Understanding the Roles of Gender in Rural Development: The Case of Labour-Intensive Chilli Production in Indonesia

Apri Laila Sayekti

Thesis submitted to the University of Adelaide
in fulfilment of the requirements for
the degree of Doctor of Philosophy

Centre for Global Food and Resources
Faculty of the Professions
The University of Adelaide
August 2019

[Page left bank intentionally]

Acknowledgements

All praises be to Allah. I believe that there is always a way if He wills.

I would like to express my gratitude to my principal supervisor, Adjunct Professor Randy Stringer, for extraordinary guidance, support, and always giving me a second chance during the times of my least progress in this study. He also gave me the opportunity to be involved in his ACIAR Project, where I learnt to be an independent researcher. I extend my gratitude to my co-supervisor, Dr. Di Zeng, for his continuous support, guidance and help in data analysis and in writing this thesis. My sincere thanks also go to another co-supervisor, Dr. Daniel Gregg, who taught me the fundamentals of data analyses and writing a good article. I would like to thank also to Dr. Dale Yi for the valuable guidance at the beginning of my PhD journey.

My special thanks to SMARTD, the Indonesian Agency for Agricultural Research and Development (IAARD), and Ministry of Agriculture Indonesia for the scholarship they provided. I also thank the Indonesian Centre for Horticulture Research and Development and my colleagues for supporting me.

Many thanks to my fellow PhD students and the staff at The Centre for Global Food and Resources, at The University of Adelaide, for sharing and discussion undertaken in a very conducive climate. You all made my journey more colourful.

Last but not least, my sincere thanks go to my husband, Abdul Muis Hasibuan, for unconditional love and support. Being a PhD couple made this journey a lot easier for me. To my son, Abrar Tsaqif Hasibuan, thank you for your love, which motivates me to finish this study. In addition to my husband, I also dedicate this thesis to my parents, my parents-in-law, and my brother and sister.

Declaration

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name, in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint-award of this degree.

I give permission for the digital version of my thesis to be made available on the web, via the University's digital research repository, the Library Search and also through web search engines, unless permission has been granted by the University to restrict access for a period of time.

I acknowledge the support I have received for my research through the provision of SMARTD Scholarship, Indonesian Agency for Agriculture Research and Development, Ministry of Agriculture, Indonesia.

Apri Laila Sayekti

Abstract

The increasing transformation of horticultural consumption in South East Asia raises issues concerning changing horticultural production. Quantity and quality improvements are required to meet the demand for horticultural products. The use of hybrid seeds is one of the agricultural improvement strategies to address demand because hybrid seeds offer more stable and higher yields. In rural areas, this transformation not only changes the horticultural products market but also inputs markets, including labour markets, which may bring advantages for certain groups of smallholder farmers in rural areas, including women. The roles of women in this transformation have been studied but the findings are controversial. Evidence shows the importance of women's roles in agricultural and rural development; however, extensive research also indicates that women' contributions in agriculture are still lower compared to men. The underestimated contributions of women could contribute to a bias in the design of development policies and strategies.

To examine the contributions of women in agriculture in-depth, this thesis explores the roles of women in agriculture in three analytical chapters. This thesis employs data which was collected from two surveys. The surveys were conducted in 2010 and 2016. The first survey involved 597 chilli farmers. The second survey included 574 chilli farmers, but only 251 out of 597 farmers grew chilli in the last one year when the second survey was conducted. The first and second analytical chapters utilise the second-round survey data, while the third chapter employs data from the first and the second- round surveys.

The first analytical chapter presented in Chapter 4 examines the impacts of hybrid chilli seed adoption on demand for male and female labour by gender. Adopting new technology, including hybrid seeds, may change the demand for labour. However, there is relatively little understanding of the impacts of hybrid chilli seed adoption on the demand

for family labour, particularly female family members. Since hybrid seed adoption often requires more labour, it may affect female members in the households to work on-farm that contributes to extra work demands on women's time in rural areas, including in Indonesia, who are mostly responsible for domestic chores and child-rearing. This study extends previous research on household labour demands through an assessment of the impacts on both family and hired labour on a gender-specific basis. An instrumental variables 2SLS approach is employed to address the endogeneity issues that may occur related to hybrid seeds choices. Results show that adopting hybrid seeds is not associated with demand for female labour within the family. However, it is found that hybrid chilli seeds are more likely to increase demand for hiring both male and female labour. Consequently, hybrid seed adoption could generate rural employment opportunities and empower women who generally have fewer employment opportunities compared to men.

The second analytical chapter explored in Chapter 5 evaluates the roles of women associated with chilli productivity and revenue. The existing literature on gender in agricultural productivity comes mainly from African countries and uses a binary gender indicator to compare productivity with and without female roles using production functions estimations. These approaches may fail to reflect the full female contribution to production since, in Asian countries, male and female farmers often jointly manage land plots. This study employs Confirmatory Factor Analysis (CFA) to outline a range of indices which indicate women's leadership and also disagreement between household heads (husband and wife pairs) about their roles in farming activities. These indices were included in interaction revenue function analysis of chilli production. The results show that woman's leadership in specific farming activities is more likely to increase chilli revenue. Moreover, household disagreement between males and females about their respective responsibilities seems to reduce revenue. The results suggest the more complex considerations of female's roles in production that are needed for examining communities in which activities and farm management are shared between male and female household. This study provides evidence that women's empowerment, through the leadership of agronomic activities, can improve both productivity and positive outcomes for households.

Chapter 6 explores the third analytical chapter discussing the roles of women in farmers' decisions about the adoption of hybrid chilli seeds. While there is an extensive literature that focuses on hybrid seed adoption in developing countries, less is understood regarding the continuity of the adoption behaviours over time. This study examines adoption behaviour using four categories — non-adoption, late-adoption, continual-adoption, and dis-adoption— to extend previous studies that mainly focus only on adoption and non-adoption. A multinomial logit model is estimated where dynamic adoption behaviours are specified for a two-period panel data set of chilli farmers. Results show that variables associated with continual-adopters are different from variables related to late-adopters, which suggests that each category of farmers has different characteristics. Results reveal that females identifying farming as their main occupation and farmer group membership are positively associated with being a continual-adopter of hybrid chilli seeds and they reduce the possibility of being a non-adopter. However, these variables are not relevant to late-adopters. These results indicate that the adoption stages are complex and may assist adoption policies to pay more attention to targeting differences among adoption categories. Also, integrating women in hybrid chilli seed dissemination programs may encourage more farmers to become continual- adopters.

Table of Contents

List of Tables

List of Figures

Chapter 1 : Introduction

1.1 Background and Motivation

The rapid agricultural transformation and economic growth in Asia in the early 2000s have continued (Mergenthaler, Weinberger & Qaim 2009; Reardon, Timmer & Minten 2012), particularly in horticultural sectors. Increasing income levels lead to a change in daily food intake patterns through the rising share of non-staple foods consumption (Reardon et al. 2019). Also, increasing awareness of health can be a trigger for the increasing demand for healthy food. Both factors contribute to the growing demand of fresh fruits and vegetables (Mergenthaler, Weinberger & Qaim 2009; Reardon, Timmer & Minten 2012), especially for vegetable consumption (Minot & Roy 2007).

The transformation of food systems might imply changes in capital, industrial organisation, and labour markets (Reardon et al. 2019; Sachs 2018). For example, in market-oriented crop-production systems, where access to production resources such as land ownership is essential, this transformation potentially poses gender inequalities. Since land ownership typically excludes females, this transformation greatly benefits male farmers (The World Bank 2008). Additionally, patriarchal social structures in many rural areas in developing countries mean women's roles are consistently under-estimated and under-valued (de la O Campos, Covarrubias & Patron 2016; FAO 2011; Oseni et al. 2015).

However, such massive economic transformation can provide more opportunities for women to become involved in formal and informal economies, and to make a more significant contribution to household incomes in rural areas. For example, Belton and Filipski (2019) found that this transformation contributes to greater balance in women's and men's participation in agricultural activities as well as the more considerable increase in wages for female labour than for male labour in Myanmar. Moreover, Doss (2018) argues that the beauty of economic empowerment interventions, such as expanding women's access to agricultural markets and financial services, are not only beneficial for women but have significant general spillover effects. These interventions may reduce poverty and encourage women to expand their sense of self and to challenge the paradigm that justifies women not being equal to men. This study investigates the importance of women's roles in agriculture, particularly in agricultural labour transformation, increasing farm productivity, and technology adoption.

Gender research has been increasingly focused on in recent decades. It has been found that the lack of attention to gender issues and gendered inequalities in agricultural development contributes to lower agricultural productivity, lower-income, higher poverty levels, and undernutrition (e.g. Meemken, Veettil & Qaim 2017; Peterman, Behrman & Quisumbing 2014). However, these issues are highly correlated with socioeconomic structure and cultural backgrounds (The World Bank 2008), which vary across nations or regions. Men and women also have different positions in decision-making, which often means that men may have higher decision-making power compared to women (Meemken, Veettil & Qaim 2017; The World Bank 2008). Failure to recognise the roles, differences, and inequities between men and women will result in an ineffective agricultural development agenda (The World Bank 2008). Even though women are the primary contributors to the world's food production and its security, they are "frequently underestimated and overlooked in development strategies" (UN 2010).

Given the importance of women's roles in agricultural and rural development, the underestimation of their roles could contribute to a bias in the design of development policies and strategies. This might happen because of the measurement of gender's roles, which is often misleading and biased. First, gender-related biases exist widely in labour statistics, with a tendency to count the typical work for men, but not women (Ayhan 2016; Bryceson 2019; Dixon 1982). For example, women's participation in agricultural post-harvest processing is often under-estimated, possibly because it is perceived as less important than the on-farm activities dominated by men (Raney et al. 2011). Second, agricultural development programs also often recognise farmers as unitary households and agricultural technologies are therefore designed for households where men are typically considered as the household representative (Udry 1996). Third, in specific cultures, such as South East Asia, where there has been limited research, males and females often work together or sometimes females are the leader of particular activities, such as harvesting and processing (Akter et al. 2017). Therefore, a deeper understanding of these differences and the strategic interests of the most disadvantaged groups are still needed to address gender issues related to production and to reduce rural poverty.

Even though policymakers and development practitioners have underpinned the implementation of gender programs, and evaluated their effectiveness across a range of social and economic sectors, empirical research on the gendered dimensions of agricultural inputs has only focused on land management (e.g. Peterman, Behrman & Quisumbing 2014). This may not be applicable in all cultural settings, such as those that have joint land ownership by husband and wife (see Akter et al. 2017; Doss et al. 2018). It may be inaccurate to compare men's and women's outcomes if they work together.

In term of gender inequality, female participation rates in agricultural sectors in Asian countries are relatively high, varying between 35 and 50 per cent (Raney et al. 2011). However, women still face constraints to increase their household income, such as inequalities in wage rates (Belton & Filipski 2019). Also, women have time and mobility constraints because, in most developing countries, they have primary responsibility for caring for children and family. Despite these limitations, women still make significant contributions to supporting male's activities and household's income, through activities such as preparing meals and tending livestock (Doss 2018). However, female farmers have often placed themselves in an unfavourable position, such as ignoring their roles and nominating their spouse, which may decrease the acknowledgement of their role in farm management (Doss 1996). Re-evaluation of women contributions, particularly in non-land related aspects is crucial to inform policymakers about rural gender development.

There are gaps in the literature regarding women's contribution to agriculture. First, gender studies usually compare male and female productivity using unitary gender indicators related to the head of the household or the plot manager; these do not identify women's contributions to households or plot management (e.g. de la O Campos, Covarrubias & Patron 2016; Guirkinger, Platteau & Goetghebuer 2015; Oseni et al. 2015). Since the majority of farmer households, particularly in South East Asia, are headed by males (Akter et al. 2017; Peterman, Behrman & Quisumbing 2014), the availability of female-headed data are too limited to identify the gender impacts (e.g.Kinkingninhoun-Mêdagbé et al. 2010; Oseni et al. 2015; Rahman 2010). Consequently, female contributions in male-headed households are difficult to measure (de la O Campos, Covarrubias & Patron 2016). Therefore, further consideration of women's roles in agriculture, particularly regarding increasing productivity or agricultural outcomes, is still needed to address these gaps.

Second, even though the roles of women in agricultural technology adoption have been widely analysed in the literature, especially in African countries (Johnson et al. 2015; Murage et al. 2015; Seymour et al. 2016), there are still only limited studies in South East Asia that evaluate the roles of women in influencing farmers' continuity or discontinuity once they have adopted hybrid seeds. The adoption of hybrid seeds is acknowledged as the critical factor in increasing productivity (Hurley, Koo & Tesfaye 2018; Zeng et al. 2017).

Considering that farm productivity is mostly lower than its potential (Kuntariningsih & Mariyono 2013), improving agricultural productivity is essential for the welfare of poor farmers and food security in developing countries (Ragasa & Mazunda 2018; Swinnen & Kuijpers 2019). Improving farmers' access to certified seeds also enhances yield and could eventually reduce poverty (e.g. Ali et al. 2015).

A growing body of literature has focused on hybrid seed adoption by comparing adopter and non-adopter farmer attributes (eq. Ali & Abdulai 2010; Kuntariningsih & Mariyono 2013; Matuschke & Qaim 2008; Mottaleb, Mohanty & Nelson 2015) using cross-sectional data. However, the adoption process is complicated and is often a changing process over time (Barrett, Carter & Timmer 2010; Doss. 2006; Ghadim & Pannell 1999). Unlike the adoption of high investment farm technologies, such as machinery, hybrid seeds can be adopted and dis-adopted later in time without sacrificing a significant investment. To measure the impacts of hybrid seed adoption, such as on farmer's welfare, a single adoption time captured by cross-sectional-data cannot identify some significant outcomes and does not permit analysis of the dynamics of technology adoption (Doss 2006).

Third, another challenge in gender studies is to understand how the adoption of new technology could provide a better opportunity for women's empowerment in rural areas. This is important because there is a gender bias in agricultural service delivery, such as extension, training and technology development where women encounter many disadvantages (IFAD 2012). On the other hand, women could contribute to increasing household income if they have more opportunity to become involved in agricultural activities (Akter et al. 2017). Improved varieties, such as hybrid chilli seeds, could generate higher yields and production and, since women do most of the picking, this technology is expected to create employment opportunities for them. However, few studies have examined the demand for labour affected by hybrid seed adoption and have disaggregated male and female labour.

This study fills those gaps in gender research by evaluating women's roles. Firstly, it explores the impacts of hybrid seed adoption on creating employment opportunities for male and female by assessing the demand for labour by gender. Secondly, we consider women's roles across a range of farming activities and agricultural production activities and include in-depth consideration of women's roles related to chilli productivity and revenue, power imbalances between men and women, and the extent to which disagreement between the genders is prevalent. Thirdly, this study evaluates the dynamics of hybrid chilli seed adoption using four adoption categories (continual-adoption, dis-adoption, late-adoption, and non-adoption). Specifically, this analysis focuses on women's roles by including wives' characteristics to clearly identify the contribution of women to technology adoption.

This study uses primary household-level panel data from West Java Province, which is the major chilli producing province and hosts the highest number of chilli farmers in Indonesia (Ministry of Agriculture 2015; Sahara 2012). The data was collected through two-rounds surveys interviewing the same farmer households. The first-round survey included 597 farmer households in 2010. In the second-round survey, in 2016, 573 farmer households were interviewed. However, only 251 farmers out of 573 farmers planted chilli in 2016. The first and second analysis only use the 2016 survey because of the availability of the data needed. The third study employs data from both rounds.

1.2 Chilli and Hybrid Seeds in Indonesia

Increasing income and health awareness lead to a change in daily dietary intake patterns, which enhances demand for fresh fruits and vegetables (Reardon, Timmer & Minten 2012). Chilli is one of the primary vegetables in Indonesians' daily intake (Nono et al. 2013). Aggregate chilli consumption increased by 2.13 per cent per year between 2008 and 2012 (Nono et al. 2013). To meet this increasing demand, chilli production is also growing. Between 2010- 2014, the average annual growth in chilli production in Indonesia was 3.76 per cent for big chillies and 4.40 per cent per year for small chillies (Ministry of Agriculture 2015).

Even though Indonesia is one of the significant chilli producers in Asia (Ali 2006), it continuously faces problems related to the dynamics of supply and demand (Bank Indonesia 2018). Consequently, there are large fluctuations in chilli price affecting the national inflation rate (Mariyono 2017). Considering its importance to the national economy, the Indonesian Government ranks chilli as one of the strategic commodities for agricultural development, whereas previously the Government focused only on staple crops in the interests of achieving food self-sufficiency (Ministry of Agriculture 2015). The Government's policy now aims to guarantee the sufficiency of chilli in the markets to reduce price fluctuations.

By addressing price fluctuation and transforming chilli farming from subsistence production into commercial production through intensive cultivation, the supply could be stabilised, aiding poverty reduction in rural areas (Mariyono 2017). Intensive commercial chilli farming; however, needs to adjust farming practices to incorporate more advanced technologies, such as hybrid seeds, which offer higher yield and quality (e.g. Kuntariningsih & Mariyono 2013; Mariyono & Sumarno 2015). Improved quality is essential since consumers are starting to consider the quality of chilli in their purchasing decisions (Minot & Roy 2007; Minot et al. 2015; Reardon, Timmer & Minten 2012). In addition, rising incomes allow consumers to choose from different marketing channels, including traditional or modern markets, based on their preferences. Modern markets only provide a high quality of fresh food and vegetable. Therefore, farmers must choose to produce a particular variety to meet modern market requirements. Hybrid seeds can usually meet modern market requirements (da Silva Dias 2010).

Developing chilli production that meets all types of markets requirements also poses some challenges. The first constraint is agro-ecological factors. Kuntariningsih and Mariyono (2013) emphasise that chilli productivity in Indonesia fluctuates because of variations due to seasons, extreme weather conditions, and the threat of pest or disease outbreaks. However, hybrid seeds are designed to adapt to climatic change, such as a heavy rainy season or a dry one. Genetically, superior seeds can contribute to higher and more stable crop yields, lowering losses due to pests, disease and adverse weather conditions and therefore produce more profitable crops. Hybrid seeds also provide a more uniform product, with typically higher quality chillies (Ali 2006).

Yet, studies of hybrid chilli variety adoption in Indonesia are still limited compared to research on staple crops, such as rice and maize. Kuntariningsih and Mariyono's 2013 work, which analysed the socio-economic factors affecting the adoption of hybrid seeds and silvery plastic mulch for chilli farming in Central Java is an exception. They show that education and access to credit are the most critical factors influencing the adoption of this technology. Basuki et al. (2014) found an increasing tendency for farmers to use the hybrid seeds because it has a higher yield compared to open pollination seeds. However, evidence to date suggests that many smallholder farmers in Indonesia regularly use more open-pollinated seeds and seeds saved from previous harvests.

Chilli is a vegetable which requires intensive labour for production (Dolan & Sutherland 2002; Maertens & Swinnen 2012). Labour availability is, therefore, an essential input in the production of chilli. For labour-intensive production, increasing yields means the creation of rural employment opportunities, especially for harvest and post-harvest activities. This implies that hybrid seeds may be not only beneficial for increasing the income of chilli producers but also have positive spill-over effects for communities. These opportunities also may play an essential role in enhancing jobs opportunities for women in agriculture, mainly because harvesting chilli is primarily done by female labour.

1.3 Research Objectives

This research attempts to understand gender's roles in smallholder chilli farming in Indonesia. To better understand the process, it is vital to specifically examine the demand for labour by gender, the roles of women related to chilli productivity and revenue, and the dynamics of hybrid chilli seed adoption. The specific research objectives are:

1. To examine the impacts of hybrid seed adoption, particularly on-demand for labour by gender;
2. To evaluate the impacts of women's leadership and disagreement between the genders on chilli productivity and revenue among chilli farmer households in Indonesia; and
3. To analyse the influence of gender on the dynamics of farmers' decision-making in relation to hybrid seed adoption.

1.4 Structure of the Thesis

This thesis is organised into seven chapters. Chapters 4, 5, and 6 are the main analytical chapters and address the research objectives of this thesis. Chapter 2 explores the current literature regarding the importance of the horticultural sector in Indonesia. This chapter also provides an overview of the role of women in chilli production.

Chapter 3 explains the data collection. This thesis uses extensive farmer household surveys conducted in 2010 and 2016, and these are explored in this chapter. Detailed fieldwork activities, including scoping studies, creating the questionnaire and re-survey to complete the data are discussed.

In Chapter 4, we address the first research objectives to analyse the impacts of hybrid seeds adoption on demand for labour by gender, including hired and family labour. This analysis employs the second round of the survey, conducted in 2016.

Chapter 5 is the analytical chapter which addresses the second set of research objectives, investigating women's participation, leadership, and disagreement between males and females in households about chilli productivity and profit. This chapter only uses the second round of survey data.

Chapter 6 addresses the third research objective by analysing the influence of women's roles on the dynamics of farmers' decision-making about hybrid seeds selection among chilli farmers in Indonesia. This analysis uses data collected in both 2010 and 2016.

Lastly, Chapter 7 provides a general discussion of this study based on the results from the three analytical chapters. It sets out the conclusions of the entire thesis and discusses its policy implications.

References

Akter, S, Rutsaert, P, Luis, J, Htwe, NM, San, SS, Raharjo, B & Pustika, A 2017, 'Women's empowerment and gender equity in agriculture: A different perspective from Southeast Asia', *Food Policy*, vol. 69, pp. 270-279.

Ali, A & Abdulai, A 2010, 'The adoption of genetically modified cotton and poverty reduction in Pakistan', *Journal of Agricultural Economics*, vol. 61, no. 1, pp. 175-192.

Ali, A, Rahut, DB, Behera, B & Imtiaz, M 2015, 'Farmers' access to certified wheat seed and its effect on poverty reduction in Pakistan', *Journal of Crop Improvement*, vol. 29, no. 2, pp. 247-265.

Ali, M 2006, *Chili (Capsicum spp.) Food Chain Analysis: Setting Research Priorities in Asia*, vol. 38, AVRDC-World Vegetable Centre, Shanhua, Taiwan.

Ayhan, H. Ö 2016, 'Avoiding gender bias in agricultural surveys: An official statistics guide for data collection and dissemination', *Statistical Journal of the IAOS*, vol. 32, no. 3, pp. 371-373.

Bank Indonesia 2018, *Economic Report on Indonesia*, Bank Indonesia, Jakarta.

Barrett, CB, Carter, MR & Timmer, CP 2010, 'A century-long perspective on agricultural development', *American Journal of Agricultural Economics*, vol. 92, no. 2, pp. 447-468.

Basuki, R, Arshanti, I, Zamzani, L, Khaririyatun, N, Kusandriani, Y & Luthfy 2014, 'Adoption studies of red pepper Tanjung-2 varieties as a results of Vegetable Crops Research Institute in Ciamis West Java Province', *J. Hort.*, vol. 24, no. 4, pp. 355-362.

Belton, B & Filipski, M 2019, 'Rural transformation in central Myanmar: By how much, and for whom?', *Journal of Rural Studies*, vol. 67, pp. 166-176.

Bryceson, D. F. 2019, 'Gender and generational patterns of African deagrarianization: Evolving labour and land allocation in smallholder peasant household farming, 1980–2015'. *World Development,* vol. 113, pp. 60-72.

da Silva Dias, J 2010, 'Impact of improved vegetable cultivars in overcoming food insecurity', *Euphytica*, vol. 176, no. 1, pp. 125-136.

de la O Campos, AP, Covarrubias, KA & Patron, AP 2016, 'How does the choice of the gender indicator affect the analysis of gender differences in agricultural productivity? Evidence from Uganda', *World Development*, vol. 77, pp. 17-33.

Dixon, RB 1982, 'Women in agriculture: counting the labor force in developing countries', *Population and Development Review*, vol. 8, no. 3, pp. 539-566.

Dolan, C & Sutherland, K 2002, 'Gender and employment in the Kenya horticulture value chain', *Globalisation and Poverty Discussion Paper*, vol. 8.

Doss, C, Meinzen-Dick, R, Quisumbing, A & Theis, S 2018, 'Women in agriculture: Four myths', *Global Food Security*, vol. 16, pp. 69-74.

Doss, CR 1996, 'Testing among models of intrahousehold resource allocation', *World Development*, vol. 24, no. 10, pp. 1597-1609.

Doss, CR 2006, 'Analyzing technology adoption using microstudies: limitations, challenges, and opportunities for improvement', *Agricultural Economics*, vol. 34, no. 3, pp. 207-219.

Doss, CR 2018, 'Women and agricultural productivity: Reframing the issues', *Dev Policy Rev.*, vol. 36, no. 1, pp. 35-50.

FAO 2011, *The State of Food and Agriculture*, Food & Agriculture Organization of the UN (FAO), Rome.

Ghadim, AKA & Pannell, DJ 1999, 'A conceptual framework of adoption of an agricultural innovation', *Agricultural Economics*, vol. 21, no. 2, pp. 145-154.

Guirkinger, C, Platteau, J-P & Goetghebuer, T 2015, 'Productive inefficiency in extended agricultural households: Evidence from Mali', *Journal of Development Economics*, vol. 116, pp. 17-27.

Hurley, T, Koo, J & Tesfaye, K 2018, 'Weather risk: how does it change the yield benefits of nitrogen fertilizer and improved maize varieties in sub-Saharan Africa?', *Agricultural Economics*, vol. 49, no. 6, pp. 711-723.

IFAD 2012, *Policy on Gender Equality and Women's Empowerment,* International Fund for Agricultural Development (IFAD), Rome, Italy.

Johnson, N, Njuki, J, Waithanji, E, Nhambeto, M, Rogers, M & Kruger, EH 2015, 'The gendered impacts of agricultural asset transfer projects: Lessons from the Manica smallholder dairy development program', *Gender, Technology and Development*, vol. 19, no. 2, pp. 145-180.

Kinkingninhoun-Mêdagbé, FM, Diagne, A, Simtowe, F, Agboh-Noameshie, AR & Adégbola, PY 2010, 'Gender discrimination and its impact on income, productivity, and technical efficiency: evidence from Benin', *Agriculture and Human Values*, vol. 27, no. 1, pp. 57-69.

Kuntariningsih, A & Mariyono, J 2013, 'Socio-economic factors affecting adoption of hybrid seeds and silvery plastic mulch for chili farming in Central Java', *SEPA Jurnal Sosial Ekonomi Pertanian dan Agribinis*, vol. 9, no. 2, pp. 297-308.

Maertens, M & Swinnen, JF 2012, 'Gender and modern supply chains in developing countries', *The Journal of Development Studies*, vol. 48, no. 10, pp. 1412-1430.

Mariyono, J 2017, 'Moving to commercial production: a case of intensive chili farming in Indonesia', *Development in Practice*, vol. 27, no. 8, pp. 1103-1113.

Mariyono, J & Sumarno, S 2015, 'Chilli production and adoption of chilli-based agribusiness in Indonesia', *Journal of Agribusiness in Developing and Emerging Economies*, vol. 5, no. 1, pp. 57-75.

Matuschke, I & Qaim, M 2008, 'Seed market privatisation and farmers' access to crop technologies: The case of hybrid pearl millet adoption in India', *Journal of Agricultural Economics*, vol. 59, no. 3, pp. 498-515.

Meemken, E-M, Veettil, PC & Qaim, M 2017, 'Toward improving the design of sustainability standards—A gendered analysis of farmers' preferences', *World Development*, vol. 99, pp. 285–298.

Mergenthaler, M, Weinberger, K & Qaim, M 2009, 'The food system transformation in developing countries: A disaggregate demand analysis for fruits and vegetables in Vietnam', *Food Policy*, vol. 34, no. 5, pp. 426-436.

Ministry of Agriculture 2015, *Ministry of Agriculture Strategic Planning 2015–2019*, Ministry of Agriculture, Jakarta.

Minot, N & Roy, D 2007, 'Impact of high-value agriculture and modern marketing channels on poverty: An analytical framework', *International Food Policy Research Institute,* Washington, DC.

Minot, N, Stringer, R, Umberger, WJ & Maghraby, W 2015, 'Urban shopping patterns in Indonesia and their implications for small farmers', *Bulletin of Indonesian Economic Studies*, vol. 51, no. 3, pp. 375-388.

Mottaleb, KA, Mohanty, S & Nelson, A 2015, 'Factors influencing hybrid rice adoption: a Bangladesh case', *Australian Journal of Agricultural and Resource Economics*, vol. 59, no. 2, pp. 258-274.

Murage, AW, Pittchar, JO, Midega, CAO, Onyango, CO & Khan, ZR 2015, 'Gender specific perceptions and adoption of the climate-smart push–pull technology in eastern Africa', *Crop Protection*, vol. 76, pp. 83-91.

Nono, R, Anwar, S, Ade, C, Ali, M, Ifan, M, Tejaningsih, Prayogo, UH, Sri, HS & Muhammad, M 2013, *Studi Pendahuluan: Rencana Pembangunan Jangka Menengah (RPJMN) Bidang Pangan dan Pertanian 2015-2019*, KPPNBPPN Direktorat Pangan dan Pertanian.

Oseni, G, Corral, P, Goldstein, M & Winters, P 2015, 'Explaining gender differentials in agricultural production in Nigeria', *Agricultural Economics*, vol. 46, no. 3, pp. 285-310.

Peterman, A, Behrman, JA & Quisumbing, AR 2014, 'A review of empirical evidence on gender differences in nonland agricultural inputs, technology, and services in developing countries', in *Gender in agriculture*, Springer, pp. 145-186.

Ragasa, C & Mazunda, J 2018, 'The impact of agricultural extension services in the context of a heavily subsidized input system: The case of Malawi', *World Development*, vol. 105, pp. 25-47.

Rahman, S 2010, 'Women's labour contribution to productivity and efficiency in agriculture: empirical evidence from Bangladesh', *Journal of Agricultural Economics*, vol. 61, no. 2, pp. 318-342.

Raney, T, Anríquez, G, Croppenstedt, A, Gerosa, S, Lowder, S, Matuscke, I, Skoet, J & Doss, C 2011, *The Role of Women in Agriculture*, ESA Working Paper No. 11-02, Agricultural Development Economics Division, The Food and Agriculture Organization of the United Nations, <http://www.fao.org/3/am307e/am307e00.pdf>.

Reardon, T, Echeverria, R, Berdegué, J, Minten, B, Liverpool-Tasie, S, Tschirley, D & Zilberman, D 2019, 'Rapid transformation of food systems in developing regions: Highlighting the role of agricultural research & innovations', *Agricultural Systems*, vol. 172, pp. 47-59.

Reardon, T, Timmer, CP & Minten, B 2012, 'Supermarket revolution in Asia and emerging development strategies to include small farmers', *Proceedings of the National Academy of Sciences*, vol. 109, no. 31, pp. 12332-12337.

Sachs, CE 2018, *Gendered Fields: Rural Women, Agriculture, and Environment*, Routledge.

Sahara 2012, 'The transformation of modern food retailers in Indonesia: opportunities and challenges for smallholder farmers', School of Agriculture, Food and Wine, PhD thesis, The University of Adelaide, South Australia.

Seymour, G, Doss, C, Marenya, P, Meinzen-Dick, R & Passarelli, S 2016, 'Women's empowerment and the adoption of improved maize varieties: evidence from Ethiopia, Kenya, and Tanzania', in *2016 Agricultural & Applied Economics Association,* Boston, Massachusetts.

Swinnen, J & Kuijpers, R 2019, 'Value chain innovations for technology transfer in developing and emerging economies: Conceptual issues, typology, and policy implications', *Food Policy*, vol. 83, pp. 298-309.

The World Bank, FAO, International Fund for Agricultural Development, 2008, *Gender in Agriculture Sourcebook*, World Bank.

Udry, C 1996, 'Gender, agricultural production, and the theory of the household', *Journal of Political Economy*, vol. 104, no. 5, pp. 1010-1046.

UN 2010, *Rural Women Key to Economic Growth, Says UN Official*, UN News, viewed 6 April 2019, <https://news.un.org/en/story/2010/03/333332-rural-women-key-economic-growth-says-un-official>.

Zeng, D, Alwang, J, Norton, GW, Shiferaw, B, Jaleta, M & Yirga, C 2017, 'Agricultural technology adoption and child nutrition enhancement: Improved maize varieties in rural Ethiopia', *Agricultural Economics*, vol. 48, no. 5, pp. 573-586.

Chapter 2 : Horticultural Subsector Development in Indonesia: A review

2.1 Introduction

The global expansion of horticultural crops has significantly contributed to increased economic growth and benefits for rural communities, especially in developing countries (Van den Broeck & Maertens 2016; Weinberger & Lumpkin 2007). This expansion is supported by the rapid transformation of the food system, spurred by such things as middle-income growth, market liberalisation, and changes in lifestyle (e.g., Mergenthaler, Weinberger, & Qaim 2009; Reardon et al. 2009; Minot et al. 2015) which increase the demand for horticultural products, especially fruits and vegetables. In the case of Indonesia, however, these opportunities have not been supported by the supply side, since imports are increasing to fulfil domestic demand. This indicates that Indonesia has not yet obtained the advantages of horticultural expansion in supporting the economic growth it can provide. This section provides a review of the empirical literature related to horticultural development in Indonesia and associated gender-related issues in order to increase farmer's welfare in rural areas.

2.2 Horticulture in Indonesia: Data and Policy

The agricultural sector has an essential place in the Indonesian economy, contributing approximately 10 per cent to the gross domestic product (GDP) (excluding forestry and fishing) in the last five years (Statistics Indonesia 2018). Horticulture, however, has contributed less than food and plantation crops, and its share of GDP was less than 1.5 per cent in 2017 (Figure 2-1). In addition, the land used for horticultural crops is only 0.76 million hectares (Statistics Indonesia 2015a), which is a low percentage of overall agricultural land use. However, horticulture value has experienced growth of more than three per cent per year in the last five years (Statistics Indonesia 2018). Based on the 2013 agricultural census, this subsector has 5.48 million households which are predominantly vegetable farmers (48.9 per cent) and fruit farmers (39.35 per cent). Interestingly, Statistics Indonesia (2015a) noted that this subsector could produce high-value products. Horticultural crops generate IDR 208.93 million per hectare, which is higher than food crops, which only generate IDR 26.10 million and plantation crops, which yield IDR 31.87 million per hectare.

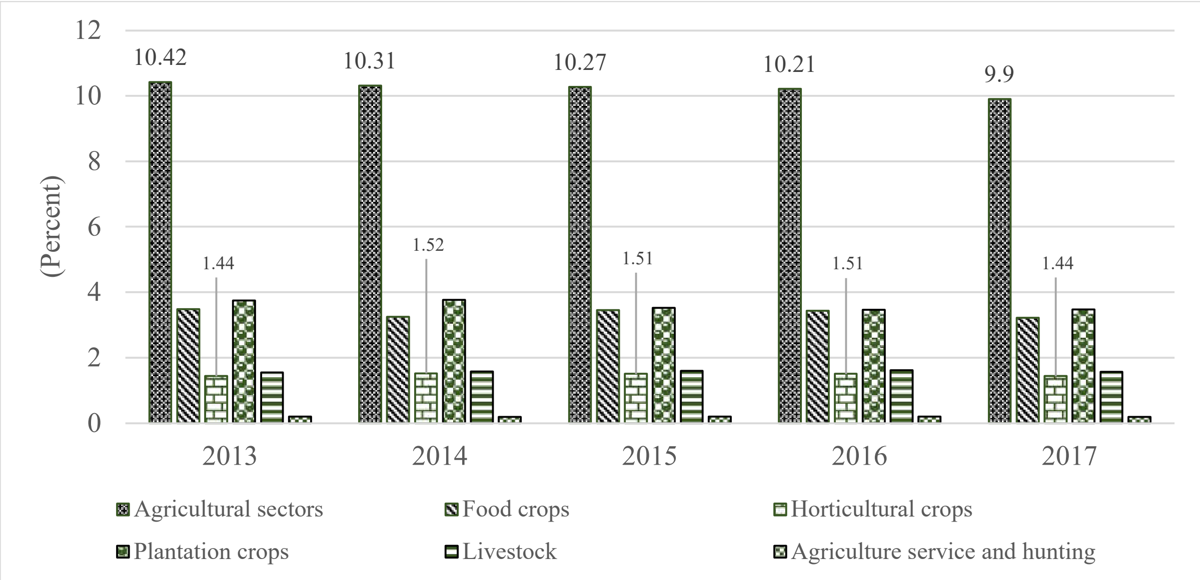

Figure 2-1. The share of Indonesia's agricultural sectors (excluding fisheries and forestry) to Indonesia's gross domestic product 2013 - 2017 (Source: Statistics Indonesia, 2018)

Horticultural production grows slower than its' GDP's share. Between 2013 – 2017, the growth of vegetable production was only 1.97 per cent annually and fruit grew only 2.04 per cent annually (Statistics Indonesia 2018). However, the growth in production is still insufficient to meet the domestic demand for horticultural products; consequently, the horticultural import is higher than the export. The FAO (2018) noted that Indonesia's trade balance for fruits and vegetables in 2016 was USD -662 million. However, for the total horticultural crops, the Ministry of Agriculture reports the greater negative balance, achieved USD -1.3 billion and increased by almost USD -1.8 billion in 2017 (Ministry of

Agriculture 2018). In the last five years, the trade balance trend has been increasing negatively (Figure 2-2).

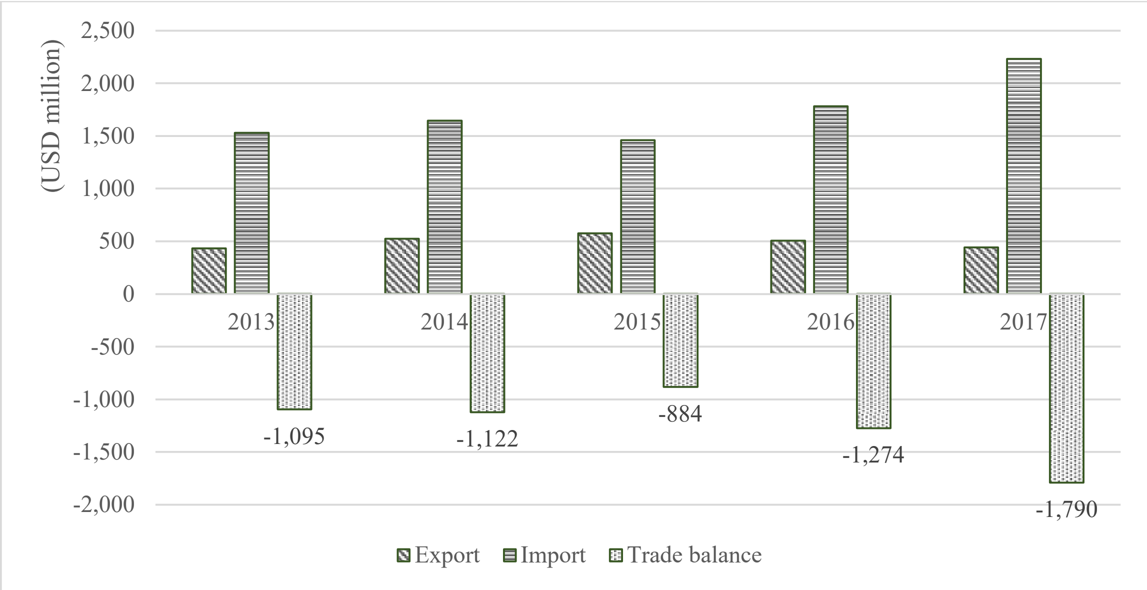

Figure 2-2. Indonesian horticultural products: export, import, and trade balance 2013 - 2017
(Source: Ministry of Agriculture, 2018)

Considering the export-import value of horticultural products, it is essential to understand government policy related to horticultural development. Based on the strategic plan of Indonesia's Ministry of Agriculture, the focus of policies related to horticultural products is: (i) the inflation controlling products (chilli, shallot and garlic), and (ii) export-oriented and import-substituted products (pineapple, mangosteen, salacca, mango and citrus) (Ministry of Agriculture 2015). The first strategy appeared to be very successful in controlling volatile food inflation. The Central Bank of Indonesia noted that chilli, shallot and garlic contribution to food inflation was 0.17, 0.33 and 0.09 per cent in 2016, respectively. In 2017, these three commodities even contributed to food price deflation of -0.18, -0.16 and -0.11 per cent, respectively (Bank Indonesia 2018). The deflation caused by chilli and shallot was influenced by the increasing domestic supply because there was no import of fresh chilli and shallot in the following year (Ministry of Agriculture 2018).

However, for garlic, the supply from import products is expected to contribute to this deflation because the imports rose almost 34 per cent from the previous year. For the three commodities, the negative trade balance increased from USD 453 million in 2016 to USD 622 million in 2017, which predominantly triggered by garlic (Ministry of Agriculture 2018).

In terms of the second strategy, government policy seems to have failed to boost horticultural exports and has substituted the imported products with ones supplied domestically. Based on 2016 – 2017 data, horticultural exports decreased from USD 506 million to USD 441 million (12.89 per cent). On the other hand, imports increased from USD 1.4 billion to USD 1.7 billion, a rise 21.5 per cent (Ministry of Agriculture 2018). Other than vegetables, fresh fruits also contributed to the increase in import, notably citrus, pear, apple and grapes, which are mostly sub-tropical fruit products. However, based on the government's target to reduce imports by substituting domestically produced products, the increasing negative balance of exports and imports shows the relative lack of success by horticulture to respond to the transformation in food systems.

The slow response of the horticultural subsector might be caused by the low level of interest in farming particularly the younger generation (Kusujiarti & Tickamyer 2012). The decreasing interest to be a farmer is not only for horticultural crops but also in agriculture in general.. Based on agricultural censuses of 2003 and 2013, Statistics Indonesia (2014) finds that horticultural farmer households decreased from 16.9 million households (HHs) to 10.6 million HHs; a decrease of more than 37 per cent. The decreasing rate of horticultural farmers is much higher than the reduction in the agricultural sector generally, which has experienced a decline of only 16 per cent. This potentially because horticultural crops have several characteristics that could be a constraint to grow horticultural crops such as the risks (Mariyono 2017; Mariyono & Sumarno 2015; Basuki et al. 2014). A study by Suprehatin

(2016) of Java Island shows that the adoption rate of horticultural crops was meagre. This study finds that farmer's characteristics contribute to this situation; older age, lower education levels, restricted access to information and relative lack of institutional supports were identified as essential factors.

Based on national census figures of the households engaged in horticulture (Statistics Indonesia 2015b), 75 per cent of the farmers were older than 45 years, higher than the average farmers' age engaged in general agriculture which was 60 percent (Statistic Indonesia 2015c) demonstrating that the horticultural farmers were relatively old. The ageing farming workforce has become a serious issue in agricultural development in many countries for decades (Clawson 1963; Mary Clare 2011; Jöhr 2012; Fairweather & Mulet-Marquis 2009; May et al. 2019; Bryceson 2019). More than 85 per cent of farmers had a primary school, or formal education of less than six years, indicating very low education levels. Several studies in Indonesia also confirm the low educational level and the dominance of older farmers in horticulture. For example, Sahara et al. (2015) found that the average age and education level of the head of households of chilli farmers in West Java was 46.24 and 6.46 years, respectively. Also in West Java, Hernandez et al. (2015)'s study of tomato farmers showed that farmers' average age was 42.1 years and the education of the head of the household was 6.8 years. In Central Java, with the focus on chilli farmers, Mariyono (2017) also found a similar picture. In terms of institutional support, Suprehatin (2016)'s findings are also reflected in the national figures. For example, the membership rate of shallot, chilli, citrus and mango farmers in a farmer's group is very low; only 21.40, 24.01, 19.64, and 11.90 per cent, respectively. Membership in a cooperative was much lower, with only 2.49, 7.73, 8.67 and 4.92 per cent, respectively (Statistics Indonesia 2015b).

2.3 Chilli in Indonesia: An Overview

Chilli is one of the essential ingredients in Indonesia because the local culture involves this commodity as an important part of daily dishes (Mariyono & Sumarno 2015). This culture contributes to the high consumption rate; 0.398 kg per capita in 2018. In 2014, the consumption rate was 2.931 kg per capita (Pusdatin 2018). Given the importance of chilli for most Indonesian people, this commodity is produced in all of Indonesia's provinces. In 2017, total chilli production was 2.36 million tonnes, mostly produced in Java and Sumatra (See Figure 2-3), because these islands are the most populated, and have better infrastructure support (Mariyono & Sumarno 2015). Between 2013 and 2017, chilli production grew 8.36 per cent per year, the harvested area increased 5.93 per cent per year, and productivity grew 2.39 per cent per year (Table 2-1). Mariyono and Sumarno (2015) argue that government policies and support from the private sector contributed to the expansion of chilli production, especially in Java.

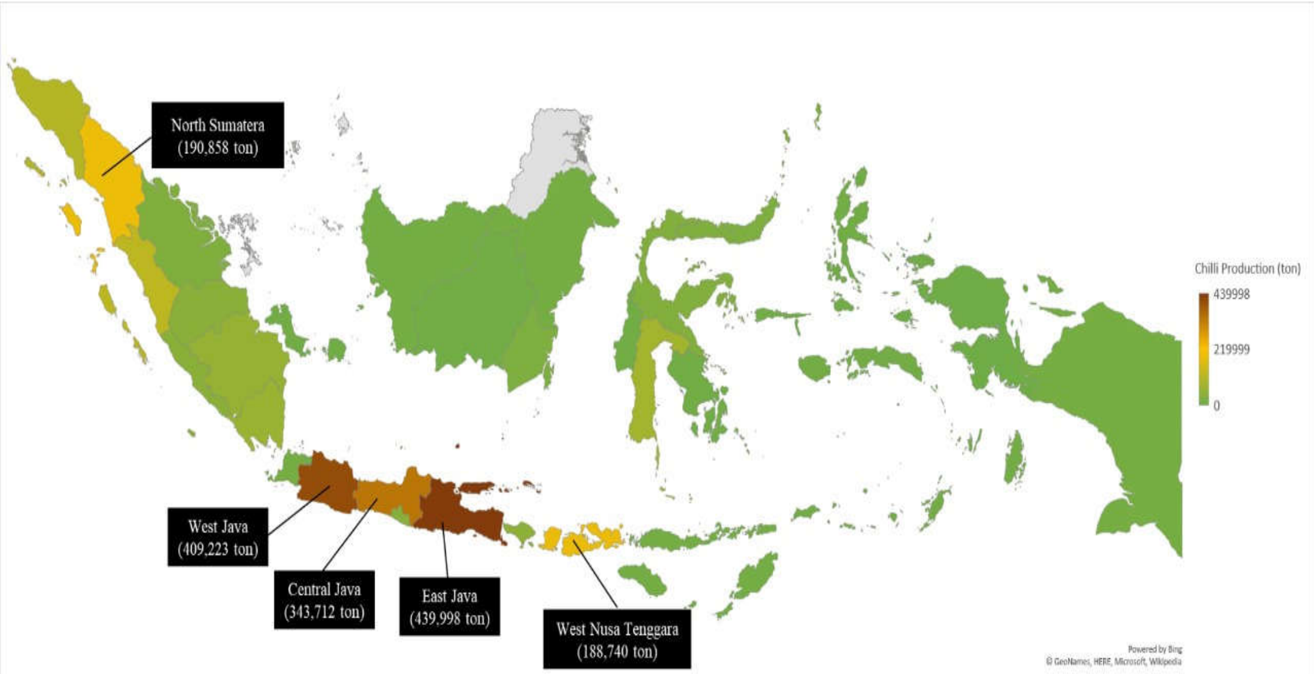

Figure 2-3. Chilli production in Indonesia 2017
(Source: Statistics Indonesia, 2018)

Table 2-1. Production, harvested area, and productivity of chilli in Indonesia, 2013 - 2017

Year	Production (ton)	Harvested area (ha)	Productivity (ton/ha)
2013	1,726,381	249,232	6.93
2014	1,875,075	263,616	7.11
2015	1,915,120	255,716	7.49
2016	1,961,575	260,222	7.54
2017	2,359,421	310,147	7.61
Average	1,967,514	267,787	7.33
Growth (per cent/year)	8.36	5.93	2.39

Source: Ministry of Agriculture (2018)

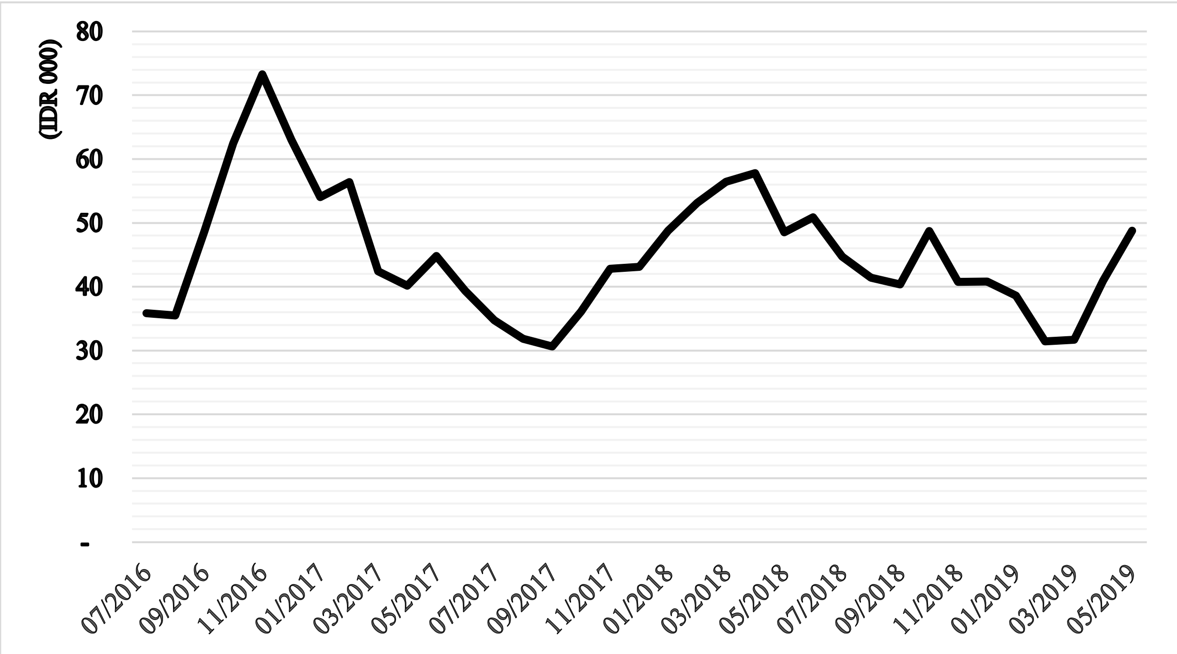

Figure 2-4. Monthly chilli price in Jakarta, July 2016 - May 2019
(Source: PIHPS, 2019)

As stated earlier, the increase in chilli production contributed to the decreasing year-to-year inflation rate in 2016 - 2017 (Bank Indonesia 2018). However, since chilli is a seasonal crop, and production can be constrained by weather conditions, the continuity of supply in the short term might fluctuate (Sativa, Harianto, & Suryana 2017). In addition, there are certain occasions where the demand for chilli increases significantly, such as during important Muslim festivals (Ramadhan, Eid al-Fitr, etc.) (Wahida 2015). This situation might contribute to the price fluctuation of chilli, as shown in Figure 2-4.

The marked volatility of chilli price makes the commodity riskier than other food crops, such as rice. In addition, farmers could face higher production risks since this crop has a higher probability of yield losses associated with susceptibility to pests and disease, and weather conditions (Mariyono 2017; Mariyono & Sumarno 2015; Basuki et al. 2014). However, farmers still perceive chilli farming to be a profitable enterprise, compared with other crops and is the main reason encouraging them to grow chilli (Mariyono 2017).

2.4 Horticulture, Gender and Wealth

In agricultural development in Indonesia, the government pays proper attention to gender issues. The strategic planning of the Ministry of Agriculture is committed to gender equity. The implementation of the Ministry's policies and programs requires gender analysis in term of participation, accessibility, control and impact (Ministry of Agriculture 2015). However, the government report related to gender-based involvement is relatively limited. The agricultural census is an exception because it includes a focus on women's participation in agriculture. Based on the census, farming in Indonesia was dominated by male farmers, who comprise 76.84 per cent of the workforce (24.36 million) (Statistics Indonesia 2014). Female farmers in the horticultural sector were lower (21.83 per cent of farmers) than in the agricultural sector in general, where female farmers were 23.16 per cent, but higher than female farmers of food crop and plantation (21.09 per cent and 16.91 per cent) (Figure 2-5).

Using the terms male and female farmer in the census could cause a bias in data collection and in the analysis, contributing to biased conclusions. The method used may affect the under-counting of female participation in agricultural activities (UN 2010; Dixon 1982). For example, females who often have a significant contribution to post-harvest and product marketing negotiation, but less participation in on-farm activities, (Raney et al. 2011; Doss et al. 2018; Akter et al. 2017) might be not counted as a female farmer. Unfortunately, gender-based policy in agriculture might use this data for policy or program design. So four aspects of gender-based assessment in agriculture (participation, access, control and impact) might be under-counted, which could eventually contribute to misplaced-strategies in programs that are implemented.

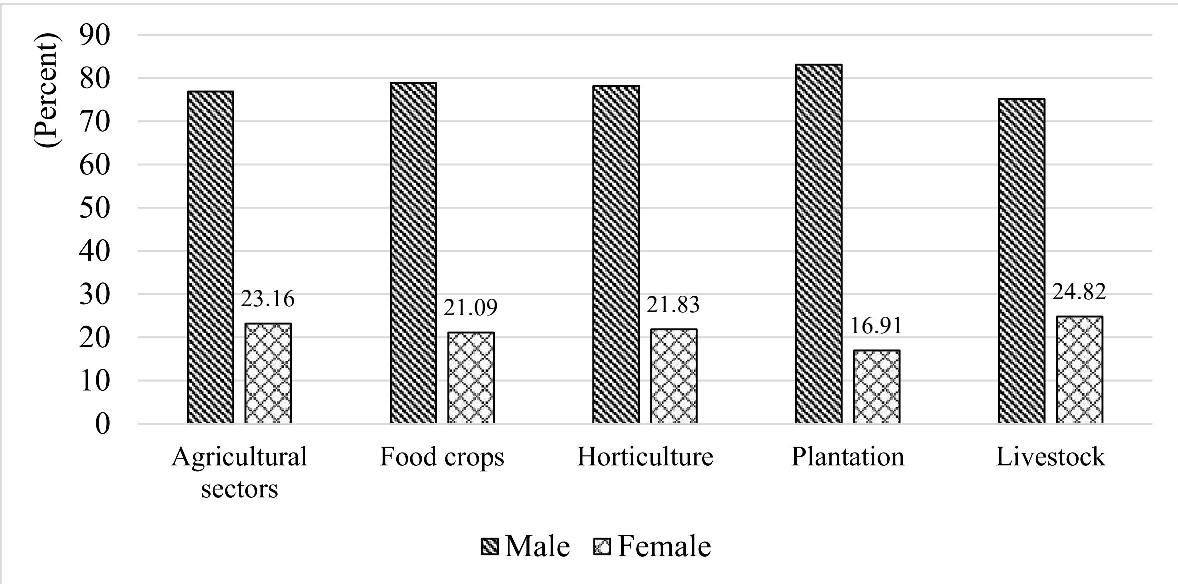

Figure 2-5. Percentages of male and female farmers based on the 2013 agricultural census (Source: Statistics Indonesia, 2015)

Given the importance of women's participation in agricultural activities to improving farm households' welfare in rural areas (Ragasa & Mazunda 2018), understanding women's contribution to the horticultural subsector is essential. Since some literature finds that women have lower productivity than men (Peterman et al. 2011; Quisumbing 1996), it is suggested not to compare male and female performance for the same activities because many farming activities are gender-specific tasks (Jacoby 1991; Doss

2014). Horticultural crops, especially seasonal or annual crops, mainly involve intensive labour farming systems which need various gendered based ‘expertise’ such as typically female task activities (Barrientos, Dolan, & Tallontire 2003; Oduol et al. 2017). Increasing women’s participation in farming activities means greater potential for them to make a greater contribution to increasing household income, which is vital to improving horticultural farmers’ welfare, especially in rural areas.

2.5 Summary

The horticultural subsector has an essential role in the Indonesian economy. However, horticultural related policies are still focused on two issues, i.e. controlling inflation causing products and reducing the negative trade balance in the horticultural subsector. The focus of development, especially for chilli, is to increase the supply and its continuity to keep the price stable. Government policy seems to be successful since chilli contributed to deflation in the 2016 – 2017 period. However, in general, the negative trade balance of horticultural products is increasing.

Promoting high-value horticultural crops to farmers, especially in rural areas, should increase their income and welfare. Optimising the government’s focus on the horticultural subsector, with the advantages of an input subsidy and infrastructure and institutional support, horticultural development should make greater contribution to the Indonesian economy. This situation should provide more opportunities for women to participate in farming activities so they can contribute more to increase their household’s income. However, policymakers need to make sure that horticultural development programs can accommodate or involve women, especially related to the development of their human capital.

References

Akter, S, Rutsaert, P, Luis, J, Htwe, NM, San, SS, Raharjo, B & Pustika, A 2017, 'Women's empowerment and gender equity in agriculture: A different perspective from Southeast Asia', *Food Policy*, vol. 69, pp. 270-279.

Bank Indonesia 2018, *Economic Report on Indonesia*, Bank Indonesia, Jakarta.

Barrientos, S, Dolan, C & Tallontire, A 2003, 'A gendered value chain approach to codes of conduct in African horticulture', *World Development*, vol. 31, no. 9, pp. 1511-1526.

Basuki, R, Arshanti, I, Zamzani, L, Khaririyatun, N, Kusandriani, Y & Luthfy 2014, 'Adoption studies of red pepper Tanjung-2 Varieties as a result of Vegetable Crops Research Institute in Ciamis West Java Province', *J. Hort.*, vol. 24, no. 4, pp. 355-362.

Bryceson, DF 2019, 'Gender and generational patterns of African deagrarianization: Evolving labour and land allocation in smallholder peasant household farming, 1980–2015', *World Development*, vol. 113, pp. 60-72.

Clawson, M 1963, 'Aging farmers and agricultural policy', *Journal of Farm Economics*, vol. 45, no. 1, pp. 13-30.

Dixon, RB 1982, 'Women in agriculture: Counting the labor force in developing countries', *Population and Development Review*, vol. 8, no. 3, pp. 539-566.

Doss, C 2014, 'Data needs for gender analysis in agriculture', in AR Quisumbing, R Meinzen-Dick, TL Raney, A Croppenstedt, JA Behrman & A Peterman (eds), *Gender in Agriculture: Closing the Knowledge Gap*, Springer Netherlands, Dordrecht, pp. 55-68.

Doss, C, Meinzen-Dick, R, Quisumbing, A & Theis, S 2018, 'Women in agriculture: Four myths', *Global Food Security*, vol. 16, pp. 69-74.

Fairweather, J & Mulet-Marquis, S 2009, 'Changes in the age of New Zealand farmers: Problems for the future?' *New Zealand Geographer*, vol. 65, no. 2, pp. 118-125.

FAO 2018, *World Food and Agriculture – Statistical Pocketbook 2018*, Food and Agriculture Organization of the United Nations (FAO), Rome.

Hernandez, R, Reardon, T, Natawidjaja, R & Shetty, S 2015, 'Tomato farmers and modernising value chains in Indonesia', *Bulletin of Indonesian Economic Studies*, vol. 51, no. 3, pp. 425-444.

Jacoby, HG 1991, 'Productivity of men and women and the sexual division of labor in peasant agriculture of the Peruvian Sierra', *Journal of Development Economics*, vol. 37, no. 1, pp. 265-287.

Jöhr, H 2012, 'Where are the future farmers to grow our food?', *International Food and Agribusiness Management Review*, vol. 15, no. Special Issue A, pp. 9-11.

Mariyono, J 2017, 'Moving to commercial production: a case of intensive chili farming in Indonesia', *Development in Practice*, vol. 27, no. 8, pp. 1103-1113.

Mariyono, J & Sumarno, S 2015, 'Chilli production and adoption of chilli-based agribusiness in Indonesia', *Journal of Agribusiness in Developing and Emerging Economies*, vol. 5, no. 1, pp. 57-75.

Mary Clare, A 2011, 'Potential challenges for beginning farmers and ranchers', *Choices*, vol. 26, no. 2.

May, D, Arancibia, S, Behrendt, K & Adams, J 2019, 'Preventing young farmers from leaving the farm: Investigating the effectiveness of the young farmer payment using a behavioural approach', *Land Use Policy*, vol. 82, pp. 317-327.

Mergenthaler, M, Weinberger, K & Qaim, M 2009, 'The food system transformation in developing countries: A disaggregate demand analysis for fruits and vegetables in Vietnam', *Food Policy*, vol. 34, no. 5, pp. 426-436.

Ministry of Agriculture 2015, *Rencana Strategis Kementerian Pertanian tahun 2015- 2019*, Kementerian Pertanian Republik Indonesia, Jakarta.

Ministry of Agriculture 2018, *Agricultural Statistics 2018*, Center for Agricultural Data and Information System, Ministry of Agriculture of the Republic of Indonesia, Jakarta.

Minot, N, Stringer, R, Umberger, WJ & Maghraby, W 2015, 'urban shopping patterns in Indonesia and their implications for small farmers', *Bulletin of Indonesian Economic Studies*, vol. 51, no. 3, pp. 375-388.

Oduol, JBA, Mithöfer, D, Place, F, Nang'ole, E, Olwande, J, Kirimi, L & Mathenge, M 2017, 'Women's participation in high value agricultural commodity chains in Kenya: Strategies for closing the gender gap', *Journal of Rural Studies*, vol. 50, pp. 228-239.

Peterman, A, Quisumbing, A, Behrman, J & Nkonya, E 2011, 'Understanding the complexities surrounding gender differences in agricultural productivity in Nigeria and Uganda', *The Journal of Development Studies*, vol. 47, no. 10, pp. 1482-1509.

PIHPS 2019, *Tabel harga berdasarkan daerah. Pusat Informasi Harga Pangan Strategis Nasional*, http://hargapangan.id/tabel-harga/pasar-tradisional/daerah, Accessed 09 June 2019.
Pusdatin 2018, *Statistics of Food Consumption 2018*, Center for Agricultural Data and Information System, Secretariate General - Ministry of Agriculture, Jakarta.

Quisumbing, AR 1996, 'Male-female differences in agricultural productivity: Methodological issues and empirical evidence', *World Development*, vol. 24, no. 10, pp. 1579-1595.

Ragasa, C & Mazunda, J 2018, 'The impact of agricultural extension services in the context of a heavily subsidized input system: The case of Malawi', *World Development*, vol. 105, pp. 25-47.

Raney, T, Anríquez, G, Croppenstedt, A, Gerosa, S, Lowder, S, Matuscke, I, Skoet, J & Doss, C 2011, *The Role of Women in Agriculture*, ESA Working Paper No. 11-02, Agricultural Development Economics Division, The Food and Agriculture Organization of the United Nations, <http://www.fao.org/3/am307e/am307e00.pdf>.

Reardon, T, Barrett, CB, Berdegué, JA & Swinnen, JFM 2009, 'Agrifood industry transformation and small farmers in developing countries', *World Development*, vol. 37, no. 11, pp. 1717-1727.

Sahara, S, Minot, N, Stringer, R & Umberger, WJ 2015, 'Determinants and effects of small chilli farmers' participation in supermarket channels in Indonesia', *Bulletin of Indonesian Economic Studies*, vol. 51, no. 3, pp. 445-460.

Sativa, M, Harianto & Suryana, A 2017, 'Impact of Red Chilli Reference Price Policy in Indonesia', *International Journal of Agriculture System*, vol. 5, no. 2, pp. 120-139.

Statistics Indonesia 2014, *Potret Usaha Pertanian Indonesia Menurut Subsektor (Hasil Pencacahan Lengkap Sensus Pertanian 2013 dan Survei Pendapatan Rumah Tangga Usaha Pertanian 2013)*, Badan Pusat Statistik, Jakarta, Indonesia.

Statistics Indonesia 2015a, *Analisis Rumah Tangga Hortikultura di Indonesia: Hasil Survey Rumah Tangga Usaha Tanaman Hortikultura Tahun 2014*, Badan Pusat Statistik, Jakarta.

Statistics Indonesia 2015b, *Census of Agriculture 2013: National Figures of Horticulture Crops Cultivation Household, Result Of ST2013 - Subsector Survey*, vol. Book C, Statistics Indonesia, Jakarta.

Statistics Indonesia 2015c. *Laporan Hasil Sensus Pertanian 2013*. Statistik Indonesia, Jakarta.

Statistics Indonesia 2018, *Statistical Yearbook of Indonesia 2018*, Statistics Indonesia, Jakarta.

Suprehatin 2016, 'Adoption of high value horticultural crops in Indonesia: Determinants and impact', Global Food and Resources, Faculty of the Profession, PhD thesis, the University of Adelaide, South Australia.

UN 2010, *Rural Women Key to Economic Growth, Says UN Official*, UN News, viewed 6 April 2019, <https://news.un.org/en/story/2010/03/333332-rural-women-key-economic-growth-says-un-official>.

Van den Broeck, G & Maertens, M 2016, 'Horticultural exports and food security in developing countries', *Global Food Security*, vol. 10, pp. 11-20.

Wahida 2015, 'Food system transformation in Indonesia: factors influencing demand and supply for alternative pest management farming systems', Global Food Studies, Faculty of the Profession, PhD thesis, The University of Adelaide.

Weinberger, K & Lumpkin, TA 2007, 'Diversification into horticulture and poverty reduction: A research agenda', *World Development*, vol. 35, no. 8, pp. 1464-1480.

Chapter 3 : Data Collection

3.1 Introduction

This chapter explains the data collection methods used for the analysis in this thesis. Data were collected as a part of the ACIAR research project entitled, "Improving market integration for high-value fruit and vegetable production systems in Indonesia". Data were collected from the same sample in two survey rounds, the first in 2010 and the second in 2016.

3.2 The 2010 Survey of Indonesian Chilli Producers

This survey was a collaboration between the University of Adelaide, the International Food Policy Research Institute (IFPRI), and the Indonesian Centre for Agriculture Socio-Economic and Policy Studies (ICASEPS). The sampling method was designed to address the major project research quesitions (Sahara 2012). The main research objective was to examine smallholder farmers participation in modern chilli value chains, focusing on market relationship with traders and the impacts on household income on those participataing in modern markets compared with those who continue to sell in tradtional markets. To address these objectives, samples were selected from two groups: farmer households supplying the modern market and a randomly selected group of farm households. The total sample was total sample was 597 households with 112 households supplying modern supermarkets and 485 households supplying traditional market channels.

3.2.1 Scoping Studies

Before constructing the questionnaire, scoping studies were conducted to explore and map the general picture of chilli farmer households. The first scoping study was conducted from May to June 2009 to investigate the chilli market at that time. The chosen location was in one of Java's major chilli production centres, the highland areas of Bandung and Garut in West Java Province and the lowland areas of Brebes in the Central Java Province. In addition to chilli farmers, traders and retailers were also interviewed.

The second scoping study was carried out between July and September 2009 in Ciamis, West Java, where the number of chilli producers supplying supermarkets was increasing. In this scoping study, the interview was focused on farmers supplying the supermarket and/or its suppliers. Information about the relationship between chilli producers and traders was also collected.

The last scoping study was conducted in January 2010 in Bandung and three primary chilli producer districts in West Java Province (Ciamis, Tasikmalaya, and Garut districts) to interview chilli producers, traders, wholesalers, and also extension service staff. The information collected from the three scoping studies was used to construct the questionnaire.

3.2.2 Constructing the Questionnaire

The questionnaire was developed based on the information collected during the scoping studies and a literature review. The questionnaire was tested and refined over time. The questionnaire consists of 14 modules: 1) household characteristics; 2) housing and assets; 3) agricultural land; 4) chilli production; 5) inputs used and information sources; 6) chilli marketing; 7) changes in production and marketing; 8) relationships with chilli buyers; 9) perception of the quality of relationship with chilli buyers; 10) perceptions of modern marketing channels; 11) experience with modern marketing channels; 12) cash income activities; 13) shopping habits; 14) food consumption and desired attributes of food among buyers (please see Sahara (2012) for detail about the questionnaire).

3.2.3 Sample Selection

West Java Province was selected as the survey site because this province was the largest chilli producing area in Indonesia (Statistics Indonesia 2010). Three districts in West

Java Province were selected: Garut, Ciamis and Tasikmalaya. Garut was selected because it is the major chilli producing district in the province. In addition, Ciamis and Tasikmalaya were chosen to represent farmer households supplying supermarkets, based on information gathered during scoping studies.

To address the project research objectives, sample selection used two different methods. First, for the sample of chilli farmers who supplied supermarkets, population data were obtained from wholesale suppliers in Bandung who provided names and contract details data for farmers selling to the local supermarkets. This process provided a list of 96 farmers. Second, a group of farm households were selected using a random sampling method. To sub-districts, a systematic random sampling was employed based on the average chilli production in those areas from 2004 to 2008. First, the sub-districts were ranked from the highest producing to the lowest producing. Then, the interval was calculated from the total average production divided by the number of sub-districts. The first sub-district was selected from the list as the starting point. The second sub-district was chosen based on the first sub-district then added with one interval. The third sub-district was selected by adding two intervals from the starting point. In total, 14 sub-districts were selected.

To select villages in the 14 sub-districts, three villages were randomly selected from each sub-district for a total of 42 villages. From every village, 12 chilli farmer households were randomly chosen, based on lists from the land tax office. In total, 506 chilli farmer households were selected from this group.

3.2.4 Enumerators

This survey involved twelve professional enumerators. Before the survey, the enumerators were trained in March 2010 to ensure they had uniform perceptions of the questionnaire and tried to interview farmers in Cianjur, West Java Province. The survey was carried out for one month from 23 March to 23 April 2010.

3.3 The Second-round Survey in 2016

The second-round survey entailed re-interviewing the sample from the first round survey. In the second survey, the research team updated the information about the chilli production system in Indonesia and created an inventory on all of the Indonesian government's intervention in the chilli production system. In the second survey, an additional research was added: to understand how chilli producers make upstream choices related to input purchases, seed varieties and labour use.

3.3.1 Scoping Study

The scoping study was conducted from 1 to 4 December 2015. Its purpose was to: 1) identify the representativeness of the first round sample; 2) identify the value chain of chilli seeds in the survey locations. To address the first purpose, the team visited seven sub-districts and 15 villages in Garut, Ciamis, and Tasikmalaya The team interviewed some key informants to verify that the first survey respondents still lived in the same villages. Of the 88 farmers of the sample, 71 farmers were still lived in their villages, constituting about 80 per cent of the sample. The other nine farmers could not be contacted because they had passed away or had moved to other villages. The results show that the percentage of the sample is still sufficiently reliable to be used as panel data.

The team also collected information about the chilli seeds value chain in the survey location from the key informants. We found that farmers used open-pollinated seeds, or saved seeds from the previous harvest, and hybrid seeds. The information from the scoping study was then used by the team to construct the questionnaire.

3.3.2 Constructing the Questionnaire

The survey used a structured electronic questionnaire. To address the objectives of the research in the second round of the survey, the questionnaire from the first-round survey was refined. Some sections were deleted and other sections were added. The final questionnaire consisted of the following topic areas: 1) household characteristics; 2) housing and assets; 3) agricultural land; 4) chilli production in three different seasons; 5) details of inputs used, except labour, and credit used; 6) details of labour employed in each production phase and any marketing activity; 7) chilli marketing; 8) seedlings used; 9) relationship with chilli buyers; 10) contract specification with buyers; 11) price satisfaction; 12) perceptions of modern marketing channels; 13) experience with modern marketing channels; 14) cash income activities; 15) male and female participation and leadership 16) institutions and collective action; 17) intervention programs; and 18) shocks. The detailed questionnaire is provided in Appendix 3.

In the section chilli production, we refined the questionnaire in order to obtain more information about the kinds of seeds used. A list of hundreds of chilli varieties was provided, including the type of chilli and who was doing the seedling seeds. This section also added a detailed question about harvesting.

The section on inputs used in the first round survey was refined with specific and detailed questions to provide sufficient and relevant data for production function analysis. A new section, labour used, explored very detailed questions about the use of family and hired labour with separate questions for male, female and child labour. This section outlined 27 activities in chilli farming that might involve family and hired labour to avoid missing any factor related to the kind of labour used.

To address the project's objectives, an expanded survey module focused on seed selection and seedling processes - whether farmers did their own seedlings or purchased seedlings.

The sections on institutions and collective action were added to obtain information about membership of organisations (cooperatives, farmers' groups, womens' farmer groups, and other organisations) and the benefits farmers might get from them. This section was followed by one on intervention programs, including government and private ones operating at village or individual levels.

A section on economic, households and production shocks was included to control outlier or unexplainable data. Lastly, to check the flow and relevancy of the questionnaire, the first pre-testing of the questionnaire was held from 28 to 30 January 2016. The feedback from the testing for every variable and question particularly for the new sections was used to refine the questionnaire. The second pre-testing of the questionnaire was carried out between 16 and 19 March 2016, in Garut and Ciamis. After improving the questionnaire again, then the questionnaire was constructed through an application called "GeoODK", an open source platform online and offline mobile-electronic based data collection. This apllication is able to collect and store geo-referenced information (GeoODK 2019).

3.3.3 Enumerator Training and Survey

This survey involved fourteen local professional enumerators who are trained and experienced. All enumerators were trained from 2 to 6 May 2016 in Bogor. They were also sent into the field to test the questionnaire that was loaded onto tablets with GeoODK application. The valuable feedback from enumerators, especially regarding the flow of the questions and wording, was used to refine the final questionnaire.

The survey was conducted over 24 days, from 5 May to 1 June 2016. Twenty-eight respondents from the initial sample could not be re-interviewed. In total, 574 respondents were interviewed in 2016 from the 602 respondents interviewed in 2010. The detail of the recapitulation of the number of the sample can be found in the Appendix 1. After gathering the necessary data, this study used a series of statistical methods to analyse the data using STATA software. The specific methods are explained in the analytical chapters.

References

GeoODK 2019. *Geographical Open Data Kit,* http://geoodk.com/. Accessed 23 January 2020.

Sahara. 2012. The transformation of modern food retailers in Indonesia: opportunities and challenges for smallholder farmers. PhD, School of Agriculture, Food and Wine, The University of Adelaide.

Statistics Indonesia. 2010. *Statistics of Seasonal Vegetables and Fruits Plants Indonesia* 2010, Jakarta.

Chapter 4 Statement of Authorship

Title of Paper	Impact of Hybrid Seeds on Demand for Labour The Case of Chilli Production in Indonesia
Publication Status	☐ Published ■ Accepted for Publication ☐ Submitted for Publication ☐ Unpublished and Unsubmitted work written in manuscript style
Publication Details	Accepeted in Journal of Agribusiness in Developing and Emerging Economies

Principal author

Name of Principal Author (Candidate)	Apri Laila Sayekti		
Contribution to the Paper	Contributed to preparation of primary survey and data collection, performed data analysis and interpretation, and wrote manuscript.		
Overall percentage (per cent)	65 per cent		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	26/08/19

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);
ii. permission is granted for the candidate in include the publication in the thesis; and
iii. the sum of all co-author contributions is equal to 100 per cent less the candidate's stated contribution.

Name of Co-Author	Adjunct Professor Randy Stringer		
Contribution to the Paper	Project director of INDOHORT, contributed in manuscript editing.		
Signature		Date	26/08/19

Name of Co-Author	Dr Di Zeng		
Contribution to the Paper	Contributed to data analysis and in manuscript editing.		
Signature		Date	26/08/19

Chapter 4 : Impact of Hybrid Seeds on Demand for Labour: The Case of Chilli Production in Indonesia

Abstract

The welfare, poverty reduction, food security and nutrition impacts of modern agricultural technologies have been widely assessed in the literature. The extent of rural employment impacts, especially farm and off-farm female labour consequences are less well understood. This chapter examines the labour demand associated with hybrid chilli adoption, a relatively labour-intensive crop in Indonesia. Using 228 chilli producing households in West Java Province, Indonesia's primary chilli producing region, the analysis extends previous research on household labour demand by assessing the impacts of hybrid chilli seed adoption on both family and hired labour on a gender-specific basis. Instrumental variables 2SLS approach is employed to address the endogeneity issues that may occur related to hybrid seeds choices. The results demonstrate that hybrid chilli seed use is more likely to increase demand for hired labour, particularly female labour. However, hybrid seed adoption is insignificantly associated with demand for male and female family labour. This indicates that hybrid seed adoption creates rural employment opportunities and provide women with additional wage-earning opportunities compared to men rather than add additional tasks on female household members who responsible for domestic chores and child-rearing.

Keywords: labour demand, chilli, gender, employment, Indonesia

4.1 Introduction

Hybrid seed adoption is one of the essential technologies supporting rural development and economic growth. Promoting hybrid seeds is a long practised agricultural and rural development strategy (Huang & Rozelle 1996). Encouraging higher yielding, higher profit, more productive hybrid seeds is a straightforward technology choice requiring relatively little investment in many cases (Ali 2006; Firdaus & Ahmad 2010). Numerous studies evaluate the impacts of hybrid seed adoption on-farm income through increasing productivity and profits (Hossain, Bose, & Mustafi 2006; Joshi et al. 2014; Matuschke, Mishra, & Qaim 2007). Additional literature examines profit increasing outcomes related to cost savings through reduced input applications (Kouser & Qaim 2011; Pray, Ma, Huang, & Qiao 2001). While most traditional cropping systems are labour-intensive, the consequences of hybrid seed adoption for labour demand is less understood.

Evidence suggests that the adoption of new technologies requires different labour inputs (Beckmann & Wesseler 2003; Doss & Morris 2000; Lin 1994; Moser & Barrett 2003). The changing demand for labour may affect farm households need for labour, the cash to pay labour and the distribution of household labour among the newly adopted crop and between crops. Increasing family labour participation is often a good sign of on-farm work interest. Younger farm family members in most developing countries are more interested in working in less risky off-farm wage jobs (Kusujiarti & Tickamyer 2012).

The composition of male and female labour, both hired and family labour may also change (Unay-Gailhard and Bojnec 2019). Adoption of hybrid seeds may increase the demand for both male and female family labour (Akter et al. 2017). Female family labour is typically responsible for domestic chores and child-rearing in addition to traditional gender-specific production and marketing activities (e.g. planting, weeding, harvesting and sorting).

To date, most existing labour demand studies focus on paid, hired off-farm labour without necessarily considering family labour particularly for female labour (Kouser, Abedullah, & Qaim 2016; Lin 1994; Simmons, Winters, & Patrick 2005). These studies ignore evidence that farm households are endowed with different fixed assets, which further influence farmers' adoption decisions (Eswaran & Kotwal 1986; Lovo 2012; Subramanian & Qaim 2010). For most low-income farmers, available family labour plays an essential role in whether hybrid seeds are adopted (Boahene, Snijders, & Folmer 1999; Croppenstedt, Demeke, & Meschi 2003). Important factors include the availability of female labour to participate (Poelmans, Chinchilla, & Cardona 2003), the proportion of fixed assets and access to cash or credit markets to hire additional labour (Boahene et al. 1999). Examining the demand for labour, both hired and family labour on the gender basis is essential to fully understand the employment impacts of hybrid seed adoption.

To help understand the employment impacts of hybrid seed adoption in more depth, this chapter employs data collected from labour-intensive chilli production in Indonesia. In Indonesia, chilli is one of the country's most important horticultural commodities. The Agriculture Census (Statistics Indonesia 2015b), documents more than 1.6 million households produce chillies. Given that the usage of hybrid seeds is farmers' choices, the possible endogeneity problem may occur if using OLS regression. The analysis employs instrument variable 2 SLS to address this issue.

This chapter is organised as follows. Section 4.2 explores the methodology followed by data explanation and descriptive statistics. Section 4.5 and Section 4.6 present the empirical results and discussion. The final section concludes with policy implications.

4.2 Methodology

An analytical framework illustrates the conceptual linkage between hybrid chilli adoption and labour demand. Assuming cost-minimising farm households, the total production cost is considered to be the sum of the product of profit-maximising input demand and their prices (Hamermesh 1996; Lin 1994). Extending this model, let *C* be the production cost; *w* the wage rate; *r* the exogenous price of capital services that characterises all other inputs; Y^* the optimised yield; *V* the technology, in this case, varietal choices; and *X* the other factors, such as household and plot characteristics. We can write the cost function as:

$$C = C\ (w, r, Y^*, V, X);\ C_i > 0;\ C_{ij} > 0;\ i, j = w, r$$

Use L^* to denote the profit-maximising demand for labour. C_i in the above equation is the partial derivative and C_{ij} is the cross partial derivative. Applying Shepard's lemma, the demand for labour can be recovered from the cost function as:

$$L^* = C_w$$

which can be further written as:

$$L^* = L^d(w, r, Y^*, V, X)$$

where L^d is the partial derivative $\frac{\partial c}{\partial w}$.

To estimate the demand for labour, the typical strategy is ordinary least squares (OLS) regression, which is widely employed in existing literature (Kanwar 1999; Lin 1994; Ruben, Kruseman, & Kuyvenhoven 2006; Simmons et al. 2005). Total labour is disentangled into different types of labour—hired by gender and family labour by gender.

Each type of labour is considered a different input factor that is not perfectly substituted with each other in production (Hamermesh 1996).

A linear equation form is used when explanatory variables satisfy certain exogeneity conditions. However, in many applications, OLS assumptions can be violated and OLS estimation, therefore, leads to biased and inconsistent results (Wooldridge 2010). It may be the case that farmers may self-select seeds, which is potentially endogenous (Berkhout, Glover, & Kuyvenhoven 2015). The instrumental variable procedure is used, therefore, to correct for endogeneity bias (Wooldridge 2010). The regression model can be expressed as follows:

$$L^*_{dhi} = \beta_0 + \beta_1 w_{dhi} + \beta_2 r_{dhi} + \beta_3 Y^*_{dhi} + \beta_4 V_{dhi} + \beta_5 X_{dhi} + \beta_6 P_{di} + u_{dhi}$$

Where L* denotes the different types of labour demand (total hired labour, total family labour, male hired labour, female hired labour, male family labour, and female family labour), measured on plot *d* in household *h* located in village *i*. *V* is a varietal choice, which is equal to 1 if the plot is planted mainly with hybrid seed, and 0 if planted mainly with an open-pollinated seed. *X* denotes a set of household characteristics, as mentioned earlier. P is the plot characteristics. B_k $(k = 0, \ldots, K)$ are the coefficients to be estimated, where K is the number of explanatory variables and u is the error term. Since V_{dhi} is potentially correlated with u, an instrument variable (Z_i) is needed for estimation. Z_i must be uncorrelated with u_{dhi} and correlated with V_{dhi}:

$$V_{dhi} = \delta_0 + \delta_1 X_{dh} + \delta_2 P_{di} + \delta_3 Z_{dhi} + \varepsilon_i$$

where ε_i is the error term.

We use the neighbours' adoption rate in the respondent's village, excluding the respondent's choice, as an instrument (Z_{dhi}), following Skoufias (1994) and Andersson, Chege, Rao, and Qaim (2015). Suppose the number of adopters in one village is 5 and the total number of respondents is 10. In this case, if the respondent is an adopter, we compute the neighbours' adoption rate as the difference between 5 and 1 divided by 9, and if the respondent is a non-adopter, we compute the instrument as 5 minus 0 and then divide by 9. The neighbours' adoption rate is legitimate as farmers usually learn from their neighbours' behaviour yet it is given for any individual farmer. This variable should, therefore, affect varietal selection (using hybrid seeds or not), but not influence labour allocation. However, in specific regressions, based on endogeneity tests, we cannot reject exogeneity. Therefore, both OLS and two-stage least square (2 SLS) estimations are reported in our main results to be presented below.

The choices of explanatory variables affecting demand for labour are based on the existing literature that underpins the importance of farmer human capital variables and production characteristics (Tocco, Davidova, & Bailey 2012), access to market (Lovo 2012), technology (Beckmann & Wesseler 2003; Tocco et al. 2012), and wage rates and output price (Kouser et al., 2016).

Considering that most agricultural production in Indonesia is a cooperation between male and female in the household, we include age and education of the wife in addition to household head characteristics commonly used in the literature (Kouser et al. 2016; Kouser & Qaim 2011; Lin 1994; Rao & Qaim 2013). The number of household members is included, as the more family members available to the farm, the lower its dependence on hired labour (Tocco et al. 2012). Farmer group membership and women farmer group membership are also included as it may reflect farmer's access to information about technology or the labour market.

Since we estimate labour demand by plot, there is also a need to control for plot characteristics, such as whether it has irrigation, and distance from farmer's home to the plot, as those can affect labour input. Different levels of fixed asset endowments across farm households are controlled by including an operated land and land ownership. These variables are expected to be associated positively with hired labour. We also use a dummy season indicator, since Indonesia has both a rainy season and a dry season; most agricultural production tends to cluster within the dry season because of less induced pests and diseases. Village dummies are also used to capture possible unobserved differences.

4.3 Data

This study uses primary household- and village-level data from the 228 chilli producing households in West Java Province as presented in Chapter 3. The analysis uses the labour specific data collected for the 2016 follow up survey survey only since in the first-round survey, not all required data for the a longitudinal analysis were available, especially the labour data which were not collected. The survey captured farm and off-farm labour days by gender for all chilli production activities. In all, the data set provides detailed labour for 228 households. For the price data, we use the respondent's reported prices if available; if not, we use regional average price data.

There are two types of chilli seeds in the study context: hybrid and open-pollinated. Hybrid seeds retain the classification only for the first generation. The next-generation of hybrid seed is categorised as open-pollinated since the performance of second-generation hybrid seeds would be different from the first generation. Therefore, open-pollinated seeds include not only local seeds but also second-generation hybrid seeds.

4.4 Descriptive Statistics

Table 4-1 presents the descriptive statistics of all variables used for the analysis. From the sample, 67 per cent of the chilli producers grow hybrid seeds, compared to 33 per cent planting local and/or open-pollinated seeds. According to Derek and Rolien (2008), before 1989, chilli production in Indonesia relied heavily on local or open-pollinated seeds. The first documented use of hybrid seeds introduced in Indonesia was TM-999 in 1989 (Derek & Rolien 2008). More recently, however, the evidence suggests that hybrid chilli seed adoption rates vary by location (Ali 2006; Derek & Rolien 2008).

Table 4-1. Variables descriptions and descriptive statistics

Variable	Description	Mean	Std. Dev.
Hybrid	Dummy varietal choices, 1 = hybrid, 0 = OP	0.668	0.472
Household characteristics and asset			
Male's age	Household head's age (years)	50.435	9.920
Female's age	Spouse' age (years)	43.689	10.279
Male's education	Household head's education (years)	6.280	2.340
Female's education	Spouse' education (years)	6.580	2.627
Adults	Productive member/s in the household (no.)	2.767	1.119
Children	Children in the household (no.)	1.435	1.126
Motorbikes	Motorbike asset (no.)	1.124	0.927
Household income			
Income	Income from non-agricultural activities (Rp 1,000,000/year)	27,200	71,700
Plot characteristics			
Plot size	Chilli plot size (ha)	0.263	0.286
Operated land	All operated land including chilli plot (ha)	0.661	0.644
Land ownership	Dummy land is owned by household, 1 = yes, 0 = no	0.606	0.490
Irrigation	Dummy all type irrigated, 1 = yes, 0 = no	0.332	0.472
Season	Dummy season, 1 = dry, 0 = rainy	0.363	0.482
Distance	Distance from home to the plot (km)	1,462	3,167
Chilli price			
Chilli price	Before peak season chilli price (Rp 1,000/kg)	13,459	9,129
Input prices			
Male's wage	Male labour wage (Rp 1,000/day)	43,675	10,063
Female's wage	Woman labour wage (Rp 1,000/day)	28,076	6,892
Fertiliser price	The most common used fertiliser price (Rp 1,000/kg)	8,845	2,415
Institutions			
Farmers' group	Dummy farmer's group member of household member, 1 = yes, 0 = no	0.456	0.499
Women farmers' group	Dummy woman farmer's group member of household members, 1 = yes, 0 = no	0.026	0.159

Table 4-2 compares household characteristics and plot characteristics by hybrid adopter farmers and non-hybrid adopter farmers. Respondents' education is similar for both adopting (hybrid seed) and non-adopting farmers, about 6 years of completed schooling. The 2013 Agriculture Census documents that approximately 75 per cent of farm household heads completed 6 years of formal education (Statistics Indonesia 2015a). There is no significant difference in the size of households, particularly for members considered as part of the productive age group (17–65 years old) and the number of children in the households. The average plot size is small, less than 0.3 hectare. There are insignificant differences for chilli plot size, total land operated and land ownership between hybrid and open-pollinated plots.

Table 4-2. Household and plot characteristics of samples by varietal choices

Variables	Open-pollinated (n = 74)		Hybrid (n = 154)		Diff.
	Mean	SE	Mean	SE	
Household characteristics					
Male's age	49.750	1.390	50.775	0.818	-1.025
Female's age	43.516	1.331	43.775	0.892	-0.260
Male's education	6.484	0.294	6.178	0.206	0.306
Female's education	6.859	0.379	6.442	0.212	0.418
Adult	2.781	0.133	2.760	0.101	0.022
Child	1.438	0.139	1.434	0.100	0.003
Plot characteristics					
Plot size	0.221	0.036	0.284	0.025	-0.063
Operated land	0.565	0.096	0.708	0.050	-0.144
Irrigation	0.281	0.057	0.357	0.042	-0.075
Land ownership	0.609	0.061	0.605	0.043	0.005
Season	0.344	0.060	0.372	0.043	-0.028
Distance	1523.000	254.986	1431.860	317.449	91.140

Note: *** different at 1 per cent, ** different at 5 per cent, * different at 10 per cent

Labour days used per plot for both hired and family labour is significantly different between adopting and non-adopting farms (Table 4-3). The data demonstrate that hybrid seed producers require more hired labour and more household member participation. There is more male labour than female labour in both hired and family labour categories. The ratio of male to female labourers are higher for preparing the land (hoeing), operating equipment, applying fertilisers and irrigating activities.

Hybrid plots use more female labour than open-pollinated plots. On average, hybrid plots use 19 days more female hired labour and 7 days more female family labour. Hybrid seeds tend to generate higher yields, requiring more harvesting days, for which predominantly female labour is used. This is important from the rural development perspective since females do not have as many alternative work options in Indonesia as in many other developing countries (Kouser et al. 2016).

Table 4-3. Labour used, hired and family labour (days/plot) by varietal choices by gender

Variables	Male				Female			
	Open-pollinated (n = 64)		Hybrid (n = 129)		Open-pollinated (n = 64)		Hybrid (n = 129)	
	Mean	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**
Total hired labour	49.781	9.198	76.783	7.069**	31.328	6.120	50.155	5.245**
Total family labour	51.594	3.837	66.047	3.820**	16.156	2.383	23.085	1.982**
Land preparation								
Hired labour for land preparation	29.578	4.183	50.550	4.598***	5.969	2.599	5.519	1.429
Family labour for land preparation	13.547	1.849	17.155	1.379	3.188	0.742	4.147	0.605
Planting								
Hired labour for planting	4.813	1.968	2.806	0.516	5.031	1.221	5.558	0.635
Family labour for planting	6.063	1.209	5.667	0.634	2.734	0.626	3.085	0.441
Maintenance								
Hired labour for maintenance	13.375	3.773	19.682	2.913	9.375	2.534	15.690	2.228**
Family labour for maintenance	24.328	1.887	33.434	2.245	6.031	1.243	9.620	1.152**
Harvesting								
Hired labour for harvesting	2.016	0.655	3.744	0.837	10.953	1.734	23.388	2.779***
Family labour for harvesting	7.656	0.797	9.791	0.732**	4.203	0.571	6.233	0.516**

Note: *** different at 1 per cent, ** different at 5 per cent, * different at 10 per cent

In term of paid wages, there is no difference between hybrid and open-pollinated farmers (Table 4-4). Finally, chilli prices are also indifferent even though it is still debatable that consumers still prefer traditional seeds, which are easier to process into sambals and have a longer storage life (Basuki et al. 2016).

Table 4-4. Wages and chilli price

Variables	**Open-pollinated (n = 64)**		**Hybrid (n = 129)**		**Diff.**
	Mean	SE	Mean	SE	
Male’s wage	43.670	1.477	43.741	0.802	-0.199
Female’s wage	28.434	1.025	27.898	0.542	0.536
Chilli price	14.648	1.354	12.869	0.716	1.778

Note: *** different at 1 per cent, ** different at 5 per cent, * different at 10 per cent

4.5 Results

Since we estimate the demand for labour as a linear function, a one-unit change of an independent variable indicates the change relative to one unit of a dependent variable while holding all other remaining independent variables constant. The first set of estimation results are presented in Table 4-5 showing that seed choices influence the demand for hired labour significantly. Estimation results using OLS estimation demonstrate an increase of 45 per cent for hired labour compared to 2 SLS which is 39 per cent. However, demand for family labour is insignificant even though the sign is also positive which implies that hybrid seed adoption needs more labour but has been supplied by hired labour. In addition, these results also suggest that family labour is substitutable with hired labour.

The second set of regressions disaggregate demand for labour by gender. Table 4-6 shows that the adoption of hybrid seeds has a significantly positive impact on demand for male and female hired labour. OLS regressions show a significant result for hired female labour, rising by 23 per cent compared to 18 per cent for male labour. If chilli production needs approximately 345 labour days per hectare (Ali 2006), this findings imply that the usage of hybrid seeds creates 79 employment opportunities for female and 62 for male in every hectare production.

Demand for family labour is shown in Table 4-7. Even though 2 SLS estimation result shows demand for male family labour is statistically significant, the OLS estimation presents an insignificant result. The female family labour demand is insignificant in both OLS and 2 SLS estimations.

Table 4-5. Demand for total hired and family labour (days/plot) estimation results

Variables	Total Hired Labour				Total Family Labour			
	OLS		2 SLS		OLS		2 SLS	
	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE
Hybrid	45.120**	18.670	38.750**	19.280	13.500	10.160	18.170**	8.429
Male's age	3.171**	1.487	3.183**	1.240	-1.169*	0.684	-1.178**	0.569
Female's age	-0.880	1.407	-0.860	1.171	1.797***	0.649	1.783***	0.540
Male's education	1.765	4.236	1.721	3.532	-3.245*	1.858	-3.212**	1.544
Female's education	8.222*	4.541	8.260**	3.776	-1.164	1.762	-1.193	1.468
Adult	-12.320	8.203	-12.400*	6.833	9.729**	4.610	9.785**	3.846
Child	8.764	8.768	8.999	7.239	-6.217	4.153	-6.389*	3.458
Motorbike	4.881	12.290	5.261	10.370	2.194	4.771	1.916	4.003
Income non-agriculture	-2.70E-08	1.01E-07	0.000	0.000	5.78E-09	5.33E-08	4.2E-09	4.38E-08
Plot size	-1.214	35.130	-0.651	29.920	24.260	18.770	23.840	15.790
Operated land	25.24	18.550	24.710	15.590	-7.988	6.956	-7.599	5.773
Land ownership	25.07	18.330	25.100	15.260	-8.141	8.950	-8.162	7.452
Irrigation	48.16*	24.980	48.71**	20.980	1.662	10.760	1.258	9.037
Dummy seasonality	19.560	21.840	19.640	18.180	13.410	9.757	13.350*	8.109
Distance to plot	0.00284*	0.00169	0.00281**	0.001	-0.000835	0.000799	-0.001	0.001
Chilli price	0.00215**	0.00101	0.00211**	0.001	0.000747*	0.000432	0.000780**	0.000366
Male wage	0.000771	0.00167	0.001	0.001	0.000459	0.000749	0.00035	0.000629
Female wage	-0.00042	0.00212	-0.001	0.002	0.0013	0.00104	0.00137	0.000865
Fertilizer price	0.0137**	0.00619	0.0139***	0.005	-0.00322	0.00406	-0.00338	0.00332
Farmer group	11.180	20.080	11.260	16.770	3.609	9.065	3.551	7.538
Women farmer group	78.010**	38.110	78.510**	32.080	27.440	25.340	27.080	21.350
Constant	-539.600***	170.800	-541.300***	-142.800	-70.760	89.050	-69.500	74.310
Observations	193		193		193		193	

Note: *** different at 1 per cent, ** different at 5 per cent, *different at 10 per cent; village dummies are included as additional explanatory variables

Table 4-6. Demand for hired labour by gender estimation results

Variables	Male Hired Labour				Female Hired Labour			
	OLS		2 SLS		OLS		2 SLS	
	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE
Hybrid	18.170**	8.429	26.570**	11.460	23.100**	11.040	18.560*	10.360
Male's age	-1.178**	0.569	1.803**	0.898	1.809**	0.747	1.368*	0.809
Female's age	1.783***	0.540	-0.375	0.907	-0.364	0.757	-0.505	0.727
Male's education	-3.212**	1.544	1.579	2.393	1.554	1.998	0.187	2.398
Female's education	-1.193	1.468	5.082*	2.895	5.103**	2.413	3.139	2.411
Adult	9.785**	3.846	-3.312	6.005	-3.353	5.010	-9.008**	4.300
Child	-6.389*	3.458	4.394	5.684	4.521	4.726	4.371	4.160
Motorbike	1.916	4.003	-0.758	7.190	-0.552	6.071	5.639	6.464
Income non-agriculture	4.2E-09	4.38E-08	-3.65E-08	8.49E-08	0.000	0.000	9.52E-09	3.61E-08
Plot size	23.840	15.790	5.953	23.310	6.260	19.750	-7.167	17.370
Operated land	-7.599	5.773	10.700	11.670	10.410	9.763	14.540	9.922
Land ownership	-8.162	7.452	14.550	11.450	14.570	9.526	10.520	10.110
Irrigation	1.258	9.037	32.81**	14.580	33.110***	12.240	15.360	14.380
Dummy seasonality	13.350*	8.109	-3.442	13.320	-3.398	11.090	23.000*	12.850
Distance to plot	-0.001	0.001	0.00400***	0.00122	0.00398***	0.001	-0.00116	0.000796
Chilli price	0.000780**	0.000366	0.00111*	0.00061	0.00108**	0.001	0.00105*	0.000581
Male wage	0.00035	0.000629	0.000118	0.00114	0.000	0.001	0.000652	0.000832
Female wage	0.00137	0.000865	0.000749	0.00131	0.001	0.001	-0.00117	0.0011
Fertilizer price	-0.00338	0.00332	0.00293	0.00331	0.003	0.003	0.0107**	0.00439
Farmer group	3.551	7.538	6.993	12.650	7.036	10.560	4.186	10.720
Women farmer group	27.080	21.350	41.220	24.960	41.480**	21.070	36.800*	20.120
Constant	-69.500	74.310	-275.5***	102.400	-276.500***	85.590	-264.100***	92.480
Observations	193		193		193		193	

Note: ***different at 1 per cent, **different at 5 per cent, *different at 10 per cent; village dummies are included as additional explanatory variables

Table 4-7. Demand for family labour by gender estimation results

Variables	Male Family Labour				Female Family Labour			
	OLS		2 SLS		OLS		2 SLS	
	Coef.	**SE**	**Coef.**	**SE**	**Coef.**	**SE**	**Coef.**	**SE**
Hybrid	9.247	7.206	11.330**	5.766	4.250	4.503	6.839	4.160
Male's age	-0.621	0.562	-0.625	0.466	-0.548*	0.308	-0.553**	0.260
Female's age	0.925	0.586	0.919*	0.488	0.872***	0.286	0.864***	0.240
Male's education	-2.213	1.559	-2.198*	1.299	-1.032	0.878	-1.014	0.726
Female's education	-1.066	1.369	-1.079	1.141	-0.098	0.803	-0.114	0.667
Adult	8.898**	3.911	8.923***	3.256	0.831	1.754	0.862	1.471
Child	-4.585	3.409	-4.661	2.834	-1.632	1.645	-1.727	1.367
Motorbike	1.914	3.847	1.790	3.230	0.280	2.167	0.126	1.817
Income non-agriculture	8.32E-09	5.17E-08	0.000	0.000	-2.54E-09	1.42E-08	0.000	1.17E-08
Plot size	18.88	11.510	18.69*	9.587	5.377	10.020	5.148	8.507
Operated land	-7.328	4.803	-7.155*	3.980	-0.66	3.797	-0.444	3.169
Land ownership	-8.172	7.105	-8.182	5.919	0.0313	3.652	0.019	3.036
Irrigation	6.347	8.345	6.167	6.999	-4.685	4.834	-4.909	4.033
Dummy seasonality	4.891	7.343	4.865	6.097	8.515*	4.373	8.483**	3.654
Distance to plot	-0.000149	0.000479	0.000	0.000	-0.000686	0.000474	-0.000676*	0.000406
Chilli price	0.000335	0.000305	0.000	0.000	0.000412*	0.000233	0.000430**	0.0002
Male wage	0.000302	0.000518	0.000	0.000	1.57E-04	0.000379	0.000	0.00032
Female wage	0.000863	0.000813	0.001	0.001	0.00044	0.000483	0.000	0.000403
Fertilizer price	-0.00224	0.00294	-0.002	0.002	-0.000976	0.00148	-0.001	0.00121
Farmer group	2.336	7.787	2.310	6.488	1.273	3.522	1.241	2.924
Women farmer group	20.260	16.730	20.090	14.000	7.186	11.830	6.986	10.030
Constant	-37.960	66.460	-37.400	55.430	-32.800	-35.810	-32.100	29.950
Observations	193		193		193		193	

Note: ***different at 1 per cent, **different at 5 per cent, *different at 10 per cent; village dummies are included as additional explanatory variables

4.6 Discussion

The results show an increase in hired labour with hybrid seed use corroborate findings from previous studies (Kouser et al. 2016; Subramanian & Qaim 2010). The higher yields produced by hybrids increase labour demand. Chilli harvesting is manual in Indonesia and typically done by females. Hybrid yields also increase the marginal product of labour (Tocco et al. 2012). In addition, farmers tend to push for higher chilli yields by hiring more labour for other production activities. The data shows that compared to the open-pollinated plots, hybrids demand more hired labour for chilli production activities measured in the survey: land preparation, irrigation and watering, weeding, fertilisation and harvesting. Consequently, hybrid seed adoption requires additional expenditure for farmers. This may be the possible reason in chilli production; there is evidence that many smallholders regularly continue to use open-pollinated seeds from previous hybrid seed harvest (Ali 2006). The higher costs of other inputs, particularly labour, which is the most critical input (Huq & Arshad 2010) discourage the adoption of hybrid seeds (da Silva Dias 2010). In chilli production systems, labour is the most, and the adoption of hybrid seeds is thus closely associated with the demand for labour.

Some studies conclude that increasing hired labour is a way for households to substitute for family labour work and becoming the major labour force in agriculture (Hill 1993; Luo, Kostandini, and Jordan 2018). In this case, presented here, the insignificant relationship between hybrid seed adoption and family labour indicates that the shift in hired labour does not change family labour essentially. The increasing demand for labour is more likely filled with hired labour.

Household characteristics do influence labour demand to some extent, with the household head and spouse influencing hiring labour in different ways. An older household head is more likely to engage more hired labour and less likely to work on the farm. However, an older female tends to work on the farm, reducing the need to hire labour. This finding is typical in research on the roles of women in agricultural households, as females tend to take care of the children and perform domestic work in most South-East Asian countries (Akter et al. 2017). As children become young adults and support domestic chores, some mothers are able to support the household through both on- and off-farm work. The analysis controls for children under school age in the household by adding the number of children under six years old in the model. Households with more children under six are more likely to hire more labour. Females in this type of family work less on the farm, in line with the established literature concluding that the more productive household members reduce hired labour and increase family labour participation (Benjamin & Kimhi 2006; Deolalikar & Vijverberg 1987).

Education affects the demand for hired and family labour in different ways. It is not only the years of education of the household head but also the years of formal education of the spouse that is more likely to increase labour hiring and decrease family labour work on the farm. This finding extends the existing literature, which includes the education of the household head but ignores that of the wife (Kouser et al. 2016; Lin 1994; Rao & Qaim 2013; Simmons et al. 2005). The positive sign of education implies that years of education is associated with more off-farm employment, thus reducing their availability for working on the farm and increasing the need to hire labour for their farm (substitution effect) (Kanwar 1999). Another possible reason is that educated farmers manage their farms more intensively, leading to hiring more labour.

Findings of this study also suggest that hybrid seeds affect male and female labour differently. These results coincide with some recent findings in the employment impacts of Bt cotton in Pakistan which increased hired labour by 55 per cent and this increase was strongly generated by female labourers. (Kouser et al. 2016). In addition, the adoption of Bt cotton in India strengthened the return to total employment, particularly for hired female labour

(Subramanian & Qaim 2010). The increasing demand for hired female labour appears to be linked to the fact that hybrid seeds produce higher yields. These findings show that the adoption of hybrid seeds creates employment opportunities in rural Indonesia, especially for women. This is beneficial for women since in many South Asian countries women are looking for more opportunities to boost household income (Akter et al. 2017).

On the other hand, some literature finds that the introduction of new technology causes women's workload to increase (Dawson 1988). However, in the case of chilli, the adoption of hybrid seeds using 2 SLS estimation significantly affects male family labour by 11 per cent, but it is not significant for female family labour (see Table 4-7). This implies that increasing yield or intensifying production of hybrids is not exploitive to women but simply increases hiring female labour.

More employment opportunities are important from the rural development perspective (Kouser et al. 2016; Lambrecht, Schuster, Asare Samwini, & Pelleriaux 2018). Moreover, earning income can empower women, giving them additional disposable pride in being able to contribute to the family income and resulting in multidimensional welfare improvements (C. Doss 2013; Kabeer, Mahmud, & Tasneem 2011). Evidence shows that if women control household income, children have better nutrition and education (Mammen & Paxson 2000; Schultz 2002). Therefore, the adoption of hybrid seeds has the potential to contribute indirectly to empowering unskilled women in rural Indonesia who have fewer opportunities to work off-farm (Kusujiarti & Tickamyer 2012).

Lastly, participating in women farmers group is more likely to increase total hired labour, particularly female hired labour. Through farmers membership, women do not only gather technology information or are assisted in solving any inefficiency problem but also building more link among farmers (Markelova, Meinzen-Dick, Hellin, & Dohrn 2009).

Farmers can have better inputs or output market access including the labour market. A better labour market access may encourage hiring more labour.

4.6 Conclusion

A large literature investigates the impacts of hybrid seed adoption on household welfare, poverty reduction and food security. Additional evidence shows that hybrids are also beneficial for rural development by creating employment opportunities, particularly for women. The impacts of hybrid seeds on rural development become more important as the rural poor are able to find more work, real wages increase and real food prices fall due to productivity increases. This study extends previous research on demand for labour by investigating employment impacts on household family labour and hired labour on a gender-specific basis.

The results of this chapter show that hybrid seeds are more likely to increase demand for hiring labour, and mostly female hired labour, but not family labour. The findings, in this case, provide evidence that increasing demand for labour associated with hybrid seed adoption does not necessarily result in female family labour having to contribute additional workload.

This study does use a relatively small sample, the external validity of the results demands further examination in rural Indonesia and other developing countries at large. Future research can focus on expanding the sample to other provinces with different socioeconomic characteristics and traditions. Also, panel data may be used to better examine the dynamic change of social and economic aspects.

References

Akter, S, Rutsaert, P, Luis, J, Htwe, NM, San, SS, Raharjo, B & Pustika, A 2017, 'Women's empowerment and gender equity in agriculture: A different perspective from Southeast Asia', *Food Policy*, vol. 69, no. 1, pp. 270 - 279.

Ali, M 2006, *Chili (Capsicum spp.) Food Chain Analysis: Setting Research Priorities in Asia*, vol. 38, AVRDC-World Vegetable Center, Shanhua, Taiwan.

Andersson, CI, Chege, CG, Rao, EJ & Qaim, M 2015, 'Following up on smallholder farmers and supermarkets in Kenya', *American Journal of Agricultural Economics*, vol. 97, no. 4, pp. 1247-1266.

Basuki, RS, Arshanti, IW, Zamzani, L, Khaririyatun, N, Kusandriani, Y & Luthfy, L 2016, 'Adoption studies of red pepper Tanjung-2 seeds as results of Vegetable Crops Research Institute in Ciamis, West Java Province', *Jurnal Hortikultura*, vol. 24, no. 4, pp. 355-362.

Beckmann, V & Wesseler, J 2003, 'How labour organization may affect technology adoption: an analytical framework analysing the case of integrated pest management', *Environment and Development Economics*, vol. 8, no. 3, pp. 437-450.

Benjamin, C & Kimhi, A 2006, 'Farm work, off-farm work, and hired farm labour: estimating a discrete-choice model of French farm couples' labour decisions', *European Review of Agricultural Economics*, vol. 33, no. 2, pp. 149-171.

Berkhout, E, Glover, D & Kuyvenhoven, A 2015, 'On-farm impact of the System of Rice Intensification (SRI): Evidence and knowledge gaps', *Agricultural Systems*, vol. 132, no. 1, pp. 157-166.

Boahene, K, Snijders, TAB & Folmer, H 1999, 'An integrated socioeconomic analysis of innovation adoption: The case of hybrid cocoa in Ghana', *Journal of Policy Modeling*, vol. 21, no. 2, pp. 167-184.

Croppenstedt, A, Demeke, M & Meschi, MM 2003, 'Technology adoption in the presence of constraints: the case of fertilizer demand in Ethiopia', *Review of Development Economics*, vol. 7, no. 1, pp. 58-70.

da Silva Dias, J 2010, 'Impact of improved vegetable cultivars in overcoming food insecurity', *Euphytica*, vol. 176, no. 1, pp. 125-136.

Dawson, VM 1988, *The Changing Role of Women in Agricultural Production: An Indonesian Case Study*, U.M.I, Ann Arbor.

Deolalikar, AB & Vijverberg, WP 1987, 'A test of heterogeneity of family and hired labour in Asian agriculture', *Oxford Bulletin of Economics and Statistics*, vol. 49, no. 3, pp. 291-305.

Derek, E & Rolien, W 2008, 'Impact of improved vegetable farming technology on farmers' livelihoods in tropical Asia', *International Symposium on the Socio-Economic Impact of Modern Vegetable Production Technology in Tropical Asia,* Wageningen, pp. 101-112.

Doss, C 2013, 'Intrahousehold bargaining and resource allocation in developing countries', *The World Bank Research Observer*, vol. 28, no. 1, pp. 52-78.

Doss, CR & Morris, ML 2000, 'How does gender affect the adoption of agricultural innovations?', *Agricultural Economics*, vol. 25, no. 1, pp. 27-39.

Eswaran, M & Kotwal, A 1986, 'Access to capital and agrarian production organisation', *The Economic Journal*, vol. 96, no. 382, pp. 482-498.

Firdaus, G & Ahmad, A 2010, 'Exploring diversity among farmers in adoption of agricultural innovation and options for smallholder farming system-a case study of Ambedkarnager district of UP', *International Research Journal of Applied and Basic Sciences*, vol. 1, no. 1, pp. 25-36.

Hamermesh, DS 1996, *Labor Demand*, Princeton University Press, New Jersey.

Hill, B 1993, 'The ‘myth’ of the family farm: defining the family farm and assessing its importance in the European Community', *Journal of Rural Studies*, vol. 9, no. 4, pp. 359-370.

Hossain, M, Bose, ML & Mustafi, BAA 2006, 'Adoption and productivity impact of modern rice varieties in Bangladesh', *The Developing Economies*, vol. 44, no. 2, pp. 149-166.

Huang, J & Rozelle, S 1996, 'Technological change: Rediscovering the engine of productivity growth in China's rural economy', *Journal of Development Economics*, vol. 49, no. 2, pp. 337-369.

Huq, AA & Arshad, FM 2010, 'Technical efficiency of chili production', *American Journal of Applied Sciences*, vol. 7, no. 2, p. 185.

Joshi, KD, Khanal, NP, Harris, D, Khanal, NN, Sapkota, A, Khadka, K, Darai, R, Neupane, RK, Joshi, M & Witcombe, JR 2014, 'Regulatory reform of seed systems: Benefits and impacts from a mungbean case study in Nepal', *Field Crops Research*, vol. 158, no. 1, pp. 15-23.

Kabeer, N, Mahmud, S & Tasneem, S 2011, *Does Paid Work Provide a Pathway to Women's Empowerment? Empirical Findings from Bangladesh, Pathways of Women's Empowerment,* Institute of Development Studies, Brighton, UK.

Kanwar, S 1999, 'The demand for labour in risky agriculture', *Oxford Development Studies*, vol. 27, no. 1, pp. 129-144.

Kouser, S, Abedullah & Qaim, M 2016, 'Bt cotton and employment effects for female agricultural laborers in Pakistan', *New Biotechnology*, vol. 34, no. 1, pp. 40-46.

Kouser, S & Qaim, M 2011, 'Impact of Bt cotton on pesticide poisoning in smallholder agriculture: A panel data analysis', *Ecological Economics*, vol. 70, no. 11, pp. 2105-2113.

Kusujiarti, S & Tickamyer, AR 2012, 'Gender and agricultural production', *Power, Change, and Gender Relations in Rural Java*, Ohio University Press, Athens, United States.

Lambrecht, I, Schuster, M, Asare Samwini, S & Pelleriaux, L 2018, 'Changing gender roles in agriculture? Evidence from 20 years of data in Ghana', *Agricultural Economics*, vol. 49, no. 6, pp. 691-710.

Lin, JY 1994, 'Impact of hybrid rice on input demand and productivity', *Agricultural Economics*, vol. 10, no. 2, pp. 153-164.

Lovo, S 2012, 'Market imperfections, liquidity, and farm household labor allocation: the case of rural South Africa', *Agricultural Economics*, vol. 43, no. 4, pp. 417-428.

Luo, Tianyuan, Genti Kostandini, and Jeffrey L Jordan. 2018. "The impact of LAWA on the family labour supply among farm households." *European Review of Agricultural Economics* vol. 45, no. 5, pp 857-878.

Mammen, K & Paxson, C 2000, 'Women's work and economic development', *Journal of Economic Perspectives*, vol. 14, no. 4, pp. 141-164.

Markelova, H, Meinzen-Dick, R, Hellin, J & Dohrn, S 2009, 'Collective action for smallholder market access', *Food Policy*, vol. 34, no. 1, pp. 1-7.

Matuschke, I, Mishra, RR & Qaim, M 2007, 'Adoption and impact of hybrid wheat in India', *World Development*, vol. 35, no. 8, pp. 1422-1435.

Ministry of Agriculture 2015, *Ministry of Agriculture Strategic Planning 2015–2019*, Ministry of Agriculture, Jakarta, Indonesia.

Ministry of Agriculture (2018). *Agricultural Sector Employment Statistics 2017 - 2018,* Center for Agricultural Data and Information, Ministry of Agriculture, Jakarta, Indonesia.

Moser, CM & Barrett, CB 2003, 'The disappointing adoption dynamics of a yield-increasing, low external-input technology: the case of SRI in Madagascar', *Agricultural Systems*, vol. 76, no. 3, pp. 1085-1100.

Neiman, G 2017, 'Agrarian restructuring and changes in the demand for labour in Argentina', *Review of Agrarian Studies*, vol. 7, no. 1, pp. 33-48.

Poelmans, SA, Chinchilla, N & Cardona, P 2003, 'The adoption of family-friendly HRM policies: Competing for scarce resources in the labour market', *International Journal of Manpower*, vol. 24, no. 2, pp. 128-147.

Pray, C, Ma, D, Huang, J & Qiao, F 2001, 'Impact of Bt cotton in China', *World Development*, vol. 29, no. 5, pp. 813-825.

Rao, EJO & Qaim, M 2013, 'Supermarkets and agricultural labor demand in Kenya: A gendered perspective', *Food Policy*, vol. 38, no. 1, pp. 165-176.

Ruben, R, Kruseman, G & Kuyvenhoven, A 2006, 'Strategies for sustainable intensification in East African highlands: labor use and input efficiency', *Agricultural Economics*, vol. 34, no. 2, pp. 167-181.

Sahara 2012, 'The transformation of modern food retailers in Indonesia: opportunities and challenges for smallholder farmers', School of Agriculture, Food and Wine, PhD thesis, The University of Adelaide, South Australia.

Schultz, TP 2002, 'Why governments should invest more to educate girls', *World Development*, vol. 30, no. 2, pp. 207-225.

Simmons, P, Winters, P & Patrick, I 2005, 'An analysis of contract farming in East Java, Bali, and Lombok, Indonesia', *Agricultural Economics*, vol. 33, no. 3, pp. 513-525.

Skoufias, E 1994, 'Using shadow wages to estimate labor supply of agricultural households', *American Journal of Agricultural Economics*, vol. 76, no. 2, pp. 215-227.

Statistics Indonesia 2015a, *Census of Agriculture 2013, National Figures of Horticulture Crops Cultivation Household, Results of ST2013-Subsector Survey*, no. 9790648138.

Statistics Indonesia 2015b, *Laporan Hasil Sensus Pertanian 2013*, Badan Pusat Statistik, Jakarta.

Subramanian, A & Qaim, M 2010, 'The impact of Bt cotton on poor households in rural India', *The Journal of Development Studies*, vol. 46, no. 2, pp. 295-311.

Tocco, B, Davidova, S & Bailey, A 2012, *Key Issues in Agricultural Labour Markets: A Review of Major Studies and Project Reports on Agriculture and Rural Labour Markets*, Factor Markets Working Paper, Brussels, Belgium.

Unay-Gailhard, İlkay, and Štefan Bojnec. 2019. "The impact of green economy measures on rural employment: Green jobs in farms." *Journal of Cleaner Production* 208:541-551.

Wooldridge, JM 2010, *Econometric Analysis of Cross Section and Panel Data*, MIT Press.

Chapter 5 Statement of Authorship

Title of Paper	Division of Roles and Leadership Between Genders: How Do Women Contribute to Farmers' Revenue? The Case of Chilli in Indonesia
Publication Status	☐ Published ☐ Accepted for Publication ☐ Submitted for Publication ■ Unpublished and Unsubmitted work written in manuscript style
Publication Details	Prepared for submission to Journal of Rural Studies

Principal author

Name of Principal Author (Candidate)	Apri Laila Sayekti		
Contribution to the Paper	Contributed to preparation of primary survey and data collection, performed data analysis and interpretation, and wrote the manuscript.		
Overall percentage (per cent)	65 per cent		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	26/08/19

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);
ii. permission is granted for the candidate in include the publication in the thesis; and
iii. the sum of all co-author contributions is equal to 100 per cent less the candidate's stated contribution.

Name of Co-Author	Adjunct Professor Randy Stringer		
Contribution to the Paper	Project director of INDOHORT, contributed in manuscript editing.		
Signature		Date	26/08/19

Name of Co-Author	Dr. Daniel Gregg		
Contribution to the Paper	Contributed to data analysis and in manuscript editing.		
Signature		Date	26/08/19

Chapter 5 : Division of Roles and Leadership Between Genders: How Do Women Contribute to Farmers' Revenue? The Case of Chilli in Indonesia

Abstract

Women's leadership in the agricultural activities of smallholder households in developing countries is a major component of women empowerment in those areas. Approaches to understanding women's empowerment in South East Asian countries require a more nuanced approach due to the lack of independently owned or managed plots by male and female spouses. Rather, in these areas, women and men tend to divide roles across activities. We present an approach which allows detailed insights into women's leadership of these activities and the extent to which male and female spouses disagree about which of them lead those activities. Using a combination of confirmatory factor analysis and a revenue production function regression we show that female leadership and disagreement are both significant factors affecting household revenues from chilli farming in rural Indonesia. Furthermore, we show that disagreements can severely diminish those revenues and act to reverse gains we observe from female leadership. Our results indicate that a more complex consideration of female's roles in revenue activities is needed at least for communities in which activities and management or ownership of household productive assets are shared between male and female household heads.

Keywords: gender, women's leadership, leadership disagreement, revenue, chilli, Indonesia

5.1 Introduction

In rural areas of developing countries, farming activities undertaken by smallholder farmers are managed typically by both male and female members of the household (Doss 2018, Akter et al. 2017, Jacoby 1991). Yet women's contributions to the household in rural areas are consistently under-estimated and under-valued in research on household production (de la O Campos, Covarrubias, and Patron 2016, FAO 2011, Oseni et al. 2015, UN 2010). Current research tends to examine gender participation and productivity issues using binary dummy variables or aggregate representations of leadership for a whole range of farming activities (Doss 2018, Whatmore 1991, Jacoby 1991, Oseni et al. 2015, Slavchevska 2015, Seymour 2017, Rahman 2010). Such approaches limit insights into gender-based differences in farming activities and household income-generating activities (Doss et al. 2018). Recent research suggests that this may be due largely to data measurement issues (de la O Campos, Covarrubias, and Patron 2016, Bayu 2017). A detailed accounting of women's contributions, however, can provide additional important information of the opportunity costs of increasing women's participation in agricultural activities (Bayu 2017, Alwang, Larochelle, and Barrera 2017) and understanding women's contributions to agricultural productivity (Smyth, Swendener, and Kazyak 2018, The World Bank 2008). In this study, we use a novel and detailed survey measure of female and male leadership to construct a comprehensive description of female leadership, male leadership, disagreement, and agreement in chilli productivity in Indonesia. Our results provide a different view of female leadership – that it can contribute substantially to productivity improvements but that these improvements are largely tied to agreement and acknowledgement of that role by the male household head. These results indicate that gender empowerment and gender-focused research associated with agricultural production in developing countries must go beyond engagement with females only and seek to engage the whole household in behavioural change and in psycho-social viewpoints on women's roles in the household, society and the economy.

Across many developing countries, women are subordinate to men in managing land preparation activities (e.g. Joshi, Roy, and Chandra 2016, Akter et al. 2017). On the other hand, women are relatively highly involved in and often lead, harvesting and marketing activities (e.g. Akter et al. 2017, Joshi, Roy, and Chandra 2016, Carranza 2014, Bayu 2017, Bozoğlu and Ceyhan 2007, Doss 2002). These patterns would not necessarily be of concern if they reflected a rational allocation of labour according to ability or marginal productivity. However, there is evidence that leadership of, or participation in, household activities are based on factors unrelated to household income maximisation (Doss 1996). For example, cultural and religious factors contribute to men tending to lead negotiations with traders (Doss 2018). Differences in preferences and/or economic or social power can also lead to a conflict of interest between household members in term of managing their farm businesses (Doss 1996). If the conflicts are not resolved, female farmers are often placed in an unfavourable position, which might decrease the acknowledgement of their roles in farm management (Doss 1996). These factors contribute to complexities in the assessment of gender roles in agricultural production in developing countries (Doss 1996, Quisumbing and Maluccio 2000). Furthermore, agricultural studies in developing countries show that women's work is undercounted in standard surveys contributing to an undervaluation of women's roles in agricultural decision making (Twyman, Useche, and Deere 2015, Dixon 1982).

A large portion of current studies on aspects of gender associated with agricultural production in developing countries are focused on countries located in Africa (Aguilar et al. 2015, Alene et al. 2008, de la O Campos, Covarrubias, and Patron 2016, Doss 2002, Horrell and Krishnan 2007, Kilic, Palacios-Lopez, and Goldstein 2015, Peterman et al. 2011, Slavchevska 2015, Wouterse 2017). Given that majority African households operates many plots that are controlled by different members of the household (Udry 1996), many crops are dominantly grown by men or women (Doss 2002). Males typically manage cash crops and females manage staple crops which allowing for different farming activities, inputs, and outputs that is influenced by cultural background (Quisumbing 1996). The existence of plots managed by only males and plots managed by only females assuming that only one person is the farm manager who makes all of the decisions relevant to agricultural production leads to many productivity gap research in Africa by comparing the production of male and female's plot (e.g. Oseni et al. 2015, Udry 1996, Aguilar et al. 2015). However, there are also collective plots in male-headed households that are jointly managed by household members but the decision making is under the authority of the head (Guirkinger, Platteau, and Goetghebuer 2015). Consequently, in many parts of Africa, males lead more than half of crop production activities while females are responsible for less than a quarter of farming activities (Joshi, Roy, and Chandra 2016).

Those African cultural factors seem to highly influence the current research on most of the gender-related agricultural production studies. The current research on agricultural productivity and efficiency often uses binary variables or aggregation of the range of farm roles and responsibilities of males and females (e.g.de la O Campos, Covarrubias, and Patron 2016, Guirkinger, Platteau, and Goetghebuer 2015, Oseni et al. 2015). Quisumbing (1996) delineates two main approaches to gender analysis: (1) use of a binary variable to indicate whether a female is the head of the household, and; (2) analysis allowing for different functions explaining male-managed and female-managed production.

The most common approach is that of using a binary variable as an independent variable in regression approaches to modelling production and efficiency from agricultural activities at the household level (e.g. Peterman et al. 2011, Rahman 2010). Typically, this binary variable represents the participation of a female in the production process of interest or, sometimes, the role of a woman as a leader in that process (Peterman et al. 2011, Rahman 2010, Chavas, Petrie, and Roth 2005, Kinkingninhoun-Mêdagbé et al. 2010, Udry et al. 1995, Rao, Brümmer, and Qaim 2012, Goldstein and Udry 2008). However, in most places, the number of female-headed households is much lower than the male-headed households leading to statistical power issues in identifying differences between male- and female-headed households (e.g.Kinkingninhoun-Mêdagbé et al. 2010, Rahman 2010, Oseni et al. 2015). Moreover, female-headed households almost invariably have fewer adult members (Doss 2018), which may lead to fundamental differences in returns to fixed factors such as land or capital. Binary variable approaches also do not reveal the roles of a female in a male-headed household or vice versa (de la O Campos, Covarrubias, and Patron 2016) and the specific gender roles which can inform gender-sensitive planning that takes into account the differential impact of programmes on women contribution in agriculture. Finally, binary variable approaches assume that all members of the household have the same preferences or characteristics, an aspect which has been demonstrated to be false (de la O Campos, Covarrubias, and Patron 2016, Udry 1996).

A more flexible approach to considering gender aspects in household agricultural production in developing countries is to consider plot-level differences for plots managed by males compared to those operated by females (e.g. Dimelu et al. 2009, Aguilar et al. 2015). This approach relies on the existence of plots managed by only males and plots managed by only females, assuming that only one person is the farm manager who makes all of the decisions relevant to agricultural production (Twyman, Useche, and Deere 2015). Cultural factors seem to highly influence this approach since most of the studies are conducted in African countries (Dimelu et al. 2009, Aguilar et al. 2015, Alene et al. 2008, Horrell and Krishnan 2007, Oseni et al. 2015) where males typically manage cash crops and females manage staple crops which allowing for different farming activities, inputs, and outputs (Quisumbing 1996). Furthermore, comparing plots by gender leads to the omission of other essential activities done by women such as preparing meals for labour and livestock-related activities (Doss 2018) which show that women contribute to male-managed plot production activities and household income but that their contributions are typically not counted or are undercounted. More recently studies addressing the existence of joint management plots have been undertaken which examine productivity gaps over the male and female plots (de la O Campos, Covarrubias, and Patron 2016, Slavchevska 2015, Guirkinger, Platteau, and Goetghebuer 2015), but do not reveal the degree of males and females' roles. Lastly, in many ways, as outlined above, this approach is not necessarily a regular occurrence in many areas such as South East Asia where the farming patterns are commonly different (Akter et al. 2017) which tends to preclude this approach from being used in these areas.

More recently, studies have used aggregate women participation indices to measure women contributions in agricultural efficiency (Bozoğlu and Ceyhan 2007, Seymour 2017). For example, Bozoğlu and Ceyhan (2007) use a women's participation score to consider gender-aspects of technical efficiency in Turkey. The participation score is measured by summing the participation degree across eight farming activities. A higher score means higher women's participation across the range of farming activities. Other studies by Seymour (2017) and Diiro et al. (2018) use women empowerment in agriculture scores based on a weighted sum of 10 indicators including production decisions, control of resources and income, leadership, and time allocations to calculate agricultural inefficiency and productivity. However, Alkire et al. (2013) note that the women empowerment in agricultural index (WEAI) has limitations such as that only female-headed households have high scores in decision making questions. This implies that it is not fully applicable to be used in many South Asian countries where female-headed households are rare (Peterman, Behrman, and Quisumbing 2014). In addition, higher aggregation scores for farming activities do not correspond to who is the leader or participating in each of a range of farming activities such as who is buying inputs or marketing output.

This study addresses three main gaps in the literature by considering women's roles across a range of farming activities of agricultural production allowing for in-depth consideration of women's role in agricultural production activities, power imbalances between men and women, and the extent to which disagreement between the genders is prevalent. Firstly, our study employs a novel measure using a specific 16 activities answered independently by male and female household heads to provide a detailed description of women's leadership, men's leadership, and agreement and disagreement between spouses. This survey-based measure deals substantially with aggregation issues whilst allowing deeper insights into bargaining in the household via a direct measure of agreement/disagreement regarding the leadership of agricultural preparation, production, and marketing activities. Secondly, we integrate the complexity of responses to the 16-activities survey tool using Confirmatory Factor Analysis (CFA) allowing a weighted aggregation of leadership responses integrating the relative importance of each activity in indices of female leadership, male leadership, agreement and disagreement. Finally, we integrate those CFA indices into a revenue function regression allowing for interactions between leadership and agreement and for direct inference on the importance of both leadership and agreement on leadership roles in the household.

The remainder of the paper is structured as follows. Section 5.2 explores a brief of women's roles in agriculture in South East Asia and particularly in Indonesia as the case study, followed by the conceptual model and methods. The next section presents the data collection. Section 5.6 describes the results, followed by discussion. The last section is the conclusion and policy implication.

5.2 Women's Roles in Agriculture in Indonesia

The role of women in the intra-household decision-making process has been widely acknowledged as being related to cultural factors and regions (Akter et al. 2017, Doss 2018). Indonesian women are some of the least empowered regarding decision making power amongst women in rural households in South East Asia (Akter et al. 2017). Yet, across Indonesia, the degrees of decision-making power vary widely. For example, in vegetable cultivation in North Sumatra, women are involved in all crop cultivation tasks, including preparing the soil and spraying pesticides (Van de Fliert 1999). In contrast, in rice farming in South Sumatra, men take a lead role in most of the field decision making (Akter et al. 2017). While in beans production in Yogyakarta, in more urban villages, women participation in agricultural activities is lower, but their roles in agricultural production decision-making are higher compared to more rural villages (Kusujiarti and Tickamyer 2012). This indicates that the type of crops and local cultural habits generally influences women participation and decision-making power.

Some of the constraints on empowerment for Indonesian women are culturally-based with the population of Indonesia being predominantly Muslim. Cultural notions of women's and men's roles in Indonesia can limit women's mobility outside the house and prohibit communication to men generating barriers to participation in a range of farming activities and access to information (Akter et al. 2017). Puspitawati (2013) reveals that women in rural areas are typically less confident in communicating with buyers and face significant demands on their time due to domestic work which impacts on their productivity in more observable activities such as in marketing or agricultural. Communities sometimes cultivate perceptions in the community that women do not deserve to work in the farm because the work is physically demanding which appears to contribute to shame felt by young women regarding working in the agricultural sector (Kusujiarti and Tickamyer 2012). Finally, programs and training generally do not target women because the head of households are usually men, who are also expected to represent their households in formal village activities (Van de Fliert 1999). Consequently, where decision making is made by the community or a farmer group rather than a household, women have minimal contributions to community-level decision making that leads to less empowerment in agricultural decision making (Akter et al. 2017).

Despite current conditions, there is evidence that female participation generates essential contributions to rural households' welfare, and that women's leadership of many activities might be associated with more significant household income and/or productivity (Doepke and Tertilt 2014, Seymour 2017, Seymour et al. 2016). In many places in Indonesia, women generally play important roles in planting, harvesting, marketing activities, and preparing meals for labourers (Akter et al. 2017, Kusujiarti and Tickamyer 2012). Moreover, women typically take the lead in managing household income and expenditure (Akter et al. 2017, Kusujiarti and Tickamyer 2012). In more urban places, women contribute to the decision of hiring labour, selling the harvest, and negotiating with traders even though their participation in agricultural activities is low (Kusujiarti and Tickamyer 2012). Yet, indirect questioning, women often minimize the importance of their roles or the discrepancy in earning and effort (Kusujiarti and Tickamyer 2012). The general result of these factors is that the contributions of women remain under-counted, which may generate a misperception that women's work is low-value (Doss 2018).

5.3 Conceptual Model

It is a non-trivial exercise to incorporate highly-detailed data on women's participation, leadership and agreement with their partner into production analysis. In particular, incorporating statements on participation or leadership across the range of production activities by male and female household heads in addition to their disagreements, and their potential interactions is likely to lead to either over-simplification or difficulties in statistical identification using standard approaches due to multicollinearity and low statistical power. The basic approach to the consideration of gender roles in agricultural outcomes in developing countries is the construction of some index which adequately captures the complexity and heterogeneity in women's roles in agricultural activities across households.

We begin by describing the basis of these indices in male and female statements over leadership for 16 activities assessed. The activities we considered were: (1) buying farming equipment; (2) buying farming inputs; (3) negotiating with buyer; (4) harvesting; (5) sorting; (6) transporting chilli; (7) land preparation; (8) mulching; (9) installing stakes; (10) applying fertiliser; (11) spraying chemical; (12) spreading seed; (13) planting; (14) weeding; (15) watering; and (16) preparing meals for labour. Male and female perceptions on their own leadership of each activity are:

ML_k : Male perception of leadership in activity *k*

FL_k : Female perception of own leadership in activity *k*

MLk is equal to 1 when the male states he led activity k and zero otherwise. Similarly, FLk is equal to 1 when the female states she led activity k and zero otherwise. The aggregation of these indices in various ways defines different variables, which can provide insights into the roles of women in chilli production in rural Indonesia.

We considered 4 categorisations for ML and FL and their interactions: female own stated leadership (FFL) which is equal to FLk for the kth activity; male own stated leadership (MML) which is equal to MLk for the kth activity; negative disagreements between household heads (DIS_NEG), and; positive disagreements between household heads on leadership (DIS_POS). Negative disagreements arise when the female states leadership of an activity but the male states she did not lead that activity. Positive disagreements arise when the female stated she did not lead an activity but the male stated she did.

There are potentially 16 activity-items in each of these indexes. However, there are likely to be substantial issues of multi-collinearity for each of these items in each index substantially impacting on the ability to identify individual contributions associated with any particular activity.

One method commonly used to generate a set of univariate indexes, accounting for multicollinearity, from high-dimensional and highly-correlated data is CFA (Brown 2014). CFA allows aggregation of high-dimensional sets of related variables into univariate indices, which retain information over relative contributions of individual elements by estimating weights for each element generating an index through a weighted sum approach.

The weights obtained for each item allow calculation of the following univariate indices:

$$FFL = \sum_{k=1}^{16} \gamma_{ik,FFL} FL_i$$

$$DIS\_NEG = \sum_{k=1}^{16} \gamma_{ik,NEG} I(FFL = 1, MML = 1)$$

$$DIS\_POS = \sum_{k=1}^{16} \gamma_{ik,POS} I(MFL = 1, FFL = 0)$$

These indices can be, respectively, interpreted as: (1) a measure of the extent of female leadership across all activities, as seen from the female's perspective (FFL); (2) a measure of the extent of female leadership across all activities as seen from the female's perspective to which male household heads disagree and as seen from male'perspective he is the leader (DIS_NEG); (3) a measure of the extent of female leadership across all activities, as seen from the male's perspective (MML) but as seen from the female's perspective she is not the leader (DIS_POS). The term of disagreement is commonly used in household and gender studies (i.e., Alwang et al., 2017; Doss and Quisumbing, 2020). The low-levels of disagreement mean the spouse within the household mostly has the same perception of who is responsible to a particular activity The conceptual framework for the CFA model can be seen in Figure 5-1.

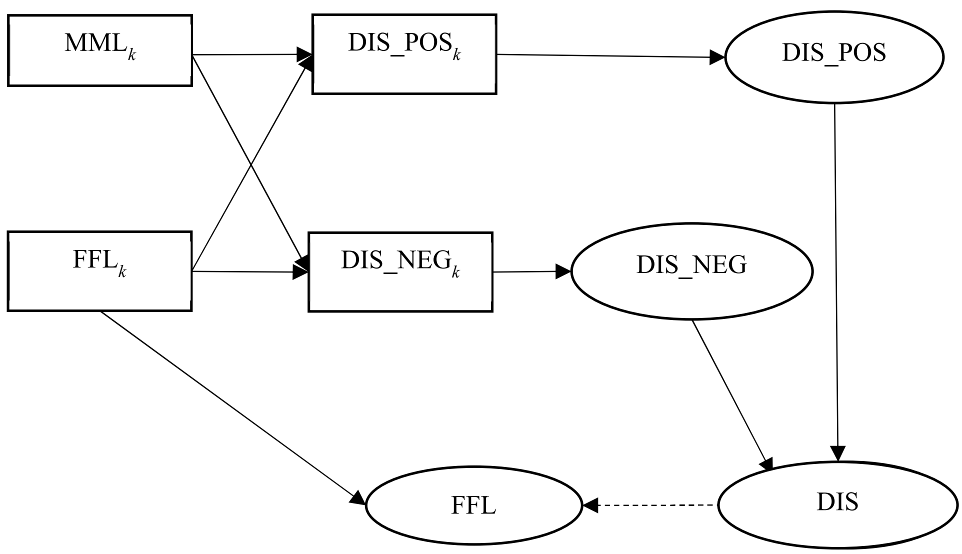

Figure 5-1. Conceptual framework with full gender indices

Regarding productivity differences associated with female leadership in agricultural activities, the main suggestion in the literature currently is that increased levels of female leadership (from the average) is associated with greater productivity (Bozoğlu and Ceyhan

2007, Seymour 2017). The increase in productivity results from a reallocation of females to leadership/participation in activities in which their leadership/participation has a higher return than that of men: an aspect that is less likely to occur when there is discrimination or lack of appreciation of women's abilities and contributions in the household. Thus we have:

$$\frac{dTFP}{dFFL} = \dot{FFL} > 0$$

$$where:$$

$$TFP = a\ measure\ of\ total\ factor\ productivity$$

Within the household, heterogeneity of preferences between male and female may be a significant factor in generating optimal allocation of effort/time in all the activities undertaken by the household including preferences over the role of the spouse (Meemken, Veettil, and Qaim 2017). For example, when husbands and wives are interviewed separately, they often disagree over who holds authority over key farming, family, and livelihood decisions, (Anderson, Reynolds, and Gugerty 2017). In some models of decision making, the role or influence of an individual spouse in the household's decisions is determined by his/her bargaining power (Kebede et al. 2013), so the level of decision-making authority allocated between male and female can vary significantly across households. This bargaining contributes to inefficient maximisation of effort and expenditure, generating lower welfare outcomes for the household as a whole. Udry (1996) and Kebede et al. (2013) provide evidence rejecting the assumption of Pareto efficiency in the households resources allocation across the production activities because male and female have different bargaining in the decision making. Furthermore, reducing gender disparities that is derived from the empowerment gaps between male and female in households increases the levels of technical efficiency (Seymour 2017). On this basis, we would expect that disagreements in the household as they relate to female leadership of agricultural activities, and indicative of issues in bargaining, are associated with the diminishment of the impact of female leadership on productivity improvements. Thus, we have the impact of FFL on productivity is diminished by disagreements (DIS) between spouses over the leadership of the female spouse in household production activities:

$$\frac{d\dot{FFL}}{dDIS} < 0$$

Finally, we expect that disagreements lead to an overall decline in TFP for agricultural activities due to duplication of effort/input or due to failure to undertake activities adequately (no leader) leading to our final hypothesis:

$$\frac{dTFP}{dDIS} < 0$$

5.4 Methods

5.4.1 Confirmatory Factor Analysis

The CFA model was estimated using Lavaan (Rosseel 2012) in the R statistical program (Team 2018). In this study, we estimate four indices as the latent variables including female own-stated leadership (FFL), male own-stated leadership (MML) and different perception of leadership between male and female in the households (DIS_POS and DIS_NEG) which are manifested by observed variables of a range of farming activities.

Model testing involved the initial specification of the four indices with all 16 activities as shown in Figure 1. Activities for which there were no variation (i.e. all ones or all zeros) were dropped for each of the series. Model testing using modification indices (Brown 2014) and checking of correlations between activities for each series was then undertaken until model-fit indices were within standard bounds used for CFA model assessments.

This paper considers five indices of goodness fit of model following Ullman and Bentler (2012) which are the Comparative Fit Index (CFI), the Tucker-Lewis index (TLI), the Standardised Chi-Squared Measure (SCM), the Root Mean Square Error of Approximation (RMSEA), and the Standardised Root Mean Square Residual (RMSR). Target limit for the CFI and TLI are more than 0.9, RMSEA is less than 0.05, and RMSR is less than 0.07. In addition, we sought to ensure the chi-squared statistic was not significant.

5.4.2 Revenue Function

Typically, evaluations of the roles of women to agricultural outcomes use the basic production function. As we also collected chilli prices from three period of harvesting times (before peak yield, during peak yield, and after peak yield) to capture the volatility of chilli price, we use the revenue function to provide more understanding of women roles not only associated with yield but also the price or revenue.

We estimated the translog production function which nests a variety of alternative specifications and which is a 2nd-order flexible approximation to any underlying function. For m factors, and a vector of productivity-shifters z (namely our gender indices and other factors), the translog function is specified as:

$$Ln\ R_i = \alpha + \sum_{l=1}^{L} \delta_l \ln z_l + \sum_{m=1}^{M} \beta_m \ln x_m + \sum_{n=1}^{N} \sum_{m=1}^{M} \frac{1}{2} \gamma_{nm} \ln x_n \ln x_m$$

Where R is the chilli production revenue as the multiplication of the weighted chilli price and output quantity or in this case is the chilli yield quantity in households i; $\boldsymbol{x}_m$ denotes a vector of independent variables which are hypothesised to affect revenue such as inputs including labour, fertilizer, pesticides, and other inputs; household characteristics; and plot characteristic; $\alpha, \delta, \beta,$ and γ are parameters to be estimated.

The translog function is a second-order flexible function that allows the representation of a variety of characteristics of technologies including non-constant elasticity of substitution, non-neutral technological change, varying rates of value marginal product across households and more. However, it is also a function which requires a large number of parameters that can lead to over-fitting of the data. In order to consider more parsimonious revenue functions we also estimated three alternative restrictions of this model which are associated with, respectively: (1) a non-neutral technical change function which doesn't account for quadratic single-input effects (i.e. it has interactions only); (2) a neutral technical change function which accounts for quadratic effects but doesn't allow for interactions between inputs, and; (3) a Cobb-Douglas function which embodies a simple production function involving a unitary elasticity of substitution between inputs everywhere (no quadratic or interaction effects). These restrictions were tested using the likelihood ratio test. We also considered the extent of violations of monotonicity, a fundamental requirement of accurate production analysis involving the assumption that inputs generate positive contributions to output at the margin (Gregg and Rolfe 2016).

As an approximation to the natural logarithm, we transformed data using the hyperbolic sin function to allow analysis using the translog family of functions (Burbidge, Magee, and Robb 1988).

5.5 Data

This study uses primary household and village-level data from chilli household farmers in West Java Province, Indonesia, the largest chilli producing province in Indonesia (Sahara 2012, Ministry of Agriculture 2015) with the largest number of chilli farmers in Indonesia. The survey involved 251 households who grew chilli in 2016 out of a total of 573 households from 41 villages in the area. The larger sample was divided into two groups. The first group involved 96 farmers supplying to modern marketing channels that were selected based on information from traders and farmer group's head. The second group was the rest of the sample, which farmers were chosen based on a random sampling method. Those included in the sub-sample analysed here were selected on the basis of whether they grew chilli in 2016. After removing incomplete records, the sample was reduced to 226 observations.

Input variables used were the cost of hired labour in man-days (COST_LABOUR), the cost of fertiliser (COST_FERT), cost of pesticides (COST_PESTICIDES), cost of other inputs (COST_OTHERINPUTS), the number of chilli plants in one plot (PLANT_NU) and plot size (AREA). For other factors influencing productivity, but not treated as variable inputs we included the presence of a crop storage house (STORAGE_HOUSE), whether the crop was hybrid or open-pollinated (HYBRID), and rainfall (RAINFALL), which is measured mm per year at the village level.

Table 5-1 presents a summary of statistics of the data used for the analysis in this study. As shown in Table 5-1, the chilli area and the yield on average indicates that chilli farmers in Indonesia are generally smallholder farmers with low productivity.

Table 5-1. Summary statistics of production variables used in the model per hectare area

Variable	Median	Mean
Revenue (Rp 1,000,000)	52.390	158.890
Yield (ton)	5.000	12.810
Area (ha)	0.140	0.233
Number of plants (1,000 plants)	20.000	44.512
Hired labour (1,000 man days)	0.495	1.473
Pesticides (Rp 1,000,000)	6.374	17.803
Fertiliser (Rp 1,000,000)	9.944	24.922
Other inputs (Rp1,000,000)	9.903	22.919
Storage house (number)	0.000	0.327
Hybrid (1=hybrid, 0=open-pollinated)	1.000	0.659
Rainfall (1,000 mm/year)	1.350	1.466

Table 5-2 presents male and female participation (MMPk and FFPk) and leadership across the 16 activities. In the most physically-demanding activities such as land preparation, applying fertiliser, spraying pesticides, and transporting the harvest, female participation and leadership rates are lower than male participation and leadership rates. However, female has higher participation and leadership rates in weeding, watering, harvesting, sorting, and preparing meals.

Table 5-2. Summary statistics of male and female participation and leadership (per cent number of observations)

Farming activities	Participation		Leadership	
	MMPk	FFPk	MMLk	FFLk
Land preparation	0.97	0.16	0.87	0.03
Buy equipment	0.97	0.21	0.85	0.05
Buy inputs	0.86	0.10	0.78	0.05
Spread seed	0.95	0.29	0.84	0.02
Mulching	0.75	0.29	0.67	0.01
Planting	0.85	0.28	0.78	0.01
Installing stakes	0.94	0.53	0.81	0.02
Applying fertiliser	0.95	0.13	0.87	0.01
Spraying pesticides	0.90	0.10	0.81	0.04
Weeding	0.93	0.60	0.81	0.04
Watering	0.94	0.73	0.78	0.04
Harvesting	0.87	0.62	0.65	0.12
Transporting	0.66	0.16	0.60	0.01
Sorting	0.96	0.76	0.72	0.06
Marketing	0.64	0.32	0.57	0.03
Preparing meals	0.29	0.85	0.03	0.75

*leadership variables are only collected if observation participated in the activities

Higher female participation rates in some activities such as weeding, sorting, and installing stakes is not in line with the female leadership. Whilst there is evidence in the literature that women tend to lead harvesting activities in Indonesia (Akter et al. 2017) our sample suggests that men tend to lead harvesting in this area. Overall, the results we have indicate that women state they tend to have low levels of leadership across all activities except meal preparation. On the other hand, females stated that males were leaders in most of the activities on average from 88 to 99 per cent. This is in line with the previous studies in several places stating that females often undervalued their roles and males tend to claim sole leadership (Kusujiarti and Tickamyer 2012, Alwang, Larochelle, and Barrera 2017, Ambler et al. 2017).

The culture of the study location may also influence these gender roles patterns. For example, in Yogyakarta Province (also on the island of Java) women decide how many hired workers to employ and undertakes marketing roles due to a perception that wives are good at bargaining and financial matters, and because they have greater control over household funds (Kusujiarti and Tickamyer 2012, Akter et al. 2017). However, in West Sumatra, where the tradition is a unique matrilineal inheritance, women have more roles in households' decisions including land allocation (Quisumbing and Otsuka 2001, Suyanto, Tomich, and Otsuka 2001). In non-matrilineal inheritance traditions such as South Sumatra, men lead roles in the field including in harvesting that is often led by women in other areas (Akter et al. 2017).

5.6 Results

5.6.1 CFA results

As outlined in Section 5.3 (Figure 5-1), we used CFA to estimate the latent variables FFL, DIS_POS, DIS_NEG and DIS. After we respecified the model by removing the variables with a low loading factor, the final CFA model is shown in Figure 5-2. The model involved three variables: FFL, DIS_POS, and DIS_NEG of which the last two were combined into a composite disagreement factor (DIS) due to their high level of correlation and direct linkage to disagreements regarding leadership in the household. A range of goodness of fit criteria was considered to check the validity of the final model presented in Table 5-3. The criteria of CFI, TLI, SCM and RSMEA easily achieved target levels. However, the SRMR is higher than the expected scores. Ullman and Bentler (2012) explain that in a small sample, the SRMR is generally large and often larger than typical cutoff criteria suggesting that this index is not preferable for small samples. Given this study only involve 226 observations, this may be a reason for the higher SRMR than the target. Alternative specifications were considered, none of which generated an improved SRMR score indicating that our specification was correct.

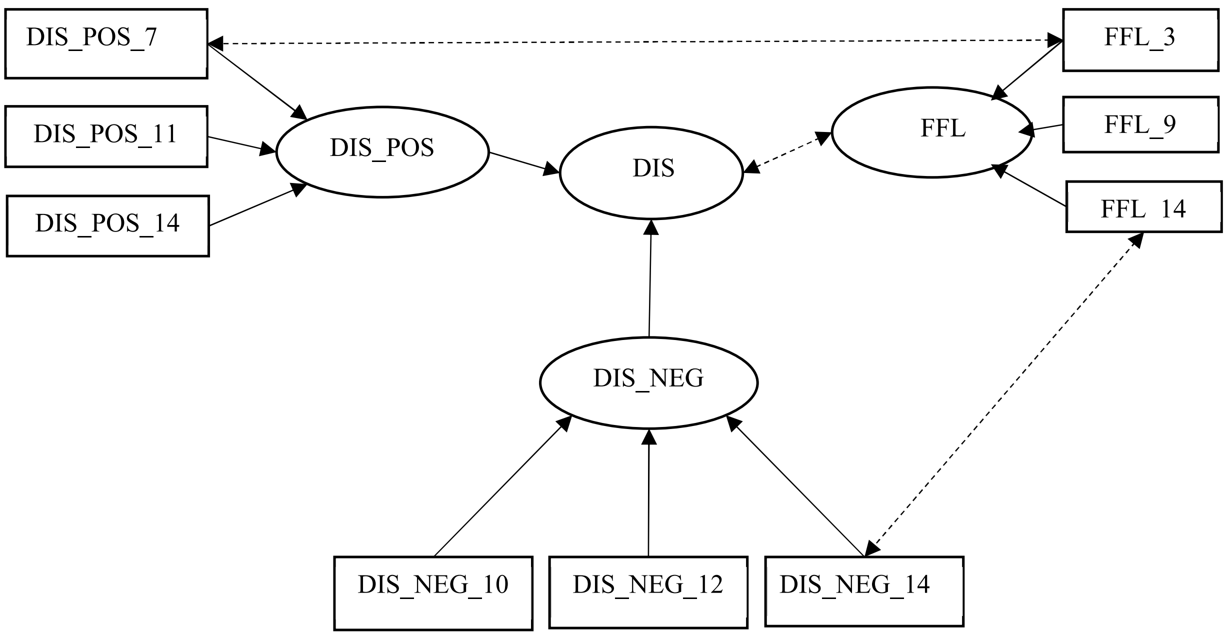

Figure 5-2. Final model after omitting variables with no variance and multiple loadings

Table 5-3. Summary of the goodness of fit criteria

	CFI	TLI	SCM	RSMEA	SRMR

Target score	> 0.9	> 0.9	< 3	< 0.05	< 0.07
Score	1.00	1.01	0.46	0.022	0.107

Table 5-4 provides parameter estimations from the CFA model. Under the final model, all variables were considered statistically significant. The prediction of FFL and DIS were included in the production function outlined in Section 5.6.2. In addition, we find correlations between FFL and DIS (0.585, P-value = 0.008), FFL_14 and DIS_POS_14 (0.341, P-value = 0.009), FFL_14 and DIS_NEG_14 (0.274, P-value = 0.094), and FFL_3 and DIS_POS_7 (0.314, P-value = 0.003).

Table 5-4. Estimation results of CFA

Variables	Estimate	Std.Err
Female leadership		
FFL_3	0.955***	(0.056)
FFL_9	0.977***	(0.048)
FFL_14	0.877***	(0.079)
Positive disagreement		
DIS_POS_7	0.832***	(0.095)
DIS_POS_11	0.792***	(0.101)
DIS_POS_14	0.795***	(0.102)
Negative disagreement		
DIS_NEG_10	0.689***	(0.166)
DIS_NEG_12	0.664***	(0.160)
DIS_NEG_14	0.627***	(0.161)
Total disagreement		
DIS_POS	0.584**	(0.261)
DIS_NEG	0.689*	(0.365)
Number of observations	216	

Note: *** different at 1 per cent, ** different at 5 per cent, * different at 10 per cent

5.6.2 Revenue Function Results

Log-likelihood and associated test statistics from the estimation of the four nested revenue functions are shown in Table 5-5. Likelihood ratio testing of the restrictions involved in the quadratic, Cobb-Douglas and the interactions functional forms relative to the translog functional form indicated that those associated with the quadratic and Cobb-Douglas functions were not supported on the basis of the likelihood ratio test. On the other hand, those associated with the interactions functional form were unable to be rejected. Furthermore, the restrictions embodied in the Cobb-Douglas functional form were also rejected compared to the interactions and the quadratic functional form. However, Cobb-Douglas and interaction functional form involved 17 per cent and 50 per cent of observations violating the basic assumption of monotonicity. This provides relatively strong support for the use of the interactions functional form in further analysis. Only the BIC measure (a highly parsimonious model selected criteria) supported the Cobb-Douglas function with the AIC also supporting the interactions functional form. Overall, the model testing results provide strong support for the use of the interactions functional form. All further results relate to that functional form.

Table 5-5.Functional form test results

	LogLik	**Likelihood ratio tests**	**P-value**	**AIC**	**BIC**	**Multiple R-squared**	**per cent MP < 0**
Translog	-288.55			653.10	783.08	0.53	0.67
Interaction	-291.16	5.22	0.52	646.32	755.77	0.52	0.50
Quadratic (Hicks-neutral)	-305.11	27.90	0.00	656.22	734.89	0.46	0.00
Cobb-Douglas	-309.33	8.45	0.21	652.67	710.82	0.44	0.17

Note: *** different at 1 per cent, ** different at 5 per cent, * different at 10 per cent

The results of estimation of the interactions functional form are shown in Table 5-6. The model performs adequately explaining approximately 46 per cent of the variance in log revenues. The maximum level of additional impact from FFL occurs at a value of FFL of approximately 0.71 due to higher levels of disagreement when the level of FFL is above this level. This leads to a potential maximum estimated revenue increase of approximately $216 USD[1] per hectare associated with female leadership.

Table 5-6. Revenue function estimation[2]

Variables	Estimate	Std. Error
Intercept	0.979	(1.006)
Dummy FFL	-1.007	(1.076)
FFL	5.596**	(2.360)
DIS	-6.432**	(3.055)
FFL* DIS	-4.242**	(1.948)
FFL squared	-0.785	(0.962)
DIS squared	5.373**	(2.253)
Ln AREA	-3.096**	(1.394)
Ln NUMBER OF PLANTS	0.652*	(0.368)
Ln COST OF LABOUR	0.319	(0.235)
Ln COST OF PESTICIDES	0.376	(0.507)
Ln COST OF FERTILISERS	1.703***	(0.602)
Ln COST OF OTHER INPUTS	-0.693	(0.614)
Ln AREA*Ln NUMBER OF PLANTS	2.858*	(1.465)
Ln AREA*Ln COST OF LABOUR	-0.069	(1.242)
Ln AREA*Ln COST OF PESTICIDES	-1.495	(1.462)
Ln AREA*Ln COST OF FERTILISERS	4.563***	(1.836)
Ln AREA*Ln COST OF OTHER INPUTS	-4.193***	(1.939)
Ln NUMBER OF PLANTS*Ln COST OF LABOUR	0.302	(0.380)
Ln NUMBER OF PLANTS*Ln COST OF PESTICIDES	-0.486	(0.580)
Ln NUMBER OF PLANTS*Ln COST OF FERTILISERS	-1.901**	(0.745)
Ln NUMBER OF PLANTS*Ln COST OF OTHER INPUTS	0.469	(0.622)
Ln COST OF LABOUR*Ln COST OF PESTICIDES	-0.580*	(0.338)
Ln COST OF LABOUR*Ln COST OF FERTILISERS	-0.385	(0.393)
Ln COST OF LABOUR*Ln COST OF OTHER INPUTS	0.446	(0.355)
Ln COST OF PESTICIDES*Ln COST OF FERTILISERS	0.263	(0.566)
Ln COST OF PESTICIDES*Ln COST OF OTHER INPUTS	1.346***	(0.516)
Ln COST OF FERTILISER*Ln COST OF OTHER INPUTS	0.056	(0.698)
STORAGE HOUSE	0.256*	(0.143)
HYBRID	0.177	(0.153)
RAINFALL	0.102	(0.090)
R-squared	0.455	
Number of observations	226	

[1] The average of exchange rates (Central Bank of Indonesia) during the survey was IDR 13470.22 per USD

[2] We also provide estimations of revenue function using the sum of FFL and DIS across 16 activities for comparison in the Appendix 4. Even though the correlation between predicted FFL and sum of FLL also shows a high correlation (0.721), the results show that there are insignificant of both sum of FFL and sum of DIS.

F-test	8.123
P-value	2.2e-16

Note: *** different at 1 per cent, ** different at 5 per cent, * different at 10 per cent

However, there are significant and seemingly substantive interactions with disagreement over leadership roles in the household. Disagreements over leadership can entirely displace any potential benefits from female leadership leading to net losses from chilli production for the household.

5.7 Discussion

5.7.1 The Relationship Between Female Leadership of Chilli Revenue Activities and Revenue

Based on Table 5-6, we find that the female leadership related to buying inputs, spraying pesticides, and sorting contribute to higher revenue, ceteris paribus. These findings are contrary to the majority of existing empirical studies of gender in agriculture which show that women' productivity is lower than men's (e.g. Aguilar et al. 2015, de la O Campos, Covarrubias, and Patron 2016, Kilic, Palacios-Lopez, and Goldstein 2015, Oseni et al. 2015). These studies, however, do not account for disagreement in leadership – a clear moderating variable in our study discussed further in the following sub-section.

Three key activities were found to be important to female leadership. First, buying inputs activities, related to the household expenditure decisions. In these cases, wives are thought to play a key role as a decision-maker (e.g. Ashraf 2009, Yusof and Duasa 2010) and there is often female farmers have better bargaining on the market in Indonesia (Doss 2018). Second, female leadership in pesticides applications was an important factor in the female leadership index. Whilst Akter et al. (2017) find that applying the pesticide is considered as a male's job, Fliert and Proost (1999)'s research in Indonesia shows that women are more accurate in observation of pests and diseases. It may be that females' roles in pesticide applications were are an important component of differentiating both households with relatively high levels of female leadership and those that have improved productivity. Thirdly, post-harvest sorting is both a common female activity but also (Akter et al. 2017) but our results also suggest that female leadership of this activity is an important component of defining female leadership in agricultural activities. This finding provides new insight into the gender literature since these activities are not considered as female-typical activities in previous studies. For example, Akter et al. (2017) found that the activities typically are done by the females in Indonesia are harvesting, planting, and preparing meals. Our different findings suggest that female farmers have encompassed a more extensive range of agricultural activities, even for the activities that are perceived identical to men.

5.7.2 The Relationship Between Male and Female Leadership Disagreement and Chilli Revenue

We find that farmer households with lower disagreement, in particular regarding women's leadership of agricultural production activities, is associated with great returns to chilli production. The result provides insights into the importance of the dual role of women and men in achieving women's empowerment. Specifically, without the agreement of men in the household on the role of women in household activities it is unlikely that the benefits of activities to enhance women's empowerment will be effective, or at least have a substantive impact on household welfare. Disagreement regarding the roles of women in enhancing household welfare through leadership of a range of household activities appears to entirely displace any perceived benefits of that leadership. This finding is in line with previous research (Seymour 2017), which found that reducing gender empowerment scores gap between spouses are associated with higher levels of technical efficiency, but adds to it be explicitly considering disagreements in leadership roles.

5.8 Conclusion

This paper utilised a unique data set including detailed male and female leadership across a range of agronomic and marketing activities from Indonesia, which represented the joint management farming activities and productive assets. We employed CFA to generate weighted gender indices across the 16 farming activities considered in our survey focused explicitly on female leadership of activities and disagreement over that leadership between the male and female household head. Disagreement was defined in terms of female and male spouses indicating that their partner did not lead that particular activity. Using a flexible revenue function approach we incorporated these female leadership and disagreement indices into analysis which has implications for household welfare. Our main findings are that female leadership of chilli-harvesting activities can generate enhanced returns from chilli farming. However, these improvements are only realised when there are low levels of disagreement regarding the roles of women in key household activities associated with chilli production and food production. Indeed, disagreements appear to be more important in generating negative effects on returns to chilli production for these households than female leadership has in generating positive returns. Coupled with the observation that disagreement and female leadership are correlated we also provide a possible alternative explanation for the common finding that female productivity is lower than male productivity in leading agricultural activities for smallholder households in developing countries.

These results suggest that future rural development interventions that aim to increase agricultural revenue may achieve a more significant impact by focusing on whole-of-household interventions wherein male spouses can develop an appreciation of their female partners' contributions.

References

Adesina, AA & Djato, KK 1997, 'Relative efficiency of women as farm managers: Profit function analysis in Côte d'Ivoire', *Agricultural Economics*, vol. 16, no. 1, pp. 47-53.

Aguilar, A, Carranza, E, Goldstein, M, Kilic, T & Oseni, G 2015, 'Decomposition of gender differentials in agricultural productivity in Ethiopia', *Agricultural Economics*, vol. 46, no. 3, pp. 311-334.

Akter, S, Rutsaert, P, Luis, J, Htwe, NM, San, SS, Raharjo, B & Pustika, A 2017, 'Women's empowerment and gender equity in agriculture: A different perspective from Southeast Asia', *Food Policy*, vol. 69, no. 1, pp. 270 - 279.

Alene, AD, Manyong, VM, Omanya, GO, Mignouna, HD, Bokanga, M & Odhiambo, GD 2008, 'Economic efficiency and supply response of women as farm managers: Comparative evidence from Western Kenya', *World Development*, vol. 36, no. 7, pp. 1247-1260.

Alkire, S, Meinzen-Dick, R, Peterman, A, Quisumbing, A, Seymour, G & Vaz, A 2013, 'The women's empowerment in agriculture index', *World Development*, vol. 52, pp. 71-91.

Alwang, J, Larochelle, C & Barrera, V 2017, 'Farm decision making and gender: Results from a randomized experiment in Ecuador', *World Development*, vol. 92, pp. 117–129.

Ambler, K, Doss, C, Kieran, C & Passarelli, S 2017, *He says, she says: Exploring patterns of spousal agreement in Bangladesh*, vol. 1616, Intl Food Policy Res Inst.

Anderson, CL, Reynolds, TW & Gugerty, MK 2017, 'Husband and wife perspectives on farm household decision-making authority and evidence on intra-household accord in rural Tanzania', *World Development*, vol. 90, pp. 169-183.

Ashraf, N 2009, 'Spousal control and intra-household decision making: An experimental study in the Philippines', *American Economic Review*, vol. 99, no. 4, pp. 1245-1277.

Bayu, TB 2017, 'The expansion of cash cropping; implications on gender division of roles: A case study from gedeo community-southern nation nationalities and peoples region, Ethiopia', *International Journal of Sustainable Development Research*, vol. 3, no. 2, p. 7.

Bozoğlu, M & Ceyhan, V 2007, 'Measuring the technical efficiency and exploring the inefficiency determinants of vegetable farms in Samsun Province, Turkey', *Agricultural Systems*, vol. 94, no. 3, pp. 649-656.

Brown, TA 2014, *Confirmatory Factor Analysis for Applied Research*, Guilford Publications, New York, United States.

Burbidge, JB, Magee, L & Robb, AL 1988, 'Alternative Transformations to Handle Extreme Values of the Dependent Variable', *Journal of the American Statistical Association*, vol. 83, no. 401, pp. 123-127.

Carranza, E 2014, 'Soil endowments, female labor force participation, and the demographic deficit of women in India', *American Economic Journal: Applied Economics*, vol. 6, no. 4, pp. 197-225.

Chavas, J-P, Petrie, R & Roth, M 2005, 'Farm household production efficiency: Evidence from The Gambia', *American Journal of Agricultural Economics*, vol. 87, no. 1, pp. 160-179.

Coelli, TJ, Rao, DSP, O'Donnell, CJ & Battese, GE 2005, *An introduction to efficiency and productivity analysis*, Springer Science & Business Media.

Diiro, GM, Seymour, G, Kassie, M, Muricho, G & Muriithi, BW 2018, 'Women's empowerment in agriculture and agricultural productivity: Evidence from rural maize farmer households in Western Kenya', *PloS one*, vol. 13, no. 5, pp. 1-27.

Dimelu, M, Okoye, A, Okoye, B, Agwu, A, Aniedu, O & Akinpelu, A 2009, 'Determinants of gender efficiency of small-holder cocoyam farmers in Nsukka agricultural zone of Enugu State Nigeria', *Scientific Research and Essays*, vol. 4, no. 1, pp. 028-032.

Dixon, RB 1982, 'Women in agriculture: Counting the labor force in developing countries', *Population and Development Review*, vol. 8, no. 3, pp. 539-566.

Doepke, M & Tertilt, M 2014, *Does female empowerment promote economic development?*, National Bureau of Economic Research.

Doss, C, Meinzen-Dick, R, Quisumbing, A & Theis, S 2018, 'Women in agriculture: Four myths', *Global Food Security*, vol. 16, pp. 69-74.

Doss, CR 1996, 'Testing among models of intrahousehold resource allocation', *World Development*, vol. 24, no. 10, pp. 1597-1609.

Doss, CR 2002, 'Men's crops? Women's crops? The gender patterns of cropping in Ghana', *World Development*, vol. 30, no. 11, pp. 1987-2000.

Doss, CR 2018, 'Women and agricultural productivity: Reframing the issues', *Development Policy Review*, vol. 36, no. 1, pp. 35-50.

FAO 2011, *The State of Food and Agriculture*, Food & Agriculture Organization of the UN (FAO), Rome.

Fliert, Evd & Proost, J 1999, *Women and IPM: crop protection practices and strategies*, Royal Tropical Inst.

Goldstein, M & Udry, C 2008, 'The profits of power: Land rights and agricultural investment in Ghana', *Journal of Political Economy*, vol. 116, no. 6, pp. 981-1022.

Gregg, D & Rolfe, J 2016, 'The value of environment across efficiency quantiles: a conditional regression quantiles analysis of rangelands beef production in North Eastern Australia', *Ecological Economics*, vol. 128, pp. 44-54.

Guirkinger, C, Platteau, J-P & Goetghebuer, T 2015, 'Productive inefficiency in extended agricultural households: Evidence from Mali', *Journal of Development Economics*, vol. 116, pp. 17-27.

Horrell, S & Krishnan, P 2007, 'Poverty and productivity in female-headed households in Zimbabwe', *The Journal of Development Studies*, vol. 43, no. 8, pp. 1351-1380.

Jacoby, HG 1991, 'Productivity of men and women and the sexual division of labor in peasant agriculture of the Peruvian Sierra', *Journal of Development Economics*, vol. 37, no. 1, pp. 265-287.

Joshi, K, Roy, M & Chandra, N 2016, 'Gender roles in dominant farming system of western plain zone of Uttar Pradesh: A case study of Meerut District', *Technofame, A Journal of Multidisciplinary Advance Research*, vol. 5, no. 1, pp. 40-49.

Kebede, B, Tarazona, M, Munro, A & Verschoor, A 2013, 'Intra-household efficiency: An experimental study from Ethiopia', *Journal of African Economies*, vol. 23, no. 1, pp. 105-150.

Kilic, T, Palacios-Lopez, A & Goldstein, M 2015, 'Caught in a productivity trap: A distributional perspective on gender differences in Malawian agriculture', *World Development*, vol. 70, pp. 416-463.

Kinkingninhoun-Mêdagbé, FM, Diagne, A, Simtowe, F, Agboh-Noameshie, AR & Adégbola, PY 2010, 'Gender discrimination and its impact on income, productivity, and technical efficiency: Evidence from Benin', *Agriculture and Human Values*, vol. 27, no. 1, pp. 57-69.

Kusujiarti, S & Tickamyer, AR 2012, 'Gender and agricultural production', in *Power, Change, and Gender Relations in Rural Java*, Ohio University Press, Athens, United States.

Meemken, E-M, Veettil, PC & Qaim, M 2017, 'Toward improving the design of sustainability standards—a gendered analysis of farmers' preferences', *World Development*, vol. 99, pp. 285-298.

Ministry of Agriculture 2015, *Ministry of Agriculture Strategic Planning 2015–2019*, Ministry of Agriculture, Jakarta.

Mishra, AK, Khanal, AR & Mohanty, S 2017, 'Gender differentials in farming efficiency and profits: The case of rice production in the Philippines', *Land Use Policy*, vol. 63, pp. 461-469.

Oduol, JBA, Mithöfer, D, Place, F, Nang'ole, E, Olwande, J, Kirimi, L & Mathenge, M 2017, 'Women's participation in high value agricultural commodity chains in Kenya: Strategies for closing the gender gap', *Journal of Rural Studies*, vol. 50, pp. 228-239.

Oseni, G, Corral, P, Goldstein, M & Winters, P 2015, 'Explaining gender differentials in agricultural production in Nigeria', *Agricultural Economics*, vol. 46, no. 3, pp. 285-310.

Peterman, A, Behrman, JA & Quisumbing, AR 2014, 'A review of empirical evidence on gender differences in nonland agricultural inputs, technology, and services in developing countries', in *Gender in Agriculture*, Springer, pp. 145-186.

Peterman, A, Quisumbing, A, Behrman, J & Nkonya, E 2011, 'Understanding the complexities surrounding gender differences in agricultural productivity in Nigeria and Uganda', *Journal of Development Studies*, vol. 47, no. 10, pp. 1482-1509.

Puspitawati, E 2013, 'Contracts and marketing decisions of Indonesian potato growers', School of Agriculture, Food and Wine, PhD thesis, The University of Adelaide, South Australia.

PuQuisumbing, AR 1996, 'Male-female differences in agricultural productivity: Methodological issues and empirical evidence', *World Development*, vol. 24, no. 10, pp. 1579-1595.

Quisumbing, AR & Maluccio, JA 2000, *Intrahousehold allocation and gender relations: New empirical evidence from four developing countries*, International Food Policy Research Institute Washington, DC.

Quisumbing, AR & Otsuka, K 2001, 'Land Inheritance and Schooling in Matrilineal Societies: Evidence from Sumatra', *World Development*, vol. 29, no. 12, pp. 2093-2110.

Rahman, S 2010, 'Women's labour contribution to productivity and efficiency in agriculture: Empirical evidence from Bangladesh', *Journal of Agricultural Economics*, vol. 61, no. 2, pp. 318-342.

Rao, EJ, Brümmer, B & Qaim, M 2012, 'Farmer participation in supermarket channels, production technology, and efficiency: the case of vegetables in Kenya', *American Journal of Agricultural Economics*, pp. 891-912.

Rosseel, Y 2012, 'Lavaan: An R package for structural equation modeling', *Journal of Statistical Software*, vol. 48, no. 2, pp. 1-36.

Sahara 2012, 'The transformation of modern food retailers in Indonesia: opportunities and challenges for smallholder farmers', School of Agriculture, Food and Wine, PhD thesis, The University of Adelaide, South Australia.

Seymour, G 2017, 'Women's empowerment in agriculture: Implications for technical efficiency in rural Bangladesh', *Agricultural Economics*, vol. 48, no. 4, pp. 513-522.

Seymour, G, Doss, C, Marenya, P, Meinzen-Dick, R & Passarelli, S 2016, 'Women's empowerment and the adoption of improved maize varieties: evidence from Ethiopia, Kenya, and Tanzania', in *2016 Agricultural & Applied Economics Association,* Boston, Massachusetts.

Slavchevska, V 2015, 'Gender differences in agricultural productivity: the case of Tanzania', *Agricultural Economics*, vol. 46, no. 3, pp. 335-355.

Smyth, JD, Swendener, A & Kazyak, E 2018, 'Women's work? The relationship between farmwork and gender self-perception', *Rural sociology*, vol. 83, no. 3, pp. 654-676.

Suyanto, S, Tomich, TP & Otsuka, K 2001, 'Land tenure and farm management efficiency: the case of paddy and cinnamon production in customary land areas of Sumatra', *Australian Journal of Agricultural and Resource Economics*, vol. 45, no. 3, pp. 411-436.

Team, RC 2018, 'R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. 2012', <http://www. R-project. org>.

The World Bank, FaAO, International Fund for Agricultural Development, 2008, *Gender in Agriculture Sourcebook*, World Bank.

Twyman, J, Useche, P & Deere, CD 2015, 'Gendered perceptions of land ownership and agricultural decision-making in Ecuador: Who are the farm managers?', *Land Economics*, vol. 91, no. 3, pp. 479-500.

Udry, C 1996, 'Gender, Agricultural Production, and the Theory of the Household', *Journal of Political Economy*, vol. 104, no. 5, pp. 1010-1046.

Udry, C, Hoddinott, J, Alderman, H & Haddad, L 1995, 'Gender differentials in farm productivity: implications for household efficiency and agricultural policy', *Food Policy*, vol. 20, no. 5, 10//, pp. 407-423.

Ullman, JB & Bentler, PM 2012, 'Structural equation modeling', *Handbook of Psychology, Second Edition*, vol. 2.

UN 2010, *Rural women key to economic growth, says UN official*, UN News, viewed 6 April 2019, <https://news.un.org/en/story/2010/03/333332-rural-women-key-economic-growth-says-un-official>.

Van de Fliert, E 1999, 'Women in IPM training and implementation in Indonesia', *Gender and IPM: crop protection practices and strategies, Royal Tropical Institute, Amsterdam*, pp. 71-78.

Whatmore, S 1991, 'Life cycle or patriarchy? Gender divisions in family farming', *Journal of Rural Studies*, vol. 7, no. 1, pp. 71-76.

Wouterse, F 2017, 'The role of empowerment in agricultural production: Evidence from rural households in Niger', *The Journal of Development Studies*, pp. 1-16.

Yusof, SA & Duasa, J 2010, 'Household decision-making and expenditure patterns of married men and women in Malaysia', *Journal of Family and Economic Issues*, vol. 31, no. 3, pp. 371-381.

Chapter 6 Statement of Authorship

Title of Paper	The Adoption Dynamics of Hybrid Chilli Seeds in Indonesia
Publication Status	☐ Published ☐ Accepted for Publication ☐ Submitted for Publication ■ Unpublished and Unsubmitted work written in manuscript style
Publication Details	Prepared for submission to Agribusiness

Principal author

Name of Principal Author (Candidate)	Apri Laila Sayekti		
Contribution to the Paper	Contributed to preparation of primary survey and data collection, performed data analysis and interpretation, and wrote the manuscript.		
Overall percentage (per cent)	70 per cent		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);
ii. permission is granted for the candidate in include the publication in the thesis; and
iii. the sum of all co-author contributions is equal to 100 per cent less the candidate's stated contribution.

Name of Co-Author	Adjunct Professor Randy Stringer		
Contribution to the Paper	Project director of INDOHORT, contributed in manuscript editing.		
Signature		Date	26/08/19

Name of Co-Author	Dr Di Zeng		
Contribution to the Paper	Contributed to data analysis and in manuscript editing.		
Signature		Date	26/08/19

Chapter 6 : The Adoption Dynamics of Hybrid Chilli Seeds in Indonesia

Abstract

Hybrid crop seeds are generally found to increase productivity, farm households' income and food security. While there is an extensive literature that focuses on hybrid seed adoption in developing countries, less is understood regarding the continuity of adoption behaviours over time. This study extends previous ones by identifying the factors associated with hybrid seed adoption and dis-adoption among smallholder chilli farmers in Indonesia, using four adoption categories: early-adoption, late-adoption, continual-adoption, and dis-adoption. A multinomial logit model is estimated where dynamic adoption behaviours are specified with a two-period panel data set on chilli farmers. The results show that variables associated with continual-adoption are different from variables related to late-adoption, indicating that each category of farmers exhibits different behaviours. The results reveal that being a female whose main occupation is farming and who belongs to a farmer's group is positively associated with continual-adoption of hybrid chilli seeds and reduces the possibility of them being a non-adopter. However, these variables are not related to late-adopters. Additionally, supplying to modern marketing channels has a positive relationship with being a dis-adopter. These results indicate that the adoption stages are complex and this insight should assist adoption policies to pay more attention to targeting different messages, or strategies, among different adoption categories. Also, integrating women in hybrid chilli seed dissemination programs may encourage more to become continual-adopters.

Keywords: hybrid; chilli; continual-adoption; late-adoption; women; Indonesia

6.1 Introduction

Adoption of hybrid seeds has played an essential role in rural development by increasing crop productivity. Research shows that hybrid seeds have superior characteristics compared to traditional open-pollinated (OP)[3] and saved seeds[4]. Hybrid seeds contribute to higher and more stable crop yields, lower losses caused by pests and reductions in the negative impacts of disease and adverse weather conditions. They are a less risky option than OP seeds (Lybbert 2006) because of their tolerance of climatic fluctuation. The yield advantages of hybrid seeds over OP, or saved seeds, (e.g. Kuntariningsih & Mariyono 2013) are likely to provide more opportunities for income alternatives for smallholder farmers. For example, evidence from Pakistan demonstrates that farmers with access to certified hybrid seeds achieve higher and more stable yields and higher incomes (Ali et al. 2015). Similar results are found in Nigeria (Awotide, Awoyemi & Diagne 2012). Also, the unit cost for hybrid chilli seeds was lower compared to OP and saved seeds (Ali 2006). Moreover, the adoption of hybrid seeds is a simple technology to adopt and does not require a substantial investment for smallholder farmers in terms of new capital costs and/or knowledge (Firdaus & Ahmad 2010).

Despite decades of hybrid seed research, which has demonstrated these benefits (Dixon 1980; Feder 1980), the adoption rates of hybrid seeds in many developing countries are still relatively low. Farmers are still using OP seeds or saved seeds (Ali 2006). Even though saved seeds are obtained from the harvesting of hybrid seeds, the performance of the saved seeds is utterly different from the originals because they are not designed for re-

[3] OP seeds are typically traditional seeds, but there are also several limited improved OP seeds that are designed to be planted for several generations (Ali 2006).

[4] Saved seeds are the seeds that are obtained from the previous harvest either from hybrid seed or OP ones. The seeds which are generated from hybrid seeds will not perform as well as the first generation of hybrid seeds because of genetic degradation (Ali 2006). However, some of the OP seeds can be planted for several generations without decreasing their performance.

planting (Ali 2006). From an agronomic perspective, farmers using OP or saved seeds face problems of inconsistency in yield and quality (van Gastel, Gregg & Asiedu 2002). Also, the use of saved seeds is riskier due to poor seed storage conditions (da Silva Dias 2010). Given these factors, however, the significant portion of farmers who still use non-hybrid seeds, or even dropout of using hybrid seeds, is a challenging phenomenon, requiring careful investigation of farmers' adoption behaviours. Viewing the adoption of hybrid seeds as a dynamic process means scientific evidence is required to assist policy design that aims to increase adoption rates and, through this strategy, improve rural welfare.

This article investigates the dynamics of adoption behaviours related to hybrid chilli seeds among smallholder farmers in Indonesia. The rapid transformation in agricultural systems and the expansion of modern food retail outlets (e.g. supermarkets, convenience stores) (Hernández et al. 2015; Neven et al. 2009; Reardon et al. 2009; Reardon, Timmer & Minten 2012) could provide additional incentives for farmers to plant hybrid seeds. For example, Sahara et al. (2015) found that farmers' participation in modern marketing channels required the use of hybrid seeds since these type of seeds could produce better quality and more uniform chilli products compared to OP and saved seeds. When access to modern retail markets are limited, farmers may lack the price and profit incentives to continue planting hybrid seeds. This adds to the evidence that farmers adopt hybrid seeds at different points in time and that, even after adopting them, farmers may not continue to use hybrid seeds in the future. Further, different factors affect different farmer's choices. Knowledge about the dynamics of seed choice is needed to assist policies and to design farmer's support systems because technology adoption is an ever-changing process over time (Barrett, Carter & Timmer 2010; Doss 2006; Ghadim & Pannell 1999). However, there are still few studies that evaluate the continuity of seed choices, particularly switching between hybrid seeds and OP/saved seeds in Southeast Asia in general and Indonesia in particular (e.g. Barham et al. 2004; Srisopaporn et al. 2015).

To fill these gaps, this study uses two rounds of panel data (2010 and 2016) from a large-scale survey of chilli farmers in Indonesia. The 2016 survey interviews the same chilli farmers who participated in the 2010 survey. We specifically try to: 1) describe the characteristics of adopting and dis-adopting farmers of hybrid chilli seeds; and 2) examine the factors explaining farmers' continuity in adopting hybrids chilli seeds. We further examine the influence of gender roles on hybrid adoption and dis-adoption and check for potential heterogeneity in this regard. A multinomial logit model is estimated using four adoption categories: early-adoption; late-adoption; continual-adoption; and dis-adoption are estimated to fully understand hybrid seed adoption dynamics.

The rest of the article is organised as follows. The next section explains the adoption factors used in this article. Section 6.3 presents the data used and supports the methodological approaches to analyse the data. The results and discussion are explored in Section 6.4. Finally, section 6.5 concludes with policy implications.

6.2 Factors Potentially Related to the Dynamic of Technology Adoption

Technology adoption studies are often considered as gender-neutral or are focused on men, even though each gender might have a different point of view (Doss & Morris 2000). Also, many technology adoption studies are frequently modelled using only the household head's characteristics or by having a dummy variable for gender (Doss 2006). In these analyses, it is assumed that adoption preferences of the members of the households are represented by the household's head, which potentially under-evaluates the female's contributions to adoption in male-headed households. Because of these assumptions, farmer's support systems for agricultural technology diffusion generally do not target women because the household's heads are usually men, particularly in South East Asian countries. In these countries, men frequently represent their households in formal village activities, including in decision-making processes within communities (Peterman et al. 2011; Van de Fliert 1999). Since some important agricultural-related strategies are decided on within the community or within farmer's groups, women farmers may not have the same opportunities for participating in the decision-making process (Akter et al. 2017). In order to understand women's' contributions to dynamic adoption behaviours, this study extends the literature by considering wives' characteristics within households in influencing seed choices. Understanding the influencing factors could provide insights into technology extension and dissemination to target more potential adopters, including women, to increase the adoption rates of hybrid chilli seeds.

A growing body of literature has analysed the factors explaining farmers' seeds choices. Firstly, we consider the influence of the number of household members, which has been widely studied (e.g. Burton, Rigby & Young 1999; Teklewold et al. 2013; Tey et al. 2013). Households with more members are more likely to adopt the technology (Burton, Rigby & Young 1999; Teklewold et al. 2013; Tey et al. 2013), particularly in vegetable production, which needs more labour than cereal production (Minot & Roy 2007). Having farming as a main occupation, for both household heads and spouses, is associated with adoption of technology (e.g. Whatmore 1991); this is related to the time allocated to on-farm and off-farm activities. If the main occupation of the households' heads, and their spouses, is farming, they will be more focused on managing their farms. However, having an off-farm occupation also means that they have other income sources (Hill 1993), which is very important in minimising the risks of being insecure while adopting the new technology. The spouse's occupation is also crucial because it may be a substitute for, or be complementary to, the household head's main occupation because a gendered division of labour still exists in households (Whatmore 1991).

Education of the household's head and spouse is also a vital factor because it is related to the farmer's entrepreneurial ability (Feder, Just & Zilberman 1985). Technological changes may require farmers to have entrepreneurial ability, where it is defined as the ability to perceive, interpret, and respond to new technology, with regard for the risks (Feder, Just & Zilberman 1985). Consequently, farmers' education is vital in technology adoption and has been a focus in most adoption studies (e.g. Ali, A et al. 2015; Awotide, Awoyemi & Diagne 2012; Boahene, Snijders & Folmer 1999; D'Souza, Cyphers & Phipps 1993; Kouser & Qaim 2011).

Production assets, including land assets, are one of the factors identified as the biggest constraint on technology adoption among smallholder farmers. Previous studies suggest that adequate production assets increase the economic scale of production (Feder, Just & Zilberman 1985). Most recent research also reveals that fragmented landholding constitutes a significant hindrance to the adoption process (Firdaus & Ahmad 2010).

Even though hybrid seeds do not need substantial investments, farmers in developing countries, particularly smallholder farmers, often do not have savings, or access to credit, to make these investments and purchase required inputs. In this case, off-farm income could typically support a farmer's household income (Hill 1993), so it could contribute to the adoption process. Off-farm income has been shown to significantly influence the adoption decisions related to the Bt hybrid eggplant in India (Krishna & Qaim 2007).

6.3 Methodology

Farmers' decisions to adopt a technology is a series of processes, or dynamics, over time that cannot be examined with snapshot data (Doss 2006). To capture dynamic adoption behaviours, this study uses two rounds of panel survey data of 251 chilli farmers in three districts (Garut, Tasikmalaya, and Ciamis), in West Java Province, Indonesia. Data were collected in 2010 and 2016. The first survey was conducted with 597 chilli farmers. In the second survey, 573 chilli farmers were interviewed. However, only 251 farmers of the farmers sampled planted chilli in 2016; their data are used in this study for the analysis of adoption dynamics on these growers who have continuously produced chilli. Due to the data limitation, we only focus on the farmers' adoption in 2010 and 2016 and does not take into account the types of seeds used by farmers outside these time.

6.3.1 Data

After data cleaning, this analysis uses 251 observations from 41 villages. Table 6-1 explains the variables used for analysis and the descriptive statistics related to farmers. Table 6-2 presents the descriptive statistics of farmers by adoption categories. Among the household characteristics, farmer's occupation is a central consideration. Farming is the main occupation of the majority of household heads in the four adoption categories. This aligns with data on the general occupation of household heads in rural areas of Indonesia (Ministry of Agriculture 2015).

Table 6-1. Descriptive statistics of the sample

Variable		Mean	Std. Dev.
Farming is the main occupation of the household head in 2010 (1=farming, 0=others)	Male's main occupation 2010	0.948	0.222
Farming is the main occupation of the spouse in 2010 (1=farming, 0=others)	Female's main occupation 2010	0.462	0.500
Farming is the main occupation of the household head in 2016 (1=farming, 0=others)	Male's main occupation 2016	0.900	0.300
Farming is the main occupation of the spouse in 2016 (1=farming, 0=others)	Female's main occupation 2016	0.351	0.478
Household head's education (years)	Male's education	6.641	2.674
Spouse's education (years)	Female's education	6.963	2.586
Household head's age (years old)	Male's age	50.375	10.626
Spouse's age (years old)	Female's age	43.777	9.891
Number of adult members in the household	Adult	2.726	1.103
Land ownership in 2010 (ha)	Land	0.550	0.959
Member of farmer's group in 2010 (1=member, 0=no)	Farmer group	0.171	0.378
Supplied to a modern marketing channel in 2010 (1=yes, 0=no)	Modern market	0.163	0.370
Income from non-agricultural sources (Rp 1,000,000)	Off-farm income	27.130	69.623

Table 6-2. Descriptive statistics on farmers by adoption categories

Variable	Non-adopters (n=39)		Continual-adopters (n=137)		Dis-adopters (n=48)		Late-adopters (n=27)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Male's main occupation 2010	0.92	0.27	0.94	0.24	0.98	0.14	0.96	0.19
Female's main occupation 2010	0.36	0.49	0.48	0.50	0.46	0.50	0.52	0.51
Male's main occupation 2016	0.92	0.27	0.88	0.32	0.90	0.31	0.96	0.19
Female's main occupation 2016	0.36	0.49	0.36	0.48	0.25	0.44	0.48	0.51
Male's education	6.36	2.75	6.70	2.80	7.08	2.55	5.96	1.99
Female's education	6.73	3.06	7.06	2.53	7.32	2.83	6.15	1.26
Male's age	50.15	12.14	49.79	10.21	50.13	11.21	54.11	9.06
Female's age	43.65	9.21	43.39	9.96	43.43	10.83	46.54	8.71
Adult	2.82	0.97	2.76	1.16	2.75	1.08	2.37	1.01
Land	0.35	0.38	0.65	1.14	0.43	0.88	0.54	0.58
Farmer's group	0.08	0.27	0.23	0.42	0.10	0.31	0.11	0.32
Modern market	0.08	0.27	0.21	0.41	0.17	0.38	0.04	0.19
Off-farm income	13.20	24.65	34.69	88.04	21.53	38.84	18.86	41.60

As expected, farming is not the main activity of wives. Females typically participate in agricultural activities less than males do in Indonesia (Kusujiarti & Tickamyer 2012). This is because females have mainly been engaged in domestic and child-care responsibilities (Doss et al. 2018). For males, farming as their primary occupation in this sample decreased by 4.8 per cent between 2010 and 2016, while farming as an occupation among females decreased by 11 per cent. This finding is in line with trends in farming as an occupation in Indonesia, which was reduced by 1.49 per cent from 2010 to 2014; a 1.54 per cent decrease for males and a 1.42 per cent decrease for females (Ministry of Agriculture 2015). A possible reason is the land conversions that are happening in rural Indonesia (Ministry of Agriculture 2015) and which are reducing the interest in on-farm jobs.

The decreasing numbers of people who had farming, as their main occupation may also be concerning if it is associated with decreasing interest in on-farm jobs, especially for young adults. The average household head's age, and that of their wives, in this sample is 40 to 50 years, which is not young. This is confirmed by data that show that in Indonesia, labour migration from agriculture to the manufacturing sector is triggered by young people aged 15 to 29 years (Ministry of Agriculture 2015). This is also happening in other countries (e.g. Bjarnason & Thorlindsson 2006; Knight & Song 2003; Piotrowski, Ghimire & Rindfuss 2013). One possible explanation is that the younger generation is not as interested in farming (Kusujiarti & Tickamyer 2012) because the manufacturing sector offers more promising career paths. Farmer's education may also be related to the decreasing proportions of people choosing farming as an occupation in rural areas. Better educated labourers tend to choose off-farm jobs (e.g. Bjarnason & Thorlindsson 2006; Knight & Song 2003). Farmer's education, on average, in this sample is six years both for the household heads and for their spouses.

In terms of access to a key input, households' land ownership on average is 0.5 hectares, meaning that, in general, our sample is smallholder farmers. Some farmers may rent land to cultivate chilli, but the more land they have, the wealthier they are. This is also in line with the average farmers' income. Continual-adopters seem to have more land and more off-farm income, indicating that they are wealthier than other adopter categories.

In this study, access to technology information and modern marketing channels are reflected by the indicators of being members of a farmer's group[5] and supplying to modern marketing channels. In this sample, the rates of both variables are meagre (less than 20 per cent); generally, higher rates are found in the continual-adopters category. Supplying to modern market channels in 2010, which required use of hybrid seeds, does not guarantee continuity of adoption, because 17 per cent of the sample were still dis-adopters in 2016. This indicates that disseminating technology and marketing information is still below the necessary target.

6.3.2 Multinomial Logit Model

This study employs a multinomial logit (MNL) model to explore factors explaining four distinct adoption categories: 1) continual-adopters, who planted hybrid seeds in both 2010 and 2016; 2) late-adopters who planted OP/saved seeds in 2010 and then switched to hybrid seeds in 2016; 3) non-adopters, who only planted OP/saved seeds in both 2010 and 2016; and 4) dis-adopters, who used hybrid seeds in 2010 but used OP/saved seeds in 2016. The MNL model allows evaluation of the determinants that are associated with each of these each category, as used in the previous studies (e.g. Burton, Rigby & Young 1999; Läpple

[5] Farmer's groups are some farmers who have the same goals, motives, and interests and form a group. Farmer's groups are formed as formal organisations, with the aim of being a forum for communication between farmers.

& Van Rensburg 2011; Nguyen - Van, Poiraud & To - The 2017; Nkamleu & Kielland 2006).

Let y_i denote farmer i adoption decision of cultivating hybrid seeds, with j is the outcome number of adoption categories mentioned previously. x_i are factors influencing farmers' decisions. The model is specified as:

$$\Pr(y_i = j) = \frac{e^{\beta_i x_i}}{\sum_{k=0}^{j} e^{\beta_k x_i}} \quad j = 0,1,2,3$$

This study uses the non-adopter category as the base outcome. However, the MNL model estimates the coefficients that correspond to the effects of explanatory variables on ratios that should be interpreted in relative terms and be compared to the non-adopters as the base category.

$$\frac{\Pr\,(y = j)}{\Pr\,(y = 0)} = \exp(\beta_j x_i)\,, for\; j > 0$$

This study accounts the marginal effects on individual probabilities to interpret the results more conveniently. The marginal effects of variable x_l is defined as:

$$\frac{\partial Pr(y_i = j)}{\partial x_l} = \left[\beta_{jl} - \sum_{j=1}^{J} \beta_{kl} \Pr\,(y = j)\right] \Pr(y = j)\,, j = 0,1,2,3$$

The marginal effects of dummy variables are given by the discrete change in individual probabilities that are evaluated at the alternative values of the dummy from zero to one. Regression results and the average marginal effects are presented and explored in the next section.

6.4 Results

The MNL is a regression model that is commonly used to analyse nominal outcomes. However, this model has restrictions including the independence of irrelevant alternatives (IIA) (e.g. Nguyen-Van, Poiraud & To-The 2017). Statistical tests are available to test the IIA. However, those tests are not recommended because of their unreliable test results (Cheng & Long 2007; Long 2006). Therefore, this study employs multinomial logit to account for the adoption categories following previous studies (Barham et al. 2004; Läpple & Van Rensburg 2011), which worked well in revealing the significant differences between adoption categories.

Table 6-3. Multinomial logit regression results of hybrid chilli seed adoption categories

Variables	Non-adopters (n=39)		Continual-adopters (n=137)		Dis-adopters (n=48)	
	Coef	Std. Err	Coef	Std. Err	Coef	Std. Err
Male's main occupation 2010	0.616	0.879	1.244	1.477	1.771	1.261
Female's main occupation 2010	1.274**	0.491	0.643	0.614	1.116**	0.543
Male's main occupation 2016	-1.023	0.889	0.272	1.346	-0.450	0.986
Female's main occupation 2016	0.083	0.471	0.304	0.596	-0.599	0.539
Male's education	-0.070	0.110	-0.106	0.159	-0.003	0.118
Female's education	-0.028	0.099	-0.036	0.143	0.018	0.107
Male's age	-0.060	0.041	0.015	0.049	-0.017	0.045
Female's age	0.005	0.046	-0.010	0.056	-0.006	0.050
Adult	-0.060	0.214	-0.499*	0.285	-0.064	0.242
Land	1.387**	0.582	0.740	0.662	1.001*	0.603
Farmer's group	1.448*	0.875	1.274	1.090	-0.013	1.010
Modern market	-0.927	1.275	-3.298*	1.699	-0.454	1.367
Off-farm income	0.015*	0.009	0.012	0.009	0.012	0.009
Garut	-2.571**	1.140	-2.849**	1.220	-1.973	1.216
Tasikmalaya	13.530	617.238	-2.289	950.865	13.582	617.238
Intercept	5.507**	2.426	1.702	3.249	0.764	2.752
Number of observations	251					
Log-likelihood	-236.993					
Pseudo R squared	0.165					

Note: *** different at 1 per cent, ** different at 5 per cent, * different at 10 per cent

The regression results of the MNL model are presented in Table 6-3. For more convenient interpretations, we will explore the results of the average marginal effects (Table 6-4) rather than the result of the MNL model. The results show that each category of adoptions behaviours is associated with different factors. Factors related to a farmer's decision to be a continual-adopter vary from those influencing the decision to be a late-adopter. Females' main occupations in 2010 played an important role in decisions to be a non-adopter and a continual-adopter. However, females' main occupation in 2016 does not influence the decision to be a non-adopter and a continual-adopter but is more likely to decrease the probability to be a dis-adopter.

Table 6-4. The average marginal effects of chilli farmer's adoption of hybrid seeds

Variables	**Non-adopters (n=39)**		**Continual-adopters (n=137)**		**Dis-adopters (n=48)**		**Late-adopters (n=27)**	
	dy/dx	SE	dy/dx	SE	dy/dx	SE	dy/dx	SE
Male's main occupation 2010	-0.114	0.093	-0.107	0.154	0.177	0.160	0.044	0.111
Female's main occupation 2010	-0.121**	0.048	0.120*	0.064	0.026	0.054	-0.025	0.041
Male's main occupation 2016	0.068	0.093	-0.177	0.110	0.030	0.092	0.078	0.096
Female's main occupation 2016	0.007	0.047	0.062	0.066	-0.102*	0.058	0.033	0.041
Male's education	0.006	0.011	-0.009	0.015	0.009	0.012	-0.006	0.011
Female's education	0.002	0.010	-0.006	0.015	0.006	0.012	-0.002	0.011
Male's age	0.004	0.004	-0.011*	0.006	0.003	0.005	0.004	0.003
Female's age	0.000	0.005	0.002	0.006	-0.001	0.005	-0.001	0.004
Adult	0.015	0.022	0.017	0.029	0.006	0.025	-0.038**	0.019
Land	-0.126**	0.060	0.150***	0.049	-0.003	0.038	-0.020	0.033
Farmer group	-0.110	0.091	0.238**	0.098	-0.169*	0.094	0.041	0.067
Modern market	0.134	0.135	0.008	0.135	0.086	0.111	-0.227**	0.106
Off-farm income	-0.001	0.001	0.001*	0.001	0.000	0.001	0.000	0.000
Garut	0.228	0.070	-0.164	0.104	0.027	0.079	-0.091	0.078
Tasikmalaya	-0.038	0.027	0.177	0.115	0.065	0.101	-0.204	0.072

Note: *** different at 1 per cent, ** different at 5 per cent, * different at 10 per cent; SE = standard error (delta method)

Older male farmers are less likely to be continual-adopters. Having larger land ownership and being a member of a farmer's group increase the possibility of being a continual adopter and, on the other hand, reduce the probability of being a non-adopter and a dis-adopter. As expected, participation in modern marketing channels in 2010 had a negative and significant relationship with late-adoption.

6.5 Discussion

Factors influencing non-adopters, continual-adopters, dis-adopters and late-adopters are significantly different. This finding is in line with a previous study (Läpple & Van Rensburg 2011). This indicates that each adoption category has a unique relationship with factors influencing decision-making. Consequently, late-adopters, continual-adopters, non-adopters and dis-adopters cannot be targeted in similar ways because they have different behaviours. This information is beneficial for policymakers in designing programs that should target farmers from each adoption category differently.

In term of farmers' characteristics, females' main occupation in 2010 is related to two adoption categories. Being a female whose main occupation is farming is more likely to increase the decision to be a continual-adopter of hybrid chilli seeds. This is in line with the dis-adoption category, where the coefficient sign is negative and statistically significant. Moreover, females' main occupation in 2016 also has a negative and statistically significant impact on dis-adopters' behaviour. These results indicate that being a female whose main occupation is farming has a strong relationship with the continuity of farmers' decisions to grow hybrid chilli seeds. This finding is in line with a previous study (Zepeda & Castillo 1997). However, the relationships between males' main occupation and all adoption categories are insignificant.

The significant role of a wife's main occupation on the dynamic of hybrid chilli seed adoption indicates that women are playing a role in the decision-making related to hybrid chilli seed adoption. This is in line with previous findings in the adoption literature (e.g.

Fisher & Carr 2015). A possible explanation is that in many places in Indonesia women typically take the lead in managing household income and expenditure (Akter et al. 2017; Kusujiarti & Tickamyer 2012). If the wife's main occupation is farming, it might be easier for the same understanding about the use of hybrid chilli seeds to be shared within the household. Hybrid seeds are more expensive than other types of seeds and could, therefore, affect smallholder household's spending patterns. Moreover, in more urban villages where farming is still the main occupation of most households, women contribute to decisions about hiring labour, selling the harvest, and negotiating with traders (Kusujiarti & Tickamyer 2012). Since hybrid seeds provide more opportunities to use high-value market channels, with better prices, the wife's role in the marketing process might affect the household's decision to continue planting hybrid chilli seeds or reduce the possibility of it being a dis-adopter. In addition, hybrid chilli seeds may be more suitable for female farmers' preferences compared with other types of seeds. Murage et al. (2015) demonstrated that if the characteristics of technology are developed to suit women's preferences, they are more willing to use it. This will mean that more women are willing to continue using the technology and to expand it.

However, hybrid chilli seed dissemination programs generally target farmers at the household level and do not specifically target women. As household heads are rarely women, the programs supporting farmers are mostly attended by men (Van de Fliert 1999). The results of this research suggest that integrating more women, by targeting training at them and/or by having female-specific extension services, will have a significant impact on the adoption of hybrid chilli seeds.

Other household's characteristics are statistically insignificant in all adoption categories, except the number of adult members of the household. The negative and significant impact of the number of adult members of the household to the late-adoption category is unexpected since the adoption of hybrid chilli seeds typically requires more labour to optimise the seeds' performance. A possible explanation is that adult members might have more off-farm jobs opportunities, which decreases the family labour available to work on-farm.

Land ownership is associated with two adoption categories. As expected, higher land ownership has a significant positive impact on the continual-adoption category. This variable also has a negative and significant relationship with the non-adoption category. These results are similar to those of previous research (e.g.Barham et al. 2004; Dercon & Christiaensen 2011). Owning more land provides more choices in allocating their land. In Indonesia, subsistence farmers still prioritise planting staple food crops, especially rice, rather than chilli, in the hope of being food secure. Having more land, therefore, provides farmers with the option to adopt hybrid chilli seeds without sacrificing their need to feel secure and without having to plant rice. Applying a new technology also creates more risks for farmers (Dercon & Christiaensen 2011). Risk-averse farmers also will choose several types of seeds when planting chilli. Holding more land allows farmers to plant not only several crops but also several types of seeds because it reduces risk and secures their income. However, farmer's land allocation patterns in relation to seed adoption are not simple but entail complex decision making related to several variables (Smale, Just & Leathers 1994). Another possible explanation is that having more land might also provide a higher return with increasing economies of scale (Srisopaporn et al. 2015). Suri (2011) has shown that hybrid seed adoption is related to the farmers' returns if the infrastructure is adequate. Therefore, increasing economies of scale will maximise profits and may, therefore, encourage farmers to adopt hybrid chilli seeds.

Planting hybrid chilli seeds require more costs than OP/saved seeds but could provide opportunities for higher yields. Logically, more wealthy farmers would have better capital support so they may have a higher probability of being in the adopter or continual-adopter categories. Our results demonstrate that the higher the off-farm income, the greater the probability of chilli farmers growing hybrid chilli seeds. This result supports previous findings (Krishna & Qaim 2007; Läpple & Van Rensburg 2011; Suvedi, Ghimire & Kaplowitz 2017). However, some studies found contrasting results (Fisher & Carr 2015; Srisopaporn et al. 2015). The paradox is expected, because, even though off-farm income supplement households' incomes, having off-farm jobs also limits time for on-farm work.

Membership of a farmer's group is associated with a significantly higher probability of being a continual-adopter. In Indonesia, information about agricultural technology and government assistance are delivered through farmer's groups and are rarely targeted at individuals (Kusujiarti & Tickamyer 2012). Thus, membership of farmer's group could be a proxy for being engaged with extension services. There is evidence that, in Uganda, farmers' access to extension services increases technology adoption (Pan, Smith & Sulaiman 2018) and, also influences continuing to be an adopter in Thailand (Srisopaporn et al. 2015). This study reflects the evidence that encouraging farmers to be in a farmer's group and spreading technological information through farmer's group might be one of strategies to increase the adoption rate of hybrid chilli seeds. Hybrid chilli seed information dissemination or providing training through farmers' group is still needed to maintain farmers' continuity in planting hybrid seeds.

As mentioned previously, farmers supplying modern marketing channels grow hybrid chilli seeds to meet their requirements. Much of the development of the supermarket industry has been underpinned by contracts between agribusiness firms and smallholders in developing countries (Sahara & Gyau 2014; Winters, Simmons & Patrick 2005). In this study, participation in modern marketing channels in 2010 reduced the possibility of being a late-adopter. As expected, farmers supplying to these channels have grown hybrid chilli seeds since 2010. Therefore, supporting farmers to supply modern marketing channels will also maintain continual adoption of hybrid chilli seeds.

6.5 Conclusion

This study assessed the possible factors associated with the adoption of hybrid chilli seeds from the perspective of adoption continuity over six years. To detect those factors, the multinomial logit model is employed to differentiate mechanisms and link these factors with the multiple categories of dynamic adoption behaviours, including non-adopters, continual-adopters, dis-adopters, and late-adopters. A two-period panel data set of chilli household producers in Indonesia is used to identify the continuity of hybrid chilli seed adoption.

Our results show that several essential factors are associated with continual-adoption and these are different from those associated with late-adoption. This implies that only distinguishing between adopters and non-adopters masks the complexity of the factors influencing adoption and the awareness of the behavior of all four adoption categories is necessary to accurately understand what motivates farmers' choices in relation to hybrid seed adoption.

This indicates that it would be necessary for hybrid seeds programs to pay attention to the different factors influencing the differing behaviours by farmers in relation to hybrid seed adoption. Policymakers, in addition to stimulating adoption, should also work on encouraging early-adopting farmers to commit growing hybrid chilli seeds in the longer term.

The major finding of this study is that farming as females' main occupation is positively related to the continual-adopters category and is likely to reduce the possibility of being a dis-adopter. This insight indicates that females play an essential role in the decision about using hybrid seeds. As one of the primary sources of technological information, being a member of a farmer's group also shows a relationship with being a continual-adopter and a dis-adopter. Land ownership and off-farm income also have positive and significant impacts on continual-adoption. This implies that income and assets still play an essential role in continual-adoption of hybrid chilli seed.

These findings suggest that the impact of hybrid chilli seeds will be greater if more females are involved in hybrid seed programs. This would be aided by increasing the targeting of extension services to women; such targeting is currently quite limited in Indonesia. It is also necessary for hybrid seed industry to encourage farmers to be active in farmers groups' activities and to provide hybrid chilli seed information, or provide supported training, to sustain the continuity of hybrid chilli seed adoption. Supporting farmers to engage with modern marketing channels should also be one of the strategies; for example, providing hybrid chilli seeds that can be paid for when farmers receive payment from the modern marketing channels. Giving credit to low-income and landless farmers could also provide an incentive to be a continual-adopter.

However, this study has some limitations. Given that this study only accounts for a small sample and had only two-round surveys with 6 years lag and the model presented in this study ignores the farmers' decision in between those survey, the results may not represent the larger area of Indonesia. Focusing on farmers' reasons for being non-adopters and, more importantly, dis-adopters could give insights for policymakers to focus on. Future research should focus on the impacts of adoption on the welfare of households. This may help persuade non-adopters to try hybrid chilli seeds and assist dis-adopters to continue using them. It would also help policymakers to pay greater attention to hybrid seed adoption programs.

References

Akter, S, Rutsaert, P, Luis, J, Htwe, NM, San, SS, Raharjo, B & Pustika, A 2017, 'Women's empowerment and gender equity in agriculture: A different perspective from Southeast Asia', *Food Policy*, vol. 69, no. 1, pp. 270 - 279.

Ali, A, Rahut, DB, Behera, B & Imtiaz, M 2015, 'Farmers' access to certified wheat seed and its effect on poverty reduction in Pakistan', *Journal of Crop Improvement*, vol. 29, no. 2, pp. 247-265.

Ali, M 2006, *Chili (Capsicum spp.) Food Chain Analysis: Setting Research Priorities in Asia*, vol. 38, AVRDC-World Vegetable Center, Shanhua, Taiwan.

Awotide, BA, Awoyemi, TT & Diagne, A 2012, 'Access to certified, improved rice seed and farmers' income in Nigeria', *Journal of Crop Improvement*, vol. 26, no. 4, pp. 558-579.

Barham, BL, Foltz, JD, Jackson-Smith, D & Moon, S 2004, 'The dynamics of agricultural biotechnology adoption: Lessons from series rBST use in Wisconsin, 1994–2001', *American Journal of Agricultural Economics*, vol. 86, no. 1, pp. 61-72.

Barrett, CB, Carter, MR & Timmer, CP 2010, 'A century-long perspective on agricultural development', *American Journal of Agricultural Economics*, vol. 92, no. 2, pp. 447-468.

Bjarnason, T & Thorlindsson, T 2006, 'Should I stay or should I go? Migration expectations among youth in Icelandic fishing and farming communities', *Journal of Rural Studies*, vol. 22, no. 3, pp. 290-300.

Boahene, K, Snijders, TAB & Folmer, H 1999, 'An integrated socioeconomic analysis of innovation adoption: The case of hybrid cocoa in Ghana', *Journal of Policy Modeling*, vol. 21, no. 2, pp. 167-184.

Burton, M, Rigby, D & Young, T 1999, 'Analysis of the determinants of adoption of organic horticultural techniques in the UK', *Journal of Agricultural Economics*, vol. 50, no. 1, pp. 47-63.

Cheng, S & Long, JS 2007, 'Testing for IIA in the Multinomial Logit Model', *Sociological Methods and Research*, vol. 35, no. 4, pp. 583-600.

D'Souza, G, Cyphers, D & Phipps, T 1993, 'Factors affecting the adoption of sustainable agricultural practices', *Agricultural and Resource Economics Review*, vol. 22, no. 2, pp. 159-165.

da Silva Dias, J 2010, 'Impact of improved vegetable cultivars in overcoming food insecurity', *Euphytica*, vol. 176, no. 1, pp. 125-136.

Dercon, S & Christiaensen, L 2011, 'Consumption risk, technology adoption and poverty traps: Evidence from Ethiopia', *Journal of Development Economics*, vol. 96, no. 2, pp. 159-173.

Dixon, R 1980, 'Hybrid corn revisited', *Econometrica: Journal of the Econometric Society*, Vol. 48, No. 6, pp. 1451-1461.

Doss, C, Meinzen-Dick, R, Quisumbing, A & Theis, S 2018, 'Women in agriculture: Four myths', *Global Food Security*, vol. 16, pp. 69-74.

Doss, CR 2006, 'Analyzing technology adoption using microstudies: limitations, challenges, and opportunities for improvement', *Agricultural Economics*, vol. 34, no. 3, pp. 207-219.

Doss, CR & Morris, ML 2000, 'How does gender affect the adoption of agricultural innovations?', *Agricultural Economics*, vol. 25, no. 1, pp. 27-39.

Feder, G 1980, *Farm Size, Risk Aversion, and the Adoption of New Technology under Uncertainty*, World Bank.

Feder, G, Just, RE & Zilberman, D 1985, 'Adoption of agricultural innovations in developing countries: A Survey', *Economic Development and Cultural Change*, vol. 33, no. 2, pp. 255-298.

Firdaus, G & Ahmad, A 2010, 'Exploring diversity among farmers in adoption of agricultural innovation and options for smallholder farming system-a case study of Ambedkarnager district of UP', *International Research Journal of Applied and Basic Sciences*, vol. 1, no. 1, pp. 25-36.

Fisher, M & Carr, ER 2015, 'The influence of gendered roles and responsibilities on the adoption of technologies that mitigate drought risk: The case of drought-tolerant maize seed in eastern Uganda', *Global Environmental Change*, vol. 35, pp. 82-92.

Ghadim, AKA & Pannell, DJ 1999, 'A conceptual framework of adoption of an agricultural innovation', *Agricultural Economics*, vol. 21, no. 2, pp. 145-154.

Hernández, R, Reardon, T, Natawidjaja, R & Shetty, S 2015, 'Tomato farmers and modernising value chains in Indonesia', *Bulletin of Indonesian Economic Studies*, vol. 51, no. 3, pp. 425-444.

Hill, B 1993, 'The ‘myth’of the family farm: defining the family farm and assessing its importance in the European Community', *Journal of Rural Studies*, vol. 9, no. 4, pp. 359-370.

Knight, J & Song, L 2003, 'Chinese peasant choices: migration, rural industry or farming', *Oxford Development Studies*, vol. 31, no. 2, pp. 123-148.

Kouser, S & Qaim, M 2011, 'Impact of Bt cotton on pesticide poisoning in smallholder agriculture: A panel data analysis', *Ecological Economics*, vol. 70, no. 11, pp. 2105-2113.

Krishna, VV & Qaim, M 2007, 'Estimating the adoption of Bt eggplant in India: Who benefits from public–private partnership?', *Food Policy*, vol. 32, no. 5–6, pp. 523-543.

Kuntariningsih, A & Mariyono, J 2013, 'Socio-economic factors affecting adoption of hybrid seeds and silvery plastic mulch for chili farming in Central Java', *SEPA Jurnal Sosial Ekonomi Pertanian dan Agribinis*, vol. 9, no. 2, pp. 297-308.

Kusujiarti, S & Tickamyer, AR 2012, 'Gender and agricultural production', in *Power, Change, and Gender Relations in Rural Java*, Ohio University Press, Athens, United States.

Läpple, D & Van Rensburg, T 2011, 'Adoption of organic farming: Are there differences between early and late adoption?', *Ecological Economics*, vol. 70, no. 7, pp. 1406-1414.

Long, JS 2006, *Regression Models for Categorical Dependent Variables Using Stata*, 2nd ed. J Freese, Stata Press, College Station, Tex.

Lybbert, TJ 2006, 'Indian farmers' valuation of yield distributions: Will poor farmers value 'pro-poor' seeds?', *Food Policy*, vol. 31, no. 5, pp. 415-441.

Ministry of Agriculture 2015, *Ministry of Agriculture Strategic Planning 2015–2019*, Ministry of Agriculture, Jakarta.

Minot, N & Roy, D 2007, 'Impact of high-value agriculture and modern marketing channels on poverty: An analytical framework', *International Food Policy Research Institute, Washington, DC*.

Murage, AW, Pittchar, JO, Midega, CAO, Onyango, CO & Khan, ZR 2015, 'Gender specific perceptions and adoption of the climate-smart push–pull technology in Eastern Africa', *Crop Protection*, vol. 76, pp. 83-91.

Neven, D, Odera, MM, Reardon, T & Wang, H 2009, 'Kenyan supermarkets, emerging middle-class horticultural farmers, and employment impacts on the rural poor', *World Development*, vol. 37, no. 11, pp. 1802-1811.

Nguyen‐Van, P, Poiraud, C & To‐The, N 2017, 'Modeling farmers' decisions on tea varieties in Vietnam: a multinomial logit analysis', *Agricultural Economics*, vol. 48, no. 3, pp. 291-299.

Nkamleu, GB & Kielland, A 2006, 'Modeling farmers' decisions on child labor and schooling in the cocoa sector: a multinomial logit analysis in Côte d'Ivoire', *Agricultural Economics*, vol. 35, no. 3, pp. 319-333.

Pan, Y, Smith, SC & Sulaiman, M 2018, 'Agricultural extension and technology adoption for food security: evidence from Uganda', *American Journal of Agricultural Economics*, vol. 100, no. 4, pp. 1012-1031.

Peterman, A, Quisumbing, A, Behrman, J & Nkonya, E 2011, 'Understanding the complexities surrounding gender differences in agricultural productivity in Nigeria and Uganda', *Journal of Development Studies*, vol. 47, no. 10, pp. 1482-1509.

Piotrowski, M, Ghimire, D & Rindfuss, R 2013, 'Farming systems and rural out-migration in Nang Rong, Thailand, and Chitwan Valley, Nepal', *Rural Sociology*, vol. 78, no. 1, pp. 75-108.

Reardon, T, Barrett, CB, Berdegué, JA & Swinnen, JFM 2009, 'Agrifood industry transformation and small farmers in developing countries', *World Development*, vol. 37, no. 11, pp. 1717-1727.

Reardon, T, Timmer, CP & Minten, B 2012, 'Supermarket revolution in Asia and emerging development strategies to include small farmers', *Proceedings of the National Academy of Sciences*, vol. 109, no. 31, pp. 12332-12337.

Sahara, S & Gyau, A 2014, 'Contractual arrangements and commitment in the Indonesian supermarket channel', *British Food Journal*, vol. 116, no. 5, pp. 765-779.

Sahara, S, Minot, N, Stringer, R & Umberger, WJ 2015, 'Determinants and effects of small chilli farmers' participation in supermarket channels in Indonesia', *Bulletin of Indonesian Economic Studies*, vol. 51, no. 3, pp. 445-460.

Smale, M, Just, RE & Leathers, HD 1994, 'Land allocation in HYV adoption models: An investigation of alternative explanations', *American Journal of Agricultural Economics*, vol. 76, no. 3, pp. 535-546.

Srisopaporn, S, Jourdain, D, Perret, SR & Shivakoti, G 2015, 'Adoption and continued participation in a public Good Agricultural Practices program: The case of rice farmers in the Central Plains of Thailand', *Technological Forecasting and Social Change*, vol. 96, pp. 242-253.

Statistics Indonesia 2015, *Census of Agriculture 2013, National Figures of Horticulture Crops Cultivation Household, Results of ST2013-Subsector Survey*, no. 9790648138.

Suri, T 2011, 'Selection and comparative advantage in technology adoption', *Econometrica*, vol. 79, no. 1, pp. 159-209.

Suvedi, M, Ghimire, R & Kaplowitz, M 2017, 'Farmers' participation in extension programs and technology adoption in rural Nepal: a logistic regression analysis', *The Journal of Agricultural Education and Extension*, vol. 23, no. 4, pp. 351-371.

Teklewold, H, Kassie, M, Shiferaw, B & Köhlin, G 2013, 'Cropping system diversification, conservation tillage and modern seed adoption in Ethiopia: Impacts on household income, agrochemical use and demand for labor', *Ecological Economics*, vol. 93, pp. 85-93.

Tey, YS, Li, E, Bruwer, J, Abdullah, AM, Brindal, M, Radam, A, Ismail, MM & Darham, S 2013, 'The relative importance of factors influencing the adoption of sustainable agricultural practices: a factor approach for Malaysian vegetable farmers', *Sustainability Science*, vol. 9, no. 1, pp. 17-29.

Van de Fliert, E 1999, 'Women in IPM training and implementation in Indonesia', in *Gender and IPM: Crop Protection Practices and Strategies, Royal Tropical Institute, Amsterdam*, pp. 71-78.

van Gastel, TJ, Gregg, BR & Asiedu, E 2002, 'Seed quality control in developing countries', *Journal of New Seeds*, vol. 4, no. 1-2, pp. 117-130.

Whatmore, S 1991, 'Life cycle or patriarchy? Gender divisions in family farming', *Journal of Rural Studies*, vol. 7, no. 1, pp. 71-76.

Winters, P, Simmons, P & Patrick, I 2005, 'Evaluation of a hybrid seed contract between smallholders and a multinational company in East Java, Indonesia', *The Journal of Development Studies*, vol. 41, no. 1, pp. 62-89.

Zepeda, L & Castillo, M 1997, 'The role of husbands and wives in farm technology choice', *American Journal of Agricultural Economics*, vol. 79, no. 2, pp. 583-588.

Chapter 7 : Summary, Conclusion, and Policy Implications

7.1 Summary of Key Findings and Conclusion

The evolving relationship between women's roles during the development process remains a key focus of policymakers, especially in developing countries. As pointed out by Duflo (2012), development could decrease the socio-economic gap between males and females. And improving the position of women can enhance rural development outcomes. The literature acknowledges that the regional variation in relationships between rural development and women's empowerment due to differing socio-economic profiles and cultures (The World Bank 2008). Therefore, generalising from findings may contribute to misunderstandings about the complexities and even contribute to gender bias in development strategies (The World Bank 2008).

The majority of gender studies in agriculture have been conducted in Africa and then extended to South Asia with the focus on plot management, using a binary indicator — gender of the household head (e.g. de la O Campos, Covarrubias & Patron 2016; Guirkinger, Platteau & Goetghebuer 2015; Oseni et al. 2015; Seymour 2017; Sraboni et al. 2014). The South-East Asia gender/agriculture literature is relatively limited. For example, in South-East Asia, farms and assets tend to be managed jointly between males and females so that the agricultural decision-making process involves husband and wife pairs (Akter et al. 2017; Ashraf 2009; Quisumbing & Otsuka 2001). At the same time, there is a division of labour in agricultural activities which typically considers some activities, such as land preparation, as men's jobs, while others are considered women's responsibility, such as harvesting and post-harvesting tasks (Akter et al. 2017). Thus, the evaluation of agricultural development using binary variables or plot management may not fully capture the gendered roles in agriculture in this region.

This thesis contributes to gender research by exploring the roles of women in agriculture, focusing on chilli farming in Indonesia, to extend the insights of the limited gender research that has been conducted in Southeast Asia. This thesis also makes an important contribution to the literature on gender research and rural development by providing alternative approaches to examining women's roles in agriculture by using detailed male and female data. The data was collected separately in order to capture households' behaviour. Finally, this thesis outlines the roles of women in agricultural development in chilli production and decision making related to hybrid chilli seed adoption. It provides empirical evidence for policy and program design for chilli production and rural development.

This thesis uses household data collected from chilli farmers in Indonesia to address the research objectives in three analytical chapters. Chapter 4 examines the demand for labour by gender associated with hybrid seed adoption. The analysis extends previous research by identifying separately the demand for labour according to whether it is hired or family labour and according gender. Using instrument variable 2 SLS estimations, the chapter addresses the possible endogeneity caused by farmers' seed choices. The results reveal that the adoption of hybrid chilli seed increases the use of hired labour, among both males and females. Specifically, for females, increasing demand for labour is only associated with hired labour, not family labour. These results suggest that, rather than adding to female workloads in adopting households, adoption of hybrid chilli seeds is more likely to increase the use of hired labour. Given that wages for females are typically lower than those of males, this finding yields the insight that for farmers hiring female labour may reduce the cost of chilli production and increase their profits. On the other hand, hiring more female labour also means creating employment opportunities (Duflo 2012).

To obtain broader insight into the roles of women, Chapter 5 examines both male's and female's role in chilli production. Rather than using simple binary variables comparing male and female productivity or revenue, this study attempts to empirically measure the association between male's and female's decision making leadership in chilli 16 separate chilli production activities. Due to high correlation between the 16 activities, the analysis sorts the activities that have high significance and loading factors only by employing confirmatory factor analysis (CFA). An Interaction form of revenue function is used to measure the association between female leadership, disagreement about leadership between spouses, and the revenue of their chilli production.

Results show that female leadership in particular activities, including buying input, spraying pesticides, and sorting, is more likely to increase chilli revenue. On the other hand, disagreement about leadership between spouses has a negative and significant relationship with revenue. This indicates that the acknowledgement of women's leadership from their spouses also increases revenue. These results confirm that women's empowerment, through leadership in some agricultural activities, has beneficial impacts for rural development. Consideration of involving both men and women may improve agricultural programs and increase the success of development strategies.

Chapter 6 explores the roles of women in hybrid seed adoption. Rather than using the conventional 'adoption' and 'non-adoption' categories (which cannot evaluate the continuity of adoption), Chapter 6 analyses adoption decision over time using four categories: early-adoption; late-adoption; continual-adoption; and dis-adoption. The aim is to understand all the factors associated with the dynamics of farmer's behaviour in the adoption of hybrid chilli seeds. A multinomial logit is employed to estimate the two-period panel data set on chilli farmers.

Female's socio-economic characteristics are involved in the adoption estimations. Results demonstrate that variables related to the four adoption categories are different, suggesting that those farmers should not be treated equally in hybrid seed adoption programs. Approaches targeting late-adopters should use a different approach to those targeted at continual-adopters. For example, late-adopters do not have experience using hybrid chilli seeds, so adoption programs that provide free-seeds may encourage them to adopt. However, for continual-adopters, providing agronomical training to optimise the yield of hybrids may have a greater impact on persuading them to continue using hybrid chilli seeds. This study reveals that females whose main occupation is being a farmer, have an increased likelihood of being a continual-adopter and the probability of them being a non-adopter of hybrid chilli seeds is reduced. This implies that women play a role in the decision to adopt hybrid seeds. These results suggest that it is vital to integrate women into hybrid seed adoption programs.

Agricultural development in rural areas, including technology changes such as newer and more productive seeds, often shift gender roles with positive and negative consequences for women. Empowering women with greater levels of influence over decision-making power often encourages more repaid adoption of technology (Seymour et al. 2016). The study results presented here do provide evidence that women contribute positively to agricultural development outcomes through increasing revenue and hybrid seed adoption.

Another lesson is that the impacts of hybrid chilli seeds play a significant role in increasing farm revenue and households welfare. Increasing rural development through increasing chilli productivity may be beneficial in decelerating rural migration from agriculture generally, and more specifically from horticulture. Higher profits and new innovations may help attract the younger generation to stay in rural areas.

Finally, alternative income sources for females not only empowers them but it is also beneficial for their families. Empirical evidence demonstrates that when women have increased control of their income, they invest more in their children and households than men do (Quisumbing 2003; Seymour et al. 2016). Policymakers do need to carefully consider and evaluate how innovations and promoted technologies impact on women's overall workload. For example, impact assessments of horticultural development, such as hybrid seeds programs, are essential. Full impact assessment of farmers and communities may address questions about how such programs could not only increase the incomes and food security of smallholder farmers but also explore the impacts on horticultural industries and rural communities. Full impact assessments of farmers and their communities may address the questions such as how programs could not only increase smallholder farmers' income and food security but also explore the impacts of the horticultural industries and rural communities.

7.2 Policy Implications

Horticulture receives increasing attention from the Indonesian government because of its importance to the national economy and as a response to market transformation, which provides opportunities for higher-value horticultural products as well as fulfilling consumer demand. Based on the 2013 agricultural census, the value added by this subsector is higher than other subsectors. Horticulture generated IDR 208.93 million per hectare, which was much higher than that of food crops, which only generated IDR 26.10 million and plantation crops with a value of IDR 31.87 million per hectare (Statistics Indonesia 2015). However, horticulture's trade balance is still negative (Ministry of Agriculture 2018), suggesting that there are opportunities for smallholder farmers to respond to market demand and to earn a greater share of the impacts of agricultural transformation (Suprehatin 2016). Given that horticultural farmer households in Indonesia decreased by 37 per cent between 2003 and 2013 (Statistics Indonesia 2014), increasing the promotion of horticultural production to smallholder farmers is essential in order to increase their interest in growing horticultural products without neglecting the staple food development that ensures Indonesia's food security.

It is widely accepted that the development of the horticultural subsector contributes to increasing smallholder farmers' incomes and welfare in Indonesia's rural areas (e.g. Suprehatin 2016). Thus, in order to promote horticultural development and enhance this subsector's contribution to rural development, this study suggests strategies that can be adopted by policymakers to design relevant policies or programs.

Firstly, this study confirms that providing hybrid varieties in chilli seed development could increase employment opportunities, particularly for women who currently have fewer work opportunities in rural areas. Since the availability of employment opportunities is very important in supporting the income of smallholder farmers households, this finding provides the scientific evidence of how hybrid seed development could contribute to women's empowerment and rural economies. Research shows that providing alternative income sources for women could empower them and strengthen the household economy, which eventually contributes to economic development (Duflo 2012).

Secondly, this thesis provides empirical evidence of how women's leadership contributes to increasing the revenue of chilli producing businesses. As explained in detail in Chapter 5, women's leadership in input procurement and pesticide application contributes to increasing revenue. This finding has consequences for policymakers and for advisory services in shaping the strategies and programs for horticultural production. Providing more favourable and accessible agricultural input outlets for women in rural areas is one important recommendation. For example, as pesticide application is considered as a male activity, the application tools are designed for men. Working with women farmers to design female-friendly equipment for pesticide application is a step in the right direction.

Men's acknowledgement of the many contributions women make to farming and household's economies support efforts for improved communication to achieve greater impacts of women efforts. For example, involve men in women's training programs and vice versa. Providing support for child-care is also important. When mothers of young children are working, child-care duties often fall to older sisters impacting their access to education (World Bank 2012).

Thirdly, policymakers should improve access to high-quality inputs and training advice to encourage farmers to continue adopting hybrid seeds. Institutional support and infrastructure development that provide a better economic climate for input producers may enhance farmers' access to better resources. In addition, policymakers or industries need to make sure that horticultural development programs accommodate or involve women, especially in human capital capacity development, such as training and technology dissemination programs. If the government aims to maintain the continuity of chilli production, engaging female farmers in horticultural development strategy might have a more significant impact on the government's achievements than some other measures.

Finally, it is crucial that future statistical reports and agricultural censuses collect data from both males and females and ensure that they are interviewed separately to avoid biased data that may be used to design rural development programs. Even though this kind of data collection is costly and time-consuming, the data will be more rigorous and will more accurately represent the situation, making it easier to maximise the impacts of development programs.

References

Agricultural Data and Information Centre 2018. *Agricultural Sector Employment Statistics for 2017 -2018*, Secretariat General of Ministry of Agriculture, Indonesia.

Akter, S, Rutsaert, P, Luis, J, Htwe, NM, San, SS, Raharjo, B & Pustika, A 2017, 'Women's empowerment and gender equity in agriculture: A different perspective from Southeast Asia', *Food Policy*, vol. 69, no. 1, pp. 270 - 279.

Ashraf, N 2009, 'Spousal control and intra-household decision making: An experimental study in the Philippines', *American Economic Review*, vol. 99, no. 4, pp. 1245-1277.

de la O Campos, AP, Covarrubias, KA & Patron, AP 2016, 'How does the choice of the gender indicator affect the analysis of gender differences in agricultural productivity? Evidence from Uganda', *World Development*, vol. 77, pp. 17-33.

Duflo, E 2012, 'Women empowerment and economic development', *Journal of Economic Literature*, vol. 50, no. 4, pp. 1051-1079.

Guirkinger, C, Platteau, J-P & Goetghebuer, T 2015, 'Productive inefficiency in extended agricultural households: Evidence from Mali', *Journal of Development Economics*, vol. 116, pp. 17-27.

Ministry of Agriculture 2018, *Agricultural Statistics 2018*, Center for Agricultural Data and Information System, Ministry of Agriculture of the Republic of Indonesia, Jakarta.

Oseni, G, Corral, P, Goldstein, M & Winters, P 2015, 'Explaining gender differentials in agricultural production in Nigeria', *Agricultural Economics*, vol. 46, no. 3, pp. 285-310.

Quisumbing, AR & Otsuka, K 2001, 'Land inheritance and schooling in matrilineal societies: evidence from Sumatra', *World Development*, vol. 29, no. 12, pp. 2093-2110.

Seymour, G, Doss, C, Marenya, P, Meinzen-Dick, R, Passarelli, S 2016. 'Women's empowerment and the adoption of improved maize varieties: Evidence from Ethiopia, Kenya, and Tanzania', *2016 Agricultural & Applied Economics Association*, Boston, Massachusetts.

Seymour, G 2017, 'Women's empowerment in agriculture: Implications for technical efficiency in rural Bangladesh', *Agricultural Economics*, vol. 48, no. 4, pp. 1 - 10.

Sraboni, E, Malapit, HJ, Quisumbing, AR & Ahmed, AU 2014, 'Women's empowerment in agriculture: What role for food security in Bangladesh?', *World Development*, vol. 61, no.1, pp. 11-52.

Statistics Indonesia 2014, *Potret Usaha Pertanian Indonesia Menurut Subsektor (Hasil Pencacahan Lengkap Sensus Pertanian 2013 dan Survei Pendapatan Rumah Tangga Usaha Pertanian 2013)*, Badan Pusat Statistik, Jakarta-Indonesia.

Statistics Indonesia 2015, *Laporan Hasil Sensus Pertanian 2013*, Badan Pusat Statistik, Jakarta.

Suprehatin 2016, 'Adoption of high value horticultural crops in Indonesia: Determinants and impact', Global Food and Resources, Faculty of the Profession, PhD Thesis, the University of Adelaide, Adelaide.

World Bank, FAO, International Fund for Agricultural Development, 2008, *Gender in Agriculture Sourcebook*, World Bank.

World Bank 2012. *World Development Report 2012: Gender Equality and Development*. World Bank.

Appendices

Appendix 1. Recapitulation of the number of sample

District	Sub District	Sample in 2010	Sample in 2016	Sample cannot be interviewed
Ciamis	Sukamantri	89	83	6
	Cihaurbeuti	58	57	1
	SindangKasih	24	22	2
	Panumbangan	36	30	6
Tasikmalaya	Leuwisari	35	32	3
	Sariwangi	35	35	0
	Cigalontang	37	36	1
Garut	Cisurupan	37	36	1
	Cikajang	35	34	1
	Bayongbong	39	37	2
	Pasirwangi	36	32	4
	Sucinaraja	36	36	0
	Sukaresmi	33	33	0
	Wanaraja	36	35	1
	Leles	36	36	0
Total		602	574	28

Appendix 2. Human Research Ethics Approval

THE UNIVERSITY *of* ADELAIDE

RESEARCH BRANCH
OFFICE OF RESEARCH ETHICS, COMPLIANCE AND INTEGRITY
THE UNIVERSITY OF ADELAIDE

LEVEL 4, RUNDLE MALL PLAZA
50 RUNDLE MALL
ADELAIDE SA 5000 AUSTRALIA

TELEPHONE +61 8 8313 5137
FACSIMILE +61 8 8313 3700
EMAIL hrec@adelaide.edu.au

CRICOS Provider Number 00123M

12 April 2016

Professor R Stringer
School: Global Food Studies

Dear Professor Stringer

ETHICS APPROVAL No: **H-2016-067**

PROJECT TITLE: **The determinants of smallholder farmers' adoption of hybrid chili seeds in Indonesia**

The ethics application for the above project has been reviewed by the Low Risk Human Research Ethics Review Group (Faculty of Arts and Faculty of the Professions) and is deemed to meet the requirements of the *National Statement on Ethical Conduct in Human Research (2007)* involving no more than low risk for research participants. You are authorised to commence your research on **12 Apr 2016**.

Ethics approval is granted for three years and is subject to satisfactory annual reporting. The form titled *Annual Report on Project Status* is to be used when reporting annual progress and project completion and can be downloaded at http://www.adelaide.edu.au/ethics/human/guidelines/reporting. Prior to expiry, ethics approval may be extended for a further period.

Participants in the study are to be given a copy of the Information Sheet and the signed Consent Form to retain. It is also a condition of approval that you **immediately report** anything which might warrant review of ethical approval including:

- serious or unexpected adverse effects on participants,
- previously unforeseen events which might affect continued ethical acceptability of the project,
- proposed changes to the protocol; and
- the project is discontinued before the expected date of completion.

Please refer to the following ethics approval document for any additional conditions that may apply to this project.

Yours sincerely

PROFESSOR RACHEL A. ANKENY
Co-Convenor
Low Risk Human Research Ethics Review Group
(Faculty of Arts and Faculty of the Professions)

Appendix 3. Household Survey Questionnaire

SURVEY OF CHILI GROWERS IN WEST JAVA

May 2016

UNIVERSITY OF ADELAIDE - ICHORD - BOGOR AGRICULTURAL UNIVERSITY

Objective: The purpose of this survey is to investigate factors affecting seed selection by chili farmers in Indonesia and the production cost of each seed type, figure out the different seed type value-chains to capture the real constraints and upgrading opportunities.

Use of data: The data collected as part of this survey are for research purposes ONLY.
Household-level data will not be shared with non-research organizations. .
Only summary results will be included in published report.

Household ID number

Village code · Enumerator code · Household code

Name of head family	Name of family $
Name of respondent	Nam of Res $
Address/location	
Phone	Phone$
Village	Village $
Sub-district	Sub District $
District	District $

	Date			Name	Sign
	Day	Month	Year		
Interview	Date 1$	Month 1$	2016	Name $	
Field check	Date 2$	Month 2$	2016		
Check kantor	Date 3$	Month 3$	2016		
Data Entry - Start	Date 4$	Month 4$	2016		
Data Entry - Finish	Date 5$	Month 5$	2016		

Research funded by a grant from the Australian Centre for International Agricultural Research (ACIAR)

Village codes for Garut

Code	District	Sub-district	Village
111	Garut	Wanaraja	1. Suka Menak
112			4. Warna Jaya
113			5. Warna Mekar
121	Garut	Bayongbong	2. Panembong
122			3. Hegar Manah
123			4. Sukarame
131	Garut	Pasirwangi	2. Barusari
132			3. Karya Mekar
133			5. Sirna Jaya
141	Garut	Cisurupan	2. Sukatani
142			4. Cisero
143			5. Cisurupan
151	Garut	Cikajang	3. Mekarjaya
152			4. Girijaya
153			5. Cikandang
161	Garut	Sukaresmi	1. Sukajaya
162			2. Mekarjaya
163			3. Cinta Damai
171	Garut	Sucinaraja	1. Tenjonegara
172			2. Sukalaksana
173			3. Cigadog
181	Garut	Lelles	1. Margaluyu
182			2. Sukarame
183			3. Jangkurang

Village codes for Tasik & Ciamis

Code	District	Sub-district	Village
211	Tasik	Leuwisari	2. Cigadhog
212			3. Ciawang
213			5. Linggawangi
221	Tasik	Cigalontang	2. Puspamukti
222			3. Pusparaja
223			5. Sirnaputra
231	Tasik	Sariwangi	3. Jayaputra
232			4 Sukaharja
233			5. Sukamulih
311	Ciamis	Panumbangan	3. Sindangbarang
312			4. Sukakerta
313			6. Golat
321	Ciamis	Sukamantri	2. Cibeureum
322			3. Sindangjaya
323			4. Mekarwangi
331	Ciamis	Cihaurbeuti	1. Sukamaju
332			2. Sukahurip
333			6. Sumberjaya
341	Ciamis	Sindangkasih	

Enumerator codes

Code	Enumerator
1. Dani	
2. Usep	
3. Thosin	
4. Cirama	
5. Pitri	
6. Dewi Marsitoh	
7. Dewi Wulan	
8. Anna	
9. Dewi Amna	
10. Erick	
11. Agus	
12. Fuad	
13. Lathif	
14. Roni	
15. Warjio	

A. CHARACTERISTICS OF MEMBERS OF THE HOUSEHOLD

					Ask these questions only for members 6 years or older	Ask tthese questions only for members 17 yrs and older		
	Name	What is the relationship between [name] and the head of household? 1 Head 2 Spouse 3 Son/daughter 4 Son/daughter in law 5 Grandchild 6 Parent or in-law 7 Young brother/sister 8 Older brother/sister 9 Other related 10 Other unrelated	Is [name] a male or female? 1 Male 2 Female	How old is [name]? [age at last birthday, use 0 for < 1 yr] Year	How many years of schooling has [name] completed? Year	What is the marital status of [name]? 1 Single 2 Married 3 Divorced - live 4 Divorced - death	What are the main activities of [name]? 1. Farming/aquaculture 2. Self-employed trader 3 Self-employed - other 4. Agricultural wage labor 5. Other wage labor 6. Housewife 7. Student 8. Government officer 9. Other 10. None	
							Main	Secondary
A1								
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								

Note: The household is defined as a group of people who live and eat together most of the time. Each member must live with others at least 6 months of the year.
The head of the household is defined as the member who makes most of the economic decisions.

B. HOUSING AND ASSETS

What is the approximate area of your house in square meters? [ ]

[If house owned] What is the approximate value of your house without farmland? [ ]

[If house rented] What is the annual rent that you pay for your house (without farmland)? [ ]

What is the main source of drinking water for your household? [ ]

1 Indoor tap	5 Collected rainwater
2 Outdoor private tap	6 River, lake, pond, spring
3 Outdoor shared tap	7 Water collected in a tank
4 Covered well	8 Aqua/bottled water

What is the main type of toilet used by your household? [ ]

1 Flush toilet	4 Latrine over canal/pond
2. Latrine with pipe	5 Public toilet
3 Pit latrine	6 Other or none

What is the main type of lighting used by your household? [ ]

1 Electric lights	4 Others
2 Oil lamps	5 None
3. Candles	

What type of fuel is used by your household for cooking? [ ]

1 Electricity	4 Kerosene
2 LPG	5 Wood
3 Biogas	6 Other

	How many of each of the following items do members of your household currently own? Number	How many of each of the following did your household own 5 years ago? Number
a radio?		
television?		
a fan?		
a bicycle?		
a motorbike?		
a car?		
a computer?		
a washing machine?		
a refrigerator?		
landline telephone?		
a mobile phone?		
smartphone/tablet		
modem		
a truck?		
a cart?		
a water pump?		
a mist blower?		
a power tiller?		
a storage house?		
cattle/buffalo?		
goats/sheep?		
poultry?		

Category	Code	Crop
Grains	101	Rice
	102	Maize
	103	Other grains
Tubers	201	Cassava
	202	Sweet potato
	203	Other tubers
Pulses	301	Red bean
	302	Groundnuts
	303	Soybeans
	304	Other bean (mung, Bogor)
Vegetables	401	Babycorn
	402	Broccoli
	403	Cabbage
	404	Caisin
	405	Carrot
	406	Chili
	407	Chinese cabbage
	408	Cucumber
	409	Eggplant
	410	Gherkin
	411	Ginger
	412	Green bean (buncis)
	413	Leak
	414	Long bean
	415	Onion
	416	Potato
	417	Shallot
	418	Tomato
	419	Other vegetable

Category	Code	Crop
Fruit	501	Banana
	502	Mango
	503	Mangosteen
	504	Melon
	505	Papaya
	506	Strawberry
	507	Watermelon
	508	Other fruit
Other	601	Flower
	602	Other spices
	603	Other annual crops
	604	Coconut
	605	Other perrenial crops

C. AGRICULTURAL LAND

Draw a simple map of the plots **owned or farmed** by members of the household in 2009 on the opposite page. Then number plots and complete this form.

Write plots number that your household have or operate	What is the area of ${C5} plot?	In what unit is the area of ${C5} plot?	What type of land is ${C5}? 1. Irrigated 2. Rainfed 3. Dryland 4 Semi-techn	What is the land tenure arrangment for ${C5} plot? 1. Owned and farmed 2. Owned and rent it out 3. Owned & pawned out 4. Owned & sharecropped out 5. Owned and not planted 6. Owned and lent out 7. Pawned from owner 8. Rented from owner 9. Sharecropped from owner 10. Borrow from owner	[If C8=1-6] How was this plot acquired? 1 Inherited 2 Gift 3 Purchased 4 Allocated by governmen	What type of irrigation does this plot ${C5} have in the RAINY season? 1 None 2 Gravity 3 Pumped surface water 4 Pumped groundwater 5. Bucket 6. Rubber tube	What type of irrigation does this plot ${C5}? have in the DRY season? 1 None 2 Gravity 3 Pumped surface water 4 Pumped groundwater 5. Bucket 6. Rubber tube	What is the distance from this plot ${C5}? to your house? Distance in meters	What were the main first crops grown in plot ${C5} during April-June 2015! crop code	What were the main second crops grown in plot ${C5} during April-June 2015! crop code	What were the main first crops grown in plot ${C5} during July - August 2015! crop code	What were the main second crops grown in plot ${C5} during April-June 2015! crop code	What were the main first crops grown in plot ${C5} during September 2015-March 2016! crop code	What were the main second crops grown in plot ${C5} during September 2015-March 2016! crop code
C5	C6a	C6u	C7	C8	C9	C10r	C10d	C11	C12	C13	C14	C15	C16	C17
1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														

D. CHILLI PRODUCTION

Season of **2015/2016**		Plot number [ENTER PLOT NUMBERS IN WHICH CHILIS WERE GROWN FROM PART C FOR EACH SEASON]	In what month were the chilis planted? 1. Jan 2. Feb 3. Mar 4. Apr 5. May 6. Jun 7. Jul 8. Aug 9. Sep 10. Oct 11. Nov 12. Dec	In what year were the chilis planted? 1. 2015 2. 2016	What was the type of chili planted for the main type? 1. Big Chili 2. Curly Chili 3. Small Chili	What type of chilies were harvested from this plot during this season? list of varieties	Who was the majority seedling your chilies? 1. My own from fresh chilli 2. My own from package seed 3. Other farmer 4. Seedling producer	How many chilli plants were planted in this plot? Number	Have these chillies ever got disease outbreak ? 1. Yes 2. No	Have you harvested? 1. Yes 2. No	How old chilies panted were harvested? Number	In what unit was the age of chilies harvested? 1. Day 2. Week 3. Month	In what color were your chilies harvested? 1. All red 2. Mostly red 3. Half each 4. Mostly gr 5. All green	Have these chillis ever being stolen [the yield loss of more than Rp. 500,000]? 1. Yes 2. No	How long did you harvest your chili from the first harvesting until the last harvesting? Number	In what unit was the age of chilies harvested? 1. Day 2. Week 3. Month	What was the average the total of your chilies production used to before (2015/2016)? (Kg/Plot)	What was the total of your chilies production in the last harvesting? (Kg/Plot)	What was the average production of chilli per plant in the last harvesting? (Kg/Plant) (Kg/Plant)	What was the average production cost of chilli per plant in the last harvesting? (Kg/Plant)	What was the average price of your chili at the peak harvesting in the last harvesting? (Rp/Kg)	How much your income from the last chili harvesting? (Rp/Plot)
			D1		D2	D3	D4	D5		D6	D7	D8	D9		D11	D12	D13	D14	D15	D16	D17	D18
Dry season 1 (planting about April 2015 to June 2015)	1																					
	2																					
	3																					
	4																					
	5																					
Dry season 2 (planting about July 2015 to August 2015)	6																					
	7																					
	8																					
	9																					
	10																					
Rainy season (planting about Sept 2015 to March 2016)	11																					
	12																					
	13																					
	14																					
	15																					
	16																					

E. INPUT USE AND INFORMATION SOURCES

What is the ROW number for the largest chili plot in the most recent completed harvest? [ ] E1

	Inputs	Did you use [..]?	What is the price of [..]?	In what unit is the price of [..]?	How much the volume per unit?	How much did you spend on [..]?	How much did you spend for […]?	Did you pay by credit for inputs expenditure [..]?	Credit spurce [..]
		1. Yes 2. No	Rp	1. Kg 2. Litre 3. Rod 4. Pack 5. Sack 6. Roll 7. Bottle	kg or ml	Number	Rp per season	1. Yes 2. No	1. Trader 2. Inputs shop 3. Cooperation 4. Government 5. Agent 6. Farmer group 7. Pawn 8. Bank 9. Others
1	Seed/Seedling								
2	Urea								
3	TSP								
4	KCl								
5	ZA								
6	NPK Mutiara								
7	Common NPK								
8	Phonska								
9	Chalk/Dolomit								
10	Leaves fertilizer								
11	Organic fertilizer								
12	Herbicide								
13	Fungicide								
14	Insecticide								
15	Powder pesticide (Furadan)								
16	Other pesticides								
17	Mulching								
18	Stake								
19	Adhessive								
20	Fuel								
21	Others								

Do you keep written records on …. (1. Yes 2. No)

… the amount of pesticides used on chilis? [ ] E6

… the dates of pesticide application on chilies? [ ] E7

… the prices received for chili sales? [ ] E8

… the quantities of chilies sold? [ ] E9

[If yes to any] Do you keep these records at least one year after being paid? [ ] E10

SECTION E1. LABOR USE

Activities			Was there any activity [..]?	Did you pay labor for activity [..]? 1. Yes 2. No	How many males did you hire for activity [..]? Number	How many days did you hire male labor for activity [..]? Day	How many females did you hire for activity [..]? Number	How many days did you hire female labor for activity [..]? Day	Was there any household member involved in activity [..]? 1. Yes 2. No	How many children [aged 18 years of age and unmarried] in your household who do activity [..]? Number	How many days were children [aged 18 years of age and unmarried] in your household doing activity [..]? Day	How many males in your household who do activity [..]? Number	How many days were males in your household doing activity [..]? Day	How many females in your household who do activity [..]? Number	How many days were females in your household doing activity [..]? Day
E11	E12		E13	E14	E15	E16	E17	E18	E19	E20	E21	E22	E23	E24	E25
1. Land preparation	1	Drying land													
	2	Cultivation and manufacture of strokes													
	3	Tillaging, fertilizing base, stirring the soil, land finishing													
	4	Mulching and holing													
	5	Other activity													
	6	Other activity													
2. Planting	7	Planting													
	8	Fertilizing													
	9	Watering													
	10	Weeding													
	11	Other activity													
	12	Other activity													
3. Caring	13	Installing stakes													
	14	Spraying													
	15	Watering													
	16	Fertilizing													
	17	Weeding and pruning													
	18	Other activity													
	19	Other activity													
4. Harvesting	20	Harvesting and rafting													
	21	Early Harvest													
	22	Middle Harvest													
	23	Late Harvest													
	24	Porter													
	25	Sorting and grading													
	26	Other activity													
	27	Other activity													

*Child is defined who age under 17 yo and not married

For male labor

What is the daily wage labor mostly male being paid? (RP / person / day)		E26
Are there any activity doing by male labor paid higher than regular wage?		E27
If E27=1, What activities are done by male workers to be paid more?		E28
What is the daily wage labor mostly male being paid? (RP / person / day)		E29

For female labor

What is the daily wage labor mostly female being paid? (RP / person / day)		E30
Are there any activity doing by female labor paid higher than regular wage?		E31
What activities are done by female workers to be paid more?		E32
What is the average wage of female workers for such activity? (Rp/ person / day)		E33

F. CHILI MARKETING

For the chili largest plot in the most recent season for which harvvest is complete (see E1)

	Period	How many times did you harvest during periode […] harvest season? number	How much chilis were harvested this periode [..]? kg	What was the grade of the chilis on the [..] harvest? 1. Superfull 2. Super 3. Medium 4. Small 5. Mix 1&2 6. Mix 2&3 7. Mix 3&4 8 Other 9 No grading	What price did you receive for these chilis? Rp/kg	Who was the main buyer of these chilis? 1. Farmer 2. Trader 3. Cooperative 4. Farmer group 5. Processor 6. Supermarket 7. Consumer 8. Other	When were you paid for the chilis? 1. Before harvest 2. At delivery 3. 1-7 days later 4. More than week later 5. Multiple payments (across categories)	Where did the sale take place? 1. On farm 2. Roadside 3. Collection place 4. Village mkt 5. Sub-dist mkt 5. District mkt 6. Wholesale market 7. Other	[If not at farm] How did you transport it there? 1. On foot 2. Bicycle 3. Motorbike 4. Car 5. Rented motorbike 6. Taxi / bus 7. Truck 8. Other	[If sale off farm & transport hired] How much did it cost to transport it? Rp
F1		F2	F3	F4	F5	F6	F7	F8	F9	F10
1	Early									
2	Middle									
3	Late									

In the last season you grew chilies, what quantity was kept for use as seed from the largest plot? (kg) [ ] F11

In the last season you grew chiles, what quantity was kept for home consumption from the largest plot? (kg) [ ] F12

What do you do after harvest to prepare the chilis for sale?

Remove debris or foreign materials	1. Yes 2. No		F13
Remove small or bad chilis	1. Yes 2. No		F14
Sort into different groups by size	1. Yes 2. No		F15
Sort into different groups by color	1. Yes 2. No		F16
Sort into different groups by quality	1. Yes 2. No		F17
Remove stems	1. Yes 2. No		F18
Put into bags or boxes	1. Yes 2. No		F19
Other _______________	1. Yes 2. No		F20

What is the distance in kilometers from the plot to the nearest…

...road of any type?		F21
…asphalt road?		F22
…village market?		F23
…sub-district market?		F24

Do yu know the current price ofchili at Kramat Jati or Caringin Wholesales Market? 1. Yes 2. No	Chili Type	Do yu know the current price of [..] at Kramat Jati Wholesales Market? 1. Yes 2. No	What is the price of [..] at Kramat Jati Wholesales Market? Rp/kg	Do yu know the current price of [..] at Pasar Induk Caringin? 1. Yes 2. No	What is the price of [..] at Pasar Induk Caringin? Rp/kg
F26		F27	F28	F29	F29
	Red Curly				
	Red Big				
	Red Small				
	Green Small				

SECTION F1. SEED USE

Did you ever do the seedling yourselves?	1 Yes 2 No	Continue to F1_28a	F1a_0
If F1_0=1 When did the most recent seedling yourselves? (month, year)			F1a_0a
From whom did you get the seeds to conduct the most recent seedling? [F1_0a, F1_0b]	1 Own seed 2 Other farmer 3 Traditional market 4 Input shop 5 Company agent 6 Government 7 Others		F1a_1
How much time did you need to get the seeds by a motorbike? (minute)			F1a_2
What varity did you use?			F1a_3
What is the size of the area you use for seedling? (m2)			F1a_4

Did you hire labors for seedling? 1. yes 2. No	How many male labor did you hire? Number	How many days of the male labor hired? Day	How many female labor did you hire? 1. yes 2. No	How many days of the female labor hired? Number	Were there any household members involeved in seedling activities? Day	How many children (aged < 18 & unmarried) of your household member were involved? Number	How many days children (aged < 18 & unmarried) of your household member were involved? Day	How many males in your household member were involved? Number	How many days males in your household member were involved? Day	How many females in your household member were involved? Number	How many days females in your household member were involved? Day
	F1a_6	F1a_7	F1a_8	F1a_9	F1a_10	F1a_11	F1a_12	F1a_13	F1a_14	F1a_15	F1a_16

SECTION F1. CONTINUED

	Input	Did you use [..]? 1. yes 2. No	What is the price of [..]? Rp/unit	What is the price unit [..]? 1. Kg 2. Litre 3. Rod 4. Pack 5. Sack 6. Roll 7. Bottle	What is the volume per unit? (Kg/ml) [..]	How much did you spend for [..] ? (units)	How much did you spend for […]? Rp per season
	F1_17	F1b_18	F1b_19	F1b_20	F1b_21	F1b_22	F1b_23
1	Seed						
2	Urea						
3	TSP						
4	KCl						
5	ZA						
6	NPK Mutiara						
7	Common NPK						
8	Organic fertilizer						
9	Pesticide						
10	Plastic for roof						
11	Bamboo for roof						
12	Plastic tray						
13	Bunbun/polybag						

SECTION F1. CONTINUED

How many seedling did you produce from seedling [${F1a_0a}]? (seedling)			F1_26
What was the chili produktivity per plant from completed harvest from your seedling production [${F1a_0a}]? (kg/plant)			F1_27
Ready-made seedling			
Do you ever use a ready-made seedling that is not your own seedling?	1 Ya 2 Tidak		F1_28_0
If F1_28_0=1			
When did you last use a ready-made seedling that is not your own seedling? (month)			F1_28a
			F1_28b
For using seedling [${F1b_29}], How much did you spend for seedling ?			F1_28
For using seedling [${F1b_29}], What was the price of those seedling?			F1_29
For using seedling [${F1b_29}], Did you pay on credit for buying seedlings	1. Cash 2. Credit		F1_30
For using seedling [${F1b_29}], From whom did you get the seelings?	1. Other farmer 2. Seedling producer 3. Government 4. Others		F1_31
How much time did you need to get the seelings [$ {F1b_29}] by a motorbike? (minute)			F1_32
What was the transportation cost for transporting seedlings [${F1b_29}]? (Rp)			F1_33
How much was seedling [$ {F1b_29}] damaged during transportation?			F1_34
What kind of seedling variety [${F1b_29}]?			F1_35
How many seedling producer in ypur village?			F1_36
What was the chili produktivity per plant from completed harvest from ready-made seedling [${F1b_29}]? (kg/plantn)			F1_38

Page 10

H. RELATIONSHIP WITH CHILI BUYERS

How many chili buyers have you sold to over the last 5 years? [ ] H1

How many chili buyers have you sold to over the last year? [ ] H2

How many chili buyers have you spoken to over the last year? [ ] H3

When in the chili production cycle do you usually first communicate with a buyer? [ ] H4
- 1, Before planting
- 2. Between planting & harvest
- 3, After harvest begins

How do you usually communicate with your chili buyer(s)? [ ] H5
1. Mobile phone
2. Landline phone
3. Buyer comes to the farm
4. Farmer goes to buyer 's place
5. Meet buyer elsewhere
6. Through intermediary person
7. Through cooperative/group

What type agreement do you usually have with the buyer? [ ] H6
1. No agreement prior to sale [skip to H19]
2. Oral/verbal agreement
3. Written agreement

[If H6=2 or 3] When in the chili production cycle do you usually agree on the sale with the buyer? [ ] H7
- 1, Before planting
- 2. Between planting & harvest
- 3, After harvest begins

[if H6 = 2 or 3]
What is specified in the agreement with the buyer? 1. Yes 2. No

Price	[ ]	H8
Quantity	[ ]	H9
Color	[ ]	H10
Time of payment	[ ]	H11
Sorting by size	[ ]	H12
Sorting by color	[ ]	H13
Removal of stem	[ ]	H14
Seed provided on credit	[ ]	H15
Other inputs provided on credit	[ ]	H16
Other ________	[ ]	H17

[if H6=2 or 3]
Has the level of detail in your agreements with chili buyers changed over the last five years? [ ] H18
1. Yes, they have become more detailed
2. No change
3. Yes, they have become less detailed
4. Not applicable (e.g. first time)

Describe your bargaining position with the chili buyers. [ ] H19
1. I always accept the price he offers
2. I sometimes bargain with him
3. I usually bargain with him.
4. I set the price and don't bargain.

Has your bargaining postion with chili buyers changed over the last five years? [ ] H20
1. Yes, I have more bargaining power than I used to.
2. No, it hasn't changed.
3. Yes, I have less bargaining power than I used to.
4. Not applicable (e.g. first time)

I. PRICE SATISFACTION

	Please select the response that reflects your opinion regarding the main buyer of chilis over the past year using the following scale: strongly agree, agree, neutral, disagree, strongly disagree.	1. Strongly disagree 2. Disagree 3. Neither agree nor disagree 4. Agree 5. Strongly agree
I 1	Price information from my buyer is understandable and comprehensive.	
I 2	In comparison to other buyers, I am satisfied with the price my buyer offers.	
I 3	The buyer always communicates properly if the price changes.	
I 4	I receive a good price-quality ratio.	
I 5	I can cover the cost of chili production from the price I receive.	
I 6	Compared to the price I received last year, I am satisfied with the current price.	
I 7	The prices I received from my buyer are similar to the prices other farmers get.	
I 8	The chili price information from my buyer is complete and correct.	
I 9	The chili prices I receive are fair.	
I 10	I would not sell to other buyers because I like being associated with my buyer.	
I 11	The buyer offers me satisfactory prices for my chilies.	
I 12	Our relationship is something that we are very committed to.	
I 13	Based on the price my buyer offers me, I will not change buyers.	
I 14	I care about the long-term success of the relationship with my buyer.	
I 15	My buyer cares about my welfare (e.g. he will buy any volume I have).	
I 16	My buyer treats me fairly and equitably, giving me the same treatment as others.	
I 17	I believe the technical and market information provided by my buyer.	
I 18	I receive payment on time.	
I 19	My buyer always keeps his promises regarding price, payment, delivery, etc.	
I 20	My buyer is quick to handle my complaints.	

J. PERCEPTION OF MODERN CHANNEL

Do you know any farmers who have sold **any agricultural products** over the last year that ended up …

1 . Yes
2. No
3. Don't know

…being sold in supermarkets? J1

… being exported? J2

Do you know any farmers who have sold any **fruit or vegetables** that ended up being bought by a large processor? J3

[If J1 or J2 or J3 = yes] What has been their experience selling into the supermarket/export/ processing channels? J4

1. Mostly very positive
2. Generally positive
3. Some positive, some negative
4. Generally negative
5. Mostly very negative
6. Don't know

Do you think most farmers would be interested in selling into the supermarket channel? J5

1 . Yes
2. No
3. Don't know

What do you see as the main advantages of selling into the supermarket channel? (up to 2) J6 J7

1. Higher price
2. Access to good seed
3. Access to other inputs
4. Getting inputs on credit
5. Technical assistance, learn new skills
6. No advantage to selling to supermarkets
7. Don't know

What factors do you think prevent farmers from selling into the modern channel? (up to 3) J8 J9 J10

1. Small farms, small quantities
2. Location far from buyers
3. Low quality of product
4. Can't supply all year (lack of irrigation)
5. Not enough experience
6. Necessary inputs are too expensive
7. Do not have equipment needed
8. Buyers don't know or trust them
9. Buyers require record keeping
10. Buyers require farmers to packge chilies
11. Buyers don't pay immediately on delivery
12. Buyer has been tied down with trader.
13. Don't know

What do you think the government could do to help more farmers sell fruis and vegetables into the modern channels? (up to 3) J11 J12 J13

1. Provide training in production methods
2. Provide training in grades & standards
3. Provide training in marketing
4. Provide information on prices and markets
5. Improve supply of horticultural seed
6. Improve supply of agricultural chemicals
7. Invest in irrigation
8. Help organize farmers into groups
9. Improve roads in rural areas
10. Provide credit
11. Other
12. Don’t know / no opinion

K. EXPERIENCE WITH MODERN CHANNEL

Do any of your agricultural products end up in supermarkets, processor, or exporter? — 1 . Yes / 2. No / 3. Don't know [ ] K1

[If K1=2 or 3, skip to Section L]

[If yes] Which crop of yours ends up in a supermarket, exporter, processor? — Crop code (see Part C) [ ] K2

Do you know where your chiles are eventually sold? [ ] K3

1. All to traditional markets
2. Some to supermarkets
3. Some to processors
4. Don't know

[If K3=1 or 4, skip to Section L]

Does your chili buyer demand higher quality standards than buyers who don't supply modern channels? — 1 . Yes / 2. No / 3. Don't know [ ] **K4**

Does your buyer help you in any of the following ways?

Delivering good quality seed	[ ]	K5
Delivering pesticides	[ ]	K6
Delivering other agricultural chemicals	[ ]	K7
Providing technical assistance	[ ]	K8
Providing inputs on credit	[ ]	K9
Guaranteeing the price before planting	[ ]	K10

Are your chili yields higher or lower than they would be if you worked with a buyer for the traditional market? — 1. Higher / 2. Same / 3. Lower / 4. Don't know [ ] K11

Is the average price you get for your chilies higher or lower than it would be if you sold to a buyer in the traditional market? — 1. Higher / 2. Same / 3. Lower / 4. Don't know [ ] K12

Have you had any problems with your chili buyer? — 1. Many / 2. Some / 3. No [ ] K13

[If K13=1 or 2] What were the problems? (maximum of 3) [ ] K14 [ ] K15 [ ] K16

1. Poor quality seed provided by buyer
2. Poor quality fertilizer provided by buyer
3. Poor quality pesticide provided by buyer
4. High cost of inputs provided by buyer
5. Delays in delivery of inputs by buyer
6. Buyer did not give promised price
7. Delay in collecting harvest
8. Delay in paying for harvest
9. Manipulation of grading to pay lower price
10. Product rejected for low quality
11. Market price higher than fixed price
12. Cheated by trader or supplier regarding the volume of sales

How has your net income changed as a result of selling to a buyer supplying the modern channel compared to before? [ ] K17

1. Large decrease
2. Small decrease
3. No change
4. Small increase
5. Large increase

L. CASH INCOME ACTIVITIES

Income activity	Code	In the past 12 months, have members of your household received income from [activity]? 1. Yes 2. No	[-------------------------- if L2 = yes How many months out of the past 12 months did members of this household receive income from [activity]? Months	For each of these months that you were involved in [activity], how much gross revenue did you make from this activity? Rp/month	For each of these months, how much does your household spend in business expenses related to this activity? Rp/month	-------------------------------] Over the past 5 years, has this activity become more or less important as a share of your income? 1. More important 2. No change 3. Less important
	L1	L2	L3	L4	L5	L6
Chili production						
Other agricultural production						
Livestock & animal product sales						
Aquaculture						
Agricultural trading						
Other trading						
Rice milling business						
Food processing business						
Other business						
Agricultural wage labor						
Non-agricultural employment						
Pension						
Remittances from family members						
Other assistance programs						
Other						

P. DESIRED ATTRIBUTES OF BUYER (Male questionnaire)

	P15	P16
	Are you involved in each of the following activities in chili production? 1. Yes 2. No	For each of the following activities in chili production, please indicate who has the main responsibility between the husband and wife? 1. Husband 2. Wife 3. Both
1 Preparing the land		
2 Buying farm equipment		
3 Buying inputs		
4 Spreading seed		
5 Mulching		
6 Planting		
7 Installing stakes		
8 Fertilizing		
9 Spraying chemicals		
10 Weeding		
11 Watering		
12 Harvesting		
13 Transporting chilli to point sale		
14 Sorting and grading		
15 Negotiating with buyer		
16 Preparing meal		

Q. DESIRED ATTRIBUTES OF BUYER (Female questionnaire)

	Are you involved in each of the following activities in chili production? 1. Yes 2. No P15	For each of the following activities in chili production, please indicate who has the main responsibility between the husband and wife? 1. Husband 3. Both 2. Wife P16
1 Preparing the land		
2 Buying farm equipment		
3 Buying inputs		
4 Spreading seed		
5 Mulching		
6 Planting		
7 Installing stakes		
8 Fertilizing		
9 Spraying chemicals		
10 Weeding		
11 Watering		
12 Harvesting		
13 Transporting chilli at point sale		
14 Sorting and grading		
15 Negotiating with buyer		
16 Preparing meal		

R. INSTITUTION AND COLLECTIVE ACTION											
Membership Organisation		Do you or a member of your household is a member of [..] currently? 1. Yes 2. No	Do you or a member of your household is a member of [..] in 2010? 1. Yes 2. No	Are you a committee of [..]? 1. Yes 2. No	If R3=1 What is your position as committe in [..]? Head Secretary Treasurer Head of section	Is [..] providing credit for the members?	Is [..] providing collective input for the member?	Is [..] providing collective marketing facility for the members?	Is [..] providing collective saving and loan for the members?	Is [..] providing irrigation management for the members?	If R9=1, What is the consequency if member did not follow the irrigation rules? [..] 1. Excluded from membership of the group and can not use irrigation 2. Reduced irrigation / no irrigation quota next round 3. Pay fine 4. Not getting government services 5. Other
						1. Yes 2. No 3. Don't know					
		R1	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**
1	Cooperative										
2	Farmer Group										
3	Woman Farmer Group										
4	Others										

Page 18

S. INTERVENTION PROGRAM

		How many times at the [..], did you get extension visiting from [..] in the last year? Number	What was the topic of visiting? 1. Providing information technology cultivation 2. Pest and disease control 3. Promoting pesticide 4. Promoting variety 5. Post-harvest 6. Marketing 7. Other	Have you ever received assistance from the[..] in the last year? 1. Yes 2. No	1, What was the [..] ass 1. Credit in the form of goods 2. Credit in the form of money for agricultural costs 3. Aid money for 4. Free seed/seedling 5. Free pesticide 6. Free fertilizer 7. Free machinary	Was there any DEMO PLOT from [..] last year in your village? 1. Yes 2. No
		S1	**S2**	**S3a**	**S4**	**S3b**
Government Program	1. Individual level					
	2. Village level					
Private Program	3. Individual level					
	4. Village level					

T. FARMING SHOCK

Household Shock

	1. Yes 2. No
	T1
1. Was there any male household member who was sick/accident that could not work for two weeks? 2. Was there any female household member who was sick/accident that could not work for two weeks? 3. Was there any male household member passed away? 4. Was there any female household member passed away?	

Production Shock

	Have you ever experienced shock of [..]? 1. Yes 2. No	What was the plot influnced by the [..]! Plot number
	T2	**T3**
1. The disease that can not be overcome / prevented 2. Flood that can damage crops with losses of more than Rp 500,000 3. Floods causing a reduction in the agricultural land area of more than 10 m2 4. Land slide causing a reduction in the agricultural land area of more than 10 m2 5. Theft of crops worth more than Rp 500,000		

Thank you for participating

Appendix 4. Revenue function estimation using aggregate of FFL and DIS

Variables	Estimate	Std. Error
Intercept	-0.327	1.176
FFL	-0.168	0.314
DIS	-0.001	0.181
FFL* DIS	0.044	0.039
FFL squared	-0.025	0.032
DIS squared	-0.004	0.018
Ln AREA	-5.301	3.617
Ln NUMBER OF PLANTS	0.942	0.955
Ln COST OF LABOUR	-1.164*	0.614
Ln COST OF PESTICIDES	1.216	1.320
Ln COST OF FERTILISERS	2.637*	1.550
Ln COST OF OTHER INPUTS	-2.465	1.589
Ln AREA*Ln NUMBER OF PLANTS	3.415	3.763
Ln AREA*Ln COST OF LABOUR	0.226	3.206
Ln AREA*Ln COST OF PESTICIDES	-1.673	3.802
Ln AREA*Ln COST OF FERTILISERS	5.970	4.775
Ln AREA*Ln COST OF OTHER INPUTS	-4.807	4.882
Ln NUMBER OF PLANTS*Ln COST OF LABOUR	1.456	0.988
Ln NUMBER OF PLANTS*Ln COST OF PESTICIDES	-2.656**	1.520
Ln NUMBER OF PLANTS*Ln COST OF FERTILISERS	-3.499**	1.929
Ln NUMBER OF PLANTS*Ln COST OF OTHER INPUTS	1.807	1.607
Ln COST OF LABOUR*Ln COST OF PESTICIDES	-1.817***	0.878
Ln COST OF LABOUR*Ln COST OF FERTILISERS	-0.138	1.021
Ln COST OF LABOUR*Ln COST OF OTHER INPUTS	0.953	0.941
Ln COST OF PESTICIDES*Ln COST OF FERTILISERS	1.977	1.465
Ln COST OF PESTICIDES*Ln COST OF OTHER INPUTS	3.236***	1.337
Ln COST OF FERTILISER*Ln COST OF OTHER INPUTS	-1.345	1.809
STORAGE HOUSE	0.927***	0.373
HYBRID	0.231	0.393
RAINFALL	0.171	0.233
R-squared	0.177	
Number of observations	226	
F-test	1.449	
P-value	0.074	

Note: *** different at 1 per cent, ** different at 5 per cent, * different at 10 per cent