, mapping the shallot supply chain, interviews with key experts, focus groups with farmer groups, women's groups, traders and local community leaders.

The project team collected the data sets to support the shallot seed choice analysis:

- Shallot seedling and variety choice in Indonesia
- Where do shallot producers source their seedlings
- Shallot variety adoption over time
- How high shallot seed costs influence tebasan practices
- Gender implications of shallot management strategies
- Asymmetry in farm-wholesale-retail price shallot transmission
- Targeting programs to enhance shallot productivity and profits
- Making use of land markets to improve shallot production
- The 2016 shallot survey income and land ownership structure
- How do producers obtain information on shallot management?
- Post-harvest and marketing practices
- Village level data on populations, land area, public infrastructure;
- Gendered labor counts for each phase of production (hired and household sources);
- Quantity measurements for every input for the most recent completed cycle;
- Yield measured in three different ways (per bush, per plot, total revenue and average price);
- Selling arrangement in each shallot plot with information on products composition (fresh shallot and shallot seeds)
- Documentation of disease, erosion, and flooding on each plot

Understanding how households make crop management decisions is highly relevant to Indonesia's current horticultural program initiatives. Shallot producing households around Brebes, for example, are constantly making decisions on which crops to plant, which varieties to choose, which seeds to use, how much labour to hire, the quantity of inputs to apply, and where to sell their output. These choices, and who makes them, impacts resource allocation, farm income, food security and the productivity increases required to close the wide yield gaps required to meet shallot production targets set by the Ministry of Agriculture.

Horticultural households on Java tend to have access to less than 0.5 ha, they earn a significant share of their total income from off-farm sources, and each of their crops are commonly managed jointly by both spouses. The household data from the chilli, shallot and citrus surveys suggest that the spousal contributions to specific crop activities vary widely across households.

The mango household survey

The project analyses of mango farms are also based on two sets of household surveys. The first was in 2011 of 404 mango farms and 150 "sprayer-traders" in East Java

and West Java. The West Java sample of about 200 was resurveyed in 2017 along with 260 mango seedling nurseries.

The original survey selected the Indonesia's two leading mango provinces, West Java and East Java, which accounted for two-thirds of national mango production in 2008. For the 2016 survey we only used the West Java sample because we wanted to pair the farm survey with a mango seedlings nursery survey. Unlike the citrus and shallots seed chains, nurseries are increasingly common in Indonesia.

In each of the two provinces, the project team selected two districts. One district is the leading and the other is the second ranked in terms of total mango volume. In each district, we selected three sub-districts based on the total number of trees in the districts (per BPS census) and their progressive distance from the province main highway. Total number of trees was used rather than mango output as there were no official data on volumes. Moreover, we could not use market channel orientation of a district or sub-district as a criterion because there were no available secondary data.

In each sub-district, we randomly selected four villages. Using the BPS census of mango farms per village and the number of trees owned by each grower, we created three universes per village by farm size strata in terms of number of trees (the marginal, small, and medium strata). We sampled from these three strata to study variation over farms in the various farm size strata. This makes the study representative in terms of market volumes of the various strata.

The shares for each size class represent the size stratum's share in the total number of trees in the areas of the provinces (not the share of that size class in the total mango farmer population). Our sampling is thus: 40% marginal farmers, who have 40% of the trees in the census areas; 40% from the 'small' stratum; 20% from the medium stratum. Marginal farmers have 4–10 trees, small, 11–100 trees, and medium, more than 100 trees. In our study, we excluded large mango farms that usually have more than 1000 trees because it is usually run as company/enterprise rather than individual ownership. There are very few such farms in the study areas.

To gain a preliminary view of the mango farmers' acquisition of seedlings and the nursery sector, a rapid reconnaissance was undertaken in December 2016 in West Java. A rapid reconnaissance in East Java suggested the nursery sector much less developed. The rapid reconnaissance revealed that in our study area has emerged a large cluster of mango seedling nurseries particular in Majalengka, supplying that area and Cirebon and other areas all around Java and into other islands in Indonesia. Based on international experience and literature, this is a major indicator of the emerging modernization of the mango sector in Indonesia. We undertook two surveys of these zones, a household survey and a mango nurseries survey.

The project team collected the data sets to support the mango seed choice analysis:

- The transformation of mango seedling and variety choice in Indonesia
- Variety diversification among mango farmers in west and east java
- Sources of mango seedlings in west and east java
- How do mango farmers obtain information on variety and seedlings?
- Converting land conversions to mango production
- Fertilizer and chemical input use in mango farming
- How do mango farmers obtain information on mango management?
- Post-harvest and marketing practices

The citrus household surveys

Citrus is the only horticultural crop of interest to the project which did not have a baseline survey. The citrus household survey was designed from scratch using multistage random sampling process to interview a sample of 500 citrus hh in East Java province. To be included in the survey, a citrus farmer is defined as a household managing more than 25 citrus trees, following the minimum business unit for citrus used by the Indonesian Statistic Agency (BPS).

The selection of districts to sample was based on production levels in East Java based on BPS data. East Java is selected because it is Indonesia's largest citrus producing province. Banyuwangi, Jember and Malang districts were purposely chosen based on the number of producers, the rapid expansion of citrus and the variation in climate risk characteristics. The sub-districts were selected through random sampling. In each of the three sub-districts, three villages were selected randomly. Village level citrus farmers were also selected randomly.

A structured questionnaire was developed by the project team with support from local experts at ICHORD's office. The questionnaire development followed a process beginning with a literature review, key informant interviews with citrus scientists, traders, retailers, nursery managers, growers, distributors, and academics. The key informant interviews shaped the context for focus groups with male and female citrus producers, traders and village leaders. This information helped to shape the survey instrument which was tested at various stages over time.

Of special interest to the ICHORD is understanding how hh used seed choices to grapple with *Citrus Vein Phloem Degeneration* (CVPD), a disease prevalent across Indonesia. One factor that contributes to the spread of CVPD is the use of uncertified seeds. The certification is for disease free plants. Citrus seedling variety choice is a key component of farm profitability over the long-term, with certified seedling varieties more available throughout Indonesia in recent years. However, the adoption rate of certified seedling varieties in East Java is unknown but thought to be quite low.

Given the long-lived nature of citrus crops and climate uncertainty, ICHORD is interested in more empirical data to understand what is influencing citrus seedling choices between certified and non-certified and the role of climate risks. To help ICHORD find answers to these questions the citrus study c carried out structured field experiments with the male and female producer households to measure risk and time preference, subjective beliefs of yield, and climate risk perception among Indonesian citrus farmers. The results demonstrate that subjective belief and climate risk perception contribute to the farmers' decision of using certified seedling, while the risk and time preferences showed an insignificant association. Even though the certified seedling is not designed to adapt to certain climate shocks, our finding suggests that farmers choose seedling based on their climate risk perception.

The survey instrument covers demographic information, housing and assets, social capital, agricultural practices (input and labour use), marketing behaviour, household income, information sources, husband and wife dynamics of their involvements and responsibilities in citrus farming, climate risk perception, and climate change adaptation practices. The survey also included the experiment to obtain the farmers risk and time preferences, both for husband and wife.

The questionnaire was designed for 'tablet use' with the CommCare software application. CommCare is an open source platform for electronic questionnaire that offers the effectiveness and efficiency for survey data collection and data management. The result is 1000 surveys from 500 citrus producing households, with both male and female heads interviewed.

The project team collected the data sets to support the seed choice analysis:

- Citrus seedling and variety choice
- Citrus seed procurement channels
- Citrus variety adoption over time
- How do citrus farmers obtain information on varieties?
- How seed and variety choice influence pesticide and fertiliser use
- Gender implications of seed and variety choice
- How does household risk influence seedling and variety choice?
- How producer time preferences influence certified seed choices?
- Gender roles and productivity outcomes among citrus producers
- How do farmers obtain information on citrus management?
- The 2016 citrus survey income and land ownership structure

Objective 3: Develop practical 'working linkages' between the public policy sectors, FFV industry associations and the academic community to encourage knowledge development, policy dialogue and industry advocacy in ways that benefit small producers.

The aim of Objective 3 is to establish a discussion network between agribusiness (seed companies), university academics and the MoA policy community. The project used the agribusiness forums in three ways. First, to establish priority issues with horticultural seed chains in chillies, shallots, mangoes and citrus. Second, to review and comment on the reports and studies. Third, to recommend ways to engage and communicate the results and lessons to the appropriate agribusiness networks.

Objective 4: Build empirical research capacity and outreach programs to better inform policy discussions and project design for improving smallholder engagement.

Objective 4 focuses specifically on building ICHORD's plant breeding staff's (and field extension) research capacity to identify key constraints and opportunities in seed value chains, evaluate upgrading options, and provide tools and strategies for development change. The capacity building objective aims to enhance skills allowing staff to answer the following types of research questions:

a) How can seed and, more generally, horticultural value chains be identified as an organizational and functional network of connected actors and evaluated for their pro-poor development performance?
b) What are the key market failures that constrain seed markets and the adoption of new technologies and management practices?
c) What are the effects of new or changing industry strategies and structures in the FFV input markets for smallholders and specific groups, eg, women?
d) What is the impact of government programs and policies on access to high quality seed and how does the operation of value chains shape their impact?

e) How are the government and private sectors able to respond (through policies, investment programs, infrastructure and regulations) to better enable the delivery of producer's seed requirements?

The capacity building activities included providing Indonesian staff with skills to: (i) define criteria and justify the value chain for analysis, measure its performance, and evaluate the benefits and costs associated with upgrading options; (ii) identify opportunities and mechanisms for smallholders to benefit from the growth in demand for high-value horticultural products and access the available retail structures, including modern retail chains; and (iii) foster institutional and infrastructure innovations to generate equitable and sustainable benefits to value chain actors, including the mitigation and management of risk. The capacity building proceeded in four phases.

Phase 1: Methodology Training Workshop for Project Participants

a) The project team organized and managed a training workshop for project participants
b) Participants worked with mentors to develop a research method.
c) Participants received feedback from mentors and trainers to revise proposal report.

Phase 2: Participative Study Design

a) Participants worked with mentors to develop interview guides and sampling grids.
b) Participants wrote the research objectives, questions, and methodology in a formal research project proposal that was reviewed by mentors and project leaders.

Phase 3: Field Training Exercises

a) Participants organized and conducted interviews/focus groups in the study sites.
b) Mentors provided guidance and supervision in conducting fieldwork.

Phase 4: Synthesis & Report Writing

a) Participants debriefed and synthesized critical information to present in a final report
b) Participants collaborated in writing and editing the report.
c) Feedback was given by mentors and project leaders.

Eight IPB staff and four ICHORD staff were recruited to participate in the project. The first training workshop successfully provided project participants with material on value-chain research methods. Workshop participants reported high learning outcomes for each of the training modules. The project produced a Value Chain Training Manual (in English and Bahasa) for use by IPB and ICHORD in future training seminars.

As a result of the training workshops and the guidance of mentors, project participants were able to produce: (1) research proposals that outlined research objectives and detailed methods to be used in the field; (2) data generated from interviews of value-chain actors in the field, and; (3) case study reports on four different horticulture value chains in Indonesia.

6 Achievements against activities and outputs/milestones

Objective 1: To assess the progress of interventions designed to improve chilli, citrus, mango and shallot seed value chains.

no.	activity	outputs/ milestones	completion date	comments
1.1	Inventory and review donor, government, supermarket and NGO projects and programs promoting horticulture seed market development in Indonesia over the past 10 years.	Project Report Value Chain Projects and Seed Regulation Initiatives Study	Value Chain report completed in Aug 2014. Additional seed report materials added in 2016.	Initial paper completed for 'non-seed review' before the variation to the project. Additional sections added to review seed chain policies. Major analytical work added to assess impacts on seeds from FDI restrictions.
1.2	Conduct key informant interviews and desk studies to analyse existing evaluations/data of projects and policies identified in Activity 1.1.	The outputs of these studies are included in the four Field Note Reports. Workshops and agribusiness forum reports.	Aug 2014 Additional work in 2015/16.	The 2014-2015 annual report varies the project to a seed study inventory, focus on shallots, citrus, mangoes and chillies, not all horticultural seed programs. Literature reviews, workshops with private sector seed companies and ICHORD project evaluation staff uncovered very few seed specific evaluations. Output report 1.1 can be amended to include seed specific programs and studies for the four project commodities.
1.3	Interview key companies to assess private sector seed value chain initiatives, identifying constraints and issues to investment.		Chilli Jul 2016. Shallot Dec 2016. Citrus April 2017. Mango Sep 2017.	ICHORD staff, private company and field work suggested that much of the 'seed chain' is controlled by ICHORD and private seed companies (ie, a very common characterisation of seed chains includes 7 stages or chains: Stage 1 Variety R&D, Stage 2 Variety Selection/Breeding, Stage 3 Breeder Seed Selection and Maintenance, Stage 4 Foundation Seed Production, and Stage 5 Quality Seed Production, Stage 6 Distribution, extension, marketing (including small and medium seed and seedling producers/retailers and Stage 7 Consumer selection. For major horticultural crops, BSI and East West control 75% of the market and manage Stages 1 through 6. ICHORD is dominant in mangoes and citrus. The majority of the work on this project focused on gathering relevant information for the household survey. BSI and East-West presented The reports will highlight the key issues of interest to ICHORD and the private companies: (i) the use of certified seeds, (ii) the varieties used, (iii) farmer seed procurement sources; (iv) the technologies used and (v) how farmers selection and procurement of seeds varies by income and land size strata.

1.4	Conduct field trips to sites identified in desk studies and key informant interviews to validate and compare to local seed chain issues.	Workshop reports and These activities are scheduled from Dec 2015 to Dec 2016	Chilli, May 2016. Shallot Sept 2016. Citrus March 2017. Mangoes Aug 2017.	Fieldwork in shallots, mangoes and chillies focuses on previous household survey areas. Initial citrus work is in East Java.
1.5	Map and link potential policy, project or private sector seed company initiatives to smallholder chain outcomes to prepare appropriate seed chain case studies.	Four Reports: (i) Horticultural Policy Intervention and Sector Growth (ii) Horticultural Policy Impacts on Trade Study (iii) Horticultural Policy Intervention on Production and Market Systems (iv) Horticultural Policy Intervention Impacts on Competitiveness	Expert workshops and reports completed during 2016/17.	Report addressing the Impacts of Indonesia's Horticulture Sector resulting from FDI completed. Case study report on the Impact of the Horticulture Laws on Production Efficiency and Trade completed. Case study report on the Production and Marketing Systems of Horticultural Seeds in Indonesia, includes case studies of shallots and chillies. Case study report on Competitiveness, Innovation and Output Prices addressing how innovation and impact seed chains from horticultural rules on FDI and market concentration issues
1.6	Design interviews for each value chain segment along the seed chain to prepare 'case studies,' mapping chain segments between seed breeders, foundation seed producers and certified seed retailers as well as suppliers and chains for non-certified seeds.	Field reports completed for chillies, shallots, mangoes and citrus.	Completed during 2016 and 2017 in sequence: chillies, shallots, mangoes and citrus.	Fieldwork, interviews and focus groups carried for shallots, mangoes and chillies in previous survey sites. ICHORD, BSI Seeds and East-West Seeds provided the details for chillies and shallots, as they combine for 95% of the market share for the first 6 stages of the seed chain. Chilli and shallot producers in our HH survey do not use nurseries. We did interview nurseries in the field studies.

PC = partner country, A = Australia

Objective 2: To examine the patterns, determinants and effects of smallholder participation in seed markets, documenting project and policy lessons on how to address constraints to improve adoption of hybrid/certified seeds for in chilli, citrus, mango and shallot value chains.

…

no.	activity	outputs/ milestones	completion date	comments
2.1	Fields trips to villages and districts to assess the validity of using previous ACIAR household surveys to create panel data sets for chillies, shallots and mangoes.	Field trip reports on sample design	Chilli Dec 2015. Shallots Aug 2016. Mangoes Dec 2016. Citrus Mar 2017	

2.2	Undertake key informant field studies for each of the four seed chains to identify hypotheses and issues for developing community level and household survey instrument.	Field reports with key issues for household survey design and semi-structured seed chain interviews.	Chilli Apr 2016. Shallots Sep 2016. Mangoes Mar 2017. Citrus Aug 2017	
2.3	Workshop to incorporate information from 2.2 into survey design and new questionnaire modules for seed markets and for gender roles.	Final HH survey prepared.	Chilli Apr 2016. Shallots Sep 2016. Mangoes Mar 2017. Citrus Aug 2017	
2.4	Enumerator training using tablets for panel surveys of chillies, shallots and mangoes and random household survey for citrus.	Tablet programmed with HH survey incorporating all pre-tests.	Chilli Apr 2016. Shallots Sep 2016. Mangoes Mar 2017. Citrus Aug 2017	
2.5	Data entry, analysis, and report writing from 2.4-2.5	Reports on HH survey, 3 articles per HH survey.	All data cleaning completed by November 2017	Multiple studies underway, including work by three Indonesian PhD students, one Thai PhD student and one Pakistani PhD student. Chilli panel data, 2011 and 2016, 1012 interviews from 506 households (separate interviews with male and female household heads). The shallot panel data includes 526 households interviewed in 2011 and 2016. Both male and female household heads were interviewed for a total of 1052 surveys. The mango data includes 200 farm households in 2009 and 2017 in West Java, and 200 farms in 2009. Plus survey of mango nurseries. Citrus survey in 2017, 1000 interviews with male and females household heads from 500 households.
2.6	Complete seed chain case studies based on semi-structured interviews and insights from HH survey.		More than 30 research briefs completed.	The short research briefs were not originally planned. The MoA policy unit and East-West Seeds requested short policy briefs, focussing on parts of the chain and specific issues rather than longer working papers. See list in Appendix.

2.7	Team conference presenting results from 2.4-2.6 to stakeholders	Conference papers	Multiple conference presentations from 2016-2019.	Two Indonesian Agricultural Economics Conferences. Two invited sessions, four papers (2016 and 2017) Three AARES conferences, 9 papers accepted 2017, 2018, 2019). One invited speaker at International Horticultural Society Conference (2018)

PC = partner country, A = Australia

Objective 3: To develop practical 'working linkages' between the public policy sectors, FFV industry associations and the academic community to encourage knowledge development, policy dialogue and industry advocacy in ways that benefit small producers.

no.	activity	outputs/ milestones	completion date	comments
3.1	Organize 2 half-day workshops to identify networking opportunities, highlight project activities and determine capacity gaps.	Organised 3 workshops per years from 2016 to 2108.	Through the end of the project.	seed companies, Indonesian Chamber of Commerce (Kadin), agribusiness firms, donors, NGOs, industry bodies, agricultural scientists and key government agencies
3.2	Hold individual (one-on-one) workshops with seed businesses to nurture project relationships, share outcomes of successful seed value	Field reports with key issues for household survey design and semi-structured seed chain interviews.	Over time during 2016, 2017 and 2018.	Collaborating contacts and established work plans with seed companies and industry bodies during 2016.
3.3	Design and conduct bi-annual agricultural business symposiums involving IPB, the agricultural science research community, policy forums with seed companies, government agencies and related stakeholders.	Symposiums and workshop reports.	Completed two per year in 2016, 2017, 2018.	
3.4	Organise one regional conference in each case study site to present project outcomes and promote lasting collaboration between	Carried out two workshops in each of the 3 ICHORD regional workshops, one to introduce project and one to discuss results.	Final workshop in November 2018.	
3.5	Establish collaboration with plant and post-harvest research community, linking project outcomes and identifying approaches to	Collaboration with science research community at IPB and involved ICHORD staff from all regional offices, including	Final workshop and conference with plant breeders in November 2018.	The final two workshops, one with ICHORD and one with East-West Seeds focused on introducing Dr. Stephen Harper, to our project networks and results. Dr Harper manages a 6 year chilli and shallot project, Sustainable productivity improvements in allium and solanaceous vegetable crops in Indonesia and sub-tropical Australia

Objective 2: To build empirical research capacity and outreach programs to better inform policy discussions and project design for improving smallholder engagement.

no.	activity	outputs/ milestones	completion date	comments
4.1	Select and train 4 ICHORD staff on how to prepare, design and carry out research proposals for 4 value chain case studies followed by	Training reports and evaluations.	Training workshops in Nov 2014, Aug 2015.	
4.2	Participating teams prepare 4 value chain case studies under supervision and participate with teams on seed value chain case studies.	Four value chain reports, mango, shallot, banana and citrus.	Four case study proposals completed by Dec 2015 and the 4 seed chain studies by Dec 2017.	
4.3	Train and mentor ICHORD and BTPT staff train for designing HH surveys and seed chain case studies.	Training report and evaluation.	Chilli Apr 2016. Shallots Sep 2016. Mangoes Mar 2017. Citrus Aug 2017	
4.4	Produce policy briefs and related communication resources based on project's research and case studies to influence and improve project and development outcomes for Indonesia's agricultural sector.	Research briefs.	Research briefs completed during 2018.	The policy briefs were shifted to research briefs. The project completed more than 30 research briefs. See list in appendix.
4.5	Produce at least 4 'Harvard Business School' style case studies for Indonesian and Australia University curricula, identifying policy and project implications.	Incomplete	Incomplete	The case studies for universities was pushed back to a low priority and has not been done.
4.6	Identify and document gaps for future research, development and capability building.	Final report	Final report, March 2019.	

7 Key results and discussion

Chillies, shallots, mangoes and citrus play a variety of roles in Indonesia's food systems. Perhaps unique to Indonesia, chillies and shallots are regarded as a staple food, iconic ingredients in Indonesian cuisine consumed daily at almost every meal and snack. More than 90% of chillies and shallots are purchased fresh every day, served in sambals, added to dishes or used as spicy flavourings served on the side. Shallots and chillies are such a widespread, common consumer purchase that they are included in the country's consumer price index formula.

Key results for Chilli and shallot

Chilli and shallot per capita consumption grows year after year. Indonesia is one of the highest per capita consuming nations on the planet of both products. Situngkir, et al, (2016) highlight how chillies and shallots are part of more than half of all Indonesian, recipes throughout the country. Sambals with chillies and shallots are served with virtually all vegetable, fish and meat dishes.

Chillies in particular are an important cash crop for millions of farmers who often produce multiple chilli crops each year. Unlike many other horticultural crops, chilli plants produce over an extended harvesting period, allowing households to pick and sell multiple times over several weeks. The multiple harvests can act as a cash flow system to support household needs, providing a risk and security hedge.

Chilli producers are able to shift from producing a standard variety chilli selling into the spot market where it is assessed and valued on quantity to producing special varieties and differentiated grades valued for their size, freshness, colour and appearance. Overtime, growers can incorporate a wider range of characteristics related to production processes, initiate traceability systems along the supply chain, establish record keeping practices, and implement risk and quality control structures.

Shallots are also an important cash crop for small farm households. Shallots can be profitable in both the rainy and dry seasons. Planted as seedlings their short harvest cycle allows them to be quickly and easily rotated into any crop production cycle. Shallots are a consistent source of wage income for landless households. Shallot producers hire much more labour per ha than they hire when producing rice, providing more jobs and more income for both male and female workers.

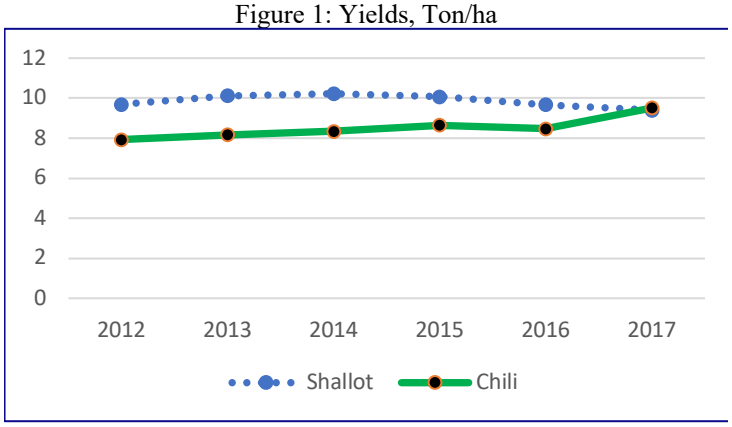
Chillies and shallots present rural development opportunities as Indonesia's rapid income and urban transformation presents horticultural farmers with new and potentially more profitable participation in modernising value chains. As producers and emerging downstream agribusinesses develop collaborative chains and build stronger links with consumer markets, they all move up the value ladder together.

One policy dilemma facing the Ministry of Agriculture, and a key focus of this project is the trade-off between expanding chilli production and shrinking staple food production. On the one hand, participating in higher value horticultural chains, like chillies, present opportunities for small holders to capture greater benefits from Indonesia's high-growth economy that has eluded them in the past.

On the other hand, horticulture area expansion may result in less area planted to important staple crops, conflicting with major policy initiatives. BPS reports national

average chilli and shallots yields are relatively flatlined, well below their potential output levels.

Figure 1: Yields, Ton/ha

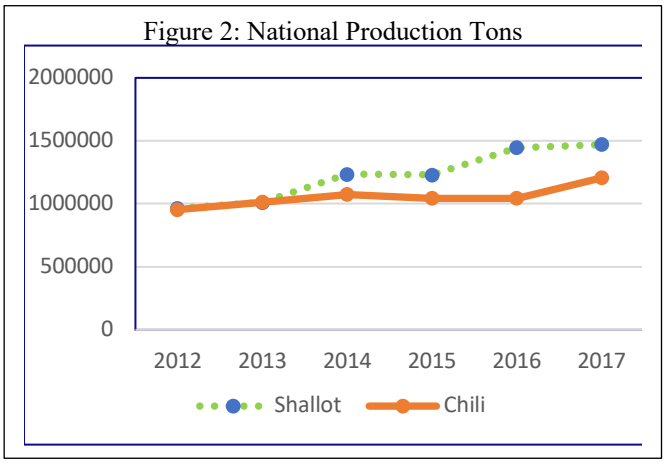


The Ministry of Agriculture consistently provides training to encourage and assist farmers to adopt certified, high-yielding varieties, to prevent diseases and reduce pests, to grapple with increasingly unpredictable weather and volatile market prices and to seek more profitable markets and value chains.

As farmers expand chilli production and join more profitable value chains, they use more labour per ha, demand more specialised services, invest in more productive assets and drive up real wages in local communities. Higher on-farm and off-farm incomes leads to improved food security, allows families to keep their children in school longer, spend money in local economies and slow rural to urban migration.

For this reason, the Ministry of Agriculture focusses research programs aimed at identifying, developing and promoting higher yielding seed varieties, and the training and extension efforts necessary to teach producers how to grow the new higher yielding varieties.

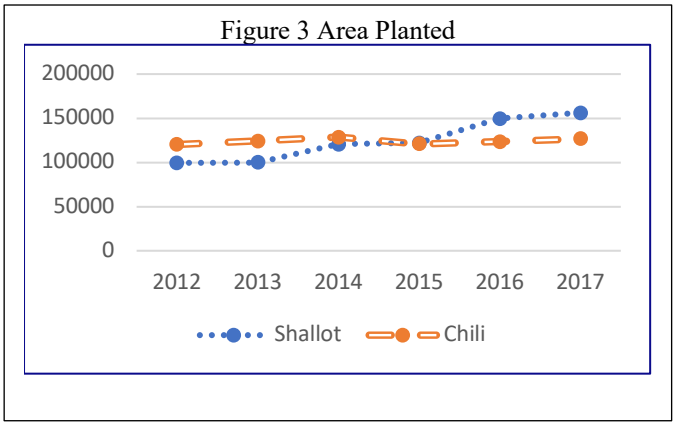
Figure 2: National Production Tons



However, to date, as demonstrated in Figures 1, 2 and 3, productivity is lagging. Between 2012 and 2017, chilli area expanded by 5% and shallot area by 9%. During this same five-year period, productivity increased by 4% in chillies and actually fell by 0.5% in shallots. Chilli and shallot yields are among the lowest in Southeast Asia.

The research presented in this project contributes to the analysis of understanding what choices farm households make in planting more productive, higher yielding hybrid and certified seeds.

Figure 3 Area Planted



The results highlighted in this final report draw on empirical findings from more 2000 households farm interviews (chili 526, mango 400, shallot 531 and citrus 500). Respondents include both male and

female household heads with questions focusing on seed choices made by households, the determinants of those choices and the implications. The issues and characteristics covered include: (i) household income and resource ownership structure, (ii) variety choice, management practices and yields by size of holding; (iii) whether and why farm households select certified, hybrid varieties; (iv) productivity impacts of family and hired labour by gender; (v) price transmission and market signals from consumers to producers; and (vii) the influence of on-farm and off-farm income.

The initial aim of the project variation in 2015 was to focus on seed chain analysis using chilli, shallot and mango households from the previous an ACIAR project with IFPRI. We had an existing set of 1500 household interviews from 2011 that looked at the chain downstream from the farm to the food retailer. The aim for this project as to examine upstream from the farm household to analyse the seed chain and other inputs.

The project's early working papers produced for Objective 1 are based on interviews and focus groups with seed companies, ICHORD seed breeders and relevant literature. This information provided a range of seed chain models for chillies, shallots, mangoes and citrus. One of our first project working paper titled, *How Horticultural Policy and Regulatory Interventions Impact Production and Marketing Systems*, examines 6 different chains for chillies and shallots, along with how these models encourage or discourage certified and non-certified seeds (the key issue for ICHORD).

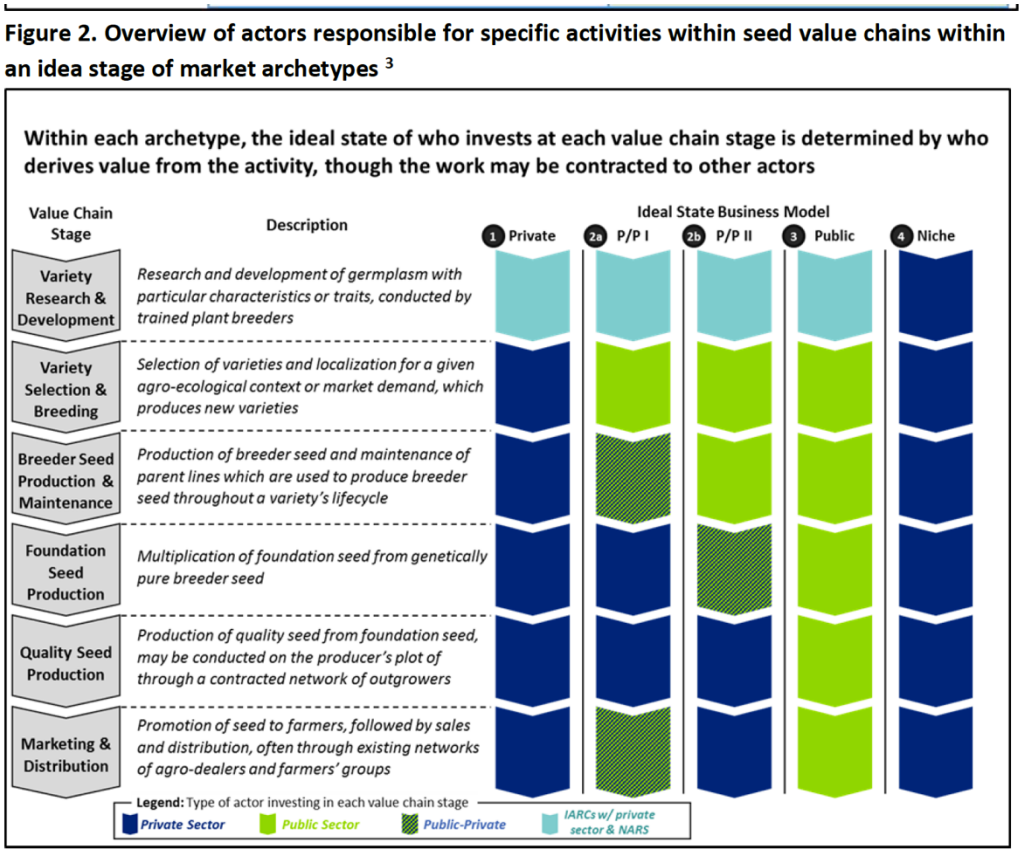
The framework we discussed and used in these early workshops come from Lion et al 2015 and is presented below in Figure 2. More than 5 small and medium sized seed companies participated along with the two dominate firms in attendance, BSI and East West. This framework is discussed in another project working paper, *Policy Initiatives and Regulations in Seed Chains.*

In our chilli field level key informant interviews and focus groups and in our interviews and workshops with seed company executives it became clear that all these seed chain links from the Variety, Research and Development to Marketing and Distribution are carried out by either ICHORD (with university support) or by the major horticultural seed companies. The small and medium companies use different business model and are selective with their seeds, few produce chilli or shallot seeds. For chillies and shallots two large seed companies dominate, managing all six links in figure 2. For citrus and mangoes, it is ICHORD.

We did learn from the field work that nurseries and traders might potentially play a role in all four of our target chains. The nurseries take either certified hybrid seeds or open pollinated seeds and raise them to seedlings to sell for transplanting. However, nurseries played no role in the chilli or shallot households we surveyed.

In summary, we learned that large seed chains dominate the following parts of the chain and ICHROD plays a similar role: (i) managing plant genetic resources; (ii) developing new varieties (i.e., the process of breeding and selection of new varieties, including the testing of varieties within different agricultural ecosystems for different horticultural groups; (iii) producing breeder seeds and early generation seeds; (iv) multiplying the early generation seeds into the certified, high quality horticultural seeds; and (v) marketing, disseminating and agronomic advise about the use of seeds in specific agricultural landscapes.

Figure 4: Seed Chain



For example, the framework for the chilli seed chain for chillies study began as shown in Figure 5.

Figure 5: Anticipated seed chain field work

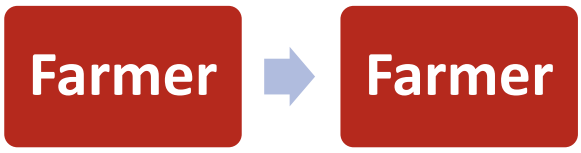
The small and medium size private sector seed companies are less able to provide such comprehensive services. For the public sector, ICHORD is designated to produce superior varieties of chilli and shallot seeds and support appropriate production technologies. The Provincial Agriculture Offices manage and control seed certification, seed distribution and seed control. In the past, ICHORD has not been responsible for the dissemination and distribution of Foundation Seeds and Stock Seeds. This lack of connection helps explain why relatively few of ICHORD's important seed varieties are adopted in the same proportions as private sector companies.

What we learned from the chilli household survey is that for 99.5 % of the households the chains look like:

The key results from the project's household survey for chillies related to seed choices are:

(i) 75% of the households buy chilli seed packets from input stores;
(ii) on average each household buy 4 packets of seeds paying IRD 109,000 per pack;
(iii) the other 25% of households used seeds saved from the previous harvest;
(iv) all of the households manage their own seedling beds, they do not purchase seedlings from nurseries;
(v) 95% of the farmers purchase chilli seed packets from either BISI or East West produced varieties, and 3% buy seed packets from varieties from BALITSA (government) produced varieties;
(vi) seed costs represent around 2% of total input costs; (vii) a major factor inhibiting farmers from not purchasing hybrid seed packets is labour costs. The higher yields from hybrid seeds require on average 89 more labour days per ha due to harvesting time for the increased yields.

For 100% shallot household survey, the seed chain looks like this:



The key results from the project's household survey for shallots related to seed choices are:

(i) none of the households buy or use true shallot seeds, they all plant mini bulbs;
(ii) 100% of the farmers use mini bulbs they save or buy from their neighbours;
(iii) on average, shallot producers save 50% of their production for the next harvest, they purchase their other mini-bulbs from neighbours and other farmers;
(iv) the majority of farmers in our survey sell mini-bulbs to neighbours;
(v) there are no true shallot seed services or mini-bulb chain services used by any of the 500 households in our survey;
(vi) seed costs, including the cost of their own saved mini bulbs represent more than 50% of total input costs.

Key findings are summarised in the Tables 1 for chillies and Table 2 for shallots.

Table 1: Summary of project findings, results and learnings in response to government and private sector issues.
Chilli

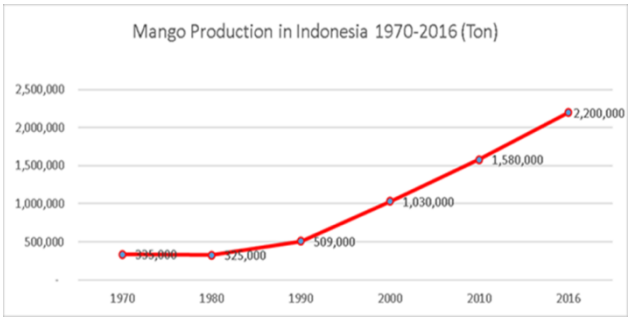
	Certified seed used by farmers?	Varieties by farmers: beyond commodity into differentiated products?	Seed procurement by farmer from certified?	Product sold to modernizing market by farmer?	Intensification technologies used by farmers?	How answers differ by strata/assets?
Key findings counters local wisdom	(i)Validated conventional wisdom: high certified seed use: 75% (ii)users of certified seeds demand much more off farm labour for harvesting, mostly female.	(i) differentiation of certified seed variety is extremely high. The 250 chilli producers in 2016 planted more than 45 different hybrid types/varieties during the 12-month period. (ii)found major chilli drop outs in second waves. Identified indicators of who remains vs who drops out includes younger and more educated farmers who are working actively within a cooperative or group.	(i)farmers procure seedling packets, mostly from input stores. Certified includes government's varieties. .	(i)few households sell to modern chains (ii)Break with conventional wisdom is that on average farmers negotiate with 4 traders to sell their chilli harvest and average selling to 2 different traders per harvest (conventional wisdom is no competition).	(i)intensive use of commercial inputs at all farm sizes: fertilisers, pesticides, plastic, irrigation. (ii)an important break with conventional wisdom is the active land markets, chilli produces almost double their land access by renting, borrowing, or sharecropping (iii) active land rental markets present a huge opportunity to scale up the 20% of larger farms who already account for more than 60% of production;	(i) Little variation in chemical/input use per ha. smallest to largest. (ii)highly skewed land and income distribution of chilli producers: 25% of households, (medium sized land owners with 1.6 ha average) control 65% of the crop land; (iii) the smallest quartile of producers has access to a total 6 ha between them (149 households) (iv)low average share of chilli income as share of on and off farm income for larger farms, less than 20%; (v)highest income and land-owning households are younger and completed 30% more formal education than other households;
Gender new knowledge	(i) certified seed producers hire substantially more off-farm female labour than non-certified	(i)less than 25% of females have ever receive any training or extension while more than 60% of males receive training		(i)biggest surprise to government officials is the high share of females in key decision-making roles negotiating with traders; - - more than 50% of females either sole or jointly responsible	(ii) very high proportion of decision-making roles of female household heads across the 16 individual chilli management activities;	(i)female household heads in highest income and land strata (quartile) have 30% more education that lowest strata

Table 2. Summary of project findings, results and learnings in response to government and private sector issues. Shallots						
	1. Certified seed used by farmers?	**2. Varieties by farmers: beyond commodity into differentiated products?**	**3. Seed procurement by farmer from certified?**	**4. Product sold to modernizing market by farmer?**	**5.Intensification technologies used by farmers?**	**6. How answers differ by strata/assets?**
Key findings counters local wisdom	(i)Zero use of certified seeds in 2016 survey. (ii)much larger share of seeds are saved for future plantings than recognized and acknowledged by government extension field officers (more than 25% of crop saved for next planting)	(i)Dominated by one long used variety. Only 2 of 500 growers used the true shallot seed variety and that was in the 2011 survey. (ii)the government provides import licenses for seed/consumption imports). Granting licensing is rare, difficult to obtain. (iv) focus group studies show imported seeds yields are more than 50% lower with lower production costs compared with local seed systems	(i)Save high share of crop as seeds (mini bulbs) or purchase from neighbours. (ii)the extremely high seed costs (more than 50% of total input and labour costs) mean farmers use seasonal and pre-harvest sales strategies to mitigate costs.	(i)Low in both survey waves. (ii)difference with conventional wisdom is that on average shallot farmers negotiate with 6 traders to sell their shallot harvest and average selling to 2 different traders during the 12-month period (conventional wisdom is no competition).	(i)Similar use of chemicals by large and small. (ii)the smallest income quartile of shallot producers has access to a total 12 ha between them with and an average holding of 0.14 ha vs 1.6 ha ave for the highest income quartile.	(i)Lower income and lower land access means less pre-harvest sales - - tebasan. (ii)big break with conventional wisdom-the highest income households are much larger users of tebasan, using it 30% more than lower income groups (iii)cash profit is 15% higher on average for producers practicing tebasan. - - a second major break with conventional wisdom. (iv)net implied profit (implied value of saved seeds) means producers not using tebasan have 20% higher profit. (v)like chilli, land and income distribution are highly skewed, for shallot farmers: the largest quartile of land owners account for more than 60% of production;
Gender new knowledge	(i)less than 20% of females receive any agricultural training or extension, more than 60% of males receive training.	.		(ii)the biggest surprise to government officials is that 75% of female household heads are solely or jointly responsible for negotiating sales and tebasan with traders;	(i) more than 60% of female heads are solely or jointly responsible for managing input purchases, sorting and grading shallots, planting and transferring seedlings, harvesting and fertilizing;	Education levels and participation in coops, groups and resources vary for females across income and land size quartiles.

Key Results for Mango and Citrus

Mango

Mango is an important fruit in Indonesia, in volume the top fruit after banana, and a government priority fruit. Mango production grew slowly before 1990 and then much more rapidly. To explore the mango seedling and variety choice, the project re-interviewed producers on Java from a 2009 household survey. and 2017. The results contradicted much of the conventional wisdom of the MoA policy community and extension officers.



The research questions and hypothesis were organsied around what the project team perceive as "conventional wisdom."

For example, one 'Common view' is that the domestic market for mango is limited and the best prospects lie in mango export markets." Our work found that less than 1% of Indonesian mango is exported; 75% of Indonesian mangoes are sold to Indonesian urban consumers and sales inter-island and to supermarkets are emerging.

A second 'common view' is that the mango sector is strongly dominated by marginal or backyard growers (4–10 trees)." Our research found that most (80%) of mango farmers are marginal growers (4-10 trees), but only 40% of Indonesia's mangoes are grown by marginal growers. Small growers (with 11-100 trees) are 19% of growers but produce 40% of the mangoes; and "medium growers" (with more than 100 trees) are but 1% of growers but grow 20% of the mangoes. The mango farm sector is relatively concentrated.

A third 'common view' is that mango farmers mainly use traditional technology, few external inputs. The project found purchased input-led intensification: 30% of producers use growth hormones to extend the season; 75% use fertilizer; and 43% use pesticides. The purchased input us is highly common among small and medium farmers but also the backyard growers.

The fourth 'common view' is that until exports becomes important, Indonesian mango farmers will maintain traditional varieties and Harumanis (the main commodity variety). Our research found that there is substantial variety diversification beyond Harumanis into newer commercial niche varieties, especially in West Java - - less so in East Java; small and medium farms focus on commercial niche varieties in West Java and Harumanis in East Java; even the backyard, marginal farms are growing commercial niche varieties.

The fifth 'common view' is that local Indonesian mango market is dominated by fragmented rural brokers. The research project found that the local, rural brokers have been largely supplanted by urban-based wholesalers buying directly ("modernizing or transition market"). Sprayer-Traders have emerged in particular for the small and medium farmers and for those with high opportunity cost of time (nonfarm income).

The sixth 'common view' is that government seedling provision programs is the main source for farmers' seedlings and private nurseries are a minor source. The research project found in the initial plantings by the farms in the early 1990s, only 8% came from government sources in West Java and 18% in East Java. In the expansion of trees in West

Java from 2010- to 2016, 38% came from government sources. In both provinces the great majority of trees from government sources went to the medium and large mango farmers. By far the most important source of seedlings is private nurseries, purveying more than half the seedlings and used by two-thirds of the farmers.

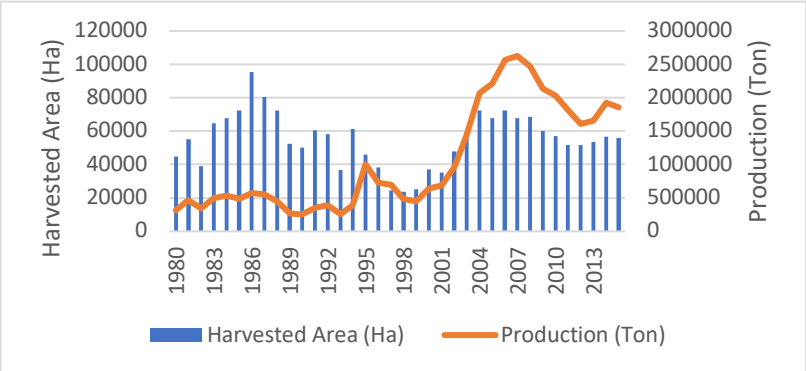
The seventh 'common view' is that mango farmers rely substantially on government extension for information and decisions on mango". The project survey results show that government extension plays a very small role in providing information to or influencing technology or variety decisions of mango farmers. Mango farmers rely by far mainly on friends or themselves for mango growing information.

The eighth 'common view' is that mango farmers started on non-paddy land. The project survey finds that in the 1990s, 50%-70% (in West vs East Java) of the initial plantings of mango trees were from converted paddy land. About 30% in West Java and 10% in East Java of marginal and small farmers' trees were planted on converted hillsides. In the 2010s, trees were mainly added by intensifying on existing orchards.

Citrus

Citrus is one of the most important fruit commodities in Indonesia, among the five largest contributors to national fruit production. Citrus production accounts for around 9% of total national fruit production, with 2016 production 1.8 million. During the period 1980 - 2015 citrus production increased greatly around 2000 before falling by 2008. Total citrus area has declined by about 12% per year over the past decade.

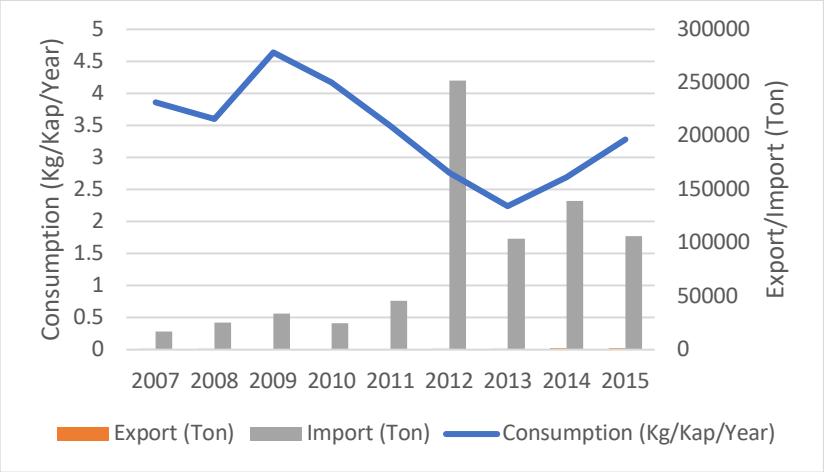
Figure 5. Development of Harvested and Production Area of Citrus 1980-2015



Pusat Data dan Informasi Pertanian (2016)

Citrus consumption, on the other hand, is growing by around 2.6% per year adding to the increases in imports as shown in Figure 6. Beginning in 2016, the MoA has targeted citrus as a priority crop with attention focused on addressing the Citrus Vein Phloem Degeneration (CVPD), a common disease across citrus plantations and farms in Indonesia.

Figure 6: Consumption, Export, and Import of Citrus 2007 – 2015



Source: Pusat Data dan Informasi Pertanian (2016)

The cause of high CVPD attacks is the use of non-certified citrus seeds. Supriyanto and Whittle (1991) explain that the use of healthy seeds is main components of CVPD control. Certified citrus nurseries are needed to solve the problem of citrus greening. Certified budwood programs might be the best way to establish disease-free citrus orchards (Batool et a., 2007). So far, research has focused on technology to deal with CVPD attacks, assembly of resistant diseases, and the importance of using certified citrus seeds.

However, there have not been many studies that examine how the technology can be adopted by the community and the appropriate dissemination strategy so that farmers adopt certified citrus seeds that are only disease free and not disease resistant. There is no incentive to purchase higher cost disease free seedlings when the citrus orchard across the field uses non-certified seeds.

Key findings are summarised in the Tables 3 for mangoes and Table 4 for citrus.

Summary of project findings, results and learnings in response to government and private sector issues. Mango						
Key findings	**Certified seed used by farmers?**	**Varieties by farmers: beyond commodity into differentiated products?**	**Seed procurement by farmer from certified?**	**Product sold to modernising market by farmer?**	**Intensification technologies used by farmers?**	**How answers differ by strata/assets?**
new knowledge counters local wisdom	(i)Very little use by farmers or supply by private nursery	(i)Big diversification beyond harumanis in West Java (iii) substantial variety diversification into newer commercial niche varieties especially among small/medium but also some among backyard	(i)Very little procured from government (ii)private nurseries are the source of non-certified seedlings for 65% of the farmers	(i) Yes, a large share by medium and small size farms, but not backyard. (i) Mango growth driven by domestic market, 1% is exported, 99% is sold to domestic market with 75% of mango output sold to cities; (iii)nurseries shifting from producing/selling harumanis, today the main variety only for 25% of the nurseries ir 2011 it was the main variety in 88% of nurseries	(i)Half use pesticides, hormones, fertilizers, mainly small & medium, not so much backyard	(i)Small and medium farmers most dynamic, less the backyard (ii)output concentrated among small/medium commercial farms "backyard" growers) - small (11-100 trees) growers are 20% of growers but produce 40% of mangoes and medium (more than 100 trees) are 1% of growers but grow 20% of mangoes
Mango additional comments	Market giving price premium for, or government being able to regulate certificate unlikely			Supermarkets but also big wholesalers in towns		

Summary of project findings, results and learnings in response to government and private sector issues. Citrus						
	1. Certified seed used by farmers?	**2. Varieties by farmers: beyond commodity into differentiated products?**	**3. Seed procurement by farmer from certified?**	**4. Product sold to modernizing market by farmer?**	**5.Intensification technologies used by farmers?**	**6. How answers differ by strata/assets?**
Citrus key findings counters local wisdom	(i)low overall average 18% (ii)larger citrus farms (ave 800 trees) plant a much higher share (35%) of disease-free certified seedlings than medium and small producers (iii)certified varieties are disease free not disease resistant. low producer incentives to adopt. (iv)Citrus is expanding rapidly average tree age is 4 years across 500 producers	(i)varies by region/district; very little variety shift. Some replanting from Siam (mandarins 72%) to Keprok (tangerines, 16% -- higher value increasing demand). (ii)the 77% buying non-certified buy for low price and easy to find.	(i)buying from local nurseries (ii)purchase seedlings from large seedling traders (47%) and seedling producers (27	(i)traditional dominates (ii)half of producers sell to traders from their village, less than 1% sell outside of East Java.	(i)higher use of chemicals, fertilisers and flower management by larger producers-30% to 50% of small using and 60 to 80% of large. (ii)70% of producers use traders to harvest and sell by kilo; about one-third using flowering hormones	(i)per tree input costs 4% higher for smallest tree quartile (113 trees ave) vs large producers (863 trees. (ii)32% of large rent in trees, 6% of small rent in. (iii)11% of large citrus producers rent out trees, 2% of small out source (iv)more than 30% of citrus farmers have begun in the past 5 years, encouraged by neighbour's success;
Gender	(i)less than 1.5% of females received any citrus training from any source vs more than 30% males			(i)more than 55% of females participate in negotiating citrus price with buyers, and the females are solely responsible for sells in 30% of households.	(i)female household head labour and decision making is concentrated in weeding, fertilizing and planting	(i)female female labour ave pay IDR 41,000 vs male IDR 61,500 (ii) citrus survey captured climate event risks related to variety choice and citrus management, females differed significantly from males related to water availability timing/shifts in rainy season shifts and the increasing droughts.

Results and Lessons from Assessment of the FDI Restrictions on Seed Companies

During the first agribusiness forum following the project variation, workshop participates from ICHORD, MoA, the World Bank, the Ministry of Trade and the seed companies requested the project to focus analytical attention on Horticulture Law no.13/2010 as part of Objective 1. Among the law's objectives include increasing horticulture production, productivity, quality, value adding, competitiveness and the market share of domestic horticulture relative to imports. Horticultural industries tended to welcome most provisions of the law, except for Article 100 which reduces the maximum foreign ownership cap from 95% to 30%; and Article 131 which allows foreign companies four years to comply with Article 100.

In collaboration with the agribusiness forum partners, the project team developed a series of studies to examine the impact of the Horticulture Law on the development of the horticulture sector in Indonesia focusing on six research questions: (1) horticultural production: what is the impact of the horticulture law on production of the priority horticulture crops, chilli and shallots plus tomatoes?; (2)VC transformation: how will seed production and marketing changes if large seed company relocated or restructure?; (3) competitiveness: will market concentration in the seed market decrease or increase as a result of the horticulture law?; (4) innovativeness: how will private extension and technological transfer be affected by FDI restriction?; (5) prices: what are the impacts of the horticulture law on the output and input prices of the priority horticulture crops (chilli, shallot and tomatoes)?; and (6) trade balance: what kind of trade policies can mitigate the negative impact of the FDI restriction?

The project completed these studies, presenting the results at several workshops and agribusiness forums to obtain feedback. The key results and lessons include:

a) restricting FDI deprives domestic vegetable producers access to best quality seeds with higher sprouting ratios, shorter harvest times, higher outputs and higher profits;
b) restricting FDI tends to limit domestic seed companies access to innovative practices in plant propagation, plant breeding and biochemistry;
c) restricting FDI means the public and private research community may be deprived of access to key intellectual property, innovative technologies, scientific knowledge and training in new research capabilities for Indonesian scientists, public research centres, universities and companies;
d) restricting FDI can result in a less competitive domestic seed industry and lower overall quality and variety of crops, leading to higher horticulture imports and higher prices for Indonesian consumers;
e) foreign seed companies will transfer their capital, research and knowledge to other ASEAN countries that are encouraging foreign investment, public-private partnerships and providing incentives to transfer research and biotechnology knowledge locally (eg, Viet Nam, India.
f) even those countries with the most liberalized seed trade and FDI have high proportions of saved seed relative to replacement seeds. The amount of saved seed depends upon several factors, including type of seed (varietal or hybrid), size of farm, ease of storage, disease and pest complex, and farmer's expertise. Farmers save seed for a variety of reasons, such as low cost, familiarity, performance under local conditions, and preferred attributes other than yield. Farmers purchase new seed from the market if they want to replace their variety or, for instance, the seed stock has deteriorated as a result of contamination.
g) two key horticultural policy issues requiring attention in Indonesia together with the FDI law are: (i) best practice and trade-offs in seed registration procedures and

for seed development and certification systems (Registering seeds is complex and a long process, taking up to 1.5 years in Indonesia. Seeds do not need to be registered in Thailand and the Philippines); and (ii) seed import licensing procedures tend to be bureaucratic, complicated and favour a handful of business who are able to use their licenses to great private advantage.

8 Impacts

8.1 Scientific impacts – now and in 5 years

The research focussed on using empirical evidence to inform policy and project design in ways that encourage more profitable and productive horticultural seed choices by farm households. As such, we do not expect scientific impacts. Information on household constraints to adopting certified hybrid seeds may inform plant breeders on the types of seed traits and attributes acceptable to growers.

The project social science impacts include: (i) one of the largest horticultural farm survey efforts in Asia, with nearly 2000 farms (400 mango, chili 526, shallot 531, citrus 500); (ii) a survey unique to Indonesia of upstream input sources and types; (iii) a rare set of panels of farms of the same households in 2011 and again in 2016 for chillies, shallots and mangoes; (iv) a comparison of two tree crops using the same method (mango and citrus) and two annuals (chili shallot); a full set of female households head interview for all 2000 surveys with gender disaggregated data; (v) detailed view for all four crops of marketing/harvesting including tebasan and market channels, as well as post-harvest handling; (vi) variety detail and variety change; and (vi) detailed information on non-seed inputs (fertilizer, pesticide, hormones) and interaction with market channel.

Surveys of both male and female heads of households is one of the key research methods to address Objective 2, to examine the patterns, determinants and effects of horticultural seed market transformation, documenting how to address constraints to improve adoption of hybrid/certified seeds for chilli, citrus, mango and shallot value chains. All except for the citrus survey are panel surveys, based on the previous ACIAR work.

The survey instruments add a detailed labour module where male and female labour days (hired and family) are collected for every labour activity on the farm from preparation through to harvesting and negotiating sales with traders. Finally, the surveys use tablets to collect and enter data.

8.2 Capacity impacts – now and in 5 years

The project's capacity building approach aimed to strengthen and improve the research abilities of individuals and partner institutions, including the University of Adelaide's Centre for Global Food and Resources. The approach focused on developing research-specific social capital in Indonesia by building organizational capacity at ICHORD and the Agricultural Economics Department at Bogor Agricultural University. The project emphasized research capacity in Australia by enhancing the University of Adelaide's international research networks and training junior staff and masters students in ACIAR projects and applied development research.

In the short-term, most capacity impacts are directly related to Objective 4, including providing research training, mentoring and experience for project staff in value chain research; (2) strengthening the capacity for project partners to use applied research to inform agricultural policy and programs, and; (3) enhancing the abilities of project partners to communicate research outcomes and strengthen working networks among policymakers,

program designers and academic community (linking to Objective 3 and the agribusiness forums).

The Objective 4 capacity building proceeded in four phases: (i) the project carried out a methodology training workshops where participants learned about value-chain research methods; (ii) experienced mentors guided project participants to develop a small value-chain research project to gain experience in research design; (iii) mentors guided participants in conducting interviews to gain field experience; and (iv) project participants drafted case study reports and received feedback on their projects. Eight masters students from Bogor Agricultural University and four 4 ICHORD staff were recruited to participate in the project. The training workshop successfully provided project participants with material on value-chain research methods. Workshop participants reported high learning outcomes for each of the training modules.

As a result of the training workshops and the guidance of mentors, project participants were able to produce: (1) research proposals that outlined research objectives and detailed methods to be used in the field; (2) data generated from interviews of value-chain actors in the field, and; (3) case study reports on four different horticulture value chains in Indonesia.

One important impact of these capacity building efforts is a new organizational research culture at ICHORD and new capacities at Bogor Agricultural University. The project activities enhanced their core capacities to identify, develop, plan, manage and communicate results of large-scale agribusiness research projects. The project strengthened the organizational research culture primarily by focusing on human skills development of their staff.

In the short term, the project's capacity building activities helped strengthen the skills of researchers and staff in four areas. The first area is questionnaire design. Project team researchers worked closely in the design of multi-topic 15-20 page questionnaires to collect information from farmers and seed companies. In addition to the standard modules on crop production and marketing, the questionnaires used in the project incorporated modules to measure the degree of risk aversion, to elicit information on time preference, to measure willingness to pay, and to assess produces attitudes to purchasing more expensive certified, hybrid seeds. This experience will make it easier for the two research institutes to use these tools to explore a wider range of social and economic issues in the future.

The second area is survey sampling. Before the project, ICHORD in particular, relied exclusively on purposive sampling, in which districts, villages, and households are selected based on the judgement of specialists that they were representative. The project informal training and Excel-based tools to facilitate stratified random sampling. For example, an Excel tool was created to select n units to survey from a total of N units using systematic random sampling. Although random sampling is not always appropriate or feasible, the new skills and tools will facilitate the use of random sampling in ICHORD and Bogor Agricultural University surveys when appropriate.

The third topic is the implementation of farmer and seed company surveys. The experience gained in the project surveys help train a new cohort of researchers. Each of the household surveys carried out by the project, a team of enumerators was given 5-7 days of training in interview techniques, completing the questionnaire, quality control, and the definition of key concepts, among other topics.

Finally, the project introduced the use of tablets. This was the first experience with tablets for both Bogor Agricultural University and ICHORD. Before this project, Excel or CSPro was generally used for data entry, which made it impossible for same day quality control checks. Both ICHORD and Bogor Agricultural University now use tablets and Comcare software to enter data from large surveys of farmers and traders. The new software will help improve the quality of the survey data they collect and analyse. In addition, the software is useful in converting data from one data format to another.

Over the medium term, the project strengthened the capacity by providing graduate training in agriculture, economics, and quantitative skills. Overall, the project contributed directly to the PhDs programs of 4 Indonesians students (2 from the Ministry of Agriculture and 1 from Padjajaran University studying at the University of Adelaide and 1 studying at Bogor Agricultural University) and 1 PhD student for Thailand (studying at the University of Adelaide.) These students received world-class training in research design and methods, survey management and sample selection and analytical writing. The students also received training and experience in conference and workshop presentations.

Among the project's students participating in the GFAR PhD program are:

Apri Sayekti, Indonesian PhD Candidate from ICHORD's staff, funded by a DIKTI and IAARD scholarship to study at the University of Adelaide. Apri's work focuses on: (i) chili seed variety choice and demand for labour in Indonesia; and (ii) gender and household income impacts of hybrid vs open-pollinated varieties. Expected completion date July 2019.

Phassara Khamthara is a PhD Candidate from Thailand studying at the University of Adelaide Scholarship. Phassara is testing one of the long-term pathways' arguments justifying the project, ie, that shifting from staple to horticultural crops and more productive varieties has positive welfare implications on agricultural household education investments. Expected completion date December 2019.

Abdul Muis Hasibuan, is an Indonesian PhD Candidate from IIARD and funded by a DIKTI and IIARD scholarship to Study at the University of Adelaide. Muis is focusing his research on how climate events and risk perceptions influence household choices on certified disease-free seedlings vs non-certified seedling. Muis is expected to complete in September 2019.

Combined, these capacity building provides several medium-term benefits toward the individuals and the institutions: (i) increase the individual's knowledge on current global food and agribusiness issues and policies as well as other supporting disciplines such as economics and international trade; (ii) increase the individual's skill in research, including developing conceptual framework and questionnaire, designing sampling frame and econometrics/ data analysis, and also the use of up to date statistical software; (iii) increase the individual's skills in English and experience with the international community to accelerate the individual's communication and teamwork abilities for future involvement in international research and activities and (iv) once the students return to Indonesia, increase the institution's capacity through improvement of its human resources skill and knowledge that leads to better institution's ability and professionalism in conducting future research that meet international standards.

8.3 Community impacts – now and in 5 years

8.3.1 Economic impacts

The economic impacts of this research project are linked to how well the project outputs encourage and induce policymakers and seed companies to provide appropriate support for small holders. This is a research, and not a direct action project, so the impact pathway is via adding to the evidence base and communicating that evidence for improved policy and program design of government (at central and province levels), ACIAR and related donor activities.

Among the outputs that can support household and community economic benefits include project generated knowledge and activities to improve policy and program design. Examples include: (i) workshops and training on using and managing the data sets for ICHORD and seed companies analysis to assist their outreach programs and better target extension; (ii) new and potentially sustainable agribusiness networks and better disciplinary linkages between horticultural scientists, the seed retail sector and value chain analysts; (iii) capacity building activities that improve the quality and practicality of the research outcomes; and (iv) case studies based on fieldwork and prepared for Indonesian curricula.

The expected economic impacts are: (i) higher returns to smallholders; (ii) improved productivity and quality products; (iii) more efficient and competitive domestic fruit and vegetable value chains resulting in fewer imports and more exports; (iv) more jobs for rural landless wage earners; (v) higher daily wages for rural workers; (vi) more diversified income sources for small producer households.

8.3.2 Social impacts

The project did not have a social development component, so we do not expect direct social impacts. However, the growth and competitiveness of high-value agricultural commodities and the farm households who are able to increase their productivity and profits through better seeds is likely to generate indirect social benefits in the communities that specialize in certified, hybrid seeds. In particular, the project results demonstrate that households using hybrid seeds higher much more off-farm labour and in particular, female labour. Female access to more jobs and potentially higher real wages provides additional empowerment over their income and spending choices.

In addition, the project has provided a unique panel sample of interviews with more than 1500 females from the 2011 and 2016 chilli and shallot survey and 500 females from the 2017 citrus survey. Our literature studies on gender work found that from 1,010 gender and agriculture studies, only 6% of the studies focuses on Southeast Asia. The majority of the gender case studies and journal articles focus on Africa (60%). This data set provides a special set of empirical research to document the impact of adoption on gender outcomes because unlike past studies in Southeast Asia, our surveys identify which household member is the responsible decision maker/manager for each of those individual crop activities.

We feel consider this work is challenging misunderstandings and conventional wisdom in Indonesia in three ways that can support positive social impacts in the future: (i) the level of female participation of both family and hired labour- - female reaches 60% overall; (ii) over and under allocation of labour related to constraints in accessing services and technologies; and (iii) how chilli, citrus and shallot farm household decision are made

- - a much higher level of joint decision making in Indonesia than recognised and certainly very different than the African literature.

One policy implication relates to male-centric extension programs. In Indonesia, a large portion of farm labour is female, who often make allocation decisions more efficiently than men do. A more a gender-inclusive approach might yield better household income results as well as more productive, more competitive and more profitable horticultural value chains.

8.3.3 Environmental impacts

The environmental impacts of seed choice are complex, and we expect mixed results depending on associated fertiliser, pesticide and water use. Certified hybrid seed farmers tend to have access to better information on pesticide use and maximize profits by using only the amount needed. This is particularly true when trying to meet the requirements of consumers who are willing to pay higher prices for low-residue or organic produce.

On the other hand, most of Indonesia's horticultural producers tend to maximise output over profit. Few producers keep records or assess the net benefits of their production and land management decisions. Pesticide use tends to decrease only when selling into export markets or participating in certification where residue standards are monitored and enforced. None of the 2000 households in our random sample participated in any certification programs.

8.4 Communication and dissemination activities

The project has used a variety of media and contexts to disseminate information about the project. The communication plan targets four audiences: (i) ICHORD and MoA Regional offices, including plant breeders and post-harvest technical officers; (ii) national level policy community within in the MoA engaging in small scale meetings based on the project's research briefs; (iii) small, medium and large private sector seed companies (workshops and data sharing); and (iv) the academic community, journal articles, access to project data (panel data of 2000 households, 4000 interviews with both male and female household heads).

The Agribusiness Forum sought project outputs in terms of succinct, two-page research briefs, rather than the traditional, longer working papers at the October 2017 planning workshop. The request came from ICASEPS and the private sector seed companies. ICASEPS is not a project partner, but they agreed to engage the national-level policy community using the research brief concept. The project has produced: 14 chilli research briefs, 8 shallot research briefs, 8 mango research, 8 citrus research briefs, and 4 general policy briefs.

The Engagement and Communication table presented below presents key activities.

Engagement and Communication Activities AGB 2009 060				
Target Audience	**Communication Tools**	**Purpose**	**Workshops**	**Participants**
Regional government offices, including technical officers at Balibu, Balijestro and Balitsa	Design Workshops Joint field work Policy Briefs Learnings Workshops	Engage local official with the project scope & objectives seek inputs, feedback, organise key informants.	*Bali Workshop with regional technical officers (December 2015)* *Balijestro Workshop August 2016*	Regional technical officers, Brawijaya University

Engagement and Communication Activities AGB 2009 060				
Target Audience	**Communication Tools**	**Purpose**	**Workshops**	**Participants**
			Balibu Workshop (May 2017) Final workshops planned for Sept and Oct 2018.	
National level policy community	Workshops Policy Briefs Working papers	Seek input on key issues. present results, engage in policy dialogue	Three Workshops with World Bank, Ministry of Trade< and KADIN. 18th August 2016, 22nd July 2016 27th April 2017)	MoA, National Planning Office (BAPPENAS) and Ministry of Trade World Bank, OECD, I
High level policy makers in MoA and National Planning Office	Collaborating with two senior ICASEPS staff to engage with policy makers at high level.	Introduce key project results into policy debate	(i) Engaging on five issues: Import restriction on shallot seeds; (ii) How free and subsidized seeds discourage commercial seed enterprise development (iii) opportunities for public seed breeding linked to private seed company marketing. (iv) strengthen farmer capacities to assess varieties (v) opportunities to increase horticultural productivity via larger scale farms based on land market results from surveys.	Two ICASEPS staff (former agricultural representative at WTO and former Vice Minister of International Programs)
Private Sector	Workshops Research briefs Small seminars Agribusiness forums	Engage Private Sector companies and establish an Agribusiness Forum	Agribusiness Forum: Seed innovation & production to modern food marketing 31st August 2015 *Workshop on Global Value Chain for Horticultural Seed: Opportunities and Challenges* 23rd March 2016 Bogor Trade and Private Sector Seed 7th August 2017 Ministry of Trade, Jakarta Agribusiness Forum Adelaide, October 2017. East-West Seed Seminar to introduce ACIAR shallot and chilli project leader, Dr. Stephen Harper	IPB, Seed companies, Seed associations, Horticulture Association, PERHORTI, Food & Beverage Association, GAPMMI, KADIN, World Bank, ACIAR, ICHORD, Ministry of Trade, BKPM, Center for Tropical Horticulture Study-IPB, and Bustanul Arifin, an Expert in Agricultural Economy. East West Seeds Indonesian Headquarters.

Engagement and Communication Activities AGB 2009 060				
Target Audience	**Communication Tools**	**Purpose**	**Workshops**	**Participants**
			Survey Data Management Workshop, providing access and training on the survey data.	East-West Seeds, Bisi Seeds, Agiprabu Seeds, Inagro Seeds and 4 Lecturers from IPB.
Academic Community	Research papers, conferences Seminars Business case studies for masters programs at IPB, Adelaide and MSU	Peer review of papers and research for feedback and validation	Five Papers Presented at the Conference New Social Economics of Sustainable Agriculture and Food System: The Rise of Welfare State Approach, Indonesian *Society of Agricultural Economics* 23rd – 25th August 2017 Denpasar, Bali Australian Agricultural and Resource Economics Society Conference ARES 2017, three papers accepted. Contributed Paper accepted at the International Association of Agricultural Economists (IAAE), Vancouver, 2018 Australian Agricultural and Resource Economics Society Conference ARES 2018, five papers accepted. One invited speaker session and 3 papers accepted at International Symposia on Horticulture, 27-30 November 2018 Australian Agricultural and Resource Economics Society Conference ARES 2019, three papers accepted. Indonesian PhD student paper accepted at Agricultural Economic Society, 92nd annual conference/Warwick, the United Kingdom. Student received travel award.	University and development organisation researchers.

9 Conclusions and recommendations

9.1 Conclusions

Among the key contributions made by this project are:

An Agricultural Business Forum providing a networking platform for seed companies, government policy makes and academics to meet, discuss, learn and share ideas. Bogor Agricultural University's Department of Agricultural Economics and Agribusiness programs are managing the forum beyond the end of project. Stakeholders include Horticultural industry bodies, food retailers, seed and input companies, MoA and the academic community.

The project established a program of training workshops with large and small seed companies with Bogor Agricultural University providing workshops to: (i) introduce seed company staff to the household questionnaires, panel data covering more than one thousand household interviews in 2011 and 2016; (ii) train seed company staff on how to use software for analyzing the data set; (iii) train staff on how to access, manipulate and evaluate the data set. Twelve staff from five seed companies have been trained to date.

New knowledge, household data and training tools to inform horticultural advisory services and university teaching and research programs. Large, small and medium sized seed companies have been trained in data management and provided the ACIAR household data for chillies, mangoes, shallots and citrus. More than 2000 household surveys with a panel based on 2011 and 2016/17 for chillies, mangoes and shallots. This data is a unique source of information for MoA extension, ICHORD staff, private sector seed companies and universities in Australia, Indonesia and the USA.

The project team is collaborating with the Dr. Mia Siscawati, Head of Gender Studies Graduate Program at the University of Indonesia and Bogor Agriculture University to promote discussion and policy dialogue related to the project's survey information from 2000 interviews with female household heads. The aim is to use the data in training and advisory services to better target female producers. The project team is promoting these initiatives with East West Seeds and BISI. East West Seeds won an international award for their work with female farmers.

Analytical insights into household use of horticultural seeds and the seed industry transformation that encourage more effective, scale neutral government regulatory and policy interventions. One example is to review the trade rules limiting shallot mini-bulb imports. The project team is organising with the MoA, Ministry of Trade and National Planning Agency Project team is working with ICASEPS (MoA's Policy Research Centre) to examine output and efficiency impacts of existing and planned interventions for shallots.

The project directly supported three four PhD students. Their PhD topics address issues such as gender and household income impact of hybrid vs open-pollinated varieties, the key role of off-farm female labour in certified chilli seed adoption, the education outcomes associated with adopting citrus production, how climate events and risk perceptions of the male and female households heads influence the choice of certified disease-free seedlings vs non-certified seedling.

In collaboration with East West seeds, the project team is making use of powerful results related to land markets from the household surveys. East West Seeds collaborates with

SMARTseeds promoting a mobile phone app called Sipindo (Information System for Indonesian Agriculture). Sipindo provides farmers with local soil nutrient and fertiliser recommendations (based on lab tests), weather predictions, chat capacity and access to information about who is planting what crops and which varieties. Sipindo aims to support 100,000 chili, tomato and cucumber farmers. The ACIAR project results provide strong evidence of very high land rental markets and the Sipindo team wishes to explore how to use the app to better connect farmers wishing to rent land in with those who wish to rent out.

9.2 Recommendations

The project team recommends three potential follow up activities we consider of value to ACIAR.

First, the shallot analysis finds that access to imported mini-bulbs increases average yields by 25% and reduces total input costs by 15% to 20%. Seed costs average well over half of total shallot production costs (on-farm and off-farm labour, fertilisers, pesticides and purchased and saved seeds). Access to imported seeds could reduce mini bulb seeds costs from 30% to 50%. However, trade restrictions (licensing and seasonal quotas) limit imports. None of the shallot producers in our sample had access to imported mini-bulbs in the past several seasons. An SRA involving some of Australia's agricultural trade economists working with the MoA policy unit, the Ministry of Trade and IBP could help highlight this issue with positive outcomes for productivity - - higher yields, improved profits and stable to lower consumer prices.

Second, the chilli seed studies find a very high acceptance and use of certified hybrid seeds, with farm profits among households using certified chilli seeds well above those households using saved seeds. One way to significantly impact production is to target advisory service programs at the relatively larger and more agricultural focused households. For example, the project's random chilli sample shows that 35% of the farmers account for around 60% of total chilli production. These 35% of farmers have access to an average of 1.3 ha per farm with on farm income accounting for 88% of their total income. In contrast, about 50% of the farmers have access to only an average of 0.25 ha per farm, accounting for less than one-third of the total output. Working with the private seed companies to develop techniques to target the larger, more agricultural-focused farmers rather than all farmers would bring significant benefits.

Third, as noted above, based on the project survey results and the ongoing collaboration with East West s, the opportunity exists to pursue the use of their Horticultural Services app to encourage more efficient land rental markets. East West Seeds collaborates with SMARTseeds promoting a mobile phone app called Sipindo (Information System for Indonesian Agriculture). Sipindo provides farmers with local soil nutrient and fertiliser recommendations (based on lab tests), weather predictions, chat capacity and access to information about who is planting what crops and which varieties. Sipindo aims to support 100,000 chili, tomato and cucumber farmers. The ACIAR project results provide strong evidence of very high land rental markets and the Sipindo team wishes to explore how to use the app to better connect farmers wishing to rent land in with those who wish to rent out. East West Seeds is interested in following up.

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11 Appendixes

11.1 Appendix 1:

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